# SYSTEMS APPROACH FOR APPLYING REMOTE VIDEO TECHNOLOGY AND THE INTERNET TO REAL TIME WEATHER AND RUNWAY CONDITION REPORTING FOR AVIATION USE: CASE STUDY AT RURAL AIRPORTS IN INTERIOR ALASKA

A

THESIS

Presented to the Faculty

of the University of Alaska Fairbanks

in Partial Fulfillment of the Requirements

for the Degree of

DOCTOR OF PHILOSOPHY

By

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Fairbanks, Alaska

May 2000

UMI Number: 9965376





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# ABSTRACT

Aviation is critical to the infrastructure of Alaska. However, systems that provide runway and weather condition information about rural airstrips are not meeting the needs of the aviation community. Accordingly, aviation safety is compromised, efficiency of operations is reduced and service to clients is mediocre. Research was conducted to determine methods of improving the accuracy and reliability of runway and weather condition reporting systems in Interior Alaska.

A thorough background study of current reporting systems was conducted. A statistical study of aviation accidents in Interior Alaska was completed to document the premise that runway condition and weather reporting systems contribute to the problem. Current reporting systems were analyzed to isolate root causes of system degradation. An analysis of primary stakeholders associated with aviation reporting systems was completed. An hypothesis was formed which favored the use of remote video camera technology to provide near real-time weather information directly to end users. A $114 K grant was obtained to conduct a test of the capabilities and benefits that would accrue from transmitting images of distant runway and sky conditions onto the Internet. For nine months, images of the sky and runway from three distant airstrips in Ruby, Kaltag and Anaktuvuk Pass, Alaska were transferred every thirty minutes to a publicly accessible website for use by the aviation community in assessing current conditions for pre-flight planning.

Technical feasibility was confirmed. It was clearly determined that the system exceeded the expectations of the aviation community and provided greatly improved weather information to pilots. The aviation community in Interior Alaska has embraced the concept, used it operationally and declared it to be a critical enhancement to current systems. The project was an overwhelming success as confirmed by surveys, national and international media releases, and intense interest in the project by both private and governmental agencies. Aspects of the system are now patent pending.

The research concluded that the remote video concept should be expanded throughout Alaska under the auspices of the Federal Aviation Administration (FAA) and/or the National Weather Service (NWS). Strong evidence was obtained to support potential expansion throughout the United States and internationally.

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| | |
|---|---|
| AASF | Alaskan Aviation Safety Foundation |
| AAWU | Alaska Aviation Weather United States Army |
| ADFG | Alaska Department of Fish and Game |
| AHP | Analytic Hierarchy Process |
| AKDOT | Alaska Department of Transportation and Public Facilities |
| ANOVA | Analysis of Variance |
| AOPA | Aircraft Owners and Pilots Association |
| ASOS | Automated Surface Observing System |
| ASTAC | Arctic Slope Telephone Association Cooperative |
| ASTF | Alaska Science and Technology Foundation |
| ATC | Aviation Technology Center |
| AWOS | Automated Weather Observing System |
| BLM | Bureau of Land Management |
| CAA | Civil Aviation Authority |
| CASA | Civilian Aviation Safety Authority |
| CWO | Contract Weather Observer |
| DOD | Department of Defense |
| EEO | Equal Employment Opportunity |
| FAA | Federal Aviation Administration |
| FSS | Flight Service Station |
| GAO | Government Accounting Office |
| GPO | Government Printing Office |
| GPS | Global Positioning System |
| IFR | Instrument Flight Rules |
| IMC | Instrument Meteorological Conditions |
| MAU | Multi Attribute Utility |
| MVFR | Marginal Visual Flight Rules |
| NAS | National Airspace System |
| NASA | National Aeronautics and Space Administration |

| | |
|---|---|
| NEXRAD | Next Generation Radar |
| NOTAM | Notice to Airman |
| NTSB | National Transportation Safety Board |
| NWS | National Weather Service |
| OCLC | Online Computer Library Center |
| PICMET | Portland International Conference on Management of Engineering and Technology |
| PIREP | Pilot Report |
| PSM | Project Stakeholders' Management |
| PTI | Pacific Telecom Incorporated |
| RAM | Regional Aviation Manager |
| RCO | Remote Communications Outlet |
| SAFE | Spring Air Fair Exposition |
| SREB | Snow Removal Equipment Building |
| TAF | Terminal Area Forecast |
| TWEB | Transcribed Weather En route Broadcast |
| UAA | University of Alaska Anchorage |
| VFR | Visual Flight Rules |
| VMC | Visual Meteorological Conditions |
| WDSI | Western Decision Sciences Institute |

# ACKNOWLEDGEMENTS

First and foremost, I want to give thanks to my Lord and Savior, Jesus Christ, without whom all of life would be a futile chasing of the wind, and with whom my life has great purpose and meaning into eternity. His grace and mercy have been evident throughout the conduct of this project and it He who is to be recognized and praised for any hint of glory that should issue from the conclusions drawn herein. He is my very life!

To my mom and dad who taught me the Truth, thank you for being faithful to one another for all these years and setting such a great example for me to love my own family. Thank you for the clear testimony of two lives lived in harmony before the Lord and to the glory of God. I am honored to be your son.

To my wonderful, loving, godly wife I am forever indebted. Your constant support, love, encouragement and willingness to walk with me through this life as my best friend is more than any man could ask for, and certainly more than any man deserves. I love you!

God has entrusted me with eight great children. They are truly, each one, a blessing from God. To Tischaria, my loving 17-year old, thank you for seeking the Lord above all things, listening to His voice and being a good encourager. To Tilaundia, my sweet 16-year old daughter, I will forever be grateful for all that you have taught me about honesty, integrity, and keeping short accounts with God and men. To Christina, my growing-up 14-year old, whose love of all things created gives me inspiration to wake up with a smile, thank you! To Jimmy, my oldest boy whose singing while he vacuums ALWAYS brings joy to my soul. I'm looking forward to getting to know you as a man. To Johnny, my 9-year old, ever full of hunting stories, funny stories, tall tales and anything to hold my attention; I love you and thank you for making me smile. To Daniel, my little 8-year old man, whose constant yearning for attention and love and hugs and kisses will not go unfulfilled by God's grace. I love you, Dan! To Maryanna, my big, little girl. You are growing so fast and I want to thank you for emptying my trash every day and finding all the things that I shouldn't have thrown away. You are precious to me. To my little Lydia, who is a constant source of love, laughter, and joy, thank you for being such a treasure for everyone in our family.

I must also heartily thank Dr. Bob Perkins and Dr. Jang Ra, co-chairs of my Ph.D. advisory committee, who have been excellent supporters, reviewers, encouragers and friends over the last three years. Thank you for your willingness to support my research and escort me down the sometimes-rough road to innovative thinking and hard work. I am also indebted to Dr. Jacob Joseph and Dr. Walt Tape who have been willing advisors and supporters throughout this process.

There are a number of agencies and individuals that have contributed immensely to this project. Their support has been absolutely essential in the design, deployment and execution of FlightCam. I would like to express my sincere thanks and appreciation to:

- The Alaska Science and Technology Foundation who provided over $75,000 in project funds and trusted me to use it wisely
- GCI Communications who provided 100,000 minutes of free long distance calls
- Tanana Air Service, Frontier Flying Service and Wright Air Service who provided free flights to bush Alaskan villages to install and maintain the hardware
- Mosquitonet my Internet Service Provider who enabled the world to see new views of remote Alaska every half-hour
- The Federal Aviation Administration
- The Fairbanks Automated Flight Service Station
- The National Weather Service
- The Alaska Department of Transportation and Public Facilities
- The Northern Alaska Aviation Users Group
- The Alaska Aviation Safety Foundation
- The Air Carriers Association
- Thousands of Pilots who provided excellent feedback
- And many, many more unnamed people who remain anonymous but were very influential in the success of this project.

**Thank You!**

# CHAPTER 1

# Introduction

This chapter addresses the goal of the research, essential background information and the report structure. Section 1.1 states the research goal. Section 1.2 is a general investigation into the depth and breadth of aviation in Interior Alaska. Section 1.3 outlines the structure of the report. Chapter 2 follows with an investigation into the relatively poor aviation safety record in Alaska that serves as a backdrop to the subsequent investigation of potential improvements or innovations to reporting systems in the state.

## *1.1 - Goal*

The original research goal was to investigate alternatives for improving upon the accuracy and reliability of systems currently in use in Interior Alaska to collect and report weather and runway information about rural airports. The need for system improvements is evidenced by problems in three distinct areas: a poor aviation safety record, inefficiencies in aviation operations, and unreliable service by air carriers. A systems approach is used to analyze the collection and reporting structures currently in use and recommend a specific solution for improving upon the current state of the art.

A pilot flying an aircraft through the weather to a remote Alaskan airport requires balance and synchronization between man (the pilot), machine (the aircraft) and the environment (the aviation infrastructure). Changes in these three entities have the potential to affect improvements in aviation safety, service and efficiency.

Changing the way pilots think and act may be investigated through disciplines related to psychology, physiology and human factors. Aircraft improvements should be addressed by engineering and technology related disciplines. This research is focused on improving two aspects of the aviation infrastructure: weather reporting and runway condition reporting.

As the research progressed and matured, the focus changed to a direct and experimental analysis of a new application of existing technology. Remote video camera technology was thoroughly investigated as a means for providing near real-time weather information to pilots in Interior Alaska.

The research that follows documents the evolution of this research goal and provides strong evidence in favor of adopting the use of remote video technology as an integral part of the aviation infrastructure in Alaska, the United States and throughout the world.

## *1.2 - Background and Need*

This section provides background information about aviation in Alaska. It then addresses the current runway maintenance and reporting system in use and why it falls short of addressing the needs of the aviation community. Finally it address the weather condition reporting system in Interior Alaska and delineates its shortfalls.

### 1.2.1 - Aviation in Interior Alaska

#### *1.2.1.1 - General*

It has been accurately stated that Alaska is "the flyingest place in the world." The state has six times as many pilots and sixteen times as many aircraft per capita as the rest of the United States [25]. There are 1112 airports, seaplane bases and other aircraft landing sites for general aviation aircraft in the 586,000 square miles that comprise the "Great Land". There are 286 public use airports in the state. They stretch from Barrow on the cold north coast, 700 miles south to Anchorage on the Cook Inlet. They spread from Wales in the west, sixty miles from Russia, eastward over 750 miles to Northway near the border of the Yukon Territory in Canada. Finally they reach southwest hundreds of miles into the Aleutian Chain.

Alaska is a remote land. Despite the continual press of population growth, industry expansion and technological development throughout the western world, Alaska has remained remote. Remoteness is not a measure of Alaska's geographical displacement from the rest of the United States, but a measure of the state's internal inaccessibility. Mr. Charles F. Willis, Jr. a former Chairman of the Board of Alaska Airlines used to make reference to Alaska's "inaccessibility quotient", a measure of the number of square miles of territory per mile of highway. When ranked by state, Alaska rates number one with an inaccessibility quotient of 80. Arizona, second on the list, scores a two. Thus, Alaska is essentially forty times less accessible than the most remote of the other forty-nine states [56].

Alaska's tremendous size and geographical diversity contribute to this difficulty as they retard the economic expansion of extensive road systems throughout the state. This in turn restricts the use of traditional means of transportation to facilitate commerce and growth which has given rise to alternate, albeit expensive, means of conveyance. While innovative means of moving people, mail and freight have been considered, none has had such an overarching impact on the livelihood of the state as aviation. Air transport has the least environmental impact of all transportation systems because men and materials can be delivered to the destination without disturbing any part of the land except that needed for the airstrip [16]. Commercial air transportation in Alaska had its beginning in the middle twenties. Air delivery of mail started in 1934. By the late 1930s, the airplane was the most reliable form of transportation in the territory [55]. Over the last sixty years, aviation has been the hallmark of Alaska's transportation infrastructure.

#### *1.2.1.2 - Airstrips in Interior Alaska*

In 1981, there was a great deal of concern that most rural communities did not have adequate aviation service. Adequate service may be expressed in terms of physical infrastructure; runways, terminal buildings, navigation aids, communications, land access, and maintenance facilities [26]. In addition, service quality as measured by safety, reliability and cost, was considered inferior. As a result, a concerted effort was made to establish a process and draw on the influence of organizations to remedy the situation. The State of Alaska Department of Transportation and Public Facilities (AKDOT), local community governments, the Federal Aviation Administration (FAA) and aviation industry collaborated to enhance the quality of outlying airports.

There is now one public use airport for every 2000 square miles in Alaska. Since they are often distributed along major river systems, there is a clustering effect that yields an average separation of 25 to 40 miles [13]. The majority of the 286 public use airports are rural airstrips in "The Bush". These small airports could more appropriately be called "airstrips", as they are usually little more than a remote, state-owned, unimproved runway with an adjacent building or two (Figure 1.1). While most have established some permanency, others have been transitory in nature. Umiat, a small village airstrip 300 miles north of Fairbanks, existed primarily to serve the oil field areas and normally supported a population of less than 10 people [18].

The typical public airstrip is 3000 feet long, 75 feet wide and is constructed of compacted gravel hauled or barged from some distant location. The airstrip and its immediate environment is cleared of vegetation that could interfere with the safe operation of aircraft during approach, departure and low-level maneuvering. It serves a small village or community that is absolutely dependent upon regular air traffic to survive (Figure 1.2). Over 80% of these airports are inaccessible by road, which accounts for the community's vital need for air service. Those that have no water or road access are often given priority in airport improvement projects [14]. Most airports have a small, state-owned, Snow Removal Equipment Building (SREB), where snow removal equipment is stored and maintained (Figure 1.3).

The primary users of these rural airstrips fall into one of two broad categories:

Commercial Pilots - These pilots fly for commercial gain and include the following groups:

Scheduled Air Carriers – These firms normally operate daily, scheduled flights to rural airstrips in Alaska to facilitate necessary commerce with the associated villages. They deliver mail, five to seven days a week, to nearly every rural village and town. Currently, seventeen different air carriers are contracted to carry the mail throughout Interior Alaska [47]. Often a village will receive several mail flights a day from different air carriers. The air carriers move passengers between villages as well as to and from larger cities. They also carry cargo to rural Alaskans ranging from necessary food and supplies to convenience and luxury items.

Air Taxis – In much the same way as a New York City cab provides for the immediate transportation needs of the paying public, the Air Taxi's provide unscheduled air service within Alaska. These flights accommodate emergencies, immediate business needs and custom-fit recreational outings.

State Agencies – The Alaska Department of Fish and Game (ADFG), the AKDOT, the Bureau of Land Management (BLM), law enforcement agencies and others use these airstrips as en route refueling stops, and terminal points to facilitate execution of their responsibilities throughout Alaska.

General Aviation Pilots – Sightseeing, hunting, and fishing excursions throughout rural Alaska are often accommodated by air transportation to the site. Individual aircraft owners use the geographically dispersed web of airports to facilitate recreational trips throughout the state. In addition, some aircraft owners conduct business using their personal aircraft and are dependent upon Alaska's public airports for safe, convenient travel.

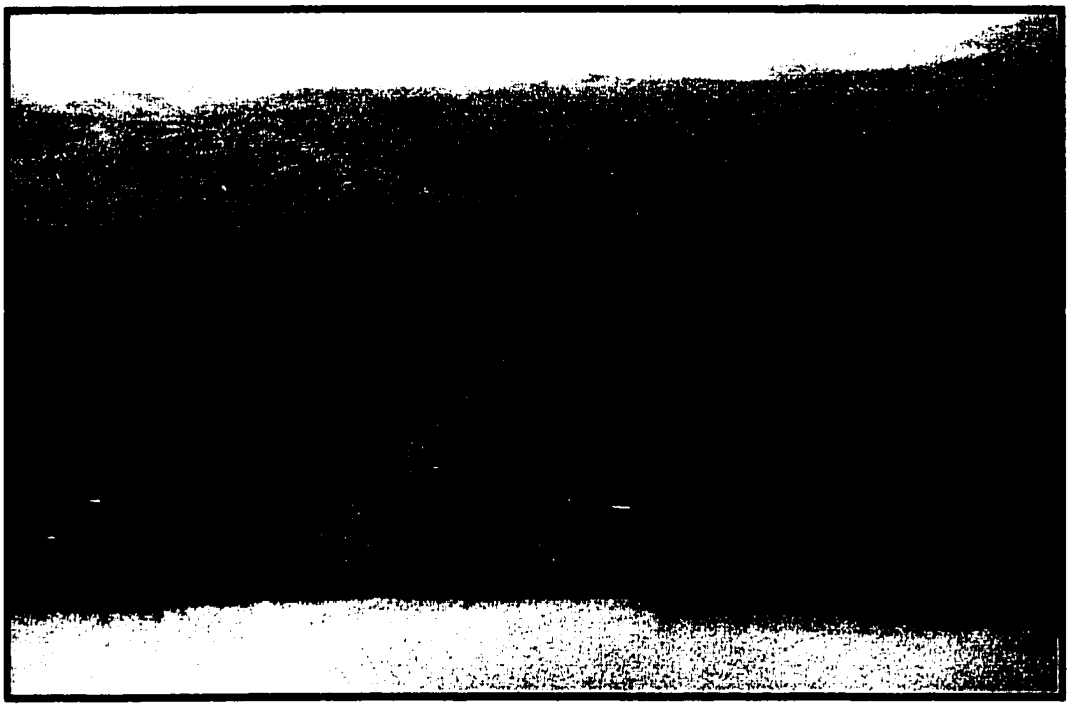


**Figure 1.1** - Typical Alaskan airstrip with adjacent buildings

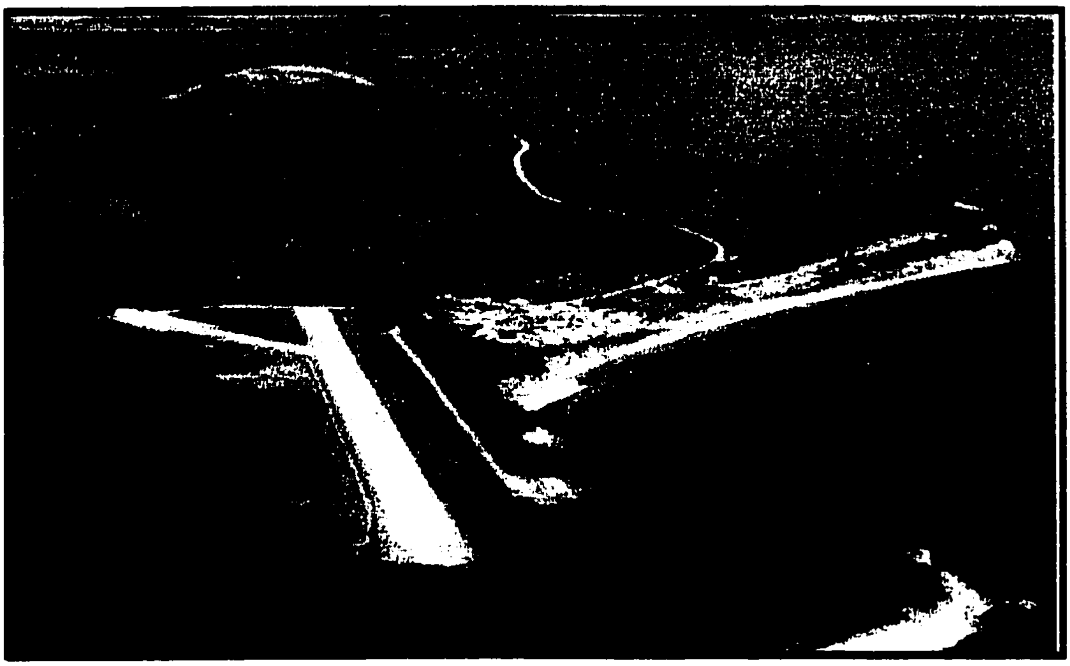


**Figure 1.2** - Typical Alaskan village with adjacent airstrip

### *1.2.1.3 - Weather in Interior Alaska*

Much like the driver of a vehicle concerns himself with the condition of the road, the pilot of an airplane concerns himself with the condition of the atmosphere through which he flies. The weather characterizes conditions in the atmosphere that may encourage safe, enjoyable flight, or provide opportunity for high risk and imminent danger. The fact that weather conditions are constantly changing requires that a pilot have access to the best weather resources available to ensure safe flight. Weather peculiar to Interior Alaska can be quite hazardous to flight. Some of the specific anomalies and extremes are explained below:

Extreme low temperatures - The average low temperature in Fairbanks, Alaska, during January and February is -27 degrees Celsius [1]. Temperatures of -40 degrees Celsius and below are not uncommon to the Interior. In one sense, cold dense air produces real benefits to flight including improved rate of climb, reduced runway length required for takeoff and increase load capability for a given runway length. However, the cold takes a tremendous toll on an aircraft's instruments, engine and airframe which can effectively reduce the life of the plane. The potential for fuel lines to freeze, engine components to fail and aircraft systems to malfunction increases with sub-zero temperatures and can compromise the integrity of a flight. In addition, survival at extreme cold temperatures becomes very difficult in the event of a forced landing due to loss of engine power.

High Winds - Alaska hosts several geographic and atmospheric phenomena that can generate high wind conditions. These include extremely high and rugged terrain and large atmospheric pressure gradients. The fast and gusty wind conditions produced can be especially hazardous during takeoff and landing at the myriad of small airstrips throughout the region. Additionally, high headwinds effectively increase the time of flight between stations and can lead to fuel starvation without proper and careful planning.

Reduced Visibility - The combined effects of wind, varying temperatures and moisture can affect very quick changes in visibility. Given the long distances between airports, and the varying topography and atmospheric conditions, pilots generally encounter widely varying visibility and weather phenomena along their route of flight. For the Visual Flight Rules (VFR) pilot, the continuous reduction in visibility over a long flight can lead to the postponing of a necessary decision to terminate the flight early. This exposes the pilot to all the dangers incumbent to flying without reference to the horizon.

Reduced Ceilings - The ceiling is a measure of the distance from the ground to the bottom of an overcast cloud layer. Federal Aviation Regulations dictate certain minimum ceilings for flying under VFR. As with reduced visibility, the gradual lowering of ceilings over a long distance, or the sudden change in the height of a cloud layer can also subject the pilot to a requirement to fly lower and lower until he has no alternative but to enter the clouds or turn back. The latter, wiser option is often rejected by the pilot in flight in favor of completing the trip. Even the experienced commercial pilot, intent upon getting his passengers and freight to his destination may err on the side of continuing a flight in the face of increasing risk. A particularly dangerous scenario involving reduced ceilings occurs when a pilot flies further and further into deteriorating conditions only to turn back and find that the ceilings behind him have also lowered thereby precluding his escape. He then has no alternative but to enter the clouds or land on whatever terrain is below him. The propensity for Alaskan weather conditions to change rapidly exacerbates these problems.

Several pilots conducting round-the-world flights have commented that the worst weather they encountered was in Alaska and Western Canada [32]. Characterizations of Alaska weather have been reduced to such phrases as "What you see is what you've got" indicating both the rapidity with which conditions change, and the relative lack of weather information throughout the state [32]. The fact that many remote airports, in particular, are losing human weather observers and being replaced by automatic reporting equipment has caused much consternation among pilots and air carrier companies. The lack of good reporting sources complicates the process of accurately forecasting the weather that leads to poor information for pilots and higher risk.

## 1.2.2 - Airstrip Condition Reporting

### *1.2.2.1 - Requirement (Airstrip Condition Reporting)*

The AKDOT is responsible for the development, maintenance and operation of its public airport system. As such, they own and operate 266 of the 286 public airports throughout the state. Most of these airports service small, remote villages that are otherwise inaccessible by road.

Almost without exception, each of these airports requires significant seasonal maintenance to support the regular and necessary daily flow of air traffic. The one universal maintenance requirement is that of snow removal which affects every airport in the state. Snow removal is critical to the safe, consistent operation of air carriers into these small villages. Since most airstrips are inaccessible by road, state maintenance employees cannot provide this service. Therefore, at each village, the state contracts a single individual or the city council to conduct snow removal and other airport maintenance throughout the year. Approximately 90% of these airports are maintained by a single individual, or by the city under contract with AKDOT. State workers maintain the other airstrips as well as the road transportation network in the vicinity of airports accessible by road.

The AKDOT provides a road grader, a bulldozer or bucket loader, the SREB and miscellaneous equipment at nearly 80% of these airstrips (Figure 1.4). This equipment provides the contractor a means for conducting required maintenance. Additionally, this contractor is responsible to both collect and report the current status of the runway to the nearest FAA Flight Service Station (FSS) for inclusion in the official airport reporting system. The need for competent, trustworthy individuals in these positions is critical to the safe operation of aircraft at these runways.

### *1.2.2.2 - Current System (Airstrip Condition Reporting)*

A detailed delineation of both AKDOT and contractor responsibilities with respect to runway maintenance and condition reporting follows. This establishes both the difficulty and importance of conducting airstrip maintenance and of providing reliable airstrip condition information to pilots.

#### AKDOT Manager Responsibilities

AKDOT has direct responsibility and oversight for individuals contracted by the state to perform airport maintenance. Whereas most airports are now maintained by either a state employee, or a contractor, the system has not always been this clean. In 1959, this work was accomplished under work orders issued to individuals, the Bureau of Public Roads, agreements with communities, force account, or carriers serving the facility [43]. So even early in the development of a maintenance structure, there was difficulty addressing the individuality as well as the remote nature of rural airports.

It is helpful to investigate the primary duties incurred by AKDOT in the management of maintenance contractors. These responsibilities are broken down into the following seven categories: recruiting; selecting; training; supervising; discipline; compensation and evaluation. The impact of remoteness on each category is discussed below.

Recruiting - Recruiting is the process of generating a pool of qualified applicants to fill the position of contractor. The first difficulty discovered comes in defining the skilled labor force population that is available to AKDOT from which they can generate a pool of applicants. Geographical issues dominate this problem. If AKDOT is searching for a contractor for Beaver, which lies 100 miles north of Fairbanks, it is unlikely that they will be able to consider anyone who is not a resident of that village. It would be infeasible for an individual contractor, living away from the airstrip, to commit to providing snow removal

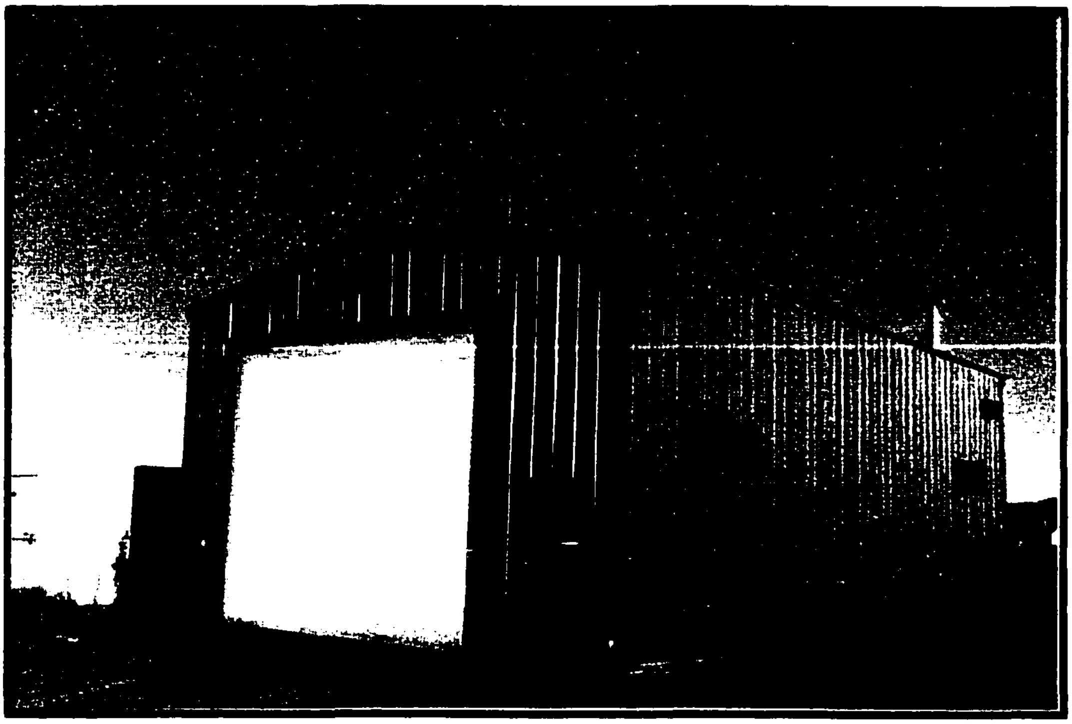


**Figure 1.3** - Snow Removal Equipment Building

**Figure 1.4** - Heavy Equipment Used for Airstrip Maintenance in Rural Villages

on the very runway he is dependent upon to access the village. Even if a highly experienced pilot with a ski plane commuted to a village to provide snow removal throughout the winter, other problems would mitigate against his providing acceptable service. Lack of information about actual weather conditions and snowfall at the village combined with the delay in travelling to the facility would frustrate the pilot-contractor's best intentions.

AKDOT is limited to an applicant population from within the village in question. Adding the supplemental criteria of finding an individual who: 1) knows how to operate and maintain heavy equipment; and 2) wants the job, usually limits the applicant pool to between zero and two individuals. AKDOT estimates that when a new contract is opened for bid, two village people bid on it 60% of the time, and only one person bids the other 40% of the time [40]. If a good operator can be found, AKDOT has to compete with North Slope operations which will hire a good worker at a much higher wage than he will make with an AKDOT contract.

Cultural issues often add another dimension of confusion to this recruiting process. Competing cultural interests may compromise the reliability and loyalty of a native village contractor. Hunting season, fish camp and native traditions may draw a contractor away from his primary duties at the airstrip for days at a time. While this would never be tolerated or anticipated in a region where road access to the work site existed, it is considered a cost of doing business in the remote reaches of Alaska. Stevens Village provides a good example of cultural interference with the recruitment process. The contractor there is the village chief. By default, he will be the only one to bid on the contract since nobody will bid against the chief. The recruiting pool is artificially diminished by cultural dictate.

What then does management do when faced with a single applicant who has no previous heavy equipment training? By force of need, AKDOT selects and hires the untrained bidder and provides him with the minimal training required to get him headed the right direction down the runway with the plow down.

All of these problems would be greatly diminished if the setting were rural Oklahoma where an extensive interconnecting road network expanded the applicant pool to a multi-cultural, multi-disciplined population of citizens seeking employment. Instead, the small applicant pool tends to reduce the quality of applicant, which eventuates in the need for more supervision.

One benefit of having a target labor force so well defined is that picking an advertising medium for the job opening is easy. AKDOT usually advertises in the Fairbanks Daily News-Miner, the local village paper, and posts openings at the village post office and store. Everybody eligible for the job gets the word.

Selection - Given one or two bidders on a contract for maintenance of a remote airport, AKDOT must select only one. By law, the AKDOT must hire the low bidder. While this requirement in itself is not exacerbated by the remoteness of the village, the follow-on issues are. Although AKDOT has no option to discriminate between bidders based on stated ability (or lack thereof), they may test the low bidder to ensure that he has the requisite skills necessary to execute the terms of the contract. Testing is an excellent and legal way, to discriminate between bidders. The problem arises when it is time to conduct the test.

State lawyers, citing Equal Employment Opportunity (EEO) guidelines, recommend that all new contractors be tested to eliminate the appearance or reality of favoritism. AKDOT has neither the time, nor the money, nor the personnel to execute a testing program of this magnitude, which would invariably involve extensive air travel for either the tester or the contractors. This is complicated by the fact that they have no standard test or dedicated tester. The result is that AKDOT must often hire untrained individuals and hope for the best. This is a difficult, yet common situation that serves to reduce the quality of airport maintenance and reporting throughout the state.

Training - Training is both necessary and lacking. The extreme nature of arctic conditions requires that contractors know their jobs. These operators must be well-trained and competent [24]. Daily, scheduled air traffic is a given, and the contractor who does not respond competently may single-handedly compromise quality-of-life for a whole community.

Training topics range from use of heavy equipment to plow snow, to operation and use of a new piece of equipment. There are currently no standard AKDOT training outlines to meet these needs. In rare instances, AKDOT sends a heavy equipment operator to the outlying village to give a new untrained contractor a quick half-day course on the operation and maintenance of heavy equipment.

Small towns in the lower 48 normally own and operate their own airport. The city takes responsibility for the upkeep of its own investment as it impacts directly on opportunities for future growth of the community. The city, concerned about its own longevity, provides necessary resources to ensure its airport manager is trained and able to perform his duties. In Alaska, training is the responsibility of the state. The physical and cultural expanse between the maintenance manager and the maintenance provider is fertile ground for neglecting necessary training.

The terms of the contract require employees to attend AKDOT sponsored training sessions. These sessions may be conducted as centralized training, decentralized training, or a combination of both.

Centralized training requires the contractor at each remote site to travel to some central location to receive training. The benefits of this arrangement are that it is very efficient and generally less expensive than other alternatives. The instructor need teach the session only once to a group of contractors. Clarifications and explanations benefit all contractors simultaneously and the positive experiences of one may be communicated to all. Training aids may be centralized at the training location and all may benefit from the hands-on experience. While contractors are required to attend centralized training sessions required by AKDOT, it is fairly common for them not to show up. One or two contractors missing the training may easily offset all the benefits. Make-up training takes time and incurs additional costs since the instructor must reproduce the class for a minority of individuals. It is difficult to schedule a session that every contractor can attend, especially when the number of people requiring training is large. Contractors miss training for various reasons and their marked absence at centralized training is a valid concern.

Decentralized training involves sending the instructor to the contractor's location. This has the obvious advantages of conducting training with equipment familiar to the contractor and in the location where he will actually provide the service. Additionally, the training show-rate for contractors is much higher when conducted in the village. Decentralized training presents one major disadvantage: it takes a tremendous amount of time on the part of the trainer. As AKDOT has no dedicated trainer, this responsibility has been contracted out in the past.

The best compromise for providing extensive instruction to a large number of public airport contractors is to combine the two methods described above. In the spring of 1998, AKDOT provided training to airport contractors on the use of a newly issued two-way radio. An instructor from the University of Alaska, Anchorage was contracted by AKDOT to travel to multiple locations throughout Alaska to provide decentralized training. However, at each location contractors were transported in from "local" villages to receive the instruction at a centralized location. Figure 1.5 demonstrates this combination centralized/decentralized method.

Although each method has its benefits, all require a significant expenditure of resources for transportation costs alone. The alternative, reduced training, incurs both near and far term costs through broken equipment, damaged facilities, poor equipment maintenance and substandard runway condition reporting. Striking the right economic balance between direct costs incurred through training, and indirect costs accrued through lack of training is a complication which is exacerbated by the remote nature of the operation.

Supervision – Contractors need supervision. Sound management demands that employees account for their work. Problems fester when the manager does not supervise adequately. An old military adage declares "you don't get what you expect, you get what you inspect." That truism is replicated throughout the expanse of the airport maintenance contractor network. In the opinion of the AKDOT Regional Aviation Manager, supervision or the lack thereof, is the single greatest deciding factor regarding how well a contractor will perform [40].

At present, airport inspections are not conducted with any regularity. For the most part, airports are visited when there is a stated need. As such, face-to-face meetings between the AKDOT manager and the contractor are irregular. This fact has a marked effect on every aspect of airport maintenance. Accidents and damage to AKDOT property tend to go unreported for long periods. Inappropriate use of equipment is hard to confirm and control. Poor contractor performance is hard to detect and correct until there is a major problem.

In 1976, the Division of Legislative Audit conducted inspections of several remote airports to conduct property inventories. At Umiat, they found multiple problems. The state vehicles and heavy equipment were not in the state owned garage, but were parked outdoors, unprotected. The state building was in disrepair and the generator behind the building was idle and not being maintained. The runway had approximately eight inches of snow on it when they landed and the contractor did not offer to clear it before takeoff. They recommended the airport be closed [17]. Lack of supervision takes its toll.

As noted in the prior section, regular on-site inspections or visits by AKDOT personnel would help mitigate the concerns held by the state over contractors failing to meet up to the terms of their agreement. The AKDOT Regional Aviation Manager maintains that the existence of a regular inspection program would solve 50% of the problems the agency has with contractors at rural airports [40].

The absence of regular, quarterly visits and inspections are a function of resource shortfalls within AKDOT. The sheer distances involved in conducting inspections on site make quarterly visits prohibitive with current AKDOT staffing. When visits are conducted, they are usually done during the warm, long days of summer when maintenance is least required. Few visits occur during the cold, dark, snowy winters, when runway maintenance and reporting is most in demand. The expanse and remote nature of this Great

Land has exacted a cost from the AKDOT manager that now precludes the successful oversight of the very one whose action's ensure that intra-Alaskan transportation routes are maintained.

Discipline – Contractors who fail to meet the terms of their agreement need to be held accountable. This is decidedly difficult from a distance. From the manager's viewpoint, the first problem is gaining knowledge of poor performance. If the manager does not visit the village, he does not understand the extent of the problems there.

The contract provides for two methods of discipline: pay withholding and termination of the contract. In spite of these specific provisions and common knowledge of failures by various contractors, discipline is rarely employed. This relates back to the recruiting issue. If the manager requires too much of the contractor, he may simply quit. The employee loses his job, but AKDOT loses an airport. The latter is too large a loss to incur, so AKDOT errs on the side of leniency to protect their interest. This "manager strait jacket" might well be avoided if managers had a large applicant pool with job hungry individuals vying for the contract. As has been demonstrated, Alaska's remoteness precludes this benefit.

Compensation - The average contractor is paid about $15K annually for his services. He is paid 1/12 of that amount each month. As his duties are light during the summer, he receives four "free" months of income while there is no snowfall. Annual contract amounts vary greatly. Figure 1.6 shows contract totals for twenty Interior Alaska airports from 1981 until present. While current dollar costs are on the rise, it is readily obvious that the value of the contracts has declined over the years from the perspective of the maintenance man.

While it may seem that the expanse of the land should have no direct impact on compensation packages for contractors, exactly the opposite is true. Two examples support this premise.

In 1983, AKDOT paid the contractor at Umiat, a generous $148,000 for his services for the year. At that time, less than 5 people lived in the village. One man bid on the contract and held it for several years. The absence of competing bids put AKDOT at his mercy. As shown in Figure 1.7, AKDOT eventually terminated the contracted position at that airport.

In 1997, the city council at Point Hope bid on the airport maintenance contract. Nobody else in the village submitted a bid. The council asked for over $100,000 to maintain their runway. Litigation continued for a period of months while AKDOT lawyers sought to investigate legal ways to prevent the city from overbidding without justification. The potential for such activity in the future has not abated.


**Figure 1.5** - Centralized/Decentralized Training of Maintenance Contractors in Rural Alaska

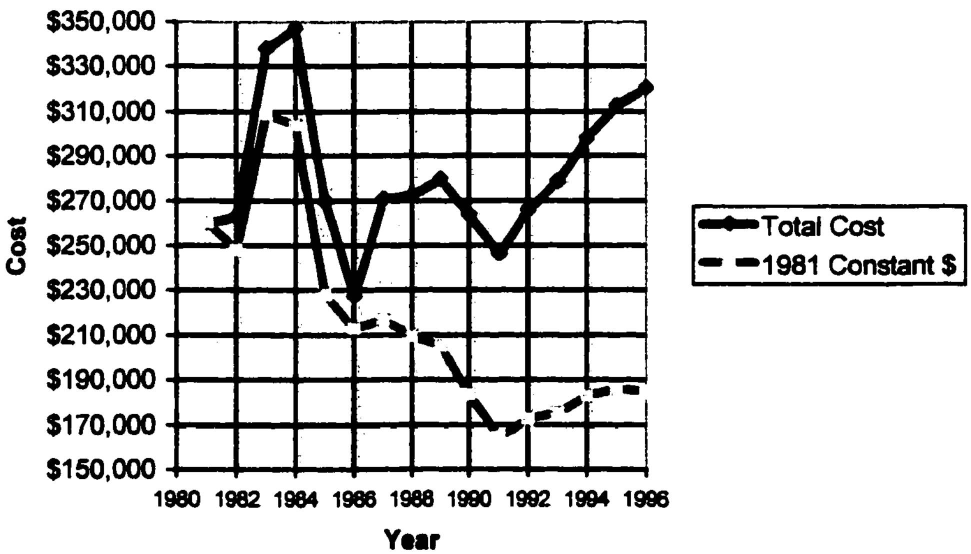



**Figure 1.6** - Total Annual Cost of Maintenance Contracts for Interior Airports

Appraisal – Employees of regular firms normally receive an annual appraisal. It serves to provide valuable feedback to the employee to encourage good performance and remedy poor performance. It is predicated on the evaluator having accurate input as to the employees past and current performance.

AKDOT airport maintenance contractors receive no regular written feedback. No formal mechanism exists to provide them with direction for the future. They have little incentive to do better other than to keep their job. Even if there was intent to provide such feedback, there would be little valid information for the manager to use to write his evaluation. This relates back directly to the supervision problem. AKDOT has little opportunity to visit with contractors and therefore has minimal information about the contractor's performance. Regular visits to airports or other means of assessing daily performance would solve this dilemma. Until that time AKDOT management will have to tolerate yet another manifestation of the inaccessibility of their contractors.

## Contractor (Employee) Responsibilities

The duties of each contractor vary slightly based on the airport infrastructure at their particular location. The primary requirements of the contract are listed below. These are discussed with a focus on the implications of remoteness and lack of supervision.

Inspect the Airport - The contractor must perform a daily inspection of the airport paying particular attention to the condition of the runway and the runway lighting system. Rutting of the airstrip, potholes, snow cover, and glare ice form the core list of discrepancies that must be discovered and corrected by the contractor. In general, contractors frequent their airstrips often enough to discover glaring deficiencies. However, thorough daily inspections are not being conducted according to the contract. Thus, a myriad of small deficiencies tends to stack up, delaying needed maintenance and increasing risk to airport users. An AKDOT employee could offset this tendency with regular inspections or daily performance feedback.

Maintain the Runway – Most rural airports have gravel surfaced runways. While some may be constructed of locally obtained river gravel, most are composed of gravel hauled or barged from distant locations [53]. Asphalt strips, with their high initial cost are not normally justified in the bush. While improved surfacing may reduce maintenance requirements, funding has not been provided to upgrade most rural airstrips [13]. The problems associated with maintaining runways in the north include severe environmental and climatic conditions including permafrost, scarcity of materials, and subzero temperatures [57].

*Winter Maintenance* – The predominant requirement of runway maintenance is snow removal. Figure 1.8 shows the extent of snow coverage in rural Alaska and the attendant need for winter

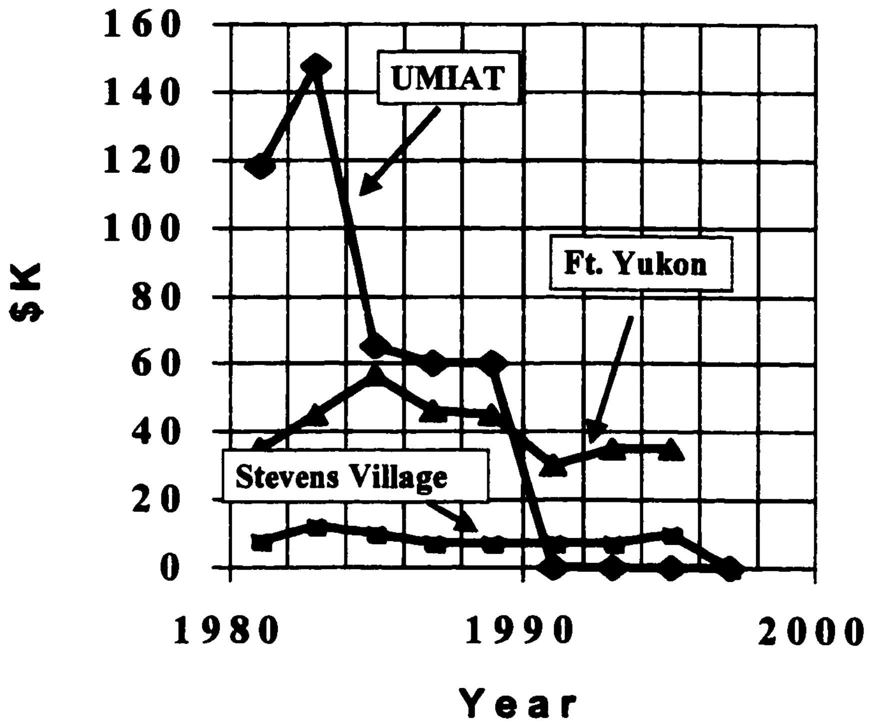



**Figure 1.7** - Comparison of Individual Maintenance Contract Amounts

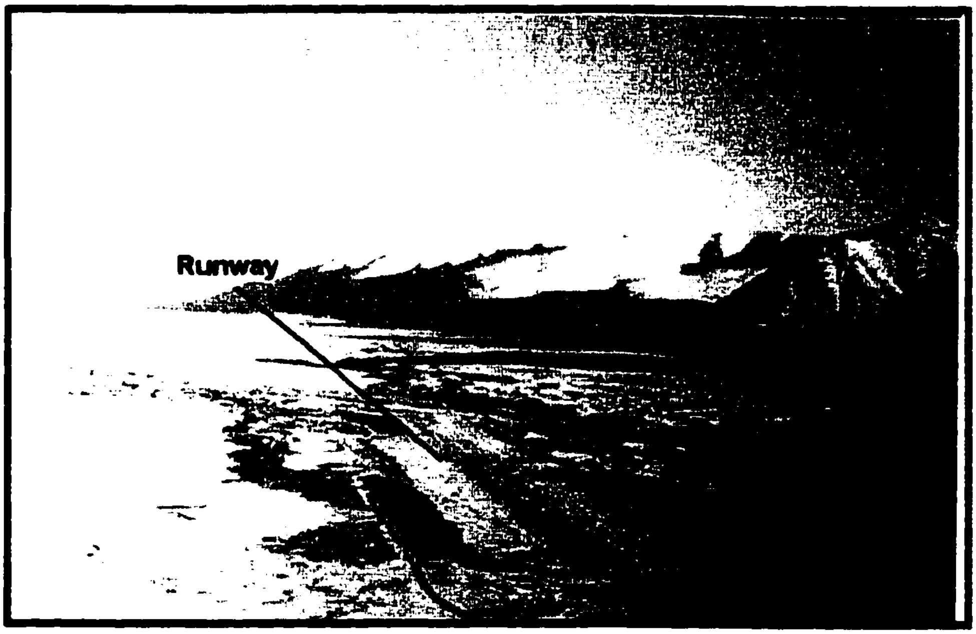



**Figure 1.8** - Extent of Snow Cover at Rural Village Airports in Alaska

maintenance of the runways. The contractor is to keep the runway clear of snow, 365 days a year and 24 hours a day. This is critical because most air carriers prefer to operate twin-engine, high performance aircraft that do not utilize skis. Thus, they anticipate landing on a surface free of loose snow and void of glare ice throughout the winter season. When predicting snow removal requirements for a particular location, snowfall is not a good measure of snow cover conditions to be anticipated. Normal snow cover may be light in areas of relatively heavy snowfall if the snow tends to be rapidly removed by winds or thaws. Similarly, heavy snow cover may develop in areas of light snowfall if conditions favor its accumulation. Regardless of the source and likelihood of snow, it may be stated with confidence that snow removal is a major factor in runway maintenance during the winter.

The primary concern with snowfall is its accumulation on the runway. However, the frequency, duration or amount of snowfall may affect the efficiency or even feasibility of conducting snow removal operations [45]. If the contractor is prevented for any reason from conducting sufficient snow removal after a significant snowfall, air traffic will be delayed. The remoteness of the airport precludes any other trained operator from immediately accessing and assisting with snow clearing operations.

*Spring Maintenance* – Breakup in the spring poses special difficulties for the contractor in terms of runway maintenance. Temperatures hovering above freezing during the day, and below freezing at night work to create glare ice that is alternately wet, slippery or both. Occurrences of aircraft sliding off the end of a runway are not uncommon. Since air traffic continues unabated during this period of year, it is essential that contractors are proactive in neutralizing the affects of glare ice. Sand and gravel are often difficult to obtain in the bush, so other methods must be used to roughen the surface. The most common means is to simply drive up and down the runway with a tracked bulldozer [23]. This puts cuts in the ice perpendicular to the runway centerline, which assists aircraft in braking. While this method works reasonably well, sanding the runway would be more effective. Again, the lack of availability of common sand and gravel in many remote villages produces a compromise in safety where an inferior method is substituted for a safer, but infeasible method.

Poor runway maintenance in the winter often leads to excessive trouble in the spring. It is important to avoid accumulations of packed snow on the runway greater than three inches to avoid excessive slush and drainage problems during the spring [30]. Removing the snowpack before spring has much the same positive effect as an individual brushing the snow off of his clothes before entering a warm house. It serves to treat the problem before it becomes harder to deal with. If snow pack is allowed to accumulate, the resulting snowmelt during breakup and subsequent damage to the runway due to rutting of soft material is more than most contractors can handle (Figure 1.9). This is yet another reason why regular inspections throughout the year are important.

*Summer Maintenance* – Summer poses only a minor threat to the integrity of the runway. The maintenance conducted during this period is meant primarily to repair damage that occurred during the winter or spring in preparation for the coming winter. The integrity of the dry runway surface determines the extent to which snow-clearing operations can succeed [3]. Any dip, or pothole existing in the dry gravel surface of the runway during summer, will fill with snow and become a soft spot in the winter. Spring thawing will only serve to worsen the problem as snow filled potholes melt. It is therefore imperative that soft spots in runways are discovered and repaired quickly. In addition, contractors must ensure that frost heaves, bulges and other runway inconsistencies are discovered and reported more quickly.

Because many operators are only minimally trained on the use of heavy equipment, AKDOT prohibits them from making significant repairs on the runways during the summer. The concern is that in their zeal, the contractor may do more damage than good. Thus, for a runway in disrepair, AKDOT may send an experienced operator from one airport to another remote site to conduct the grading operation. This is an inefficiency which must be endured because of the lack of trained, available personnel at all the airports.

<u>Maintain the Equipment</u> – To the uninitiated, snow removal in the north sounds like a strange and difficult process. However, the same type of equipment as is employed by highway departments in the northern states, is entirely satisfactory [30]. As early as 1949, road graders and bulldozers were used for construction and maintenance of airfields in the arctic [46]. Today, contractors at most Alaskan airports use the same type of equipment.

*Heavy Equipment Maintenance* – The arctic environment quickly takes its toll on equipment that is not properly maintained. Contractors are obligated to provide basic vehicle maintenance throughout the year. This includes preventive maintenance on all equipment and involves checking, filling and replacing all fluids as well as lubricating, inspecting and cleaning equipment according to manufacturer specifications. Much of this maintenance is not performed regularly due to a lack of AKDOT supervision. This will have a deleterious effect over the long term as equipment ages more quickly and breaks down more often. Regular oversight by AKDOT personnel would correct this problem.

**Figure 1.9** - Rutting of Gravel Surface on Rural Airstrips

When major maintenance is required to repair broken equipment, an AKDOT mechanic usually flies to the village and performs the repair on the spot. A major repair, such as replacing a blown engine, may require additional personnel and time due to the inaccessibility of a complete shop. The impact of a major repair could also imply a halt on all snow clearing operations for a period. The inaccessibility of the village prohibits the immediate availability of a replacement vehicle. Thus, a village could potentially be without outside contact for an extended period.

*Tool Accountability* – AKDOT provides each airport contractor with simple tools to conduct maintenance on state owned equipment and grounds. The value of these tools at each airport is approximately $600. Currently there is no formal procedure for maintaining accountability of these tools.

In 1976, the Division of Legislative Audit conducted an audit of bush airport property. The results were disheartening as they found that nearly 10% of state equipment was unaccounted for. They recommended that the Division of Aviation undertake a comprehensive physical inventory of equipment. They also encouraged the Division to ensure that all personnel responsible for equipment be given uniform written procedures to follow for additions, deletions or other changes to property [17]. Tools and state equipment used to be marked with state stickers to facilitate inventories. Recently the state abandoned the inventory program and instead has committed to purchasing without verification of loss, any tool for a contractor costing less than $500. This results from their inability to enforce property accountability from a distance. If quarterly inspections included a tool inventory, and the contractor paid for lost tools, there would be savings to the state. Instead a policy has been adopted which may encourage poor property accountability or even pilferage.

*Parts Distribution* – Repair parts for state owned equipment are provided to contractors in the bush. The efficient repair of a broken vehicle requires a proper diagnosis of the problem, identification of the required part, movement of the part to the bush, and an experienced mechanic to conduct the repair. Poor tracking of these repair and replacement parts often leads to them being sent to the wrong location. Lack of experience on the part of the contractor as well as lack of staffing at AKDOT has resulted in inefficiencies in both the movement of these parts and the repair of the equipment.

*Equipment Storage* – The SREB which is present at most airstrips, is intended to provide warm storage for state owned equipment. This assumes that the contractor keeps the building warm and that he stores the equipment in the building. Based on previous concerns about contractor reliability, proper storage is not assured. Here again, lack of direct supervision opens the opportunity for waste.

<u>Maintain Airport Lighting</u> – Runway lighting is critical in Alaska. The long winters, with their short days necessitate lighting at airports to assist pilots in finding the airport, and landing safely. In the early days, gallon-can flare pots were placed along the runway edges. These required constant maintenance to keep them filled with fuel and to light them as dusk ensued [45]. The lack of electrical power dictated the use of flare-pots and remained the controlling factor for years. As recently as 1970, few villages had electrical power. By 1985, few were without it [50].

As commercial air traffic to remote villages increased, the need for better and more reliable lighting grew. FAA regulations dictated that certain minimal lighting requirements were necessary to allow air taxi operators to conduct legal night operations [50]. The demand for commerce to the villages increased and in 1981 a major report entitled *Rural Airport Lighting, Resources and Conditions Inventory*, was prepared for AKDOT delineating the requirements for lighting at thirty-three primary airports in rural Alaska. The report found that the requirements greatly exceeded the budget. It also found that the remoteness of the airports required the following issues to be carefully considered in the design and selection of rural airport lighting systems: standardization, minimal maintenance, potential for upgrade using the same components, preference for public or private power, and vandalism [48]. Each of these requirements places an additional demand on the design of the system that is exacerbated by the remoteness of the project.

*Components* – A basic airport lighting system includes the runway and taxiway lights, threshold lights, the rotating beacon and a lighted wind cone. Runway lights are normally controlled by an approaching pilot through an aircraft radio. The requirement for minimal maintenance of lighting components is again a function of the remote location of these airports. Two important design considerations for runway lights are elevation and frangible construction. Runway lights are elevated to a height where they will not be buried by snowfall except infrequently. However, they must not be so high as to be hazardous to aircraft. The lights are constructed so as to be easily repaired if damaged by snow clearing activities. Windsocks enable a pilot to discern wind direction from the air prior to landing. Since most remote runways are not constantly monitored, pilots must determine wind direction by observation from the air prior to landing. If windsock lights are out, wind direction is impossible to determine at night, which increases risk in landing. A lighting system meeting these specifications was proposed at Stevens Village in 1981 at a cost of $350,000 [52]. An equivalent system today would cost $500,000.

*Electrical Power* – Although remote, self-powered, unattended airfield lighting systems are technically feasible, they are unnecessary where public or private power is available [11]. At one point, radioluminescent lights, which consist of phosphorescent tubes excited by tritium, were also considered [31]. Reliable power at remote villages eventually reduced the need for such novel ideas.

*Impact on Snow Removal* – One negative repercussion of the installation of above ground lighting was the increased snow removal and grading cost. The costs can be attributed to three items: increased time required to remove snow from the runway due to the presence of light fixtures; the manual removal of snow from around the fixtures; and the replacements costs of the fixtures that are damaged [51]. The operator, who with one pass can dislodge a whole row of runway lights, must be especially vigilant while plowing.

*Vandalism* – The last issue to be considered is the deliberate destruction of remote lighting equipment by the local populous. The airport is an attractive open place to run snow machines and conduct target practice. Repeatedly, studies have found runway markers and lighting components riddled with bullet holes. Law enforcement in remote areas is not so prominent as it is in the city. One report cited that 30% of runway lights may be destroyed by vandalism annually.

Maintenance of airport lighting varies greatly depending upon the contractor. To the extent that burned-out lights are not detected and replaced daily, risk to aircraft may be dramatically increased. The need for regular supervision of contractors in the bush is evident.

<u>Report Notices to Airmen (NOTAMs) as required</u>. A NOTAM is an advisory message distributed to airport users by the FAA regarding airport conditions that may be hazardous. An airport contractor may formally enter a NOTAM into the FAA computer reporting system with a toll-free phone call. A pilot will be informed of all NOTAMs applicable to his route of flight when he receives his pre-flight briefing from the FAA FSS.

Airport contract maintenance personnel are required to call in a NOTAM every time the airport is at a reduced level of operational capability. Snow cover, glare ice, ongoing snow removal operations and reduced airport lighting are all conditions that should generate a NOTAM. Contractors often fail to report NOTAMs affecting their airstrips. The value of the NOTAM is not well appreciated by the contractors. Thus they often do not make the effort to make the report. This has a huge detrimental affect on all air traffic arriving at the airstrip. A pilot arriving after a two-hour flight, only to find that the runway has 6 inches of unplowed new snow may have to abort the mission and turn back. Pilots often resort to calling their village agents to determine runway condition. This bypasses the existing reporting system and introduces information into a pilot's decision-making process that is unofficial in nature.

The accuracy and consistency of the official reporting mechanism is questionable enough to cause doubt in the mind of a pilot who gets a "no NOTAMs" report from FSS regarding his destination airport. In order for the runway condition reporting process to be successful, a sequential chain of events must occur as follows:

a. An abnormal runway condition is produced through natural or manmade means. Natural means may include snow, ice, rain (producing a soft surface) and flooding while manmade means include rutting (produced by aircraft on a soft runway), burned out runway lights, inoperable windsock etc.
b. The contract maintenance worker must inspect the runway.
c. The contract maintenance person must be knowledgeable of reportable conditions.
d. The contract maintenance person must contact the supporting FSS and provide them with a timely, accurate and complete NOTAM.
e. The flight service station must log the information into the computer.
f. A pilot must call the FSS for pre-flight information.
g. The FSS personnel must be able to readily retrieve appropriate NOTAMs from the computer.
h. The FSS personnel must offer NOTAM information to the pilot, or the pilot must request NOTAM information for appropriate destination airports from the FSS.

If any one of these events does not occur, the necessary runway information will be lost to the pilot. Items b., c., and d. above are of particular concern because they rely upon a diverse, segmented work force to consistently collect and report accurate information. Table 1.1 establishes NOTAM reporting responsibilities by airport for 23 airports in Interior Alaska.

Pilots operating on and around the airstrip feel the detrimental affect of poor NOTAM reporting. Lack of training, poor supervision and an out-of-sight, out-of-mind attitude on the part of inexperienced contractors are all related to the remoteness issue. NOTAM deficiencies impact directly on safety and thus require attention.

#### *1.2.2.3 - Shortfalls (Airstrip Condition Reporting)*

The obvious concern regarding runway condition reporting is that the system encourages the employment of an under-trained, under-paid, under-disciplined, and under-supervised individual as the primary resource for maintaining rural runways and for collecting flight critical runway information.

| VILLAGE | Weather Reporting Sources | | | NOTAM Reporting Sources | |
|---|---|---|---|---|---|
| | AWOS | Contract Weather Observer | Satellite Coverage | Contract Maintenance Worker | Road Crew |
| Allakaket | | | X | X | |
| Beaver | | | X | X | |
| Bettles | X | X | X | X | |
| Birch Creek | | | X | X | |
| Central | | | X | | X |
| Chalkyitsik | | | X | X | |
| Chicken | | | X | X | |
| Circle City | | X | X | X | |
| Circle Hot Springs | | | X | | X |
| Eagle | X | | X | X | |
| Fort Yukon | X | | X | X | |
| Hughes | | | X | X | |
| Huslia | X | | X | X | |
| Kaltag | X | | X | X | |
| Koyukuk | | | X | X | |
| Manley Hot Springs | | X | X | | X |
| Minchumina | X | | X | X | |
| Minto | | | X | | X |
| Nulato | | | X | X | |
| Rampart | | | X | X | |
| Stevens Village | | | X | X | |
| Tanana | X | X | X | X | |
| Tok | | | X | | X |

**Legend**

DOT - Alaska Department of Transportation Maintenance Building on Site
NWS - National Weather Service Automated Surface Observation System on Site
FAA - Federal Aviation Administration building on site - usually old Flight Service Station
Private - Privately owned buildings on site

**Table 1.1** - Interior Airports versus Weather and NOTAM Reporting Sources

The common thread that emerges is a need for systematic changes which will allow for better supervision of AKDOT contract employees who are often working hundred of miles from their direct supervisor and who have little to no direct accountability for many aspects of their work.

## 1.2.3 - Weather Condition Reporting

### *1.2.3.1 - Requirement (Weather Condition Reporting)*

The National Weather Service (NWS) and the FAA each play a part in making current, accurate weather information available to pilots. In general, the NWS is tasked with the responsibility of collecting and interpreting weather information through all possible resources. They then provide this information to the FAA where it is disseminated to pilots through the FSS. The FSSs primary obligation is to provide the best available pre-flight information to pilots to assist them in making wise decisions regarding planned flights. This information includes current and forecast weather conditions at the point of departure, the destination, and the route between the two. Both the NWS and the FSS draw on many resources to assemble, package and disseminate this information. However, the ability of the best briefer to portray accurate and current information is completely contingent upon the availability of accurate collection resources.

The NWS and FSSs in Alaska draw on the same type of collection resources as their counterparts in the other states. However, budget reductions and the huge geographical area of Alaska combine to make the relative ratio of collection resources per square mile much smaller than in the rest of the country. Subsequently, their ability to accurately state current conditions and reliably forecast future conditions is often stymied. This translates into less accurate weather information for pilots which increases risk.

Pilots operate under either VFR in Visual Meteorological Conditions (VMC) or Instrument Flight Rules (IFR) when they fly in Instrument Meteorological Conditions (IMC). In general, VFR flight is legal when the pilot has at least 3 miles of visibility and 1000 feet of ceiling (distance between the ground and the base of the first overcast cloud layer). A pilot operating VFR is restricted from entering the clouds at any point during a flight. IFR flight allows the pilot the freedom to fly in spite of the ceiling and visibility. However, IFR flight is tightly controlled and the pilot must fly a prescribed route from his departure point to his destination. In addition, certain minimum ceiling and visibility requirements are prescribed for IFR flight when landing. The requirements differ for each airport in the National Airspace System (NAS). In the past, ground-based navigation systems were required to conduct instrument approaches and landings at any particular airport. With the advent of the Global Positioning System (GPS), ground based systems are not always required. However, the airport must be surveyed and designated with a GPS approach before pilots can land under IMC.

The majority of airports in Alaska do not have instrument approaches. These small rural communities cannot be legally accessed by air unless the pilot is flying under VFR. Therefore, weather reporting systems at rural locations are extremely important as they assist the pilot in making an informed decision about whether he will be able to successfully complete a VFR flight into a rural location.

Section 1.2.3.2 addresses the primary collection resources currently in use in Alaska. Section 1.2.3.3 then delineates the shortfalls in weather reporting.

#### *1.2.3.2 - Current System (Weather Condition Reporting)*

Various means are used to gather information about the weather at terminal locations in Alaska. These range from human presence (contract weather observer on site) to no local means whatsoever of gathering information. Between these two extremes lie Automated Weather Observing Systems (AWOS) and Automated Surface Observing Systems (ASOS). Both systems will be referred to as ASOS or automated systems throughout this study. Satellite imagery is another existing resource which aviators can use to help paint the weather picture. Finally, Next Generation Radar (NEXRAD) is now being used to gather information about ongoing precipitation . Each of these resources is discussed below.

Weather Observers - A human observer is an excellent source of weather information. He may be under contract with the FAA, NWS or a third party contractor that provides information to federal agencies. The human observer typically collects information on wind direction, wind speed, temperature, dew point, altimeter setting, visibility and sky conditions. He then communicates this information at regularly established intervals back through a system which disseminates the information for immediate use and archives it for future study. The aviation community prefers the trained weather observer over any form of automated system because of his ability to provide accurate and timely information. In addition, he is able to discern trends and make judgements which automated systems are not capable of doing. As such the human observer is the most flexible collection resource available. The weather observer conducts observations that are then interpreted and translated into a written format for public use. The primary disadvantages of the human observer are cost and reliability. The human observer exacts an annual salary from the funding source which typically increases with time. In addition, he may forget to publish an observation at the required interval. Cuts in federal budgets have encouraged a move away from human observers to automated systems.

Automated Systems - AWOS and ASOS are in use by both the FAA and the NWS. They are designed to provide information on wind speed, wind direction, temperature, dew point, altimeter setting, ceiling and visibility. In addition, ASOS provides information on restrictions to visibility such as precipitation type or fog [35]. Information from these automated systems is broadcast over aviation frequencies and is also available as a recorded telephone message. The trend is toward installation and commissioning of more AWOS units throughout Alaska, however the aviation community is not entirely satisfied with the system.

Pilots consistently complain of unreliable ceiling and visibility data produced by ASOS (Appendix A - Pilot Survey). These difficulties are exacerbated by the extreme cold. This is of particular concern because ceiling and visibility are the two pieces of weather data most in demand by pilots upon launching out into rural locations. Pilots are wary of making go/no-go flight decisions based on these automated systems alone. Air Taxis and small commuter operations often resort to calling local villagers by phone prior to departure to determine if the ceiling is high enough to get into the village (Appendix A - Pilot Survey). The specific difficulties with ceiling and visibility reporting are discussed below.

*Ceiling* - Automated systems use a laser ceilometer and a time averaging technique to look directly above the collection system at the sky. While their algorithms can provide useful information regarding ceiling type (broken, overcast, few etc.) and ceiling height up to 12,000 feet, they are lacking in two ways. First, they provide no information about sky conditions in any of the cardinal directions (north, south, west or east). While an overcast ceiling directly above the airport may discourage a pilot to attempt a flight to that location, it is completely plausible to have poor conditions directly over the airport, but clearing or completely clear conditions to the north or south. Thus, the systems are limited in the extent to which they cover information about the complete celestial dome. Secondly, the sensors that report ceiling often do not operate properly in some weather phenomenon. Low temperatures, ice-fog, haze and other anomalies often cause these systems to erroneously report that conditions do not support VFR flight when in fact they do.

*Visibility* - Automated systems use an emitter and sensor in close proximity to one another (several feet) to measure reflected light scattered by the atmosphere. Algorithms use the amount of reflected light to extrapolate over a large distance and establish a measure of visibility in miles. This system is also flawed in two ways. First, it measures local visibility at the point of the instrument. To the extent that the microclimate at the point of the instrument is applicable to the area surrounding the airport for 15 miles, it is accurate. However, this is a poor assumption and not very beneficial to the pilot. Secondly, the automated systems extrapolate over a distance of 3 feet to a distances measured in miles. Variations in weather, as well as smoke, haze, blowing dust, local fog, idling engines, chimney smoke etc. confuse the sensors and may produce a completely inaccurate representation of current conditions.

*Satellite Imagery* - These products provide both visible spectrum and infrared images of the weather from space. While they provide excellent information about the presence of major cloud layers or the lack thereof, they provide no information about the actual conditions beneath a broken or overcast layer of clouds. Therefore, once they establish that the sky is overcast at a particular location, they cannot discern the ceiling, the type of clouds, fog layers or other local weather information which would be helpful to a VFR pilot.

*NEXRAD Radar* - Radar helps immensely in establishing the density of cloud buildups and the amount of precipitation or water vapor within the region. Thus, while they detect the presence of very bad flying conditions due to heavy precipitation, or impaired flying conditions due to light precipitation, the absence of information from NEXRAD does not positively identify areas where the ceiling or visibility is such that it is conducive to VFR flight.

The FSS personnel tasked with the responsibility of providing current, accurate weather information to pilots during pre-flight briefings draw from available resources to assist in providing the pilot with good weather information. For some airports they have local observer information, ASOS, satellite imagery and NEXRAD. At others they may have only satellite imagery and the report from an airport 100 miles distant. Table 1.1 tabulates existing weather reporting sources by airport. This tremendous variation in information reduces the overall quality of weather reporting in Alaska. Additionally, this adds tremendous variability and risk to trips planned to airstrips with poor reporting. These difficulties ultimately reduce safety and efficiency for air carriers and pilots operating throughout Alaska.

#### *1.2.3.3 - Shortfalls (Weather Condition Reporting)*

It is clear from the previous section that the aviation community in Alaska lacks current and accurate visibility and ceiling data about terminal locations throughout the state. Where no weather collection resources exist, there is a lack of information altogether. Where automated systems exist, there is the potential for a dangerous lack of accuracy in the reporting of ceiling and visibility.

There is a need to either improve existing systems, or corroborate current data with new systems. Similarly there is a need to provide low cost visibility and ceiling information at locations which are void of ground based collection systems.

## *1.3 - Report Structure*

This report pursues a systems approach to reaching the stated research goal. It conducts four major analyses: a historical data analysis, a document analysis, a systems analysis and a stakeholder analysis. The results of these studies are integrated, and categorized to assist in developing the proposed solution. A feasibility test was conducted to determine if the solution could be tested. Based on the results of the feasibility study, an operational test was undertaken. Data was collected during the test and the results were analyzed. Conclusions and recommendations are provided for full implementation of the solution. These steps are discussed in more detail below.

Chapter 2 documents the historical data analysis. This is an Alaska aviation safety statistical study which draws on 14 years of aviation accident data. Its purpose is to establish a correlation between improving runway and weather condition reporting and reducing the risk of accidents. It also provides incentive to pursue improvements in these areas and thus continue the research.

Chapter 3 provides a document analysis. This involves an extensive literature search whose purpose is threefold: 1) to determine the state of the art in runway condition reporting; 2) to determine the state of the art in weather condition reporting and 3) to determine if there are existing solutions which could be employed to resolve the reporting system problems in Interior Alaska.

Chapter 4 pursues a rigorous system analysis. The runway and weather condition reporting systems are defined explicitly and modeled. The components, inputs, outputs and interrelationships of the system are analyzed. The alternatives for improving the existing system are defined and presented.

Chapter 5 conducts a stakeholder analysis. It investigate all the agencies and entities that could affect or be affected by improvements or changes to the existing system. It identifies the primary stakeholders in anticipation of enlisting their support for any potential improvement or project to investigate improvements.

Chapter 6 integrates the four analyses in Chapters 2 through 5 to develop a proposed solution. A hypothesis regarding the implementation of the solution is presented. At this point in the research, the potential for remote video technology to substantially improve upon existing weather collection and reporting systems is presented. The solution for runway condition reporting systems is interpreted to be a combination of problems involving primarily the training and supervision of rural airport maintenance contractors. The reader is directed to two appendices that investigate options for improving both the supervision and training of these individuals. The rest of the research is then focused in the implementation of remote video technology.

Chapter 7 documents the operational test of the remote video concept. It begins with a feasibility study to determine if remote video is adaptable to rural Alaskan airports. The study investigates technical feasibility and stakeholder interest. It provides a technical model and method for selecting sites at which to test remote video technology. This chapter continues with clear documentation of the project that was conducted at three rural villages in Interior Alaska. It covers the operational test of hardware, the involvement of stakeholders, and the collection of data through multiple surveys. It provides information on project advertising, project media releases and the patent that grew out of the operational test.

Chapter 8 continues with the detailed analysis of the data collected during the operational test. The results of the analysis are presented and a logical proof is provided in support of the hypothesis generated in Chapter 6.

Chapter 9 concludes with recommendations for the implementation of the proposed solution to runway condition reporting problems in Interior Alaska. It also recommends widespread implementation and expansion of the use of remote video technology throughout Alaska and the United States to improve weather condition reporting shortfalls.

CHAPTER 2

# Aviation Safety in Alaska

This chapter investigates issues involving the safety of flight in Alaska. Section 2.1 provides preliminary information and pertinent results of a safety study that was conducted by the National Transportation Safety Board (NTSB) in 1995. Section 2.2 is a statistical analysis of 43 aviation accidents that occurred in Interior Alaska. This accident analysis provides incentive to focus proposed solutions to aviation safety issues on weather and runway condition reporting systems. Chapter 3 follows with the results of a literature search focused on uncovering potential solutions to the reporting system problems.

## *2.1 - Background*

Aviation is part of the fiber of Alaskan history. The Alaskan bush pilots of old pushed the edge of the flying envelope in a way that would be discarded as foolhardy by the conscientious pilot of the nineties. Despite much activity on the part of federal and state agencies to curb the unsafe practices of the past, the temptation to dovetail the adventurous ways of old with the technology and maturity of the present still gnaws at the average pilot. This compelling force coupled with the physical expanse, geographical diversity and unpredictable weather patterns of Alaska generates an accident rate higher than the balance of the other forty-nine states of the union. Figure 2.1 demonstrates this imbalance as gleaned from pages 16 - 21 of reference [33]. During the 9-year period from 1986 to 1994, the relative frequency of Alaska accidents (accidents per 100,000 flight hours) ranged from 1.4 to 3.2 times higher than the rest of the United States. This elevated Alaska accident rate has continued into the year 2000 [29].

While the root cause of this elevated accident rate is not clearly evident, many have articulated opinions, some of which are based on fact. The ability of a well-meaning researcher to hypothesize about the high accident rate has been greatly enhanced as the NTSB accident investigation data base has grown and matured. Today this information is accessible to the average consumer over the Internet and thus subject to wide application in the investigation of the root causes of Alaskan aviation accidents.

In 1995, the NTSB conducted a thorough review of aviation safety in Alaska. The results of that study were published in an NTSB publication entitled "Safety Study – Aviation Safety in Alaska" [33]. The report indicated that while progress has been made over the last 15 years in reducing the number of accidents, there are still major areas of concern that must be addressed [34]. Specifically, Alaska's aviation safety record is consistently the worst among the fifty states. Many of the NTSBs concerns call into question the accuracy, availability and consistency of runway and weather information at remote airstrips. These concerns, borne out of a thorough review of aviation accidents, resulted in a number of recommendations to leading agencies to assist in improving Alaska's safety record. Among these recommendations were the following:

<u>To the State of Alaska [37]</u>

1. Develop, by December 31, 1996, with the assistance of the FAA, appropriate procedures and establish a training program to enable mike-in-hand (near real-time) reports of airport conditions by designated State and contractual airport maintenance personnel.

2. Develop, by December 31, 1996, a program to participate with the FAA in its airport inspection program.

These two recommendations follow a conclusion of the NTSB that runway condition reporting and actual runway conditions contribute to the high number of takeoff and landing accidents in Alaska.

<u>To the National Weather Service [37]</u>

1. Evaluate, with the assistance of the FAA, the technical feasibility and aviation safety benefits of remote color video weather observing systems in Alaska.

2. Revise current policies to provide mike-in-hand (near real-time) radio service for aviation weather information at locations in Alaska where National Weather Service and contract personnel are sited until automated surface weather observing systems transmit observations of all operationally significant weather phenomena to pilots operating in the terminal area.

These two recommendations also follow NTSB concerns which call into question the accuracy, availability and consistency of weather information at remote airstrips.

Additional recommendations to the FAA support the conclusion that accurate weather and runway condition reporting information is not readily available. Although some of the recommendations above have been addressed, the problems have not been solved.

## *2.2 - Accident Statistical Study*

As part of the research into runway and weather condition reporting at remote airstrips in Alaska, there was a need to study aviation accidents that have occurred in Interior Alaska. Statistical data based on these accidents justifies the need for solutions to these problems. It will also serve to bring the issues into focus so that recommendations to correct the problems will be properly directed at root causes.

Section 2.2.1 investigates the issues involved in data collection to support the statistical analysis of aviation accidents. Section 2.2.2 is the in-depth analysis. It covers descriptive statistics, point estimates, multinomial analysis and interval analysis.

### 2.2.1 - Data Collection

Data collection in and of itself is a significant part of the process of statistical analysis. The difficulty lies not only in the availability of data, but in the screening of large volumes of available data to select only that which will answer the questions or hypotheses posed. Sources of data were readily available. To assist in the process, an effort was made to define the problem and formulate questions that would assist in solving it. This problem statement led to a natural enumeration of search criteria. These criteria were then applied to assist in retrieving the data required to answer the questions posed. Having retrieved the necessary data, it was compiled into a single matrix representing 43 accidents of import. This single page matrix then became the primary source document for several statistical analyses designed to identify and rank significant factors causing accidents.

#### *2.2.1.1 - Data Sources*

In general, there are three methods of gathering data for any statistical study: surveys, field observations, and archival or document analysis. In our case accidents are past occurrences, thus archival information is the primary means of collection. The primary agency responsible for compiling the data that was used is the NTSB. This agency has been writing and compiling accident synopses since its inception in 1967. The agency is mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the effectiveness of government agencies involved in transportation. They make their actions and decisions public through accident reports, safety studies, special investigation reports, safety recommendations and statistical reviews [33].

Data from three sources was reviewed: the NTSB Safety Study on Alaska; the Aviation Accident Analysis and Data Division of NTSB; and an on-line NTSB database of synopses of aviation accidents. The database was the primary source. These three sources are discussed below.

NTSB Safety Study – This study, entitled "Aviation Safety in Alaska" was conducted and compiled in 1995. It included a review of accident statistics from 1986 through 1994. It also included the results of a survey of Alaskan pilots and operators of Commuter Airlines and Air Taxis. This information was presented in narrative, tabular and graphical form in the aforementioned publication. The safety study provided good insight into the state of aviation safety in Alaska.

Analysis and Data Division of NTSB – The NTSB maintains an aviation section in Washington D.C. whose primary purpose is to respond to inquiries from the public regarding aviation accident data. Their capabilities include criteria-driven searches of the complete aviation accident database. The Division is responsive to telephonic, e-mail, or FAX requests. They will conduct a requested search, print a hardcopy of the results and mail them to the requester at no charge. Turn-around time for the service is approximately two weeks. The data which was requested through this source was not used directly, although the accident reports provided valuable insight into the capabilities of the agency.

NTSB Accident/Incident Database Online –The NTSB database online provides immediate access to all aviation accident synopses since 1983. The database provides a query sheet that may be used to narrow the focus of the search. Although some specific criteria may be designated to limit the search, the system is not as robust as that available through the Analysis and Data Division. As a result, unwanted data was often retrieved and discarded which consumed time. This database provided the primary raw data for the issues addressed herein.

#### *2.2.1.2 - Determination of Search Criteria*

A problem statement was formulated to help focus the search and the formulation of questions. This problem statement follows:

> To determine the primary causes and supporting factors of on-airport accidents at remote airstrips in Interior Alaska. To rank order the significant factors causing accidents if statistically possible.

Based on the problem statement above, the following search criteria were developed to assist in determining the specific variables to be investigated. Each question is directed at that sample of accidents that meet the following criteria:

1. Occurred in Alaska – The stated concern is that the accident rate in Alaska is higher than that of the rest of the United States for certain types of flight operations. Thus, we limit the scope of the study to accidents in Alaska to try and determine what factors contribute to takeoff and landing accidents in this state.

2. Occurred between 1983 and 1996. – The NTSB database contains all accidents 1983 – present. However, it often takes a year or longer to complete the final accidents report that contains probable cause information. At the time of this study, final reports were available for accidents that occurred in 1996 and earlier. Thus, we limit the search to fourteen years of accident reports.

3. Occurred at airstrips in the Interior of Alaska as defined by the following criteria.

a. All public airports within a 200 statute mile radius of Fairbanks, AK and in the Northern Region as established by the AKDOT.

b. In addition, the following airports were considered: Nulato, Galena, Ruby, Huslia, Koyukuk, and Chena Hot Springs.

c. The following were not considered because they are easily accessible by road and not considered remote: Tok, and Fairbanks.

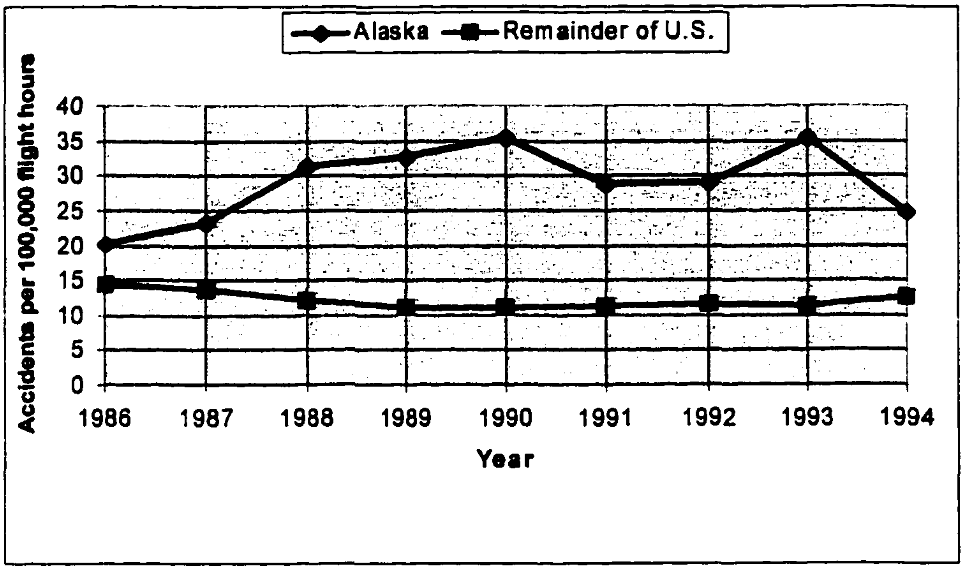



**Figure 2.1** - Relative Frequency of Aviation Accidents in Alaska vs. Remainder of the United States (Accidents per 100,000 hours flight time)

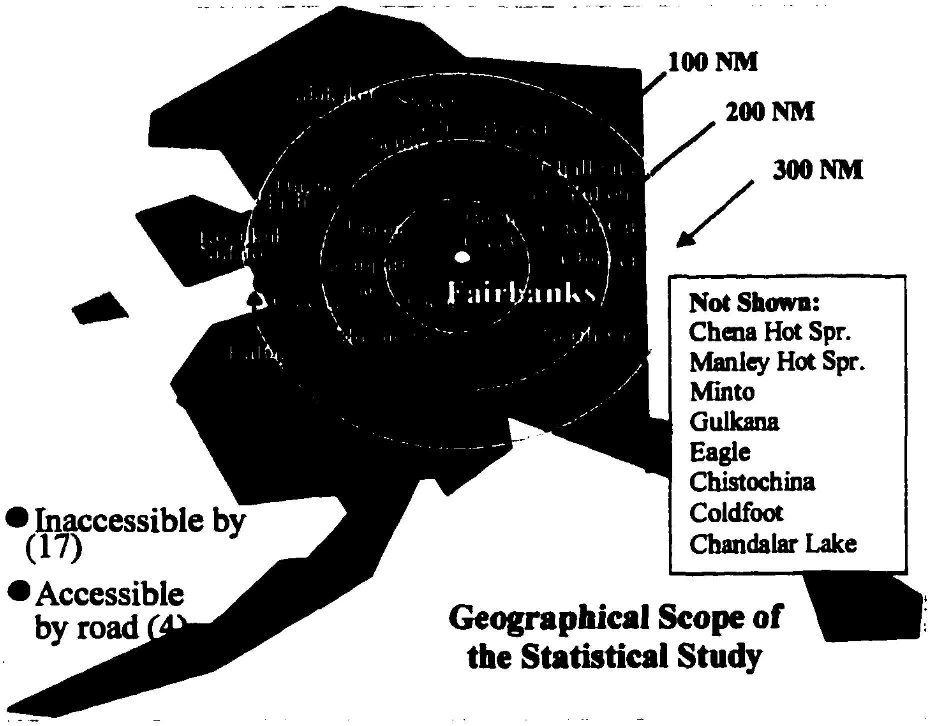



**Figure 2.2** - Geographical Area from which Accident Data was Collected

4. Occurred during taxi, takeoff, approach to landing, or landing – This is the particular accident sample that we are concerned about because these can be directly related to runway and/or weather condition reporting at remote airstrips.

This sample of accidents at interior airports is a good representation of the total population of accidents which have occurred at airports in the Interior of Alaska. The graphic in Figure 2.2 shows the geographical scope of the study.

#### *2.2.1.3 - Formulation of Questions*

The following questions were formulated to provide a focus for the study. These questions assist in selecting the actual data to be retrieved from each accident record . They will not be used to forecast or predict future occurrences, but simply to establish the primary causes of accidents at remote airports to demonstrate the need for study into the benefit of improving runway condition and weather reporting.

<u>Question 1 - During which of the following phases of flight is an accident most likely to occur?</u>

*Taxi* – Movement on the apron, or taxiway under the sole power of the airplane's power plant.

*Takeoff* – Begins with the application of power on the end of the runway and ends once the plane has departed the immediate airport environment.

*Approach to Landing* – Begins when the airplane enters the landing pattern for an airstrip and ends just prior to touchdown on the runway.

*Landing* – Begins with touchdown on the runway and ends when the aircraft has completed its rollout and slowed to taxi speed.

<u>Question 2</u> – What percentage of accidents can be attributed to the following factors?

*Weather*

1. Airframe Icing – Buildup of ice on the structure of the aircraft due to environmental conditions.
2. Wind – Gusts, turbulence, windshear or wind speed.
3. Other weather related factors - Could include poor visibility or low ceilings.

*Airport Environment*

Runway Condition – Multiple factors influence the condition of the runway surface including – ice, snow, potholes, berms, standing water, roughness, vegetation and firmness. Most of these factors may be mitigated through dedicated and frequent runway maintenance.

*Pilot Error*

1. Alignment with Runway – Poor alignment during takeoff or landing is usually an issue of pilot error that can be exacerbated by runway condition, or wind.

2. Aiming Point for Landing – A pilot misjudging the proper point of landing may undershoot or overshoot the proper touchdown point. The former results in touchdown on an unprepared surface that is difficult on the airframe. The latter often results in not having sufficient runway to stop and thus again subjecting the airframe to unprepared surfaces.

3. Stall – A dangerous condition near the ground in which the airplane loses the lift required to keep it in the air, noses over and often strikes the ground in a nose down attitude. May occur during takeoff when the pilot maintains an inappropriate nose high attitude during climb. May occur during landing when the aircraft is inadvertently slowed below the stall speed. The problem is accentuated when flaps are extended. A stall in itself is a normal maneuver requiring several hundred feet for proper recovery. Stalls near the ground during takeoff and landing normally result in an accident.

4. Other Pilot Procedure – Distractions in the cockpit, poor judgment, failure to lower the landing gear, poor choice of landing area for existing conditions and a multitude of other miscellaneous pilot error issues are encompassed here. These could also include weather related pilot errors.

*Mechanical Failure*

1. Landing Gear Failure – As most small aircraft used in the interior have fixed landing gear (not retractable), this category refers primarily to fracture or failure of structural components of the landing gear. Multiple rough landings over the years contribute to fatigue of materials which, if not maintained, result in eventual failure.

2. Engine Failure – Substantial loss of engine revolutions per minute (RPM) resulting in insufficient power to maintain aircraft altitude, thus necessitating a forced landing.

While these two questions will generate sufficient data for our needs, some additional questions are significant and have been included here for completeness.

Question 3 – Do accidents at remote airports occur with more frequency to pilots involved in general aviation or commercial operations – The general aviation pilot generally flies less frequently than the commercial pilot. One would expect that commercial operators would experience fewer accidents than general aviation pilots per hour flown.

Question 4 – What percentage of accidents at remote airports result in injury in the following categories:

*None* – Pilot and or passengers walk away from the accident requiring no medical attention.
*Minor* – Any accident requiring medical attention that is not a serious accident. See below.
*Serious* – A serious injury is one that meets any of the following criteria:

1. Requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received
2. Results in a fracture of a bone
3. Causes severe hemorrhages, nerve, muscle, or tendon damage
4. Involves any internal organ
5. Involves second or third-degree burns, or any burns affecting more than 5 percent of the body surface

Question 5 – What percentage of accidents results in damage to aircraft in the following categories:

*None* – No repair required
*Minor* – Any repair not meeting the criteria of substantial damage listed below.
*Substantial* – Damage or failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component.

#### *2.2.1.4 - Data Retrieval*

Having established the appropriate search criteria, the on-line NTSB database was then used to retrieve individual accident records. This portion of the process was somewhat slow and deliberate. Initially, the search was conducted by entering the name of the Alaskan village beside the "City" designation in the on-line query sheet as follows:

City: ALLAKAKET

Unfortunately, this returned every accident that occurred anywhere in the vicinity of the listed city. This was far too broad and had to be narrowed. Later it was discovered that the "Airport Name" entry would return only accidents or incidents that occurred at the named airport. Specifically this meant that the accident involved an aircraft that was taxiing, taking-off, landing, or on approach for landing at the named airport. This narrowed the search sufficiently and allowed for good data retrieval. The entry was made as follows:

Airport Name: ALLAKAKET

Each airport name had to be manually changed to render the required reports. This process was tedious but eventually yielded reports for every on-airport accident for the cities and villages enumerated in the section on search criteria determination. Forty three accidents reports were retrieved.

#### *2.2.1.5 - Data Compilation*

The next step was to compile the specific data points from each accident into a spreadsheet that would contain all the information required to answer the stated questions or others which benefit the research. After reviewing the questions, the following pieces of information were compiled:

*Accident Report Number* – For quick reference back to the database
*Month Accident Occurred*
*Year Accident Occurred*
*Airport Name*
*Event Type* - Accident or Incident
*Injury Severity*: None, minor or serious
*Category of Operation* – General Aviation or Commercial Aviation

*Aircraft Damage* - Minor, Substantial or Destroyed

*Phase of Flight* – Taxi, Takeoff, Landing, Approach to Landing

*Cause Type* – Pilot, Mechanical

*Causal Factor* - Wind, Runway Condition, Pilot Procedure, Runway Alignment, Stall, Landing Gear, Aim Point, Airframe Icing, or Engine Failure.

*Landing Gear Type* – Tricycle, Tailwheel, Ski, Wheel Ski

*Basic Weather Condition* – VMC or IMC

*Wind Speed*

*Visibility*

*Light Condition* – Dawn, Day, Dusk, Night

This information was extracted from each accident report and compiled on a spreadsheet. The resulting matrix is shown in Table 2.1.

## 2.2.2 - Statistical Analysis

Three different software packages were evaluated to determine which would be most appropriate for the required analyses.

StataQuest® – This package serves as a combination statistics, graphics and data management package. It proved to be disappointing in that it had no mouse support and the graphics were rather primitive. Additionally, the data management tools were difficult to use.

MiniTab (Student Edition® – This package has very strong statistical computation capabilities and a fairly user friendly approach. However, its graphics capability was also limited in terms of quality of output. MiniTab functions were used to help confirm manual calculations of interval estimates.

Microsoft Excel® – Excel is a very user-friendly spreadsheet package with a fairly complete set of statistical functions. In addition it has an extremely robust graphics capability which distinguished it from the other two packages. All the analyses that follow were conducted using Microsoft Excel and/or its Chart functions unless otherwise stated.

These tools were applied to answer the stated questions based on the accident data compiled in the spreadsheet. The forty-three accidents extracted from the aviation database represent a statistically significant number of accidents for Interior Alaska. These are the basis around which the following statistical studies are conducted.

Several studies are conducted. The first determines point estimates for important statistics relating to the sample. The second pursues analytical analyses including multinomial analysis and interval estimates, which are more valuable in ascertaining statistics representative of the population.

#### *2.2.2.1 - Descriptive Statistics*

The first portion of the analysis addresses only point estimates. It analyzes the sample to determine single values of certain statistics [58]. These point estimates begin to provide some focus as to the root causes of aviation accidents in the Interior. In this section, we will establish Pareto Charts, a Fishbone Chart, and multiple other graphs representing point estimates for various statistics obtained for the sample.

The Pareto Chart

A Pareto Chart is simply a histogram with the bars ordered from largest to smallest to assist the analyst in focusing efforts on the areas where there are the largest potential gains. It is constructed in the same manner as a standard histogram except that the bars are sequenced in descending order of size. In this fashion, the probable cause factors most to blame for accidents in the sample are highlighted first. This chart graphically confirms the 80-20 rule that states that "20% of the factors create 80% of the problem". Therefore it is more efficient to focus on the factors which have the biggest influence on accidents. If these factors can be mitigated, then we are more likely to affect a significant change with minimum input.

Figure 2.3 is a Pareto Chart for the primary causal factors gleaned from the sample accident data in Table 2.1. It was produced using Microsoft Excel's Chart feature. The histogram demonstrates that the primary causal factor is wind that accounted for 28% of all the accidents at rural airports. Runway condition accounts for an additional 19% of this class of accidents. Thus, 47%, or nearly half of the accidents, are wind or runway condition related. Pilot procedure accounts for an additional 19% of accidents in the sample. Wind, of course, cannot be controlled. However, given good weather information, the pilots who were overcome by wind factors, may have been able to avoid these accidents. Runway condition is a factor that can be controlled to a large extent. Pilot procedure is difficult to affect directly. Judgement training for pilots is an avenue that is currently being pursued to mitigate the proportion of accidents that are attributable to poor judgement.

| Report Number | Month | Year | Airport | Accident Incident | Injury Severity | Category of Ops | Aircraft Damage | Phase of Flight | Pilot/ Mech. | Causal Factor | VMC IMC | Wind | Vis | Light Cond. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 92FA006 | 10 | 1991 | Allakaket | Accident | None | S-135 | Substantial | Landing | Pilot | Aim Point | VMC | 0 | 5 | Day |
| 94LA055 | 5 | 1994 | Allakaket | Accident | None | NS-135 | Substantial | Landing | Pilot | Runway Alignment | VMC | 0 | 50 | Night |
| 84LA055 | 4 | 1984 | Bettles | Accident | None | GA | Substantial | Landing | Pilot | Runway Cond | VMC | 7 | 50 | Day |
| 90LA120 | 7 | 1990 | Bettles | Accident | Minor | GA | Substantial | Takeoff | Pilot | Stall | VMC | 4 | 10 | Day |
| 87LA133 | 8 | 1987 | Central | Accident | None | GA | Substantial | Landing | Pilot | Wind | VMC | 15 | 60 | Day |
| 84LA158 | 9 | 1984 | Chandalar Lake | Accident | None | GA | Substantial | Takeoff | Pilot | Wind | VMC | 11 | 15 | Day |
| 93LA036 | 2 | 1993 | Chena Hot Springs | Accident | None | GA | Substantial | Landing | Mechanical | Landing Gear | VMC | 0 | 70 | Day |
| 96LA090 | 6 | 1996 | Chena Hot Springs | Accident | None | GA | Substantial | Landing | Pilot | Runway Cond | VMC | 4 | 70 | Day |
| 84LA160 | 9 | 1984 | Chistochina | Accident | None | GA | Substantial | Takeoff | Pilot | Airframe Icing | VMC | 0 | 60 | Day |
| 87LA087 | 7 | 1987 | Chistochina | Accident | Serious | GA | Substantial | Approach | Pilot | Stall | VMC | 3 | 25 | Dawn |
| 93LA083 | 6 | 1993 | Chistochina | Accident | None | GA | Substantial | Landing | Pilot | Runway Cond | VMC | 0 | 30 | Day |
| 96LA143 | 9 | 1996 | Chistochina | Accident | None | GA | Substantial | Landing | Pilot | Wind | VMC | 15 | 60 | Day |
| 85LA065 | 3 | 1985 | Circle City | Accident | None | GA | Substantial | Takeoff | Pilot | Pilot Procedure | VMC | 0 | 20 | Night |
| 94LA025 | 12 | 1993 | Circle City | Accident | Serious | GA | Substantial | Approach | Pilot | Airframe Icing | VMC | 0 | 3 | Day |
| 83LA066 | 5 | 1983 | Circle Hot Springs | Accident | None | GA | Substantial | Landing | Pilot | Wind | VMC | 10 | 30 | Day |
| 93LA117 | 7 | 1993 | Circle Hot Springs | Accident | None | GA | Substantial | Taxi | Pilot | Runway Cond | VMC | 0 | 40 | Day |
| 94LA056 | 5 | 1994 | Circle Hot Springs | Accident | None | GA | Substantial | Landing | Pilot | Wind | VMC | 15 | 30 | Day |
| 90LA148 | 8 | 1990 | Coldfoot | Accident | Serious | GA | Substantial | Landing | Pilot | Runway Cond | VMC | 0 | 60 | Day |
| 88LA066 | 6 | 1988 | Eagle | Accident | None | NS-135 | Substantial | Landing | Pilot | Wind | VMC | 10 | 60 | Day |
| 91LA155 | 9 | 1991 | Eagle | Accident | None | NS-135 | Substantial | Takeoff | Pilot | Runway Cond | VMC | 15 | 10 | Day |
| 85MA157 | 8 | 1985 | Gulkana | Accident | Fatal | NS-135 | Destroyed | Approach | Pilot | Pilot Procedure | VMC | 11 | 7 | Night |
| 85LA185 | 9 | 1985 | Gulkana | Accident | None | GA | Substantial | Landing | Pilot | Wind | VMC | 22 | 160 | Day |
| 90LA128 | 7 | 1990 | Gulkana | Accident | Serious | GA | Substantial | Takeoff | Pilot | Stall | VMC | 20 | 40 | Day |
| 96LA076 | 6 | 1996 | Gulkana | Accident | None | GA | Substantial | Landing | Pilot | Pilot Procedure | VMC | 6 | 25 | Day |
| 85FA135 | 7 | 1983 | Healy River | Accident | None | GA | Substantial | Approach | Mechanical | Engine Failure | VMC | 0 | 75 | Day |
| 96LA002 | 10 | 1995 | Healy River | Accident | Minor | GA | Substantial | Landing | Pilot | Wind | VMC | 0 | 50 | Day |
| 93LA017 | 11 | 1992 | Huslia | Accident | Minor | GA | Substantial | Approach | Pilot | Aim Point | VMC | 10 | 0 | Dusk |
| 95LA065 | 6 | 1995 | Manley Hot Springs | Accident | None | GA | Substantial | Landing | Pilot | Wind | VMC | 10 | 60 | Day |
| 93LA316 | 8 | 1993 | Minto | Accident | None | GA | Substantial | Landing | Pilot | Pilot Procedure | VMC | 0 | 20 | Day |
| 83FA171 | 9 | 1983 | Northway | Accident | None | GA | Substantial | Takeoff | Pilot | Pilot Procedure | VMC | 5 | 40 | Dusk |
| 85LA098 | 6 | 1985 | Northway | Accident | None | GA | Substantial | Landing | Pilot | Wind | VMC | 8 | 40 | Day |
| 85LA156 | 6 | 1985 | Northway | Accident | None | GA | Substantial | Landing | Mechanical | Landing Gear | VMc | 4 | 40 | Day |
| 88LA098 | 7 | 1988 | Northway | Accident | None | GA | Substantial | Landing | Pilot | Pilot Procedure | VMC | 5 | 40 | Day |
| 90LA077 | 5 | 1990 | Northway | Accident | None | GA | Substantial | Taxi | Pilot | Runway Cond | VMC | 5 | 40 | Day |
| 93LA139 | 8 | 1993 | Northway | Accident | None | GA | Substantial | Landing | Pilot | Wind | VMC | 11 | 40 | Day |
| 93LA137 | 8 | 1993 | Northway | Accident | None | GA | Substantial | Landing | Pilot | Wind | VMC | 6 | 30 | Day |
| 94LA076 | 7 | 1994 | Northway | Accident | None | GA | Substantial | Landing | Mechanical | Landing Gear | VMC | 9 | 35 | Day |
| 96LA108 | 7 | 1996 | Northway | Accident | None | GA | Substantial | Landing | Pilot | Pilot Procedure | VMC | 9 | 50 | Day |
| 85LA057 | 3 | 1985 | Nulato | Accident | None | GA | Substantial | Landing | Pilot | Runway Cond | VMC | 0 | 40 | Day |
| 86IA089 | 6 | 1986 | Nulato | Incident | None | NS-135 | Minor | Landing | Pilot | Pilot Procedure | VMC | 10 | 50 | Day |
| 83FAA05 | 3 | 1983 | Rampart | Accident | Serious | GA | Substantial | Takeoff | Pilot | Runway Alignment | VMC | 15 | 60 | Day |
| 88LA039 | 3 | 1988 | Ruby | Accident | None | GA | Substantial | Landing | Mechanical | Engine Failure | VMC | 0 | 30 | Day |
| 96LA023 | 12 | 1995 | Stevens Village | Accident | None | GA | Substantial | Landing | Pilot | Runway Alignment | VMC | 0 | 2 | Dusk |

**Table 2.1** - Matrix of 43 Accidents in the Sample

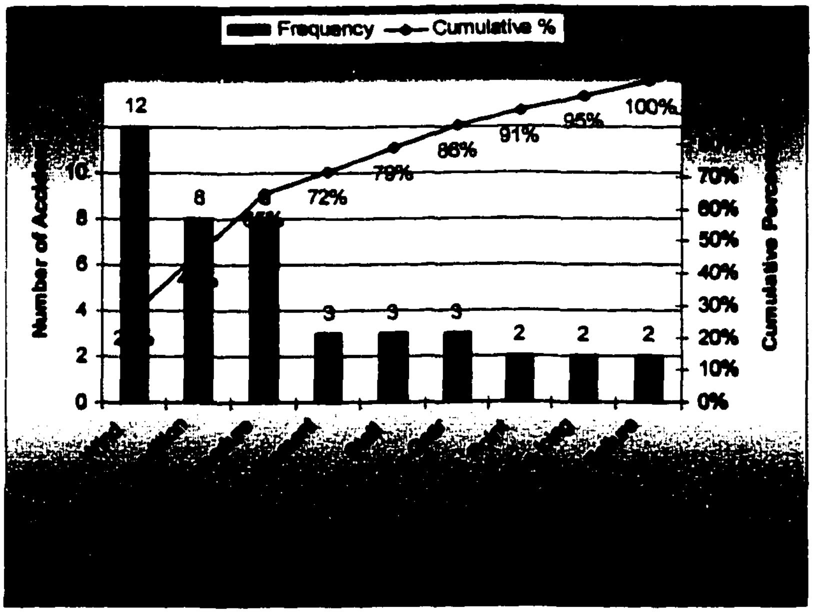



**Figure 2.3** - Pareto Chart of Causes of Accidents in the Sample

Table 2.1 also contains an entry for the phase of flight in which each accident occurred. Figure 2.4 breaks these out by percentage. Clearly, most accidents occurred during landing. The Pareto Chart may be applied again with only the sample of accidents that occurred during landing with the results shown in Figure 2.5. This chart was also produced using Microsoft Excel's Charting feature. We note that wind and runway condition account for 57% of all landing accidents.

The Pareto Chart has enabled us to quickly determine that weather and runway condition, the two top causal factors of accidents at rural airports from our sample should be addressed when seeking solutions that will reduce accidents at rural airports.

The Fishbone Chart

This type of diagram is simply a cause and effect diagram that highlights the potential causes of a problem. The problem is shown on the right side of the diagram. The major categories of causes are presented as branches on the diagram, and specific causes are delineated under each branch. Figure 2.6 is the fishbone chart that delineates potential causes that lead to aviation accidents at rural airports. This chart was produced manually. The major categories on this chart will be used in Section 2.2.2.2 for interval analyses.

Table 2.1 provides excellent data from which we can construct other point estimates and draw additional preliminary conclusions that will be helpful. The questions posed by these additional analyses are each explained below with the accompanying figure.

Question 1 - Did accidents at remote airports in the sample occur with more frequency to pilots operating in a general aviation or commercial capacity as shown in the "Category of Ops" column of Table 2.1? (See Figure 2.7)

This chart establishes that accidents were six times as likely to involve a general aviation rather than a commercial pursuit. We cannot conclude that general aviation pilots are more likely to have accidents than commercial pilots because we do not know the number of each type of operation being conducted through the period in question. However, it is clear that any solution to mitigate accidents must not target only commercial operations but must include general aviation operators as well.

Question 2 – What percentage of accidents in the sample resulted in injury in the following categories: none, minor, serious, or fatal as shown in the "Injury Severity" column of Table 2.1? (Figure 2.8)

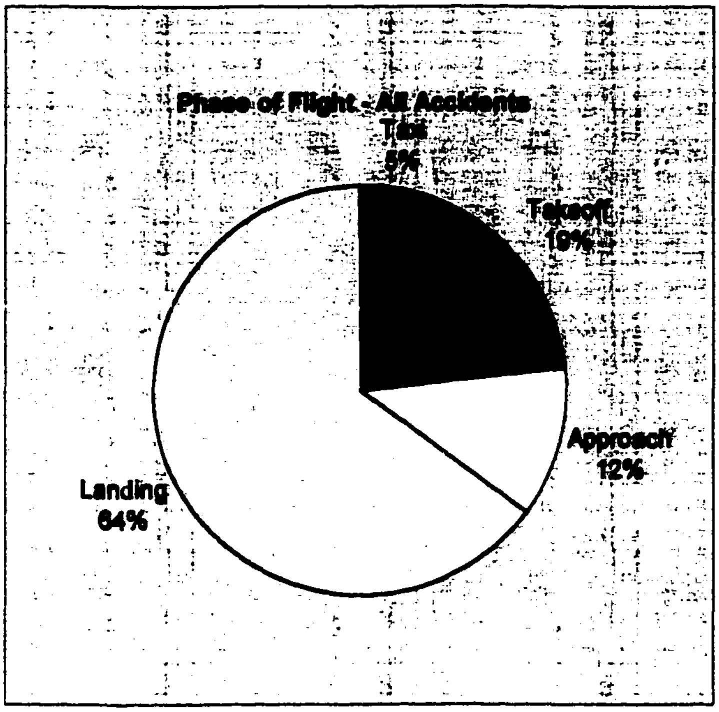



**Figure 2.4** - Phase of Flight During which Accidents Occurred at Airports in Sample Study

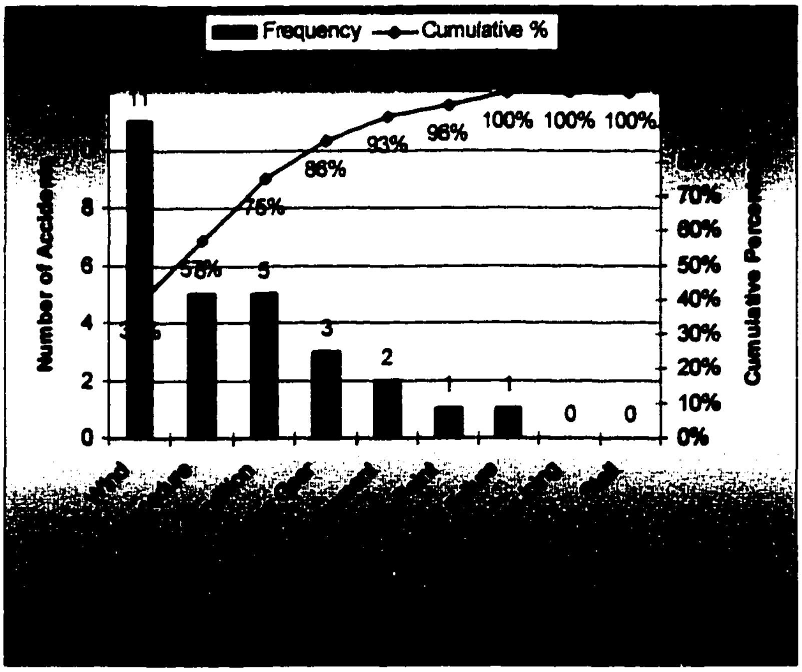



**Figure 2.5** - Pareto Chart of Causes of Landing Accidents in the Sample

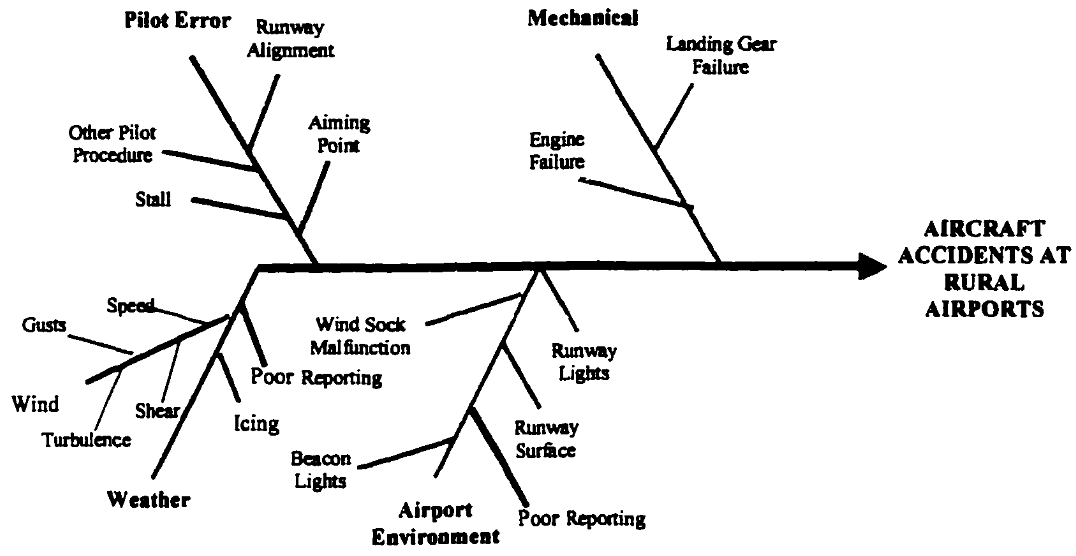



**Figure 2.6** - Fishbone Chart for Accidents in the Sample

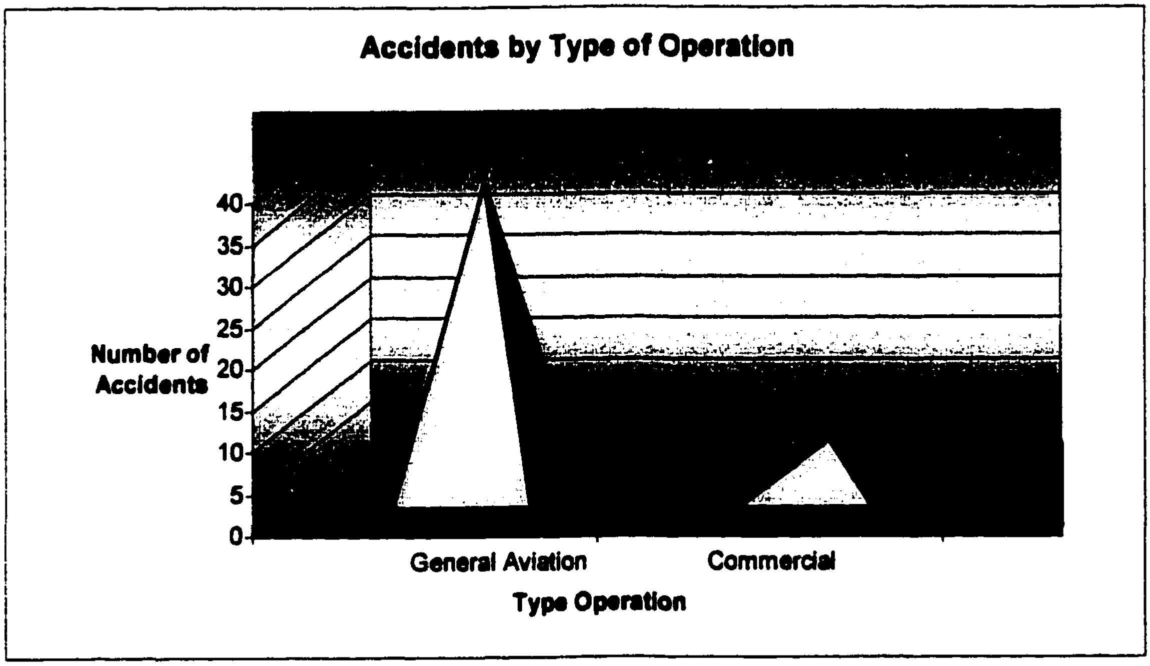



**Figure 2.7** - Accidents in the Sample by Type of Operation

This chart demonstrates that the vast majority of accidents in the sample resulted in no injury to crew or passengers. The fatal accident appears to be a rarity.

Question 3 – What percentage of accidents resulted in damage to aircraft in the following categories: none; minor; substantial or destroyed as shown in the "Aircraft Damage" column of Table 2.1? (Figure 2.9)

This chart demonstrates that the preponderance of the accidents that occurred on-airport resulted in substantial damage to the aircraft.

Question 4 – Is there a trend in the number of accidents that occurred in the period 1983 – 1996 as designated in the "Year" column of Table 2.1? (Figures 2.10 and 2.11)

Figure 2.10 is not conclusive regarding trends in the number of accidents which have occurred over the period described. Figure 2.11 shows the same data with a trend line. The trend line, as calculated using Microsoft Excel, shows an increase from a calculated value of 2.94 accidents in 1983 to 3.2 accidents in 1996. While this appears to indicate that the total number of accidents is growing, it amounts only to a rate of one additional accident every 54 years, which is certainly not significant. Additionally, the sample coefficient of determination ($r^2$) for the line is .0019 indicating the inability of the line fit to establish a trend in the sample provided. We conclude from this that there is no established downward trend in the number of accidents in the sample during the period in question. Thus we have incentive to continue to pursue methods of reducing aviation accidents in Interior Alaska.

Question 5 – Did accidents occur more frequently during any particular time of year as designated in the "Month" column of Table 2.1? (Figure 2.12)

From this chart it is clear that more accidents occurred in the three month interval between June and August (22 incidents) than during the nine month period from September to May (21 incidents). This is consistent with the anticipated increase in the number of hours pilots fly during the warm, light months of summer, versus the cold dark days of winter in Alaska.

Question 6 – Do accidents occur more frequently during any particular time of day as shown in the "Light Condition" column of Table 2.1? (Figure 2.13).

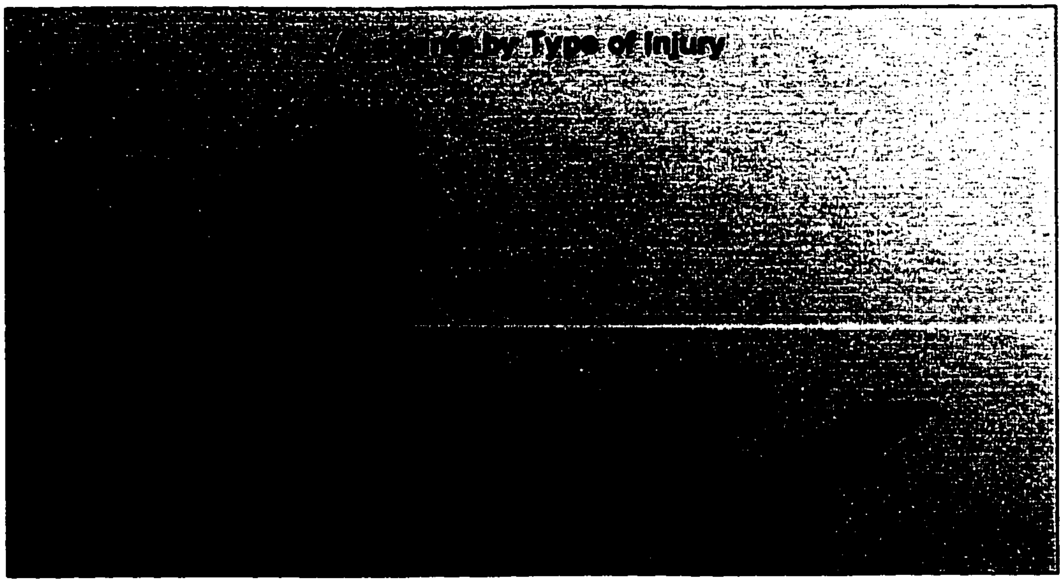


**Figure 2.8** - Accidents in the Sample by Type of Injury

**Figure 2.9** - Number of Accidents in the Sample by Degree of Aircraft Damage

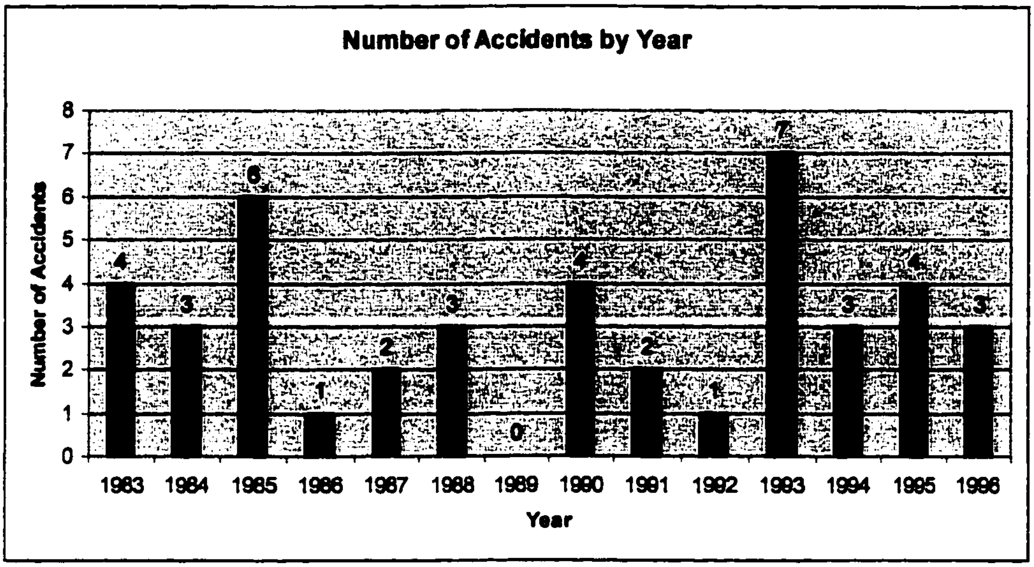



**Figure 2.10** - Number of Accidents in Sample by Year of Occurrence

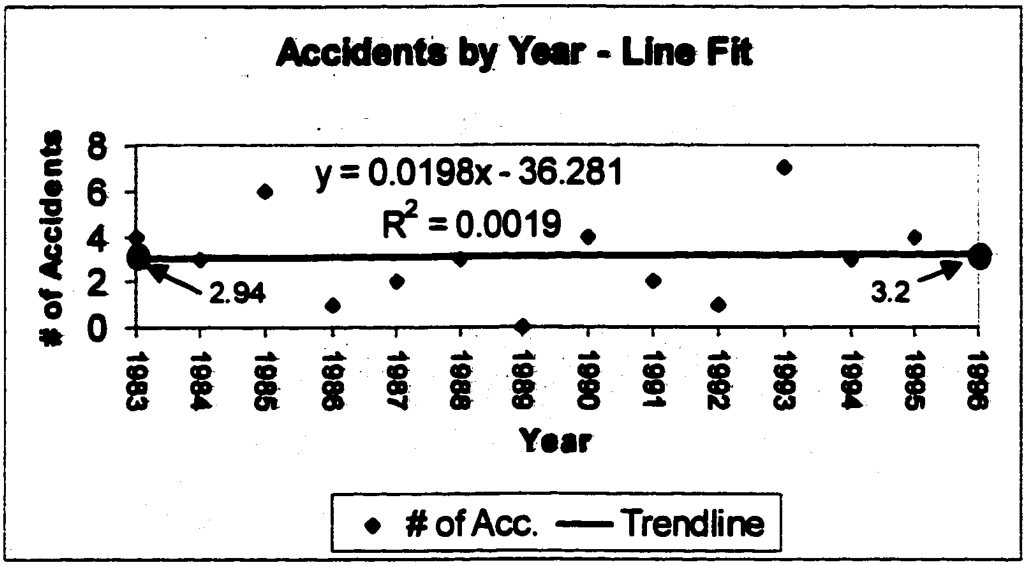



**Figure 2.11** - Number of Accidents by Year - Line Fit

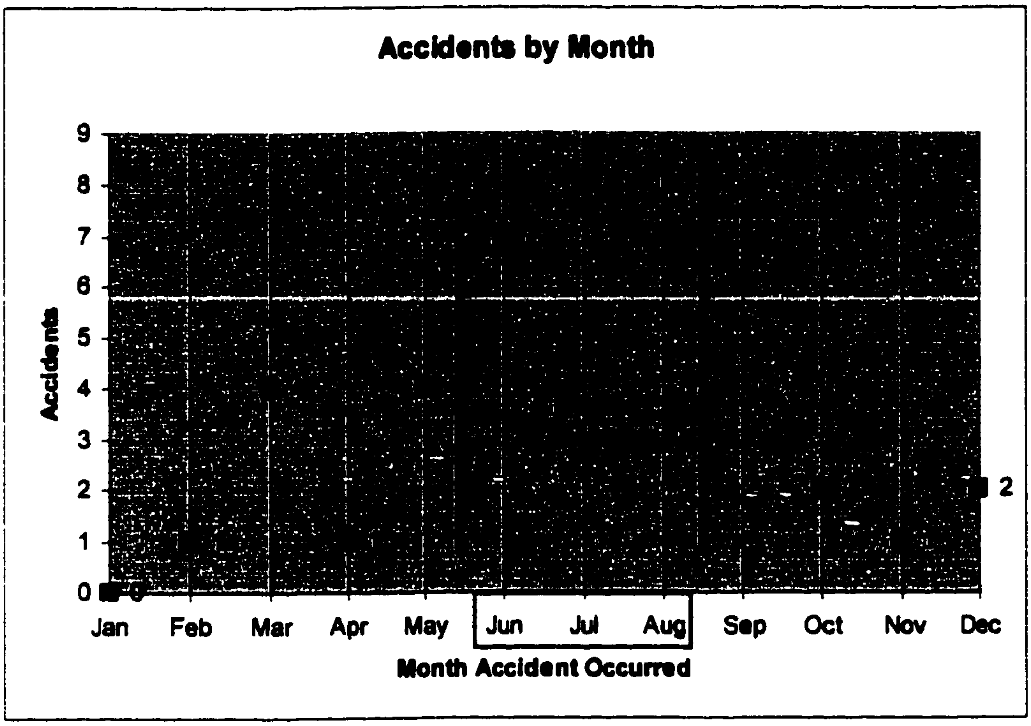



**Figure 2.12** - Number of Accidents by Month of Occurrence

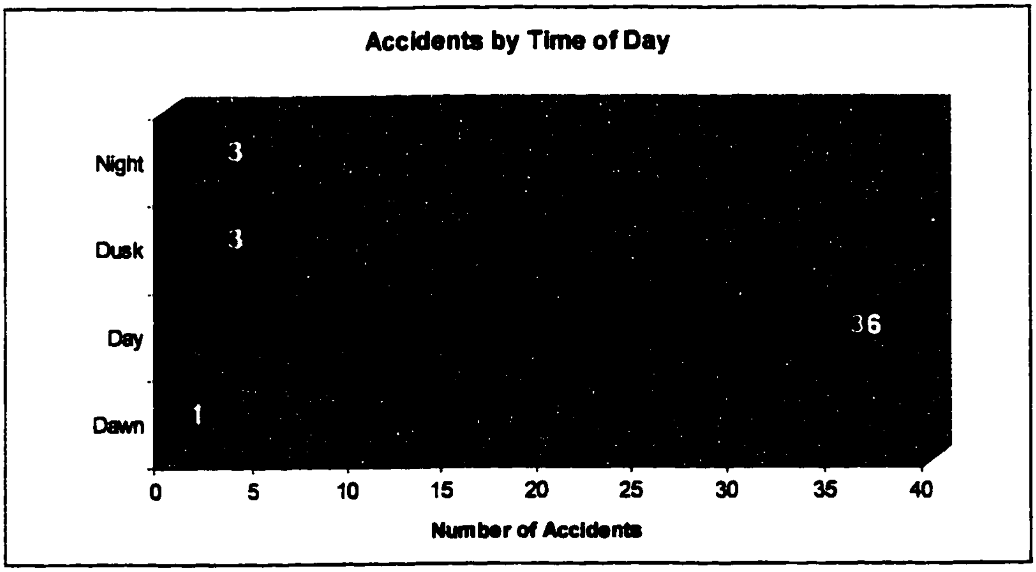



**Figure 2.13** - Histogram of Number of Accidents by Time of Day

This chart demonstrates that accidents occurred primarily during daylight hours. We cannot conclude that night operations are safer than day operations, but simply that given that an accident has occurred, it is highly probable that it occurred during the day.

#### *2.2.2.2 - Analytical Analysis*

A point estimate, derived from the sample, will not necessarily accurately represent the population. Therefore, we proceed with other analyses that will statistically establish the validity of certain conclusions that are important to our study.

It is important at this point to define the statistics that we are computing. This will provide a frame of reference from which we can proceed to several statistical tests.

Population - The population we are concerned with is all on-airport aviation accidents that have occurred in Interior Alaska.

The choice of population is important in the analysis that follows. We would like to establish that weather and runway conditions are primary causal factors in accidents. Specifically we are interested in conducting analyses that will assist in ranking the causes of accidents in the population above.

Our population could be defined with variations of the following:

1. Geographical Boundaries - All of the United States, Alaska only, Interior Alaska (our choice), or some other geographical portion of Alaska.
2. Time Partitions - One year, certain months of the year, all years (our choice).
3. Classes of Flights - General Aviation, Commercial Aviation (Air Taxi, Air Carrier, Scheduled Airlines), or all classes (our choice).
4. Phase of Flight - Takeoff, cruise, approach to landing, landing, taxi etc. We chose all phases of flight that occur in the vicinity of the airport.
5. Occurrences in Flight - Accidents, Incidents, Safe flight etc. We have limited our population only to accidents. If we were interested in determining probabilities of accidents occurring, then our population would not be limited to those flights in which accidents occurred, but all flights. This is not within the scope of our pursuit. There is no empirical data that establishes the total number of flights occurring at rural airports in Alaska. This information is only estimated based on fuel sales or pilot surveys.

Parameter - Having established the specific population of concern, we must determine the parameter(s) of interest. A parameter is a characteristic of the population about which we want to glean information. We are specifically concerned with the following parameters:

1. Percentage of accidents caused by pilot procedure
2. Percentage of accidents caused by runway alignment
3. Percentage of accidents caused by stalls
4. Percentage of accidents caused by aim point
5. Percentage of accidents caused by runway condition
6. Percentage of accidents caused by landing gear
7. Percentage of accidents caused by engine failure
8. Percentage of accidents caused by wind
9. Percentage of accidents caused by airframe icing

In order to assist in focusing our conclusions on runway and weather reporting issues, we will group the parameters above into categorical parameters as follows:

1. Percentage of accidents caused by **Pilot Error** = $p_{PE}$. (Includes pilot procedure, runway alignment, stalls and aiming point errors).

2. Percentage of accidents caused by **Airport Environment** = $p_{AE}$. (Runway condition).

3. Percentage of accidents caused by **Mechanical Failure** = $p_{MF}$. (Includes landing gear failure and engine failure.)

4. Percentage of accidents caused by **Weather Conditions** = $p_{WC}$. (Includes wind and airframe icing).

These groupings are consistent with that presented in Figure 2.6.

Sample - A sample is a representative part of a population. In our case, the sample is all the accidents in the population which have occurred between 1983 and 1996 and which have been reported. Although the FAA requires that every accident be reported, it is possible that in rural parts of Alaska there are unreported accidents. We anticipate that our sample adequately represents the total population of accidents in the Interior that have occurred at airports.

Statistic - A statistic is a number calculated from the sample that may be used to make inferences about the population.

Statistics pertinent to our problem are now discussed. In section 2.2.2.1, point estimates were established for the proportion of accidents caused by different factors. Based on the new groups established above, the basic data and point estimates are now as follows:

Basic Data

$n$ = 43 Accidents in the sample

$n_{PE}$ = Number of accidents caused by Pilot Error = 16
$n_{AE}$ = Number of accidents caused by Airport Environment = 8
$n_{MF}$ = Number of accidents caused by Mechanical Failure = 5
$n_{WC}$ = Number of accidents caused by Weather Condition = 14

Point Estimates

$p_{PE}$ = Proportion of accidents caused by Pilot Error = 16/43 = 0.3721
$p_{AE}$ = Proportion of accidents caused by Airport Environment = 8/43 = 0.1860
$p_{MF}$ = Proportion of accidents caused by Mechanical Failure = 5/43 = 0.1163
$p_{WC}$ = Proportion of accidents caused by Weather Conditions = 14/43 = 0.3256

These point estimates simply reflect the "best" estimate of a parameter's value. They indicate at face value that the proper rank order of accident causes is: pilot error; weather conditions; airport environment and then mechanical failure. However, they do not provide any means of estimating the *precision* of those statistics. Therefore we must provide some range of values within which we expect the parameter's actual values to fall in the whole population. These are called interval estimates.

Before we establish these interval estimates we must provide some discussion about our data. Our accident data consists primarily of categorical or "count" data as opposed to quantitative data. Essentially, we have an individual accident that was or was not caused by a certain causal factor. There is no degree (quantitative measure) to the causal factors, but instead they are multinomial in character. For example, let us suppose that weather is the causal factor in a specific accident. We do not have any quantitative information on the extent or degree of the weather condition, but simply that it was due to weather. This is true for each causal factor. Since each accident has multiple possible causes, we have what is deemed multinomial or polytomous data. That is, each accident has more than two possible outcomes. If only two were possible, it would be called binomial or dichotomous data. We will begin by evaluating our data using multinomial analysis that assumes a multinomial distribution. This analysis was conducted manually and presented using Microsoft Excel.

Multinomial Analysis

Essentially, we have a case in which each trial (accident) has one of $q$ possible outcomes where $q = 4$. Each trial is assumed independent and the probability of each causal factor is considered constant. Our compilation of statistics is shown in Table 2.2. Column A is the stated accident cause. Column B is the number of accidents out of the sample of 43. Column C is the proportion of accidents, by cause, in the sample. Column D is the probability of each cause contributing to an accident given equal probabilities.

Our test then consists of the following hypothesis:

$H_0$: (Null hypothesis) The proportions of accidents for each causal factor are equal to 0.25 (= 0.25).
$H_A$: At least one of the four proportions of causal factors of accidents is not equal to 0.25 ($\neq$ 0.25).

While this test will not directly provide a ranked order, it will provide information as to whether we can rank them with any confidence.

Based on the null hypothesis, the number of accidents we expect to see for each cause is the expected value which is the probability (.25) multiplied by the total number of accidents (43) = 10.75. This is shown in column E of the table. The standard method of comparison for categorical data is the Pearson residual that is presented in column F of the table. These residuals indicate with some directionality whether the proportion falls above or below the mean.

Pearson's $\chi^2$ (chi-squared) statistic is computed to test the reasonableness of the null hypothesis. This value as shown in Table 2.2 is 7.33. Small values of $\chi^2$ indicate that observed values are similar to the expected values therefore supporting the null hypothesis. Large values will be found whenever the observed values are far from the expected values. To perform a valid test, we need to determine how large $\chi^2$ could be and still support the null hypothesis.

The null distribution for this problem is approximately $X^2 = \chi^2(q-1)$ when:

1. We have a fixed number of cells ($q$=4)
2. We have a null hypothesis with known probabilities (0.25)
3. We have relatively large sample sizes for each cell

The cell sizes in this test are 16, 8, 5 and 14. While two of the cell sizes appear small, the literature presents no minimum sample size for each cell regarding point 3 above. We proceed with this method computing the degrees of freedom as $q$-1 = 4-1 = 3. That is, only 3 of the cells are free to vary and the fourth is dependent on the other three since all of the proportions must add up to unity. At this point we invoke a $\chi^2$ distribution table and enter it with 3 degrees of freedom (Table 2.3). However, we must choose a level of significance ($\alpha$) at which to conduct our test. We begin with $\alpha$ = .05. Then we have, from the table, $\chi^2$ (0.95,3) = 7.815. Based on the 95[th] percentile, we find that our calculated value of $\chi^2$ = 7.33 does not exceed the critical value of 7.815 and thus we cannot reject the null hypothesis. This indicates that there is not sufficient evidence to conclude that the proportion of accidents caused by any particular factor is different from the expected value of .25. It is worth investigating the effect of the choice of $\alpha$ on our conclusion. Figure 2.14 is the equivalent of a sensitivity analysis of the critical value of $\chi^2$ for varying $\alpha$.

Table 2.3 and Figure 2.14 may be interpreted as follows. At a significance level of alpha =~ .07 or greater, we may reject the null hypothesis and conclude that there is a difference between the proportions of accidents caused by various factors. This would allow us to continue with some confidence in ranking the various factors. At this level, there is a 7% chance of experiencing a Type I error where $H_0$ is true and we reject it. Assuming we are satisfied with this 7% probability of being wrong, then a p-value = .07 is acceptable. Since we are simply trying to rank order the accident data in terms of primary causal factors we are inclined to accept a p-value = .07. If we were going to commit significant resources on the basis of this analysis, we would be inclined to use a more stringent (smaller) value of alpha.

At a significance level of alpha =~ .07 or less, we may NOT reject the null hypothesis and would conclude that there is no significant difference between the proportions of accidents caused by various factors.

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| Cause of Accident | Number of Accidents (O) | Proportion of Accid. | Prob. P | Exp. Value (E) | Pearson Residual (O-E) / E^.5 |
| Pilot Error (PE) | 16 | 0.3721 | 0.25 | 10.75 | 1.6012 |
| Airport Environment (AE) | 8 | 0.1860 | 0.25 | 10.75 | -0.8387 |
| Mechanical Failure (MF) | 5 | 0.1163 | 0.25 | 10.75 | -1.7537 |
| Weather Conditions (WC) | 14 | 0.3256 | 0.25 | 10.75 | 0.9912 |
| TOTAL | 43 | 1 | 1 | 43 | |
| Pearson's Chi-Squared $\chi^2$ Statistic = $\Sigma$ $(O-E)^2/E$ for all cells = | | | | | 7.33 |

**Table 2.2** - Pearson Residuals for Causal Factors of Accidents

| $\alpha$ | $X^2$ |
|---|---|
| 0.01 | 11.345 |
| 0.02 | 9.837 |
| 0.025 | 9.348 |
| 0.05 | 7.815 |
| 0.1 | 6.251 |
| 0.2 | 4.642 |

**Table 2.3** - Chi-Squared Values for Three Degrees of Freedom

At this point, we establish that a level of significance of alpha = .07 (which is equal to the p-value of .07) is acceptable and proceed with the expectation that there is a difference in the proportion of causes attributable to accidents. Thus, we may certainly state with 90% confidence that the proportions are different. Although we recognize that at least some values are different from the expected value, we need more information to understand how or if we can rank them.

Interval Estimates

In addition to simply establishing point estimates, it is preferable to establish intervals within which we expect to find the actual value of the parameter in the population [59]. Interval estimates will provide upper and lower values of the interval at some designated level of confidence. The level of confidence and the size of the interval then allow us to gain information about the quality of the estimate. Essentially, the confidence interval tells us the likelihood that the true value of the parameter lies somewhere between the upper and lower limits. From this we can draw some conclusions about rank ordering accident causes.

We will now develop interval estimates for each of the causal factors. If we consider only pilot error, for example, then each accident can be viewed as a trial in which we have success (the cause was pilot error) or failure (the cause was not pilot error). With this in mind we proceed as follows.

We must know four things:

1. The parameter of interest

   a. Pilot Error - $p_{PE}$
   b. Airport Environment - $p_{AE}$
   c. Mechanical Failure - $p_{MF}$
   d. Weather Conditions - $p_{WC}$

2. The estimate of the parameter (from Table 2.2)

   a. $p_{PE} = .372093$
   b. $p_{AE} = .186047$
   c. $p_{MF} = .116279$
   d. $p_{WC} = .325581$

3. The standard error of the estimate calculated as the square root of $pq/n$ where $q = 1-p$. Therefore the standard error is the square root of $(p(1-p)/n)$.

a. Standard Error $p_{PE}$ = square root $(p_{PE}(1-p_{PE}))/n$ = 0.073712
b. Standard Error $p_{AE}$ = square root $(p_{AE}(1-p_{AE}))/n$ = 0.059344
c. Standard Error $p_{MF}$ = square root $(p_{MF}(1-p_{MF}))/n$ = 0.048885
d. Standard Error $p_{WC}$ = square root $(p_{WC}(1-p_{WC}))/n$ = 0.07146

4. The correct reference distribution - With $n = 43$, we anticipate that we may use the normal distribution to find approximate binomial probabilities for our proportions. We check this by computing $np$ and $nq$ to ensure that they are greater than or equal to 5. We recognize $npq \geq 5$ to be another more conservative test for sufficiency.

| | $np$ | $nq$ | $npq$ |
|---|---|---|---|
| a. Given $p_{PE}$ | 16.00 | 27.00 | 10.05 |
| b. Given $p_{AE}$ | 8.00 | 35.00 | 6.51 |
| c. Given $p_{MF}$ | 5.00 | 38.00 | 4.42 |
| d. Given $p_{WC}$ | 14.00 | 29.00 | 9.44 |

All values meet the criteria with the exception of $npq$ for $p_{MF}$ that is very close to 5. We proceed therefore with the use of the normal approximation of the binomial distribution.

The last step is to establish values of $z_{\alpha/2}$ for selected values of $\alpha$. From a table of areas under the normal curve we find:

At 95% confidence, $\alpha = .05$, $z_{\alpha/2} = z_{0.025} = 1.96$.
At 90% confidence, $\alpha = .10$, $z_{\alpha/2} = z_{0.05} = 1.65$.

The results of these calculations for all four causal factors are displayed in Table 2.4 and shown graphically in Figure 2.15 for $\alpha = .05$. This figure was produced using Microsoft Excel's Charting feature. It provides some information about ranking the causal factors as it indicates that that at 95% confidence, the proportion of accidents attributable to pilot error is greater than that attributable to mechanical failure. Similarly it indicates at 90% confidence that pilot error and weather conditions are both greater than mechanical failure.

| Cause | p | Std Error | alpha = .05 Lower Limit | alpha = .05 Upper Limit | alpha = .10 Lower Limit | alpha = .10 Upper Limit |
|---|---|---|---|---|---|---|
| Pilot Error | 0.372093 | 0.073712 | 0.23 | 0.52 | 0.25 | 0.49 |
| Airport Environment | 0.186047 | 0.059344 | 0.07 | 0.30 | 0.09 | 0.28 |
| Mechanical Failure | 0.116279 | 0.048885 | 0.02 | 0.21 | 0.04 | 0.20 |
| Weather Conditions | 0.325581 | 0.07146 | 0.19 | 0.47 | 0.21 | 0.44 |

Where:

$z(\alpha/2 = .025) = 1.96$ for 95% Confidence Interval

$z(\alpha/2 = .05) = 1.65$ for 90% Confidence Interval

**Table 2.4** - Interval Estimates for Causal Factors of Accidents

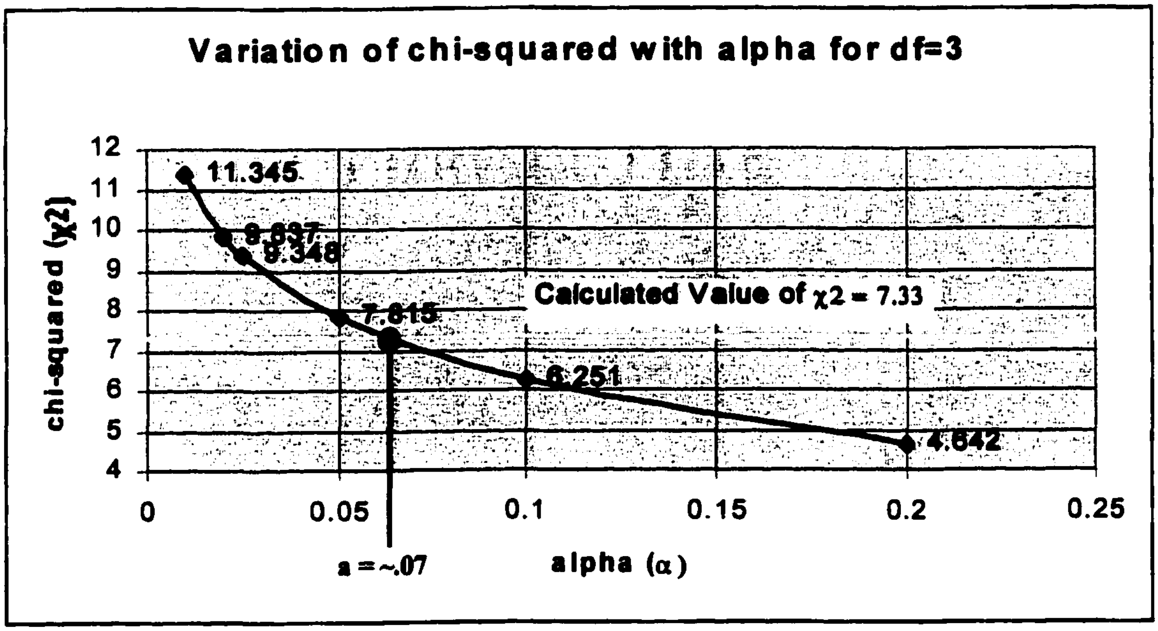



**Figure 2.14** - Variation of Chi-Squared with Alpha for Three Degrees of Freedom

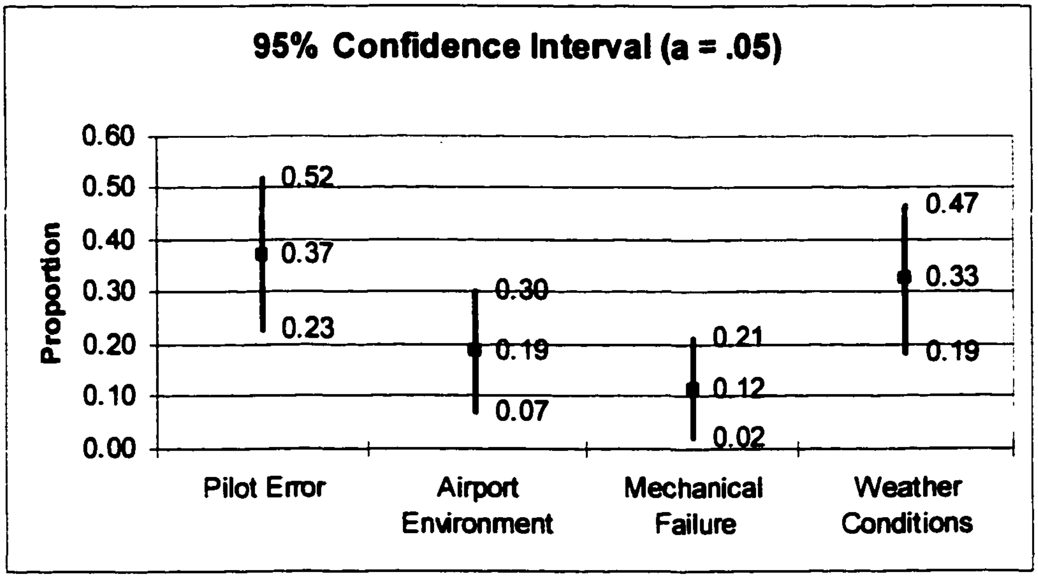



**Figure 2.15** - Interval Estimates for Alpha = .05

However, these interval estimates do not guarantee that the actual value of the proportion of any specific causal factor in the population will lie within the interval. Therefore there is a small probability that the actual parameter values are such that a completely different ranking exists. We note that the intervals are smaller when the alpha value is bigger because we are asking for less of a guarantee that the parameter's value lies within the interval.

The only thing we can do to improve the clarity of this picture is to increase the number of accidents in our sample. This effectively reduces the standard error that narrows the interval and provides greater probability that our ranking is accurate. We could do this if we increased the population to more regions of the state or all of Alaska.

Comments on the Use of Multiple Regression

If our intent were to establish the fact of an aviation accident (accident or no accident) as a variable dependent upon multiple independent factors (wind, pilot proficiency, visibility, aircraft type etc.), then we would be at a tremendous loss. In order to conduct such a study, we would need data not only for accidents that had occurred, but also for safely conducted flights. Unfortunately, such data is not compiled for rural airports in Alaska. Count data on individual VFR flights in rural Alaska is not tabulated directly. Instead, inferences are made about the number of takeoffs and landings by looking indirectly at fuel consumption and pilot surveys. While these figures are available, they provide only an estimate of flight hours for general aviation aircraft. From that one must make some assumptions about the duration of a typical flight to deduce the number of takeoffs and landings at rural villages. Even then, there is no good way to establish where those flights initiate and terminate. This begs the question of finding data about environmental factors, pilot proficiency, etc. for individual flights in the Interior. Without this specific information, a multiple regression analysis is not warranted. Although it would be possible to design methods of directly obtaining count data at individual rural airports, the time and expense is not warranted. Air traffic volume varies tremendously by month of the year so it is difficult to extrapolate data from a small sample to incorporate multiple airports over multiple seasonal changes.

The question could be framed differently. If we wanted to establish severity of injury in an accident as our dependent variable as affected by environmental factors, pilot proficiency, cause of accident, etc., then that data is available in accident databases. Conceivably a regression equation could be constructed to help determine the likelihood of no injury, minor injury or severe injury given multiple factors. However, this is a different pursuit than identifying and ranking factors causing accidents. Instead, it would identify factors that affect the severity of injury or perhaps the degree of airframe damage given that an accident has occurred. The regressor variable coefficients would then provide the relative degree of influence each variable would have on the outcome. These could be interpreted to provide a rank order of the effect of independent variables. Such a study could be used to pinpoint factors of significance in an effort to focus resources and research on mitigating the degree of influence of those factors on accident severity.

#### *2.2.2.3 - Conclusions*

From the analyses performed, we make the following conclusions that pertain to weather and runway condition reporting at rural airstrips in Alaska:

1. For the sample, using descriptive statistics:

a. Most accidents occurred during the landing phase of flight

b. Most accidents had wind as the primary causal factor

c. Runway condition was the second most prevalent causal factor in accidents

d. General aviation accidents occurred with 6 times the frequency of commercial aviation accidents. General aviation pilots must be included in whatever audience receives benefit from improved runway and weather condition reporting

e. 79% of the accidents resulted in no injury to occupants of the aircraft

f. 95% of the accidents resulted in substantial damage to the aircraft

g. The accident rate over a period of 14 years shows no valid increasing or decreasing trend in the number of accidents per year

h. More accidents occurred during the months of June, July and August than in the rest of the months combined. Any improvement to reporting systems should capitalize on these months of significant flying activity.

i. 84% of accidents occurred during daylight hours

j. 51% of the accidents can be attributed to weather or runway conditions

2. For the population, using point estimates and analytical techniques:

a. Point estimates of the proportion of accidents attributable to the four probable cause factors indicate that the proper order is pilot error, weather conditions, airport environment and mechanical failure.

b. Multinomial analysis indicates that at a 90% confidence level, (alpha = .10), there is a statistical difference between the proportion of causes attributable to accidents. That is, we reject the null hypothesis that the proportion of accidents for each causal factor is equal.

c. Interval analysis indicates that at a 95% confidence level, pilot error is ranked above mechanical failure. That is, there is no overlap in the intervals between these two factors. At 90% confidence, pilot error and weather conditions may both be ranked above mechanical failure without any overlap in the intervals.

While our analyses do not enable us to conclude with the exact ranking of the proportions of accident cause in the population, they give strong credence to our statement that both runway and weather conditions contribute to aviation accidents. Therefore we have justification to focus on these two factors in any attempt to reduce accidents.

The research goal in section 1.1 established the link between man, machine and his environment in aviation operations. These three entities serve as categorizations for the four primary causal factors that have been investigated in this chapter.

Pilot error is focused on the man. Accidents that are attributed to mistakes, oversights, or ignorance on the part of the pilot can be mitigated primarily by focusing on issues of pilot judgement, decision-making, cognitive reasoning and choice. Pilot judgement may be influenced by facts about the machine he flies, or the environment in which he flies. Thus, these issues may have some secondary effect in reducing incidences of pilot error. This study is not intended to address the subjective issues related to accidents caused by pilot error.

Mechanical failure is focused on the machine. The structural integrity of the airframe, the quality of the instrumentation, the aerodynamic characteristics of the aircraft and the reliability of the engine must be addressed in order to reduce accidents related to mechanical failure. The research that follows is not focused on addressing the issues related to accidents caused by mechanical failure.

Airport environment and weather are entities related to the aviation infrastructure or environment. Weather is produced by acts of God and cannot be directly affected by man. The reporting of current weather conditions is undertaken by systems that are part of the aviation infrastructure or environment. These systems may be examined and improved with direct benefits to the pilot who is the primary user of this information. Runway conditions may be directly affected by man and thus may be improved with direct benefit to the pilot who uses this part of the aviation infrastructure. Similarly, the reporting of runway conditions is also governed by systems that are part of the environment. These systems may be analyzed and modernized with attendant benefits to the pilot. The research that follows is focused on these two environmental entities which man can directly affect and which hold opportunities for reducing the number of accidents attributed to airport environment and weather related conditions. The conclusions of this chapter provide support to justify an investigation of methods of reducing the likelihood of accidents due to weather and runway conditions.

## CHAPTER 3

# Literature Search

This chapter explains the literature search that was conducted coincident with research into improving runway and weather condition reporting systems in Interior Alaska. Section 3.1 details the conduct of the search. It includes search method, search databases, search keywords and strings and finally search results presented as a matrix of written references. Section 3.2 highlights the references that were found that relate to runway condition reporting. Section 3.3 addresses the references that were found that relate to weather condition reporting. Chapter 4 follows with a systems approach to uncovering a solution to the abiding problems with runway and weather condition reporting.

## *3.1 - Conduct of the Search*

### 3.1.1 - Search Method

During the summer of 1998, a literature search was conducted to establish if there had been any work done to address the need for improvements in runway and weather condition reporting in Interior Alaska. At that point the author had completed a number of studies which included papers on:

1. A statistical analysis of aviation accidents in Interior Alaska
2. The impact of remoteness on the maintenance of rural Alaskan airports
3. An economic analysis of three alternatives for providing oversight to AKDOT contract maintenance personnel at rural airports in Interior Alaska.
4. Development of performance measures to gauge the success of improvements to reporting systems at airstrips in Interior Alaska.
5. Contract maintenance of rural airstrips in Interior Alaska.

Coincident with the literature search the requirements of a grant from the University of Alaska Anchorage Aviation Technology Center (UAA ATC) were being fulfilled. The study was conducted with funds received through the National Aeronautics and Space Administration (NASA) Space Grant Program. The purpose of the study was to determine the best-qualified airports in Interior Alaska at which to conduct a test of the use of remote video to improve runway and weather condition reporting. Thus, some understanding of both the systems in use at various locations, the poor Alaskan aviation safety record, and the need for improvements had already been achieved. Much of this information has been presented in Chapters 1 and 2. This chapter documents the process of seeking to fill in gaps in knowledge to provide the best possible background from which to suggest resolution to the reporting problem. The search also served to suggest ideas that could be developed into solutions.

The search was conducted using "First Search" which is an online Internet search database available through the Rasmuson Library at the University of Alaska Fairbanks. "First Search" is provided by Online Computer Library Center (OCLC), a non-profit organization that provides access to 64 existing databases of reference information [39].

### 3.1.2 - Search Databases

Each of the databases used in the search is explained below. The definitions of each database are quoted from the on-line database explanation pages [39]:

1. World Cat - Include records of any type of material cataloged by OCLC member libraries worldwide. Contains 39 million records.

2. Article First - Journals in science, technology, medicine, social science, business, the humanities and popular culture. Contains 18 million records.

3. Contents First - Complete table of contents page and holdings information for journals in many fields. Contains 1.2 million records.

4. Electronic Collections Online - Collection of journals in a variety of subject areas, all with full text articles available online. Contains 108 thousand records.

5. Fast Doc - Collection of articles that have a high percentage of citations that can be ordered for online viewing or email delivery. Contains 1.5 million records.

6. Applied Science and Technology - International and English-language periodicals, covering engineering, mathematics, physics, and computer technology. Includes articles, interviews, meetings, conferences, exhibitions, new product reviews, announcements and more. Contains 1 million records.

7. Dissertation Abstracts - The complete range of academic subjects appearing in dissertations accepted at accredited institutions. Contains 1.5 million records.

8. ERIC - References to thousands of educational topics. Includes journal articles, books, theses, curricula, conference papers, and standards and guidelines. Contains 1 million records.

9. General Science Abstracts - Journals and magazines from the U.S. and Great Britain. Includes articles, reviews, biographical sketches, and letters to the editor. Contains 577 thousand records.

10. Government Printing Office (GPO) Monthly Catalog - Records on all subjects of interest to the U.S. Government. Contains 522 thousand records.

11. Papers First - Papers included in every congress, conference, exposition, workshop, symposium, and meeting received at The British Library. Contains 2.4 million records.

12. Proceedings First - Citations included in every congress, conference, exposition, workshop, symposium, and meeting received at The British Library. Contains 61 thousand records.

In addition to the databases searched through "First Search", papers and references were collected from searches of the University of Alaska Fairbanks, Rasmuson Library files and personal sources encountered during the research. Two publications, the Alaskan Flyer and FAA Aviation News both provided informative and current articles that were uncovered in the search. Other references and documents were found subsequent to the formal search and are included herein.

### 3.1.3 - Search Keywords and Strings

"First Search" requires that key words relating to the search topic be chosen and submitted as search criteria. The subsections below describe the key words used for the two primary subjects of search.

#### *3.1.3.1 - Runway Condition Reporting Keywords*

The words "runway", "remote", "condition" and "report" were chosen as primary keywords. Synonyms for these words were also selected and used interchangeably in the search strings. The following synonyms were used:

1. Runway: Airport, airstrip, runway, airfield, landing strip, flying field, landing field and aerodrome.
2. Remote: Inaccessible and isolated.
3. Condition: State, status and situation.
4. Report: NOTAM, notice to airman and reporting.

#### *3.1.3.2 - Weather Condition Reporting Keywords*

The words "weather", "remote", "condition" and "report" were selected as primary keywords. Synonyms for these words were also selected and used in the search strings. The following synonyms were used:

1. Weather: Meteorology, cold regions and snow.
2. Remote: Inaccessible and isolated.
3. Condition: Condition, state, status and situation.
4. Report: AWOS and ASOS.

These keywords were combined into search strings that were used in the various databases. Certain search strings were clearly more representative and yielded search returns more closely approximating research interests.

### 3.1.4 - Search Results

The search yielded thousands of references of which approximately 100 seemed related to the research. The sources included papers, articles, theses, books, technical reports, proceedings, and circulars. These were categorized and are displayed in Table 3.1. The columns of the table are explained below:

1. Database Number - Indicates the number assigned to the database which yielded the document. Numbers 1-12 reference a database from "First Search" as discussed in section 3.1.2. Numbers 13 - 17 reference sources other than "First Search".
2. Item Number - Indicates the document number within a particular database. For example, database number 2, Item Number 1 means the first item (NOTAM News Flash) found in the second database searched (Article First). This document would be referenced hereafter as document 2/1.
3. Database - This is the name of the database that yielded the document.
4. Title - Title of the document
5. Runway Condition - This column is checked if the article seems to provide information about runway condition reporting.
6. Weather Condition - This column is checked if the article seems to provide information about weather condition reporting.
7. Primary Area - Indicates the basic subject matter of the document.
8. Year - Year the document was published.
9. Publication - Type of publication from which the document was extracted.
10. Publisher - Self explanatory
11. Status - Indicates whether or not the document was retrieved and reviewed, and whether or not a copy was retained.
12. Priority - Indicates the priority number assigned to the article when it was reviewed. 1 - Very important resource that is closely related to the subject matter; 2 - Important material which appears to have some relationship to the subject matter; 3 - Material which may be related; 4 - Material which is clearly unrelated or provides no new information.
13. Notes - These are notes obtained during a review of the document. They provide a quick reference to enable me to find and review documents needed for the study.

## *3.2 - Runway Condition Reporting References*

### 3.2.1 - Primary Sources

Documents relating to the collection and reporting of runway or airstrip condition information fell into three categories: airport contractor; equipment; and managing agencies. The information provided by each of these primary documents is articulated below and may be traced to its source in Table 3.1 by the associated document number. Document X/Y indicates it is from database number X, item number Y.

### *3.2.1.1 - Contractor Related Documents*

Document 1/21 - *FAA, Airports Strive for Safer Snow Operations*

This paper establishes that accidents between aircraft and maintenance vehicles on runways are most likely to occur at airports that receive heavy winter snows. Poor runway conditions bring out maintenance vehicles that often have to operate in conditions of reduced visibility to plow runways. This increases the risk of accidents. The document suggests that marking runways more clearly will help maintenance vehicles recognize their position on the airport and reduce the risk of accidents. Additionally, they suggest that maintenance vehicles be equipped with rotating beacons that automatically turn on when the vehicle is started. The document also suggested that lighted signs be placed on the end of the runways during plowing operations to signal to arriving aircraft that the runway was closed.

While the document provides no specific information on the reporting of runway conditions, it focuses on an aspect of mitigating those conditions...which reduces both the need and the importance of timely reporting.

Document 2/5 - *Winter Maintenance at Airports Requires a Different Approach*

This article establishes two important points. First, contract maintenance personnel must take extreme care not to damage runway lights, markers and navigational aids while plowing snow. Secondly, emphasizes the critical necessity of having well-trained, loyal and competent operators.

As with the previous document, this one provides no direct information on the reporting of conditions. However, it reestablishes the importance of competent contractors. We have already noted that contractor loyalty may be lacking in rural Alaska. It is now apparent that this is a critical issue because of the nature of the job.

Document 13/1 - *Notices to Airmen (NOTAMs) for Airport Operators*

This FAA Advisory Circular is an excellent source of information regarding NOTAM reporting requirements. Airport managers are required to report any condition on or in the vicinity of the airport, existing or anticipated, which would prevent, restrict, or present a hazard to arriving or departing aircraft. This reporting occurs through the NOTAM system. The same system is used to report when the condition is removed or corrected. The paper establishes that only certain individuals have the authority to initiate a

NOTAM. It lists several primary reportable situations including: airport closure, conditions that restrict the use of any portion of a runway, poor braking action, and the existence of snow, ice, slush, or standing water on the runway.

This information may be used to ascertain the knowledge level of current maintenance contractors to determine if they are aware of their reporting responsibilities. A loyal operator who is not fully aware of his responsibilities is almost as ineffective as one who knows his job but will not do it well.

<u>Document 17/1</u> - *Arctic Airports Maintenance Manual*

The discovery of this document in the UAA library is a significant find. It is a Canadian manual written specifically to inform maintenance contractors at rural Canadian airfields. It covers airfield equipment, airfield maintenance, airfield lighting, airfield security and other duties attendant to the job of maintenance contractor. It is simply written yet thorough.

This 1980 document provides a stark contrast to resources available to Alaskan airport maintenance contractors who have no such handbook. It offers an example of a simple and inexpensive resource that could significantly improve the level of maintenance performed at airstrips, thereby reducing the need for reporting of discrepancies.

<u>Document 2/4</u> - *NOTAM Nightmare*

This article highlights the fact that the system for posting NOTAMs is generally adequate throughout the NAS, but the system for retrieving NOTAMs is often quite inadequate and difficult to manage.

Perhaps the critical point here is that Alaska has the additional burden of a poor NOTAM collection system in that it is dependent upon contract maintenance personnel who are often not up to the task.

### 3.2.1.2 - Equipment Related Documents

Document 1/12 - *Runway Surface Condition Sensor: Specification Guide/ U.S. Dept. of Transportation, FAA*

This paper discusses the use of sensors mounted flush in the pavement of a runway which are used to detect the present of ice on an airstrip. These sensors, mounted at several locations on the runway transmit information about temperature and moisture to a central location where tower personnel can quickly determine where friction may be reduced and runway conditions may be poor.

While the article presents a system for collecting information on the presence of ice, it makes no provision for detecting the depth of snow that is of primary concern on rural Alaskan airstrips. It also makes no provision for use of such a system on gravel airstrips that are most prevalent in Alaska. Additionally, it assumes the presence of a control tower, or other airport personnel who monitor the runway constantly. In Alaska, these are poor assumptions.

Document 9/4 - *Camera Keeps an Eye on Airport Vehicles*

Proposes the use of a camera system with imbedded artificial intelligence to discern what type of vehicles are operating on the surface of the runway, and where they are located.

This is the first document found which proposes the use of video cameras for anything related to activities on or near a runway. However, it makes no provision for the use of such systems to report the condition of a runway.

Document 11/1 - *Application of Thermal Imaging to Remote Airfield Assessment*

This technical paper investigates the use of thermal imagery to assess the condition of runways. It was determined that thermal imagery could detect cracks and voids in and under the pavement.

This method has no direct application in rural Alaska where most runways are gravel and subsurface voids are not a problem. However it does provide an additional potential tool for the automated collection of runway surface information. It is important also to note that the system as presented in the paper is completely manual and requires human operators.

<u>Document 11/2</u> - *Automated Airfield Condition Data Collection*

This document proposes the use of multiple 35-millimeter photographs taken in a grid pattern on a runway to assess pavement distress in runways over time. It is a manual system, as proposed, and has no use in the detection of snow on a distant, rural, Alaskan airstrip.

#### *3.2.1.3 - Agency Related Documents*

<u>Document 1/13</u> - *Transportation Needs and Priorities in Alaska*

This AKDOT publication lists all planned airport improvement projects for the stated year. Typical projects include construction of new runways, extension and widening of existing runways/taxiways and purchasing/clearing of land for construction of new runways. No mention is made of systems to improve the collection or reporting of runway condition information.

<u>Document 10/4</u> - *Runways at Small Airports are Deteriorating Because of Deferred Maintenance: Action Needed by FAA and the Congress.*

This government document establishes that although much money has been spent in the construction and improvement of over 1700 of the nation's smaller runways, local governments have not programmed for funding to maintain them. The primary associated problem is a failure to fix pavement cracks, which results in too much deferred maintenance.

The conclusions of this document are applicable to Alaska where federal Airport Improvement Program (AIP) funds are accepted and expended in building new airports, but where the state is not programming funding for long term maintenance. This slow and steady deterioration of runways effectively increases the requirement for runway condition reporting.

### 3.2.2 - Conclusions

The absence of references relating to runway condition reporting is more revealing than the presence of the sources presented above. There appears to be nothing in the literature relating to the specific problem of improving runway condition reporting at rural airports in Alaska where the primary maintenance concern is snow removal. None of the references above present any key ideas that are adaptable to Alaskan conditions. Suffice it to say that where manual collection of runway condition information is required, and automated collection seems technically infeasible, the solution must involve some improvement or adjustment involving human factors. The other alternative is to suggest an innovative method of improving the accuracy and/or regularity of reporting using new or existing systems.

## *3.3 - Weather Condition Reporting References*

### 3.3.1 - Primary Sources

Documents relating to the collection and reporting of weather condition information fall into three categories: automated versus human weather observations; weather reporting systems and the use of video cameras in capturing weather information. The information provided by each of these primary documents is shown below and may be traced to its source in Table 3.1 by the associated document number.

#### *3.3.1.1 - Automated versus Human Weather Observations*

Document 1/20 - *Installation of AWOS for FAA at Commercial Airports is not Justified*

This 1985 report compiled by the General Accounting Office (GAO) recommended against purchasing 304 AWOS systems costing $60 million. The report establishes that the systems, which were designed to replace human observers, did not meet the technical specifications in four areas: ceiling, visibility, thunderstorm detection and precipitation. The paper establishes that new sensors are being designed and tested but that as currently tested, they did not meet the established specifications.

The report helps establish a historical trail of difficulties with AWOS - specifically with the ceiling and visibility measurements. This trend in AWOS problems continues today and provides incentive for developing or modifying a system that will both corroborate existing AWOS ceiling/visibility information and independently provide information to the user about these conditions.

Document 11/7 - *Comparison of ASOS and Observer Ceiling-Height and Visibility Values*

This document focuses on differences between ASOS reports and human observer reports of both ceiling height and visibility around the important threshold values which distinguish between IFR and marginal VFR (MVFR) conditions. Ceilings less than 1000 feet and/or visibility less than three miles implies that aircraft must operate IFR. When automated sensors and human observers differ in their reports around these critical thresholds there can be significant implications for flight operations. The report concludes that ASOS and observer reports may occasionally differ by significant amounts. It also clarifies that ASOS systems report changes as they occur (every 6 minutes), whereas observers report less frequently. Frequent changes around critical thresholds make it hard for aviators to discern the legality of VFR flight in marginal conditions. The report also reveals that the observers used in the study had access to the automated report, but that it was assumed that the automated information did not affect the observers manual report.

Several key thoughts from this paper are pertinent to this research. The study appears to include no data from AWOSs located in arctic locations. Thus, it does not account for the anomalies attendant to extreme conditions. The study clearly states that there are differences between automated systems and manual observation. It is anticipated that extreme climatic conditions will serve to exacerbate the frequency and severity of those discrepancies. Finally, the aviation community wants a system that provides clear information from which they can make flight decisions. There is clearly consternation among aviators over the discrepancies between automated and human observations.

Document 11/9 - *Comparability of ASOS and Human Observations*

This document poses the question "Why isn't ASOS more like a human in terms of the weather observations it produces?" The primary conclusion is that the location of the sensor, be it automated or human, is the most important determinant in closing the gap between differences in observations. It states that ASOS can indeed provide a sky condition report that is representative of an area 3 to 5 miles around the airport. It also concludes that ASOS is unable to provide information about weather distant from the airport. Finally it implies that the most important observation information should be taken at the touchdown location near the runway. This is not normally located near the point of human observation in the tower or at the NWS office.

This paper indirectly clarifies the limited scope of information provided by both the ceiling and visibility observations from ASOS. In both cases, information collected at the sensor must be extrapolated to apply to an area larger than what is actually sampled. In Alaska, where small changes in location can yield vastly different weather phenomenon, these extrapolations introduce great opportunity for error.

Document 11/19 - *Comparability between human and ASOS Ceiling/Visibility Observations*

This study investigated the comparability of human and ASOS ceiling and visibility. Comparability was defined as the "percent of time that the difference between an automated ceiling height and NWS-observer ceiling height, or between an automated visibility and NWS-observer visibility, is less than or equal to a specific threshold value." These threshold values were provided in the study. The report concludes that ASOS observations are different from manual observations. It reveals that ASOS is limited in that it cannot detect an approaching cloud layer or a nearby fog layer which is not directly over the sensor. It clarifies the fact that "ASOS values represent point values from a very small volume integrated over time, rather than instantaneous values integrated over a very large volume of space." A human observer provides the latter. A final conclusion of the report is that both ASOS and human observations are equivalent depictions of the weather.

This report inappropriately concludes that manual and automated observations are equivalent. It is shortsighted in the breadth of geographical locations considered. It does not account for the many hours of down time often attendant to the automated systems. It underestimates the importance of the information that ASOS cannot report, that of distant sky and visibility conditions. This report provides additional incentive to pursue research in improving weather-reporting systems in Interior Alaska. The discrepancy between this report's conclusions and the fact of the aviation community's disappointment with and lack of trust in the system requires resolution.

#### *3.3.1.2 - Weather Reporting Systems*

Document 6/4 - *Sensors and Systems to Enhance Aviation Safety Against Weather*

This excellent paper discusses several different existing and upcoming weather collection systems to enhance aviation safety. With regard to AWOS it makes several very important points. Most automated weather collection systems use physical instruments to gather weather data, but all subsequent steps of transmitting, interpreting and disseminating the information are strongly human-centered. This makes the systems more costly and less responsive to the needs of the aviation community. The article establishes that AWOS is designed primarily to provide weather information to support landing and takeoff operations and thus have little to offer in terms of information on conditions away from the physical sensors. Additionally, AWOS is designed as a modular system so that additional sensors may be added. While AWOS can provide good objective information (when operating properly), it is inferior in that there is an absence of "human perception, intelligence, and subjective judgement in the automated system." The article proposes that the characterization of weather systems will be different for each different airport, and that AWOS will be the primary collection system at small, rural airports. The article concludes by suggesting that the best way to manage weather systems of the future will be to balance automation of the collection system and limited human involvement at certain nodes.

This article provides strong support to the idea that a system that can blend a maximum of automation in collection of data and the opportunity for a presentation that is highly intuitive to the user, would be ideal. Additionally, a system that can reach out and discern the state of the environment away from the immediate sensor location would be highly complementary to existing AWOS systems.

Document 6/5 - *Advances in Weather Technology for the Aviation System*

This reference makes two important points. First, AWOS does not provide information in the "remarks" section of the weather observation which normally includes such information as type and coverage of distant clouds, thunderstorm information, and information on obstructions to vision like blowing snow, dust, smoke or haze. The report reiterates how important this information is to the overall weather picture. Secondly, it proposes that we must ensure that pilot decision-making takes weather fully into account.

Building on the previous document, this reference implies that a better solution would be one which allows a pilot to quickly and easily discern the extent and type of weather he will encounter before the flight commences, thus allowing him to make a wise decision about how to proceed.

Document 6/7 - *Nonfederal Automated Weather Stations and Networks in the United States and Canada: A Preliminary Survey.*

This paper provides clear evidence that there are many nonfederal automated weather observing systems around the United States which could all be tapped in order to provide more complete coverage of current weather for federal systems.

Regarding the research, this document reveals that improving reporting systems need not necessarily be federally financed or executed. A system of private collection systems, formed, maintained and serviced at the grass-roots level may still provide an excellent source of information to a federally supported system.

Document 11/16 - *Status of ASOS Planned Product Improvements*

This 1997 document establishes that planned improvements to ASOS included: "an ice-free wind sensor, a replacement dewpoint sensor, an all-weather precipitation accumulation gauge, and an enhanced precipitation identification sensor". It recognizes that improvements to the modular ASOS system will be the primary avenue to improving terminal automated weather information in the future.

It seems reasonable to anticipate that any improvement to existing reporting systems should be able to be included as a modular expansion to existing ASOS units. This provides an immediate infrastructure (structure, power and telecommunications) to support the new innovation.

Document 11/18 - *Operational U.S. Observing Systems for the Early 1990s*

This document reemphasizes the that ASOS will have no backup system if it fails and does not provide detailed remarks on sky condition or cloud type away from the site.

The idea of providing backup to a failed ASOS is critical. If an airport is relying on ASOS alone to provide weather information, and the system fails, then the aviation community is heavily restricted in its options. This is especially true at rural, unmanned airports in Alaska. Any innovation should help provide some backup coverage to ASOS in the event of failure, especially in terms of visibility and ceiling information that is always in high demand.

Document 14/5 - *ASOS and Contract Weather. Where are we?*

This FAA article provides an update on the status of ASOS commissioning throughout Alaska. As of December 1998, only 54% of the 44 FAA ASOSs were commissioned. The commissioning process has been very slow due to equipment problems, lack of maintenance resources and procedural issues.

The article helps establish the need for weather reporting in Alaska, if for no other reason than that all of the scheduled ASOSs are not yet operational. It also mentions that 34 of the 44 ASOS sites planned for Alaska have been assigned as stand-alone automated weather systems...with no other resources as a back-up.

Documents 14/2 and 14/5 - *Alaska Region Restates ASOS Policy* and *Determining Clearance Needs with ASOS*

IFR flights require that the pilot have current official weather about his terminal (landing) location that states that the ceiling and visibility requirements are above the minimum required to shoot the IFR approach into the airport. Currently, if a pilot receives an official briefing that indicates that the weather at the destination is below minimums, then he must get an updated en route briefing stating that weather is above minimums before landing IFR at the airport. Unfortunately, that current data is often 15 to 20 minutes old, but the ASOS radio transmissions are updated every 6 minutes. This updated Alaska ASOS policy enabled pilots to use the current updated ASOS data to determine if it was legal to land instead of relying on the old data provided by radio through the controller.

These two articles reemphasize the tremendous importance of timely, current weather information in the cockpit. Any innovations should have some ability to provide current weather in the cockpit if at all possible. It also opens the door for the use of other innovative weather reporting enhancements to be used as official weather when verified by the pilot.

### *3.3.1.3 - Use of Video Cameras in Capturing Weather Information*

Document 11/11 - *The Use of Video Cameras as a Supplement to ASOS and the Total Observation Concept*

This article proposes an innovative idea for capturing current weather information - the use of still video camera images transferred from remote sites to provide observers with a graphic of actual weather conditions at another geographic location. It suggests combining these images with NEXRAD information, satellite information, lightning data, and the latest ASOS data on an Internet website made accessible to the general public. The idea is deemed "The Total Observation Concept." They indicate that distant weather parameters such as mountain obscurement, virga, mountain clouds and snow depth can be discerned from the images.

This article proposes the most innovative use of available technology in improving weather reporting that was encountered. There is application directly to Interior Alaska where we have remote airports, poor weather reporting resources, fast-changing weather conditions and high demand for current information from the community. Specifically, this article provides the basis for a project to provide remote video images from airport locations in rural Alaska to the Internet both for improving weather reporting, and potentially for improving runway condition reporting. The article does not make any recommendation for using video specifically at rural airports, but instead as an augmentation to existing ASOSs. This is an important reference for this research.

<u>Document 11/17</u> - *Eyes for ASOS*

This article capitalizes on the idea of using remote video to capture distant weather information by proposing that the digital images be interpreted using artificial intelligence software. The intent is to develop algorithms which can determine the category and extensiveness of clouds and atmospheric without manual interpretation. The article concludes by saying that the operational software required to conduct such evaluations would be complex and challenging. It also anticipates that even mild success in the effort would be beneficial to the weather community.

<u>Document 17/4</u> - *Present Weather Camera Project*

A team in the United Kingdom prepared this technical report after a project in which they used video camera technology to observe meteorological conditions. They focused on observation of precipitation, cloud type, visibility and ground states. They also sought to determine whether the images could be used to give information about a remote site. They concluded that useful information was gleaned through the use of video cameras. The author attended a workshop in Salt Lake City, Utah 1998 when portions of this technical report were presented. The workshop was a National Weather Service Forecast Office Vide Camera Workshop on 9 - 10 September.

The study and subsequent report are important in that they represent the successful use of video cameras to detect weather conditions at remote locations. The report made no attempt to relate the use of the images to the aviation community but instead was focused on determining quantitative information specifically for meteorological use. However, it provides excellent incentive to apply a similar technology specifically for consumption by the aviation community in the reporting of runway and weather conditions.

<u>Document 17/3</u> - *First Year Results and Next Steps for the NWS Video Camera Demonstration Project*

This paper was prepared by the NWS subsequent to the conference the author attended in September 1998. It outlines the field results of NWS tests on the use of video camera images in weather observations. The paper concludes that the cameras were not beneficial in observations, but that they were helpful in forecasting. They determined that the camera resolution was not sufficient to ascertain visibility, cloud height and cloud amounts as required by a NWS forecast office.

The conclusions of this report indicate a need for an imaging system capable of providing quantitative information about the image if it is to be used for NWS applications. The report does confirm again that the use of video camera for determining weather conditions is on the rise, but currently in its infancy.

Document 17/2 - *Cameras Tell Whether or Not to Land*

This short excerpt from an article publicized on AvWeb (an Internet based aviation website at www.avweb.com) documents the use of cameras by NASA to assist tower controllers at San Francisco International Airport. The cameras provide real-time information about fog conditions and low clouds at the approach corridor to the runway that will assist controllers in opening and closing runways more efficiently. This is a specific example of the application of video camera technology to large-scale aviation needs at a major airport.

### 3.3.2 - Conclusions

The literature search for items relating to weather condition reporting was particularly beneficial. The conclusions from this section are itemized below:

1. Discrepancies between automated and human weather observations clearly exist.

2. The primary difficulty with automated systems lies with the inconsistencies in their measurement of cloud ceiling and visibility.

3. The ceiling and visibility information provided by automated systems is limited in scope in that they cannot provide information about distant weather phenomena.

4. There are no formal studies delineating the problems with AWOS/ASOS in arctic conditions.

5. There is a tendency in the literature to praise automated systems in spite of their shortcomings. Specifically, the literature seems to defend ASOS even though there is much consternation over the information it provides.

6. Future additions to automated systems need to blend automation with the subjective judgement provided by a human.

7. Innovations in reporting systems need not be federally funded.

8. New systems should be capable of modular expansion to existing AWOS/ASOS systems.

9. Innovations that can backup or corroborate automated ceiling and visibility data would be ideal.

10. Video cameras have been used to discern weather phenomenon primarily for the NWS. There is the potential, through video technology, to glean weather information from remote locations.

| DataB No. | Item No. | Database | Title | Run. Cond. | WX Cond. | Primary Area | Year | Type of Pub. | Publisher | Status | Pri | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | World Cat | A Scenario approach to airport evaluation in remote communities: with particular reference to the Pibara region of Australia | | | Remote | 1987 | Periodical | Transportation, Vol. 14 No. 1 | Not Reviewed | 4 | Not pertinent |
| 1 | 2 | World Cat | Provision of airports to isolated communities | | | Construction | 1986 | Book | Transport Canada, Development | Not Reviewed | 4 | Not pertinent |
| 1 | 3 | World Cat | Geographically isolated New Zealand relies on air travel: government wants to privatized airport authorities | | | Remote | 1986 | Periodical | Airport Forum, Vol 16, No.2 | Not Reviewed | 3 | Not pertinent |
| 1 | 4 | World Cat | Evaluation of radio remote control systems for airport visual aids | | | Runway Maintenance | 1977 | Book | DOT, FAA, Syst Research and Dev. Service, NTIS | On Hand | 3 | FAA report of a system tested in 75-76 *to determine* if a radio control system could be used to control and monitor airport visual aids. No pertinent material |
| 1 | 5 | World Cat | How can we protect isolated aeronautical infrastructures? | | | CCTV | 1986 | Periodical | *ICAO Bulletin, Vol 41,* No. 10 | On Hand | 2 | Focus on surveillance systems to protect isolated aeronautical structures from intrusion. Includes idea of using video surveillance cameras to provide images to surveillance personnel at a hub location. Purpose would be to detect type of intruder. |
| 1 | 6 | World Cat | The importance of local airports to rural business | | | *Economics* | 1996 | Article | University of Wisconsin, Extension | On Hand | 3 | Talks about contradiction in the literature about the importance of local airports to businesses and the economy of a town. Not only the existence of an airport, but the services it provides need to be improved to improve the economy of the town. |
| 1 | 7 | World Cat | Financing Alaska's rural airports: a review of options and opportunities | | | Economics | 1992 | Book | Hickey and Associates | Not Available | 3 | No lending libraries or sources |
| 1 | 8 | World Cat | Multiobjectives airport system planning for rural Alaska | | | Remote | 1976 | Thesis | Johns Hopkins University | Not Available | 3 | No lending libraries or sources |
| 1 | 9 | World Cat | 1988 continuous aviation system planning: special study: secondary, Native American and emerging rural airports | | | Remote | 1988 | Book | Arizona Department of Transporation | Not Reviewed | 4 | Not pertinent |
| 1 | 10 | World Cat | Evaluation of the aviation weather and NOTAM system (AWANS) : final report | X | X | NOTAM/Weather | 1980 | NTIS | National Technical Information Service | *Not Available* | 1 | *No lending libraries or sources* |
| 1 | 11 | World Cat | Unnecessary procurement of an aviation weather and notice to airmen system by FAA: report | X | X | *NOTAM/Weather* | 1979 | Report | *General Accounting Office* | Not Available | 1 | No lending libraries or sources |
| 1 | 12 | World Cat | Runway surface condition sensor: specification guide/ U.S. Dept. of Trans FAA | X | | Runway Maintenance | 1991 | Guide | Federal Aviation Administration | On Hand | 2 | Specifies requirements for the design of in-pavement sensors to detect icing conditions on runways. Sensors must measure temperature and presence of moisture on the surface. |
| 1 | 13 | World Cat | Transportation needs and priorities in Alaska | X | | Construction | 1995 | Report | Alaska Department of Transportation and Public Facilities | On Hand | 2 | DOT publication which lists all the transportation needs and priorities in Alaska from 1995. Chapter on Airport Improvements. Pages were extracted for Interior Airports. |

**Table 3.1** - Results of Literature Search - Page 1 of 8

| DataB No. | Item No. | Database | Title | Run. Cond. | WX Cond. | Primary Area | Year | Type of Pub. | Publisher | Status | Pri | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14 | World Cat | Alaskan airports adapt to changing times | | | Construction | 1995 | Periodical | Airport Forum, Vol. 25, No. 1 Feb 95 | On Hand | 3 | Highlights the challenges and successes of improvements to Anchorage and Fairbanks airports with notes on the implications of a shift from revenue generated by passengers to freight. |
| 1 | 15 | World Cat | Airports in winter: AACI takes up the winter challenge | X | | Maintenance | 1992 | Book | Jane's Airport Review | Not Reviewed | 4 | Not needed |
| 1 | 16 | World Cat | Airport winter safety and operations | X | | Safety/Maintenance | 1991 | Book | Federal Aviation Administration | Not Reviewed | 4 | Not needed |
| 1 | 17 | World Cat | ASOS, NWS ready reference guide | | X | AWOS/ASOS | 1998 | Book | National Weather Service | Not Reviewed | 4 | Not needed |
| 1 | 18 | World Cat | VHF lightning sensors and field measurements and application to airport weather monitoring | | X | Remote Sensing | 1993 | Thesis | Tufts University | Reviewed | 3 | Ph.D. Thesis on design of VHF lightning sensors for airport monitoring, possible inclusion with ASOS. |
| 1 | 19 | World Cat | Automated Surface Observing System: guide for pilots: ASOS | | X | AWOS/ASOS | 1997 | Book | Dept. of Commerce, NOAA, NWS | Not Reviewed | 4 | Not needed |
| 1 | 20 | World Cat | Installation of AWOS for FAA at commercial airports is not justified | | X | AWOS/ASOS | 1985 | Report | General Accounting Office | On Hand | 1 | Established that preliminary tests of AWOS failed in 4 areas: ceiling, visibility, thunderstorm detection and precipitation Recommended not to purchase AWOS until fixed. |
| 1 | 21 | World Cat | FAA, airports strive for safer snow operations | X | | Runway Maintenance | 1987 | Periodical | Airport Services Mgmt., Vol. 27 No 9 (Sep 87) | On Hand | 2 | Addresses problem of runway incursions between aircraft and airport maintenance vehicles. Solution is to add lights or signals at runway intersections to alert ground vehicle operators to trouble. |
| 1 | 22 | World Cat | A comparison of ceiling and visibility observations for NWS manned observation sites and ASOS sites | | X | AWOS/ASOS | 1993 | Thesis | Colorado State University | Reviewed? | 2 | Thesis on agreement between ASOS and human weather observations of ceiling and visibility. |
| 1 | 23 | World Cat | Roads and Airfields in cold regions: a state of the practice report | X | | Construction | 1996 | Book | American Society of Civil Engineers | Reviewed | 4 | Not pertinent |
| 1 | 24 | World Cat | Arctic and subarctic construction runway and road design | | | Construction | 1993 | Book | Headquarters, Department of the Army | Not Reviewed | 4 | Not pertinent |
| 1 | 25 | World Cat | Buildings for storage and maintenance of airport snow and ice control equipment and materials. | | | Structures | 1993 | Book | Federal Aviation Administration | Not Reviewed | 4 | Not pertinent |
| 1 | 26 | World Cat | Runway ice prediction and monitoring | X | | Maintenance | 1992 | Book | Airport Forum, Vol. 22, No. 4 | Not Reviewed | 4 | Not pertinent |
| 2 | 1 | Article First | Planning for Aviation and Diversification on Small Rural Airfields in England and Wales | | | Construction | 1998 | Periodical | Regional studies, Vol 32, No 4 | On Hand | 4 | Discusses use of demilitarized and older airfields in England and Wales countryside. |
| 2 | 2 | Article First | NOTAM News Flash | X | | Military Operations | 1995 | Periodical | Flying Safety, Vol 51, No 5 | On Hand | 4 | Air Force article with no relationship to my studies |
| 2 | 3 | Article First | IFC Approaches: NOTAM Nightmare Revisited | X | | NOTAM | 1993 | Periodical | Flying Safety, Vol 49, No 1 | On Hand | 2 | Same fictional story as 2/4 but from Air Force point of view. |
| 2 | 4 | Article First | NOTAM Nightmare | X | | NOTAM | 1992 | Periodical | Flying (Including Industrial Avn., Volume 119, No 3 | On Hand | 2 | Fictional story of incursion of a jet with construction barricade...followed by discussion of NOTAM access to pilots. |

Table 3.1 - Results of Literature Search - Page 2 of 8

| DataB No. | Item No. | Database | Title | Run. Cond. | WX Cond. | Primary Area | Year | Type of Pub. | Publisher | Status | Pri | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 5 | Article First | Winter Maintenance at Airports Requires a Different Approach | X | | Runway Maintenance | 1991 | Periodical | Public works (NY, NY) Municipal journal and PW contracting PW manual, Vol 122, No 8 | On Hand | 2 | *Talks about snow and ice prevention and clearing at airports.* Operations must be performed before or during the onset of a snow or ice storm. Aircraft ops must be maintained during snowfighting. Operators *must be well trained and competent.* Commitment, training, experience of these dedicated snowfighters will provide the safest winter conditions in the world. |
| 2 | 6 | Article First | Work Related Aviation Fatalities | | | *Safety* | 1997 | *Periodical* | Morbidity and Morality Vol 46, No. 22 | *Not Reviewed* | 4 | *Not pertinent* |
| 3 | 1 | Contents First | None | | | | N/A | N/A | N/A | N/A | 5 | No documents found |
| 4 | 1 | Elec Coll. Online | None | | | | N/A | N/A | N/A | N/A | 5 | No documents found |
| 5 | 1 | *FastDoc* | None | | | | N/A | N/A | N/A | N/A | 5 | No documents found |
| 6 | 1 | Applied Sci. and Tech. | A *Scenario approach to airport* evaluation in remote communities: with particular reference to thePibara *region of* Australia | | | Remote | 1987 | Periodical | Transportation v. 14, No. 1 | Not Reviewed | 4 | Not pertinent |
| 6 | 2 | Applied Sci. and Tech. | Polar base planned to justify unnecessary airstrip | | | Remote | 1991 | Periodical | New Scientist vol. 132 30 Nov 91 | Not Reviewed | 4 | Not pertinent |
| 6 | 3 | Applied Sci. and Tech. | Britain Plans New Antarctic Airstrip | | | Remote | 1989 | Periodical | New Scientist vol. 121 21 Jan 89 | Not Reviewed | 4 | Not pertinent |
| 6 | 4 | Applied Sci. and Tech. | Sensors and systems to enhance aviation safety against weather | | X | *Remote* Sensing | 1991 | Periodical | Proceedings of the IEEE Vol 79 (Sep 91) p. 1232-1267 | On Hand | 1 | Excellent reference on existing WX sensing systems and use of AWOS at small airports.Two phases of Avn WX ops. Terminal ops and en route ops.. Human centers observ are expensive and slow. AWOS for landing and takeoff. Highly current data. AWOS designed on modular basis, additional sensors can be integrated readily.AWOS does not present quadrant wise visibility differences., cloud types, present wx type etc. Sat. good for large scale features. Type and number of WX instr. varies by airport. AWOS the only thing at small airports.. Instruments enhance safety, economy efficiency comfort. Automation doesn't directly utilize human experience. Balance - automation with limiteed human involvement at nodes. |
| 6 | 5 | Applied Sci. and Tech. | Advances in weather technology for the aviation system. | | X | Remote Sensing | 1989 | Periodical | Proceedings of the IEEE Vol 77 (Nov 89) p. 1728-1734 | On Hand | 2 | WX Service Modernization: Doppler Radar, AWOS, Aircraft reports, Vertical Wind profiler, and satellite. Talks about modernization of weather systems: Info transfer and sensing systems *two basic problems.* WX products will improve... more specific, timely, geographically explicit. |
| 6 | 6 | Applied Sci. and Tech. | Automated weather station for harsh environments. | | X | *Remote* | 1993 | Periodical | Offshore Vo 53 Agu 93 | Not Reviewed | 3 | Not new information over and above ASOS/AWOS *info.* |
| 6 | 7 | Applied Sci. and Tech. | Nonfederal automated weather stations and networks in the United *States and Canada: a preliminary* survey. | | X | Technology | 1992 | Periodical | Bulletin of the American Meteorological Society Vol 73 (Apr 92) p. 449-57 | On Hand | 2 | During the 80s many non-federal automated weather stations (AWS) were put up around the country. These provide a network of data collection *centers that could fill in the gaps in weather* collection sites around the country. |

**Table 3.1** - Results of Literature Search - Page 3 of 8

| DataB No. | Item No. | Database | Title | Run. Cond. | WX Cond. | Primary Area | Year | Type of Pub. | Publisher | Status | Pri | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 1 | Diss. Abstracts | A computer assisted general aviation airport location and evaluation system for virginia | | | Construction | 1980 | Thesis | Virginia Polytechnic Institute | Not Reviewed | 4 | Thesis to automate the process of selecting airport sites. |
| 7 | 2 | Diss. Abstracts | An investigation into the economic *impact of airfield and navaid* investment at general aviation and nonhub air carrier airports | | | Economics | 1994 | Thesis | Georgia Institute of Technology | Reviewed | 3 | This thesis attempted to correlate economic success of communities with *presence of airfields* and navigation aids in the vicinity of the town. |
| 7 | 3 | Diss. Abstracts | An investigation of aviator problem-solving skills as they relate to amount of total flight time | | | Safety | 1997 | Thesis | The Ohio State University | Not Reviewed | 4 | Evaluates difference between aviator problem solving and aviator decision making as related to safety. |
| 7 | 4 | Diss. Abstracts | Aviation Safety: an analysis of various human factors and their effects upon the safety of US Aviation Systems | | | Safety | 1995 | Thesis | University of Louisville | Not Reviewed | 4 | Reduction of pilot error will provide best improvement in safety of flight according to thesis. |
| 7 | 5 | Diss. Abstracts | *The Legal and Institutional Aspects of* Communication, Navigation, Surveillance and Air Traffic Management Systems for Civil Aviation | | | Legal | 1995 | Thesis | McGill University (Canada) | Not Reviewed | 4 | Assesses the institutional and legal contributions of different services to civil aviation. |
| 7 | 6 | Diss. Abstracts | Quantitative Assessment of Human Performance in Cockpit-related systems | | | Human Factors | 1991 | Thesis | Wichita State University | Not Reviewed | 4 | Thesis determine the causes of human error and performance at a specific time. |
| 7 | 7 | Diss. Abstracts | Aviation Accidents, Incidents, and Violations: Psychological Predictors among US Pilots | | | Safety | 1992 | Thesis | Colombia University | Not Reviewed | 4 | Thesis investigates predictors of aviation accidents, incidents and violations among US pilots. |
| 7 | 8 | Diss. Abstracts | The FAA decision-making process of the NTSB recommendations | | | Safety | 1991 | Thesis | University of La Verne | Not Reviewed | 3 | Abstract establishes that there are some problems with the process wherein the FAA must respond to NTSB recommendations to improve safety. |
| 7 | 9 | Diss. Abstracts | An empirical investigation of certain organizational climate influences on flying safety | | | Safety | 1980 | Thesis | University of Arkansas | Not Reviewed | 4 | Investigated organizational influences on the safety of flight operations. |
| 8 | 1 | ERIC | *Definition of Alaskan Aviation* Training Requirements. Final Report. | | | Training | 1982 | Report | American Airlines Training Corporation | Not Reviewed | 4 | Developed a training program for airline pilots flying over Alaska. |
| 9 | 1 | Gen. Sci. Abstracts | How is visibility determined in weather reports or at the airport? | | X | Visibility | 1992 | Newspaper | New York Times 2 May 95 | Not Reviewed | 4 | Reader queried how visibility is determined in weather reports and at the airport. |
| 9 | 2 | Gen. Sci. Abstracts | Waves smash Antarctic airstrip | | | Remote | 1994 | Periodical | New Scientist, Vol 141, 26 Feb 94 | Not Reviewed | 4 | *Storm destroyed a controversial airstrip near the* French research base of Dumon d'Urville in Antarctica. Environmentalists don't like affect on bird population. |
| 9 | 3 | Gen. Sci. Abstracts | An Alaskan Land Grab? | | | Construction | 1994 | Periodical | Environment, Vol 36, p. 22 | Not Reviewed | 4 | Alaska given $600K to enlarge two airports inside Denali and Wrangell-St. Elias |
| 9 | 4 | Gen. Sci. Abstracts | Camera Keeps an Eye on Airport Vehicles | X | | CCTV | 1992 | Periodical | New Scientist, Vol 136, p. 21 | On Hand | 3 | Discusses the use of a video camera at an airport to monitor vehicles and use artificial intelligence to determine what type of vehicles they are and what they are doing. |
| 9 | 5 | Gen. Sci. Abstracts | Polar base planned to justify unnecessary airstrip | | | Remote | 1991 | Periodical | New Scientist, Vol 132, 30 Nov 91 | Not Reviewed | 4 | Not pertinent |
| 9 | 6 | Gen. Sci. Abstracts | Antarctica: airstrip plans on ice | | | Remote | 1990 | Periodical | Nature, Vol 346, p. 4 | Not Reviewed | 4 | Not pertinent |
| 9 | 7 | Gen. Sci. Abstracts | Britain plans new Antarctic airstrip | | | Remote | 1989 | Periodical | New Scientist, Vol 121, 21 Jan 89 | Not Reviewed | 4 | Not pertinent |

**Table 3.1 - Results of Literature Search - Page 4 of 8**

| DataB No. | Item No. | Database | Title | Run. Cond. | WX Cond. | Primary Area | Year | Type of Pub. | Publisher | Status | Pri | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 8 | Gen. Sci. Abstracts | Weather monitor promotes airport safety | | X | AWOS/ASOS | 1986 | Periodical | High Technology, Vol. 6, Oct 86 | On Hand | 3 | Early AWOS article establishing the potential for AWOS to provide up-to-date, real time weather information. |
| 10 | 1 | GPO Monthly Catalog | Snow depth monitor project implementation plan | X | | Remote Sensing | 1994 | Book | Federal Aviation Administration | Reviewed | 2 | Nothing to add to existing knowledge. |
| 10 | 4 | GPO Monthly Catalog | Runways at small airports are deteriorating because of deferred maintenance: action needed by FAA and the Congress | X | | Maintenance | 1982 | Report | General Accounting Office | On Hand | 3 | Makes the point that FAA funds were used to construct and improve runways at 1700 of the nation's smaller airports, but that local governments have not maintained them. Too much deferred maintenance. Primary problem is failure to fix pavement cracks. |
| 10 | 5 | GPO Monthly Catalog | Remoteness-compensation methodology for benefit/cost establishment and discontinuance criteria | | | Economics | 1977 | Book | Federal Aviation Administration | On Hand | 2 | Remote airports could not qualify for federal funds because of high construction costs. This compensated for remoteness to make them competetive. Also takes into account greater reliance of community on aviation when surface trans ins not available. Remoteness defind. Most remote sites in Alaska. |
| 10 | 6 | GPO Monthly Catalog | Aviation Safety: Federal Regulation of public aircraft:briefing report to the chairman, subcommittee on aviation. | | | Safety | 1986 | Book | General Accounting Office | Not Reviewed | 4 | Nothing to add to existing knowledge. |
| 10 | 7 | GPO Monthly Catalog | Aviation Weather Services | | X | | 1995 | Book | National Weather Service | Not Reviewed | 3 | Too broad |
| 10 | 8 | GPO Monthly Catalog | Airport Winter Safety and Operations | X | X | Safety | 1991 | Book | Federal Aviation Administration | Not Reviewed | 3 | Nothing to add to existing knowledge. |
| 10 | 9 | GPO Monthly Catalog | Aviation Weather Briefings:FAA should buy Direct User Access Terminal Systems, not develop them. | | X | Technology | 1986 | Book | General Accounting Office | Not Reviewed | 3 | Not pertinent |
| 11 | 1 | Papers First | Application of thermal imaging to remote airfield assessment | X | | Remote Sensing | 1997 | Proceedings | Proceedings SPIE the International Society for Optical Engineering Issue 3079 p. 819-830 | On Hand | 3 | Discusses the use of thermal imaging to assist in assessing remote airfields. |
| 11 | 2 | Papers First | Automating airfield condition data collection | X | | Remote Sensing | 1991 | Proceedings | ASCE: Airfield Pavement Committee Conference Sep 91 | On Hand | 4 | Use of photography (35 mm) to document pavement distress in runways over time. |
| 11 | 3 | Papers First | Coupling Terminal Weather Information to Next Generation Automation, Traffic Flow Management | | X | Technology | 1997 | Proceedings | American Meteorological Society 7th Conf Feb 97 | On Hand | 4 | Discusses affects on terminal weather providers of changes in the nature of U.S. terminal air traffic management. |
| 11 | 4 | Papers First | Automation of observations in the Netherlands | | X | Technology | 1993 | Proceedings | American Meteorological Society 5th Conf Aug 93 | Not Reviewed | 3 | Low priority |
| 11 | 5 | Papers First | AWOS Performance Evaluation: Data Analysis Methods | | X | AWOS/ASOS | 1998 | Proceedings | American Meteorological Society 14th Conference Jan 98 | Not Reviewed | 3 | Low priority |

Table 3.1 - Results of Literature Search - Page 5 of 8

| Details No. | Item No. | Database | Title | Run. Cond. | WX Cond. | Primary Area | Year | Type of Pub. | Publisher | Status | Pri | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 6 | Papers First | AWOS Performance Evaluation: Data Analysis Results | | X | AWOS/ASOS | 1998 | Proceedings | American Meteorological Society 14th Conference Jan 98 | Not Reviewed | 3 | Low priority |
| 11 | 7 | Papers First | Comparison of ASOS and Observer Ceiling-Height and Visibility Values | | X | AWOS/ASOS | 1998 | Proceedings | American Meteorological Society 14th Conference Jan 98 | On Hand | 2 | There are differences between observer and ASOS reports. Especially around important ceiling thresholds (IFR/MVFR 1000') etc. |
| 11 | 8 | Papers First | Performance of Production and Enhanced ASOS Precipitation Identification Sensors During the Winter 1996-1997 Testing | | X | AWOS/ASOS | 1998 | Proceedings | American Meteorological Society 14th Conference Jan 98 | Not Reviewed | 3 | Low priority |
| 11 | 9 | Papers First | Comparability of ASOS and Human Observations | | X | AWOS/ASOS | 1995 | Proceedings | American Meteorological Society 14th Conference Jan 98 | On Hand | 2 | Asks why human and ASOS are not more alike. Conclusion is that sensor location (human or automated) is the most critical factor in obtaining a representative observation. |
| 11 | 10 | Papers First | Automated Snow Accumulation Measurements for ASOS | | X | AWOS/ASOS | 1998 | Proceedings | American Meteorological Society 14th Conference Jan 98 | Not Reviewed | 3 | Nothing to add to existing knowledge. |
| 11 | 11 | Papers First | The Use of Video Cameras as a Supplement to ASOS and the Total Observation Concept | | X | CCTV | 1997 | Proceedings | American Meteorological Society 7th Conf. Feb 97 | On Hand | 1 | This is by far the most critical discovery of the literature search. Cameras are being used to supplement weather data for the NWS. |
| 11 | 12 | Papers First | *The Rhyme and Reason of* ASOS | | X | AWOS/ASOS | 1998 | Proceedings | American Meteorological Society 14th Conference Jan 98 | Not Reviewed | 3 | Nothing to add to existing knowledge. |
| 11 | 13 | Papers First | AWOS Performance Evaluation Data Analysis: Methods and Results | | X | AWOS/ASOS | 1997 | Proceedings | American Meteorological Society 1st Symposium Feb 97 | Not Reviewed | 3 | Nothing to add to existing knowledge. |
| 11 | 14 | Papers First | Early Results of Climate Data Continuity with ASOS | | X | AWOS/ASOS | 1995 | Proceedings | American Meteorological Society 10th Conference Jan 95 | Not Reviewed | 3 | Nothing to add to existing knowledge. |
| 11 | 15 | Papers First | ASOS: New Weather Sensors | | X | AWOS/ASOS | 1995 | Proceedings | American Meteorological Society 6th Conference Jan 95 | Not Reviewed | 3 | Nothing to add to existing knowledge. |
| 11 | 16 | Papers First | Status of ASOS Planned Product Improvements | | X | AWOS/ASOS | 1997 | Proceedings | American Meteorological Society 1st Symposium Feb 97 | On Hand | 3 | Planned improvements to ASOS includeice-free wind sensor, replacement dewpoint sensor, all-weather precip gauge, enhanced precip identification sensor. |
| 11 | 17 | Papers First | Eyes for ASOS | | X | AWOS/ASOS | 1996 | Proceedings | American Meteorological Society 15th Conference Aug 96 | On Hand | 2 | Talks about algorithms for interpreting photographic imagery of clouds and sky. |

**Table 3.1** - Results of Literature Search - Page 6 of 8

| DataB No. | Item No. | Database | Title | Run. Cond. | WX Cond. | Primary Area | Year | Type of Pub. | Publisher | Status | Pri | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 18 | Papers First | Operational U.S. Observing Systems for the Early 1990s | | X | AWOS/ASOS | 1995 | Proceedings | National Center for Atmospheric Research | On Hand | 2 | Four weather collection sources are discussed: NEXRAD, ASOS, ACARS, Next Generation Satellites. Good discuss on what ASOS cannot provide. |
| 11 | 19 | Papers First | Comparability between human and ASOS Ceiling/Visibility Observations | | X | AWOS/ASOS | 1995 | Proceedings | American Meteorological Society 6th Conf. 75th Annual Meeting Jan 95 | On Hand | 2 | Concludes primarily that ASOS and manual observations are different...but not necessarily better or worse. ASOS represents point values integrated over time whereas manual observation are instantaneous values integrated over a large volume |
| 12 | 1 | Proceedings First | None | | | N/A | N/A | N/A | N/A | N/A | 4 | No documents found |
| 13 | 1 | None - UAF Library | Notices to Airmen (NOTAMS) for Airport Operators | X | | NOTAM | 1993 | Advisory Circular | Federal Aviation Administration | On Hand | 1 | Excellent reference on NOTAM reporting procedures at airports. Definition of NOTAM. Glossary of terms. Responsibility of Airport Managers |
| 13 | 2 | None - UAF Library | Safer Skies - A Focused Agenda | | | Safety | 1998 | Article | FAA Aviation News | On Hand | 2 | Provides FAA Administrator Jane F. Garvey's plan for FAA support of safety. Primary areas for GA: Pilot Decisionmaking, loss of control, weather, CFIT, Survivability, runway incursions. For Comm. Avn. CFIT, Loss of Control, Uncontained Enginee Failures, Runway Incursion, Approach and landing, weather. |
| 13 | 3 | None - UAF Library | Maintenance of airport visual aid facilities | X | | Runways | 1982 | Advisory Circular | Federal Aviation Administration | On Hand | 4 | Discusses maintenance of airport lighting primarily. Lots of electrical info. Includes section on maintenance management which is probably closest to what I need. Primarily concerned with safety of airport operators when maintaining lighting systems. |
| 13 | 4 | None - UAF Library | Airport surface safety research:hearing before the | X | | Runways | | Report | National Technical Information Service | Not Reviewed | 4 | Not pertinent |
| 13 | 5 | None - UAF Library | Study of Alaskan Airports under Public Law 647 | X | | Runways | | Report | U.S. Department of Commerce | Not Reviewed | 4 | Not pertinent |
| 13 | 6 | None - FAA | Good Operating Techniques for off airport landing and takeoff sites | X | | Runways | 1998 | Article | FAA Aviation Safety Program Fairbanks FSDO | On Hand | 4 | Discusses details of off airport landings. If we put this much effort into normal landings we would be safer. |
| 14 | 1 | None - Personal | Tips on Flying in Canada | | | | 1998 | Article | Alaskan Flyer - Aug 98 | On Hand | 4 | Provides contact information for aviation safety and flight planning |
| 14 | 2 | None - Personal | AK Region restates ASOS Policy | | X | AWOS/ASOS | 1998 | Article | Alaskan Flyer - Apr/May 98 | On Hand | 1 | IFR and AWOS reports - FAA Policy indicating that FAA will not question a pilot's decision to land or takeoff or pursue enforcement action with respect to non-representative AWOS/ASOS weather reports. |
| 14 | 3 | None - Personal | Internet Sites for FAA Information | | | Internet | 1998 | Article | Alaskan Flyer - Jul 98 | On Hand | 2 | Interet Sites regarding aviation (FAA primarily) |
| 14 | 4 | None - Personal | Determining Clearance needs with ASOS | | X | AWOS/ASOS | 1997 | Article | Alaskan Flyer - Nov/Dec 97 | On Hand | 1 | Talks about frequency of AWOS broadcasts versus what the FSS has. You tell controller whether you need a clearance. |

**Table 3.1** - Results of Literature Search - Page 7 of 8

| DataB No. | Item No. | Database | Title | Run. Cond. | WX Cond. | Primary Area | Year | Type of Pub. | Publisher | Status | Pri | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 5 | None - Personal | ASOS and Contract Weather. Where are we? | | X | AWOS/ASOS | 1998 | Article | Alaskan Flyer - Dec 98 | On Hand | 1 | Current info on number of AWOS commissioned, planned etc. |
| 15 | 1 | None - Personal | SABRE Soars | | | | 1998 | Article | OR/MS Today - June 98 | On Hand | | Good quote - Academics need to spend more time in the real world getting dirty working on real problems with real data. |
| 16 | 1 | None - Personal | Swimming against the tide | | | Safety | 1998 | Article | FAA Aviation News - Oct 98 | On Hand | 2 | Maintenance related causal factors in aircraft accidents are way down. |
| 16 | 2 | None - Personal | Current versus Proficient | | | Safety | 1998 | Article | FAA Aviation News - Oct 98 | On Hand | 2 | Pilot most important component of any accident prevention strategy. Pilot must maintain high degree of proficiency in critical flight skills. List of Most frequent cause factors of GA Accidents |
| 17 | 1 | None - Personal | Arctic Airports Maintenance manual | X | | Maintenance | 1980 | Booklet | Government of the Northwest Terrirotires, Local Govt. Airports Division | On Hand | 2 | Excellent sourcebook on how to maintain a rural airstrip. Produced in Canada. No similar document that I am aware of in Alaska. |
| 17 | 2 | None - Personal | Cameras Tell Weather or not to land | | X | CCTV | 1998 | E-Mail Article | AvWeb | On Hand | 1 | Establishes a program in San Francisco to use video cameras to help detect fog to assist tower controllers with opening and closing runways in a timely fashion. |
| 17 | 3 | None - Personal | First Year Results and Next Steps for the NWS Video Camera Demonstration Project | | X | CCTV | 1999 | Paper | American Meteorological Society, 3rd Symposium on Integrated Observing Systems 10-15 Jan 99 | On Hand | 1 | Establish the NWS use of video cameras to assist with weather observations |
| 17 | 4 | None - Personal | Present Weather Camera Project | | X | CCTV | 1997 | Technical Report | The Meteorological Office Observations | On Hand | 1 | Report by U.K. Meteorological Office on use of CCTV to assist with weather observations and forecasting. |

Table 3.1 - Results of Literature Search - Page 8 of 8

# CHAPTER 4

# System Analysis and Results

This chapter invokes a systems approach in solving the problem of poor runway and weather condition reporting in Interior Alaska. Section 4.1 provides an overview of the systems approach. Section 4.2 provides a definition of the system including a detailed system diagram. Section 4.3 is the formal analysis of the system. Section 4.4 provides the results of the analysis. Chapter 5 follows with a specific aspect of system analysis, that of stakeholder management.

## *4.1 - Systems Approach*

The systems approach is a methodology for both framing and solving a complex problem. It seeks to establish root causes as opposed to simply addressing the symptoms of a problem. The approach requires that the probiem-solver look at the dilemma from all angles and consider all perspectives. In this fashion, no key issue goes without consideration.

This approach requires that one model the system in terms of separate components, each of which is interconnected with other components through procedures or processes. The interdependencies between components serve to assist the problem-solver in considering every primary entity in the problem. While all the interdependencies cannot be modeled perfectly, they can certainly assist in forecasting how the total system may behave as inputs are varied. Given a desired output, the system can be used to modify inputs, or to suggest additions or deletions to the system that may improve efficiency, or help meet the desired objective.

The systems approach provides not only a framework for looking at, but also for solving a problem. Solutions may incorporate the use of decision support systems such as operations research, benefit/cost analysis, hierarchical decision-making, multi-attribute utility analysis and methods for comparing alternatives. The problem solver seeks to use the tools at his disposal to best execute a solution.

We will use a modified systems approach to define the existing reporting system and analyze it. Later we will integrate those results with other aspects of the research conducted thus far.

## *4.2 - System Definition*

We begin by defining the reporting system currently in use. The first section describes a basic system model and the following section provides an expanded, detailed diagram.

### 4.2.1 - Basic Model

Figure 4.1 shows a very basic system model that captures the elements that we are concerned about in this study. A brief explanation of this model is necessary prior to presenting the detailed system diagram. Our system is shown in the green box labeled "Aviation Reporting System". Its purpose is to provide current, accurate information to the aviation community about the physical condition and prevailing weather at rural airstrips in the Interior of Alaska. There are two inputs to the system: the actual weather and the actual condition of the runway. The system must collect that data, transmit it, interpret it and disseminate it to the end-user. The outputs of the system are also two-fold: weather condition information and runway condition information. These two outputs are the focus of our study. Our system boundary will be drawn specifically to limit our focus on this reporting system. However, it is important to note that the outputs of our system serve as inputs to the aviation community as depicted by the yellow box.

The aviation community could be considered a system in and of itself with various other inputs such as pilots, airplanes, regulations, fuel, and passengers. Similarly there are many outputs to that system which we have not delineated. We anticipate however, that the outputs of our system will be received, evaluated and processed by the aviation community to assist them in flight planning and execution. Ultimately, therefore we anticipate that this information will contribute to improving safety, service and efficiency. These are explained below:

1. Improve Safety - This means reducing the number of aviation accidents. Better runway and weather information will serve to alert pilots to conditions that add risk to flights. This information ultimately translates into a reduction in the number of accidents. The link between the runway condition, weather conditions and the occurrence of accidents was made in Chapter 2.

2. Improve Service - The consumer of aviation services is the focus of improved service. The timely, effective movement of passengers, mail and cargo constitutes better service. Better runway and weather information allows aviation companies to make more informed decisions about flight departure times, en route flight times and deviations. The benefits of this better information are passed on to consumers.

3. Improve Efficiency - Efficiency focuses on internal aviation operations. It is a measure of the aviation community's ability to perform transportation services at a lower operating cost thereby enhancing the livelihood of the company providing the service.

While there is sound reason to expect that these three societal benefits will accrue through better reporting, these benefits are not the focus of this study. We are concerned specifically with improving those aspects of runway and weather condition reporting which we have determined to be substandard.

Modernization of remote aviation support systems could be an objective in itself. Improved runway and weather condition reporting systems contribute a certain status and level of technology to the airstrips and villages which they serve. This in turn may have a decided positive affect on commerce, population and transportation at these remote areas in future years. While we will not establish modernization as an objective, we do recognize it as an ancillary benefit.

### 4.2.2 - Detailed Diagram

The detailed system diagram is presented in Figure 4.2. This diagram expands on the basic model in several ways: it designates entities that affect the inputs, it deletes emphasis on the downstream affects of the system outputs, and it enhances the details of the system proper. A brief orientation to the diagram is provided here, followed by the detailed analysis in section 4.3.

Factors Affecting Inputs: Factors that affect the inputs to the system are shown at the far left of the diagram. These factors are not shown in the basic model. The only factor affecting actual weather is Acts of God. Factors affecting actual runway condition include runway properties, factors causing poor runway conditions, and factors correcting poor runway conditions. These are explained in detail in the system analysis.

System Inputs: The two inputs are shown to the left of the system boundary as the actual weather and actual runway condition. These are the same inputs described in Figure 4.1.

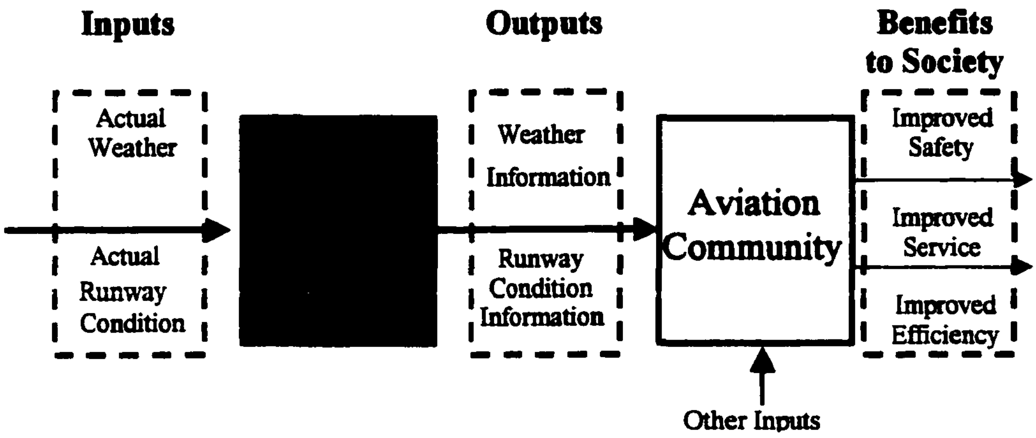



**Figure 4.1 - System Inputs and Outputs with Societal Benefits**

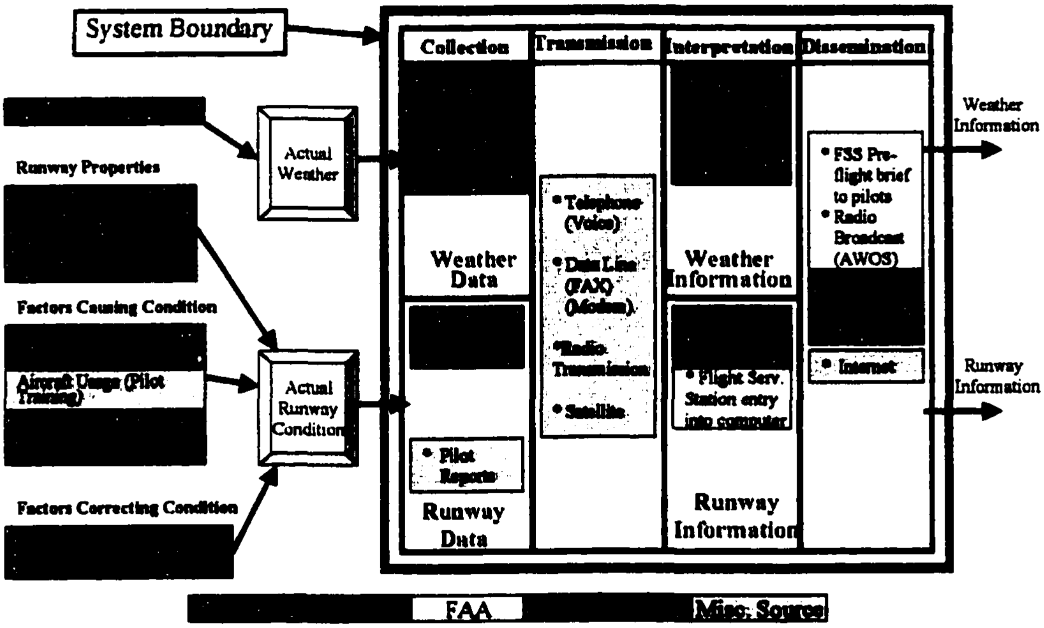



**Figure 4.2 - Detailed System Diagram**

System Proper: The system boundary, in blue, encompasses the system proper. The top half of the system proper relates specifically to the weather reporting system. The bottom half of the diagram relates to the runway reporting system. The system proper is composed of four modules: collection, transmission, interpretation and dissemination. Collection is the act of gathering data on current conditions. Transmission relates to the movement of that data to a processing location. Interpretation is the act of translating data into useful information. Dissemination is the act of providing the information to the end-user.

System Outputs: The two outputs are shown on the right side as weather information and runway information. These are the same outputs presented in Figure 4.1.

Stakeholders: The color coding at the bottom depicts the agency or entity responsible for the specific component shown in the diagram. The five entities are the National Weather Service (NWS), the Alaska Department of Transportation and Public Facilities (AKDOT), the Federal Aviation Administration (FAA), Acts of God (natural acts) and miscellaneous sources. The latter includes primarily telecommunications companies and pilots.

## *4.3 - System Analysis*

Since our goal is to improve the quality of the outputs (weather and runway information), we want to investigate any alternative that results in improved information. Since we have already established certain weaknesses and needs within the reporting system, we will focus our analysis of runway condition reporting primarily on determining the status of snow plowing operations at a distant airport. We will focus our analysis of weather condition reporting on improving our ability to report visibility and ceiling information at distant airports. While these will be our focus, we will also consider ancillary issues that could improve the quality of other reportable information. We analyze factors that affect the inputs, the inputs themselves, the components of the system, and component interdependencies.

### 4.3.1 - Analysis of Factors that Affect the Inputs

It is important to note that factors that affect the system inputs may be important in reducing the system load. For example, rutting of the runway is a reportable condition. However, if the factors that cause rutting can be mitigated, then rutting is reduced and the need for reporting of that condition is reduced. Prevention or correction of a poor condition is better than accurate reporting of a bad condition. For this reason we will examine both factors that affect the inputs and the inputs themselves.

#### *4.3.1.1 - Weather Related Factors*

For all practical purposes, we have no way of controlling the weather. The factors influencing weather are simply deemed Acts of God and are considered to be uncontrollable through any direct means. We conclude that the actual weather occurring at an airport is an unalterable aspect of the problem.

Ways to Improve: None
Potential for Improvement: None

#### *4.3.1.2 - Runway Related Factors:*

Chapter 1 established that the primary maintenance requirement related to air traffic at rural airports was that of dealing with mitigating the effects of snow on the runway. This is important when considering factors that influence the state of the runway. Three groups of factors are identified and shown in Figure 4.2: runway properties; factors causing poor runway conditions; and factors correcting poor runway conditions. Each is described below.

*Runway Properties* - These factors include all physical aspects of the runway. Changes to these properties are generally measures that provide passive control of the runway condition. Important factors are discussed below.

- Location - The physical location of an airstrip will have an impact on runway condition. Each airport by definition supports an existing community or village. From that perspective, location options are limited and selection should be based on microclimate and geography peculiar to the village. The most important consideration in location is the potential for flooding from runoff, rivers or bodies of water. Moving an airstrip is an expensive proposition which relegates improvements in this area only to villages where conditions require that new airstrips be built or relocated. Allakaket, Alaska is located on the Koyukuk River. The old airstrip in Allakaket had a very high flood potential each spring. One end of the runway was often submerged as the river expanded its banks during spring breakup effectively shortening the usable length of the runway. AKDOT funded and executed a project to construct a new village airstrip at a higher elevation over a mile from the river. Many airstrips in the Interior are now located where the flood potential is very low.

Responsibility: AKDOT

Cost to Relocate: HIGH

Ways to Improve: Locate new runways or relocate existing runways out of flood zones.

Potential for Improvement: LOW - While the physical location of a runway is important, the flooding issue is being adequately addressed by AKDOT. Relocating a runway is a measure which only passively addresses runway condition issues, and which does not address the issue of snow removal at all.

- Orientation - Several factors govern how a runway should be oriented during construction. Normally airstrips in the Interior are oriented parallel to the prevailing winds to minimize crosswind landings that are more hazardous. An orientation perpendicular to the prevailing wind could produce worse snow drifting onto the runway. Although the degree of drifting on a runway is affected by orientation, this issue is already being addressed through the design of runways when they are initially constructed. Reorienting a runway is a measure that only passively addresses runway condition. The potential for improving runway condition through reorientation of the runway is low.

  Responsibility. AKDOT

  Cost to Reorient: HIGH

  Ways to Improve: Orient new runways or reorient existing runways in line with prevailing winds

  Potential for Improvement: LOW

- Surface Selection - Most rural airstrips have a gravel surface. Hard surface runways, besides being much more expensive to construct, are also more expensive to maintain once cracks and potholes begin to surface. Many runways in the lower 48 contiguous states suffer from poor long-term maintenance that results in unsafe surfaces [20]. The difficulties with asphalt surfaces are exacerbated in cold climates where frost heave, freeze-thaw cracking and continual subjection to heavy equipment may require expensive repairs. Rutting, potholes and uneven surfaces on a gravel strip are relatively easy to repair with a road grader or bulldozer. No substantive improvements in runway conditions would accrue from the use of a hard surface, as it relates to the problem of snow. Summertime condition of the runways would be initially better, but would rapidly deteriorate causing worse conditions than gravel surfaces.

  Responsibility: AKDOT

  Cost for Hard Surface Construction and Maintenance: HIGH

  Ways to Improve: Construct new runways or modify existing runways with asphalt surfaces.

Potential for Improvement: LOW

- Landscaping - Some long-term runway problems could be avoided through smart landscape planning. In some cases, the environment around the airstrip has been seeded from the air. This practice sometimes results in accidental seeding of the runway proper which has long term implications for vegetation growth and control on the runway. Landscaping however has no real potential for affecting or changing snow related runway conditions.

  Responsibility: AKDOT
  Cost to Landscape: MED
  Ways to Improve: Modify seeding practices to preclude seeding of runways
  Potential for Improvement: LOW

*Factors Causing Poor Runway Conditions* - These factors contribute directly to detrimental runway conditions that must be reported through the NOTAM system. If these factors could be completely controlled then the need for runway reporting would be negated. Thus it is critically important to analyze the potential for developing and enforcing controls in these areas.

- Climate - Climate is a function of airport location in Interior Alaska and is also produced by Acts of God. Climatic factors of particular importance are extreme cold and snow that are present every year in the Interior. These factors cannot be controlled.

  Responsibility: Acts of God
  Cost: N/A
  Ways to Improve: None
  Potential for Control/Improvement: None

- Near-Term Weather - Near-term weather includes the actual weather conditions that prevail during any particular time of year at the specified airport. Precipitation, either in the form of rain or snow, is the greatest single contributor to poor runway condition. A soft gravel runway produced by heavy rains is subject to quick deterioration. Use of the runway then causes potholes, ruts and other surface abnormalities that can be dangerous to aircraft. During the winter, snowfall on the surface can make the airstrip absolutely unusable to aircraft with wheels. Thus, the air carriers are completely dependent upon airport contractors to remove snow from the surface. While the weather conditions themselves cannot be controlled, the reporting of these conditions may contribute to providing information about anticipated runway conditions. For example, if it is reported that heavy snow is falling in the Tanana Valley, there is an expectation that the runway at Tanana may be covered with snow and thus unavailable for landing for a period of time. Again, however, there is no potential for controlling the near-term weather so as to reduce the affects of weather on the runway proper.

Responsibility: Acts of God
Cost: N/A
Ways to Improve: None
Potential for Control/Improvement: None

- Aircraft Usage - The surface of the runway is affected by the aircraft that use it. They takeoff, land, taxi and turn on the surface. The use of the runway by aircraft is expected. Pilots have a vested interest in conducting smooth aircraft operations on the runway surface. This reduces wear and tear on the aircraft and provides for safe aircraft operation. Thus, pilots are rarely to blame for conducting operations in a way that contributes to poor runway conditions. The worst affect produced by aircraft on the surface of the runway is rutting. This normally occurs during spring breakup when the snowpack on the surface of the runway melts and makes the surface very soft. Normal runway usage by aircraft on a soft gravel runway can produce permanent rutting of the surface that can only be corrected with heavy equipment. The primary preventive measure to reduce this type of rutting is to conduct a thorough plowing of the runway down to the gravel surface when temperatures begin to rise above freezing in the spring. This is investigated more thoroughly in another section below.

Responsibility: Pilots
Cost: LOW
Ways to Reduce/Prevent Condition: No practical means. Rutting is fair, wear and tear in the rural airport setting.
Potential for Improvement: LOW

- Other Vehicles - The local village populous often inappropriately uses rural airports for recreation. During the summer, the airstrip makes a tempting race track for vehicles of all types (motorcycles, four-wheelers and automobiles). During the winter it provides open space for snow machining. While snow machines don't cause significant damage to a snow-covered surface, motorized vehicles can cause rutting and gradual deterioration of the surface in the summer. AKDOT puts runways off limits for recreation, both to prevent runway damage and to reduce the risk of runway incursions between villagers and aircraft operating on the runway. The primary preventative measure is to enforce the prohibition of runway abuse by motorized vehicles. The AKDOT and local village authorities must take the lead in this enforcement.

Responsibility: AKDOT, Local Village Authorities
Cost: LOW
Ways to Reduce/Prevent Condition: AKDOT and local village authorities must enforce prohibitions against using the runway for recreation.
Potential for Improvement: LOW

- Maintenance Practices - Maintenance contractors normally have heavy equipment at their disposal that is used to plow snow. AKDOT policy is to keep approximately two inches of hard packed snow on the runway during the winter. This prevents inexperienced maintenance contractors from damaging the gravel surface. It also provides an acceptable runway surface for use by aircraft operating on skis. AKDOT believes that many of their maintenance contractors are not experienced enough with heavy equipment to maintain or correct damage to the gravel surface. However, the primary preventive measure to reduce rutting is to remove the two-inch layer of snow in the spring that reduces the amount of water on the surface as temperatures rise. Therefore, in order to conduct a precise plowing operation in the spring either the maintenance contractor must be given additional training, or AKDOT must establish a plan to send an experienced heavy equipment operator to each runway in the spring. This latter idea is prohibitively expensive and logistically difficult. However, additional training for the contractors is a reasonable initiative.

  Responsibility: AKDOT
  Cost: MED
  Ways to Reduce/Prevent Condition:
  - Train operators to conduct precise grading operations to remove the snow pack in the spring.
  - Train operators on the use of heavy equipment to increase AKDOT confidence in their ability allowing them to remove prohibitions against use of heavy equipment on the gravel runway surface.
  - Increase on-site supervision of problem villages during spring breakup

  Potential for Improvement: HIGH

*Factors Correcting Poor Runway Conditions* - These factors represent active measures that can be taken to correct poor runway conditions when they occur. These are clearly the most important factors in terms of removing the need for runway condition reporting through the NOTAM system. A survey of maintenance contractors was performed by the author in the summer of 1998 and is provided at Appendix A. Statements made below are drawn in part from the results of this survey.

- Equipment (Type and Maintenance) - Village contractors obtain heavy equipment from one of three sources: AKDOT provides it; the contractor owns it; or the village owns it. In order to do a precise job plowing snow, or correcting runway surface problems, the contractor needs a road grader. Some of the airports in Interior Alaska do not have a road grader and are thereby immediately disadvantaged in their ability to properly maintain the runway. Operator training on the maintenance of equipment varies greatly among the villages. Some operators have had formal equipment maintenance training, and some have had none at all. This disparity constitutes immediate concern over the longevity of the equipment, and the potential for equipment failures at critical times during the snow season. AKDOT should ensure that all airports are equipped with a road grader as one of the primary pieces of snow plowing equipment. They should also provide training to operators on the maintenance of the equipment for which they are responsible. Finally, AKDOT should embark on a formal program to supervise and document preventive maintenance of heavy equipment in the villages.

  Responsibility: AKDOT
  Cost: MED
  Ways to Reduce/Prevent Condition:
  - Train village contractors on how to perform standard equipment maintenance
  - Provide a road grader to every village contractor
  - Check maintenance of equipment regularly and supervise preventive maintenance operations

  Potential for Improvement: HIGH

- Operator - Chapter 1 explored the difficulties in recruiting and hiring experienced heavy equipment operators in the villages. There are two primary concerns in this area. First of all, the operator must be skilled in the plowing snow. Secondly, he must be responsible enough to plow the runway when need requires it. Both of these concerns are legitimate in Interior Alaska. Many operators have had little to no formal training in the use of heavy equipment. It is not uncommon for AKDOT to hire a maintenance contractor, then send an experienced operator to work with him for a small part of day to train him to plow snow. This happenstance training program often results in poorly plowed runways, damaged heavy equipment, and damaged airport equipment (lights, buildings etc.). AKDOT should have an organized, scheduled and funded program for ensuring that all their operators receive a basic level of training. The second issue, that of contractor loyalty is just as important. If the operator is trained but unwilling to exert the effort to do his job responsibly, the poor runway condition is not

| Responsible Party / Factors that influence inputs | ACTS OF GOD | AKDOT | | | | FAA | | NWS | PILOTS | | TELCOM COMP. | VILLAGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Airport Design Section | Rural Airport Contractors | Regional Airport Manager | State Maint. | Airways & Facilities | FSS | | Air Carriers | General Aviation | | |
| **Weather Related** | None | | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Runway Related** | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Runway Properites | | | | | | | | | | | | |
| *Location* | | ■ | | | | | | | | | | |
| *Orientation* | | ■ | | | | | | | | | | |
| *Surface Selection* | | ■ | | | | | | | | | | |
| *Location* | | ■ | | | | | | | | | | |
| | | | | | | | | | | | | |
| Factors Creating Poor Runway Condition | | | | | | | | | | | | |
| *Climate* | None | | | | | | | | | | | |
| *Current Weather* | None | | | | | | | | | | | |
| *Aircraft Usage* | | | | | | | | | ■ | ■ | | |
| *Other Vehicles* | | | | ■ | | | | | | | | ■ |
| *Maintenance Practices* | | | | ■ | | | | | | | | ■ |
| | | | | | | | | | | | | |
| Factors Correcting Poor Runway Condition | | | | | | | | | | | | |
| *Equipment Type* | | | | ■ | ■ | | | | | | | |
| *Equipment Maintenance* | | | ■ | ■ | | | | | | | | |
| *Operator (Contractor)* | | | ■ | ■ | | | | | | | | |
| *Contractor Oversight* | | | | ■ | | | | | | | | |
| | | | | | | | | | | | | |
| **Collection of Information** | | | | | | | | | | | | |
| **Runway Related (NOTAMS)** | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Human Observation (Paid) | | | ■ | ■ | | | | | | | | |
| PIREPs | | | | | | | | | Medium | Medium | | |
| | | | | | | | | | | | | |
| **Weather Related** | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| AWOS | | | | | | ■ | | | | | | |
| ASOS | | | | | | ■ | | ■ | | | | |
| PIREPs | | | | | | | Medium | | Medium | Medium | | |
| Human Observation | | | | | | | ■ | ■ | | | | |
| Satellite | | | | | | | | ■ | | | | |
| NEXRAD | | | | | | ■ | ■ | | | | | |

**Table 4.1** - Potential for Improvement to Reporting System - Page 1

| Responsible Party / Factors that influence inputs | ACTS OF GOD | AKDOT: Airport Design Section | AKDOT: Rural Airport Contractors | AKDOT: Regional Airport Manager | AKDOT: State Maint. | FAA: Airways & Facilities | FAA: FSS | NWS | PILOTS: Air Carriers | PILOTS: General Aviation | TELCOM COMP. | VILLAGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Transmission of Information** | | | | | | | | | | | | |
| **Runway Related (NOTAMS)** | | | | | | | | | | | | |
| Telephone (Voice) | | | | | | | | | | | Medium | |
| Telephone (Data) | | | | | | | | | | | Medium | |
| Radio Broadcast | | | | | | ■ | | ■ | | | | |
| Satellite uplink or downlink | | | | | | | | | | | ■ | |
| **Interpretation of Information** | | | | | | | | | | | | |
| **Runway Related (NOTAMS)** | | | | | | | | | | | | |
| Human (NOTAM Verification) | | | | Medium | | | Medium | | | | | |
| Human (NOTAM Entry into Computer) | | | | | | | None | | | | | |
| **Weather Related** | | | | | | | | | | | | |
| Computational Models | | | | | | | | ■ | | | | |
| Human (Satellite Photos) | | | | | | | ■ | ■ | | | | |
| Human (Observations) | | | | | | | | ■ | | | | |
| Human (NEXRAD) | | | | | | | ■ | ■ | | | | |
| **Dissemination of Information** | | | | | | | | | | | | |
| **Runway Related (NOTAMS)** | | | | | | | | | | | | |
| Flight Service Station | | | | | | | ■ | | ■ | ■ | | |
| Internet Resources | | | | | | | | | Medium | Medium | | |
| **Weather Related** | | | | | | | | | | | | |
| Flight Service Station | | | | | | | ■ | | | | | |
| Transcribed Weather Broadcast | | | | | | | None | | | | | |
| Internet Resources | | | | | | Medium | | Medium | | | | |

**Table 4.1** - Potential for Improvement to Reporting System - Page 2

resolved quickly and aircraft will either be delayed or subjected to higher risk when landing. The primary method of resolution is increasing the level of supervision over contractors in the villages and being willing to exercise discipline over those contractors who refuse to comply with the basic requirements of their contract.

Responsibility: AKDOT
Cost: MED
Ways to Correct Condition:

- Train village contractors on how to operate heavy equipment
- Supervise contractors in the performance of their duties
- Discipline contractors who do not meet the contract requirements

Potential for Improvement: HIGH

This completes the analysis of the factors that affect the inputs to our system. The results are tabulated in Table 4.1.

## 4.3.2 - Analysis of System Inputs

Based on the analysis of factors that affect our inputs, we now provide summary statements regarding the two inputs to our system: actual weather and actual runway conditions.

Actual Weather - We conclude that the actual weather present at any point in time on a rural village airstrip in Interior Alaska cannot be practically affected by any manmade intervention. Figure 4.2 then reveals that the only alternative is to efficiently translate actual weather conditions into weather information through use of the system proper.

Actual Runway Conditions - We conclude that the runway condition is affected by three things as detailed below:

1. Runway Properties - The orientation, location, surface selection and landscaping of runways in the Interior may play a passive and minimal role in preventing poor runway conditions.

2. Factors Causing Poor Conditions - Climate and near-term weather cannot be controlled, thus weather conditions that affect the runway will be present. The affect of vehicles on the runway is difficult

to control. The maintenance practices of the village contractors may contribute to poor conditions. These may be mitigated through training and supervision.

3. Factors Correcting Poor Conditions - The type of equipment used on Interior runways as well as the skill and dedication of maintenance contractors is critical to correcting poor runway conditions. The primary requirement for improvement in these areas is increasing both training and supervision of maintenance contractors.

Prevention or correction of poor runway conditions can reduce or remove the need for runway condition reporting. This effectively reduces the risk to pilots and the load on all of the system components involved in the runway condition reporting process. This is shown in Table 4.2. If runway condition is good, then risk to pilots is low weather or not the reporting system works properly. If runway condition is poor, and reporting is good, there is still increased risk because pilots may still opt to use the runway. If runway condition is poor, and the reporting system is poor, then risk is high because users of the runway may be uninformed as to the dangers incumbent to use of the airstrip. To the extent we can mitigate the poor condition, we can both reduce the load on the reporting system and provide a safer environment for aircraft operations.

## 4.3.3 - Analysis of System Components

Having analyzed the inputs and the factors affecting the inputs, we now turn to an analysis of the system proper. The author performed a survey of commercial pilots in the summer of 1998 and the results are provided at Appendix B. Some of the statements made below are drawn in part from the results of this survey.

### *4.3.3.1 - Analysis of Components of Collection*

Collection components consist of those entities that gather current weather or runway condition data. These entities may be automated or manual, the latter being conducted by a human observer. In some cases, the human observer may use technical instruments to collect the data.

Weather Collection Components

*ASOS/AWOS* - These automated collection systems are modular in construction. They are the primary automated means for collecting site specific information to include ceiling and visibility measurements. However, acceptance of these systems has been somewhat slow. The excerpt below from the NTSB 1995 Alaska Safety Study explains the difficulty:

> "Some operators and pilots who were interviewed expressed appreciation for the coming expansion of the weather observing network. Others expressed dissatisfactions with the systems' reliability. Another complaint expressed by users about automated surface weather observing systems was the absence of remarks concerning the surrounding weather in these systems' reports submitted to the weather observing network. VFR pilots are concerned about weather along the route of flight, and the remarks of distant weather (beyond the airport boundaries) from the surface weather observations taken by human observers are very useful in filling in the "big picture." Pilots consider information such as cumulonimbus clouds, fog banks, mountain obscuration, lenticular and rotor clouds, and other distant weather phenomena crucial in making sound decisions on whether to initiate or to continue flights under VFR conditions [36]."

There are over 90 AWOS/ASOS planned for Alaska [35]. While the accurate collection of some very objective weather data is accomplished well by these systems, it is clear that there is much room for improvement in the areas of visibility, ceiling and the reporting of distant weather phenomena. A modular addition to these existing automated systems that could complement the weaknesses in these areas would greatly improve existing collection resources.

Responsibility: NWS and FAA

Cost: Unknown

Ways to Improve Collection:

- Develop a means for corroborating existing ASOS ceiling and visibility measurements
- Develop a means for providing information about distant weather phenomena

Potential for Improvement: HIGH

*Pilot Reports* - The pilot reporting system (PIREP) requires that pilots report observed weather while en route or at a distant location to a local FSS via radio or telephone. The system is completely voluntary and as such lacks the regularity of automated systems. The following information is provided in a PIREP: route or current location; time; altitude; aircraft type; sky conditions; flight visibility and weather; temperature; wind; turbulence; icing and other remarks. While this collection means has the potential to provide current, accurate observations by human observers, it lacks regularity and participation. The PIREP program is currently under scrutiny to improve its execution. Recommendations include amending the report format, updating the PIREP data system at the FSS, ensuring that FSS personnel put all PIREPs into the computer system, and educating pilots on providing better reports [21]. The primary weakness of the program is that collection is irregular. General aviation pilots, who tend to fly primarily during the summer months in Alaska, provide little participation in the PIREP program during the winter. Commercial pilots fly to airstrips throughout Interior Alaska five or six days a week. Thus, there is little coverage on Sunday. The location of the report is also somewhat random as it depends completely on the route being flown by the pilot conducting the report. Suffice it to say that someone must be the first one to collect the information and report it as a PIREP. If weather conditions are extremely poor, then nobody may venture into the area where whether information is most needed, and the PIREP may never be generated.

Responsibility: FAA

Cost: LOW

Ways to Improve Collection:

- Educate Pilots
- Modify PIREP reporting format
- Encourage FSS to enter all PIREPs into system
- Update the PIREP data system at the FSS

Potential for Improvement: MED

*Satellite* - Every airport in Interior Alaska has satellite coverage. However, the information that can be gleaned from satellite data is limited and falls short of filling in the gaps in ceiling and visibility information. Satellite data provides a view from above a weather system. However, it provides no information about conditions underneath existing cloud layers. It cannot provide site-specific information about ceiling and visibility. The collection of weather information through satellites is very limited for short-term forecasting or observation. Anticipated improvements for the future include measurement of winds, temperature, humidity and precipitation from space [42]. However, there is much testing and validation yet to be accomplished before these systems are available for aviation weather purposes. The enhancement and modification of the existing satellite network to accomplish these additional collection tasks will require significant resources.

Responsibility: NWS Related Agencies

Cost: HIGH

Ways to Improve Collection: Technical enhancements to enable collection of quantitative measures in the atmosphere

Potential for Improvement: LOW

*Human Observations:* Human observations are the oldest and most trusted form of weather collection components available. Humans add a level of subjective perception that is very difficult to match with automated means. However, fiscal constraints have encouraged a strong move away from the use of human observers. As a result there is no practical expectation that the use of human observers should be pursued as a widespread collection means for the future. It is important to note that the Alaskan aviation community believes that the human observer is the preferred collection means because of the believability of his reports and the institutional knowledge of weather systems available through a human who has experience in the geographical area. For this reason alone, it would be helpful if any improvements to existing collection means included the "human touch" in the process of visualizing the weather.

Responsibility: NWS, FAA, Independent Weather Contractors
Cost: HIGH
Ways to Improve Collection: Retain human observers. Based on the fiscal climate, this is deemed infeasible.
Potential for Improvement: LOW

*NEXRAD* - Doppler weather radar currently available at the FSS in Fairbanks is good for a range of approximately 125 miles. It is a tool that assists briefers in determining the presence and severity of precipitation in the covered area. Currently, there are only a few briefers at the Fairbanks FSS which are certified in the use of NEXRAD. Additionally, the FSS does not yet have overlays to establish geographic references for the NEXRAD readout. While it can provide good information on the presence of severe weather, it is not useful in determining cloud ceiling or visibility for individual sites. It is also very weak in identifying snow events. NEXRAD is used primarily for determining severe weather hazards such as thunderstorms, and tornadoes.

Responsibility: NWS, FAA
Cost: MED (System Maintenance)
Ways to Improve Collection: None. The system works well within the boundary of its own limitations
Potential for Improvement: LOW

Runway Collection Components

*Human Observation* - The primary means of collecting current runway condition information at rural airports is through the maintenance contractor employed by AKDOT. Chapter 1 delineated the specific responsibilities of the maintenance contractors regarding NOTAM reporting. Human collection of this information has the potential to be the most reliable collection means available. The difficulty at present concerns whether contractors have sufficient knowledge to know what constitutes a reportable condition, as well as having the loyalty to ensure that poor conditions are reported promptly. Three factors can affect a positive change in current reporting difficulties: training, supervision and discipline. Referring to Appendix A, it is noted that there are inconsistencies and misunderstandings among maintenance contractors as to what constitutes a reportable condition. This is a training issue that AKDOT can affect. Improving the level of supervision and willingness to discipline contractors is the other correctional issue which could improve the reliability of reporting. Again, we see the need for hiring and maintaining high quality maintenance contractors at the rural airports.

Responsibility: AKDOT
Cost: LOW
Ways to Improve Collection: Improve training, supervision and discipline of maintenance contractors
Potential for Improvement: HIGH

*Pilot Reports* - Pilots and users of the Interior Alaska airport system are at liberty to call and report poor rural airport conditions. However, these reports must be verified by AKDOT before they can be formally entered into the NOTAM system. This verification process may be easily interrupted if the AKDOT regional airport manager is not available. This is discussed more directly under the section on Interpretation. The collection of airport information by pilots could be improved if pilots were educated about the method of reporting problems.

Responsibility: FAA, AKDOT
Cost: LOW
Ways to Improve Collection: Educate pilots regarding the method of reporting poor runway conditions.
Potential for Improvement: MED

#### *4.3.3.2 - Analysis of Components of Transmission*

Transmission components consist of those means by which data is moved from the rural or remote location to a central location where it can be processed and interpreted. Only electronic means are considered as they alone have the ability to move information over long distances in a short time. These include telephone (voice), telephone (data), radio transmissions and satellite.

The means for transmitting weather and runway data are identical. Each of the collection means is restated below with an explanation of the transmission links used to move data from the collection source to the hub where it is interpreted. This data is tabulated in Table 4.3.

AWOS/ASOS - Automated data collection is conducted at the AWOS/ASOS. This information is broadcast on radio frequencies for use by pilots operating in the area. The information is also sent automatically via a data telecommunications line back to the NWS and the FSS for their use. Users may use a voice line to call the AWOS/ASOS facility directly and hear a recording with current conditions.

Pilot Reports - PIREPs are generally transmitted from the airplane directly to the FSS on aviation radio frequencies. These reports are then processed by FSS personnel and entered into a computer system for retrieval at a later time. PIREPs may also be called in to the FSS using normal voice telephone lines.

Satellite - Satellite data is transmitted from the satellite to ground stations where the information may be sent by data line to end-users.

Human Observations - Data collected by weather observers is normally transmitted by data telecommunications line to central locations where the data is processed, archived and sent back out to the NWS and the FSS by data line. Weather observers also transmit current weather information to pilots using radio. Some observations are passed by voice line to a central processing location. Maintenance contractors use voice telephone means to transmit their NOTAMs to the FSS or to the regional airport manager at AKDOT.

NEXRAD - These systems are normally collocated with the using agency. Data from the radar is presented on graphic terminals in the NWS or the FSS.

Each of the transmission means is discussed below with an end to establishing their potential for improving the weather and runway condition reporting system.

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">EFFICIENCY OF REPORTING SYSTEM</td></tr>
<tr><td>GOOD</td><td>POOR</td></tr>
<tr><td rowspan="4">RUNWAY CONDITION</td><td rowspan="2">GOOD</td><td colspan="2">Low Risk (1)</td></tr>
<tr><td colspan="2">Low Load (4)</td></tr>
<tr><td rowspan="2">POOR</td><td>Medium Risk (2)</td><td>High Risk (3)</td></tr>
<tr><td colspan="2">High Load (5)</td></tr>
<tr><td colspan="4">Notes<br>(1) Risk to pilots is low because runway condition is good<br>(2) Risk to pilots is medium even though they are aware of poor conditions because of runway danger<br>(3) Risk to pilots is high because runway condition is poor and they do not know it.<br>(4) Load on reporting system is low because there is nothing to report<br>(5) Load on reporting system is high because there are poor conditions to report.</td></tr>
</table>

**Table 4.2 - Risk to Pilots and Load on Reporting System**

| | Voice | Data | Radio | Satellite |
|---|---|---|---|---|
| ASOS / AWOS | X | X | X | |
| PIREPs | X | | X | |
| Satellite | | X | | X |
| Human Observation | X | X | X | |
| NEXRAD | | X | | |

**Table 4.3 - Means of Transmission Used by Collection Resource**

Telephone (Voice and Data)

Private companies provide telephone service to rural Alaska. However, a voice or data transmission from a rural Alaskan village to Fairbanks may fall under the authority of three different companies. A call originating in the bush will fall under the auspices of the local bush telephone company. It is then processed through a satellite earth station that is maintained by a long distance carrier. This carrier moves the signal to Fairbanks where it connects to another local telephone company. This process often results in slower and less reliable telephone service. It is not atypical for a standard voice or data call to be terminated while in process because of technical problems. Phone service outages in rural locations often take several days to repair because maintenance personnel have to travel to the village from a distant site. The difficulties add to the reduced reliability of telephone systems as a source of transmission. While phone service in the Alaska bush is less reliable than it is in other states it is sufficient for the purpose of transmitting weather data. Private companies who provide these services work continuously to improve them. The economic incentive to maintain these systems is sufficient to expect that they will continue to get more reliable.

Responsibility: Private Companies
Cost: Unknown
Ways to Improve Transmission: Market based economic pressure is sufficient
Potential for Improvement: MED

Radio Transmissions

Radio broadcast means are technically acceptable. The primary difficulty is broadcast range. A pilot seeking to transmit a PIREP to the FSS may find that he is not within range of either the FSS directly or of a Remote Communications Outlet (RCO). The RCOs are positioned around the State of Alaska to assist pilots with long distance transmissions. Unfortunately, they are not adequate to cover all geographical areas in the Interior. PIREPs are the only collection means that would be improved through construction and placement of additional RCOs. However, new RCOs would also enhance other aspects of aviation communication and navigation throughout the state. It is not anticipated that additional RCOs would have a large impact on the reporting of weather conditions.

Responsibility: FAA

Cost: HIGH

Ways to Improve Transmission: Construct new RCOs to cover gaps in radio communications

Potential for Improvement: LOW

Satellite - The transmission of satellite data is reliable. Improving upon the current system would have no marked affect on the quality of weather or runway information available to the end-user.

#### *4.3.3.3 - Analysis of Components of Interpretation*

Interpretation components consist of those entities that compile available data on weather and runway conditions and convert it into information that can be easily understood and disseminated to the end-user. Not all data requires interpretation because some data, as collected, represents consumable information. An instrument that collects temperature information, for example, reports temperature data in degrees Celsius, which is useable in that form by pilots. For weather reporting, there are two primary means of interpreting weather data: computational models and human perception. For runway reporting, interpretation includes both the verification of reported NOTAM information and entry of NOTAM data into the FSS computer. These are discussed below.

Weather Interpretation Components

*Computational Models* - The NWS uses several different computational computer models to help forecast the weather from 6 to 24 hours out. These models have been developed through both federal and university research and use multiple sources to obtain current observations, and then model atmospheric activity so as to produce an accurate forecast of weather events in the future. While these models are constantly being improved, forecasting remains an elusive science because of the unpredictable and fluid nature of the elements that govern natural weather phenomena. The NWS uses the models to write a long-term forecast that is then passed electronically to the FSS. FSS personnel use the NWS forecast to assist pilots in preflight planning. There is little expectation that any significant improvement will be made in computational models in the near future that could radically improve forecasting. Similarly, these models only indirectly assist the forecaster in establishing ceiling and visibility information for specific locations. Since our stated interest is in determining current weather information, there is little probability that improvements to computational models will assist with this requirement.

Responsibility: NWS

Cost: MED

Ways to Improve Interpretation: Refine existing models or develop new ones

Potential for Improvement: LOW

*Human Interpretation* - Near term weather information, generally called nowcasting, is derived by NWS personnel from several sources. Surface observations (human observers, AWOS and ASOS), combined with satellite imagery and Doppler radar provide the basic data from which the 3 to 6 hour forecast is written. The accuracy of these forecasts is a function of the available data as well as the experience and ability of the forecaster. Regarding current ceiling and visibility conditions, NWS personnel are limited by the availability and accuracy of collection systems in place throughout the Interior. There is little room for improvement over reporting of these conditions by virtue of improving the forecasters level of experience or expertise.

Responsibility: NWS

Cost: N/A

Ways to Improve Interpretation: None that would affect current ceiling and visibility reports

Potential for Improvement: LOW

Runway Interpretation Components

*NOTAM Verification* - As mentioned previously, NOTAM reports about runway conditions that come from unofficial sources must be confirmed by AKDOT before they can be entered into the official NOTAM reporting system at the FSS. If the regional airport manager is not available to confirm the report, then good runway information may be lost to the aviation community. Thus there is room to improve this portion of the system by streamlining the AKDOT approval process of NOTAMs from unofficial sources. One option is simply to amend the regulation to allow pilot reported NOTAMs to be considered as official, just as PIREPs can be entered into the FSS system. This would circumvent the need for AKDOT approval and streamline the NOTAM process by providing additional legitimate collection resources. At present the FSS has a system for noting unverified NOTAMs and making them available to pilots. As long as this program is continued, it should fill the need.

Responsibility: AKDOT, FAA

Cost: N/A

Ways to Improve Interpretation: Amend the NOTAM confirmation process

Potential for Improvement: MED

*FSS Entry and Retrieval of NOTAM Information* - From the survey results in Appendix B, it is clear that pilots have confidence that once NOTAM information reaches the FSS, it gets into the system and is made available to end-users. There appears to be little room to improve this aspect of runway information reporting.

Responsibility: FSS
Cost: N/A
Ways to Improve Interpretation: None
Potential for Improvement: None

#### *4.3.3.4 - Analysis of Components of Dissemination*

Dissemination components represent methods by which information is conveyed to the primary consumer or end-user. These methods may be separated into pre-flight and in-flight components. Both components are important.

Preflight Information

*Flight Service Station* - The FAA FSS is the principal provider of pre-flight aviation weather information to the aviation community. Briefings may be obtained in person at the FSS, or by telephone. FSS personnel are primarily weather information "readers". That is they take information that has been provided by the NWS and package it for consumption by the flying community. However, they do very little interpretation of weather data. As far as availability of current or near-term visibility or ceiling information, FSS briefers can only provide that information which has been collected, transmitted and interpreted by the NWS. They do have access to information provided directly by automated resources such as ASOS. In-person pre-flight briefings are perhaps the most helpful because the end-user can see the weather products being used by the briefer to provide information. Satellite imagery and graphical products are available to the pilot which reduces the risk of misunderstanding or miscommunication from briefer to pilot. Telephone briefings are generally readily available. The primary benefit of telephonic briefings is that the user need not be near a FSS to obtain one. In the Interior Alaskan bush, pilots must generally call the Fairbanks FSS to obtain weather information before flying to another bush location or to Fairbanks. Briefings provided by the FSS include NOTAM information that has been entered into the FSS computer system. Therefore, both weather and runway information is disseminated principally through the

FSS. The survey at Appendix B confirms that pilots have no substantive dissatisfaction with the operation of the FSS.

Responsibility: FAA
Cost: N/A
Ways to Improve Dissemination: None that would affect current ceiling, visibility or NOTAM reports, however, some priority should be placed on maintaining a fully staffed and qualified FSS.
Potential for Improvement: LOW

*Internet Resources* - The Internet has become an excellent source of weather information from the FAA, the NWS and multiple private agencies. These agencies provide access through the Internet to graphical and written weather products. These resources can provide the pilot an opportunity to view virtually the same graphic products as the FSS briefer when obtaining a briefing by telephone. The biggest detractor from the use of Internet weather products is that it is not yet considered official weather for the purpose of constituting a legal weather briefing for IFR flight. The Internet is an excellent source of information that can place exceptional weather products in the hands of users all throughout Interior Alaska.

Responsibility: FAA, Pilots
Cost: None
Ways to Improve Dissemination:

- Pursue changes to regulations that would permit the designation of certain Internet weather products as official weather.
- Encourage pilots to access Internet products

Potential for Improvement: MED

<u>In Flight Information</u>

*Flight Service Station* - The Flight Service Station has a briefer that caters to pilots that are en route. Pilots access the in-flight briefer by radio from the air using various RCOs throughout the state. The briefer has access to the same information described in the previous section. This system works fairly well in that pilots can obtain updated weather information that may have changed since their pre-flight briefing prior to departure. To the extent that FSS personnel have current information from distant locations, this information can be made available to pilots en route. The primary problem with this service occurs when pilots are not within range of an RCO and cannot access the briefer.

*Transcribed Weather Broadcast (TWEB)* - The TWEB contains weather information that is recorded on tape and broadcast continuously over selected navigational aid frequencies. The information usually contains route-oriented information and can be of help to pilots during flight [27]. The information is of course limited to that which has been collected. The program is helpful but should not be construed as a replacement for briefings provided by FSS specialists. Current visibility and ceiling information may be obtained through the TWEB if the information has been collected previously.

*ASOS/AWOS Broadcasts* - This information is provided by computer-generated voice and broadcasts the information collected by the automated system. The ASOS therefore acts as collector, transmitter and disseminator where the information requires no interpretation. This information is particularly helpful during approach to an airport while en route. The pilot tunes his radio to the local ASOS and obtains winds, temperatures, visibility and ceiling information just prior to landing. This system works well as long as the information is accurate.

Responsibility: FAA, NWS, Department of Defense (DOD)
Cost: N/A
Ways to Improve Dissemination: None that would assist in providing better ceiling and visibility information
Potential for Improvement: None

## 4.3.4 - Analysis of Interdependencies

Interdependencies among system components may provide opportunities to improve system efficiency or remove system conflicts. Two interdependencies are delineated below.

Among the factors that affect the inputs we discussed operator use of heavy equipment. While an operator's skill directly affects his ability to conduct efficient snow clearing operations, we note that his ability to clear snow pack in the spring could reduce the damage caused to the runway by both aircraft and extraneous vehicles. Ultimately, operator training helps reduce the need for operator maintenance at a later time. This simply amplifies the need for better operator training and supervision.

Referring to Figure 4.2, we also note an interdependency between weather information and maintenance contractors in the villages. If a good system was in place to alert operators as to potential severe weather (heavy snow warnings for example), then operators could better prepare to meet the challenge. They could prepare equipment, and be poised and ready to remedy the situation before it happened.

### *4.4 - Results of Analysis*

The results of the system analysis are summarized here. At this point we make no attempt to suggest any specific solution. This will be accomplished in Chapter 6 when we integrate information gained from Chapters 2, 3, and 4 and then state our hypothesis regarding improvements to the reporting system. Referring to Table 4.1 we make the following observations

#### 4.4.1 - Weather Condition Reporting Results

Since we cannot affect any of the factors that produce actual weather conditions, we must put our energy into developing better means of reporting current conditions. The greatest opportunity to improve the reporting of weather information lies in the collection arena. The ceiling and visibility reports produced by ASOS and AWOS need to be either improved upon or replaced by additional collection means. The responsible agencies appear to be the FAA and the NWS. Modification or improvement to the PIREP system appears to have some merit. Changes or modifications to the transmission, interpretation or dissemination modules of the reporting system afford little opportunity for improvement.

#### 4.4.2 - Runway Condition Reporting Results

Man is able to influence multiple factors that affect the runway condition. The focus must be on those factors that either prevent or correct poor runway conditions since they lower both pilot risk and system load. In this regard the primary opportunities involve increasing the training, supervision and discipline of rural airport maintenance contractors. The responsible agency appears to be the AKDOT. With the exception of improving the AKDOT NOTAM verification procedure, and investigation of enhancements to the current PIREP system, there are no other significant improvements that may be made to collection, transmission, interpretation or dissemination of runway condition reporting.

CHAPTER 5

# Stakeholder Analysis

This chapter provides an analysis of stakeholder involvement as it relates to the current runway and weather reporting system. The chapter accomplishes two tasks simultaneously. It outlines a new method, devised by the author, for producing a comprehensive stakeholder diagram that assists in analyzing project stakeholders' influences. Secondly, it accomplishes a stakeholder analysis of a project to address aviation-reporting needs in Interior Alaska. The author devised the methodology and it was modified in conjunction with Dr. Jang Ra, co-chair of the doctoral committee overseeing this research. The method was presented at the Portland International Conference on Management of Engineering and Technology (PICMET) 99 conference in Portland, Oregon in July 1999. It will also be presented at the Western Decision Sciences Institute's (WDSI) twenty-ninth annual meeting in Maui, Hawaii in April 2000. Finally, it is being prepared for submission to the Project Management Journal.

Section 5.1 is an introduction to stakeholder theory. Section 5.2 presents the stakeholder analysis method. Conclusions are specified in section 5.3. Chapter 6 follows with a proposed solution to the reporting problem and a requisite statement of hypotheses.

## *5.1 - Introduction to Stakeholder Theory*

Stakeholder management theory has been applied to a myriad of applications over a range of disciplines. Within the confines of project management, Project Stakeholders Management (PSM) has emerged as a legitimate process for achieving project objectives. Essentially, this is accomplished by managing both the adverse and supportive influence that key stakeholders can exert [12]. These influences can neither be understood nor managed until a thorough analysis is undertaken of the interrelationships between the project and its stakeholders, as well as among its stakeholders. A graphic representation of these associations provides an excellent source document to facilitate the PSM process.

A four-step method is used to develop a three-environment stakeholder diagram as shown in Figure 5.4. The method is applicable to any project. We add clarity to the explanation of the method by focusing on a stakeholder analysis of an anticipated project to improve the aviation reporting system that was defined in Chapter 4.

As with every varied technique for achieving project objectives, stakeholder analysis does not claim to reveal some single truth that can lead decision-makers to the right course of action. However, it "realizes and legitimizes the diversity of interests" at stake in the project [7]. It ensures, by definition, that each party with a stake in the outcome of, or investment in, the project has its interests considered. This increases everyone's awareness of the issues that may influence project success or failure. Whereas project success used to be measured primarily in terms of the triad "on time, within budget and to standard", A better definition includes a measure of the customer's satisfaction with the project [28]. Stakeholder analysis opens the avenues for more complete communication with interested parties, better consideration of the issues and thus greater success. In Chapter 6 the results from this analysis will be integrated with the system analysis (Chapter 4), the literature search (Chapter 3), the statistical analysis (Chapter 2) and the background information (Chapter 1) to arrive at a specific recommendation for improving the current reporting system.

Perhaps the primary challenge in the stakeholders' approach is the time required to correctly analyze each stakeholder's interest and then balance competing interests throughout the life of the project. This is hard enough when there is no mandate to consider the concerns of relatively insignificant players. But when the seemingly unimportant agendas of small entities must be considered alongside those of primary stakeholders, the need for effective organization and administration of the project rises sharply. It is especially noteworthy that some of these small groups (activists, lobby groups, etc.) are able to exert tremendous pressure upon the project by influencing entities that exert direct pressure on the project [60]. It is for this reason that we present a methodology for graphically depicting the place each stakeholder maintains in the project.

## *5.2 - Methodology for Development of Diagram*

Development of the stakeholder diagram is undertaken in four steps involving several distinct diagrams:

1. Step 1 – Establish the system and develop a diagram (Figures 4.1 and 4.2)
2. Step 2 – Identify the stakeholders (Table 5.1)
3. Step 3 – Analyze the stakeholders' claims (Tables 5.2 through 5.5)
4. Step 4 – Integrate the previous steps into a formal stakeholder diagram (Figures 5.1 through 5.4)

Step 1 - Establish the System Proper

The system diagram was developed in Chapter 4 and forms the basis for the stakeholder analysis. The system analysis previously undertaken has provided a clear understanding of the basic elements, inputs, outputs and interdependencies that constitute the system. This firm understanding of the system must be in place prior to delineation of stakeholder interests. Identification of the agencies that contribute to the structure of the system provides the first bit of constructive information toward the delineation of our three-environment diagram shown in Figure 5.4. Specifically, we can identify stakeholders, identify relationships between stakeholders, and discern those stakeholders that exist within the internal (system) environment. We will extract specific information from this diagram in the sections that follow.

At this point we must define the three levels of environment that will characterize our diagram:

1. Internal Environment – Composed of those stakeholders within the system boundary.
2. Operating Environment – Made up of those stakeholders that interact directly with the system.
3. General Environment – Comprised of those stakeholders that compose the social, political, regulatory, economic and technological context of the system [12].

Step 2 - Identify the Stakeholders

A stakeholder in a project may be defined as any group or individual who can affect or who is affected by the achievement of the project objectives [4,19]. If the identification of stakeholders does not follow some degree of rigor, important players may be left out resulting in a loss in ability to manage the true stakeholders' interests.

Given Figures 4.1 and 4.2 that establish system outputs, societal benefits, and the details of the established system, a series of questions are posed to help identify critical stakeholders:

1. System Proper – Which stakeholders are identified in the system diagram?

2. Benefits – Who profits from the stated system outputs and anticipated benefits?
3. Disbenefits – Who will be hurt or disadvantaged by the project?
4. Financiers – Who will resource the project with funds, material, or personnel?
5. Contractors – What entities will profit monetarily from investments in the project?
6. Decision Makers – Who holds decision authority for execution of aspects of the project?
7. Interest Groups – What other organizations have a vested interest in the success or failure of the project?
8. Legal – What agencies have legal or regulatory authority regarding execution of this project?
9. Technological - What groups will impact or be affected by technological aspects of the project.

Table 5.1 demonstrates the formation of a stakeholder list using this approach. Column 1 is generated by moving sequentially through columns 2 – 14 asking the questions denoted above. The shaded region identifies the question that produced the first occurrence of a stakeholder in the list.

For example, the NTSB is identified the first time by the question in column 5, "Who benefits from improved aviation safety". It is again identified by the question in column 13. Column 15 indicates the total number of times the NTSB was identified in the process. This summation of occurrences, while assuming equal importance among questions posed, begins to provide some insight as to the degree of stake that each stakeholder may have in the project.

The bottom row of the chart shows the cumulative percentage of stakeholders identified as the questioning proceeds. Of interest here is that for this public project, over three-fourths of the list is complete by column 6 which may lead one to believe that a point of diminishing returns has been reached wherein the effort required to identify other stakeholders is not justified. This is a common and unfortunate conclusion that often leads managers to underestimate the influence that can be exerted by relatively anonymous stakeholders present in the general environment [41].

Twenty-three stakeholders have been identified in Table 5.1. The table suggests that the FAA, the NWS and AKDOT will be primary players in any project that encompasses improvements to the aviation runway and weather reporting system. It also indicates that very few stakeholders will be negatively effected by such a project. Finally, there is strong evidence that there are many entities that will be benefited by the project.

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAKE-HOLDERS | SYSTEM | BENEFITS *Who benefits from ...* | | | | | DIS-BENEFITS | PROJECT FINANCIERS | CON-TRACTORS | DECISION MAKERS | INTEREST GROUPS AND ORGS. | LEGAL OR REG. INTEREST | TECH-NOLOGY INTEREST | TOTAL TIMES IDENTIFIED |
| | Who is in the System? | Better Runway Info | Better Weather Info | Improved Aviation Safety | Improved Aviation Service | Improved Aviation Efficiency | Who will be hurt by Project? | Who will pay for the project? | Who will make money? | Who holds decision authority | Other misc. groups | Who has legal resp. to this project? | Who has tech. interest or claims? | |
| FAA | X | X | X | X | | | | X | | X | | X | X | 8 |
| NWS | X | | X | | | | | X | | X | | X | X | 6 |
| AKDOT | X | X | | X | X | | | X | | X | | X | | 7 |
| Airport Maint. Pers. | X | | | | | | | | | | | | | 1 |
| Telecom Co. | X | | | | | | | | X | | | | X | 3 |
| Pilots (Comm.) | X | X | X | | X | X | | | | | | | | 5 |
| Pilots (Gen. Avn.) | X | X | X | | X | X | | | | | | | | 5 |
| CWOs | X | | X | | | | | | | | | | | 2 |
| NTSB | | | | X | | | | | | | | X | | 2 |
| AOPA | | | | X | | | | | | | X | | | 2 |
| ACA | | | | X | X | X | | | | | X | | | 4 |
| Air Carriers | | | | X | X | X | | | | | | | | 3 |
| Rural Villages | | | | X | X | | | | | | | | | 2 |
| Hub Community | | | | X | X | | | | | | | | | 2 |
| Tourists | | | | X | X | X | | | | | | | | 3 |
| NASAO | | | | | X | | | | | | X | | | 2 |
| Village Retailers | | | | | X | | | | | | | | | 1 |
| Hub Retailers | | | | | X | | | | | | | | | 1 |
| USPS | | | | | X | | | | | | | | | 1 |
| Aircraft Repair Co. | | | | | | | X | | | | | | | 1 |
| Tech. Prod. Co. | | | | | | | | | X | | | | X | 2 |
| Construction Co. | | | | | | | | | X | | | | | 1 |
| NAAUG | | | | | | | | | | | X | | | 1 |
| *% of Stakeholders identified* | 35% | 35% | 35% | 61% | 83% | 83% | 87% | 87% | 96% | 96% | 100% | 100% | | |

Shading indicates the first time the stakeholder in this row was identified by a question

| | | |
|---|---|---|
| FAA - Federal Aviation Administration | NTSB - National Transporation Safety Board | Village Retailers - Retailers in Rural Villages |
| NWS - National Weather Service | AOPA - Aircraft Owners and Pilots Association | Hub Retailers - Retailers in Hub communities |
| AKDOT - Alaska Department of Transportation | ACA - Alaska Air Carriers Association | USPS - United States Postal Service |
| Airport Maint. Pers - DOT Maintenance Personnel at Airports | Air Carriers - Air Carrier comp. based in Interior Alaska | Aircraft Repair Co. - Repair damaged aircraft |
| Telecom Co. - Telecommunications Companies | Rural Villages - Rural Villages served by Air Carriers | Tech. Prod. Co. - Offer technical products |
| Pilots (Comm.) - Commercial Pilots based in Interior Alaska | Hub Community - Communities air carriers operate from | Constr. Co. - Do construction work at airports |
| Pilots (Gen. Avn.) - General Aviation Pilots in Interior Alaska | Tourists - GA Pilots and passengers of air carriers | NAAUG - Northern Alaska Aviation Users Group |
| CWOs - Certified Weather Observers | NASAO - National Association of State Aviation Officials | |

**Table 5.1** - Identification of Stakeholders

Step 3 - Analyze the Stakeholders

Having established a stakeholder list, we proceed to analyze each stakeholder in terms of information critical to defining the stakeholder diagram. Specifically, we investigate their charter, classification, environmental level, interrelationships and degree of stake in the project.

1. Charter – The function of the stakeholder should be investigated fully. It should be summarized in a clear, concise statement relating the stated purpose of the organization to the function of the system. Although this information will not be presented directly in the final diagram, it provides the background for the rest of the analysis. Table 5.2 demonstrates the abbreviated result of this investigation for our project.

2. Classification – What classifications apply to this stakeholder? Is it an individual, community, organization, company, interest group, government agency or country? These groupings will vary based on the type and level of project. Some stakeholders may be classified into more than one group. The far right column of Table 5.2 breaks out the stakeholder classification for the rural airport information project. The information from this table will be used explicitly in the final diagram. The percentage of stakeholders by type in our project is: Government (22%), Private (30%), Special Interest Group (17%), Community (9%), and Individuals (22%).

3. Environmental Level – Based on our definitions in step 1, we proceed to categorize each stakeholder into one or more environmental levels. It is fully acceptable for a stakeholder to enjoy status in all three levels. Table 5.3 categorizes this information for our project. Compilation of this table will allow us to place each stakeholder in its proper environment on the final diagram. We note that the only three stakeholders present in all three levels are the FAA, the NWS and the AKDOT. This fact is beginning to lend credence to the idea that these three government agencies may play a large part in our project.

4. Stakeholder Interrelationships – Understanding the movement of funds, exertion of lobby or political influence, and exercise of supervision or standards of one stakeholder over another is key to successful management of stakeholder interests. Each stakeholder must be considered in relation to each other in terms of these three elements. The results are shown in Table 5.4. All stakeholders are listed both in the far-left column and across the top of the table. For example, the exercise of supervision of the FAA over commercial pilots is indicated in the intersection of the two with an "S", for supervision. Every intersection is considered and labeled where appropriate. The information gleaned from this table will be

| Stakeholders | Charter | Class. |
|---|---|---|
| Federal Aviation Administration | May provide Federal Aviation Regulation input or oversight regarding weather or runway condition reporting criteria. Provides regulatory guidance to pilots regarding Flight Rules that are impacted by known weather and runway conditions. Initiating Flight 2000 program which would benefit from increased weather and runway information flowing to pilot in cockpit. | G |
| National Weather Service | Purchases and Maintains Automated Weather observation and collection systems. Provides contract weather observers at remote locations. Interprets weather data and provides weather information to FAA Flight Service Stations for dissemination to pilots. | G |
| Alaska Department of Transportation and Public Facilities | Owns public airports throughout Alaska. Increased weather and runway condition reporting enhances DOT reputation and provides better information for DOT decision-making. Provides for safer and more reliable air travel throughout the State which reflects well on state government and improves economy to the bush. | G |
| National Transportation Safety Board | Sustained interest in improving air travel safety throughout the United States. Recently conducted a Safety Study on Aviation Safety in Alaska wherein specific recommendations were made to several agencies. | G |
| United States Postal Service | Client of air carriers who is dependent upon regular commercial air travel to transport mail and packages to remote locations throughout Alaska. Executor of bypass mail system which is also dependent upon regular air service for movement of bulk cargo to remote locations. Benefits if commercial air service becomes more reliable. | G |
| Telecommunications Companies | Provide and maintain telecommunications to rural villages and airports. Telecommunications are required in the transmission of weather and runway information from rural locations to central hubs. | P |
| Air Carriers | Increases knowledge of remote area terminal conditions thus improving probability of successfully completed trip. | P |
| Village Retailers | Improves safety and reliability of air cargo intended for villages retailers to sell to village populous. Potentially adds a measure of consistency to village retail operations. | P |
| Hub Retailers | Improves safety and reliability of air cargo sent to villages. Potentially reduces travel time of retail products from major hubs to remote villages. | P |
| Aircraft Repair Companies | Provide aviation repair services to air carriers in the Interior. Stand to lose some business if aviation accidents decrease. | P |
| Technical Product Companies | Provide technical products to improve runway and weather condition reporting system. Stand to make money on improvements to the sytem. | P |
| Construction Companies | Conduct construction at rural airports as deemed necessary to improve the runway and weather condition reporting system or mitigate the need for reporting. Stand to make money on construction projects. | P |
| Aircraft Owners and Pilots Association Air Safety Foundation | Constant voice for air travel safety in the United States. Improves safety and usability of remote airports, effectively assists in meeting national AOPA goals. | IG |
| Alaska Air Carriers Association | Provides increased information about remote airports thus improving interest in maintaining safe, reliable flights into these airports. | IG |
| National Association of State Aviation Officials | Provides improved safety and reliability in air passenger service which translates into better reputation for the state's aviation oversight. | IG |
| Northern Alaska Aviation Users Group | Special interest group dedicated to representing the needs and concerns of pilots in Interior Alaska. | IG |
| Rural Villages | Increases commerce with outside world and improves safety and reliability of passenger, cargo, and mail trips. | C |
| Hub Community | Provides improved safety and reliability in air passenger service to the flying public. Potentially could translate into cheaper fares for the public. | C |
| Airport Maintenance Personnel | Contracted by DOT to conduct daily inspections of rural airports, maintain them in safe condition, plow snow and report discrepancies to the FAA FSS to be entered as a NOTAM for the airport. Personnel normally live and work in the rural village associated with the airport. Provides current job security and potential for increased income with new responsibilities in weather reporting. | I |
| Pilots (Commercial) | Improves accessibility of remote locations. Reduces flight turn-around. Improves safety for pilots and crewmembers. Increase pilot knowledge of terminal area and thus pilot confidence. | I |
| Pilots (General Aviation) | Makes remote locations more accessible to pilots. Reduces flight terminations and potential for unsafe terminal area operations by GA pilots. | I |
| Contract Weather Observers | Normally employed by or contracted through the National Weather Service to collect hourly weather observations at selected airports and provide them to a central hub. | I |
| Tourists | Includes all tourist traffic through the Interior of Alaska that use aviation services in their travels. Provides added safety, and service to these visitors. | I |
| LEGEND | G - Government P - Private I - Individual IG - Interest Group C - Community | |

**Table 5.2 - Stakeholders' Charter and Classification**

| STAKE-HOLDERS | ENVIRONMENT | | |
|---|---|---|---|
| | Internal (Part of System) | Operating (Interacts with System) | General (Compose context of System) |
| FAA | FSS Interpret/Disseminate Notices to Airmen (NOTAMS). Collect weather information (pilot reports). Disseminate weather information | Operates air traffic control and navigation systems. | Provides federal aid to airports. |
| NWS | Collect and interpret weather information for local use. | State Agencies provide supervision, information and funds to support system. | Provide funds to resource weather collection and interpretation. |
| AKDOT | Northern Region - Collect and verify NOTAM information. | Statewide Aviation - Primary contact with Federal, State and Local agencies on aviation issues. Alaska DOT owns 266 public airports. | Federal Level - Develops and promotes national transportation policies and programs. |
| NTSB | | | Provides oversight for federal agencies which impact aviation safety. |
| USPS | | | Major aviation client in rural Alaska. |
| Telecom. Co. | Provides infrastructure to transmit weather and runway information from point of collection to point of dissemination. | Provides infrastructure to communicate weather and runway information to aviation community. | |
| Air Carriers | | Primary user of weather and runway information. | Forms a portion of the basis of Alaska's rural transportation infrastructure. |
| Village Retailers | | | Dependent upon aviation services for business. |
| Hub Retailers | | | Dependent upon aviation services for business to rural customers. |
| Aircraft Repair Co. | | | Repairs damaged aircraft |
| Tech. Prod. Co. | | | Provides technical products to maintain or enhance weather and runway collection sources. |
| Construction Co. | | | Conducts construction projects at rural airports. |
| AOPA | | | Represents the interests of pilots to decision makers. |
| ACA | | | Represents the interests of pilots to decision makers. |
| NASAO | | | Represents state government aviation agencies who serve the public interest. |
| NAAUG | | | Represents the aviation community in interior Alaska. |
| Rural Villages | | | Depends upon aviation services for mail, cargo and passenger service. |
| Hub Communities | | | Depends upon aviation services for mail, cargo and passenger service to rural communities |
| Airport Maint. Pers. | Collects and transmits runway information. | | |
| Pilots (Comm.) | | Direct user of runway and weather information | Employed by air carriers and thus influence their companies' actions. |
| Pilots (Gen. Avn.) | | Direct user of runway and weather information | |
| CWOs | NWS or FAA employees who collect weather information used in the system. | | |
| Tourists | | Pilots who are users of runway and weather information | Non-pilots who benefit from aviation services for transportation and sightseeing. |

**Table 5.3** - Environmental Level of Stakeholders

| FROM \ TO | FAA | NWS | AK DOT | NTSB | USPS | Tele-Comm. Comp. | Air Carr. | Vill. Retail | Hub Retail | Aircraft Repair Co. | Tech. Prod. Co. | Const. Co. | AOPA ACA NASAO NAAUG | Rural Vill. | Hub Comm. | Airport Maint. Pers. | Pilots (Comm) | Pilots (GA) | CWOs | Tour-ists | SUM OF "S" | SUM OF "$" | SUM OF "L" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FAA | | | S $ | | | S$ | S | | | S | S$ | | | | | | S | S $ | S$ | | 8 | 5 | |
| NWS | | | | | | S$ | | | | | S$ | | | | | | | | S$ | | 3 | 3 | |
| AKDOT | | | | | | | | | | | S$ | S$ | | | | S$ | | | | | 3 | 3 | |
| NTSB | S | S | S | | | | | | | | | | | | | | | | | | 3 | | |
| USPS | | | | | | | S$ | | | | | | | | | | | | | | 1 | 1 | |
| Telecom Comp. | | | | | | | | | | | S$ | S$ | | | | | | | | | 2 | 2 | |
| Air Carriers | $ | | $ | | | $ | | | | $ | | | | | | | S$ | | | | 1 | 5 | |
| Village Retailers | | | | | S$ | S$ | S$ | | $ | | | | | | | | | | | | 3 | 4 | |
| Hub Retailers | | | | | S$ | S$ | S$ | | | | | | | | | | | | | | 3 | 3 | |
| Aircraft Repair Co. | | | | | | | | | | | | | | | | | | | | | | | |
| Tech. Prod. Co. | | | | | | | | | | | | | | | | | | | | | | | |
| Construction Comp. | | | | | | | | | $ | | | | | | | | | | | | | 1 | |
| AOPA | L | L | L | | | | L | | | | | | | | | | | | | | | | 4 |
| ACA | L | L | L | | | | | | | | | | | | | | | | | | | | 3 |
| NASAO | L | L | L | | | | L | | | | | | | | | | | | | | | | 4 |
| NAAUG | L | L | L | | | | L | | | | | | | | | | | | | | | | 4 |
| Rural Villages | | | $ | | S$ | S$ | S$ | S$ | S$ | | | | | | | | | | | | 5 | 6 | |
| Hub Communities | | | | | S$ | S$ | S$ | | S$ | | | | | | | | | | | | 4 | 4 | |
| Airport Maint. Pers. | | | | | | | | | | | | | | | | | | | | | | | |
| Pilots (Comm.) | | | | | | | | | | | | | | | | | | | | | | | |
| Pilots (Gen. Avn.) | | | | | | | | | | | | | | | | | | | | | | | |
| CWOs | | | | | | | | | | | | | | | | | | | | | | | |
| Tourists | | | | | S | | S | | | | | | | S | S | | | | | | 4 | | |
| SUM OF "S" | 1 | 1 | 2 | | 5 | 6 | 7 | 1 | 2 | 1 | 4 | 2 | | 1 | 1 | 1 | 2 | 1 | 2 | | | | |
| SUM OF "$" | 1 | | 3 | | 4 | 7 | 8 | 1 | 4 | 1 | 4 | 2 | | | | 1 | 1 | 1 | 2 | | | | |
| SUM OF "L" | 4 | 4 | 4 | | | | 3 | | | | | | | | | | | | | | | | |

S - Imposition of Standards or Supervision / $ - Investment or transfer of Funds / L - Lobbying or political pressure

[ ] High count in row or column

**Table 5.4** - Stakeholder Interrelationships

shown in the final diagram as arrows from one stakeholder to another. We note from this table the following indications:

a. The FAA, NWS and AKDOT are the primary recipients of pressure by special interest groups. This is clear from the tabulations in the "Sum of 'L" row of the table where four special interest groups affect each of these three organizations. As they are each government entities it is expected that private organizations will seek to influence them toward decisions favorable to the aviation community.

b. The telecommunications companies and air carriers receive economic benefit from the greatest number of stakeholders as shown in the "Sum of $" row. These same two also have strong supervisory ties with other stakeholders as demonstrated by the tabulations in the "Sum of S" row. We anticipate that these two organizations will be interested in supporting improvements to the system that could increase business transactions in their sector.

c. The "Sum of S" column indicates that the FAA exerts supervisory or regulatory influence over the greatest number of peer stakeholders. Gaining FAA support of improvements to the system will undoubtedly be important in entraining the continued interest of other stakeholders.

d. The FAA, air carriers and rural villages all move funds to a significant number of other stakeholders as shown in the "Sum of $" column. Their economic interests will be tied to improvements in reporting.

5. Degree of Stake – The degree or level of stake that an entity has in the project should be determined with some rigor. This assists us in focusing our efforts where we may gain the most benefit. The in-depth analysis used in educating oneself on a stakeholder's charter will greatly assist with this step. Familiarity with the stakeholder's intent and ability to influence the project will provide some insight into the influence that they will exert. The goal is to rank order the stakeholders into a list that represents a reasonable measure of their stake in the project.

Table 5.5 depicts a weighted average approach to determining degree of stake. This table is similar to Table 5.1 in that all stakeholders are listed down column 1, and many of the same headings are used to help assess stake. Each stakeholder is evaluated using a very straightforward scoring scheme as shown. Weights are selected based on the analyst's familiarity with the importance of each criterion. The weighted average is computed in column 15. The list of stakeholders is then sorted to produce a rank ordered list based on the total weighted average. The stakeholders are separated into quintiles in column

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAKEHOLDER | SYSTEM | BENEFITS To what degree does stakeholder benefit from: | | | | | DIS-BENEFITS | PROJECT FINANCIERS | CON-TRACTORS | DECISION MAKERS | INTEREST GROUPS AND ORGS. | LEGAL OR REG. INTEREST | TECH. INTEREST | TOTAL WTD. AVE. | GROUP RANK |
| *Rank ordered based on final weighted average in column 14* | *At what level is the stakeholder in the environment?* | *Better Runway Info* | *Better Weather Info* | *Improved Aviation Safety* | *Improved Aviation Service* | *Improved Aviation Efficiency* | *How much will stake-holder be hurt by project?* | *How much will the stakeholder invest in the project?* | *How much will stakeholder earn on the project?* | *How much decision authority does stakeholder have?* | *How much political/lobby pressure will stakeholder exert?* | *What degree of legal resp. does stake-holder have to project?* | *What degree of tech-nological int. does stake-holder have?* | | *Sepa-rated into quintiles* |
| Weight ⟶ | 15% | 5% | 5% | 5% | 5% | 5% | 10% | 15% | 5% | 15% | 5% | 5% | 5% | 100% | |
| FAA | 3 | 3 | 3 | 2 | 2 | 2 | | 3 | | 3 | | 3 | 2 | 2.20 | 1 |
| NWS | 3 | | 3 | 1 | 1 | 1 | | 3 | | 3 | | 3 | 2 | 1.90 | 2 |
| AKDOT | 3 | 3 | 1 | 2 | 2 | 1 | | 2 | | 3 | | 3 | 1 | 1.85 | 2 |
| Air Carriers | 2 | 3 | 3 | 3 | 3 | 3 | | | | | 1 | | | 1.10 | 3 |
| Pilots (Comm.) | 2 | 3 | 3 | 3 | 2 | 3 | | | | | | | | 1.00 | 3 |
| Pilots (Gen. Avn.) | 2 | 2 | 3 | 3 | 2 | 2 | | | | | | | | 0.90 | 4 |
| Telecom. Co. | 3 | | | | 1 | 1 | | | 2 | | | | 3 | 0.80 | 4 |
| NTSB | 1 | | | 3 | | | | 1 | | 1 | | 1 | 2 | 0.75 | 4 |
| Rural Villages | 1 | | | 2 | 3 | 3 | 1 | | | | 2 | | | 0.75 | 4 |
| ACA | 1 | 1 | | 2 | 2 | 2 | | | | | 2 | | 1 | 0.65 | 4 |
| Airport Maint. Pers. | 3 | | | 1 | 1 | | 1 | | | | | | | 0.65 | 4 |
| Tourists | 2 | | | 2 | 2 | 2 | | | | | | | | 0.60 | 4 |
| NASAO | 1 | | | 1 | 1 | 1 | | 1 | | | 1 | 1 | 1 | 0.60 | 4 |
| CWOs | 3 | | | | | | 1 | | | | | | 1 | 0.60 | 4 |
| USPS | 1 | | | 1 | 3 | 3 | | | | | | | | 0.50 | 4 |
| Tech. Prod. Co. | 1 | | | 1 | | | | | 3 | | | | 3 | 0.50 | 4 |
| AOPA | 1 | | | 2 | 1 | 1 | | | | | 2 | | 1 | 0.50 | 4 |
| Village Retailers | 1 | | | 1 | 2 | 2 | | | | | | | | 0.40 | 5 |
| NAAUG | 1 | | | 1 | | 1 | | | | | 1 | | 2 | 0.40 | 5 |
| Hub Community | 1 | | | 1 | 2 | 1 | | | | | | | | 0.35 | 5 |
| Hub Retailers | 1 | | | 1 | 1 | 1 | | | | | | | | 0.30 | 5 |
| Aircraft Repair Co. | 1 | | | | | | 1 | | | | | | 1 | 0.30 | 5 |
| Construction Co. | 1 | | | | | | | | 1 | | | | | 0.20 | 5 |
| | 1 - General<br>2 - Operating<br>3 - Internal | *Cell Blank - No Benefit*<br>1 - Low Benefit<br>2 - Medium Benefit<br>3 - High Benefit | | | | | 0 - None<br>1 - Little<br>2 - Some<br>3 - Much | | | | | | | | |

**Table 5.5** - Degree of Stake in the Project

16. This final grouping is represented in the stakeholder diagram by font size. This table provides good evidence that the FAA, NWS, AKDOT, air carriers and commercial pilots will be primary stakeholders in any project to improve the reporting system in Interior Alaska.

Step 4 - Integration

The results of steps 2 and 3 are integrated into a single diagram as shown in Figure 5.4. This diagram is developed sequentially in four stages. Information is drawn from each of the previous tables to produce the diagram according to the following scheme.

1. Stage 1 - Three boundaries are drawn enclosing the separate environments. They are labeled as internal, operating and general. Table 5.3 is used to place each stakeholder within his appropriate environmental level. Stakeholders that occupy more than one level are drawn such that they cross boundaries as necessary. The results of this step are shown in Figure 5.1.

2. Stage 2 - Table 5.2 is invoked to label each stakeholder with a suffix representing its classification (P for private, G for government etc). Figure 5.2 is the result.

3. Stage 3 - The quintile ranking in Table 5.5 is used to establish a font size for each stakeholder that represents his degree of stake in the project. A larger font size represents greater stake. Figure 5.3 demonstrates the result.

4. Stage 4 - Table 5.4 is used painstakingly to establish important stakeholder interrelationships by drawing arrows representing the investment of funds, imposition of standards, or potential to lobby or exert political pressure on another stakeholder. Not every relationship need be represented as this may only congest the diagram.

Finally, the diagram must be arranged to present a neat and orderly appearance. While Figure 5.4 is not meant to be a completely stand-alone diagram, it provides at a single glance a good deal of information about the stakeholders in the project. Additional detail and clarity may be realized by making a stakeholder diagram for each of the three interrelationships: flow of resources, imposition of standards and exertion of special interest group pressure. The other tables and diagrams stand as ready references to add detail.

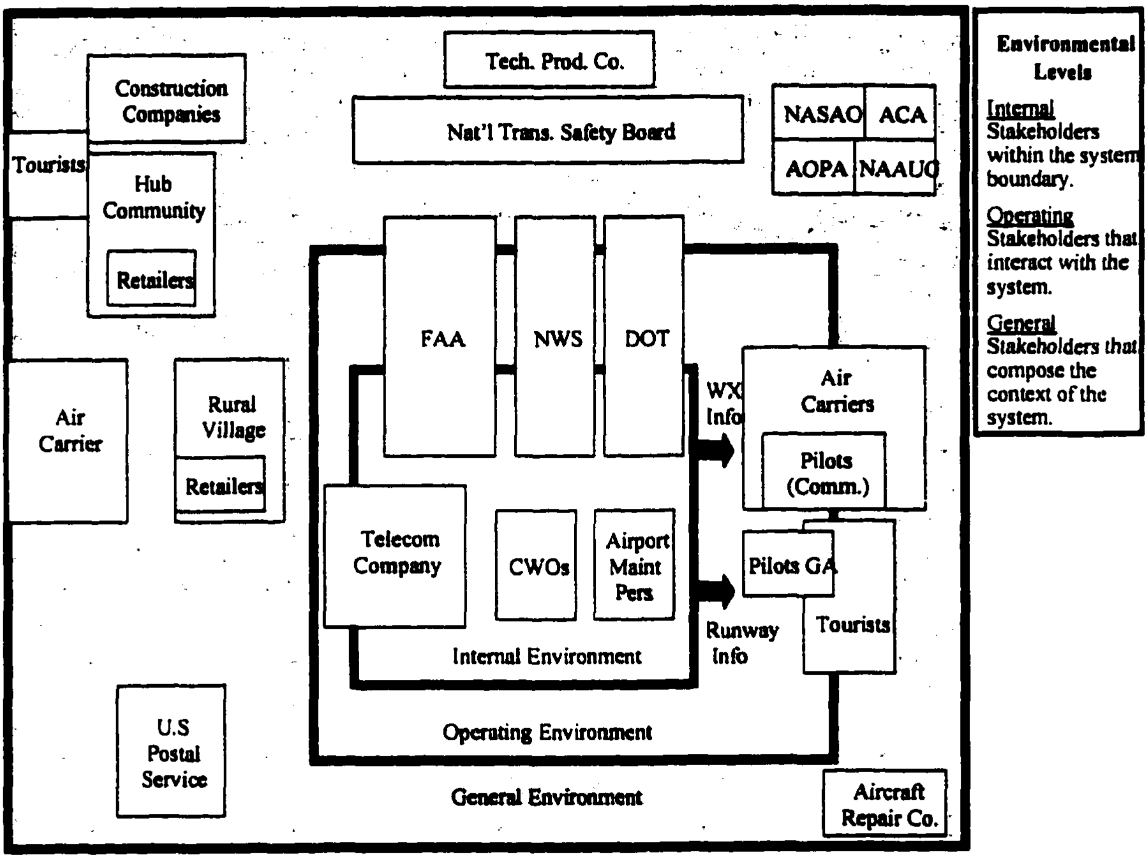



**Figure 5.1** - Comprehensive Stakeholder Diagram - Stage 1

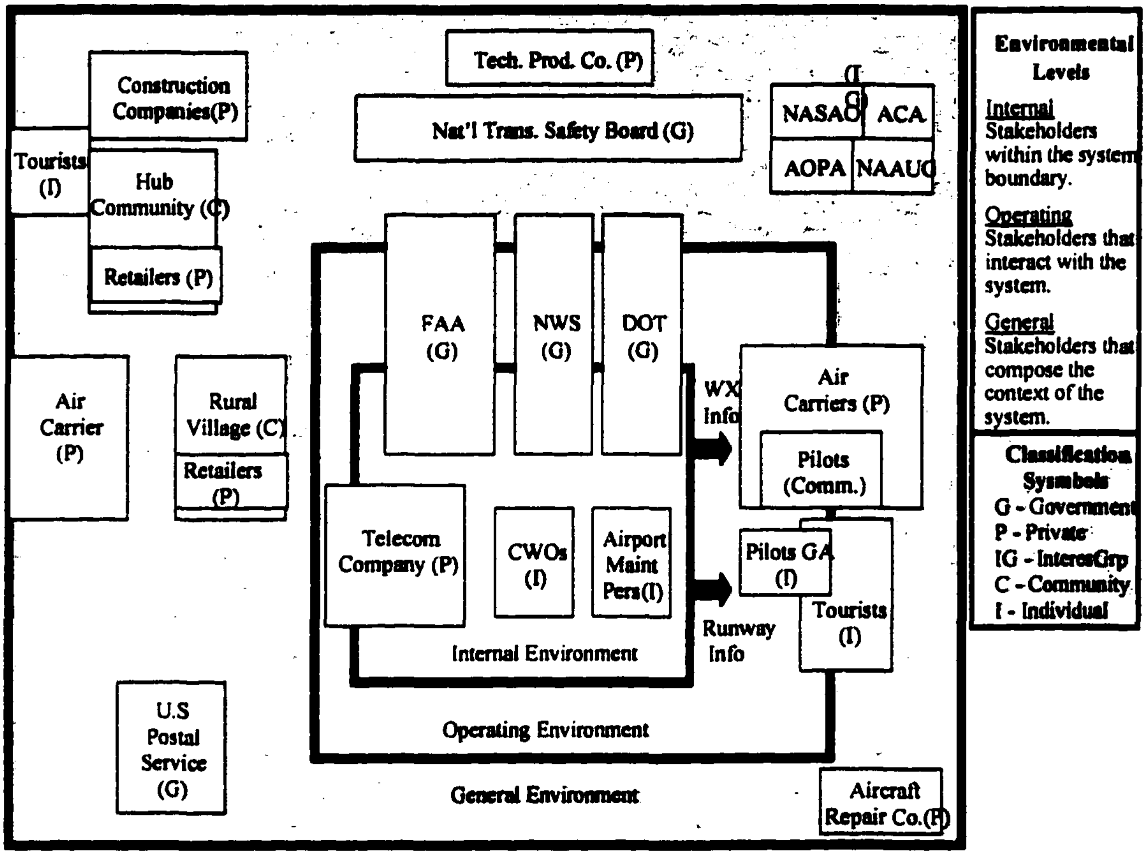



**Figure 5.2** - Comprehensive Stakeholder Diagram - Stage 2

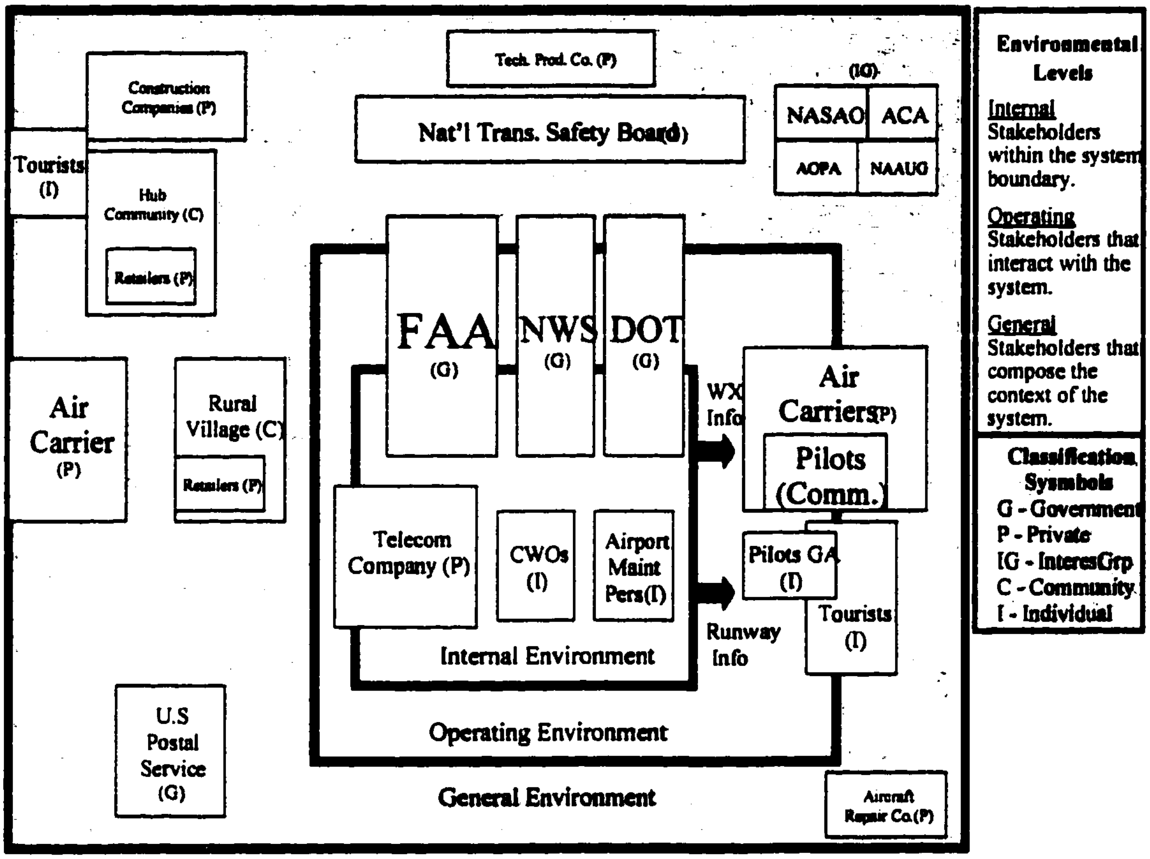



**Figure 5.3** - Comprehensive Stakeholder Diagram - Stage 3

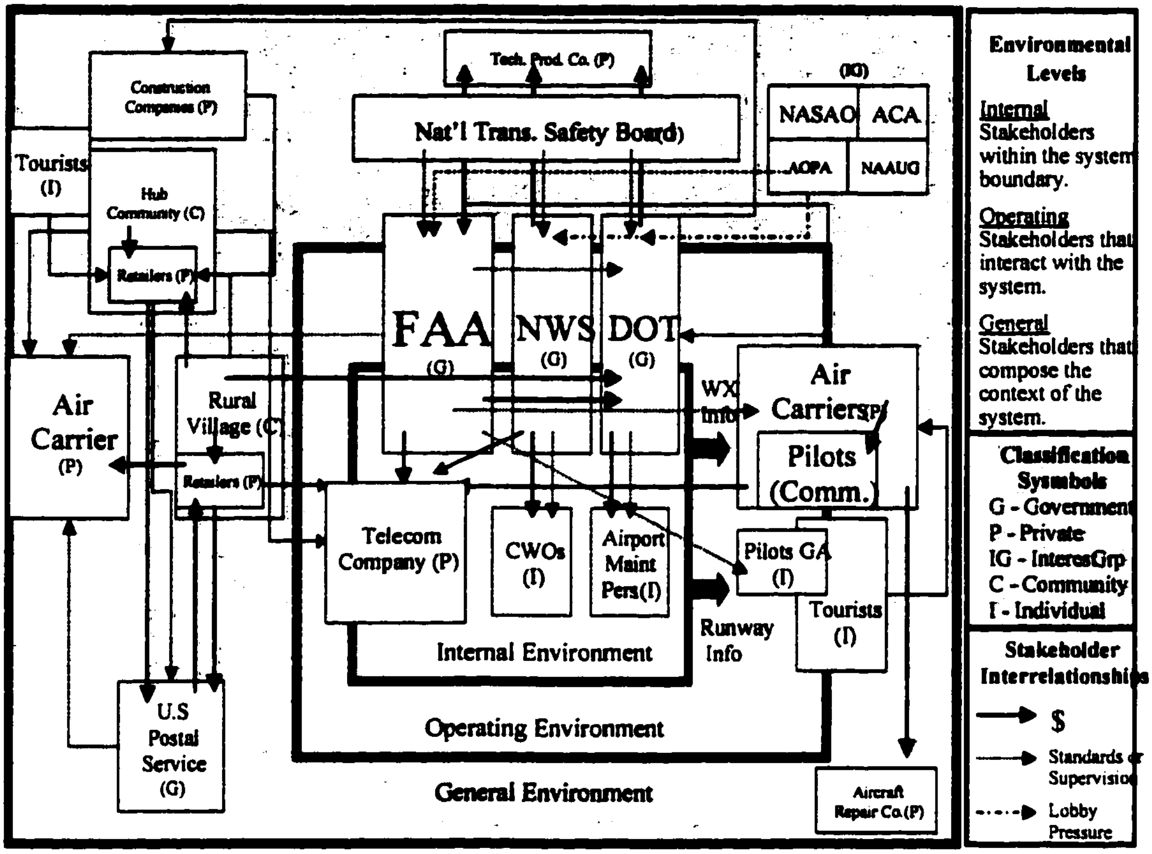



**Figure 5.4 - Comprehensive Stakeholder Diagram - Stage 4**

## 5.3 - Conclusions

### 5.3.1 - Stakeholder Diagram Methodology

The development of a stakeholder diagram representing an in-depth analysis of all the primary players in a project is a worthwhile venture. It may be pursued using a very logical and sequential approach.

A significant benefit of this methodology is that it requires the analyst to become intimately familiar with the interests and concerns of each stakeholder. This opens communication with those involved and serves to put the project manager in a much better position to understand how to manage competing interests and leverage support from stakeholders. It also helps the manager prevent future difficulties with parties whose interests might have otherwise gone unnoticed.

The stakeholder diagram should be developed early in the project life. Its primary use is to enable the identification of major stakeholders thereby promoting early coordination among the various project entities most likely to affect project success. It should be referenced and revised frequently as the project proceeds. The final diagram, as well as those used in the development process, provides excellent documentation for post-project analysis. Specifically, the project manager may use it with his project team to determine the accuracy of their pre-project assessment of relative stakeholder importance. This is very educational for the team and assists them in better anticipating stakeholder influence in subsequent projects.

### 5.3.2 - Stakeholders and the Reporting System in Interior Alaska

The process we have undertaken to develop a comprehensive stakeholder diagram for the reporting system has provided some important insights into the pursuit of improvements. Five specific stakeholders have emerged as those with the highest stake in the project: the FAA, the NWS, the AKDOT, air carriers and commercial pilots. While this discovery may not provide much specific guidance as to what improvements should be made, it does confirm a need to maintain good communication with each of these five groups throughout any project which pursues upgrades to the existing system. A few brief comments about each of these stakeholders are in order.

The FAA - The FAA has emerged as the single stakeholder with the greatest stake in the project. It is a disseminator of aviation weather and NOTAM information. It is a government organization that has a vested interest in improving the level of aviation safety and service to passengers. The FAA hosts the FSS that provides pre-flight and in-flight information to pilots on the conditions of rural runways and the weather. The FAA is dependent upon the NWS as its primary source of weather information. It is responsive to the NTSB. It provides regulatory guidance to pilots regarding flight rules that are impacted by weather and runway conditions. It is a decision-making organization that can make sweeping changes in the aviation business and therefore must be considered in any reporting system improvements. It is often the target of special interest groups.

The NWS - The NWS also has great stake in any project to improve weather reporting. It is a supplier of weather information. It is also a government organization whose charter includes providing accurate weather observations and forecasting to the aviation community through the FAA. In Alaska, the NWS oversees the Alaska Aviation Weather Unit (AAWU) which has the specific responsibility of providing aviation related weather information to the aviation community. The NWS is also responsible to respond to NTSB inquiries. It maintains CWOs at various rural airports. It is also a decision-making organization that has the resources to affect a change in the reporting system.

The AKDOT - AKDOT is particularly interested in issues regarding runway condition reporting (NOTAMs). It is an arm of the Alaska State Government and as such owns some 286 public airports in Alaska. The regional aviation manager for Interior Alaskan public airports resides in the Fairbanks office of the AKDOT. He has the responsibility of establishing and maintaining airport maintenance contractors at rural villages. It is his job to supervise these contractors and ensure they have all the resources required to maintain their airports in good condition.

Air Carriers - The air carriers, as individual groups, are users of weather and runway condition reporting information. They are generally privately owned companies. These organizations fly 5 to 6 days a week to rural locations throughout the Interior. Daily GO/NO GO decisions are made by these companies based on weather and runway information gleaned through several sources: their agent in the village, official weather through the FAA, and official NOTAMs through the FAA. These companies earn revenue only if they complete flights into the surrounding villages hauling passengers, cargo and mail. Thus, there is a strong incentive to maximize awareness of weather and runway conditions.

Pilots - The pilot is the primary consumer of aviation weather and NOTAM information. The pilot actively uses all weather and NOTAM information possible to make a wise and credible decision as whether he should launch a flight into the bush. As a commercial pilot, he is generally employed by one of the air carriers. His decision as to whether or not to fly has immediate and direct implications for his customers. When current weather is not available through official sources, the pilot will often call his agent in the bush and ask for a "heads-up" as to current weather conditions even though the agent is not trained in weather collection. Improvement to the system must be validated by pilot feedback as to the usefulness of the new information. Indeed this is the strongest and most convincing measure of project success.

## CHAPTER 6

# Proposed Solution and Hypothesis

Chapter 6 integrates the results of the previous chapters to logically establish a proposed solution to the problems of poor runway and weather condition reporting in Interior Alaska. It then proceeds to articulate a formal hypothesis regarding weather reporting in particular. Section 6.1 compiles the results of runway condition conclusions and proposes a solution. Section 6.2 compiles the results of weather condition conclusions and proposes a solution. Section 6.3 articulates the formal hypothesis regarding the proposed weather reporting solution. Chapter 7 follows with a presentation of a project that was accomplished to test the proposed solution to weather reporting concerns.

Chapter 1 provided background on current reporting systems in Alaska. Chapter 2 followed with a statistical study on aviation accidents. Chapter 3 delineated the results of a literature search on the subject. Chapter 4 provided a formal analysis of the existing runway and weather reporting systems. Chapter 5 identified and analyzed the major stakeholders in a project to improve the existing system. This chapter combines the conclusions from each of the previous chapters to argue logically for a solution to the shortfalls of existing systems. While some quantitative method could be invoked to support the selection of the proposed solution, this is deemed inappropriate at this point in the study. The previous chapters have used quantitative methods to draw pertinent conclusions. Those conclusions are now presented and organized such that a logical solution may be extracted, presented, and in the case of weather reporting, tested.

## *6.1 - Integration of Runway Condition Reporting Findings*

### 6.1.1 - Compilation of Results

Table 6.1 presents the tabulated results and conclusions drawn from each previous chapter as applied to runway condition reporting issues. The conclusions have been grouped and sorted by category to accentuate the key issues that would govern the proposition of a successful solution to the reporting problem. These key issues are discussed by category and culminate in a recommendation or proposed solution.

Improve the Poor Runway Condition

The key conclusion is that our effort should be focused primarily on improving poor runway conditions as opposed to reporting poor runway conditions. We started our study with an expectation that the reporting system needed improvement. We have instead established that the primary opportunity for improvement lies in adjusting those factors that mitigate or reduce the existing runway problems. Having established this as our primary thrust, we have discovered in Table 6.1 that there are three primary shortfalls that need correction to remedy the problem: AKDOT policy, AKDOT supervision of maintenance contractors and training of maintenance contractors. These three shortfalls are highlighted in yellow, blue and green respectively in the table.

*AKDOT Policy* - Among the policy shortfalls, the primary problem as identified in Table 6.1 is resources, and specifically manpower. AKDOT does not set aside money for aviation needs within the state. Instead the regional director splits available resources between the competing maintenance requirements of highways and aviation. Highway needs are often given priority due to their high visibility within the populated areas. Aviation needs are somewhat out of sight and out of mind and generate less concern among administrators. This is a statewide problem that must be addressed at the state level. The current state budget shortfall impacts directly on the aviation maintenance backlog. However, AKDOT northern region airports manager states that while current funding levels are good, the real problem is manpower [38]. AKDOT resources are sufficient to support additional manpower, but internal support is lacking to ensure that additional manpower is secured in the regional airport office. This is discussed further in section 6.2.

| Category - Improve the Poor Runway Condition | | | | |
|---|---|---|---|---|
| **Conclusion/Finding** | **Primary Shortfall** | **Secondary Shortfall** | **Remark** | **Source of Info** |
| NTSB recommended that AKDOT participate in the FAA airport inspection program. | AKDOT Policy | Supervision of Contractor | Need Personnel and funds | Chapter 2 - Aviation Safety |
| We can influence factors that affect the runway condition | AKDOT Policy | Supervision of Contractor | Internal Change | Chapter 4 - System Analysis |
| Many rural runway environments are in disrepair. | AKDOT Policy | Supervision of Contractor | Need funds, supervision, training | Appendix A - Contractor Survey |
| Funding needs to be programmed for runway maintenance. | AKDOT Policy | | Need funds | Chapter 3 - Literature Search |
| Improving poor runway condition reduces the need for reporting poor runway condition and is the best way to reduce risk and reduce load on any existing reporting system. | AKDOT Policy | | Focus should be on mitigating poor conditions | Chapter 4 - System Analysis |
| No references on automated systems for collecting runway info that are applicable to Alaska. | Need Automated System | | Need to "SEE" the runway environment | Chapter 3 - Literature Search |
| Contractors feel qualified to plow snow on their runways. | No Shortfall | | Not necessarily to standard | Appendix A - Contractor Survey |
| Most pilots believe that airstrips are plowed within a reasonable time after a snowfall. | No Shortfall | | With exception of several specific airports. | Appendix B - Pilot Survey |
| Most pilots believe that the quality of snow clearing is adequate to safely operate their aircraft. | No Shortfall | | | Appendix B - Pilot Survey |
| Most pilots believe maintenance workers know how to operate their heavy equipment well enough to clear snow. | No Shortfall | | | Appendix B - Pilot Survey |
| Overall, pilots consider winter runway maintenance to be adequate. | **Supervision of Contractor** | Training for Contractor | Adequate, but not to standard. | Appendix B - Pilot Survey |

**Table 6.1** - Integration of Runway Reporting Conclusions (page 1)

| Category - Improve the Poor Runway Condition | | | | |
|---|---|---|---|---|
| **Conclusion/Finding** | **Primary Shortfall** | **Secondary Shortfall** | **Remark** | **Source of Info** |
| NTSB believes runway conditions contribute to accidents | Supervision of Contractor | Training for Contractor | Safety Incentive | Chapter 2 - Aviation Safety |
| Statistical Analysis indicates runway conditions are a causal factor in rural airport accidents accounting for 19% of such incidents. | Supervision of Contractor | Training for Contractor | Safety Incentive | Chapter 2 - Aviation Safety |
| Mitigating or reducing snow conditions on runways helps reduce risk | Supervision of Contractor | Training for Contractor | Safety Incentive | Chapter 3 - Literature Search |
| The maintenance contractor is the key individual in correcting poor runway conditions. Need to improve supervision and training aspects of maintenance contractor job. | Supervision of Contractor | Training for Contractor | Contractor is KEY | Chapter 4 - System Analysis |
| Nearly half of pilots feel they often have to land on a poorly plowed airstrip. | Supervision of Contractor | Training for Contractor | | Appendix B - Pilot Survey |
| Pilots rarely abort a flight due to poor runway conditions. | Supervision of Contractor | Training for Contractor | Safety Incentive. Pilots are going to land so condition must be fixed. | Appendix B - Pilot Survey |
| Need better supervision of Maint. Contractors | Supervision of Contractor | | | Chapter 1 - Background |
| Need to appraise contractors | Supervision of Contractor | | | Chapter 1 - Background |
| Need to discipline contractors | Supervision of Contractor | | | Chapter 1 - Background |
| Most contractors do not really conduct daily inspections of their runways as required by contract. | Supervision of Contractor | | | Appendix A - Contractor Survey |

**Table 6.1** - Integration of Runway Reporting Conclusions (page 2)

| Category - Improve the Poor Runway Condition | | | | |
|---|---|---|---|---|
| **Conclusion/Finding** | **Primary Shortfall** | **Secondary Shortfall** | **Remark** | **Source of Info** |
| 40% of surveyed contractors do not feel qualified to grade the surface of their runways. | Training for Contractor | AKDOT Policy | Train, then authorize contractor to repair. | Appendix A - Contractor Survey |
| Well trained, loyal competent operators are imperative. | Training for Contractor | Supervision of Contractor | | Chapter 3 - Literature Search |
| Need better training for Maint. Contractors | Training for Contractor | | | Chapter 1 - Background |
| Runway maintenance workers must be knowledgable | Training for Contractor | | | Chapter 3 - Literature Search |
| Runway maintenance workers need training resources (handbook) | Training for Contractor | | | Chapter 3 - Literature Search |
| Over half of maintenance contractors surveyed have had no formal training on the operation of heavy equipment. | Training for Contractor | | | Appendix A - Contractor Survey |
| Contractors that desired heavy equipment operations training did not receive any from AKDOT | Training for Contractor | | | Appendix A - Contractor Survey |
| Over half of maintenance contractors surveyed have had no formal training on the maintenance of heavy equipment. | Training for Contractor | | | Appendix A - Contractor Survey |
| Contractors sense the need for more maintenance training on their equipment. | Training for Contractor | | | Appendix A - Contractor Survey |
| **Category - Reporting System Problem** | | | | |
| Need to improve NOTAM verification procedure through AKDOT | AKDOT Policy | | Interpretation Issue | Chapter 4 - System Analysis |
| Over half of pilots indicate that they call someone in the village if runway conditions are reported as unfavorable. | AKDOT Policy | | Verification Issue | Appendix B - Pilot Survey |
| Pilots believe that once a NOTAM is in the FSS system, it is complete, specific and available to the pilot. | No Shortfall | | | Appendix B - Pilot Survey |
| Improving PIREP system could assist with improving runway reporting | PIREP Implementation | | Collection Issue | Chapter 4 - System Analysis |

**Table 6.1** - Integration of Runway Reporting Conclusions (page 3)

| Category - Reporting System Problem | | | | |
|---|---|---|---|---|
| **Conclusion/Finding** | **Primary Shortfall** | **Secondary Shortfall** | **Remark** | **Source of Info** |
| Runway maintenance workers must report NOTAMS | Supervision of Contractor | Training for Contractor | Collection Issue | Chapter 3 - Literature Search |
| State of the art for runway condition information is human or manual collection. | Supervision of Contractor | Training for Contractor | Collection Issue | Chapter 3 - Literature Search |
| There is not much sense of urgency among contractors about the importance of calling in NOTAMs. | Supervision of Contractor | Training for Contractor | Collection issue | Appendix A - Contractor Survey |
| Pilots believe there is a large margin for error in NOTAM reporting | Supervision of Contractor | Training for Contractor | Collection Issue | Appendix B - Pilot Survey |
| 44% of pilots feel that contractors do not regularly inspect their runways and therefore do not know when a reportable condition arises. | Supervision of Contractor | | Collection issue | Appendix B - Pilot Survey |
| Accurate runway condition reporting is not available at many sites. | Training for Contractor | Supervision of Contractor | Collection Issue | Chapter 2 - Aviation Safety |
| There is lack of understanding among contractors about what constitutes a reportable condition for NOTAMs. | Training for Contractor | | Collection Issue | Appendix A - Contractor Survey |
| Half of pilots believe that village contractors don't know what to report on a NOTAM | Training for Contractor | | Collection Issue | Appendix B - Pilot Survey |
| **Category - Stakeholder** | | | | |
| Air Carriers are primary stakeholders | Air Carrier Involvement | | They use the information. | Chapter 5 - Stakeholder Analysis |
| AKDOT is a primary stakeholder | AKDOT Policy | | They collect the information. | Chapter 5 - Stakeholder Analysis |
| FAA is a primary stakeholder | FAA Involvement | | They disseminate the information. | Chapter 5 - Stakeholder Analysis |
| Pilots are primary stakeholders | Pilot Involvement | | They use the information. | Chapter 5 - Stakeholder Analysis |

**Table 6.1** - Integration of Runway Reporting Conclusions (page 4)

*Supervision of Rural Maintenance Contractors* - Supervision of contractors is sorely lacking in rural Alaska. The blue highlighting in Table 6.1 demonstrates that most of the conclusions from the preceding chapters regarding runway condition problems could be addressed by increased supervision. AKDOT personnel in Interior Alaska average one or two trips per year to the airports under their control. These visits are relatively informal and do little to provide rural maintenance workers with incentive to strive for excellence in their work. Improvements in this single area could have a far-reaching impact on the responsiveness and loyalty of rural contractors. Additionally, it would help offset the lethargic attitude toward runway maintenance that is often prevalent among these maintenance workers when supervision is scarce.

*Training of Rural Maintenance Contractors* - Lack of training ensures substandard performance. Training is lacking among maintenance contractors. Table 6.1 establishes that many of the shortfalls identified previously could be addressed simply through more training. While supervision needs to be increased, additional oversight will be most beneficial if the contractors have been trained in the proper execution of their airport duties. This includes operation of equipment, maintenance of equipment and maintenance of appurtenances to the runway environment. Not only will this improve the contractors level of knowledge about how to perform his duties, but also it will provide a sense of ownership and loyalty that will result in better performance.

Improve the Reporting System

To the extent that the maintenance contractor cannot quickly improve poor runway conditions, these conditions must be efficiently and accurately reported through the NOTAM system. It is again emphasized that the load on the reporting system and the risk to pilots is greatly reduced if the poor conditions are corrected. Even if supervision and training are increased among rural contractors, the reporting system is an important element in the prevention of accidents and dissemination of critical information to pilots. Table 6.1 also establishes benefits to the reporting system through changes in AKDOT policy, increased supervision and training. These are articulated below.

*AKDOT Policy* - The verification of NOTAMs by AKDOT needs to be streamlined. The potential exists for a valid NOTAM not to be entered into the FSS system while it awaits verification by AKDOT personnel. Currently, that verification is performed by one individual and in his absence the verification process does not work. Pilots seeking to verify the accuracy of NOTAMs make unofficial calls to rural villagers to verify the reported runway problem. Pilots need a ways of conducting this verification process within the official reporting system.

*Supervision of Rural Maintenance Contractors* - While additional supervision will help correct poor runway condition problems before they need to be reported, additional oversight will also serve to improve the collection of derogatory runway information. The maintenance contractor has the primary official responsibility to recognize and report NOTAM information at his rural airport. This includes a contractual responsibility to physically inspect the airport daily. The whole reporting system is dependent upon this human element in the reporting chain. Supervision of this duty will increase the contractor's awareness of the importance of his job and also provide incentive to do it well.

*Training of Rural Maintenance Contractors* - Table 6.1 also clearly establishes the link between improved contractor training and improved reporting. During the physical inspection of the airport, contractors must understand what constitutes a reportable condition. Ignorance in this area may deny the user valuable information that is critical to flight safety. Many contractors have only a cursory understanding of the details of their contract regarding reportable conditions. Organized training on the part of AKDOT would improve knowledge in this area.

Involve the Right Stakeholders

Our stakeholder analysis revealed that air carriers, the AKDOT, the FAA and pilots are all stakeholders in the runway reporting system. To this extent, each of these entities must be considered in any proposed solution to runway condition problems. Air carriers and pilots are involved in the collection system to a small extent. They are at liberty to report poor runway conditions that must then be verified by AKDOT as stated previously. The pilots are key users of the system. AKDOT has primary collection responsibility through their maintenance contractors. Finally, the FAA through their FSS is directly involved in dissemination to end-users.

### 6.1.2 - Proposed Solution

AKDOT Northern Region should develop and execute programs to increase the level of supervision and training over rural airport maintenance contractors. It is anticipated that this will require one additional person to be hired in the regional airport manager's office to execute these programs. The office of the regional aviation manager at AKDOT is currently staffed one deep, excluding the secretary. For a period of about six months in 1999, an additional person was hired by DOT to assist the regional manager. For that period, the frequency of visits to rural airports increased dramatically. On 31 Dec 1999, the regional airport manager retired, his assistant took his place, and the assistant's position is now vacant.

Unfortunately, AKDOT management is not convinced that the assistant position needs to be filled. The current regional aviation manager feels strongly that he will be unable to fulfill his administrative responsibilities in the office and provide the required presence in the field to improve supervision and training. From the stakeholder analysis we see the need to involve AKDOT directly in these recommendations.

Great improvements in both maintenance of runways and reporting of poor runway conditions could be realized through improved supervision and training. Anticipated major improvements are listed below:

Immediate Benefits from Improved Supervision

1. AKDOT supervisor has first hand knowledge of the needs and current condition of the airport.
2. AKDOT supervisor has better understanding of strengths and weaknesses of contractor from which he can conduct formal employee appraisals.
3. AKDOT supervisor is better able to administer corrective measures to address problems.
4. AKDOT supervisor is able to provide on-the-spot corrections to contractors.
5. AKDOT supervisor is able to conduct formal inspections of airports on a regular basis that provides incentive for the contractor to know and execute the terms of his contract.
6. Maintenance contractor receives regular evaluation and feedback from his supervisor. This encourages those who are doing well to maintain their high standards. It provides a warning and incentive to do better for those who are not meeting the standards.
7. Maintenance contractor feels part of the AKDOT team and strives to do well.
8. Runways are plowed more quickly after a snowfall.
9. Runways are inspected more often and more thoroughly throughout the year.
10. Maintenance contractors are more diligent to maintain their equipment in anticipation of inspections by their supervisor.

Immediate Benefits from Training Program

1. AKDOT supervisor has more opportunity to see contractors at training sessions and provide guidance.
2. Maintenance contractor is more knowledgeable about how to operate heavy equipment.
3. Maintenance contractor is more knowledgeable about how to maintain heavy equipment.

4. Maintenance contractor is more knowledgeable about how to conduct daily inspections of the airport as required by contract.
5. Maintenance contractor is more knowledgeable about how to correct runway problems.
6. Maintenance contractors can exchange information and ideas about how to maintain their airports.
7. Maintenance contractor is more knowledgeable about what constitutes a reportable runway condition.
8. Maintenance contractor better understands AKDOT policies and expectations.

Long Term Benefits of Improved Supervision and Training

1. Runway maintenance is performed quickly, efficiently and to a standard in keeping with the contract.
2. The need for runway reporting is reduced because runway maintenance is improved.
3. Runway condition reporting through the NOTAM system is performed quickly and accurately.
4. Risk to pilots is reduced.
5. Pilots gain confidence in the accuracy of NOTAMs they receive through the FSS.
6. Service to aviation clients is improved.
7. Air carriers are more efficient in the conduct of aviation operations.

These benefits are consistent with what we anticipated in the system analysis of Chapter 4.

This constitutes the completion of our study regarding runway condition and runway condition reporting. Two additional resources are attached as appendices. Appendix C is an economic analysis of three alternatives for providing additional supervision or oversight to AKDOT contract maintenance personnel. It compares a "do nothing" alternative with the options of hiring a new AKDOT employee or hiring an independent contractor to provide supervision. It will be provided to AKDOT for their perusal as alternatives are considered. Appendix D is a practical training plan to address the shortfalls that have been discovered in the training of rural maintenance contractors. This will also be provided to AKDOT for their use in drafting or modifying training for the future. AKDOT has indicated an interest in these studies.

## *6.2 - Integration of Weather Condition Reporting Findings*

### 6.2.1 - Compilation of Results

Table 6.2 presents the tabulated results and conclusions drawn from each previous chapter as applied to weather condition reporting issues. These conclusions have also been grouped and sorted by category to bring out the important issues that will assist in proposing a solution to the weather reporting shortfalls. Unlike runway condition reporting, there is no way that we can affect a change in the factors that contribute to poor weather conditions. Therefore the focus is squarely on the system itself as far as proposing changes or improvements. As shown in Table 6.2, only two categories are obvious from the conclusions drawn previously: reporting system problems and stakeholder issues. We address these two categories below.

Improve the Reporting System

Table 6.2 provides strong evidence that the primary shortfall in the weather reporting system is related to collection of information. There appears to be no strong indication that there is any major problem in the transmission of information that has been collected. Regarding interpretation of information, there is evidence that the pilots perceive a missing human element with the onset of automated weather reporting. Finally regarding dissemination, it would be highly beneficial to pilots to have weather information delivered directly to the cockpit vice receiving it only during pre-flight. We recognize therefore three primary shortfalls or needs regarding the reporting system: new or improved visibility and sky condition collection resources; a missing human element in interpretation; and employment of remote video in collection. Each of these sub-areas is discussed below.

*New or Improved Visibility and Sky Condition Collection Resources* - Clearly, pilots believe that visibility and sky condition information is critical in flight planning and execution. However they also feel that these two critical elements are the ones they have the least confidence in as reported by automated systems. Both the reliability and the capability of visibility and sky condition (ceiling) collection resources need improvement.

Visibility sensors are not fully reliable in the extreme climatic conditions in Interior Alaska. Because official visibility measurements have implications as to the legality of VFR flight, reliability must be improved. Poor reliability involves both inaccuracies in reporting and failure to report altogether. The

| Category - Improve the Reporting System | | | |
|---|---|---|---|
| **Conclusion/Finding** | **Primary Shortfall or Need** | **Remark** | **Source of Info** |
| NTSB recommended an evaluation of remote color video to augment observing systems in Alaska in 1995 | Employ video in collection | | Chapter 2 - Aviation Safety |
| Remote video cameras have been used to discern distant weather information for the NWS. There is a potential to glean aviation weather information through use of imaging. | Employ video in collection | | Chapter 3 - Literature Search |
| Pilots would rather have human weather observers than an automated system. | Missing Human Element in Interpretation | | Appendix B - Pilot Survey |
| Weather collection systems lack the important ingredient of human perception, intelligence and subjective judgement. | Missing Human Element in Interpretation | | Chapter 3 - Literature Search |
| Need collection system that is more intuitive to the user. | Missing Human Element in Interpretation | | Chapter 3 - Literature Search |
| NTSB recognized a glaring lack of weather observing and reporting facilities in Alaska. | More collection facilities | | Chapter 2 - Aviation Safety |
| System improvements which could provide real time weather information in the cockpit would be ideal. | Need weather in the cockpit | | Chapter 3 - Literature Search |
| Pilots do not have confidence in the accuracy of visibility and sky condition reports from AWOS/ASOS | New or Improved Visibility and Sky Condition Collection | | Appendix B - Pilot Survey |
| Pilots believe that visibility and sky conditions are decidedly the most important pieces of information they can have about weather at a remote airstrip. | New or Improved Visibility and Sky Condition Collection | | Appendix B - Pilot Survey |
| Need current, accurate ceiling data | New or Improved Visibility and Sky Condition Collection | | Chapter 1 - Background |
| Need current, accurate visibility data | New or Improved Visibility and Sky Condition Collection | | Chapter 1 - Background |
| Improve existing systems or corroborate current data | New or Improved Visibility and Sky Condition Collection | | Chapter 1 - Background |
| AWOS has a history of problems with ceiling and visibility reporting | New or Improved Visibility and Sky Condition Collection | | Chapter 3 - Literature Search |

**Table 6.2** - Integration of Weather Reporting Conclusions (page 1)

| Category - Improve the Reporting System | | | |
|---|---|---|---|
| Conclusion/Finding | Primary Shortfall or Need | Remark | Source of Info |
| The aviation community wants better information about ceiling and visibility | New or Improved Visibility and Sky Condition Collection | | Chapter 3 - Literature Search |
| ASOS Ceiling measurements are not applicable to areas distant from the airport (I.e. distant cloud information) | New or Improved Visibility and Sky Condition Collection | | Chapter 3 - Literature Search |
| ASOS visibility measurements cannot provide information about visibility distant from airport. | New or Improved Visibility and Sky Condition Collection | | Chapter 3 - Literature Search |
| ASOS cannot provide information about distant clouds, thunderstorm information, blowing snow, dust, smoke or haze. Important to overall weather picture. | New or Improved Visibility and Sky Condition Collection | | Chapter 3 - Literature Search |
| Need collection systems that can reach out and get information at a distance. | New or Improved Visibility and Sky Condition Collection | | Chapter 3 - Literature Search |
| Need systems to provide backup to ASOS failure...especially at rural airports where visibility and ceiling information is critical for VFR flights. | New or Improved Visibility and Sky Condition Collection | | Chapter 3 - Literature Search |
| Greatest shortfall is in the area of collection of visibility and ceiling information as opposed to transmission, interpretation or dissemination. | New or Improved Visibility and Sky Condition Collection | | Chapter 4 - System Analysis |
| Ceiling and visibility reports produced by ASOS and AWOS must either be improved, replaced or enhanced by another collection means. | New or Improved Visibility and Sky Condition Collection | | Chapter 4 - System Analysis |
| 32% of accidents in past due to weather related conditions | New or Improved Visibility and Sky Condition Collection | | Chapter 2 - Aviation Safety |
| Pilots are reasonably confident in the accuracy of AWOS/ASOS temperature, dew point, wind speed, wind direction and altimeter reports. | No Shortfall | Keep these aspects of ASOS | Appendix B - Pilot Survey |

**Table 6.2** - Integration of Weather Reporting Conclusions (page 2)

| Category - Improve the Reporting System | | | |
|---|---|---|---|
| **Conclusion/Finding** | **Primary Shortfall or Need** | **Remark** | **Source of Info** |
| ASOS and manual observations are different. ASOS provides point information integrated over time, manual provides instant values integrated over space. | No Shortfall | | Chapter 3 - Literature Search |
| Modular enhancements to ASOS would be ideal since they can provide both stand alone information and corroborate existing information. Capitalizes on existing power, structure and telecommunications requirements. | No Shortfall | Changes to existing system should be an enhancement to ASOS | Chapter 3 - Literature Search |
| We cannot influence the factors that affect the weather. | No Shortfall | Must change elements of system | Chapter 4 - System Analysis |
| Emphasis must be on improving the weather reporting system. | No Shortfall | Must change elements of system | Chapter 4 - System Analysis |
| The primary agencies that would be involved in improvements to weather collection are the FAA and the NWS. | No Shortfall | Involve FAA and NWS | Chapter 4 - System Analysis |
| Changes or modifications to the transmission, interpretation or dissemination modules of the reporting system affords little opportunity for improvement in basic weaknesses. | No Shortfall | Collection is the weak link in the system. | Chapter 4 - System Analysis |
| **Category - Stakeholder** | | | |
| FAA is a primary stakeholder | No Shortfall | Involve FAA | Chapter 5 - Stakeholder Analysis |
| NWS is a primary stakeholder | No Shortfall | Involve NWS | Chapter 5 - Stakeholder Analysis |
| Pilots are primary stakeholders | No Shortfall | Involve Pilots | Chapter 5 - Stakeholder Analysis |
| Air Carriers are primary stakeholders | No Shortfall | Involve Air Carriers | Chapter 5 - Stakeholder Analysis |

**Table 6.2** - Integration of Weather Reporting Conclusions (page 3)

former is the most concerning because it may lure unsuspecting pilots into dangerous conditions. The capability of visibility sensors is also lacking. The sensors determine approximate visibility over a small three foot distance and extrapolate that data to apply to the surrounding area. While this may be acceptable when the sensor is located in the touchdown zone on the runway, it is completely unable to discern varying visibility conditions in different directions. Thus there may be 5 miles of visibility to the south, 2 miles to the north, and 3 miles at the location of the sensor. The sensor is only capable of reporting the 3-mile visibility data that may be completely unrepresentative of the surrounding area.

Sky condition sensors also lack reliability. Ice fog, extreme low temperatures and other arctic phenomenon may cause the vertically oriented laser ceilometer to report completely inaccurate information about cloud heights and layers. The capability of sky condition sensors is also greatly limited because they look only at a small area of the celestial dome directly above the sensor and average conditions over time to produce information. They have no capability to discern conditions laterally around the sensor. Therefore, information on distant ground fog, distant thunderstorms, blowing snow, sand or smoke, and cloud types cannot be determined or reported.

Our proposed solution should improve on these shortfalls and also provide some method to corroborate reported data. For example, if the visibility sensor states that visibility is 3 miles, then some redundant system that could confirm or deny the accuracy of that data would be ideal.

*Missing Human Element in Interpretation of Information* - Most weather information is reported either graphically (satellite imagery), or in written form. That information may then be relayed in verbal form directly to a pilot in person, over the phone or as a radio broadcast. Automated reporting systems such as ASOS produce very succinct, quantitative data which is lacking a human element. Pilots appreciated the human interface that was provided by contract weather observers. The pilot could ask questions like "how does it look to the east", or "when do you think the snow will start falling". With the demise of the contract weather observer as a primary weather collection resource, pilots have lost the comfort of human involvement in the process. Since the pilot was physically removed form the location where the weather was occurring, he had no gut feeling about true conditions. Any solution that would help restore a sense of intuitive understanding or human involvement in the visualization of the weather would be a strong step in the right direction. We will seek such an opportunity in our proposed solution.

*Employ Remote Video Cameras in Collection* - This single piece of information, gleaned from both aviation safety studies and from an exhaustive literature search, has great promise. The fact is that remote video has been tested in the past as an information collection device. However, poor resolution, and technical complexity rendered this option difficult to incorporate. With the continuing evolution of remote video technology and telecommunications, there is promise that the idea of using cameras to collect distant weather information is perhaps a great hidden secret whose time has arrived. The NWS has successfully used remote video to collect near real-time imagery of distant locations for use in observation and forecasting. However, widespread use of such systems specifically for aviation has not been realized.

Involve the Right Stakeholders

Our stakeholder analysis established that the FAA, the NWS, air carriers and pilots are the primary stakeholders in weather reporting systems. Each of these entities should be consulted and involved in the testing of improved solutions to weather reporting shortfalls. The NWS is directly involved in the collection and interpretation of weather information. The FAA is involved in collection, and dissemination of weather data. Air carriers and pilots are users of the information thus collected. Pilots may also be directly involved in information collection through the PIREP program. The PIREP program was discussed under runway condition reporting and will not be reevaluated here.

### 6.2.2 - Proposed Solution

All of the preceding research provides strong support to the following recommendation. Remote video camera technology should be added as a collection resource to existing systems. The purpose of the cameras will be to collect near real-time images of the sky and horizon in several different cardinal directions around the camera location. These images will be transmitted electronically from the point of collection back to a hub location where they can be disseminated to users. The anticipated application is to push images onto a publicly accessible web site where any user can access them. Each live image will be accompanied on the screen by a clear-day image. The purpose of this comparison image will be to provide the user with a visualization of what would be visible on a clear-day so that the implications of the current image are evident. The clear-day image should be annotated with information such as elevation of distant terrain, distance to distant terrain, names and distances to familiar man-made landmarks, etc.

This proposed solution meets all of the criteria established above. Anticipated benefits of the addition of remote video technology are provided below:

<u>Immediate Benefits from Use of Remote Video Cameras for Information Collection</u>

1. Images provide a new visibility and sky condition collection resource that is completely different in nature from existing sensors. It provides visibility and sky condition information with an image instead of a sensor. This provides corroborating information to be used for comparison with existing sensor information.
2. Images provide reliability that existing visibility and sky condition sensors do not. If the image is current and clear, then the visibility and sky condition information is intuitive and obvious and should not be easily mistaken.
3. Images provide a capability that existing visibility sensors do not have. Images will allow the user to see distant visibility conditions in all surrounding quadrants as opposed to mechanically determining visibility in the immediate area of the collection resource and extrapolating to surrounding conditions.
4. Images provide a capability that existing sky condition sensors do not have. Images will allow the user to see distant sky condition information in all surrounding quadrants. This will provide information about cloud types, ceiling, blowing obstructions (sand, snow, smoke etc.) and directional trends.
5. Images provide a redundant system to existing visibility collection sensors. If the existing sensor reports ¼ mile visibility, the image can determine if the condition is widespread or localized.
6. Images provide a redundant system to existing sky condition collection sensors. If the existing sensor reports cloud ceilings of 1000 feet, the image can determine if the sky condition is widespread or localized.
7. Images help restore the human element in weather collection. The idea of looking at a current image of a distant location allows the pilot to assume a sense of "being there". It provides the pilot with an intuitive look at existing conditions, which provides an immediate representation of the sky that needs no formal interpretation. It is as if the pilot is in the distant location looking out the window at current weather conditions. This helps restore the sense of visualization that has been lost with the demise of the weather observer.
8. Images in digital form may be uploaded to cockpit graphic displays allowing pilots to see conditions ahead of them while en route.
9. Images provided over the Internet to a website will be immediately accessible to the aviation community and will not require any formal interpretation through aviation or weather agencies. The intuitive nature of the image provides not only data, but also usable information without any additional intervention.

10. Images may also be immediately integrated into major stakeholders' systems to provide them with a new capability for collection of weather information.
    a. The FAA may use the images in the FSS to conduct pre-flight or in-flight briefings.
    b. The NWS may use the images to conduct observations or for forecasting.
    c. Pilots may use the images directly off the Internet.
    d. Air Carrier administrators may use the images to help anticipate delays, thus providing better information to those they service.
11. Cameras oriented at various aspects of the runway environment may also provide valuable runway condition information. This is an added benefit that was not immediately obvious in our evaluation of runway condition system improvements.

<u>Long Term Benefits of Use of Remote Video Cameras for Information Collection</u>

1. Pilots will conduct safer aviation operations
    a. They will have better, more intuitive information about the weather they will encounter as they fly.
    b. They will be able to make wiser decisions about whether to initiate a flight to a particular location.
    c. Inexperienced pilots will be able to make decisions about whether or not to fly based on an intuitive understanding of the weather ahead instead of having to interpret written reports.
2. Air Carriers will conduct more efficient aviation operations
    a. They will cancel flights that cannot be completed due to poor weather at destination locations. This will save money.
    b. They will launch flights that can be completed even when existing automated systems indicate (incorrectly) that weather conditions are poor.
    c. In both circumstances, passengers, cargo and mail missions will become more efficient.
3. Aviation services will be improved for clients
    a. Passengers will be less likely to board flights that cannot be completed because carriers will cancel flights that cannot be completed.
    b. Mail and cargo service will improve, as carriers become more efficient with the use of the new information.

This section represents a major benchmark in our research. As mentioned in section 6.2.2 we have essentially terminated our investigation of runway condition issues. We will now doggedly pursue the implementation of a test to determine the benefits that may accrue from the use of remote video in weather condition reporting in Interior Alaska. Our primary intent is to discern what capabilities will accrue to users of a remote video weather collection system in terms of visibility and sky condition information.

## *6.3 - Hypothesis*

The following hypothesis is established as a guide for the subsequent research and testing into the use of remote video as a weather collection resource for rural airports in Interior Alaska.

> Remote color video cameras may be used as an aviation collection resource at rural village airports in Interior Alaska. The following capabilities and benefits will accrue to the end-users:

1. Visibility Related

    a. Quantitative visibility information may be obtained.
    b. Qualitative visibility information may be obtained.
    c. Visibility information may be used to corroborate the accuracy of ASOS/AWOS sensors.

2. Sky Condition Related

    a. Quantitative sky condition (ceiling) information may be obtained.
    b. Qualitative sky condition information may be obtained which is not available through other weather collection resources.
    c. Sky condition information may be used to corroborate the accuracy of the ASOS/AWOS ceilometer.

3. User Related

    a. FAA

        1) The FAA, as a primary stakeholder, will support the concept
        2) The FAA FSS will determine that images add accuracy to their briefings
        3) The FAA FSS will determine that images add completeness to their briefings
        4) FAA FSS personnel will desire this technology for operational use

b. NWS

1) The NWS, as a primary stakeholder, will support the concept
2) The NWS will determine that images can be helpful in preparing NWS weather products.
3) The NWS will desire this technology for operational use

c. Pilots

1) Pilots will find the images useful in making decisions to launch, cancel or delay flights.
2) Pilots will be very supportive of the concept as end-users
3) Pilots will find that images provide weather information that they cannot get through any other source. Specifically:
    - Ceiling information
    - Visibility information
    - Fog
    - Local Precipitation
    - Cloud Types
    - Other Data

d. General Comments

1) The aviation community will embrace the concept and use it.
2) Once the aviation community recognizes the benefits of such images, they will demand images from other locations throughout the state.

## CHAPTER 7

# The FlightCam Project

Chapter 7 provides a detailed overview of the research project which was undertaken to determine the capabilities and benefits of employing remote video technology in the collection of weather information at rural airports in Interior Alaska. Section 7.1 is a statement of the concept of the project. Section 7.2 presents the feasibility study that was conducted in anticipation of research funding. Section 7.3 is a detailed explanation of the conduct of the FlightCam project. Chapter 8 follows with an analysis of the project data and a logical proof of the hypothesis stated in Chapter 6.

### *7.1 - Concept*

A research project was conceived to demonstrate to the aviation community the significant improvements in weather and runway condition information reporting which could be realized through an effective, yet comparatively inexpensive technology. The project involved the use of remote video camera systems positioned at rural airports to collect near real-time images of airport and weather conditions and to make them available over the Internet for flight planning.

For example, a pilot who is planning a flight to a remote village in rural Alaska will often find that the local FAA FSS cannot provide him with specific information about current weather conditions at the airport due to a lack of weather collection resources. Similarly, the FSS will be unable to verify if the runway is clear of snow or obstructions unless the AKDOT contract maintenance worker at that village happened to call in and make a report. As a result, a pilot hauling mail, cargo, passengers or hunting buddies may fly hundreds of miles to the remote location only to find that the visibility is too poor, the ceiling is too low, or the runway is too snow-covered to permit a safe and legal landing. Similarly, the pilot may be tempted to continue into deteriorating weather conditions in order to complete a flight that he never would have attempted given more accurate information. This is an inefficient and unsafe way to conduct business or pleasure flights.

Remote video technology would allow this pilot to sit at his computer, log-on to an Internet website, click the button for the distant location and see a current image of the runway, and two sectors of the sky hundreds of miles away (Figure 7.1). He could then make a more informed decision, in a low stress environment, about whether he could safely complete the flight.

The need for remote video for weather condition reporting is relatively constant throughout the year. Visibility and sky conditions can be just as restrictive during summer months as during winter. Winter ice fog poses a particular seasonal visibility probiem that could be detected by remote video. A single image showing low overcast, and obscuration of nearby terrain at a remote site, may be sufficient to convince a pilot that operations into that location are questionable, if not unsafe. Images of the horizon can be positioned on the screen adjacent to an image of the same horizon on a clear day. The clear day image can be labeled with distance and elevation information to assist in determining visibility and ceiling respectively when compared with the current image. In this fashion, the image may be effective in ascertaining quantitative information. The images can be posted on an Internet web-site and thus made available to the flying public. The images may also be provided to the NWS and/or the FAA FSS to clarify automated reports or NOTAM information.

## *7.2 - Feasibility Study*

A feasibility study was conducted in the summer of 1998 [8]. It was a two-month project whose purpose was threefold: 1) to determine if it was technically feasible to execute such a project in rural Alaska; 2) to determine if the stakeholders in the project had sufficient interest; and 3) to select the three best locations at which to conduct a test of remote video technology. The author conducted the study with a $2,000 grant from the UAA, Aviation Technology Center.

### 7.2.1 - Technical Feasibility

Technical feasibility was confirmed in this preliminary study. It was determined that the hardware and software necessary to move an image from a distant location to an Internet website was available but would require slight modifications. The hardware appeared to meet the basic requirements for operation in an arctic environment. The setup included the use of an environmental housing for the cameras that provided heat in the winter and cooling in the summer. The minimum infrastructure requirements for the system included a structure to mount the cameras on, electrical power and telecommunications. Most villages in Interior Alaska meet these basic requirements. In section 7.2.3.1, these requirements are established as feasibility criteria in the selection of the best sites at which to test the system. Sites without this basic infrastructure were dropped from further consideration.

### 7.2.2 - Stakeholder Interest

Stakeholder support for the use of remote video for weather collection was determined to be strong:

FAA - The FAA had been charged by the NTSB in 1995 to investigate the use of remote video for weather reporting [37]. It was assumed therefore that the FAA would readily accept any assistance in the evaluation of such a system. The FAA was fully engaged at this point in a program called Flight 2000 that could potentially make use of imaging technology. It was later discovered that the FAA had already been provided with a Federal appropriation to execute a test of remote video, but was proceeding very slowly in the execution.

NWS - The NWS had received the same charge from the NTSB. They were testing a remote video system in Valdez, Alaska at this time with the intent of supporting an ongoing NWS study on the use of remote video for enhancing NWS products. This technology had been successfully demonstrated by the NWS in Utah as well [6]. They currently maintain an Internet web-site that displays hourly video images from several locations around the state. They have pioneered a "Total Observation Concept" which integrates video technology, AWOS and satellite imagery into a single graphic report that may be accessed by the general public [10].

AKDOT - Discussions with AKDOT provided strong evidence that they would support a program to enhance the NOTAM reporting system at rural Alaskan airports.

Pilots - Surveys conducted during the summer of 1998 confirmed that pilots would be in support of such a weather collection resource (Appendix B). The pilots were considered the primary users of improved weather information. 85% of pilots that were surveyed indicated that they would be interested in using remote video during pre-flight to help ascertain current weather information. Additional survey information established that over 35% of pilots had flown to remote locations and been surprised by poor visibility or low ceilings which they had not anticipated. Thus the need and incentive to perform further research was established.

## 7.2.3 - Selection of Test Sites

The primary focus of the feasibility study was to select the top three locations at which to conduct a test of the use of remote video for collecting runway and weather information. This section explains the method that was used initially to select test site locations.

### *7.2.3.1 - Approach: Model for Selection of Airports*

A sequential process was used to select the best qualified of twenty-three airports in Interior Alaska to serve as test locations for remote video. The process first included a screen for feasibility. Then a combination of the Analytic Hierarchy Process (AHP), and Multi-Attribute Utility analysis (MAU) was used to optimize the selection of the top three locations. These steps are detailed below.

Screen for Feasibility

A feasibility screen was conducted to limit the number of airports to those that met basic criteria necessary for the employment of remote video. Four feasibility criteria were established as follows:

1. Structure - The airport must currently have on site either an AKDOT maintenance building, a NWS ASOS site, or an old FAA FSS building to serve as a mounting structure for the system. This criterion was specifically included to preclude a lengthy and expensive requirement to construct a supporting structure for the cameras. It was later recognized that use of federal or state facilities would directly involve major stakeholders and create a sense of ownership which would enhance the likelihood of success of the project. Table 7.1 provides a tabulation of information by airport, to include the type of mounting structure on site.

2. Telecommunications - The village adjacent the airport must have an existing telecommunications network that can service the proposed mounting structure. Generally speaking this meant that there must be ground-based long distance telephone service in the village. It also required that the local phone company be able to connect a telephone line to the proposed mounting structure at a standard installation cost. The local telephone company for each of the 23 villages was contacted to ascertain installation and operating costs.

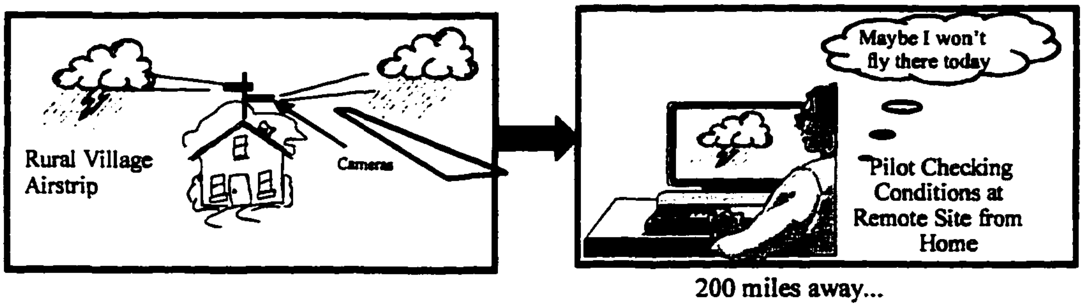



**Figure 7.1** - Schematic of Remote Video System

| RURAL AIRPORT | Runway Condition Reporting Sources | | Weather Condition Reporting Sources | | | | Mounting Structure | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Contract Maintenance Worker | Road Crew | AWOS | Contract Weather Observer | Satellite Coverage | Ground Based Sources? | DOT | NWS | FAA | Private | None |
| Allakaket | X | | | | X | No | X | | | | |
| Beaver | X | | | | X | No | X | | | | |
| Bettles | X | | X | X | X | Yes | | X | X | | |
| Birch Creek | X | | | | X | No | X | | | | |
| Central | | X | | | X | No | | | | | X |
| Chalkyitsik | X | | | | X | No | X | | | | |
| Chicken | X | | | | X | No | X | | | | |
| Circle City | X | | | X | X | Yes | | | | | X |
| Circle Hot Springs | | X | | | X | No | | | | | X |
| Eagle | X | | X | | X | Yes | | X | | | |
| Fort Yukon | X | | X | | X | Yes | | X | | X | |
| Hughes | X | | | | X | No | X | | | | |
| Huslia | X | | X | | X | Yes | X | X | | | |
| Kaltag | X | | X | | X | Yes | X | X | | | |
| Koyukuk | X | | | | X | No | X | | | | |
| Manley Hot Springs | | X | | X | X | Yes | | | | X | |
| Minchumina | X | | X | | X | Yes | X | X | X | | |
| Minto | | X | | | X | No | | | | | X |
| Nulato | X | | | | X | No | | | | X | |
| Rampart | X | | | | X | No | X | | | | |
| Stevens Village | X | | | | X | No | X | | | | |
| Tanana | X | | X | X | X | Yes | X | X | X | | |
| Tok | | X | | | X | No | | | | X | |
| X - Indicates presence of indicated resource at this location | | | | | | | Preferred Structure | | | | |

**Table 7.1** - Airports versus Reporting Sources and Mounting Structures

3. Line-of-Sight - There must be line-of-sight between the proposed mounting location of the camera and the closest section of visible runway. If the runway was completely obscured, the village was deemed infeasible as a test location. As long as a portion of the runway was visible, the village was retained on the list.

4. Postal Service - The village adjacent the airport must have regular mail delivery by air. This would ensure a high volume of air carriers to that location from which feedback could be collected regarding the benefits of remote video.

The availability of electrical power was initially established as a feasibility criterion. Once it was determined that every village had power, this was dropped from the feasibility screen.

As a result of the feasibility screen, nine airports were deemed infeasible and dropped from further consideration. Table 7.2 tabulates these results and shows the application of these four criteria by airport. Shaded rows indicate infeasible airports. The last column states the reason for unfeasibility.

Integration of AHP and MAU

MAU and AHP are both well established in their roles as decision-making models. MAU was invoked as the prevailing structure for this model for two reasons: the predominantly quantitative nature of the data used for comparison of alternative airports, and a fairly straightforward conversion of this data into a measure of utility [15]. Determination of the relative importance of competing criteria was much more subjective. Pairwise comparison, a strength of AHP, was employed in the calculation of criteria weights [22]. This integration of the two models proved to be efficient and robust in this application.

Criteria for Comparison of Alternatives

The twelve specific information requirements needed to provide input to the model were used as decision criteria. They were grouped into three categories; three under General Criteria (G1 through G3), five under Runway Condition Criteria (R1 through R5), and four under Weather Condition Criteria (W1 through W4).

Three different types of utility curves and a look-up table were invoked to convert both quantitative and qualitative measures of criteria into utiles.

1. Linear (Continuous) – R1 and R2 in Figure 7.2b & 7.2c.
2. Linear (Discontinuous) – R4 in Figure 7.2d.
3. Non-Linear (Continuous) – G2 in Figure 7.2a.
4. Table Look-Up – G1, G3, R3, R5, W1, W2, W3, and W4 in Table 7.3.

An explanation of each of the criteria is provided below:

*G1: Receptivity of Village* – This criterion represents the willingness of the village populous to host a remote video test at their airport. It includes concerns over potential vandalism of equipment. Scoring was subjective based on discussions with villagers, interviews with contract maintenance workers and feedback from the regional airport manager. It was assumed that the further the airport was from the village, the less likely villagers would be to reject the imposition of a video camera at their locale.

*G2: Accessibility from Fairbanks* - Accessibility is concerned primarily with transportation by light plane to remote sites to conduct system maintenance. Any new system will require adjustment, cleaning and repositioning. Test sites close to Fairbanks will minimize time and money spent on travel. As daylight becomes a scarce commodity in winter months, a one-day maintenance trip quickly grows to two for distant sites. The utility curve used to represent these considerations is shown in Figure 7.2a. The absolute slope increases radically in the region where trips are extended to two days.

*G3: Ease of Installation and Accessibility of Structure* - Each type of mounting structure is different. The AKDOT and FAA structures have a roof on which a small platform could be mounted to support the video cameras. The NWS sites are modular in construction and would require a more sophisticated design approved by the NWS. Structures allowing easy installation and state approval scored highest.

*R1: Distance from Camera to Runway* - The distance from the proposed camera location to the nearest section of runway at which the camera would be aimed constitutes this attribute. Closer is better because it implies more detail in the image and an improved likelihood of being able to extract useful information about runway condition. Figure 7.2b depicts the associated utility curve.

*R2: Orientation of Runway from Camera* - The orientation of the camera to the runway differs at each site. Some proposed camera locations look perpendicularly across the runway. Others look obliquely down the runway. It is expected that the oblique view is more likely to give valuable information about current runway conditions because more of the runway can be seen. Figure 7.2c shows an appropriate utility curve.

*R3: Cardinal Direction to Runway* - The video image quality is anticipated to be best when the sun is behind the camera. Since the runway image will be beneficial primarily in the winter months to determine the status of snow plowing, a north-facing camera should be best, as this will provide light from a southern sky on the object in focus. This benefit is reflected in Table 7.3

*R4: Visible Length of Runway* - This is the length of runway that can be viewed by the camera given the orientation mentioned above. The assumption is that the more of the runway which can be seen, the greater the ability to determine its condition. Regarding snow plowing operations, the best information will answer the question "has the plowing operation begun?" with the expectation that once begun, it will be completed. Additionally we may be able to determine if there is new snow and thus a need for plowing. It is anticipated that the video image will be unable to provide useful information about runway condition beyond 2000 feet. With this exception, conversion to utiles was fairly linear. Figure 7.2d demonstrates this discontinuity in the otherwise linear utility curve.

*R5: Need for Runway Condition Reporting* - A determination of need at a particular site is not critical for a test case, but it is helpful. In order to validate the usefulness of the system, users will be queried about their use of the system and its value to them. If the camera is located at an airport where there is a perceived need for runway condition reporting, cooperation from air carriers will be improved.

*W1: Use of Surrounding Terrain for Ceiling Determination* - While the resolution of video images is sufficient to make some estimation of ceiling, this can be accomplished with much greater accuracy when there are terrain relief features on the horizon. These features will be annotated in the clear-day image to allow for a comparison with the current image. To this extent, more visible terrain with varied elevations is best.

*W2: Use of Surrounding Terrain for Visibility Determination* - Visibility can be best confirmed by video if there are terrain features on the horizon at known distances from the camera. Sites with relief features at various distances scored the highest.

*W3: Line of Sight from Camera to Terrain* - Line-of-sight from the camera to terrain on the horizon is necessary if surrounding terrain is to be used to gather accurate visibility and ceiling information.

| | General Feasibility Criteria | | | | Runway Feasibility Criteria | Feasible? | Reason Not Feasible |
|---|---|---|---|---|---|---|---|
| **RURAL AIRPORT** | *Is there an elevated Structure for mounting the camera on site?* * | *Is Electrical Power Available?* | *Is Telephone Communication (TELCOM) Available?* | *Does village have regular mail delivery?* | *Can the runway be seen from the proposed camera location?* | *Is this airport feasible as a test site based the criteria?* | |
| Allakaket | Yes - DOT | Yes | Yes | Yes | Yes | | |
| Beaver | Yes - DOT | Yes | Yes | Yes | Yes | | |
| Bettles | Yes - NWS/FAA | Yes | Yes | Yes | Yes - FAA | | |
| Birch Creek | Yes - DOT | Yes | Yes | Yes | Yes | | |
| Central | No | Yes | Yes | Yes | - | No | No mounting structure |
| Chalkyitsik | Yes - DOT | Yes | Yes | Yes | Yes | | |
| Chicken | Yes - DOT | Yes | No | Yes | Yes | No | No Telecommunications |
| Circle City | No | Yes | Yes | Yes | | No | No mounting structure |
| Circle Hot Springs | No | Yes | Yes | | | No | No mail delivery |
| Eagle | Yes - NWS | Yes | Yes | Yes | Yes | | |
| Fort Yukon | Yes - NWS/Private | Yes | Yes | Yes | No | No | No runway line of sight from NWS facility |
| Hughes | Yes - DOT | Yes | Yes | Yes | Yes | | |
| Huslia | Yes - DOT/NWS | Yes | Yes | Yes | Yes - DOT | | |
| Kaltag | Yes - DOT/NWS | Yes | Yes | Yes | Yes - DOT/NWS | | |
| Koyukuk | Yes - DOT | Yes | Yes | Yes | Yes | | |
| Manley Hot Springs | No - Private Only | Yes | Yes | Yes | | No | Private mounting structure |
| Minchumina | Yes - NWS/FAA/DOT | Yes | Yes | Yes | Yes - NWS/FAA | | |
| Minto | No | Yes | Yes | Yes | | No | No mounting structure |
| Nulato | No - Private Only | Yes | Yes | Yes | | No | Private mounting structure |
| Rampart | Yes - DOT | Yes | Yes | Yes | Yes | | |
| Stevens Village | Yes - DOT | Yes | Yes | Yes | Yes | | |
| Tanana | Yes - DOT/NWS/FAA | Yes | Yes | Yes | Yes - FAA/NWS | | |
| Tok | No - Private Only | Yes | Yes | Yes | | No | Private mounting structure |
| * Indicates agency which owns structure | | | | | | | |

**Table 7.2** - Airport Feasibility Screen

| e. Table Look-Up | | | | | | |
|---|---|---|---|---|---|---|
| **Criterion** | **Score** | | | | | |
| **G1 - Receptivity of Village** | a. Raw Score | 1 | 2 | 3 | 4 | 5 |
| *Subjective score based on visits to villages* | b. Utiles | 2.0 | 4.0 | 6.0 | 8.0 | 10.0 |
| **G3 - Ease of Installation/Accessibility of Structure** | a. Raw Data | NWS Site | | FAA Site | | DOT Site |
| *Raw data lists owner of camera mounting structure* | b. Utiles | 2.0 | | 6.0 | | 10.0 |
| **R3 - Cardinal Direction to Runway** - Raw data is | a. Raw Data | S | SW,SE | E,W | NW,NE | N |
| *direction. N - North, W - West, E - East, S - South.* | b. Utiles | 2.0 | 4.0 | 6.0 | 8.0 | 10.0 |
| **R5 - Need for Runway Condition Reporting** | a. Raw Data | 0 | 1 | 2 | 3 | 6 |
| *From pilot survey, raw score is number of times pilots selected this location.* | b. Utiles | 1.0 | 2.5 | 4.0 | 5.5 | 6.0 |
| **W1 - Use of Terrain for Ceiling Determination** | a. Raw Score | 1 | 2 | 3 | 4 | 5 |
| *Higher and closer terrain, gets the highest score.* | b. Utiles | 2.0 | 4.0 | 6.0 | 8.0 | 10.0 |
| **W2 - Use of Terrain for Visibility Determination** | a. Raw Score | 1 | 2 | 3 | 4 | 5 |
| *Terrain at varying distances scored highest.* | b. Utiles | 2.0 | 4.0 | 8.0 | 8.0 | 10.0 |
| **W3 - Line of Sight from Camera to Terrain** | a. Raw Score | 1 | 2 | 3 | 4 | 5 |
| *The fewer the obstructions, the higher the raw score.* | b. Utiles | 2.0 | 4.0 | 6.0 | 8.0 | 10.0 |
| **W4 - Need for Weather Condition Reporting** | a. Raw Data | 0 | 1 | 3 | 4 | 6 |
| *From pilot survey, raw score is number of times pilots selected this location.* | b. Utiles | 1.0 | 2.5 | 5.5 | 7.0 | 10.0 |

**Table 7.3** - Table Look-Up

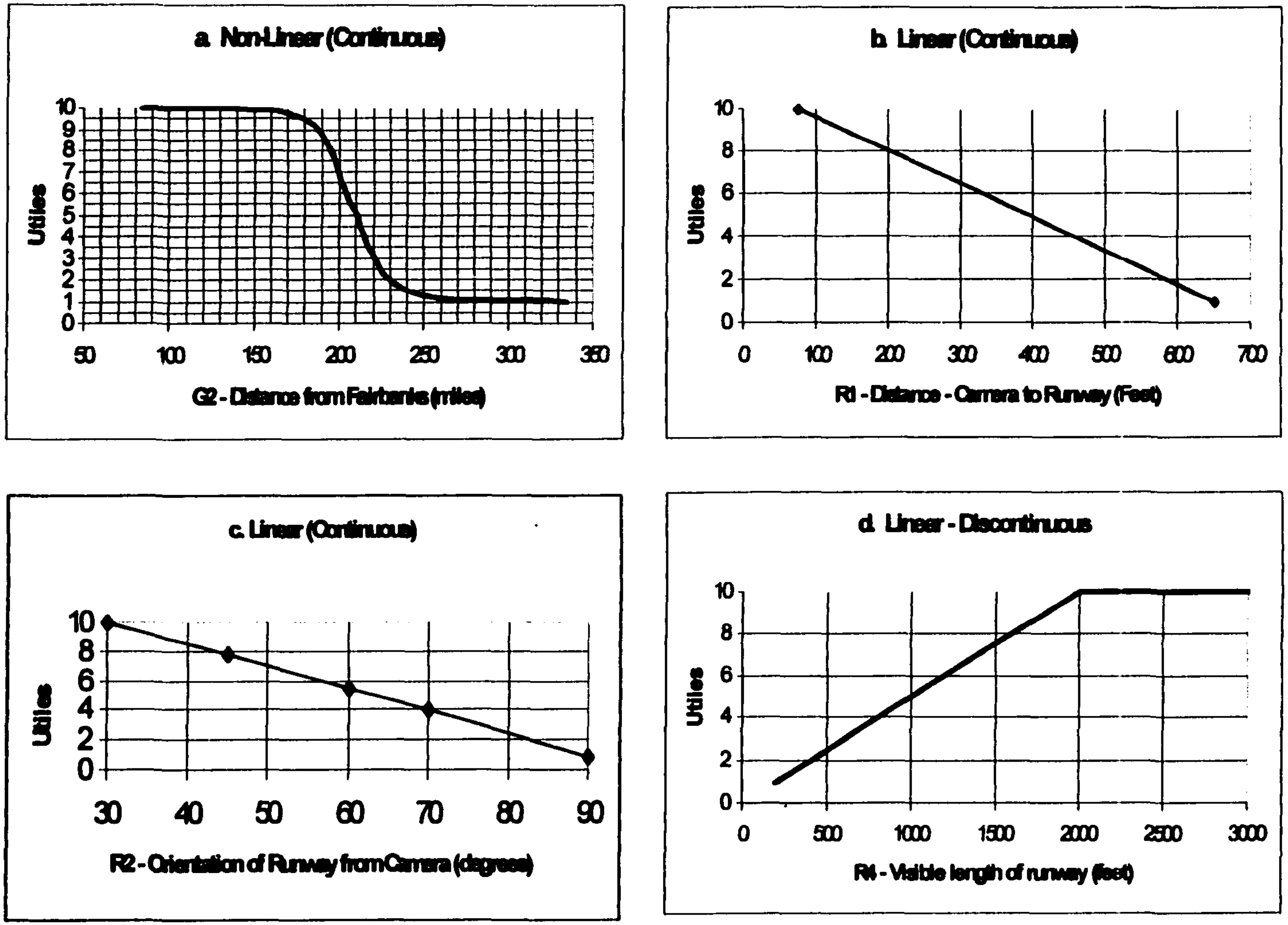



**Figure 7.2** - Utility Curves Used in Optimality Criteria

Views of the horizon are obstructed at some locations by vegetation that reduces the amount of useful information in the image. Most locations have relatively good line-of-sight atop the proposed structure.

*W4: Need for Weather Condition Reporting* – As mentioned prior, if the camera is located at an airport where there is a perceived need for weather condition reporting, cooperation from air carriers will be improved. Greater cooperation and use by stakeholders will provide better data for analysis.

These criteria formed the basis around which data was collected for the model.

#### 7.2.3.2 - Methods of Data Collection

Given the specific information requirements delineated above, a determination was made as to the appropriate data collection methods. The four methods listed below were determined to be both necessary and sufficient:

1. Physical Inspection of each airport – Approximately 2400 air miles were required to complete the physical inspection of each airport. At each site, a survey form was completed and multiple photographs were taken. Figure 7.3 is a copy of a blank survey. The form provided a basis around which to gather all the data needed to satisfy the optimality criteria.

2. Map reconnaissance – This was accomplished throughout the data collection phase. It was necessary to obtain quantitative terrain relief information to assist with criteria W1 & W2.

3. Survey of commercial pilots (Appendix B) – Pilots from seven air carrier companies out of Fairbanks International Airport were surveyed and provided their perspectives on conditions and requirements at specific rural airstrips. Additionally they scored the perceived benefits of remote video at rural sites on a linear scale from 1 to 5. This information was used in the model to specify the relative "need" for improved reporting for each airport.

4. Survey of airport contract maintenance personnel (Appendix A) – Peripheral information regarding the NOTAM reporting system was obtained through a survey of contract maintenance personnel at rural airports.

# AIRPORT SURVEY

______________________
**Name of Village**

**Date of Survey** ______________
**Name of Maint. Contractor** ____________________
Telephone # ____________-

**PHOTOGRAPHS**

| Shot # | View | | Photo # |
|---|---|---|---|
| | From → | To | |
| | Maint. Bldg | Terrain off end of runway ___ | |
| | Maint. Bldg | Terrain off end of runway ___ | |
| | Maint. Bldg | Closest Point on runway | |
| | ASOS/AWOS | Terrain off end of runway ___ | |
| | ASOS/AWOS | Terrain off end of runway ___ | |
| | ASOS/AWOS | Closest Point on runway | |
| | Runway ___ | Far end of runway | |
| | Runway ___ | Far end of runway | |
| | Air | Down runway ___ | |
| | Air | Down runway ___ | |
| | Air | Runway + Village | |
| | Air | Runway + Village | |
| | | | |
| | | | |
| | | | |

**SITE MAP**

M - Maint. Bldg
A - ASOS/AWOS
P - Electrical Power
R - Rotating Beacon
L - Lighting Building
W - Windsock

**QUESTIONS**

***Which of the following are on site?***

| | | | |
|---|---|---|---|
| *ASOS* | *YES* | | *NO* |
| *AWOS* | *YES* | | *NO* |
| *Is ASOS/AWOS commissioned?* | *YES* | *N/A* | *NO* |
| *Is ASOS/AWOS operating?* | *YES* | *N/A* | *NO* |
| *State Maint. Bldg* | *YES* | | *NO* |
| *Contract Weather Observer?* | *YES* | | *NO* |

***From ASOS/AWOS:*** **N/A**
*What percentage of runway can be seen?* ______
*What portion of runway can be seen?* ______
*Can detail of runway surface be seen?* *YES* *NO*
*Straightline dist. to closest section of visible runway* ______
*Can terrain off end of runway ___ be seen?* ______
*Can terrain off end of runway ___ be seen?* ______
*Is windsock visible?* ___ ______

***From State Maint. Bldg*** **N/A**
*What percentage of runway can be seen?* ______
*What portion of runway can be seen?* ______
*Can detail of runway surface be seen?* *YES* *NO*
*Straightline dist. to closest section of visible runway* ______
*Can terrain off of runway ___ be seen?* *YES* *NO*
*Can terrain off of runway ___ be seen?* *YES* *NO*
*Is windsock visible?* *YES* *NO*
*Approximate distance to nearest terrain relief off runway* ____
*Approximate distance to nearest terrain relief off runway* ____

**How many planes are located here?** ______

**Proposed Location of CCTV?** ______________

| | *Worse ← → Better* | **REMARKS** |
|---|---|---|
| *Structure for Mounting* | 1 2 3 4 5 | |
| *Receptivity of Village* | 1 2 3 4 5 | |
| *Availability of Power* | 1 2 3 4 5 | |
| *Availability of Telcom* | 1 2 3 4 5 | |
| *Need for Weather Info* | 1 2 3 4 5 | |
| *Need for Runway Info* | 1 2 3 4 5 | |
| *Runway Line of Sight* | 1 2 3 4 5 | |
| *Sufficient Terrain* | 1 2 3 4 5 | |
| *Terrain Line of Sight* | 1 2 3 4 5 | |
| **Overall Suitability as CCTV Test Site** | | 1 2 3 4 5 |
| Need Ladder? | | |
| Phone in SREB? | | |
| Heat in Bldg? | | |
| Where to hang housing? | | |

**Figure 7.3 - Sample Airport Survey Sheet**

The synthesis of these four methods provided excellent data that was organized and sorted to provide the necessary information for the criteria listed. It was then applied to the combination AHP/MAU model to rank order the airports.

#### *7.2.3.3 - Results and Conclusions*

Table 7.4 establishes the final tabulation for each airport. These locations are rank ordered by final weighted average and presented as a histogram in Figure 7.4.

It was determined that a combination of AHP and MAU techniques were beneficial in identifying the select group of airports meeting multiple criteria imposed to maximize the benefits of a one-year test of remote video. More importantly these decision techniques provided firm justification for the selection as the project entered a request for funding stage. Finally, the intellectual process of selecting objective criteria to distinguish relative differences between sites mandated a thorough investigation of the competing issues at hand. This in itself was beneficial to the study.

This study represented an initial investment in the study of potential benefits of remote video to the aviation community. It was recommended that State and Federal agencies with a vested interest in Alaskan aviation be queried for monetary support to assist in a one-year test of remote video at a minimum of three sites. Based on the outcome of this one-year test, these agencies would be encouraged to invest in this technology for the future. The primary potential benefits of remote video at rural airstrips in Alaska are improved safety, efficiency and service. All are legitimate goals that should be pursued wholeheartedly by decision-making aviation organizations [5].

## *7.3 - Conduct of the Project*

This section provides background on the funding of the project. It also provides detailed information about the schedule that was implemented to conduct a proof-of-concept test of remote video at rural Alaskan airports.

### 7.3.1 - Funding and Support

With the feasibility test complete, the focus of research changed to a search for funding to conduct a test at three locations. In the fall of 1998, the author contacted the FAA Alaska Region, a primary stakeholder, to determine if they would like to provide funding for such a venture. They expressed little interest in providing resources to an independent researcher for such a purpose. Burdened with an internal

| | Criteria Weight | Allakaket | Beaver | Bettles | Birch Creek | Chalkyitsik | Eagle | Hughes | Huslia | Kaltag | Koyukuk | Minchumina | Rampart | Stevens Village | Tanana |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GENERAL CRITERIA** | 0.2 | | | | | | | | | | | | | | |
| **1. Receptivity of Village** | 0.14 | | | | | | | | | | | | | | |
| a. Raw Score | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 4 | 2 | 5 |
| b. Utiles | | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 8 | 10 | 10 | 10 | 8 | 4 | 10 |
| **2. Accessibility from Fairbanks** | 0.43 | | | | | | | | | | | | | | |
| a. Raw Score (distance in miles from Fbks) | | 186 | 109 | 181 | 116 | 176 | 185 | 207 | 261 | 334 | 298 | 152 | 84 | 91 | 130 |
| b. Utiles | | 5.7 | 8.2 | 5.9 | 7.9 | 6.0 | 5.7 | 5.0 | 3.3 | 1.0 | 2.1 | 6.8 | 9.0 | 8.7 | 7.5 |
| **3. Ease of Installation** | 0.43 | | | | | | | | | | | | | | |
| a. Raw Score | | 5 | 5 | 3 | 5 | 5 | 1 | 5 | 5 | 5 | 5 | 1 | 5 | 5 | 3 |
| b. Utiles | | 10 | 10 | 6 | 10 | 10 | 2 | 10 | 10 | 10 | 10 | 2 | 10 | 10 | 6 |
| **Weighted Score for General Criteria** | | 8.2 | 9.2 | 6.5 | 9.1 | 8.3 | 4.7 | 7.9 | 6.8 | 6.1 | 6.6 | 5.2 | 9.3 | 8.6 | 7.2 |
| **RUNWAY CONDITION** | 0.4 | | | | | | | | | | | | | | |
| **1. Distance - *Camera to Runway*** | 0.5 | | | | | | | | | | | | | | |
| a. Raw Score (feet) | | 225 | 500 | 250 | 375 | 225 | 650 | 75 | 450 | 450 | 450 | 300 | 150 | 200 | 150 |
| b. Utiles | | 7.7 | 3.3 | 7.3 | 5.3 | 7.7 | 1.0 | 10.0 | 4.1 | 4.1 | 4.1 | 6.5 | 8.6 | 8.0 | 8.8 |
| **2. Orientation of runway from Camera** | 0.1 | | | | | | | | | | | | | | |
| a. Raw Score (degrees) | | 60 | 90 | 70 | 30 | 30 | 45 | 60 | 90 | 90 | 90 | 60 | 60 | 60 | 60 |
| b. Utiles | | 5.5 | 1.0 | 4.0 | 10.0 | 10.0 | 7.8 | 5.5 | 1.0 | 1.0 | 1.0 | 5.5 | 5.5 | 5.5 | 5.5 |
| **3. Cardinal Direction to Runway** | 0.05 | | | | | | | | | | | | | | |
| a. Raw Score | | E | N | W | N | S | NE | SW | SE | NW | N | E | E | N | NW |
| b. Utiles | | 6 | 10 | 6 | 10 | 2 | 8 | 4 | 4 | 8 | 10 | 6 | 6 | 10 | 8 |
| **4. Visible Length with 80 deg field of view lens** | 0.28 | | | | | | | | | | | | | | |
| a. Raw Score (feet) | | 1200 | 600 | 600 | 2000 | 2000 | 800 | 1400 | 1500 | 1400 | 200 | 800 | 300 | 900 | 1500 |
| b. Utiles | | 6.0 | 3.0 | 3.0 | 10.0 | 10.0 | 4.0 | 7.0 | 7.5 | 7.0 | 1.0 | 4.0 | 1.5 | 4.5 | 7.5 |
| **5. Need (from Pilot Survey)** | 0.09 | | | | | | | | | | | | | | |
| a. Raw Score | | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 0 | 0 | 6 | 1 |
| b. Utiles | | 5.5 | 2.5 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 4.0 | 4.0 | 4.0 | 1.0 | 1.0 | 10.0 | 2.5 |
| **Weighted Average for Runway Criteria** | | 6.9 | 3.3 | 5.3 | 7.0 | 7.8 | 2.9 | 7.6 | 4.8 | 4.9 | 3.3 | 5.3 | 5.6 | 7.2 | 7.7 |
| **WEATHER CONDITION** | 0.4 | | | | | | | | | | | | | | |
| **1. Use of Surrounding Terrain for ceiling determination** | 0.4 | | | | | | | | | | | | | | |
| a. Raw Score | | 3 | 1 | 3 | 1 | 1 | 5 | 4 | 1 | 4 | 2 | 2 | 4 | 1 | 4 |
| b. Utiles | | 6 | 2 | 6 | 2 | 2 | 10 | 8 | 2 | 6 | 4 | 4 | 8 | 2 | 8 |
| **2. Use of Surrounding Terrain for visibility determination** | 0.4 | | | | | | | | | | | | | | |
| a. Raw Score | | 3 | 1 | 2 | 1 | 1 | 5 | 4 | 1 | 4 | 1 | 2 | 5 | 1 | 3 |
| b. Utiles | | 6 | 2 | 4 | 2 | 2 | 10 | 8 | 2 | 8 | 2 | 4 | 10 | 2 | 6 |
| **3. Line of Sight from Camera to terrain** | 0.1 | | | | | | | | | | | | | | |
| a. Raw Score | | 4 | 1 | 5 | 1 | 1 | 4 | 5 | 1 | 5 | 1 | 4 | 5 | 1 | 4 |
| b. Utiles | | 8 | 2 | 10 | 2 | 2 | 8 | 10 | 2 | 10 | 2 | 8 | 10 | 2 | 8 |
| **4. Need (from Pilot Survey)** | 0.1 | | | | | | | | | | | | | | |
| a. Raw Score | | 3 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 4 | 0 | 1 | 6 | 3 | 1 |
| b. Utiles | | 5.5 | 1.0 | 2.5 | 1.0 | 1.0 | 1.0 | 2.5 | 2.5 | 7.0 | 1.0 | 2.5 | 10.0 | 5.5 | 2.5 |
| **Weighted Average for Weather Criteria** | | 6.2 | 1.9 | 5.3 | 1.9 | 1.9 | 8.9 | 7.7 | 2.1 | 8.1 | 2.7 | 4.3 | 9.2 | 2.4 | 8.7 |
| FINAL WEIGHTED AVERAGE ⟶ OF GENERAL, RUNWAY and WEATHER CATEGORIES | | 6.83 | 3.94 | 5.60 | 5.39 | 5.54 | 5.66 | 7.76 | 4.12 | 6.42 | 3.73 | 4.86 | 7.84 | 5.56 | 7.18 |
| | | 4th Place Allakaket | | | | | | 2nd Place Hughes | | | | | 1st Place Rampart | | 3rd Place Tanana |

**Table 7.4 - Combination MAU/AHP Optimality Matrix**

obligation to expend federally appropriated funds on a similar project, the FAA declined to involve the author directly. An independent, unsolicited project proposal was therefore prepared and submitted to the Alaska Science and Technology Foundation (ASTF) in October of 1998 to solicit funding. ASTF is an instrumentality of the State of Alaska whose purpose is to provide grants for technology related projects which benefit Alaskans.

The proposal outlined a concept that included the employment of three cameras at each village. Two cameras were to be trained on different parts of the horizon to gather weather information. One camera was to be oriented at the runway (where applicable) to gather runway condition information. The images were to be accessed twice hourly, sent to a hub computer in Fairbanks and loaded onto an Internet file. The images would then be presented on an Internet based website for public use. Stakeholders and end-users were to be involved in the study. The test was to be conducted from 1 April 1999 to 1 October 1999 during which time feedback would be collected from users. At the end of the test, the feedback was to be compiled and reports prepared for the major stakeholders.

ASTF strongly urged that the proposal package include documentation showing pledges of in-kind and cash support from other supporting agencies. The following agencies pledged support as indicated:

1. AKDOT Provided:

- Use of AKDOT structures at rural airports upon which to mount video camera hardware
- Donation of electrical power to operate hardware at selected sites
- Use of AKDOT personnel (electrician) to assist with the installation, mechanical and electrical troubleshooting of hardware installed on AKDOT structures
- Assistance of AKDOT contract maintenance personnel at rural villages to provide access to AKDOT owned structures
- Transportation to rural sites on a space-available basis for the project manager when flights are already scheduled for that location
- $10K to assist with cash requirements for the project, contingent upon the Northern Region Highways and Aviation ending the 1999 State Fiscal Year with a budget surplus

2. The University of Alaska Aviation Technology Division promised technical expertise and simulation capabilities in support of the project.

3. Tanana Air Service provided, without charge, transportation for the project manager and hardware to and from Ruby, Alaska. In addition they pledged support to other scheduled locations contingent upon room in the aircraft.

4. The FAA Fairbanks FSS pledged to regularly assess the images and provide feedback regarding how effective the information would be if it were available for pilot briefings.

5. The NWS Alaska Region provided strong endorsement for the project.

6. The Alaskan Aviation Safety Foundation (AASF) provided strong endorsement for the project.

Letters from each of these agencies were included in the proposal. The ASTF board approved the project on 10 December 1998 for a grant of $62,000 under project number 98-4-119 [2]. The supporting letters and grant related documents are attached at Appendix G. Once the project was approved by ASTF, several other agencies pledged support of the project. Three different local air carriers contributed free travel for the project manager to rural sites to install and maintain the hardware. A major telecommunications company in Alaska contributed 100,000 minutes of free long distance telephone calls ($15,000) to support the transfer of images from rural locations back to the hub. A local Internet service provider and several aviation special interest groups provided additional support.

### 7.3.2 - Project Schedule

The original project schedule is provided at Appendix E. This schedule was included with the ASTF proposal and provided a guideline for the conduct of the project. The schedule included 5 benchmarks that were used to gauge project progress. The benchmarks were:

1. Benchmark #1 - Successful home base test - This included final site selection, acquisition of equipment, construction of a website, and a home base test of equipment prior to fielding.
2. Benchmark #2 - Successful field test - This required that the system be fielded and tested once installed.
3. Benchmark #3 - 50% Completion of 6 month test - The formal test was scheduled to run from 1 April to 1 October 1999. This represented the halfway mark on 1 July 1999.
4. Benchmark #4 - 100% Completion of 6 month test - Originally scheduled to end on 1 October 1999, the test was extended to 31 December 1999 for reasons discussed below.

5. Benchmark #5 - Project Complete - Due to the success of the project and ASTFs continuing interest in expansion of the program, the project completion date was eventually extended to 1 May 2000.

Benchmarks 1 through 4 are discussed in detail below. Benchmark #5 is of no consequence to this research but represents an obligation the author has to ASTF at the termination of the project.

## 7.3.3 - Benchmark #1 - Successful Home Base Test

### *7.3.3.1 - Site Selection*

Between 21 August 98 when the feasibility study was complete, and 28 February 1999 when installations were begun, additional data was collected regarding the selection of test sites. The results of the initial selection process concluded that the best locations would be Allakaket, Hughes, Rampart and Tanana. Later it was determined that there were other significant factors, and new information that provided strong impetus to change these initial selections. A new runway at Allakaket was going to open during proposed remote video test. The proposed mounting structure at the old airport was the AKDOT maintenance building. It was to be demolished in June 1999. Thus, Allakaket was removed from the list. Tanana was discounted due to the presence of a CWO on site precluding the need for remote video. Rampart was determined to have little air traffic, reducing the perceived need for remote video at that location significantly. A village that had not been included in the initial feasibility test displaced Hughes.

The AHP/MAU model that was used in the initial selection of test sites was important in establishing the basic criteria around which site selection should be determined. While the formal model was not employed in the final selection, the academic process of listing and defining the optimality criteria provided insight into the critical factors. Discussions with air carriers, pilots and aviation stakeholders established that the "need" related criteria were more important than initially anticipated. A large-scale study to prioritize locations at which remote video should be installed would certainly benefit from a formal application of the AHP/MAU model discussed herein.

The process used to select the final test sites was less formal, but more inclusive than that conducted during the feasibility study. The greatest factor affecting the final choice of sites was stakeholder input. Once the project was approved and funding was imminent, the FAA, the NWS, the AKDOT, pilots and special interest groups were queried for their suggestions about which sites would be best. The level of interest was heightened among these stakeholders when they realized their input could directly impact the quality of the test and the immediate availability of better weather information.

Stakeholder input at this phase was critical to the ultimate success of the research. In some cases, stakeholder input prompted additional site surveys, and an investigation of airports that had not been included in the original feasibility study. During January and February of 1999, site visits were conducted to Allakaket, Anaktuvuk Pass, Kaltag and Ruby. The final three choices were made from this group of four and are delineated below:

*Anaktuvuk Pass* - This location was not included in the feasibility study because it is not formally an Interior Alaskan village. However, it has heavy air carrier traffic, a general aviation interest due to hunting and adventure trips, dangerous terrain, a history of poor aviation weather, and an AWOS whose accuracy and reliability is often in question. In addition, one Interior air carrier argued that installing the system at Anaktuvuk Pass would provide very high visibility throughout the State of Alaska. This was considered an important issue as far as gaining user input during the course of the test. These factors combined to make it an excellent choice for the remote video test. The proposed mounting location at Anaktuvuk Pass was on the FAA maintained AWOS.

*Ruby* - Ruby was not considered in the initial feasibility study because the author was unable to conduct an on-site survey of the runway. It was later recognized that Ruby had no ground-based weather collection system and was in a location on the Yukon River which often had weather significantly different from either Galena or Tanana (the next closest reporting stations). Another air carrier was vocal about the benefits that would accrue from placing a system in Ruby. They pledged strong support for the project if a system was installed there. The proposed mounting location was on the AKDOT owned maintenance building.

*Kaltag* - Kaltag is the furthest west of the Interior villages. The weather at Kaltag, Koyukuk and Nulato is often different from Galena. It is not atypical for pilots hauling mail, cargo and passenger flights to have to hold up in Galena waiting for the weather to clear further down river. Cameras at this location would assist in determining weather conditions out west. Kaltag was high on the list in the feasibility study and was determined to be an excellent choice. The proposed mounting location in Kaltag was on the NWS operated ASOS.

The choice of these three villages provided an opportunity to involve three major stakeholders in the project: the FAA, the NWS and the AKDOT.

### *7.3.3.2 - Acquisition of Equipment*

Hardware and software were purchased in January 1999 to outfit the three rural Alaskan villages, and one hub location in Fairbanks with equipment necessary to conduct the project. The main hardware for the test was purchased from a company in Salt Lake City, Utah that had previously provided similar equipment to the NWS there. A proprietary software package was also obtained from a company in Utah. A trip was made to Salt Lake City to finalize the hardware and software requirements for the three villages. Additional hardware was purchased locally. The following hardware and software was purchased for the project:

<u>Remote Site Components</u> - This equipment was installed in each of the villages.

1. Three cameras - These are CCD solid state high resolution color cameras with a built-in electronic iris. (Sanyo, Model VDC2974, Sanyo Industrial Video Division, 1200 West Artesia Blvd., Compton, CA 90220)
2. One camera server - This piece of hardware polls the camera for an image and sends the image through a modem back to the hub site. (AXIS 240, manufactured by AXIS Communications, Inc., 100 Apollo Drive, Chelmsford, MA 01824)
3. Three environmental housings to protect the cameras from the elements. (Pelco Company, 300 E. Pontiac Way, Clovis CA 93612)
4. Video cables
5. Electrical power cables
6. Mounting hardware - (Different for each site)
7. External modem (Sportster External 33.6 Faxmodem, U.S. Robotics 8100 N. McCormick Blvd., Skokie, Illinois 60076-2999)
8. Uninterrupted power supply (APC Back-Ups 650, APC)

<u>Hub Location Components (Fairbanks)</u>

1. Desktop computer to receive and forward images to the Internet Service Provider (ISP)
2. External modem (Same model as above)
3. Proprietary software to automatically conduct image downloads and uploads (FatPipe VueAnywhere Software, Ragula Systems Inc., Salt Lake City, UT)

#### 7.3.3.3 - Development of Web Site

An Internet website was designed and implemented in March 1999 to host real-time images from the three different villages. The website was designed to portray the current image alongside an annotated clear-day image for comparison (Figure 7.5). The clear-day image provides the user with distances, elevations, natural landmarks, man-made facilities and other points of interest annotated on an image taken when there were no weather related obstructions to vision. This enables the user to discern both quantitative and qualitative information about the current image. The pair of images provides an intuitive, real-time presentation of the weather and runway conditions at airstrips hundreds of miles away. This method of side-by-side comparison of images is now patent pending [9].

The website was completed on 11 March 1999 and the domain name "FlightCam.net" was registered. The project and associated weather collection system became known thereafter as FlightCam. Its first full day of operation was 12 March 1999. The operational website was first presented in public on 13 March 1999 at the Fairbanks Spring Air Fair Exposition (SAFE) in Fairbanks, Alaska. At this point, only images from Ruby, Alaska were available as Anaktuvuk Pass and Kaltag were awaiting telecommunications and installation of hardware. At this point in time, the FAA had developed their own web page featuring remote video images and they presented it at SAFE as well.

The site was initially designed with a home page and four subordinate pages - one for each of the three villages, and one that provided background information on the project. The intent was to provide a very simple, easy to navigate architecture which would allow users to quickly access the pertinent images. Each village page contained an inset view of a VFR sectional chart with annotated boundary lines indicating the direction of view of each of the three cameras (Figure 7.6). The user clicks on the desired view, and the site jumps down the page to the set of dual images (Figure 7.5) that provide the current and clear-day views. Each of the three pairs of camera views is presented on a single page. This provides the user with immediate access to the images from all three cameras at any particular village. The FAA website did not initially employ a clear-day image for comparison. However, within three weeks after the SAFE exposition, the FAA adopted the author's method of side-by-side comparison of images.

#### 7.3.3.4 - Home Base Test of Equipment

Prior to fielding the equipment in Ruby as explained above, a test was conducted in Fairbanks to ensure that the equipment would operate as anticipated. A single camera with housing was mounted outside in Fairbanks. The intent was to provide an opportunity to fix obvious problems before deploying

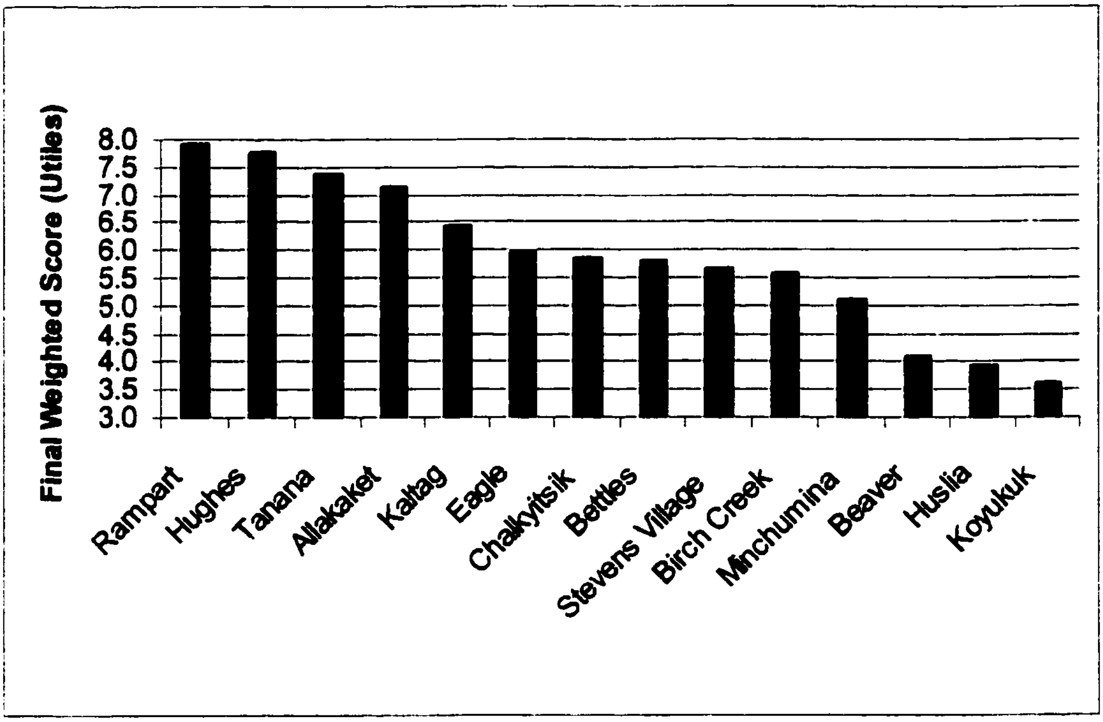
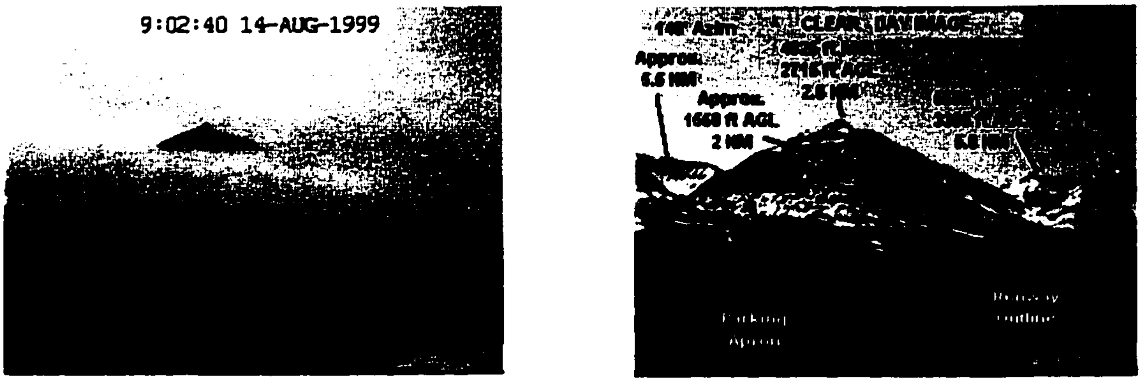



**Figure 7.4** - Final Weighted Utility Score of Rural Airports Considered for Test Sites




Current Image

Clear-Day Image

**Figure 7.5** - Current versus Annotated Clear-Day Image

the equipment in a remote location. The automated system was tested in conjunction with the camera and it performed successfully. The system was able to download current images from the local camera and upload them to the Internet. Some software problems were encountered in the transition from the home base test to the field test. These were addressed by the software producer and after many iterations were fixed. The home base test also confirmed that cold weather operation was viable with the equipment as purchased. The equipment operated reliably for a two-week period at -31 to -37 degrees Celsius. Even though the test was not anticipated to last into the winter of 1999, this cold weather home base test provided needed confirmation that the system could withstand extreme low temperatures for an extended period. Having successfully completed this home base test, the project focused on Benchmark #2, the field test.

## 7.3.4 - Benchmark #2 - Successful Field Test

The field test required that all the camera hardware be installed at Anaktuvuk Pass, Ruby and Kaltag. It further required that the automated system function in conjunction with each of these three sites and sequentially pass images from each distant location to the hub base computer and then to the Internet.

### *7.3.4.1 - Installation of Equipment*

The hardware was fielded at these three villages in early 1999 under arctic conditions. Having determined the major stakeholders in the project, an attempt was made to involve each of the federal and state agencies in the installation of equipment. This provided them with first-hand information and created a sense of ownership and interest in the project. Installation required one day on site at each village and proceeded as follows:

*Anaktuvuk Pass* - A local FAA office in Fairbanks assisted with the installation of hardware on their AWOS in Anaktuvuk Pass, Alaska. Anaktuvuk Pass is located 215 miles north northwest of Fairbanks at a major pass in the Brooks Range. The cameras were mounted directly to the AWOS mast (a long vertical pole) using a pole connector (Figure 7.7). Electrical power was provided through the AWOS equipment at no cost to the project. A telephone line was requested through the Arctic Slope Telephone Association Cooperative, Inc (ASTAC). The line was considered a temporary installation and took approximately 3 weeks to install. Installation of telephone lines was the primary bottleneck in the commissioning of the remote video system. At Anaktuvuk Pass, one camera was pointed north through the pass, one was pointed south through the pass and one was oriented on the runway. These views provided

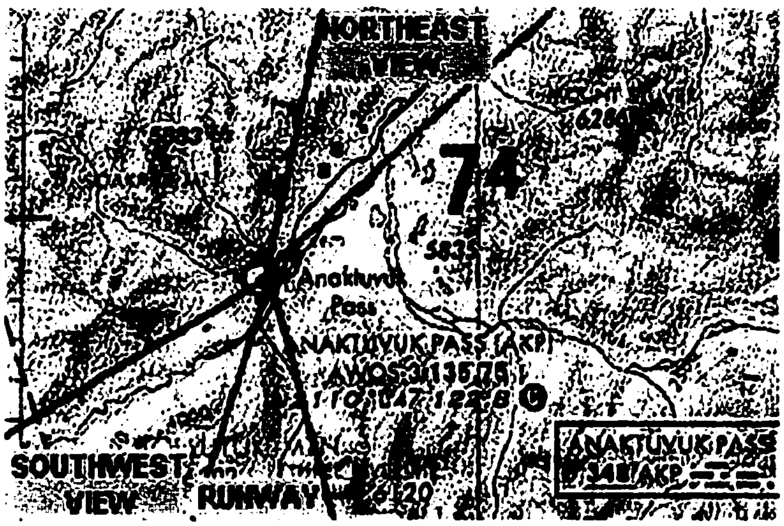



Figure 7.6 - Inset View of VFR Sectional Chart with Camera Views Indicated

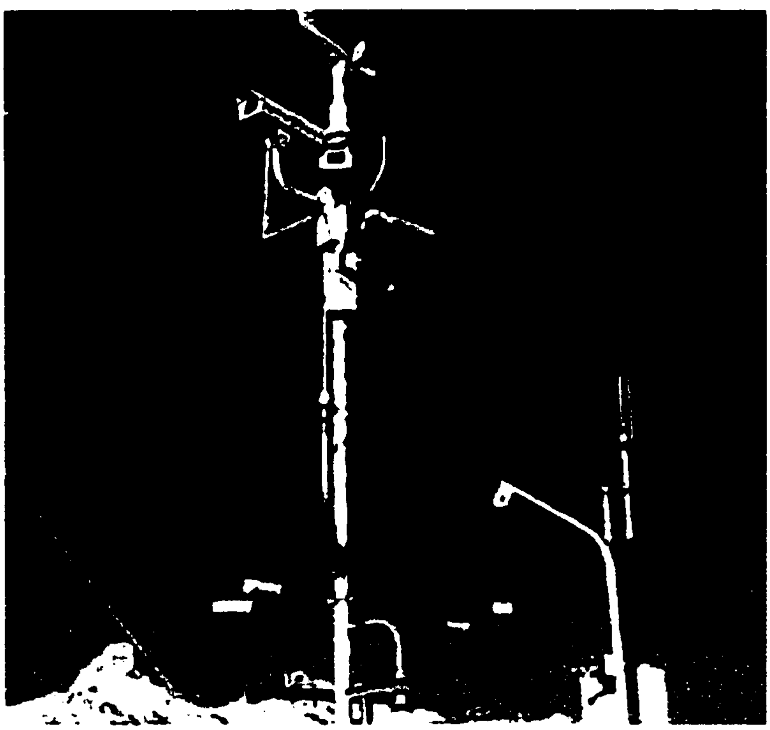


Figure 7.7 - Cameras Installed on AWOS at Anaktuvuk Pass, Alaska

information along the primary routes of approach and departure to the airport. In addition they provided an excellent view of the parking apron and the runway.

*Ruby* - The AKDOT provided a technician to assist with installation of hardware in Ruby, Alaska. Ruby is 180 miles west of Fairbanks and has no ground-based weather collection system. The cameras were mounted on a pole that was attached to the top of the AKDOT maintenance building (Figure 7.8). This installation was the most difficult as it required the construction of a platform on the roof of the building. Once the platform was in place, the pole was erected and the cameras were attached. Electrical power was obtained through the maintenance building at no cost to the project. The telephone line was provided by Yukon Telephone Company and was installed within 10 days of the request. This telephone line was a permanent installation. At Ruby, one camera was pointed northeast toward the Tanana Valley, one was pointed north toward the Yukon River, and one was oriented west toward Galena 39 miles away. These views provided excellent information about the primary east-west approaches to Ruby. In addition they provided a clear view of the river to help ascertain fog and visibility restrictions related to the waterway.

*Kaltag* - The NWS office provided a technician to assist with installation of camera hardware on their ASOS in Kaltag, Alaska. Kaltag is 280 miles west of Fairbanks, which is 60 miles from the Norton Sound. The cameras were mounted on a pole that was erected in the corner of the ASOS complex (Figure 7.9). Electrical power was provided by the ASOS at no cost to the project. The telephone line was provided by Pacific Telecom Incorporated (PTI) Communications and took approximately 2 weeks to install. At Kaltag, one camera was directed southwest looking at the primary route to the coast, one was pointed north toward the village of Nulato up the river, and one was pointed at the runway which provided a view of the windsock. These views addressed the primary approach routes into Kaltag. The windsock also proved helpful in discerning information about prevailing winds.

The early involvement of major stakeholders proved to be key in the ultimate success of the project. As a result of partnering in the installation process, each of these key agencies willingly participated in the process of evaluating the system.

#### *7.3.4.2 - Field Test*

Images were successfully transferred from Ruby beginning on 12 March 1999 and from Anaktuvuk Pass beginning on 17 March 1999. Installation at Kaltag was completed on 26 March 1999, but due to technical problems with the telephone line, the system was not operational until 2 April 1999. These

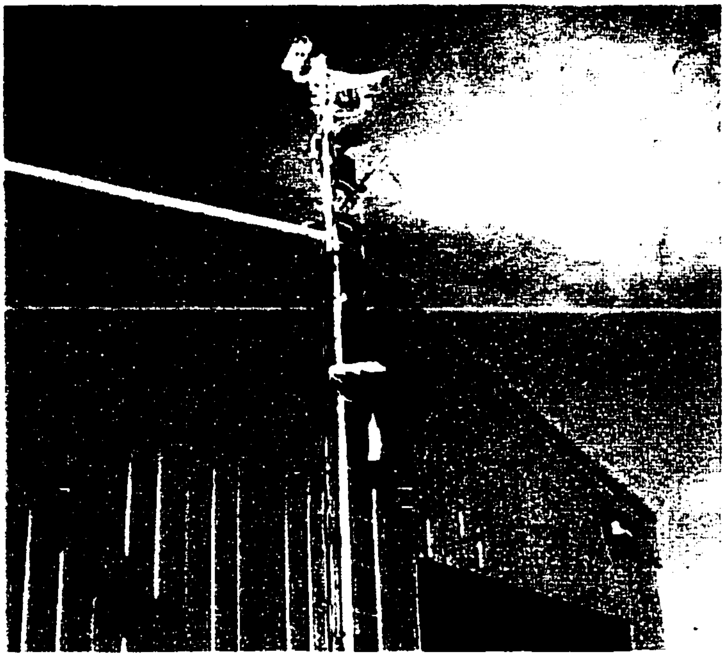


**Figure 7.8** - Cameras Installed on Maintenance Building at Ruby, Alaska

**Figure 7.9** - Cameras Installed on ASOS at Kaltag, Alaska

problems were related to the commercial telecommunications system and completely independent of the hardware used in the project. The field test included not only successful manual downloads from each village, but successful unattended operation of the camera server system at each site. The system as tested performed the following unattended operations:

- 10 minutes past the hour - Called Anaktuvuk Pass and downloaded a current image from each camera onto the hub computer in Fairbanks. It then terminated that call, dialed the local ISP and uploaded the three current Anaktuvuk Pass images onto the ISP where they were made available to the website.
- 20 minutes past the hour - Called Ruby and downloaded a current image from each camera onto the hub computer in Fairbanks. It then terminated that call, dialed the local ISP and uploaded the three current Ruby images onto the ISP where they were made available to the website.
- 30 minutes past the hour - Called Kaltag and downloaded a current image from each camera onto the hub computer in Fairbanks. It then terminated that call, dialed the local ISP and uploaded the three current Kaltag images onto the ISP where they were made available to the website.
- 40 minutes past the hour - Repeated the call to Anaktuvuk Pass
- 50 minutes past the hour - Repeated the call to Ruby
- 60 minutes past the hour - Repeated the call to Kaltag
- 10 minutes past the hour - Started the process over again

In this manner, three images from each site were transferred to the ISP every 30 minutes.

In conjunction with the fielding and testing of the hardware, the FAA, the NWS and the AKDOT each gave the author full access to their structure at their respective sites for the duration of the test. 2 April 1999 marked the successful completion of Benchmark #2 and the start of the formal 6-month operational test.

## 7.3.5 - Benchmarks #3 and #4 - 6-Month Test

Benchmarks #3 and #4 are combined for purposes of discussing the operational test. In accordance with the proposal submitted to ASTF, the formal proof-of-concept test was planned for 1 April 1999 to 1 October 1999. The test had three goals: 1) Demonstrate that the physical system could withstand the severe northern climate and reliably provide real-time images to the aviation community; 2) Establish that the information gained from such images provided new or complementary information which was useful to end-users. 3) Provide incentive for aviation decision-makers to implement such a system in rural Alaska. Chapter 8 presents the achievement of these goals and the logical proof of the hypothesis stated in

Chapter 6. This section presents a chronological history of the test. It includes comments on system operation, system maintenance, advertising, media releases, and data collection.

#### *7.3.5.1 - April 1999*

6-7: Conducted a maintenance trip to Anaktuvuk Pass to clean lenses and install a digital timer. It was determined that the modem, under certain circumstances, had a tendency to "hang" and stop receiving calls. The purpose of the timer was to automatically reset the modem and camera server at predetermined intervals. This was accomplished by turning off the electrical power for 1 minute, then turning it back on. This solved the preponderance of telecommunications related problems at all three villages. In general, maintenance trips included the following: cleaning lenses; checking and adjusting timer settings; checking and changing timer battery; checking integrity of electrical connections; repositioning cameras; focusing cameras; and changing vent covers as needed. Each environmental housing has two vent openings. These vents are to be covered in the winter (to retain heat in the housing) and uncovered in the summer (to permit circulation of air). The cameras were installed in March with the vents open. These vents were covered in early winter.

8: Conducted a maintenance trip to Kaltag to clean lenses and install a digital timer.

20: Conducted an interview with the *Fairbanks Daily News-Miner* about the FlightCam system.

21: An article entitled "Bush cameras show weather status on Web" was printed in the *Fairbanks Daily News-Miner*. The article highlighted the FlightCam system and was the first major media release about the project (Appendix H). This helped promote the project within Interior Alaska.

23: Interviewed by KUAC, a local Fairbanks radio station. The 10 minute interview highlighted the FlightCam project and provided additional visibility within the aviation community in Interior Alaska.

30: Traveled to Anchorage to make a presentation on FlightCam to the U.S. Army Alaska Aviation Safety meeting. The audience was composed of Army pilots and upper level management who meet to assess flight safety among Army aviators in Alaska. The Alaska National Guard also participated. The presentation was well received.

#### *7.3.5.2 - May 1999*

8-9: Traveled to Anchorage to participate in the Alaska State Aviation Conference and Trade Show. Maintained a booth that presented a live, on-line demonstration of FlightCam to generate support within the Alaska aviation community.

13-14: Conducted a maintenance trip to Anaktuvuk Pass, Kaltag and Ruby.

17-20: Traveled to Salt Lake City to participate in a NWS conference. At the conference the author conducted a presentation on FlightCam to an assembled group of NWS personnel, hardware distributors and software providers. The presentation generated much interest. As a result of this meeting, AXIS Communications, maker of the camera server used by FlightCam, decided to hire a writer to assemble an article on FlightCam for their clients (Appendix H).

#### *7.3.5.3 - June 1999*

7-8: Conducted a maintenance trip to Anaktuvuk Pass. In addition, conducted visits to Rampart, Five-Mile, Birch Creek, Beaver, Fort Yukon, Circle, and Circle Hot Springs to assess the potential for remote video technology at these locations.

18: The Fairbanks NWS began a formal procedure for evaluating FlightCam images on this date. They had their lead forecaster view and assess the usefulness of images once each 8-hour shift. This program worked very well and they continued the feedback process through 5 Oct 99.

24-25: Conducted a maintenance trip to Anaktuvuk Pass, Kaltag and Ruby.

#### *7.3.5.4 - July 1999*

1: The Fairbanks FSS began evaluations of FlightCam images on this date. The local FSS normally provides pre-flight and in-flight briefings to pilots. They had 5 staff members look at the images once a day for the next three months to assess the benefits to their operation. The FAA, at this point in time, had taken a firm position against using Internet images for operational purposes until FAA had approved the concept at the national level. As a result, the FSS briefers were not permitted to use FlightCam images to assist with operational briefings to pilots. Instead, the experienced staff conducted evaluations as if they were to be used operationally.

4: An on-line survey was added to the FlightCam website. The purpose of the survey was to capture input primarily from commercial and general aviation pilots. This survey proved to be extremely beneficial in capturing input from all five primary stakeholders as well as other interested parties. A comment block on the survey provided the means for the audience to provide any comment they felt pertinent.

7: A patent search was initiated to determine if aspects of FlightCam had potential to be patented. The results later indicated that there was an opportunity to obtain a utility patent.

19: Conducted a maintenance trip to Anaktuvuk Pass

23: Conducted a maintenance trip to Ruby and Kaltag

25-28: Presented two papers at a conference at PICMET 99 in Portland, OR. Both papers were related to aspects of the project.

#### *7.3.5.5 - August 1999*

4: Conducted a maintenance trip to Anaktuvuk Pass

5: The FlightCam website was published in *USA Today* and mentioned as a method of checking runway conditions in Alaska (Appendix H). This single media release raised the average number of hits/day on the site from 85 to 350.

23-28: Traveled to 32 rural villages in Western Alaska and conducted site surveys in anticipation of future camera installations. This trip was undertaken in response to an ASTF requirement to prepare a plan for placing remote video systems at other rural airstrips that the FAA might consider.

30: Conducted a maintenance trip to Anaktuvuk Pass.

#### *7.3.5.6 - September 1999*

1: *Aircraft Owners and Pilot's Association (AOPA) Pilot* magazine mentioned the FlightCam website as an Alaskan innovation which could be of use to general aviation pilots.

7: Conducted a successful test to determine if images could be transmitted using a satellite telephone in anticipation of developing a completely remote system using wind/solar power, and satellite phone to transmit the images.

13: *AvWeb*, an Internet based aviation news site with about 110,000 subscribers published a short explanation of FlightCam on this day. During the next 24 hours, the website received 10,000 hits and the daily average number of hits grew to about 400.

20: Initial patent application was drafted and sent to Anchorage area patent agent.

25: The Alaska Journal of Commerce published an article highlighting FlightCam. In addition it discussed the FAAs on-line website and the interest that the FAA had in the FlightCam program.

29: On this date, ASTF approved an extension of this project from 10 December 1999 to 1 May 2000 to accommodate opportunities to convert it from a knowledge project to a technology project. This extension provided an opportunity for the systems in the three villages to be turned over to an appropriate recipient at the termination of the project.

#### *7.3.5.7 - October 1999*

5: Fairbanks FSS ceased filling out surveys. Approximately 100 individual surveys were collected. At this point, the FAA in Anchorage had begun to take a more lenient stance on the use of images in operational briefings. However, they needed to establish operational guidelines before implementation.

5: The Fairbanks NWS ceased filling out surveys. Approximately 100 surveys were collected.

15: Conducted a maintenance trip to Anaktuvuk Pass

16: Made several changes to the FlightCam website to include a graphic showing the location of the rural village in Alaska, and showing camera installation photographs at that location.

18-25: Presented FlightCam at the AOPA Exposition 1999 trade show in Atlantic City, New Jersey. This provided an opportunity to advertise the project and to educate a segment of the aviation community in the lower 48 States on the benefits of the FlightCam technology.

28-29: Traveled to Anchorage and accomplished the following: 1) Attended an FAA Weather Enhancement meeting wherein expansion of FAA camera systems was discussed. The FAA also indicated that they would use the author's website as a template for their own. 2) Met with the patent agent to review patent documents; 3) Met with ASTF to discuss future options for the project; 4) Taped a segment for the show "Hangar Flying" to be viewed on 11 Nov 99.

#### *7.3.5.8 - November 1999*

1: *AOPA Pilot* magazine featured a "Weather Watch" article which focused primarily on FlightCam and the benefits which could accrue from use of such a system (Appendix H).

4: Made a presentation to an Engineering Management class at the University of Alaska Fairbanks regarding FlightCam and the decision tools used to determine which sites to select for camera installation.

11: FlightCam was highlighted in a 10 minute interview on Channel 7 television in Anchorage on a show entitled "Hangar Flying" which airs during the Alaska Weather show.

#### *7.3.5.9 - December 1999*

9: ASTF board approved a revised and substantially increased budget to $114,000 to continue operation of FlightCam to 1 May 2000. The board also approved the change from a "knowledge" to a "technology" project (Appendix G).

31: FlightCam was highlighted in the ASTF annual report as a project which air carriers are using to make GO/NO GO decisions which is saving these companies money and providing better, safer service to passengers.

#### *7.3.5.10 - January 2000*

12: FlightCam patent application put in the mail to the U.S. Patent Office. FlightCam is officially "patent pending" (Appendix G).

13: Final FlightCam survey is posted on the website to ascertain overall capabilities of the system and benefits to the users.

### 7.3.6 - Final Remarks on the FlightCam Project

The previous section chronicled the history of the project. A few comments are required to consolidate thoughts pertinent to individual events listed above.

#### *7.3.6.1 - FlightCam Advertising*

Three events constituted the primary advertising effort for the FlightCam system. The first was the demonstration at the Fairbanks Spring Air Fair Exposition in March 1999. This provided good coverage for the Interior of Alaska. This was followed in May 1999 by presentation of the system at the Alaska State Aviation Conference and Trade Show in Anchorage Alaska. This event provided Alaska-wide visibility for the project. The purpose of these first two advertising events was to enlist the interest and support of the aviation community in Alaska. This was necessary to produce a sufficient number of informed visitors to the website who could fill out the survey and be of assistance in assessing its capabilities. Finally, a thrust into the aviation community in the 48 contiguous states was made at the AOPA EXPO '99 trade show in Atlantic City in October 1999.

#### *7.3.6.2 - FlightCam Media Releases*

The article in the *Fairbanks Daily News-Miner* in April of 1999 constituted the first media release. This was followed quickly by a radio interview with KUAC in Fairbanks. The next major releases in *USA Today*, and *AOPA Pilot* all occurred 5 to 6 months into the project and are assumed to have been prompted by the natural diffusion of information about the site through the public. Copies of these releases are at Appendix H. The *AvWeb* article was prompted by an ASTF board member who contacted *AvWeb* about the FlightCam project. This article alone sparked a record 10,000 hits on the website and 800 survey responses in a 24-hour period. Figures 7.10 and 7.11 document the effect of these media releases on FlightCam website "hits". Numerous other media releases occurred, all of which cannot be named here.

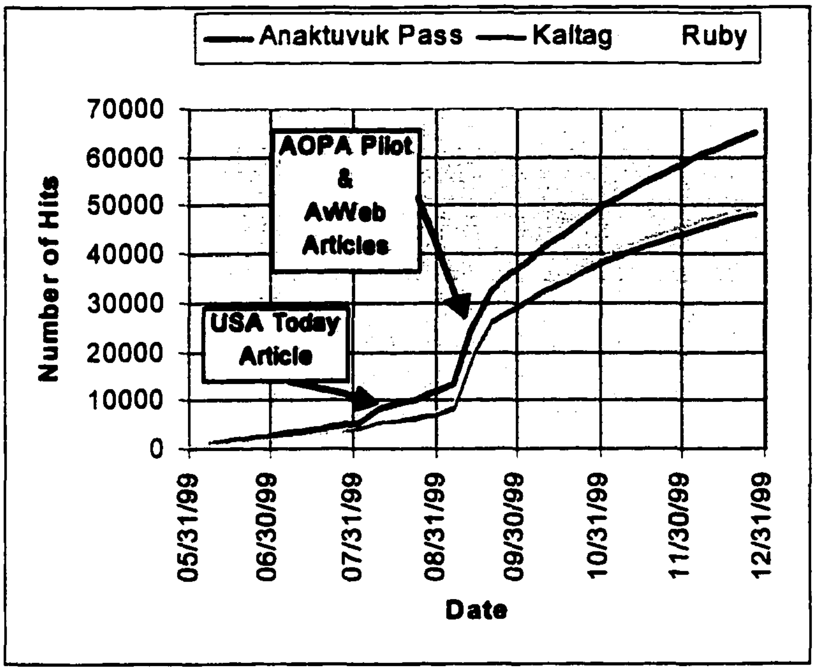



**Figure 7.10** - Total Hits on FlightCam Website by Date

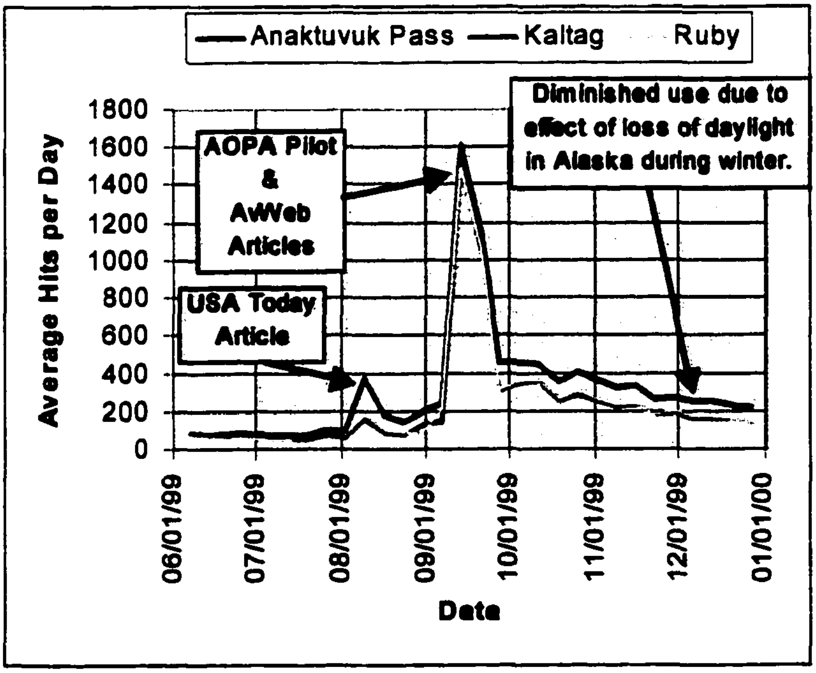



**Figure 7.11** - Average Hits per Day on FlightCam Website by Date

Several small newspapers throughout the country highlighted the project. *New Scientist* magazine in the United Kingdom also printed an article about the project. Several other Internet based aviation organizations requested permission to link their sites to the FlightCam site. Needless to say, the contacts and publicity provided excellent coverage for the project that in turn provided the author with access to the thoughts and suggestions of many aviators throughout the world.

#### 7.3.6.3 - FlightCam Patent

ASTF encouraged pursuit of a patent on the FlightCam "current versus clear-day" image innovation. From the time the initial draft for the patent search was submitted on 9 July 1999, it took 6 months to complete the application and put it in the mail to the United States Patent Office on 12 January 2000 (Appendix G). Confirmation of receipt is expected in February 2000. Initial feedback regarding the viability of patent issue is not expected until January 2001. The cost of the patent application process was borne by ASTF and amounted to approximately $3,100.

#### 7.3.6.4 - Data Collection

Throughout the test, the author maintained frequent contact with the primary stakeholders to entrain their support and interest. During the initial three months of the project no formal survey data was collected. This period was needed for users to become comfortable with using and relying on the system. The primary data collection period occurred after July 1999. Four surveys were conducted to assist in determining the capabilities and benefits of the system. They were directed at the major stakeholders. The FSS staff accessed the images for a three-month period and filled out over 100 daily surveys to capture the operational benefits. The NWS provided a similar service, capturing daily data on the usefulness of the images in producing weather products on over 100 surveys. The first on-line survey captured input from a multiplicity of users resulting in over 3500 responses in a 7-month period. A final on-line survey was employed early in January 2000 to provide summary information about the capabilities of the system. The information gleaned from the analysis of these data sources is provided in Chapter 8.

The system was so widely accepted by the end of September 1999 that ASTF requested that the project manager continue to maintain the project beyond 1 October 1999 with a subsequent increase in the total grant to $114,000 (Appendix G). Data was therefore collected until 31 December 1999. During this period, images were transmitted every thirty minutes from each rural site during daylight hours and made available to the general public on the Internet. The website will be on-line under the management of the author at www.FlightCam.net until 1 May 2000.

# CHAPTER 8

# Survey Analysis and Results

Chapter 8 provides the analysis of data collected during the operational test of FlightCam as a weather collection resource in Interior Alaska. Additionally, it establishes the results of that analysis in terms of the three goals established for the project. In the process it directly addresses the hypothesis established in Chapter 6. This chapter provides strong evidence through survey data, survey comments and images of the capabilities and benefits of remote video. Section 8.1 explains the purpose of the surveys. Section 8.2 provides an analysis of the collected data. Section 8.3 summarizes the results of the analysis. The hypothesis is revisited and discussed in light of the survey results in section 8.4. Chapter 9 follows with conclusions from the research.

## *8.1 - Survey Purpose*

Four surveys were conducted during the operational test of FlightCam. The purpose of the surveys was to capture user input about the capabilities of remote video to assist with weather condition reporting at rural airstrips in Alaska. The information gathered was to be used to logically support the claims of the hypothesis stated in section 6.3. In addition to the surveys, operational images were captured and saved throughout the project to serve as definitive evidence in support of both the hypothesis and claims of users. The individual goal of each survey is explained below.

<u>Online Survey - During Test</u>

This survey was targeted at commercial and general aviation pilots and companies. Its intent was to capture real-time information about the extent to which the images assisted the user in aviation operations on the specific day the images were accessed. It provided information about the extent to which the images assisted in making decisions to cancel, delay or launch a flight. It also captured data about the specific environmental phenomena which the user could discern from the image of a remote location. This survey had over 3500 respondents in a 7-month period. The survey was conducted on-line coincident with the FlightCam website.

FAA Survey

The purpose of this survey was to obtain feedback from trained FAA FSS briefers regarding the potential for FlightCam to improve pre-flight and in-flight briefings given to pilots. The survey was also intended to enlist the support of FSS personnel in the integration of remote video for operational use in the FSS. FSS personnel completed approximately 100 surveys. The survey questions specifically sought to determine the extent to which images could improve the accuracy and completeness of pre-flight briefings.

NWS Survey

The NWS survey was designed to obtain the input of trained weather observers from the NWS regarding the potential for FlightCam to assist in the preparation of NWS weather products. These products directly affect the quality of aviation weather products available to the FAA FSS. It was also intended to create an interest in the use of remote video within the Alaskan NWS community. NWS personnel completed approximately 100 surveys.

Online Survey - Final

This survey was conducted at the end of the FlightCam operational test. Its purpose was to gather information from FlightCam users about the general capabilities and benefits that would accrue from the use of remote video. Instead of seeking real-time input about specific uses of the images, it sought to extract overarching user perspectives after 9 months of use. This information was particularly helpful in establishing the feasibility of employing FlightCam as a new weather collection resource.

## 8.2 - Analysis

This section analyzes the images and four surveys to provide support for the results in section 8.3. The analyses are conducted in the following order: 1) Images; 2) Online Survey - During Test; 3) FAA Survey; 4) NWS Survey; and 5) Online Survey - Final. Prior to the formal analysis of the surveys, a representative group of images in analyzed to demonstrate the capabilities of the system and to assist in understanding the survey results.

### 8.2.1 - Analysis of Images

The purpose of this section is to provide visual proof to support aspects of the hypothesis presented in Chapter 6. The section provides actual images gathered during the remote video project which demonstrate the many capabilities of the system to collect weather and runway information. These images in concert with the previously analyzed survey data provide clear proof of the capabilities of the system. Figures 8.1 through 8.30 are described in detail to establish the capabilities of FlightCam.

Figure 8.1 - This image clearly demonstrates the value of remote video. ASOS at the camera location would be reporting clear skies. However, a mere 10 miles to the west there is a major buildup of cumulus clouds covered with a thick, less-defined cloud layer. Current automated systems cannot detect distant weather phenomenon. The picture would also corroborate an automated report of clear skies overhead.

Figure 8.2 - This image clearly identifies a buildup of cumulonimbus clouds to the north of Ruby over the Yukon River. It shows variable ceilings, rain and an overcast layer of clouds. This image provides clear evidence of thunderstorm activity which is extremely valuable to pilots.

Figure 8.3 - This image establishes that there is a broken overcast layer with clear breaks in the clouds. The sun is shining on the terrain in the foreground indicating a large hole in the layer overhead. It establishes a relatively uniform layer with a consistent ceiling for 8 miles to the south of Kaltag. There is no rain, no virga, and the visibility (as evident when compared to the clear day image in Figure 8.30) is at least 8 miles.

Figure 8.4 - This picture demonstrates the opposite of Figure 8.1. It shows overcast conditions at the location of the cameras and blue sky with clearing conditions to the north. AWOS would report overcast and give no indication of weather on the approach route from the north.

Figure 8.5 - This picture clearly identifies localized ground fog to the north of the airport at Anaktuvuk Pass, Alaska. This condition could not be detected by the AWOS system there.

Figure 8.6 - This image shows heavy fog in the pass looking south. Visibility is less than ½ mile and conditions are clearly not conducive to VFR flight. This picture would discourage any pilot from attempting a flight to this location.

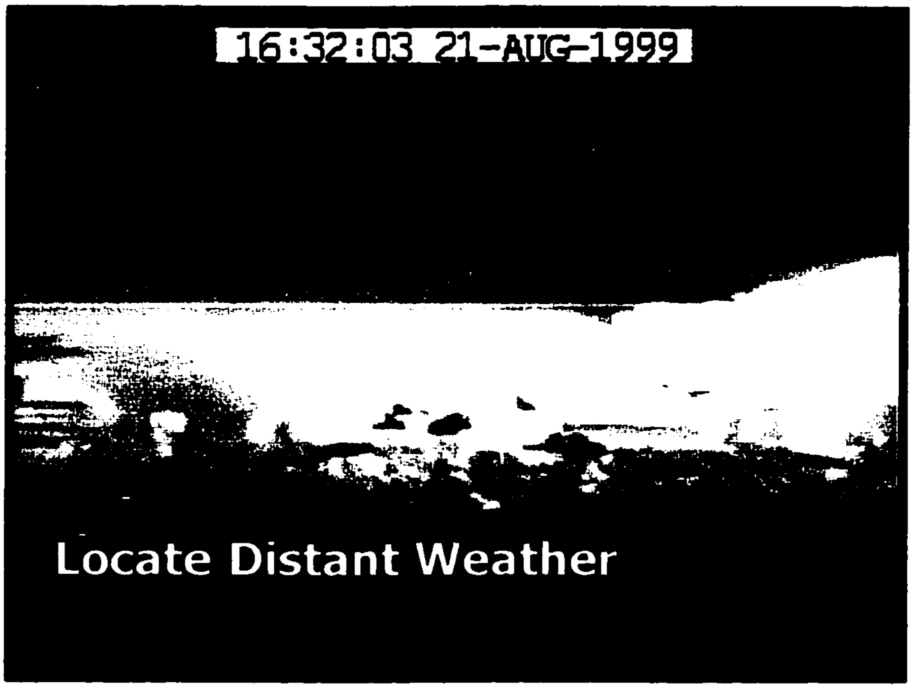



**Figure 8.1** - Distant Cloud Buildup over Mountains - Kaltag, Alaska

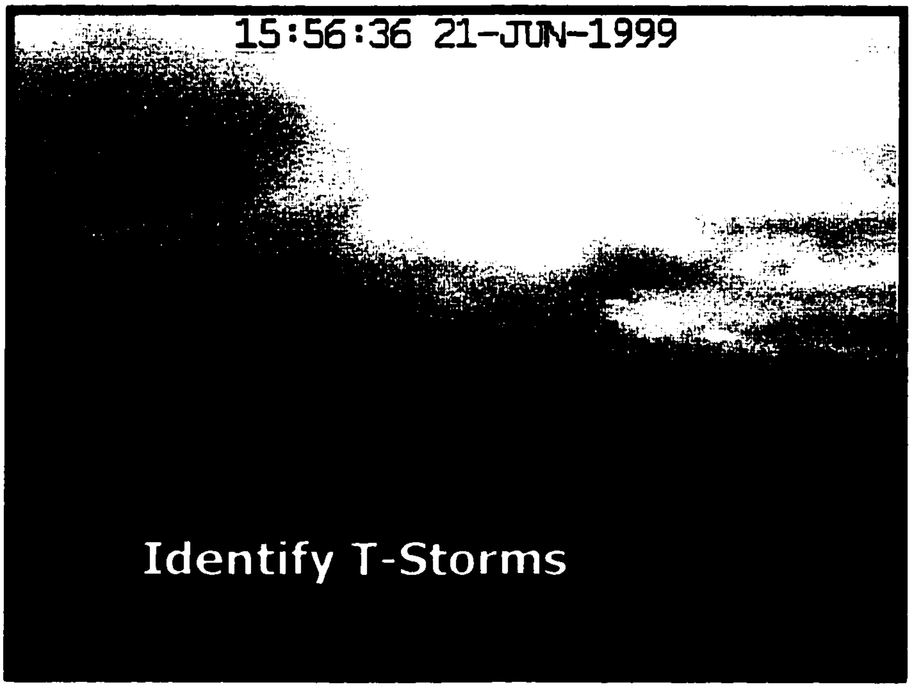



**Figure 8.2** - Thunderstorm over Yukon River - Ruby, Alaska

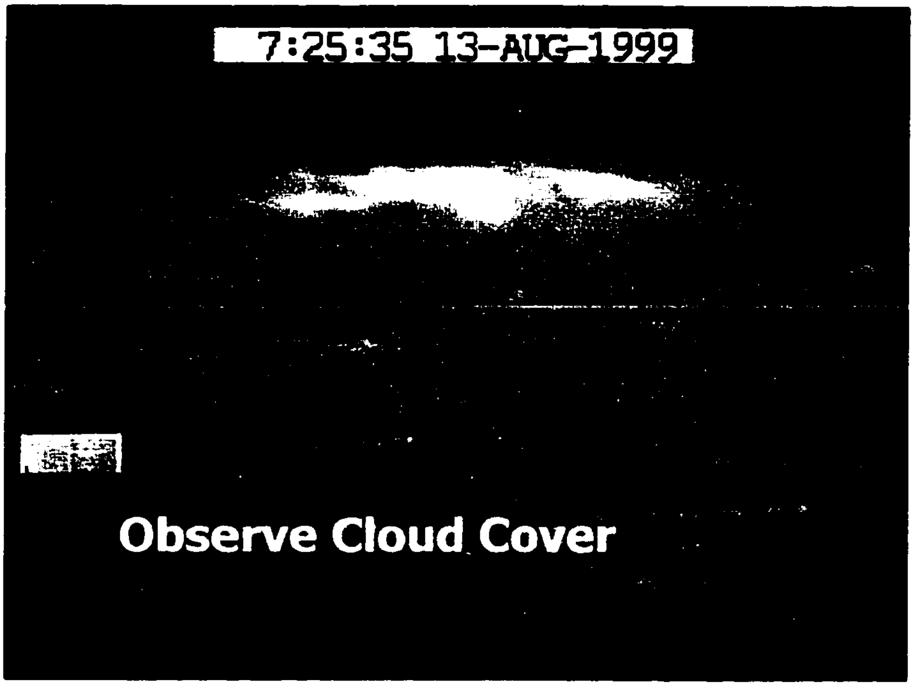



**Figure 8.3** - Breaks in Overcast Layer - Kaltag, Alaska

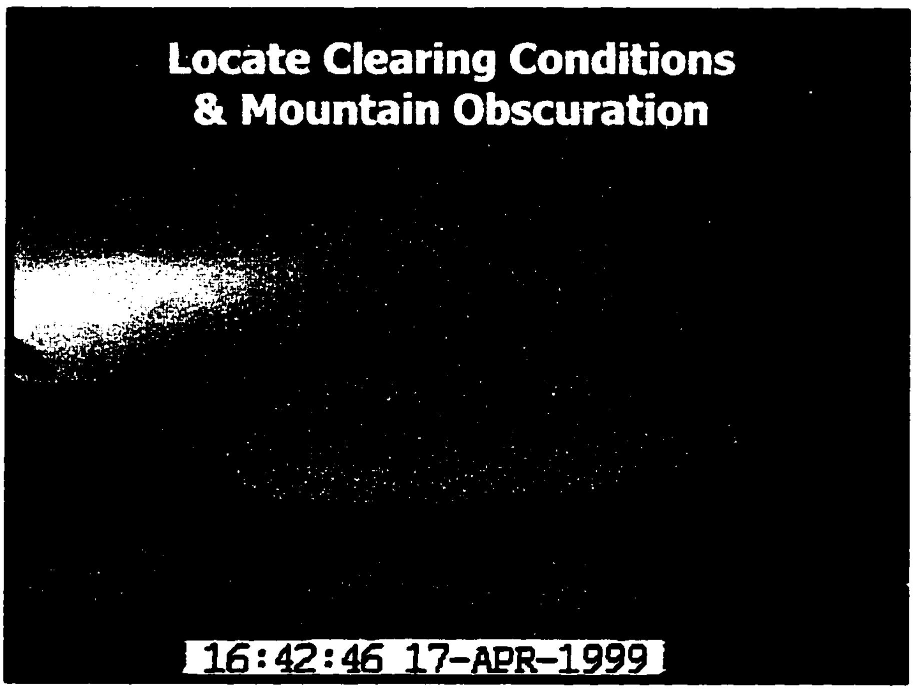



**Figure 8.4** - Clear Skies to the North and Overcast Overhead - Anaktuvuk Pass, Alaska

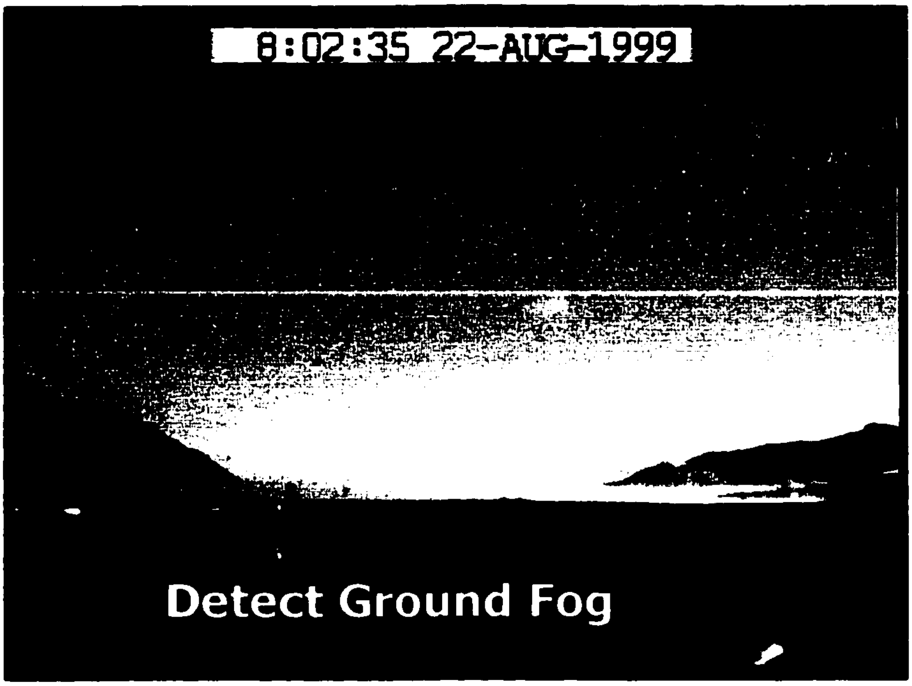



**Figure 8.5** - Localized Ground Fog North of the Airport - Anaktuvuk Pass, Alaska

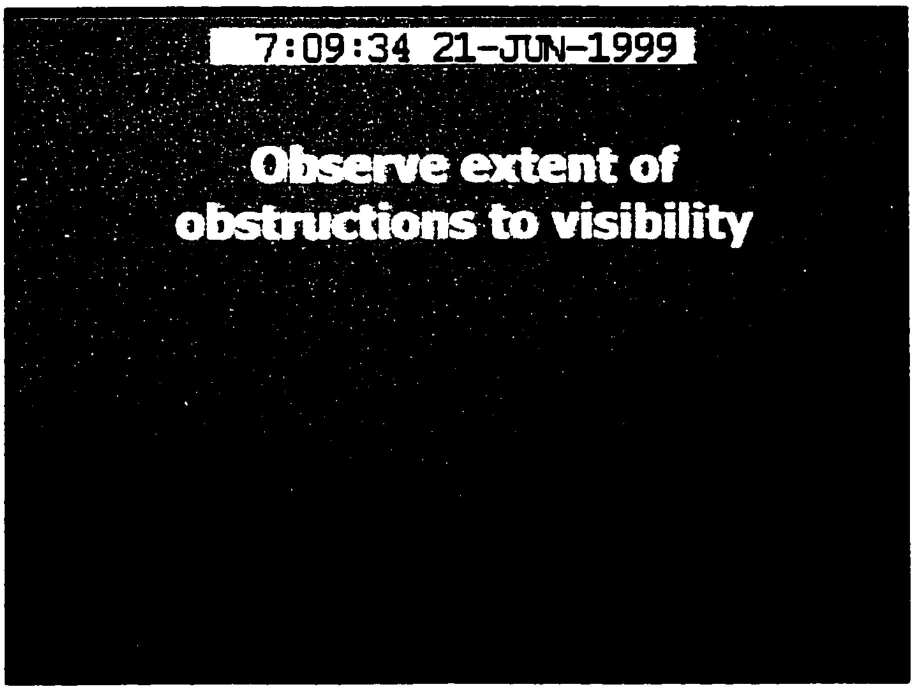



**Figure 8.6** - Heavy Fog Looking South Through the Pass - Anaktuvuk Pass, Alaska

Figure 8.7 - This image demonstrates heavy fog and mist over the Yukon River to the north of Ruby. Visibility is less than 3 miles as is evidenced by comparison with the clear-day image (Figure 8.29). The frozen Yukon River is visible to the north. The ceiling is indeterminate.

Figure 8.8 - Localized fog over the Yukon River is clear from this image. Note the vast difference between this report of fog and that shown in Figure 8.7. Ruby has no automated weather reporting systems. Images provide excellent information in a stand alone capacity of the conditions in the vicinity of Ruby, Alaska.

Figure 8.9 - This image verifies that conditions at Anaktuvuk Pass are clear and that visibility is unrestricted. The village is clearly visible in the lower right corner of the picture. The roof of the post office and its chimney are visible in the bottom of the image. The mountains in the distance set visibility at greater than 14.8 nautical miles (Figure 8.28). AWOS at this location can only report visibility to 10 miles. This indicates excellent VFR weather for a pilot.

Figure 8.10 - This picture shows water on the parking apron indicating recent precipitation. It shows low hanging clouds over the runway. In spite of the clouds, visibility is at least 2.6 nautical miles which coincides with the distance to the top of the mountain showing in the image. The ceiling appears to be a solid overcast and no sunlight is visible. This image indicates marginal weather which most general aviation pilots would not choose to fly in.

Figures 8.11 and 8.12 - These images provide clear proof of the potential for AWOS sensors to be wrongly influenced by manmade environmental phenomena. The camera that took this image is collocated with the AWOS sensors. This chimney smoke can cause these systems to provide absolutely false visibility and sky condition reports.

Figures 8.13 and 8.14 - Both of these images were taken in relatively low-light conditions. However, each shows relatively clear skies with excellent visibility. All terrain features are apparent. Figure 8.13 shows high clouds on the right side of the picture, but the lack of definition and localized structure indicates that this would be good flying weather.

Figure 8.15 - The one primary shortfall of the cameras as tested is their inability to "see" conditions during periods of darkness. This figure demonstrates that in northern latitudes, excellent information may be obtained for many hours due to the extended daylight during the summer. This picture was taken 20 minutes before midnight in Anaktuvuk Pass. It is still a clear day and excellent flying weather.

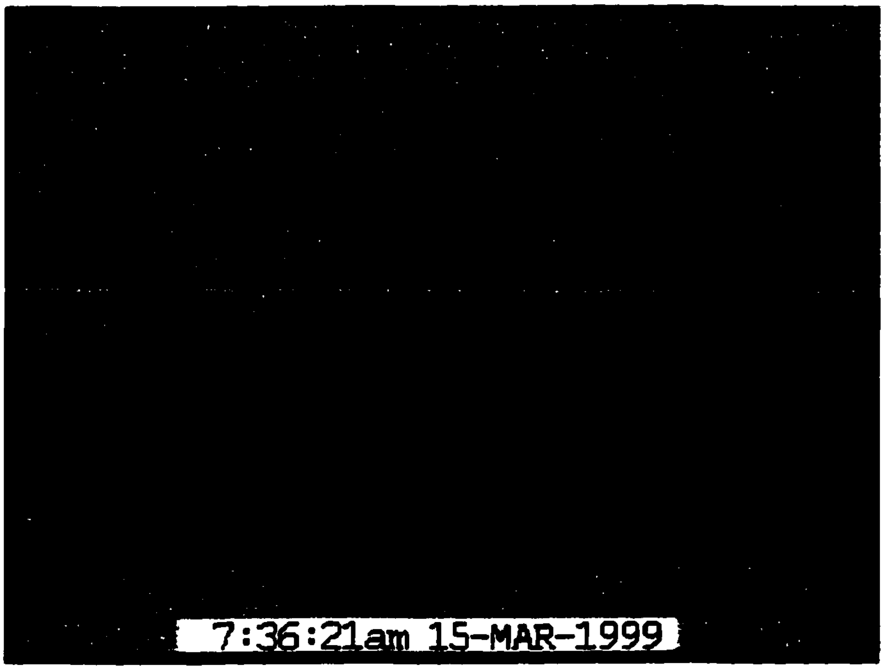



**Figure 8.7** - Heavy Fog and Mist over Yukon River - Ruby, Alaska

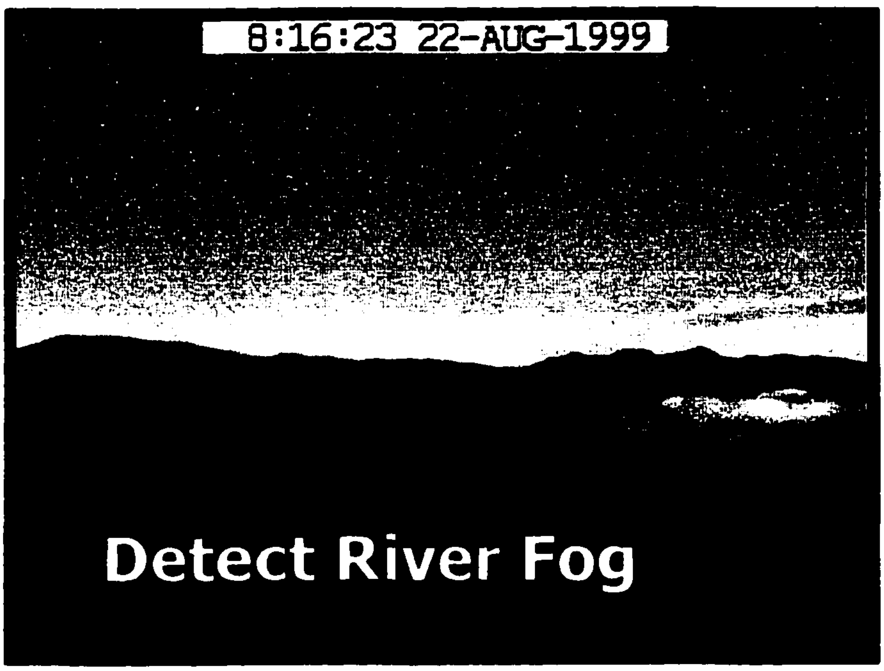



**Figure 8.8** - Localized River Fog over the Yukon River - Ruby, Alaska

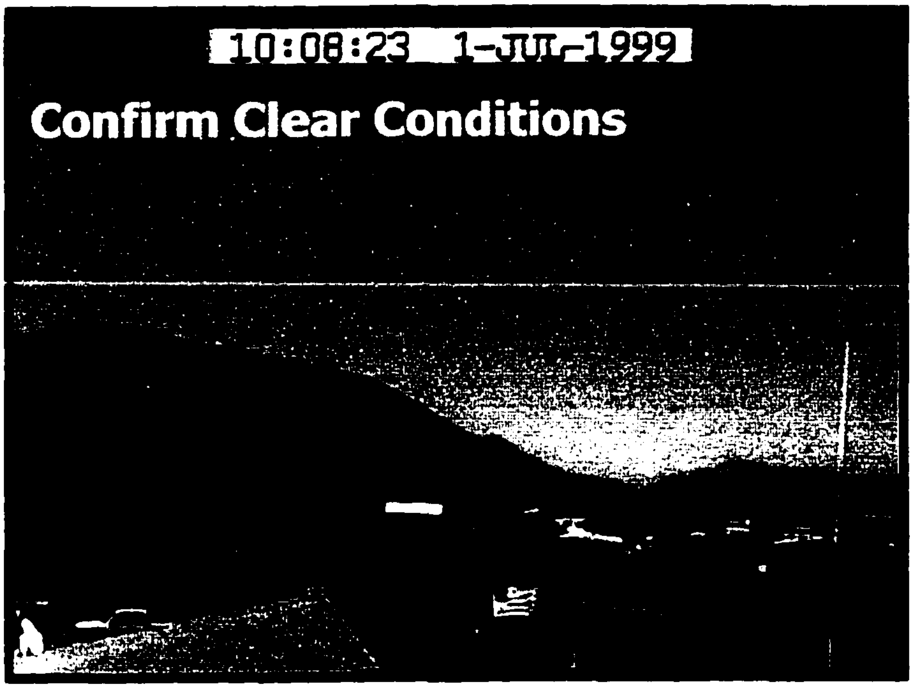



**Figure 8.9** - Clear Conditions Looking South Through the Pass - Anaktuvuk Pass, Alaska

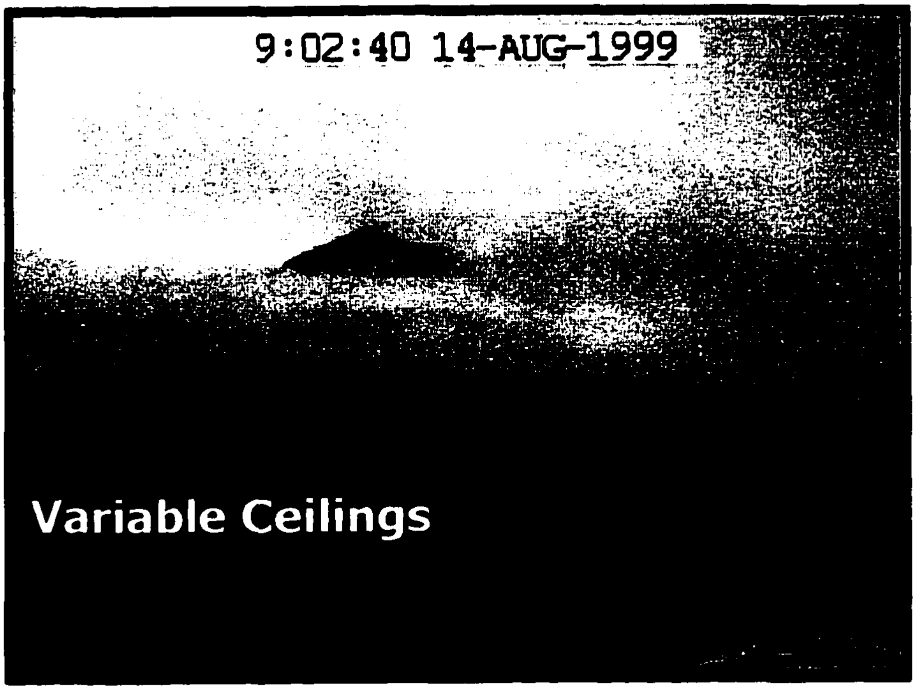



**Figure 8.10** - Variable Ceiling, Low Fog and Reduced Visibility over Runway - Anaktuvuk Pass, Alaska

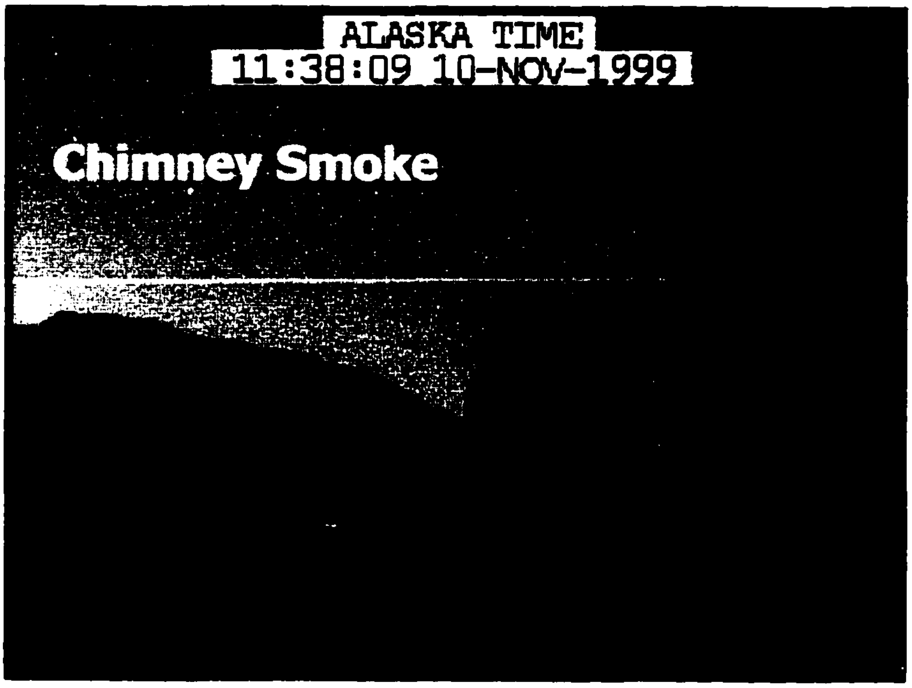



**Figure 8.11** - Chimney Smoke from Post Office Building - Anaktuvuk Pass, Alaska

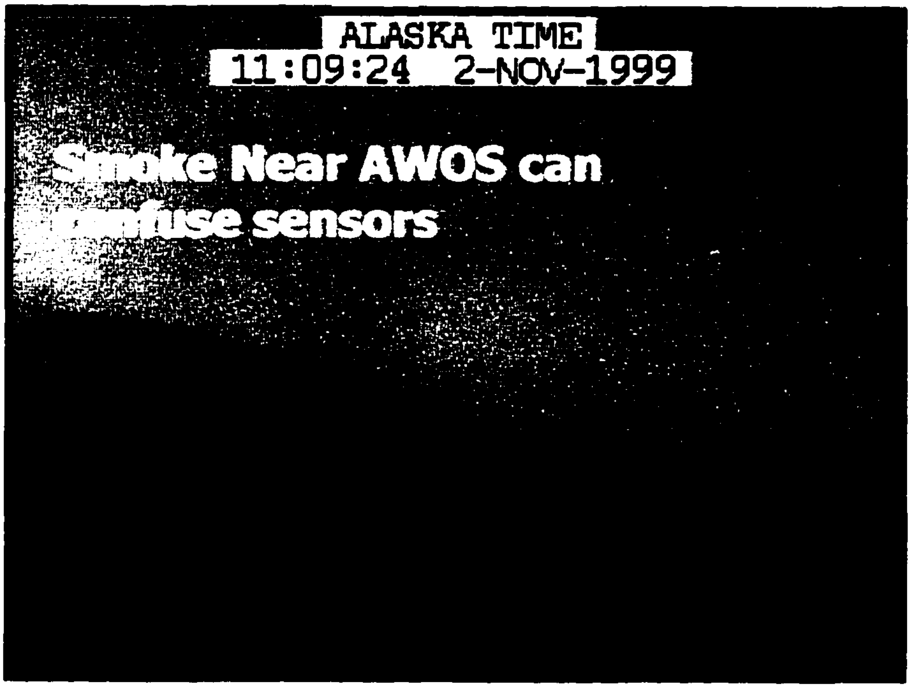



**Figure 8.12** - Thick Smoke in Vicinity of AWOS - Anaktuvuk Pass, Alaska

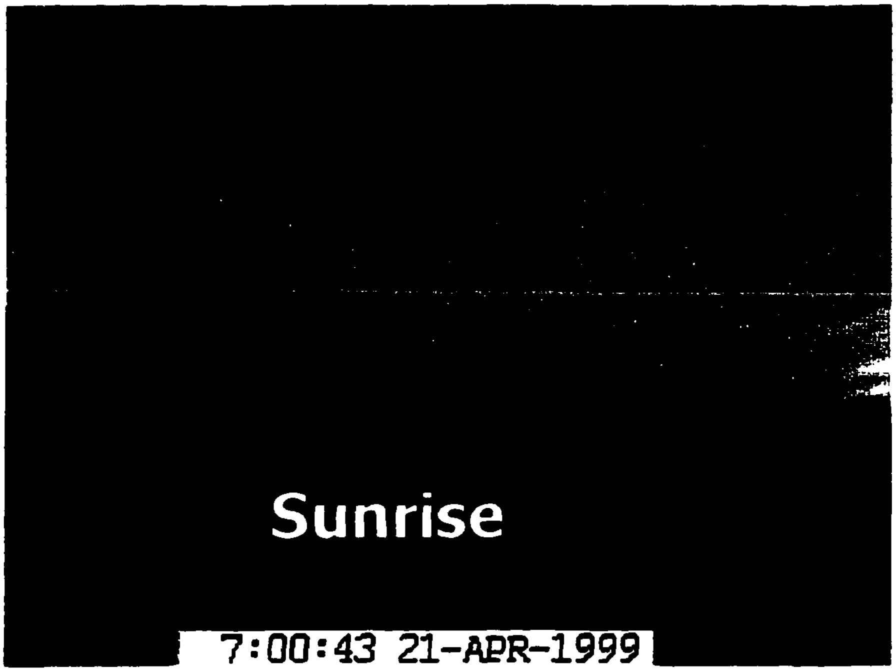



**Figure 8.13** - Sunrise Visibile in Low Light - Kaltag, Alaska


**Figure 8.14** - Sky Conditions Visible in Low Light - Kaltag, Alaska

Figure 8.16 - Similarly, this picture indicates that even during periods of total darkness, a distant light (in this case the moon) may provide usable weather information. The fact that the moon can be seen clearly indicates that there is no solid overcast and the visibility is relatively good at a slant angle.

Figure 8.17 - This image demonstrates the system's capability to detect precipitation. Raindrops have gathered on the outside of the window of the environmental housing. The camera itself is completely isolated and protected from this moisture. The drops indicate that the wind is blowing generally towards the camera lens. Pictures taken simultaneously from the other two cameras at this location would not show any drops on the lens. The image establishes the presence of ongoing or recent precipitation and gives some indication of the wind direction at the site.

Figure 8.18 - This image is similar in that it indicates the presence of precipitation. However it also establishes that the temperature is below freezing by the presence of ice on the lens. While ice and raindrops on the lens restrict the view through the lens, the condition is normally very short-lived. Defrosters on the housing window melt the ice and evaporate the water within several hours after the precipitation has stopped.

Figure 8.19 - This picture falls somewhere between figures 8.17 and 8.18. Snow on the ground indicates predominantly freezing conditions. Drops on the window indicate that either rain or snow has fallen. Snow on the lens may have quickly melted to water drops by the action of the defroster or the ambient temperature conditions.

Figure 8.20 - This picture provides decisive wind information. The camera view is perpendicular to the runway at Kaltag. The windsock is straight out, indicating a 15-knot wind, and it is aligned with the runway. This is good information to establish that in spite of a strong wind, it is aligned with the runway minimizing the cross wind component and providing reasonable conditions for landing. Additionally, the sky is clear and visibility is excellent.

Figure 8.21 - This picture provides confirmation of the system's capability of detecting precipitation at night and in low-light conditions. The streaks in the image are snowflakes being illuminated by the rotating beacon which is mounted several feet below the cameras. A strobe light could be connected to the camera server providing a synchronized flash of light in conjunction with the grabbing of the image. In this fashion, precipitation could be clearly recognized and reported.


**Figure 8.15** - Extended Daylight During the Summer in Northern Latitudes - Anaktuvuk Pass, Alaska


**Figure 8.16** - Demonstration of Low Light Visibility Determination

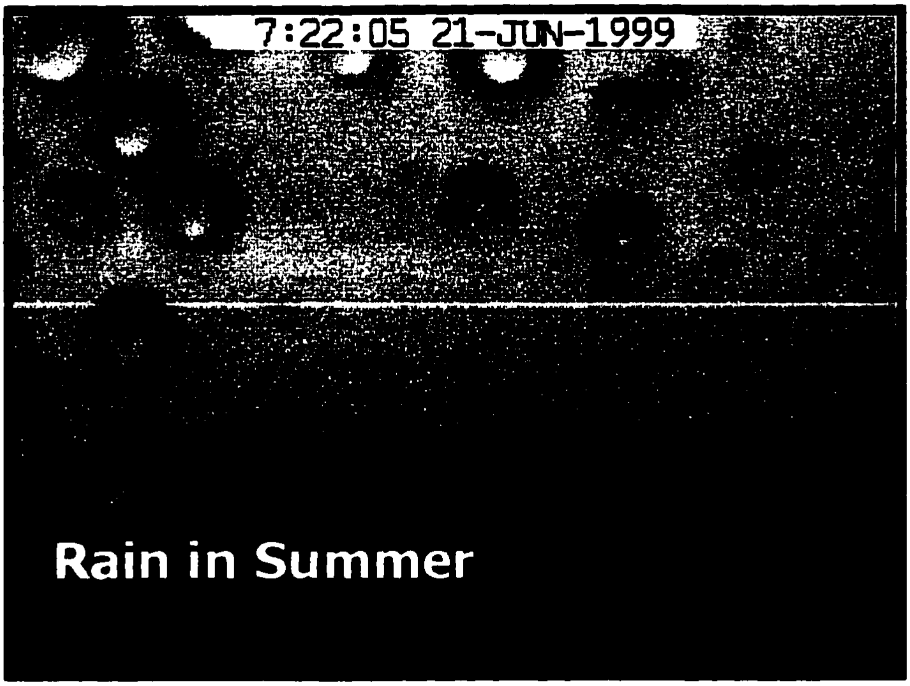



**Figure 8.17** - Raindrops on Lens During Summer - Ruby, Alaska


**Figure 8.18** - Ice on Lens During Late Winter - Kaltag, Alaska

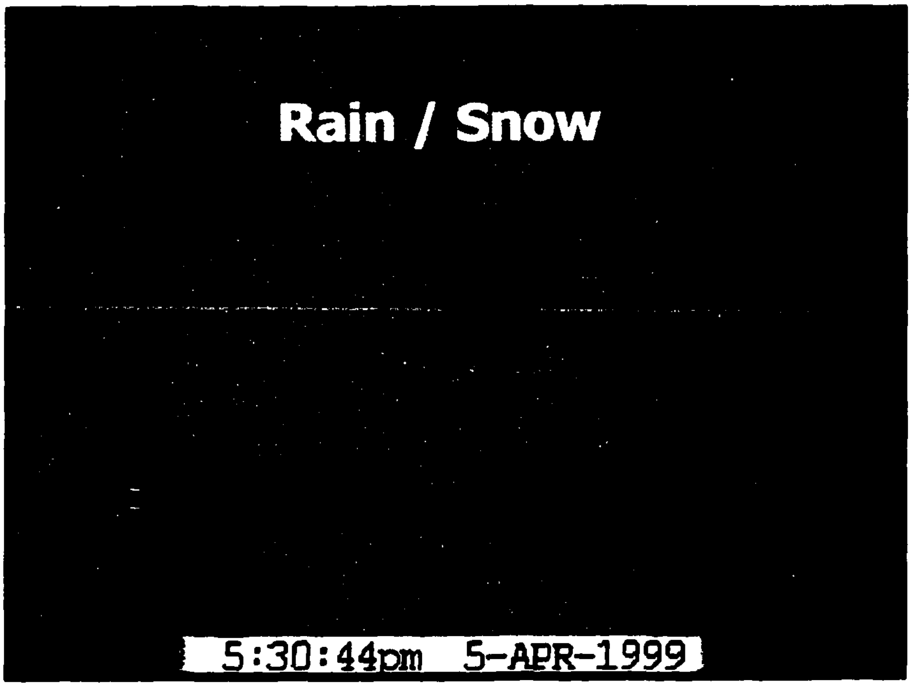



**Figure 8.19** - Melted Snow on Lens During Late Winter - Kaltag, Alaska

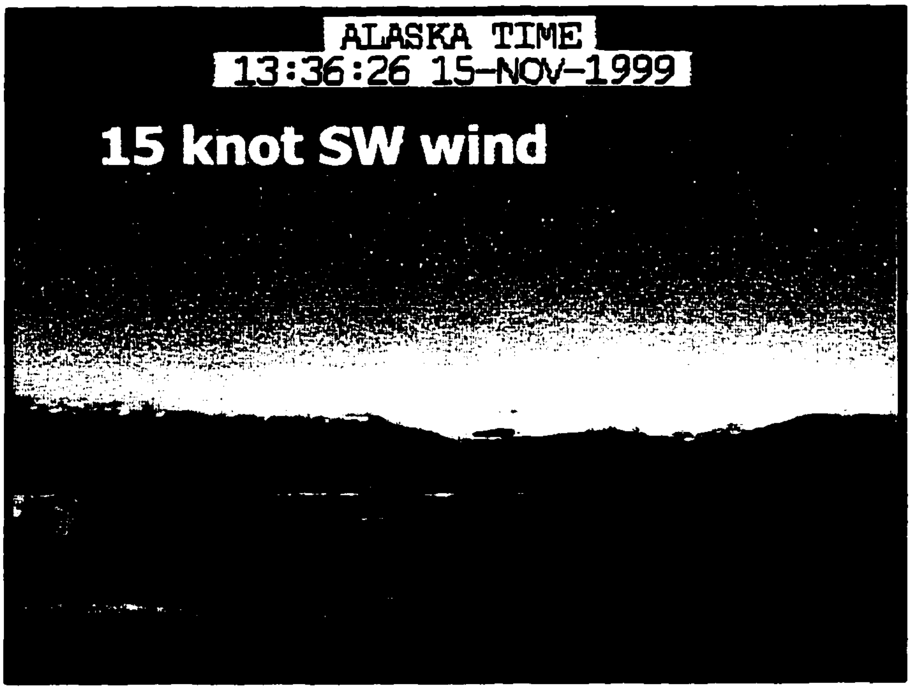



**Figure 8.20** - 15 Knot Wind Aligned with Runway - Kaltag, Alaska

Figure 8.22 - This image shows a broken to overcast layer overhead with clear conditions to the south in Kaltag. The ASOS at this time was reporting 8000 feet overcast. The image provides excellent additional information about clearing conditions in the distance. ASOS could not detect or report these conditions.

Several other uses of FlightCam images became evident throughout the test. The next four images demonstrate some of these benefits.

Figure 8.23 - In this figure, an aircraft is clearly visible on the parking apron at Anaktuvuk Pass. Air carriers have indicated that if pictures were pushed onto the Internet every 2 or 3 minutes, they could use the system to track the location of their aircraft, thus improving service and efficiency.

Figure 8.24 - In this picture, the scraped, frozen ground in the foreground on the parking apron establishes that some snow clearing has taken place. This may assist users in establishing whether or not runway snow clearing operations have been performed. During the winter this is important information for carriers who fly there daily.

Figure 8.25 - In this picture, the runway lighting is clearly visible at dusk. While runway lights may not currently be activated from a remote location, the cameras are able to confirm that they are working whenever a local pilot activates the lights. This is good information for AKDOT as well as for pilots.

Figure 8.26 - During the summer of 1999, the runway at Anaktuvuk Pass was reoriented. One FlightCam user accessed the images quite regularly to track the progress of construction in this remote location.

Figure 8.27 - This series of four images shows the window defroster in action. The first picture shows ice covering the window. Thirty minutes later, the ice is thinning. One hour after the first image was taken, the ice is considerably thinner. Two and a half hours later the ice was completely gone. This was typical of ice and water drops on the windows throughout the test. Neither ice nor water ever had to be physically removed from the lenses as a maintenance activity.

Figure 8.28 - This triad of images shows the clear-day annotated pictures that were used for comparison to the current images from the three cameras at Anaktuvuk Pass.

Figure 8.29 - These three images are the clear-day annotated images for Ruby.

Figure 8.30 - These images are the clear-day annotated images for Kaltag.


**Figure 8.21 - Detection of Snowfall During Low Light - Ruby, Alaska**

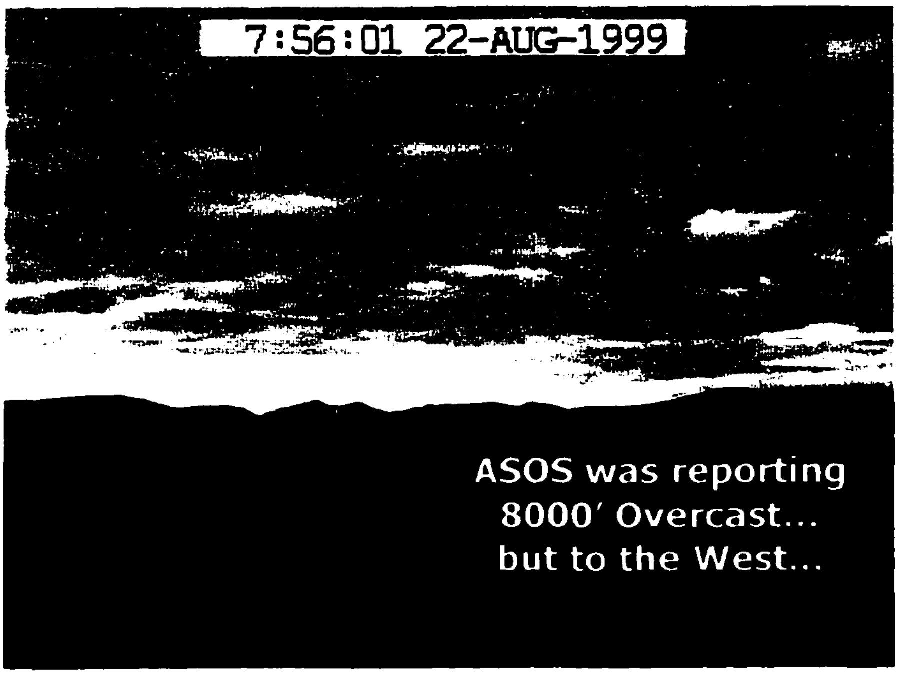



**Figure 8.22 - Broken Layer Overhead with Clear Conditions to the South - Kaltag, Alaska**

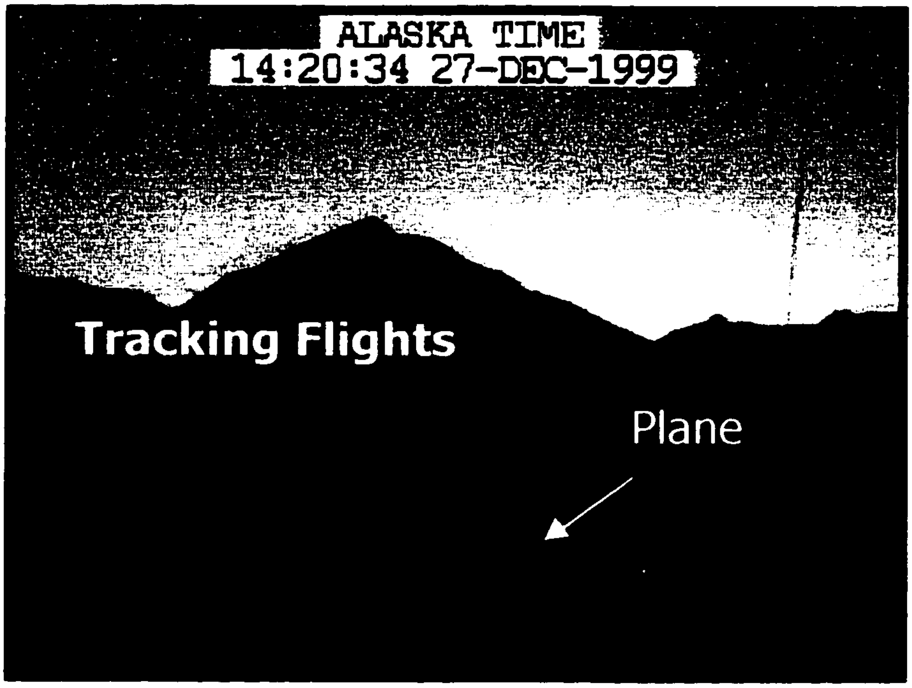



**Figure 8.23** - Plane on Parking Apron - Anaktuvuk Pass, Alaska


**Figure 8.24** - Evidence of Snow Clearing Operations on Apron - Anaktuvuk Pass, Alaska

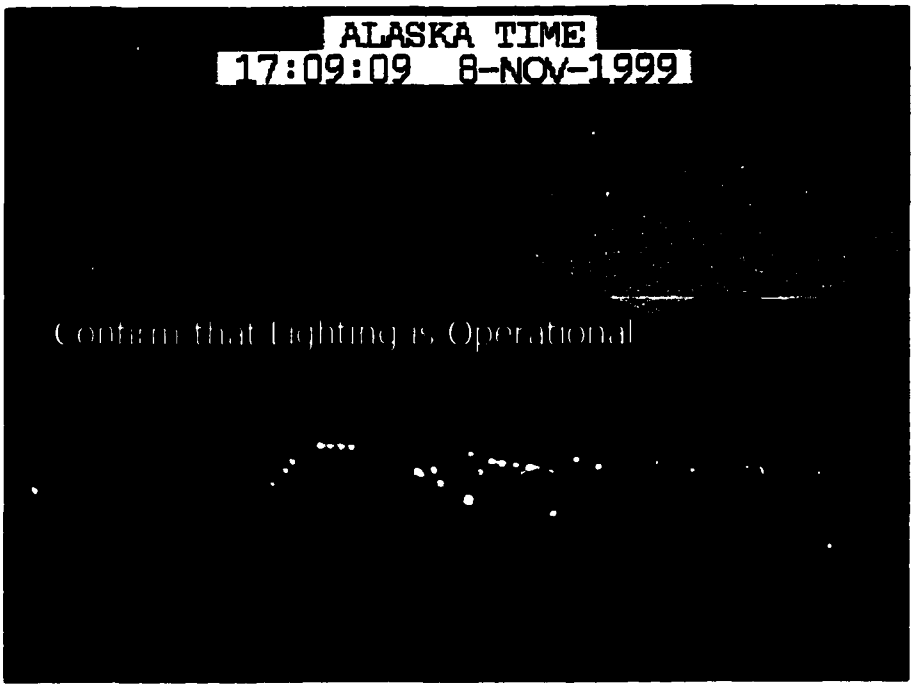



**Figure 8.25** - Runway Lights Visible at Dusk - Anaktuvuk Pass, Alaska

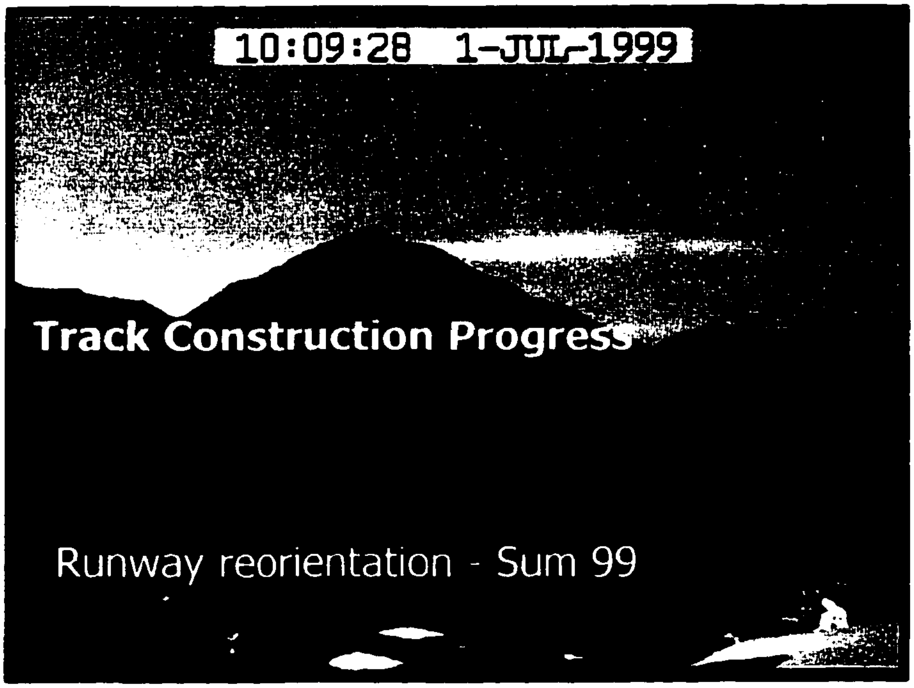



**Figure 8.26** - Monitoring Construction Progress on Runway - Anaktuvuk Pass, Alaska

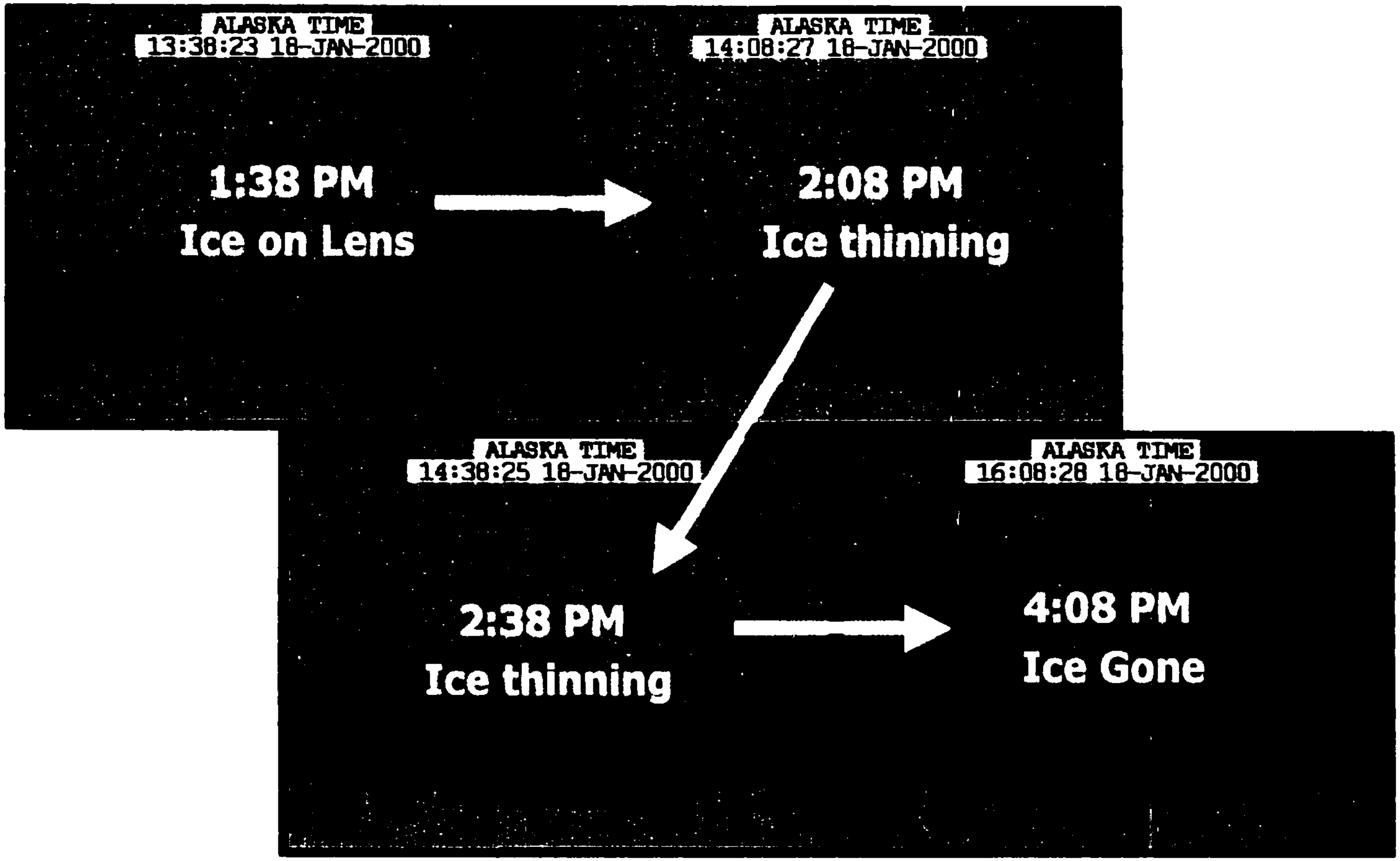



**Figure 8.27** - Melting Action of Window Defroster on Ice - Ruby, Alaska

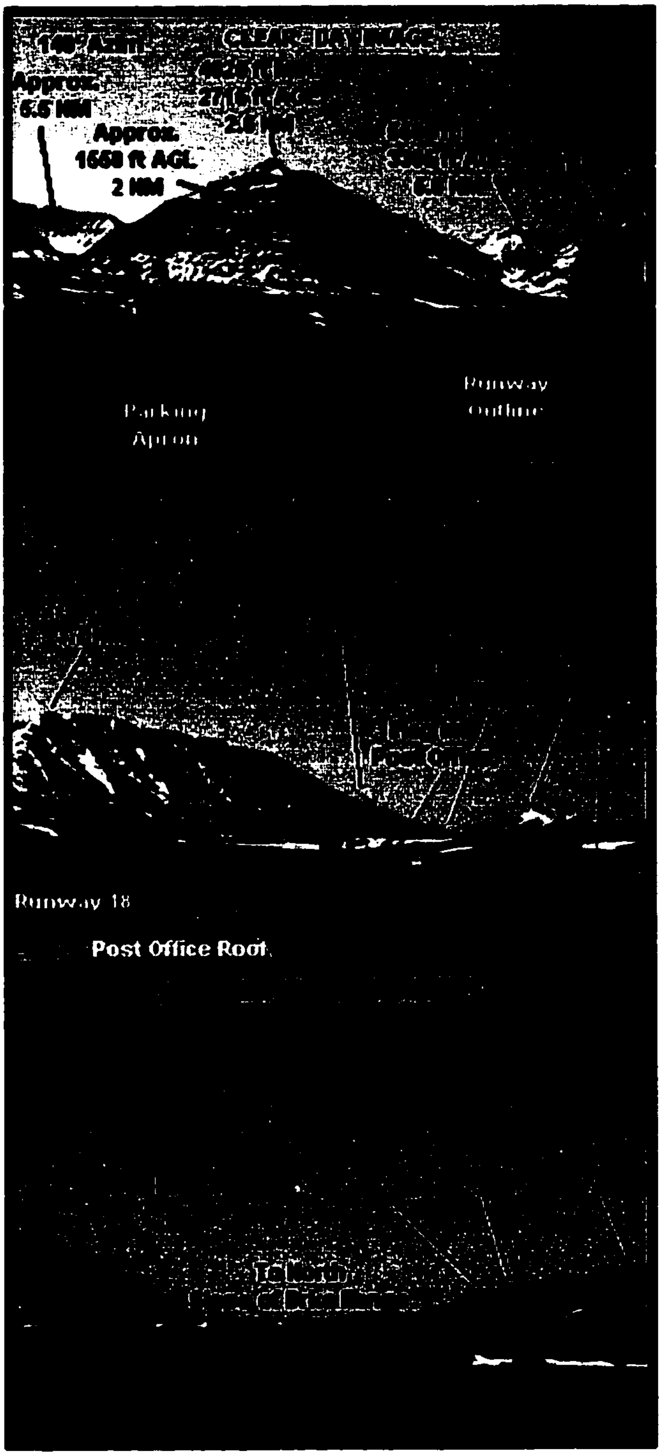



**Figure 8.28 - Anaktuvuk Pass Clear Day Images**
**Top (Runway), Middle (South thru Pass), Bottom (North thru Pass)**

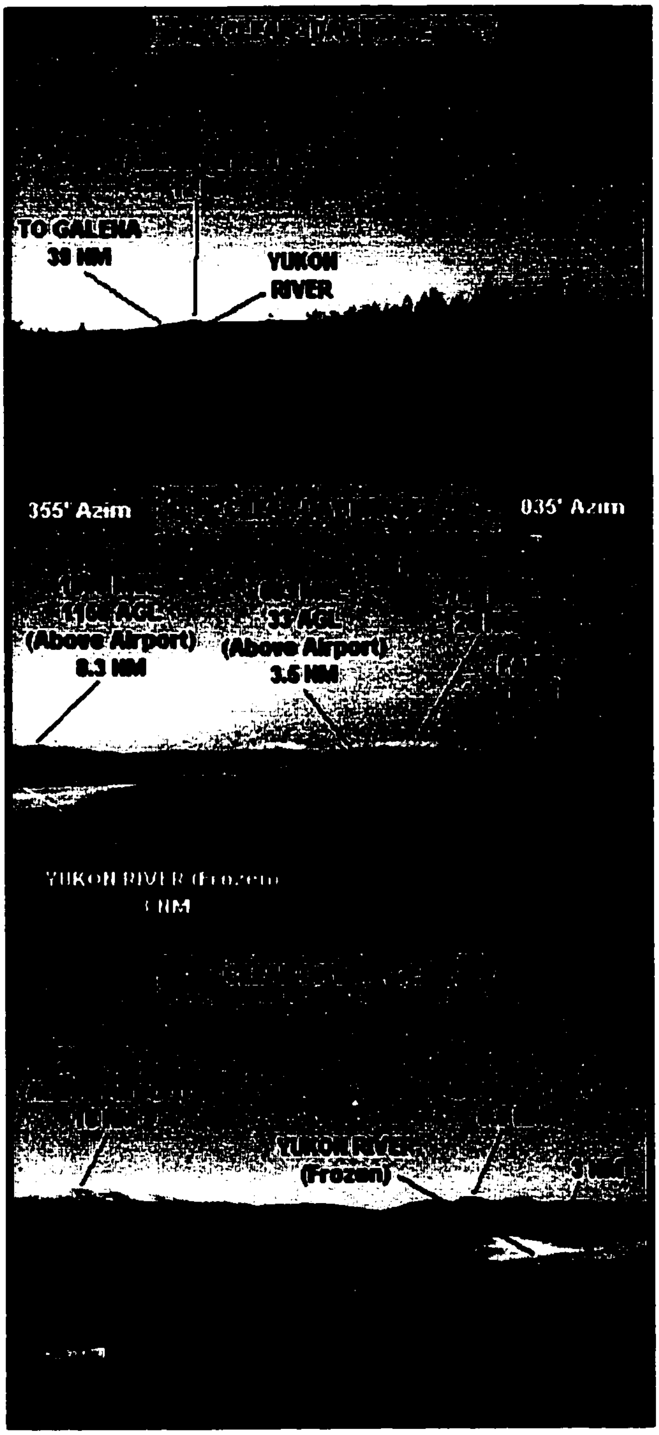



**Figure 8.29 - Ruby Clear Day Images**
**Top (West), Middle (Northeast), Bottom (North)**

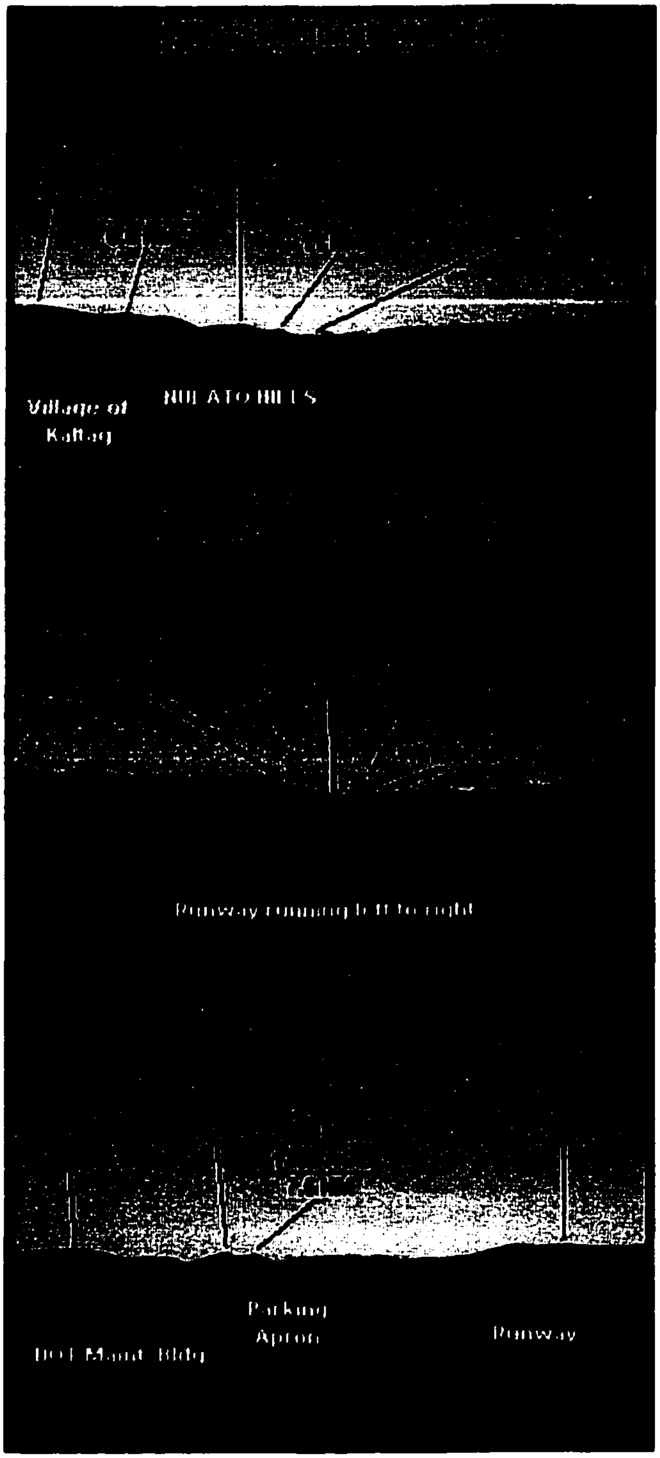



**Figure 8.30 - Kaltag Clear Day Images**
**Top (North), Middle (West), Bottom (Southwest)**

## 8.2.2 - Online Survey - During Test

This survey was initiated on 5 July 1999. It was an online survey that had the distinct advantage of providing users of the website with an avenue for immediate feedback. This enabled the author to capture very specific user information about the use of the images as it was occurring. The survey was arranged such that user feedback was appended to a delimited data file at the ISP. The author downloaded the contents of the file on a regular basis during the test. The file was then uploaded into a spreadsheet and was already in a format that allowed analysis of the data. The survey questions are shown at Figure 8.31. In addition to the information shown, the data file also captured the date and time that the respondent submitted the survey.

The effect on survey response of two major media releases is shown in Figure 8.32. The AvWeb article in particular generated a huge response during the week following its release on 13 Sep 1999. For a portion of the analysis, the data collected from this week has been stripped out to better portray normal system use during the test.

### *8.2.2.1 - Basic Demographics*

This survey was online for 179 days from 5 July to 31 December 1999. During that time there were 3,586 responses which equates to approximately 20 surveys per day. Removing the effect of the AvWeb article, approximately 12 surveys were completed per day over the course of the test. This response alone demonstrates the excellent opportunity that arises through use of an online survey when the product itself is online. The opportunity for immediate and direct feedback is maximized. During this survey period, there were approximately 61,931 hits on the website indicating a survey response rate of 5.8%.

General aviation pilots accounted for 72% of the respondents, or 2603 responses in total. Removing the effect of the AvWeb article, we have 1,383 general aviation pilot responses out of 2,158 total surveys and this average drops to a more representative 64%. With a total of 50,606 hits on the website during this same period, we estimate 32,387 general aviation pilots accessed the website for an average of 188 hits per day by general aviation pilots. This is significant. It indicates not only a passing interest in the information available on the website, but a strong, continuing interest in use of the website for operational and evaluative purposes.

1. **For what purpose(s) will you use FlightCam images today? (Select all that apply)**

   a. Flight Planning - Get **Weather** Info
   b. Flight Planning - Get **Runway environment** Info
   c. Other Purposes - Get **Weather** Info
   d. Just browsing

2. **Who do you represent at this viewing of FlightCam? (Select one)**

   a. Myself (I am a General Aviation pilot)
   b. Air Carrier or Air Taxi in **Interior Alaska**
   c. Air Carrier or Air Taxi **elsewhere in Alaska**
   d. Alaska DOT & PF
   e. Federal Aviation Administration (FAA)
   f. National Weather Service (NWS)
   g. Other (Please Specify)

***ANSWER THE FOLLOWING ONLY IF YOUR INTEREST TODAY IS AVIATION RELATED***

3. **Did FlightCam images influence your decision?**

   a. Yes, I decided to CANCEL a flight due to weather
   b. Yes, I decided to DELAY a flight due to weather
   c. Yes, I decided to LAUNCH a flight
   d. No they did not influence my decision
   e. Not applicable

4. **Which site(s) did you look at? (Check all that apply)**

   a. Anaktuvuk Pass
   b. Ruby
   c. Kaltag

5. **Which of the following information did FlightCam provide that was otherwise unavailable or unreliable through official sources (FSS, AWOS, ASOS, CWO etc.)? (Check all that apply)**

   a. Ceiling information
   b. Visibility information
   c. Fog
   d. Local Precipitation
   e. Cloud Types
   f. Other (Please Specify)

6. **Comments?**

**Figure 8.31** - Online Survey - During Test

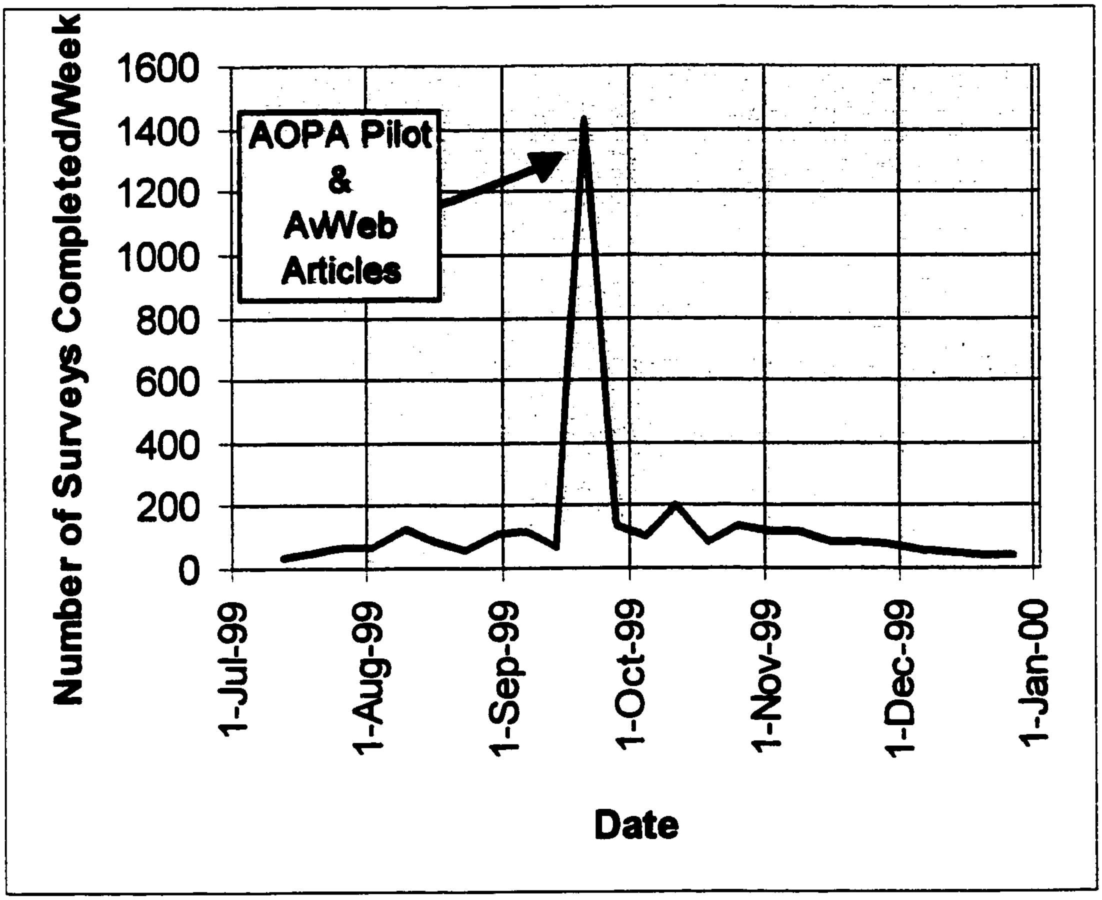



**Figure 8.32** - Surveys Completed and Effect of Media Releases on Survey Submission

7.2% of respondents (258 individual responses) were pilots for air carriers operating in Interior Alaska. This is an excellent focus group because these operators have a daily need for weather information at the airports available on the website. This number increases to 11.35% when the week of 13-19 Sept is stripped out to reduce the affect of the AvWeb article. This again is significant. Proportionally, given 50,606 hits on website during this same period, this would indicate that approximately 5,743 Interior Alaskan air carrier pilots accessed FlightCam during that period of time. This equates to an average of 33 hits per day by this group.

FAA personnel represented 1.1% of the respondents for a total of 41. FAA personnel were completing a special hardcopy survey during this period, so their online survey results were discounted. The FAA survey is discussed in section 8.2.3.

NWS personnel represented .6% of respondents for a total of 20. This agency was also completing a separate hardcopy survey throughout this period, so their online results were similarly discounted. The NWS survey is discussed in section 8.2.4.

AKDOT filled out 17 surveys representing .5% of the total. Since the focus of the project was on weather condition reporting, there was no major focus on ascertaining AKDOT use of FlightCam images. However, AKDOTs comments on the online survey indicate a strong interest in the use of such technology for runway condition reporting purposes as was originally suggested. This is discussed in sections 8.2.2.3 and 8.2.5.3 in the analysis of written comments.

43 respondents were from Alaskan air carriers operating in locations other than Interior Alaska. While the comments from this group were helpful, the operational information was not strongly considered because of their geographical distance from the three villages involved in the test.

The final 17 % of respondents were other people, agencies and companies browsing or evaluating the site for their own purposes. This group of respondents is extremely diverse and deserving of recognition by virtue of the agencies and countries they represent. Some of these are highlighted below:

People, Agencies and Companies

*Pilots* - The list of pilots includes a Boeing 747 Captain, a Boeing 727 Captain, a Synthetic Aperture Radar pilot, a French air taxi pilot, several military pilots/instructors, and a Federal Express pilot.

*Airlines* - Individuals representing the following airlines participated in the survey: United, Alaska Airlines, American Airlines, Atlantic Skyways, Comair Airlines, Delta Airlines, Southwest Airlines, and TAESA Airlines in Mexico City.

*Military* - Respondents included the Alaska Air National Guard, two U.S. Air Forces Bases in Alaska (Eielson and Elmendorf), the U.S. Navy, U.S. Army Aviation, the U.S. Army Corps of Engineers, and the U.S. Coast Guard.

*Aviation Related Companies* - Many aviation companies responded to the survey, to include representatives of the following: aerial photography companies, an Australian air traffic control services supplier, avionics manufacturers, FAA contractors, Jeppesen (supplier of U.S. aviation charts), Mitre Corporation, U.S. Aviation Underwriters, an aerial survey company, Flight Safety International, and FlightGest, Inc.

*Aviation Organizations* - The primary respondents in this category were the AOPA Air Safety Foundation, and AOPA Australia.

*Federal Aviation Administration or Equivalent* - The FAA and its equivalent in foreign countries were well represented in the list of respondents. These included: the Australian Civil Aviation Safety Authority (CASA), Austrian Civil Aviation Authority (CAA), Canadian FSS, Department of Transport Canada, Peruvian CAA, and FAA inspectors and consultants.

*Schools or Educational Institutions* - These included: King Schools (major provider of general aviation instructional videos), Aviation Theory Education Centre Australia, Flight Instructor at Western Michigan University, instructor at SimuFlite Training International, University of Arizona Department of Atmospheric Science and Take Flight Alaska (Anchorage based flight school).

*Airports* - These included the Tulsa Oklahoma Airport Authority, and airport manager in New Mexico, an airport owner and a Florida based airport.

*Science Related* - Scientists included: a physicist, the Alaska Climate Research Center, an anthropologist working in Anaktuvuk Pass, and a micrometeorologist.

*State Government* - This list includes: The Alaska Bureau of Land Management (BLM), Texas Department of Transportation, the Minnesota Environmental Quality Board and Colorado State Parks.

*Federal Government* - Federal organizations represented were: the Department of the Interior Office of Aircraft Services, NASA, the National Park Service, the National Transportation Safety Board, U.S. Fish and Wildlife, and the U.S. Department of Agriculture Predator Control.

While this is not an exhaustive list, it is representative of the respondents.

Foreign Countries

There were 15 foreign countries among the respondents providing comments. The countries are listed in descending order of the number of comments received from each: Australia (17), England (9), New Zealand (5), Germany (2), Scotland (2), South Africa (2), Sweden (2), Brazil (1), Holland (1), Indonesia (1), Ireland (1), Mexico (1), Nova Scotia (1), Ontario, Canada (1) and Venezuela (1). Representative comments from respondents from these countries are included later in this section.

Media

Many media releases were not self-evident until the survey data was analyzed. The survey revealed that FlightCam information was released in the following public media: Anchorage Daily News, the Alaska Weather Channel, AOPA Pilot, Axis Communications Circular, Flyer Magazine, New Scientist Magazine, Pilot Magazine, the Rochester Democrat Paper, the Shreveport Times, USA Today, and at least three other small town local papers.

#### *8.2.2.2 - Analysis of Survey Responses*

This section provides an analysis of responses to the questions posed in the survey in Figure 8.31. The two primary groups of focus were Interior Air Carriers and General Aviation pilots.

Weather and Runway Information

Interior Air Carriers that filled out the survey were seeking weather information for flight planning 93% of the time. Given that we estimated air carrier daily use at 33 times per day, this equates to 31 uses of FlightCam for weather information every day among air carrier pilots in Interior Alaska. This is a sustained number throughout the test period indicating that air carrier pilots see FlightCam as a significant weather collection tool. Additionally, air carriers were looking for runway information 41% of the time or an average of 14 times per day throughout the test. This was unanticipated, as it appeared that runway information was less discernable than initially hoped. We have sought to demonstrate that remote video is useful as a weather tool but have discovered that users also see it as a viable runway information collection tool.

General aviation pilots that accessed the site were seeking weather information 11% of the time. This equates to an average of 22 times per day. 5% of the time, these pilots were seeking runway information that equates to 10 times per day. These figures demonstrate that the general aviation population also had embraced the concept of remote video images to assist with both weather and runway information collection.

Flight Decision-Making

One of the primary benefits perceived by users of the system is assistance in making a very intuitive decision to launch, delay or cancel a planned flight. This section investigates user documentation of remote video for this purpose.

Question 3 in the survey asks whether the images influenced the pilot's decision to cancel, delay or launch a flight. It provides the opportunity to indicate that the image had no effect on the decision, or to establish that the question was not applicable. The latter is a primary indicator that the respondent was not using FlightCam for operational flying purposes. For this analysis, all records were stripped out that included a response of "not applicable" for question 3. The following information follows from the analysis.

*Air Carriers*

Air carriers indicated that 46.6% of the time that FlightCam was used for operational purposes, it assisted them in making a decision to launch a flight. Several scenarios could result in this decision. If the automated system (AWOS or ASOS) indicated that flight conditions were good, FlightCam may have confirmed these good conditions and prompted a decision to launch. If the automated system indicated flight conditions not conducive to safe flight, FlightCam may have provided additional new information demonstrating that the flight could be safely conducted. This circumstance is particularly important because it allows the air carrier to complete a mission safely which otherwise may have been aborted due to lack of current weather information. For Ruby, which has no automated system, FlightCam often provided new information not available in the weather synopsis for that area which convinced the pilot that conditions were acceptable for safe flight. Regardless of the specific scenario, the system provided valuable information that was used by pilots to make operational decisions.

28% of the time that remote video was used for operational purposes, air carriers opted to delay a flight based on information from the image. Instead of launching a flight, flying several hundred miles, and returning unable to complete the mission, air carriers began using FlightCam to determine when conditions had improved sufficiently to justify the launch. This effectively improves their mission completion rate. It also improves service to their customers, reduces risk in launching into poor conditions, and improves the air carriers efficiency in completing flights at minimum cost.

13% of the time that air carriers accessed the images for operational purposes, a decision was made to cancel the flight altogether. Comments from carriers have indicated that one of two scenarios may occur. If the automated system indicates conditions are conducive to completing the flight, FlightCam may provide information that deems the automated system to be in error. Additionally, it may provide additional information which the automated system cannot provide (distant weather for example) which may support canceling the flight. If the automated system indicates that weather conditions are poor, FlightCam may corroborate that information and help prevent a pilot from launching just in case the automated system is in error. Given the pilots' distrust of the visibility and sky condition reports from AWOS and ASOS, this final scenario is a common one.

Finally, operational use of FlightCam results in no change to the pilot's flight plans 12% of the time. More importantly, this emphasizes the finding that 88% of the time, pilots find that FlightCam provides operationally valuable information that affects their decision to launch, delay or cancel a flight. Pilots documented on the survey that they had used the system 111 times to support a decision to launch, 67 times to support a decision to delay, and 31 times to support a decision to cancel a flight.

*General Aviation Pilots*

General aviation pilot responses were somewhat different. 11.7% of the time that they accessed FlightCam for operational purposes, they decided to launch a flight. This reflects the pressure which is heavy upon air carriers to conduct a daily flying mission into the bush to support their livelihood. General aviation pilots, on the other hand, typically have more latitude in the decision about whether or not to fly. If the weather is poor en route or at the destination, general aviation pilots will exercise caution that favors a safe flight. Thus they will typically be predisposed not to fly. If FlightCam indicates that conditions are better than reported (but still marginal) the general aviation pilot will exercise greater caution and choose not to fly based on his own limitations, the possibility of poor weather and the lack of a monetary incentive to fly.

Remote video images helped general aviation pilots to decide to delay a flight in 8.4% of the cases where they used it for operational purposes. Most significantly, general aviation pilots decided to cancel their flights in 65.9% of the situations where they used it for operational purposes. This is consistent with the benefits attendant to the intuitive nature of the images. It also represents the intrinsic safety benefits of the images for general aviation pilots who are generally less experienced than air carriers. These pilots range from students performing cross country flights, to amateur pilots who may fly once or twice a month to highly experienced pilots with many hours. For each, the image provides an easy to interpret representation of actual conditions from which he can make an informed decision.

In summary, general aviation pilots documented 69 cases where they chose to launch, 50 times where they decided to delay and 390 times where they cancelled flights based on FlightCam images. This is encouraging news as it supports the hypothesis that general aviation pilots, who generally fly less, will make a decision prior to departure to cancel a flight based on conditions they can see with their eyes instead of going out to take a look and flying into deteriorating conditions.

Specific Weather Information

Question 5 on the survey has the very pointed purpose of discerning what additional weather information is available through FlightCam images that is not discernible through any other weather collection means. Survey respondents were asked to select as many conditions as were visible in the images each time they took the survey. The results are a general indication of the type of weather that accompanies Interior Alaska, but they are also a specific indication of the additional information gleaned from images which pilots would otherwise be unaware of prior to their flight. In addition, question 5 provided respondents with an opportunity to list any other conditions or observed phenomena that they could see in the images.

Given that the user was looking for weather information for flight-planning purposes (answered a. for question 1), the following was determined:

*Ceiling Information* - 63% of the time, users discerned additional information about the cloud ceiling and sky conditions that they would otherwise have been unaware of. The AWOS for example, may report that the cloud ceiling is 500 feet directly overhead. The FlightCam image could provide information about cloud cover to the north or south of the airport (Figure 8.4).

*Visibility Information* - 68% of the time, users discerned additional visibility information. The automated sensor may report 8 miles visibility whereas there may be a heavy fogbank a mile to the north that goes completely undetected by the ASOS. FlightCam provides this additional information for the pilot assisting him in making a sound decision as to whether or not to launch the flight (Figure 8.5).

*Fog* - In 45% of the observations, users detected fog in one of the images which otherwise would have gone undetected prior to flight. While fog is not usually an en route hazard, it can prevent a pilot from landing at his destination even after an otherwise uneventful flight (Figure 8.7).

*Precipitation* - Users discerned some sort of precipitation (rain or snow) in 40% of their viewings. Rain by itself is not a major hindrance to safe flight. However, rain signals certain atmospheric phenomenon that may alert a pilot to other dangers. These include thunderstorms, rough air, low ceilings, and overcast conditions. Precipitation is discernible in the images because raindrops settle on the window of the housing where they remain until they evaporate. In this manner it is even possible to make good assumptions about the wind direction based on which lens has an accumulation of water drops (Figure 8.17).

*Cloud Types* - In 48% of observations, user were able to determine the types of clouds they might encounter along their route or at their destination. Information as to the type of clouds can assist users in discerning weather patterns (Figure 8.2).

#### *8.2.2.3 - Analysis of Written Comments*

Valuable information was discovered in the written comments of respondents. While the other questions covered the basic data required to evaluate the usefulness of the system, the comment blocks provided respondents with an opportunity to explain specific scenarios and situations which otherwise would not have been captured. Two important comment blocks are explained herein.

The first allowed the user to comment on other information that he was able to discern through the images that was not listed in the question. Users found the images useful for the following purposes:

- Observing aircraft on the runway at the distant site (Figure 8.23)
- Observing the layout of the airport
- Monitoring the progress of construction - Anaktuvuk Pass had a major runway construction project during the summer and interested parties kept up with the progress (Figure 8.26).
- Observing distant weather (Figure 8.1)
- Evaluating the FlightCam system for possible integration at their own airport, or for their own purposes.
- Observing General Conditions - 150 times users indicated that they were most impressed with the capability to get a general "feel" for the weather and environment from the images. This intuitive understanding was by far the most useful and popular benefit to users.
- Observing mountains - Air Carriers often used the mountains as a reference to determine just how bad the visibility or the ceiling conditions were (Figure 8.4).
- Observing the runway (Figure 8.24)
- Observing the snow cover
- Observing the surrounding terrain (Figure 8.15)
- Observing the local village (Figure 8.9)
- Observing wind conditions - One of the Kaltag cameras had a windsock in view that provided good subjective information about the wind direction and speed (Figure 8.20).

The second comment block was meant to capture general feedback from users. 1459 individual comments were collected. These were all read, categorized and sorted to discern pertinent information. There were 865 comments (59.3%) that intimated that FlightCam was a good program that provided and improvement over existing weather information systems. The comments were divided into the following primary categories: flight planning; safety; ASOS/AWOS; expansion to other locations; international; and comments on other uses of the system. A number of these comments have been included to provide a sense of the excitement, interest and knowledge that was generated by the project. These comments are edited for the sake of space and clarity but are otherwise verbatim quotes from the survey.

<u>Flight Planning</u> - The general consensus was that FlightCam images are an excellent tool for both preflight and in-flight planning. It is helpful for students, amateurs or professionals. There were 129 comments (8.8%) that specifically noted that FlightCam would be useful in the flight planning process.

"Very useful for flight planning. This service has saved us a bunch of time and money by allowing us to plan animal radiotelemetry trips." - Park Service Employee

"This info is very helpful in the planning process. Thank you. - Instruction for my students, I'm a CFI."

"FlightCam helps] to get a picture of places I don't often go. (Knowing) what the clouds are and how high they are makes a huge difference. This is truly an asset to get a picture now and see how it compares with real time when approaching the area and see what's different."

"After gathering all available weather information, to actually visualize the airport environment can put the picture all in perspective to help make the decision to fly or not. Please keep up the good work!!!"

"This is great! So often the official information is not useful (The universal "VFR not recommended" is not particularly helpful.) There is often no alternative to, 'I will just go up and see.' With real-live visibility information I could make better decisions."

"This is a great idea that could help pilots at all general aviation airports plan their flights. Since so much flight planning and weather review is performed using the web, it makes sense to install relatively inexpensive cameras to add this type of information. Thank you for starting something useful!"

"I read the article called EYES ON THE SKY on page 128 of the Nov. 1999 issue of AOPA PILOT and saw mention of your work. We were on a group flight (10 aircraft) in July 1997 and flew to Anaktuvuk from Fairbanks - only to circle the field and return south due to deteriorating weather. Your camera would have been a great help. We hope the program continues."

"Great system but I really wish it would show me some good weather for a change. I have cancelled several flights in the last couple weeks and want to FLY! Ruby cameras are wonderful because they give me a true look at weather between Fairbanks and the Lower Yukon communities. I have saved a ton of time and money with real time photos of what is really out there." - AKDOT Rural Airports Manager

"EXCELLENT SITE! Nicely done and very useful even when I'm not 'inbound'. Nice layout and excellent photos, both current and the ones for reference. This is a new aspect to aviation weather and planning that I've not seen before. KUDOS!"

<u>Safety</u> - 68 respondents commented specifically on the safety aspect of FlightCam images for aviation. The following comments provide some of that feedback. There were 68 comments (4.7%) regarding how FlightCam could reduce risk and improve safety in aviation.

"I am on a team that is chartered to make safety recommendations to upper FAA management and industry that will reduce accidents. This concept has already been recommended but who knows where it will go. Your site and its safety benefits are appreciated."

"Demonstrated this amazing new weather tool to several local pilots. Conclusions are that we need this type of information available at remote sites all around the country. Both in Alaska and at other places where many planes travel in remote areas without the benefit of good weather reporting, this type of system can save lives."

"A great idea, the safety factor is an A+. Just being able to take a look should save fuel, time and lives!"

"A great idea! I hope that the FAA can see the value for other locations and pay for and install some where they can help pilots make smart weather decisions."

"Cancelled again today. I also talked to a Pilot for a local flying service who was headed for Ruby on a VFR flight plan and suggested he might take a look at Flight Cam. He did and cancelled his flight as well. His decision to go initially was based on weather at Tanana. Ruby is a perfect site for not only determining weather there but also to see if low flight down the Yukon is possible."

"This sort of visual confirmation of what flight service is telling you would add greatly to my comfort level for deciding to go or not."

"I think you have developed a very useful new tool for improving aviation safety." --Mal Gormley Air Safety Center - *Aviation Week and Space Technology's* Air Safety Center

"I am a recent VFR Private Pilot in Portland Oregon, and got the link to the site via AvWeb magazine. My compliments on a well conceived and executed experiment. I hope you will continue to get funding for this project, and some form of it will be officially adopted by the Alaska DOT and the FAA. I'll bet it's cheaper in the long run to place and maintain these camera systems than to do search and rescue for lost aircraft, and all the other associated costs, such as NTSB investigations. I'm sure this has already been a tremendous lifesaver!"

"Just heard about this new idea with AvFlash. It would greatly effect my decision to fly or not to fly...better than calling the airport and asking someone to look outside and tell me what they saw..need more of this around the country."

"Congratulations - - - Great idea. It will save lives." - Jim Collison

"Could have used this service a couple of years ago, flying out of Fort Yukon, when unforecast and unreported weather gave us some hairy moments."

"Great idea that could be put into operation at airports anywhere.....and perhaps should be.....with enormous potential to make huge improvements in safety."

"I'm now retired, but used all 3 airports, from 1960 to 1993 and had I had your project and GPS available, much less aviation gas and adrenaline would've been used. I hope your project is only the beginning for the coverage of all bush airports. Safety would be greatly enhanced." - Retired FAA Inspector

"Keep up the good work, it seems much more informal and much more enlightening then working with Flight Service which usually is overly conservative leading to too often disregard which in turn results in pushing the weather more than should be done."

"Outstanding idea. I am a Colorado pilot and could really use this information for some of our numerous mountain passes here. Just browsing your site today to see how you approached the project. I will forward your site to the Colorado State Aviation folks so they can check out your site too. Thanks, seems like it would be extremely useful. We have had at least half a dozen crashes on local passes this summer alone, I think this technology could help prevent them. I would certainly make go/no go decisions based on a recent picture a lot more comfortably. Thanks." Mark Carlson, Colorado Springs, Colorado.

"This has to be the best idea for general/commercial aviation put forth in the last 50 years. I am a new pilot but have been interested in aviation for the last 30 years and with the advent of the internet and real time imaging, this should provide a quantum leap in safety by giving pilots the proverbial "worth a thousand words" assessment vs. the typical short, coded and rather antiseptic weather reports provided by the FAA. I truly hope that this is taken to heart by the FAA/NOAA folks and expanded. Great Job."

"This should be standard throughout the world. I am not a pilot so I don't know if this exists in the cockpit anywhere else. It could be the kind of information that helps a pilot make the right decision." - Tourist-plane crash survivor seeking info on flight safety for all.

AWOS/ASOS Comments - Many pilots have been frustrated with ASOS and AWOS reports over the years. The system was touted as a replacement for the contract weather observer, but pilots feel it has not fulfilled that expectation. There were 59 comments (4.0%) that specifically mentioned the comparison between AWOS/ASOS and FlightCam and primarily established that FlightCam was either superior to, or a good enhancement to automated systems. The following comments provide user perspectives on FlightCam images and their ability to enhance or corroborate automated reports.

"I needed to fly to the North Slope. Anaktuvuk AWOS was missing, leaving me NO reports to get an idea of central Brooks Range weather. Your weather cam showed me it was clear. We launched. Would have had to decide whether to "go look" without your info. Thanks very much!!" --Tom George

"This is an excellent tool!!! It really allows us again to get a 'look out the window' at remote locations in Alaska, which was decreased with the closing of local weather observers. It makes the ASOS, AWOS data more useable."

"Ceiling & Visibility at the airport was operational however ceiling and Visibility out to the northeast was on the ground and ceiling / visibility to the southwest appeared marginal. Information directly over the station is often misleading without peripheral observations to fill out the picture. In 51 years of Alaska flying I have often seen situations where the station observation was excellent but the flight was cancelled due to the observer's remarks indicating the pass leading to the station was closed. This is critical information which AMOS/ASOS/AWOS is incapable of providing. I wish we could have had your system back in the 50s."

"As a professional pilot I deal with AWOS/ASOS reports all across the states and the only reliable reports are altimeter and wind. Ceiling and visibility reports are never reliable."

"A very useful resource. This should be available in more locations where a live weather observer is not available. It would be especially useful to supplement AWOS or ASOS, both of which are notorious for their inability to look to the side for weather info. 'A picture is worth a thousand words.', ya know."

"I often fly into Real County Airport (49R) in Leakey, TX. It is more than 50 miles from the nearest AWOS, It is located in a river valley, and surrounded by 600-1,000' hills on three sides. Many times I have been able to get to within 2 or 3 miles, only to find the ceiling on the deck at the airport. A service such as this would be invaluable for preflight preparation. Outstanding idea!"

"I think the video images are actually more useful than most weather briefings or AWOS info. We're visual creatures and seeing what is there is very valuable.... I do not infer that the weather briefings nor AWOS should be replaced... these images simply enhance the information."

"Recently I decided not to fly to Anaktuvuk pass due to conditions shown (by FlightCam) when AWOS was acceptable. The pass was definitely not open to the south."

"This is a great idea for those wanting to know what it is really like and how that compares to AWOS info."

"This is a much-needed tool and one that I have been waiting for. It's for integration into other systems. You know, the FSS in Homer has a great tower with wonderful 360 degree visibility. I'd love to see four cameras or so in that tower with one pointed towards Seldovia. There is no reason that for flight cams to not be integrated into all our ASOS sites, FSS, etc."

"We should get FSS to supplement their briefing info with data from the FlightCam for every location that there is ASOS/AWOS. It helps fill the gap between the big picture and ASOS/AWOS. When the weather is very good or very bad ASOS/AWOS is most accurate. It's those times when the weather is somewhere in between that we need better info. This can provide it."

"Years of experience with AMOS-AWOS-ASOS have proven that all needed information is either unavailable or suspect."

"I used the cam info to verify the information displayed on ASOS. It works very well." Tom Lees, ASOS Electronic Tech, NWS

Expansion to Other Locations - Over 470 respondents indicated or intimated that the system should be expanded to many other airports and locations around Alaska, and the United States. The intensity of these suggestions provided strong evidence of the need for additional weather collection systems that are user friendly to pilots. There were 84 comments (5.8%) indicating that FlightCam should be expanded to more locations around the State of Alaska. A total of 396 comments (27.1%) recommended expansion of the system throughout the United States and into foreign countries around the world.

“This is a magnificent step forward for airports without decent reporting facilities. I would have loved to have such a tool when I was flying these routes in Alaska. You are to be complimented for your forward thinking and innovation. Now, get cameras in remote spots like Lake Clark, Ptarmigan and Windy Passes and you've really got something.”

“Would like to see more cameras throughout Alaska. It is a valuable tool in making competent decisions. I personally would like to see them put in Windy Pass, Healy, Denali Park, Cantwell, and other remote places in Alaska. Thanks for your support of general aviation.”

“Great system!! How about adding cameras at Lake Clark Pass and Rainy Pass? Places that general aviation really needs current weather info, especially winds, fog, low clouds... thanks.”

“I love it! we need one in the passes between Kenai and Lake Clark. Hundreds of pilots use this pass on a daily basis. Maybe the FAA can find it in their heart to spend some of their millions on a great service like this instead of coming up with new regulations!”

“I wish there was a broader range of cameras through out Alaska.” - Air Carrier in Alaska

“This is the future of flight weather information in Alaska. Please continue this useful service and consider extending it to say Fort Yukon (on a CAVU day there the visibility is always 10 miles) Thanks!”

“You’re on to something very useful. Keep working on it. I can see this going National.” David Smith

“I salute your effort in providing such vital information for the safety of fellow pilots in your great state of Alaska. This very technology should be used at most if not all airports in the U.S. when weather for landing is marginally VMC or is actually IMC. It is the next best way to look at the destination "MDA or DH" before one ever departs from his/her originating point. With the FlightCam, we don't have to ask a friend or relative at the destination airport to look out their windows to tell us the "real weather" at that end. I hope this is a wake up call for all who fly. I wish you the best of luck in obtaining future funding from the FAA.”

"I would like to see this installed in all mountainous airports in the United States, especially Jackson Hole and Vale. I fly B757 into these airports and It would be helpful for us someday, especially if we could upload the info right into the cockpit...........someday...." - American Airline Pilot

"I think that FlightCam is an excellent pre-flight resource and should be expanded to as great an extent as possible." - Civil Air Patrol

"I like it, be nice if the FAA could be convinced to install FlightCams at remote airstrips in the lower US." - Corporate Pilot

International - Comments from around the world suggest that many other locations could benefits from the use of remote video for weather reporting. There were 47 comments (3.2%) from individuals in foreign countries around the world. The quotes below provide a representative sample of international interest in the program.

Australia - "Looking at the idea for use here in Australia" - Aviation Theory Education Center

Indonesia - "I wish this service had been available when I flew helicopters in AK many years ago. Terrific stuff you've done with the cameras. If it proves useful to those flying, I hope you get all the support you need to continue and even expand the service." FES Jakarta, Indonesia

England - "Great Idea, please come and install the same at my local field, Popham, England."

Mexico - "I think its a great idea! Congratulations! We have a pass between Mexico City and Toluca that many helicopters use everyday that pass is located at about 11,000 ft mean sea level and we are always wondering if well be able to go through." - TAESA Airlines in Mexico City

New Zealand - "The best use of the Internet for VFR flight I have seen. What a great Idea. I will have another look during your day time." - Aviation Consultant

New Zealand - "Well, you have impressed an Airline Pilot and active Soaring enthusiast from New Zealand. We have similar problems here. Big mountains, changeable weather and a thinly spread weather service. From my point of view the value of FlightCam for VFR operations is self-evident. All the best for the continued operation and extension of this service." - Airline Pilot.

Sweden - "Great idea for our GA Airport here in Sweden. We're not big enough to rate official weather. Your idea is probably inexpensive enough to be carried out by a club such as ours. The flying weather here in Scandinavia (Sweden, Norway, Finland and Denmark) is known to be among the worst in the world. So we're very interested in knowing the weather at ports of destination." Great idea! - Flying Club

South Africa - "I am a South African Commercial Pilot - Brilliant idea! - Wish we had a similar system given the large number of rural uncontrolled airports in South Africa."

Scotland - "I really like this idea. I am based in Aberdeen (Scotland) and we too might benefit from this kind of technology in some of the outer isles." - General Aviation Pilot

Other Uses - Many users had recommendations and personal accounts of how FlightCam could be used for other purposes. Several of these suggestions are provided below. There were 16 comments (1.1%) that provided suggestions on other ways which FlightCam images could be used to benefit either the aviation community or society at large. A few examples are included below.

Check on Status of Company Aircraft - "It had just been reporting 500 scattered and 10sm. Visibility immediately went down to 1 1/4 and 200 overcast... I needed to (find out) why because our flight should be landing there momentarily."

Weather in the Cockpit - "I am a private pilot. I fly VFR. I have not yet visited Alaska, but am looking forward to it. FlightCam is a GREAT idea. Pilots need more real weather in the cockpit, presented graphically. The next logical extension would be to have this information transmitted digitally, perhaps by VOR stations to receivers and flat panel displays in the plane. Near real-time RADAR weather could be presented for a geographical region in much the same way. FlightCam, as it exists today, is a very valuable tool for flight planning. One of the greatest advantages of FlightCam is that it removes the subjectivity of another observer and the potential for misinterpretation when someone else is describing the weather. Obviously, the other advantage is that it does not require someone else to actually describe the weather. It provides near real time weather information whenever the pilot wants it. A picture is truly worth a thousand words. This system should be funded and expanded."

Winter Olympics - "Looking at this web site for possible application for the 2002 Winter Olympic Games at Salt Lake City, Utah."

Tourism - "I was just browsing, but seeing the beautiful images of Alaska make me want to plan a flying vacation to your great state. I hope the project survives. Maybe you could ask the tourism board for some money. It definitely has made me want to visit the state more."

Astronomy - "Checked FlightCam tonight hoping to get a glimpse of the Northern Lights. Tonight's show is a severe display....not visible, however! I am in San Jose CA."

Runway Condition Reporting - "As a user both as an aviator in making go/no go decisions and as Rural Airports Manager for DOT I regularly check the FlightCam web site. Cameras looking directly down the runways would be a tremendous aid in monitoring runway and lighting conditions. In winter we could monitor the snow pack and also the runway condition such as snow berms left by improper grading. I currently learn of runway problems only when a pilot calls to complain about improper grading. Another feature that would help us all as pilots is a good view of the windsock at the airport. Even with AWOS/ASOS we could get a verification and idea of direction and speed. Thanks for the project. I hope it continues well past the end date as these cameras can greatly improve safety in Alaska aviation."

## 8.2.3 – FAA Survey

The FAA Fairbanks FSS participated in a three month survey to evaluate the potential benefits that would accrue to FSS briefers from the use of FlightCam images. The FSS serves as a primary point of dissemination of weather information to pilots. They provide preflight briefings to pilots before they fly, and can provide in-flight weather information via radio while a pilot is en route.

FAA policy precluded the use of FlightCam images for operational purposes during the test. However, the FSS staff agreed to look at the images on a regular basis and provide feedback based on the degree to which the images would have enhanced their ability to provide sound information to pilots. To accomplish this, they were instructed to first ascertain weather conditions at each of the three sites based on information from existing weather collection resources. Then they were to observe the FlightCam images for the locations and see what additional information they could extract that was otherwise unavailable to them. The FSS staff completed approximately 90 surveys. Figure 8.33 is a sample FAA survey. Analysis of this data revealed the following information.

### *8.2.3.1 - Analysis of Survey Responses*

When asked if the current images improved the briefer's ability to provide sound terminal information to pilots, 84% responded in the affirmative. This implies two things: 1) briefers were able to

## FlightCam Log for Federal Aviation Administration (www.FlightCam.net)

| Your Name: | Time: (Use 24 Hr Local Time e.g. 1830) | Date (MM/DD/YY): |
|---|---|---|
| | | |

| | | | | |
|---|---|---|---|---|
| **PAKP** Anaktuvuk Pass | 1. Do the current PAKP images improve your ability to provide sound PAKP terminal information to pilots? | | | Yes / No / N/A |
| | Comment?: | | | |
| | 2. If Yes, would this information help a pilot in making a decision as to Cancel, Delay or Launch a flight? | | | Yes / No / N/A |
| | Comment?: | | | |
| | 3. At this viewing, what info does FlightCam provide in addition to that which AWOS provided? (Circle all that apply) | Local Precip | Distant Precip | Thunderstorm |
| | | Local Virga | Distant Virga | Cloud Types |
| | Comment?: | Local Var. in Vis. | Fog | Variable Ceiling |
| | | Mtn. Obscuration | Cloud Layers | Sector Visibilities |
| | 4. To what extent would todays PAKP images help you improve pilot briefings in each of the following areas? (Circle a number) | *1-None 2-Very Little 3-Some 4-Much 5-Very Much* | | |
| | | Briefing ACCURACY | | 1 2 3 4 5 |
| | Comments? | Briefing COMPLETENESS | | 1 2 3 4 5 |
| **PAKV** Kaltag | 1. Do the current PAKV images improve your ability to provide sound PAKV terminal information to pilots? | | | Yes / No / N/A |
| | Comment?: | | | |
| | 2. If Yes, would this information help a pilot in making a decision as to Cancel, Delay or Launch a flight? | | | Yes / No / N/A |
| | Comment?: | | | |
| | 3. At this viewing, what info does FlightCam provide in addition to that which ASOS provided? (Circle all that apply) | Local Precip | Distant Precip | Thunderstorm |
| | | Local Virga | Distant Virga | Cloud Types |
| | Comment?: | Local Var. in Vis. | Fog | Variable Ceiling |
| | | Mtn. Obscuration | Cloud Layers | Sector Visibilities |
| | 4. To what extent would todays PAKV images help you improve pilot briefings in each of the following areas? (Circle a number) | *1-None 2-Very Little 3-Some 4-Much 5-Very Much* | | |
| | | Briefing ACCURACY | | 1 2 3 4 5 |
| | Comments? | Briefing COMPLETENESS | | 1 2 3 4 5 |
| **RUBY** Ruby | 1. Do the current RUBY images improve your ability to provide sound RUBY terminal information to pilots? | | | Yes / No / N/A |
| | 2. If Yes, would this information help a pilot in making a decision as to Cancel, Delay or Launch a flight? | | | Yes / No / N/A |
| | 3. Which of the following information did FlightCam provide that was otherwise unavailable (circle all that apply)? | Ceiling information | Visibility Info. | Wind Information |
| | | Local Precip | Distant Precip | Thunderstorm |
| | Comment?: | Local Virga | Distant Virga | Cloud Types |
| | | Local Var. in Vis. | Fog | Variable Ceiling |
| | | Mtn. Obscuration | Cloud Layers | Sector Visibilities |
| | 4. To what extent would todays RUBY images help you improve pilot briefings in each of the following areas? (Circle a number) | *1-None 2-Very Little 3-Some 4-Much 5-Very Much* | | |
| | | Briefing ACCURACY | | 1 2 3 4 5 |
| | Comments? | Briefing COMPLETENESS | | 1 2 3 4 5 |
| Final Comments | | | | |

**Figure 8.33 - FAA Survey Form**

extract operational information from the images and 2) The information enabled them to provide a better service to pilots.

In the other 16% of observations, the briefer's indicated that the images did not improve their ability to provide information to pilots. However, on 47% of these occasions, clear skies prevailed over the area. Therefore, the briefer perceived no benefit in FlightCam images because there was no new information to obtain. 29% of the time, the images provided sound information, but did not add new information to what was already available to the briefer. 17% of the time, the images were too old to be operationally significant. This can be attributed primarily to telecommunications problems with Kaltag. None of the briefers indicated a "not applicable" response on any of the observations.

When asked if the information gleaned from current images would help a pilot make a decision to cancel, delay or launch a flight, 85% of the briefers responded in the affirmative. This demonstrates that the perceived value of the information as presented to the end user was very high.

The other 15% of observations indicated that the images would not provide information to help decide to cancel, delay or launch a flight. In 86% of these cases, it appears that the prevailing weather was VFR and the briefer assumed that existing resources would have been sufficient to help the pilot make a GO/NO GO decision. In 14% of these cases, the image was too old to be operationally significant. This again can be attributed primarily to telecommunications problems with Kaltag.

The following information was gleaned from FlightCam images by FSS personnel. This is information that was otherwise not available through any official weather collection resource. The percentage figures represent the average probability of observation of these phenomena at any particular viewing by FSS personnel.

| | |
|---|---|
| Cloud Types | 52% |
| Cloud Layers | 46% |
| Mountain Obscuration | 38% |
| Sector Visibilities | 34% |
| Local Precipitation | 23% |
| Local Variations in Visibility | 22% |
| Variable Ceilings | 18% |
| Distant Precipitation | 18% |
| Fog | 17% |
| Local Virga | 13% |
| Distant Virga | 9% |
| Thunderstorms | 3% |

These results not only support the assertion that these phenomena may be observed, but they give some indication of the frequency with which they may be observed. The conclusion is that if the phenomena is present, it may be observed and defined using FlightCam images.

At each viewing the FSS staff recorded the extent to which the images would improve the accuracy and completeness of their briefings. Figures 8.34 & 8.35 document the responses.

Figure 8.34 establishes that in 61% of the cases, briefers felt the images improved the accuracy of their briefings "much" to "very much". That is, in over half the cases, the images provided substantial improvement to the accuracy of the briefings. The chart also indicates that no benefit was gained from the images only 3 % of the time. Thus, substantive information was available during 97% of the viewings.

Figure 8.35 demonstrates that this same level of improvement in the "completeness" of the briefings was achieved 63% of the time. Again, no benefit was obtained in only 3% of the cases. The images added value to the briefing picture in 97% of the viewings by FSS personnel.

These two findings are significant. The FSS is the primary agency through which pre-flight and in-flight information is disseminated to the aviation community. Seasoned professionals have established with these survey responses that FlightCam images invariably provide useful information which improves their ability to give the pilot a more accurate and complete picture of the weather.

#### *8.2.3.2 - Analysis of Written Comments*

FSS personnel provided a number of written comments that help establish benefits of the images that may not be captured in the other responses. Some representative comments, along with appropriate explanations are provided in this section.

7 Jul 99 - Anaktuvuk Pass - "High clouds not reported by AWOS" - AWOS and ASOS are limited to reporting data up to 12,000 feet above ground level. Here, the images established the presence of cloud layers that were either above 12,000 feet, or were otherwise not being reported by AWOS.

15 Jul 99 - Anaktuvuk Pass - "Showers in pass to southwest; mountain obscuration to the northeast." - Neither of these pieces of data could be captured by AWOS. They both represent distant weather conditions AWOS cannot detect. Both pieces of data are significant to pilots.

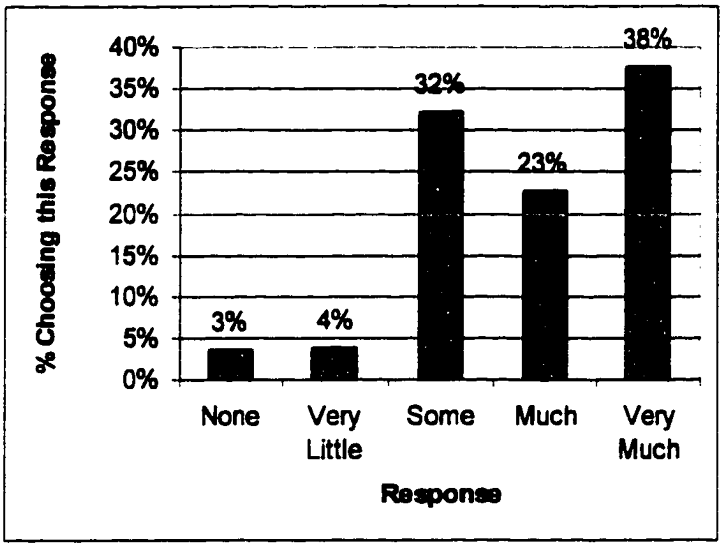



**Figure 8.34** – Extent to Which FlightCam Improves FSS Briefing Accuracy

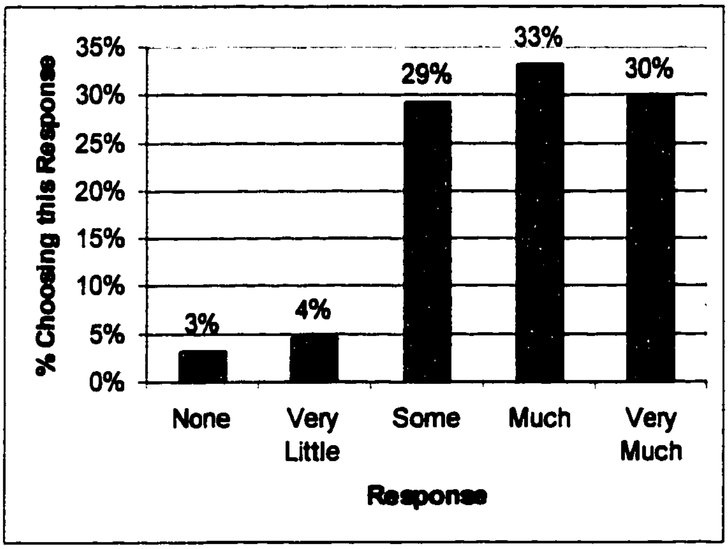



**Figure 8.35** – Extent to Which FlightCam Improves FSS Briefing Completeness

15 July 99 - Ruby - "VFR with overcast skies. No precipitation visible." - Ruby has no ground based weather collection systems. Satellite imagery for this day could have established the presence of overcast conditions (the satellite sees that from above), but the satellite could not discern that conditions were VFR below the clouds. Neither could they establish, as the images did, that there was no precipitation in the vicinity of Ruby.

20 Jul 99 - Anaktuvuk Pass - "Ceiling and Visibility lower to the northeast." - The images provided clear information about ceilings that were lower to the north, and visibility that was less to the north. AWOS cannot provide this information. This is useful to pilots to assist in determining the direction from which they should approach the airport. In this case, an approach from the south or the east would be preferred over an approach from the north.

28 Jul 99 - Anaktuvuk Pass - " Anaktuvuk (automated weather) indicated scattered (cloud layer) - video shows a broken layer." - In this case, the images demonstrated that the overcast was more dense than reported by AWOS. This is vital information to a pilot. The automated report might suggest that the pilot could fly VFR into this location at a high altitude, then descend to the airport without entering the clouds. The images showed a broken layer indicating only few breaks in the overcast. The pilot may not be able to descend through this layer upon arrival at Anaktuvuk Pass. He may instead have to retrace his flight back to a point where he could safely descend under the clouds and then fly in to the airport.

11 Aug 99 - Kaltag - "Kaltag ASOS missing. Video cam essential." - The observer noted that the Kaltag ASOS was not reporting. Therefore FlightCam provided essential information about conditions at that site. This is typical of the redundancy provided by FlightCam that helps fill in information gaps when other systems are nonfunctional.

11 Aug 99 - "(Automated) weather at Anaktuvuk Pass, Kaltag and Galena missing unless long distance phone call made. Obvious picture worth a thousand words. Consider video cams essential for pilot briefing." - In this instance, there was no information available at any of the three sites except for that provided by the images. FlightCam would have enabled the briefer to provide good pre-flight information in the absence of AWOS and ASOS data.

11 Aug 99 - Anaktuvuk Pass - "View to north shows blue sky. View to southeast shows lower conditions. AWOS reporting 5000 broken." - This is excellent information. Without FlightCam, a pilot would expect a 5000 foot broken cloud layer in the area. He would have no understanding of the extent of that layer and may anticipate a requirement to fly low through a valley to reach the airport. Instead, the images

demonstrate clear conditions to the north. In this case, the pilot could opt to approach the airport from the north with very little concern about encountering clouds.

11 Aug 99 - Ruby - "At Ruby by comparing with clear day view able to determine approximate ceiling and visibility". This corroborates the usefulness of the clear-day image in establishing quantitative information about the ceiling and visibility at a remote site.

23 Aug 99 - Ruby - "Great view of fog over the Yukon (River)". The observer confirmed an isolated meteorological condition (fog) over the Yukon River which otherwise would go unreported.

27 Aug 99 - Anaktuvuk Pass - "Pass appears obscured / cloud height and coverage differs from AWOS. AWOS indicates skies clear" - This represents critical information for a pilot. Many general aviation pilots fly through the John River Valley from the south to approach Anaktuvuk Pass. If the pass is obscured, then both the access route and the airport area may not be accessible. This information could cause a pilot to cancel a trip and save the fuel, time and heartache of flying 200 miles only to have to turn back. The fact that AWOS did not reveal any of this information indicates the potential for increased risk that could result from not having the images.

31 Aug 99 - Kaltag - "AWOS limited especially with IFR - MVR (Marginal VFR) conditions. Pilot would be given "VFR not recommended". VFR pilot would cancel or delay flight. Precipitation indicates possible icing conditions. FlightCam provides more sector (information). Variable visibility and ceiling conditions which are changing rapidly." The briefer is expressing her perspective that images provide good information in rapidly changing conditions which AWOS does not provide. One look at this image would convince a VFR pilot to cancel or delay his flight.

2 Sep 99 - Kaltag - "FlightCam indicating visibility is 5 statute miles at best, AWOS is reporting 10 statute miles. AWOS not providing accurate ceiling and visibility" - This report demonstrates the ability of FlightCam images to corroborate AWOS. The two systems indicate very different information. However, a current image with a time/date stamp confirming its currency is much more convincing and believable than a sensor based AWOS report.

2 Sep 99 - Anaktuvuk Pass - "Northeast is VFR, views southwest and looking at runway show marginal VFR and mountains obscured. (FlightCam shows) more accurate ceiling, visibility and precipitation information." - The AWOS was reporting 10 statute miles visibility and a trend from overcast to broken at about 3500 feet during this period. To a VFR pilot this would indicate acceptable conditions for flying into

Anaktuvuk Pass. The fact that the briefer confirmed marginal conditions demonstrates the reason that pilots are extremely wary about making launching or canceling flights based on AWOS alone.

17 Sep 99 - Anaktuvuk Pass - "Indicates scattered to broken clouds distant north. Flag indicates higher wind speed than reported (by AWOS). An excellent briefing tool. Pictures are worth a thousand words whereas AWOS/ASOS is limited. However, the weather cams and web site must be maintained continually." This briefer recognizes the benefit of images in seeing distant weather that AWOS cannot report. In addition, he sensed that the reported wind speed did not justify the visual image of the flag on the post office which was being blown hard. Finally, he emphasizes that maintenance of the system must be a high priority. The FAA weather cameras and website have not been maintained to the extent necessary to engender pilot's loyalty to the system.

17 Sep 99 - Ruby - "Shows visibility is greater than 10 statute miles. As a pilot, weather briefer and certified weather observer, I feel that the use of these images in a briefing would increase safety and accuracy in briefings." - Pat Magnuson - Fairbanks AFSS. The ASOS is limited to a 10 mile limit in reporting visibility. In this case, the clear-day image with annotated distances was compared to the current image and the briefer recognized that visibility was much greater than reported. This is extremely useful information to a pilot. Some pilots set their personal minimum visibility at 10 miles, meaning they will not fly unless they have at least 10 miles reported visibility. ASOS would do little to encourage such a pilot that conditions were acceptable for flight. With FlightCam images, users can verify that visibility is much greater than 10 miles by observing distant terrain features.

17 Sep 99 - "This product gives me a picture - which speaks more than text from an ASOS or AWOS. It is easy for me to interpret as a trained weather observer. - Mike Welch, Fairbanks AFSS.

17 Sep 99 - Anaktuvuk Pass/Kaltag/Ruby - "Excellent pictures. A pictures is worth a million words! Can see a mid to high level cloud layer north of Anaktuvuk Pass. Can see sector visibility and clouds. You can see weather - some clouds moving in from the southwest. Looking southwest one can see lower thicker dark blue clouds with some precipitation. A picture gives full sector conditions. Looks as if there's a stratus layer north of Ruby obscuring mountains. Layer looks shallow. Excellent information. FlightCams are an excellent tool for accurate preflight briefings. - John Siron - Fairbanks AFSS

22 Sep 99 - "Let the briefer use them for briefings." - Mike Simmons - Fairbanks AFSS

23 Sep 99 - "Images are currently not available for briefers/in-flight specialists use. Program should be expanded to include all airports and passes in Alaska." - Patrick Kerber - Fairbanks AFSS.

23 Sep 99 - Ruby - Since we have no AWOS or ASOS, pictures tell a thousand words. Seeing a picture of the actual weather gives me a complete picture of the weather particularly in the distance." - Greg Murray - Fairbanks AFSS.

23 Sep 99 - "FlightCam is a very good tool to help NWS and pilot briefers to incorporate actual conditions with forecast conditions and also determine ASOS/AWOS accuracy." - Steve McAnally - Fairbanks AFSS

27 Sep 99 - Kaltag - "More accurate than AWOS. Visibility lower than indicated on AWOS / mountains obscured. If we had a fourth sector FlightCam we could take a weather observation." - Kat DuFresne - Fairbanks AFSS.

These comments indicate a strong appreciation among FSS staff and briefers for the benefits that FlightCam could bring to the aviation community.

### 8.2.4 – NWS Survey

The Fairbanks office of the NWS participated in a three month survey to evaluate the potential benefits that would accrue to the NWS. The NWS is the primary supplier of weather information to the FAA FSS. NWS products include zone forecasts, weather advisories and weather warnings. Zone forecasts are prepared regularly, regardless of weather conditions. Advisories and warnings are prepared only when a weather advisory or warning is in effect. NWS products are supplied not only to the aviation community, but to the public at large to provide advanced warning of significant weather phenomena.

The NWS agreed to have their lead forecasters look at FlightCam images once each shift. They were instructed to first ascertain weather conditions at each of the three sites based on information from existing weather collection resources. Then they were to observe the FlightCam images for the locations and see what additional information they could extract that was otherwise unavailable to them. Additionally, they were to determine whether the images helped them in the preparation of any of the products mentioned above. The NWS staff completed approximately 90 surveys. Figure 8.36 is a sample NWS survey. Analysis of this data revealed the following information.

| FlightCam Log for National Weather Service (www.FlightCam.net) | | | | |
|---|---|---|---|---|
| Your Name: | | Time: (Use 24 Hr Local Time e.g. 1530) | | Date (MM/DD/YY): |
| PAKP Anaktuvuk Pass | 1. Does AWOS *visibility* appear to agree with what you see in the images? | | | Yes / No / N/A |
| | Comment?: | | | |
| | 2. Does AWOS *ceiling* appear to agree with what you see in the images? | | | Yes / No / N/A |
| | Comment?: | | | |
| | 3. At this viewing, what info does FlightCam provide in addition to that which AWOS provided? (Circle all that apply) | Local Precip | Distant Precip | Thunderstorm |
| | | Local Virga | Distant Virga | Cloud Types |
| | Comment?: | Local Var. in Vis. | Fog | Variable Ceiling |
| | 4. Do these images improve your ability to prepare or update the: | Zone Forecast | | Yes / No / N/A |
| | Comment?: | Advisories (if in effect) | | Yes / No / N/A |
| | | Warnings (if in effect) | | Yes / No / N/A |
| PAKV Kaltag | 1. Does ASOS *visibility* appear to agree with what you see in the images? | | | Yes / No / N/A |
| | Comment?: | | | |
| | 2. Does ASOS *ceiling* appear to agree with what you see in the images? | | | Yes / No / N/A |
| | Comment?: | | | |
| | 3. At this viewing, what info does FlightCam provide in addition to that which ASOS provided? (Circle all that apply) | Local Precip | Distant Precip | Thunderstorm |
| | | Local Virga | Distant Virga | Cloud Types |
| | Comment?: | Local Var. in Vis. | Fog | Variable Ceiling |
| | 4. Do these images improve your ability to prepare or update the: | Zone Forecast | | Yes / No / N/A |
| | Comment?: | Advisories (if in effect) | | Yes / No / N/A |
| | | Warnings (if in effect) | | Yes / No / N/A |
| RUBY Ruby | 1. Which of the following information did FlightCam provide that was otherwise unavailable (circle all that apply)? | Ceiling Information | Visibility Info. | Wind Information |
| | | Local Precip | Distant Precip | Thunderstorm |
| | Comment?: | Local Virga | Distant Virga | Cloud Types |
| | | Local Var. in Vis. | Fog | Variable Ceiling |
| | 2. Do these images improve your ability to prepare or update the: | Zone Forecast | | Yes / No / N/A |
| | | Advisories (if in effect) | | Yes / No / N/A |
| | | Warnings (if in effect) | | Yes / No / N/A |
| Other | 1. Did Ruby/Kaltag images assist with evaluation or preparation of the Galena TAF? | | | Yes / No / N/A |
| Final Comments | | | | |

**Figure 8.36** - NWS Survey Form

#### *8.2.4.1 - Analysis of Survey Responses*

When asked in question 1 if the AWOS/ASOS visibility agreed with the image, forecasters indicated that they did not agree 8% of the time. While this may not appear significant, it indicates that the automated sensors appear to be in error 1 out of every 12 observations. There is no specific data regarding the degree to which they differ except for that contained in the information that is captured by comments in section 8.2.4.2. Needless to say, this is a worrisome figure when pilots from 15 different air carriers are depending on this automated data for daily operations into these locations.

When asked in question 2 if AWOS/ASOS ceiling information agreed with the image, forecasters indicated that they differed 14% of the time. This again is a troubling statistic from the point of view of those who depend upon this data for the safety of their passengers and the economic viability of the companies they represent. The comments in 8.2.4.2 provide additional data supporting these statistics.

The following specific information was gleaned from FlightCam images by NWS personnel that was otherwise not available through any official weather collection resource. The percentage figures represent the average probability of observing these phenomena at any particular viewing.

| | |
|---|---|
| Cloud Types | 79% |
| Variable Ceiling | 23% |
| Local Precip | 14% |
| Distant Precip | 9% |
| Fog | 8% |
| Local Variations in Vis. | 7% |
| Distant Virga | 3% |
| Thunderstorm | 1% |
| Local Virga | 1% |

As with the FSS survey, these results support the assertion that these phenomena may be observed and recognized using remote video camera images. They also provide some indication of the frequency with which they may be observed. The latter is not directly a matter of concern for this research because it involves the probability of occurrence of the phenomenon naturally.

At each viewing the NWS staff documented whether or not the images assisted in the preparation of NWS products

Zone Forecast

Forecasters indicated that images assisted in preparation of this product 82% of the time. Images provide an opportunity to ascertain current conditions at a distance and use the information to forecast conditions elsewhere in the immediate future. Current automated systems provide quantitative information, but do not provide the intuitive picture of general conditions which images do. For example, the zone forecast may include a prediction of mountain obscuration in the Tanana Valley. The image provides an opportunity to look and see whether or not mountains are indeed being obscured by weather phenomenon. This helps provide data to determine where this obscuration will exist in the next several hours.

Weather Advisories and Warnings

Weather advisories and warnings are produced when potentially severe weather conditions are anticipated or occurring. The NWS survey indicated that FlightCam images assisted in the preparation of the product 8% and 15% of the time respectively. This is a respectable figure given that advisories and warnings are only produced when severe weather conditions are anticipated or in effect. These advisories may consist of heavy snow, high winds, or low wind chill. During warmer months, they encompass thunderstorms, and flash flooding. Imagery helps NWS forecasters in these situations by providing information as to the extent or degree of occurrence of the weather phenomena at a distant location prior to its arrival in the area for which the product is being prepared. NWS personnel indicate that the imagery is particularly helpful in assessing cloud types and the character of the cloud cover which helps anticipate specific types of environmental phenomena.

The final question on the NWS survey asks if the imagery assisted in the preparation of the Galena Terminal Area Forecast (TAF). Forecasters responded in the affirmative 77% of the time. This particular product is focused on forecasting weather conditions in the vicinity of the Galena airport. Given that it lies between Kaltag and Ruby, it is significant that the imagery benefits the preparation of a TAF for Galena. Cameras at Galena would unquestionably raise this percentage higher.

### *8.2.4.2 - Analysis of Written Comments*

NWS personnel provided a number of written comments that help establish benefits of the images that may not be captured in the other responses. Some representative comments, along with appropriate explanations are provided in this section. It is important to note that these are the comments of trained weather observers and forecasters.

4 Aug 99 - Anaktuvuk Pass - "AWOS reported clear while FlightCam reported 50% cloud cover. Flat top cumulus at times broken" - This comment provides a clear case where the AWOS ceiling did not agree with the image. A report of "clear" from AWOS might improperly encourage a pilot to launch into conditions that were other than reported. FlightCam reveals the error of the current automated observation.

4 Aug 99 - Kaltag - "Images (shows) borderline (visibility) of 6 miles. ASOS reports 10 miles. Would have a hard time agreeing with ASOS, image looks like 4000 to 5000 feet overcast." - This comment demonstrates a clear case where the ASOS reported visibility was vastly different than that shown in the images. The forecaster also indicated the presence of fog which would have gone unreported by ASOS alone.

4 Aug 99 - "Raindrops on northeast lens at Kaltag agrees with light northeast wind in observation (ASOS). Prevailing wind over the zone was southeast. This indicated local phenomena at work. Occlusion was moving north and east over the area. FlightCam helped indicate conditions." - Don Aycock, NWS Fairbanks. This comment demonstrates that the images helped corroborate a local phenomenon that differed from the prevailing condition.

13 Aug 99 - Ruby - "Indicated clearing behind cloud front. Helpful in zone and local forecast." In this instance, FlightCam provided an indication of a transition from cloud cover to clear skies.

16 Aug 99 - Anaktuvuk Pass - "Raindrops on camera lens. AWOS has no precipitation counter." Here the images indicated the presence of precipitation that AWOS could not detect.

23 Aug 99 - Anaktuvuk Pass - "FlightCam visibility about 2 statute miles. AWOS has 10 statute miles. Galena terminal area forecast was difficult due to in and out fog. With FlightCam I was better able to get a first hand look at what was happening." This comment shows another failure of the automated system to report the correct visibility. The difference between the two constitutes the difference between IFR and VFR flight. The comment also provides clear evidence of the usefulness of images in producing a NWS product.

23 Aug 99 - Kaltag - "Assessing cumulus, towering cumulus development." The observer was able to watch the development of a system which could result in thunderstorm activity.

24 Aug 99 - Kaltag - "ASOS has fog, none in pictures." In this case, the images demonstrated clear conditions when the automated system reported fog. A pilot might have opted not to launch based on the automated report. FlightCam would have demonstrated that the flight was possible.

25 Aug 99 - Anaktuvuk Pass - "Visibility clearly lower northeast in pass than AWOS reporting. Cloud intercept on hills lower on hills than AWOS but not radically." Distant visibility and sky condition is recognized to be clearly different from that reported by AWOS.

27 Aug 99 - Anaktuvuk Pass - "Can see clouds to north associated with approaching cold front." In this situation the forecaster was anticipating the movement of a cold front from other weather resources. The images corroborated these reports by showing the clouds preceding the arrival of the front.

27 Aug 99 - Anaktuvuk Pass - "FlightCam most useful today in Anaktuvuk Pass showing low overcast and light rain to north, clearing to south." Excellent example of the capability of detecting weather which differs by quadrants.

8 Sep 99 - Anaktuvuk Pass - "Fresh snow on summits." Establishes capability of FlightCam to detect snowfall.

8 Sep 99 - Anaktuvuk Pass - "Good look at city lights. An indication of good visibility." This comment demonstrates the capability of images to establish subjective visibility at night through use of local light sources.

9 Sep 99 - Anaktuvuk Pass - "Visibility and ceiling look lower over mountains to south. Southeast and southwest views of camera show mid to high clouds. AWOS shows clear. FlightCam provides info not easy to deduce from best satellite images. Fine case!" - Ruby - "Gorgeous fall afternoon! No weather report could equal this. Ruby north and northeast views will help on river ice this spring, I think." Yet another indication of AWOS inability to report distant conditions.

15 Sep 99 - Kaltag - "Clouds to southwest not reported by ASOS." Demonstrates capability to detect distant sky conditions.

19 Sep 99 - Ruby - "Fog on Yukon River." Demonstrates detection of distant localized fog over a body of water.

1 Oct 99 - Ruby - "Rain, visibility 6 to 10 nautical miles overcast. The Ruby and Kaltag images showed a good cold rain and good look at snow cover. This was useful in continuing freezing rain warning for Kobuk and Koyukuk Valleys." Demonstration of capability of images to assist in both observations and weather warnings at a location where no automated system exists (Ruby).

15 Oct 99 - Ruby - "Water on lens. Called DOT in Ruby and they confirmed that rain and snow was mixed but it had changed to all snow. Snow cover had increased from 2 days ago. Area temperatures were 3 degrees below freezing, so we concluded that the drops on the lens were melted snow. A call to Ruby confirmed this. This info was important because no other western interior stations reported any precipitation." Excellent demonstration of use of images in confirming a deduction based on other automated reports.

These comments, like those from the FSS, indicate a strong appreciation among the NWS staff and briefers for the benefits that FlightCam could bring to the weather reporting community.

## 8.2.5 – Online Survey - Final

This survey was online from 13 - 30 January 2000 and received approximately 100 responses. While the other online survey captured daily data, this survey was intended to provide an assessment of users' overall perspectives on the use of FlightCam images. Respondents were instructed to take the survey only one time and provide answers to indicate the degree to which they agreed or disagreed with specific statements. Appendix F provides the complete list of survey questions. It also indicates how the total group of respondents answered.

### *8.2.5.1 - Basic Demographics*

Pilots and support personnel for commercial air carriers, or agencies accounted for 25% of the respondents. The twelve Alaska based agencies represented in this group were: Alaska Air Taxi, Brooks Fuel Inc., Era Aviation, Frontier Flying Service, Grasshopper Aviation, Larry's Flying Service, Northern Air Fuel, Servant Air, Tanana Air, Wright Air Service, Yukon Eagle Air, and Air Cargo Express.

One-third (33%) of the respondents were general aviation pilots. Some of the companies represented by these individuals include: Alaska Department of Environmental Conservation, Duane Miller and Associates, ASCG Consulting Engineers, Fairbanks International Airport, University of California, Reasoning Inc., and Rosser Graphics.

The FAA, the NWS and AKDOT accounted for 11% of those filling out the survey. The final 29% of respondents were from other backgrounds including: the Bureau of Land Management, the University of Alaska Fairbanks Geophysical Institute, New Horizons, Telecom Inc., the North Slope Borough Police Department, Passage Air Service, Royal Oak Enterprises, Terra-Terpret (aerial photography), the U.S. Navy, Texas A&M University, Washington Air Search and Rescue and the Victoria University of Technology in Melbourne Australia.

#### *8.2.5.2 - Analysis of Survey Responses*

The survey included 27 questions, several of which had multiple parts. The analysis of each of these questions is discussed below. Questions 1 and 2 addressed demographics and were discussed in the last section. We begin with question 3.

Question 3 - 96% of respondents indicated that they normally accessed FlightCam images themselves. In only 4% of the cases, another individual accessed the images and provided the information to the respondent. Among air carriers, 8% of respondents received the information from a third party. Some air carriers have an operations section which is responsible for gathering basic weather data for pilots prior to flights.

Question 4 - 84% of all respondents indicated that the system was reliable and that images were available when needed. Among air carriers and general aviation pilots these percentages were 92% and 94% respectively. Among those users who indicated in questions 24, 25, or 26 that they had used the images specifically to make a decision to launch, delay or cancel a flight, 98% indicated that they felt the system was reliable. These figures are encouraging as they clearly establish that those using the system for operational purposes feel that it is one they can trust to provide information when it is needed.

Question 5 - 88% of all users felt that the quality of the images was sufficient to discern operational information. 92% of air carriers and 94% of general aviation pilots agreed that image quality was good. Among those pilots who had used FlightCam to cancel, delay or launch a flight, 96% considered the image quality acceptable.

Question 6 - This question asked respondents whether the clear-day image was helpful in interpreting what was visible in the current image. This is of particular interest because the innovation reflected in the patent application addresses this issue specifically. Among commercial air carriers and those who had used FlightCam to make an operational decision to cancel, delay or launch, there was unanimous agreement that the clear-day image was needed. 100% of these respondents felt the clear-day image was important. Among those that had used FlightCam to make operational decisions to cancel, delay or launch flights, 78% indicated that they "strongly agreed" with the need for the clear-day image. This is an important finding. Images standing alone serve as data about the remote site. Only when the image is compared to the clear-day, annotated image does this data become useful information for users.

Questions 7 - 12 - These six questions addressed the relative importance of different aspects of the clear-day image. The results of these six questions are summarized below. The questions ask for the degree to which respondents felt that the information on the clear-day image was helpful to them. The percentage of those who felt the information was important is indicated.

| | All | Air Carriers | General Aviation | Operational Users |
|---|---|---|---|---|
| *Elevation* | 89% | 88% | 97% | 93% |
| *Distance* | 92% | 96% | 97% | 98% |
| *Magnetic Direction* | 84% | 79% | 97% | 87% |
| *Annotation of man-made Features* | 86% | 79% | 97% | 87% |
| *Annotation of airport environment* | 86% | 88% | 97% | 89% |
| *Annotation of natural features* | 89% | 92% | 91% | 91% |

Several conclusions may be drawn from this data. Annotated distance information ranks as the most important piece of clear-day image information in every group. Annotated distances give rise to quantitative visibility information for the user. The least important information appears to be magnetic direction. The FlightCam website specifies the general cardinal direction that each camera faces. This information is perhaps specific enough for an aviation user. Once the user knows he is looking at a north-facing image, then the specific magnetic direction is less important. However, it is important to note that all of the annotated information was considered important by the majority of responders. The data indicates that 1% of users felt that annotation of man-made features was not helpful. The data strongly supports the assertion that the clear-day image is considered important in the interpretation of the current image.

Questions 13 and 14 - These two questions asked users to assess whether they would rather have FlightCam images, or AWOS/ASOS data for a VFR flight to a distant location. The response to this question is staggering as it provides strong support for the implementation of this technology. Among air carriers, 75% said they preferred FlightCam images over automated systems for visibility information. The other

25% indicated a neutral response to this question. The implication is that none of the air carriers said they would prefer the automated report over FlightCam. Similarly, 75% of air carriers indicated that they preferred FlightCam images over automated systems for ceiling information. 8% were neutral on the issue. 17% disagreed, indicating that they would prefer the automated report. Among those users who had specifically used images to cancel, delay or launch a flight during the 9-month test, preference of FlightCam over automated information was even higher. 89% preferred FlightCam for visibility information, and 82% preferred FlightCam for sky condition information. The data implies that the aviation community would be better served in VFR flights by replacing all automated systems with remote video cameras. Establishing remote video as an enhancement to existing automated systems would clearly maximize the benefits of both systems and radically improve the availability of useful preflight information.

Question 15 - This questions examines whether remote video cameras are useful in a stand-alone capacity. As such, they would provide an image, but would not provide temperature, dew point, altimeter, wind speed or wind direction information. 82% of air carriers felt that the system was useful without this other quantitative data. This is useful in developing a remote video implementation plan. While one may argue that remote video would be best deployed as an enhancement to ASOS/AWOS, the results of this question provide strong support to the idea of deploying stand-alone remote video systems in locations where no automated weather collection resources exist. Ruby is an example of this arrangement. As multiple written comments have confirmed, remote video at Ruby has provided many users with excellent weather information where no other information is available. Even FSS briefers and NWS personnel indicated that Ruby images helped to fill in large gaps in weather information when providing preflight briefings, or preparing weather products.

Question 16 - Among air carriers, general aviation pilots and operational users of FlightCam, over 94% of respondents agreed that the images helped to verify the accuracy or inaccuracy of existing automated system reports. The images therefore provide both redundancy, and a level of corroboration of existing systems. Much anecdotal information has been collected to verify these figures. The FAA and NWS surveys also provided strong support for the use of images in verifying automated information.

Question 17 - 100% of air carriers surveyed believe that remote video would be a good enhancement to AWOS/ASOS systems. In this arrangement, the image would provide an excellent intuitive picture of general weather conditions in each cardinal direction. The automated systems would fill in the picture by providing quantitative information on temperatures, winds and cloud layer heights. 97% of general aviation pilots and 98% of operational users of the system supported remote video as an enhancement. One benefit of this arrangement is that AWOS/ASOS may be used as official weather information with FlightCam images providing confirmation of the validity of the automated report. Once images are accepted as an official weather resource, then the joint use of these collection systems will provide excellent information to users.

Question 18 - This question asked about the extent to which users would use images to help track the status of their company's planes. In Anaktuvuk Pass for example, one camera is trained on the runway and parking apron. Aircraft may be clearly seen on the ramp loading and unloading passengers and cargo (Figure 8.23). 68% of air carrier respondents indicated that they would find images useful for this purpose. 27% were neutral, and only 5% indicated that they would not encourage use of images for this purpose.

Question 19 - This question had four parts. It queried users as to benefits that would accrue to users if FlightCam was employed on a larger scale (i.e. more airports).

*19A - Would images improve aviation safety in Alaska for commercial carriers?* - 91% of commercial carrier respondents believe that image would improve safety for their operations. 9% were undecided or neutral.

*19B - Would images improve aviation safety in Alaska for general aviation pilots?* - 94% of general aviation pilots indicated that FlightCam images would make their operations safer. 6% were neutral or undecided.

*19C - Would images improve the level of service air carriers provide to passengers?* - The purpose of this question was to determine if air carriers felt that FlightCam would help them better determine whether a flight could be completed to the given destination. If so, this information could be passed to passengers, improving the carriers reputation and service to clients. 86% of air carrier respondents felt the images would help them improve service. 9% were neutral on the issue. 5% felt that the images would not be particularly helpful in improving service.

*19D - Would images improve the efficiency of air carrier operations by saving money due to fewer turnbacks and a higher mission completion rate?* - 100% of air carriers agreed that the images would save them time and money. This speaks volumes for the economic benefits which could accrue from the widespread implementation of remote video throughout Alaska, the United States and internationally.

Question 20 - This question investigated respondents perspective on their personal use of FlightCam images if remote video systems were deployed on a wider scale.

*20A - Would you use images regularly during pre-flight to assess conditions at your destination?* - 100% of air carriers and those who had used FlightCam to cancel, launch or delay flights indicated that they would personally use FlightCam as a pre-flight resource. 97% of general aviation pilots agreed. None of the respondents indicated that they would not use FlightCam as a resource.

*20B - Would you use images regularly during pre-flight to assess conditions along your route?* - General aviation pilots responded in the affirmative 97% of the time. Air carriers responded positively 91% of the time. 9 % of air carriers indicated they would not use FlightCam to assess weather at locations along their route. This response is indicative of the fact that air carriers tend to fly higher performance aircraft that can fly over weather along their route, but must negotiate weather at their destination location. While these responses indicate strong support for the use of images to assess en route weather, they also may reflect a lack of understanding of the true benefits that can accrue to users regarding en route weather. Cameras stationed at multiple locations along a route can provide a pilot with a fairly complete picture of weather systems that will be encountered along a trip. Additional cameras and additional tests would undoubtedly encourage users to access images for every available location along their route of flight.

Question 21 - This question queried respondents as to whether FlightCam images should be disseminated through the FSS. Over 90% of respondents in every category were in favor of this as a deployment method. While other methods are certainly feasible, it seems appropriate to allow dissemination through the FSS since this is the pilot's primary source of pre-flight information. The response to this question should not be construed as a disapproval of dissemination through other means such as via a public website, a subscription service, or uplink to a private aircraft.

Question 22 - Currently, images are available to pilots through ground based computer systems. Once airborne, pilots do not have access to these images. If the FSS had access to FlightCam images, then pilots could call the in-flight desk at the FSS and request information while in flight. This could assist a pilot in ascertaining critical information about his destination while still en route. If conditions were poor, he could make a decision to divert and land elsewhere until conditions improved. This question asked pilots if such an arrangement would be beneficial in making decisions prior to landing. 94% of general aviation pilots indicated they would benefit from such an arrangement. 6% were non-committal. Among air carriers, 78% indicated that such an arrangement would be helpful to them. 8% felt that they would not be able to use FlightCam information conveyed to them from the FSS. This may reflect one of two things: 1) Lack of comfort with trusting the interpretation of the image to another person; 2) The pressure inherent in commercial air carrier operations to complete a flight once begun. While the latter is not commendable, it is evident.

Question 23 - This question investigated pilot interest in access of images through an uplink to their aircraft. Specifically it asks if FlightCam would assist in in-flight decision-making if images were up-linked to a multi-function display in their aircraft. 83% of air carriers responded in the affirmative. 17% were neutral on the issue. The technology to perform such an up-link is available. Once images are in a digital format as they are with FlightCam images, it is simply a matter of providing the infrastructure to transmit and display images in an aircraft. This opportunity holds great potential for the future as many newer commercial aircraft are being outfitted with graphic displays for other purposes.

Questions 24, 25 and 26 - These questions provided excellent insight into the operational use of FlightCam during the 9-month test. The questions ask whether the respondent has personally cancelled (question 24), delayed (question 25), or launched (question 26) a flight primarily because of weather information received through FlightCam images.

*24 - Have you personally cancelled a flight primarily because of weather information received through FlightCam images?* - 29% of general aviation pilots responded affirmatively. Among air carriers, 65% indicated they had cancelled at least one flight. 30% of air carriers indicated they had cancelled 5 or more flights. This is significant as it demonstrates both pilot confidence in the system, and accrued benefits to users of the system. Cancellation of an air carrier flight implies a possible loss of revenue from mail, cargo and passengers. These pilots have indicated the FlightCam provided sufficient information to justify a cancellation even with the possible implication of loss of revenue. Apparently, they deemed it likely that any flight launched under those weather conditions would either be at risk, or have to return without completing the mission.

*25 - Have you personally delayed a flight primarily because of weather information received through FlightCam images?* - 13% of general aviation pilots indicated delaying 5 or more flights, while 19% documented delaying between 1 and 4 flights. Thus a total of 32% of general aviation pilots responding to the survey had delayed flights based primarily on remote video images. Among air carriers, 48% had delayed 5 or more flights, and 30% between 1 and 4 flights. A total of 78% of air carriers had delayed flights on the basis of weather information from FlightCam. In terms of raw numbers, survey respondents alone during the course of the test delayed at least 62 flights.

*26 - Have you personally launched a flight primarily because of weather information received through FlightCam images?* - 38% of general aviation pilots responded positively to this question. Invariably this involves a situation where existing weather collection resources indicated that weather conditions look less than favorable, but FlightCam indicated they were better than reported. Among air carriers, 78% indicated they had launched flights based on FlightCam images. 38% of air carriers had launched 5 or more flights. Air carriers appear to be more likely to launch flights based on FlightCam images than general aviation pilots. This is assumed to be driven by the economic incentive to fly if at all possible.

Question 27 - This question sought to determine if pilots thought images could be helpful in assessing wind conditions. One of the cameras at Kaltag had a windsock in view. In Anaktuvuk Pass, the flag on the post office building was in the view of a southwest pointing camera (Figure 8.28). These provided the only opportunities to assess the collection of wind information. 84% of general aviation pilots and 74% of air carriers indicated that wind information could be collected through an image. With small modifications, the potential to collect wind information could be greatly improved at remote sites. This question indicates that this idea should be pursued.

Question 28 - Cameras in Anaktuvuk Pass and Kaltag were trained on the runways at those locations. This question asked respondents if images were useful in assessing runway conditions such as snow on the runway, flooding and runway obstructions. 84% of general aviation pilots and 68% of air carriers were in agreement with this assessment. While the primary focus of the project was to determine the benefits that accrue to collection of weather information, it is clear that the aviation community sees benefit in the use of remote video for other purposes as well.

Question 29 - This question simply asked individuals to provide their overall impression with the FlightCam system. Among general aviation pilots, 84% rated it excellent, 13% rated it good and 3% rated it neutral. Among air carriers, 70% rated it excellent and 30% rated it good. The clear statement of the analysis of the survey data is that the users of the system are very pleased with the usefulness of the images in weather reporting and aware of the potential benefits in runway condition reporting.

#### *8.2.5.3 - Analysis of Written Comments*

The final on-line survey contained a number of written comments. Of the 98 respondents, 56 provided written comments on the survey. These comments were read, sorted and categorized with the following result. There were 38 comments (67.9%) that intimated that the FlightCam program initiative was an important program which provided an improvement over existing systems. There were 27 comments (48.2%) which specifically indicated that the FlightCam program should be expanded to locations throughout Alaska and the United States. There were 8 comments (14.3%) which indicated that the images were important for flight planning. Respondents also provided 8 comments indicating that FlightCam would reduce risk and improve aviation safety. Six comments (10.7%) specifically mentioned automated systems (AWOS/ASOS) and established that FlightCam would make a good enhancement to existing resources. Several of these are included below to clarify and expand on issues presented above.

"Living and flying exclusively out of Galena causes me to be your biggest fan. It is no exaggeration to state that flight cam has saved me thousands of dollars and has saved some pilots a few scary moments or even their lives. The reliability of your cameras is amazing, I wish FAA could be as good with theirs." - Colin Brown, Yukon Eagle Air

"Great start to a potential great asset in weather information to pilots. It really is true that a picture is worth a thousand words. A big expansion of this system to many more airport and remote locations in the state would be a great thing for flight planning and flight safety." - Shackleford, Alaska Air Taxi

"FlightCam system should be available at all airports in Alaska and lower 48 states in conjunction with AWOS." - Paulette Wille, Fairbanks International Airport

"This is an indispensable service. We need more sites at airports and at passes." - Mikal Hendee, Duane Miller and Associates

"On 2 occasions, when ceiling at Anaktuvuk was reported good, I cancelled due to the view North and South which showed low clouds and scud. The video picture was worth it's weight in gold by saving fuel and a/c component times. This is the ONLY way to go. Question # 18 was a new thought but an obvious benefit. This system should be the wave of the NEAR future. Hopefully they will soon be at all airports and in addition, at a lot of strategic en route locations such as in mountain passes. You have done the Aviation Community a great service in demonstrating the flexibility and various uses and advantages which are possible with this new technology. We owe you a big THANK YOU Jim." - Doug Millard, retired Wien pilot.

"I always find the images THE single most valuable information for a pilot. It would be wonderful to have this information available for popular routes as well as airports. This appears to be one of the most valuable capital investments the FAA could make for ALL sectors of aviation." - A.R. Tiritilli

"Would like to see this kind of service in Canada as well. I have not yet flown to Alaska, but when I do I will bring my notebook computer along." - Gene Hogan

"I am a private pilot but my main interest in Flight Cam has been as a Fire Management Officer for the BLM. Aviation operations are fundamental to our mission success. While we do not haul the mail knowing what the weather is doing is critical for daily operations in the summer season. Our pilots see a great benefit from this technology and as a passenger on many flights I use this technology to satisfy my need for weather information prior to directing that flights be made." - BLM Fire Management Officer

"I believe we could see an enhancement in safety on our airports with cameras situated so they can not only give good weather images but also clear images of the runway environment. This should include views of the runway, taxiways and parking aprons. DOT could get up to the minute views of conditions which could result in timely NOTAMs and condition reporting on airports that are otherwise unmonitored. In many instances, DOT only is made aware of deteriorating conditions such as snow drifting and standing water when pilots call after arriving to find difficult landing conditions." - Bill O'Halloran, Rural Airports Manager, AKDOT

"Very impressive capability. Can be valuable as stand alone, however real strength would be in conjunction with other information (ASOS, Pilot Reports, forecasts, etc.)." - Tom George, Commercial Pilot

"The major advantage of flight cam is the matching of a clear day image to the current image." - Fred Ciarlo, Director of Operations, Tanana Air

"What a great idea, you should do this at airports all around the world!" - Milton Hockmuth, government contracted weather observation technician

"The system is very good. AWOS / ASOS has the obvious dusk / dawn / night advantage, but in daylight the images are very descriptive and useful. In some cases, I am sure that cameras could be positioned to pick up distant community lights. I am sure that thought is already part of your planning program. My company, New Horizons Telecom, installs ASOS systems in Alaska for Systems Management, Inc. This would be a very useful addition to that system. As a pilot, I would like to see your FlightCam system everywhere." - John Lee, Business Pilot and CEO New Horizons Telecom

"An excellent tool to gain an understanding of Alaskan climate, terrain, and flying conditions. It has become a daily ritual to seen how "today" is in Alaska. The work and research effort is appreciated, I hope it is ongoing and expanded for it seems from this distance and from this pilots perspective it has to add significantly to pilot planning, decision making and safety." - Australian Civil Engineering Academic with strong aviation interest.

## *8.3 - Results*

The results provided herein are organized in accordance with the goals of the project as delineated in section 7.3.5. Information presented in the previous section on analysis is referred to where appropriate, but not repeated in detail.

### 8.3.1 - Goal #1 – Demonstrate Technical Success

The video system provided reliable color images from the three rural airports to a public domain website for nine months. During that period there were no substantive gaps in service. Throughout the preponderance of the test period, images were transferred every 30 minutes during daylight hours from each active site to a hub computer in Fairbanks and uploaded onto a web-site continuously accessible to the public. Performance measures for this goal are evaluated below.

1. Successful Installation of Hardware - Hardware was mounted in winter conditions at all three sites. In Anaktuvuk Pass, the cameras were attached directly to a pole integral to the AWOS system and the communications hardware was located inside the AWOS "teepee" (heated enclosure used for AWOS electronics). In Ruby the cameras were mounted atop a maintenance building and the other hardware was located inside the heated structure. In Kaltag, the cameras were mounted on a pole erected in the corner of the ASOS complex. The communications hardware was also mounted outside in an environmental enclosure. Temperatures ranged between 15 and 25 degrees below zero Celsius during installation.

2. Reliable Telecommunications between Fairbanks and Rural Villages - The system as tested was wholly dependent upon standard long distance telephone lines for operation. The systems at Ruby and Anaktuvuk Pass operated for the duration of the test with almost no interruptions. The village of Kaltag experienced a two-day telephone outage and generally had less reliable data transfer service than the other two villages. These infrastructure issues were unrelated to the system as installed, but must be anticipated in future installations.

3. Successful Operation in Arctic Conditions - Each camera was mounted inside an environmental housing to provide protection from the elements. The housings, equipped with thermostatically controlled heaters for the winter and a fan for the summer, performed reliably. A defroster was employed to prevent precipitation (ice, water and snow) from obstructing the camera's view through the window in the housing. The windows were cleared of small foreign debris during regular maintenance trips. The environmental housings did not have thermal insulation. In early winter therefore, each housing was wrapped with an insulated covering to help keep the cameras within their operating temperature. During two extended periods of 40 below zero Celsius weather, all cameras performed flawlessly.

4. Vandalism to Field Hardware - There was significant concern at the outset of the project that the camera systems might fall prey to local vandals. However, there was not a single instance of equipment tampering at any of the three sites.

5. Electrical Power - Large diesel generators provide electrical power for rural Alaskan villages. Fears about frequent power interruptions and failures were not founded. There were no substantive power related failures at any of the three sites throughout the test.

6. System Maintenance - Not a single hardware component failed during the nine month test. Visits to the sites were conducted approximately every six weeks to clean lenses, inspect the system and refocus or reorient the camera views. Maintenance trips were conducted to ensure very reliable service during the period when data was being collected. None of these trips entailed substantive maintenance work. The structure of the system provided a fail-safe mode to ensure that users would not misinterpret an old image as a current one. Each image is time-date-stamped at the time the image is produced. If the camera system failed, then the last image produced would remain on the website with its attendant time-date-stamp. Users were warned in the website verbiage to pay close attention to the time and date stamped on the image.

## 8.3.2 - Goal #2 – Ascertain the Capabilities of the Technology

The capabilities, limitations and general comments discussed below are drawn from analysis of survey data, analysis of images, personal observation and from direct discussions with users of the system.

1. Weather Condition Reporting

a. Capabilities of the System - As tested, the system can:

- Provide quality, color images sufficient for users to discern operational information for aviation use
- Provide ceiling and sky condition information which is more in demand by users than ASOS information
- Provide visibility information which is more in demand by users than ASOS information
- Act as a stand-alone weather information collection resource (Ruby for example)
- Corroborate ceiling and visibility data generated by ASOS when the systems are collocated
- Improve aviation safety in Alaska for commercial carriers and general aviation pilots (93% of survey respondents agreed)
- Improve the level of service air carriers provide to passengers e.g. better able to determine if a flight can be completed given the weather at the destination (83% of survey respondents agreed)
- Improve the efficiency of air carrier operations e.g. save money due to fewer turnbacks and a higher mission completion rate (86% of survey respondents agreed)
- Provide FSS briefers with information to improve the accuracy and completeness of pre-flight and in-flight information provided to pilots. Out of 250 individual observations, FSS personnel determined that 83% of the time, the images they saw would have improved their ability to provide good terminal information to pilots.
- Assist pilots with making a pre-flight decision to cancel, delay or launch a flight. Over 40% of pilots responding to the survey indicated they had cancelled, delayed or launched flights specifically because of information provided by the images.
- Assess wind conditions at the distant location (put windsock in the view of the camera)
- Identify the following sky conditions which cannot be determined by existing automated systems: distant precipitation, thunderstorms, cloud types, variable ceilings, sector visibility, distant virga, fog, mountain obscuration, local virga and local variations in visibility. This information is in demand by the NWS, the FAA, and pilots.
- Identify rain. This shows up as drops on the housing lens.
- Identify snowfall in progress. This is best seen at night when a strong light source illuminates the snowfall.

b. Limitations of the System

- The system, as tested cannot positively identify and distinguish between all types of precipitation
- The system, as tested, cannot normally identify sky conditions or visibility during periods of darkness. This could be overcome through the use of infrared cameras.

c. General Comments - The annotated clear-day image is considered by users to be absolutely critical in interpreting the current image.

2. Runway and Airport Environment Condition Reporting

a. Capabilities of the System - As tested, the stem enables the user to:

- Determine if snow has been plowed from areas within 150 feet of the camera. This could include runways, taxiways or parking aprons.
- Confirm that runway lights are working. This is accomplished by viewing the image at night when the runway lights have been activated.
- Confirm the presence and integrity of structures, equipment, windsocks and lighting on those portions of the airport environment within the view of a camera.

b. Limitations of the System

- In order to confirm that snow on a runway has been plowed, cameras must be positioned specifically for that purpose and within 150 feet of the area of interest.

c. General Comments - While video technology provides excellent potential to improve runway condition reporting as described, further operational tests should be conducted with the specific intent of collecting runway information. In an online survey, 73% of respondents indicated that they felt that images would assist them in determining runway conditions. 14% of respondents disagreed.

3. Other Uses

a. Capabilities of the System - As tested, the stem enables the user to:

- Detect river freeze up
- Track airplanes at selected locations

### 8.3.3 - Goal #3 – Encourage Widespread Implementation

The project has verified the feasibility and applicability of using this system in Interior Alaska. The FAA in Alaska has adopted the annotated clear-day image concept and has incorporated it into their own website. They currently host images from six different locations and have received federal appropriations in excess of $1.7M to expand the number of remote video sites around the State of Alaska. The NWS in Interior Alaska heartily supports the remote video concept and has determined that it can provide information for zone and terminal area forecasts. Both commercial and general aviation pilots are overwhelmingly in favor of widespread expansion of the project. Nine months of operational use has convinced air carriers of the vital need for this technology in remote locations. General aviation pilots from around the country have embraced the concept and demonstrated their interest in seeing the program continued and expanded.

The philosophy behind the project was to create a groundswell of support within the aviation community that would provide strong incentive to aviation stakeholders to fund widespread implementation. The support base is now in place.

During the test, the technology was presented at aviation trade shows in Fairbanks, Anchorage and Atlantic City. These presentations generated media support that has encouraged major stakeholders to stay involved. An independent weather technology contractor has expressed strong interest in adopting the remote video concept to enhance their weather collection products. Ultimate success of this project would realize extensive deployment of remote video systems at rural airports in Alaska and throughout the United States in the next five years.

## *8.4 - Hypothesis Revisited*

The hypothesis established in Chapter 6 has been fully addressed and confirmed in this chapter. The hypothesis is restated here with a few explanatory comments. The proof of the statements contained in the hypothesis is self-evident from the overwhelming evidence provided in the two online surveys, the FAA survey, the NWS survey and the images.

Remote color video cameras may be used as an aviation weather collection resource at rural village airports in Interior Alaska. The following capabilities and benefits will accrue to the end-users.

1. Visibility Related

    a. Quantitative visibility information may be obtained. - Both FAA and NWS personnel established this as a fact in their surveys.

    b. Qualitative visibility information may be obtained. - This fact was demonstrated in every one of the data sources.

    c. Visibility information may be used to corroborate the accuracy of ASOS/AWOS sensors. - This statement was established in many of the written comments as well as in the final online survey where it was addressed as a specific question.

2. Sky Condition Related

    a. Quantitative sky condition (ceiling) information may be obtained. - Both FAA and NWS personnel established this as a fact in their surveys.

    b. Qualitative sky condition information may be obtained which is not available through other weather collection resources. - This fact was demonstrated in each one of the data sources.

    c. Sky condition information may be used to corroborate the accuracy of ASOS/AWOS. - This statement was also established in many of the written comments as well as in the final online survey where it was addressed as a specific question.

3. User Related

    a. FAA

        1) The FAA, as a primary stakeholder, will support the concept. - The FAA provided a technician to help install the equipment. They also participated in the three month survey. Finally, multiple FAA personnel provided online comments indicating strong support for the project.

2) The FAA FSS will determine that images add accuracy to their briefings - This was specifically established in the FSS survey where briefers expressed a strong sentiment of support to the statement. They are convinced it makes their briefings more accurate.

3) The FAA FSS will determine that images add completeness to their briefings. This issue was also specifically address in the FAA surveys where briefers felt very strongly that the images helped round-out the overall briefing.

4) FAA FSS personnel will desire this technology for operational use. - The Fairbanks FSS briefers were very clear in their pronouncement that FlightCam images should be used operationally on the floor off the FSS.

b. NWS

1) The NWS, as a primary stakeholder, will support the concept. The NWS provided a technician to assist with installation of a camera system on their ASOS. They participated daily in a three month survey.

2) The NWS will determine that images can be helpful in preparing NWS weather products. The NWS survey clearly established that the images were useful for zone forecasts. It also provided evidence that the images assisted with preparation of weather warnings and advisories.

3) The NWS will desire this technology for operational use. NWS forecasters consider FlightCam images helpful in producing accurate forecasts. They are in favor of placing remote video at many locations throughout the State of Alaska to increase the number of sights at which they could collect data.

c. Pilots

1) Pilots will find the images useful in making decisions to launch, cancel or delay flights. This fact was clearly established in both online surveys.

2) Pilots will be very supportive of the concept as end-users. Pilots are clearly the most enthusiastic about the use of FlightCam images in aviation operations.

They are always interested in having better weather information. This group favors expansion of the system throughout Alaska and the United States.

3) Pilots will find that images provide weather information that they cannot get through any other source. Specifically:
    - Ceiling information
    - Visibility information
    - Fog
    - Local Precipitation
    - Cloud Types
    - Other Data

The first online survey clearly established the pilots are able to observe and identify each of the weather phenomena above using FlightCam images. The NWS and the FAA also verified that these conditions can be observed with the cameras. The figures attendant to this chapter also provide strong evidence that these conditions may be observed with this system.

d. General Comments

1) The aviation community will embrace the concept and use it. The five primary stakeholders: the FAA; the NWS; the AKDOT; air carriers and general aviation pilots all participated in aspects of the test and each was highly enthusiastic about the use and expansion of such a system.

2) Once the aviation community recognizes the benefits of such images, they will demand images from other locations throughout the state. Written survey comments demonstrate the truth of this statement. Users are frustrated that the technology is available, inexpensive and relatively easy to maintain and yet remains available in only a few isolated locations.

3) Users will find the system to be reliable. The final online survey established the truth of this statement. Users were very complementary of the reliability of the system during the nine month test.

4) Users will find the clear day image to be critical in interpreting the current image. The analyzed survey results demonstrate that those who use the system are all but unanimous in their support of this statement. 100% of air carriers believe the clear-day image is necessary.

This completes our logical proof of the hypothesis. Chapter 9 presents conclusions and recommendations.

# CHAPTER 9

# Conclusions and Recommendations

Chapter 9 states the conclusions of this research into improving weather and runway condition reporting at rural airstrips in Interior Alaska. Additionally, it provides several recommendations to assist with the implementation of programs to enhance the quality of information available to pilots operating in Alaska. Section 9.1 reviews the primary conclusions developed from this study. Section 9.2 provides specific recommendations. Section 9.3 provides final comments. Chapter 9 represents the conclusion of this study.

## *9.1 - Summary of Conclusions*

The conclusions are divided into sections on runway condition reporting, weather condition reporting and the systems approach. These conclusions are provided in clear, concise statements. Support for these statements has been provided throughout the document.

### 9.1.1 - Runway Condition Reporting

1. The current system for collecting derogatory runway condition information at rural airports in Alaska is lacking. (Chapter 1)
2. The system places heavy emphasis on the collection of information by a human agent. Supervision and training of this agent (normally a native villager under contract to AKDOT contractor) is lacking. (Chapter 1)
3. Lack of reliable runway condition information increases risk to users of these remote runways. (Chapter 2)

4. A thorough literature search concluded that there are no existing, acceptable automated means for improving the collection of runway condition information as required at rural airports in Alaska. Similarly, the search revealed no specific means or methods by which the collection of this information could be improved. (Chapter 3)
5. Factors that produce and sustain poor runway conditions can be influenced. Our focus with regard to poor runway conditions should be primarily on correcting the bad condition, not reporting it. Correcting the condition reduces the load on the reporting system and lowers risk to runway users. (Chapter 4)
6. A major improvement in the mitigation of poor runway conditions can be realized through improved training, supervision and discipline of AKDOT contracted maintenance workers at rural locations. (Chapter 4)
7. The AKDOT is the primary agency responsible for implementing such changes. (Chapter 5)
8. The primary stakeholders in any project that is runway condition related are the AKDOT, the FAA and pilots. (Chapter 5)
9. Correction of runway condition problems will specifically involve improvements in the following areas: AKDOT policy; supervision of maintenance contractors, training of maintenance contractors and involvement of primary stakeholders. (Chapter 6, Appendix C, Appendix D)

### 9.1.2 - Weather Condition Reporting

1. Rural airports in Alaska lack systems for providing current, accurate and complete visibility and sky condition information to the aviation community. (Chapter 1)
2. This information is in high demand by the aviation community. (Chapter 1)
3. A need exists to improve existing systems, or corroborate current data with enhancements to existing systems. (Chapter 1)
4. There is a need to provide visibility and ceiling information at airports which currently have no ground based weather collection capability. (Chapter 1)
5. The lack of reliable visibility and ceiling information increases risk to those who conduct flight operations on these airports. (Chapter 2)
6. A thorough literature search provided important information about means and methods to consider for improving weather condition information. (Chapter 3) The following facts were established:
    - Discrepancies between automated and human weather observations clearly exist

- The primary liability with automated systems lies in the measurement of cloud ceiling and visibility
- Current automated systems are limited by their inability to provide information about distant weather phenomenon
- There are no formal published studies delineating the problems with automated systems in arctic conditions
- Enhancements to current automated systems need to blend automation with the subjective judgement provided by a human
- New or improved systems should be considered as enhancements to automated systems
- These enhancements should be capable of corroborating automated ceiling and visibility information provided by existing systems
- Video cameras have been used to discern weather phenomenon

7. We cannot directly affect the factors that produce poor weather conditions. Thus our efforts must focus on improving the accuracy, reliability and timeliness of the reporting of this information. (Chapter 4)
8. The greatest shortfall lies in the collection of weather information as opposed to the transmission, interpretation or dissemination of the information. (Chapter 4)
9. The ceiling and visibility reports from automated systems need to be replaced or improved upon by additional collection means. (Chapter 4)
10. The FAA and the NWS appear to be the agencies primarily responsible for implementing such improvements. (Chapter 4)
11. Modification or improvement of the PIREP system could provide some improvement in weather condition reporting. (Chapter 4)
12. The primary stakeholders in any project to improve weather condition reporting are the FAA and the NWS (as information providers) and pilots (as users). (Chapter 5)
13. Correction of weather condition reporting problems will specifically involve new or improved visibility and sky condition collection resources as well as involvement of primary stakeholders. (Chapter 6)
14. Remote video camera systems provide an excellent new collection resource to improve weather condition reporting at rural airstrips in Alaska. The following specific points about these systems were gleaned from the study (Chapters 7 and 8). Remote video systems provide
    - Both quantitative and qualitative information about visibility and sky conditions
    - Corroboration of information produced by existing automated systems

- Utility in a stand alone capacity
- Improved accuracy and completeness of pilot briefings as provided by FAA FSS personnel
- Support to the NWS in preparing NWS weather products
- Intuitive weather information which is easily interpreted and in high demand by pilots
- An excellent degree of reliability to end-users
- Information which reduces the risks inherent in flight
- Information which improves air carrier service
- Information which improves air carrier efficiency

## 9.1.3 - The Systems Approach

Several important conclusions may be stated regarding the use of systems related tools in approaching the research. The systems approach is intended to identify and address root causes of problems. Several systems tools were invoked to assist with the research goal.

Systems Analysis - The analysis conducted in Chapter 5 enabled a shift in emphasis regarding runway condition reporting. The expectation was that the reporting system was the primary problem requiring resolution. The analysis revealed that the runway condition, an input to the system, was the true source of the problem. As a result, the emphasis was shifted from correcting the system, to correcting an input to the system thus reducing the system load.

Decision Tools - A combination of AHP and MAU were used in Chapter 7 to assist in the selection of airports at which to test the remote video concept. This integration of two independent decision tools capitalized on the strengths of each to provide a robust method of supporting the selection of the best locations.

Stakeholder Analysis - Chapter 6 provided a new method of identifying project stakeholders and presenting their interests, relationships and degree of stake in the project graphically. This process was applied to the FlightCam project to identify the primary stakeholders. A concerted effort was then made to involve these stakeholders in the project that resulted in excellent data collection, good visibility for the project and good project synergy. This ultimately resulted in a high degree of project success.

## 9.2 - Recommendations

The following recommendations are also divided into sections on runway condition reporting and weather condition reporting. These recommendations follow from the conclusions of section 9.1.

### 9.2.1 - Runway Condition Reporting

1. The AKDOT Northern Region should take steps to increase the level of supervision of their rural airport contractors. Using Appendix C as a guide, they should consider hiring additional personnel specifically dedicated to increasing AKDOT presence at rural villages throughout the year. The AKDOT Regional Airports Manager for Northern Region is in agreement with this recommendation to increase supervision [38].

2. Using Appendix D as a guide, AKDOT should develop and implement a coordinated training plan to improve the level of knowledge and technical expertise among rural airport maintenance contractors. This plan should include the development of a handbook of information that can be distributed to rural airport maintenance contractors to assist them in their jobs. The implementation of improved supervision and training will provide the best opportunity to improve runway conditions and thus reduce the requirement for reporting runway conditions at these rural airports. AKDOT has indicated agreement with this recommendation and has expressed an interest in reviewing Appendix D as a possible template for formalizing a new training program.

3. The AKDOT should work with FAA FSS management to streamline the NOTAM verification process. Specifically, they should provide a system which functions in the absence of the rural airports manager and allows NOTAMs generated by pilots to be verified by AKDOT and entered into the official FSS NOTAM reporting system.

4. In concert with the suggestions in 9.2.2 below, AKDOT should seek to capitalize on the installation of video camera systems at rural airports and encourage the deployment of at least one camera per village to collect runway condition information. The AKDOT was one of the original supporters of the remote video project. They have stated that they are "firmly committed to evaluating any potential opportunity which can increase the safety, efficiency and service of public transportation systems." They stated that "the results of the project will be carefully considered and DOT will actively participate in dialogue that would consider the potential for widespread application of this technology throughout the Northern Region of Alaska [54]."

## 9.2.2 - Weather Condition Reporting

The conclusions argue strongly for the deployment of remote video systems at rural airports in Alaska. This study has demonstrated that Alaskan airports as well as airports nationwide and internationally would benefit from this additional weather collection capability. The clear, strong recommendation of this research is that a plan be developed and implemented to employ remote video technology in the collection of weather information in Interior Alaska. The follow-on recommendation is to use Interior Alaska as a stepping stone to wider spread implementation throughout the State of Alaska, the United States and the world. Three questions remain to be answered: 1) Who is to spearhead the deployment of these systems? (The Lead Agency); 2) In what configuration should the systems be deployed? (System Deployment); and 3) How can the benefits of deployment of these new systems be maximized to the primary end-users (System Integration)? These questions should be the subject of additional research in this area. Although this study is not intended to provide a fielding plan for remote video systems, each of these questions is discussed below in light of the knowledge uncovered by this research.

### *9.2.2.1 - The Lead Agency*

The FAA and the NWS are the top contenders to act as the lead agency for deployment of this technology. The FAA is primarily interested in the aviation application of remote video. In this respect, they would favor the deployment of cameras at airports and at critical, remote locations where safety is often compromised such as mountain passes. The NWS has an interest in collecting weather information for both aviation purposes and for NWS use in non-aviation weather products. Thus, they would favor both aviation related locations and locations which fill in gaps in current weather collection services.

Either of these agencies could take the lead in a project to outfit Alaska with remote video technology. It is likely that the two agencies could contribute jointly to a deployment plan enabling the needs of both agencies to be met. Regardless of the agency selected as lead, a team should be formed to represent the needs of all major stakeholders. The team should consist of representatives from the FAA, the NWS, the AKDOT, commercial air carriers and other major stakeholders as outlined in Chapter 5. The purpose of the team would be to establish the specific requirements for the system and provide input regarding deployment.

### 9.2.2.2 - System Deployment

The deployment of remote video cameras will include two configurations. In those locations where ASOS or AWOS are already deployed, remote video should be installed as an enhancement to the existing system. In Anaktuvuk Pass and Kaltag, the FlightCam project used the existing automated systems as the infrastructure around which the cameras were installed. This provided a physical location, telecommunications and power for the camera system. Installation at each location required only one day. Expansion to multiple sites around Alaska would happen most quickly if the systems were installed as AWOS/ASOS enhancements. The other logical configuration is that of a stand alone system at locations where no ground based collection resources currently exist. In Ruby, cameras were installed on an AKDOT maintenance building. This installation was a little more awkward, but still used an existing structure on which to mount the cameras. The structure also provided access to power and telecommunications. In order to properly cover Interior Alaska with remote video systems for aviation use, locations without automated systems must be included.

Much careful thought and analysis needs to be focused on the selection of sites for a fielding plan. To date, the FAA has not employed any rigorous analysis in the selection of sites. To the disappointment of potential users of this system, the FAA has relied primarily on several Anchorage-based public meetings to gather information to prioritize potential sites for the entire State. The FAA Alaska Region has requested that the author provide them with specifics about the AHP/MAU method contained in Chapter 7 of this document to assist them in the selection of new sites throughout Alaska at which to install remote video systems. The fielding plan demands a rigorous analysis that includes a thorough understanding of the various end users of the system. It may be appropriate to let a contract to develop this fielding plan to ensure that the interests of all stakeholders are considered.

### 9.2.2.3 - System Integration

A total system that provides good service to all users will include the following:

- A fielding plan establishing sites, priorities and schedule
- Installation of hardware in the field on either existing ASOS/AWOS systems or as stand-alone systems
- Installation of hardware and software at the hub site to integrate digital images into existing FAA and NWS weather collection and depiction systems
- A website providing access to the public

- A maintenance or service plan

It would be preferable to find a single contractor that could provide all of these services. While the FAA, NWS and AKDOT may have some in-house capability to demonstrate the feasibility of such systems, they are not staffed to conduct major deployments, integration or maintenance of these systems to the extent required. The aviation community wants not only a fielded product, but a reliable and well-maintained product. If system maintenance and reliability is poor, users will lose confidence in the capability.

The following singular recommendations are made based on the preceding comments,

1. Remote video systems should be deployed at rural airstrips in Interior Alaska to significantly improve the availability of accurate and reliable weather information for the aviation community.

2. The FAA should assume responsibility as the lead agency. They should establish a joint team represented by major stakeholders in the aviation community to pursue the project.

3. The implementation of the total system should be contracted to a technical company capable of accomplishing the fielding plan, installation, integration and servicing of the system.

4. Images captured through the system should be disseminated as follows:

   a. To the FAA FSS and integrated into existing computer displays to assist with pre-flight and in-flight briefings to pilots
   b. To the NWS and integrated into existing displays to assist with preparation of NWS weather products including the aviation forecast
   c. To the aviation community through a public website to assist with flight planning
   d. To AKDOT through a public website to assist with runway condition monitoring

5. Once systems are successfully deployed and used in Alaska, the template for success should be used on a national scale to expand systems throughout the United States.

## 9.3 - Final Comments

In the June 1998 issue of *OR/MS Today*, an article entitled Sabre Soars, provided the following advice to researchers in the academic world, "academics need to spend more time in the real world getting dirty working on real problems with real data rather than taking the easy road to tenure and promotion by publishing papers that interest only fellow researchers and have little practical value." The senior vice president of the SABRE Group made this comment.

This research employed the systems approach to investigate the solution to a real-world problem. The application of existing engineering management tools, and the development of new tools and methods in the conduct of this research led to the implementation of an unsolicited project. This project matched an existing technology to a current need and provided a novel solution to a multi-faceted problem. The technology that is required to transfer images from one location to another over the Internet is not new. However, the application of this technology to aviation weather and runway reporting systems is in its infancy. Many times, the old adage "a picture is worth a thousand words" has been attributed to the remote video aspect of this project. This is a classic example, in a practical setting of the truth of that old adage.

As multiple new technologies emerge, many existing opportunities may be lost in the flurry of excitement. Project managers must exercise due diligence in conceiving and initiating unsolicited project proposals to meet the needs of our ever-changing society.

Within five years, partnering between the FAA, NWS, private contractors and the aviation community is expected to provide pilots with near real-time images from many airports throughout the country. This expansion will undoubtedly enhance aviation safety, service and efficiency within Alaska, the United States and the world.

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# APPENDIX A

# Airport Maintenance Contractor Survey

## SECTION A
## GENERAL INFORMATION

**A1. Village Name** ____________________

**A2. Contractor Name** ______________________________

**A3. Contractor Phone Number** __________________

**A4. How many years have you had the airport contract?** Average 6.6 Years

**A5. Which pieces of heavy equipment do you have at your airport?**

80% - Road Grader  80% - Bulldozer  20% - Bucket Loader

**A6. Who owns the equipment?**  80% - DOT  20% - Contractor  ____ City

## SECTION B
## HEAVY EQUIPMENT OPERATIONS

**B1. Before you took the contract, how many years experience did you have operating the following pieces of heavy equipment?**

Ave. 3 years - Road Grader  Ave. 6.25 years - Bulldozer

Ave. 2 years - Bucket Loader

**B2. Before you took the contract, which pieces of heavy equipment had you had formal training on in how to <u>operate</u> the equipment?**

| ____ Road Grader | ____ Bulldozer | ____ Bucket Loader |
|---|---|---|
| 40% OJT | 25% OJT | |
| 60% No Tng | 25% Formal Tng | |
| | 50% No Tng | |

**B3. Who provided the heavy equipment <u>operations</u> training you had prior to taking the contract?**

50% from Company     25% from Vocational School     25% self-taught

**B4. Did you DESIRE any training in the <u>operation</u> of heavy equipment from DOT?** 40% - Yes 60% - No

**B5. Did you RECEIVE any training in the <u>operation</u> of heavy equipment from DOT?** 0% Yes 100% No

**B6. Do you feel qualified to plow snow on your runway so that it is safe?** 100% Yes 0% No

**REMARKS:**

"A bigger blade on dozer or wings on one side would help."

**B7. Do you feel qualified to grade the surface of your runway to remove ruts etc.?** 60% - Yes 40% - No

"I would need more training with a grader…to read level stakes."

## SECTION C
## HEAVY EQUIPMENT MAINTENANCE

**C1. Before you took the contract, which pieces of heavy equipment had you had formal training on in how to <u>maintain</u> the equipment?**

| ____ Road Grader | ____ Bulldozer | ____ Bucket Loader |
|---|---|---|
| 50% - OJT | 75% - OJT | 100% - None |
| 50% - None | 25% - None | |

**C2. Who provided the heavy equipment <u>maintenance</u> trai ning you had prior to taking the contract?**

66% - Company 33% Self

**Describe the extent of your training:**

"We had mechanics on the job and I didn't have to learn maintenance."

**C3. Did you DESIRE any tng. in the <u>maintenance</u> of heavy equipment from DOT?** 40% - Yes, 60% - No

**C4. Did you RECEIVF any tng. in the <u>maintenance</u> of heavy equipment from DOT?** 40% - Yes, 60% - No

**If Yes, how long did it last? ______**

"I received annual training when the mechanic visited during the summer."

**C5. Who does the maintenance on your heavy equipment?**

100% - Me (Go to C6)

0% - DOT (Go to B )

**C6. Do you feel qualified to perform basic preventative maintenance your heavy equipment? (Oil changes, belt changes, etc.) 100% - Yes 0% - No**

"I don't feel qualified to perform heavy duty maintenance."

**C7. Do you feel qualified to perform basic repairs on your heavy equipment? (Hydraulic hoses, blade edges, changing tires etc.)** 60% - Yes 20% - No 20% - Some

**C8. Would you like any more training on how to conduct preventative maintenance of your heavy equipment?** 60% - Yes, 40% - No

**WHAT TRAINING SPECIFICALLY?**

"Safety training would be good for younger contractors."

"Changing oil, belts, hoses, blades, edges, etc."

"Basic preventive maintenance."

**C9. Would you like any more guidance on when to perform preventative maintenance of your heavy equipment?** 40% - Yes, 60% - No

"I use the manuals."

**C10. Would you like any more training on how to perform basic repairs on your heavy equipment?**

60% - Yes 40% - No

**C11. If DOT provides you with petroleum, oils and lubricants for your equipment, are you able to get them when you need them?** 100% - Yes 0% - No

"I buy and haul my own from Fairbanks."

**C12. If DOT provides you with repair parts, are you able to get them when you need them?**

100% - Yes 0% - No

"I buy and haul my own from Fairbanks."

**C13. Is your heavy equipment getting the maintenance it deserves?**

100% - Yes 0% - No

**C14. What could be done to improve the maintenance on your heavy equipment?**

0% - More frequent visits from the DOT maintenance guy

20% - More maintenance training for me

60% - Nothing

20% - Other

**OTHER IDEAS:**

"We like the system."

"I need a heated maintenance building."

## SECTION D
## NOTAM REPORTING

**D1. What does NOTAM stand for?** 100% comprehension

**D2. Do you normally call in your NOTAMs to the AFSS or the Rural Airports Manager (Dean Owen)?**

83% - AFSS 17% - Rural Airports Manager

**D3. Approximately how many times a month during the WINTER do you call in NOTAMs?**

On average, 2 1/2 times a winter.

"Only once last winter for a storm that lasted two days."

"Whenever I plow, I call in a NOTAM."

**D4. Approximately how many times a month during the SUMMER do you call in NOTAMs?**

All reported zero, or nearly zero.

**D5. For the following, place an "X" next to conditions which would justify a NOTAM and then describe how bad the problem would have to be before you would call one in:**

60% - Yes, 40% - No **Airport Lights Burned Out**

"If 4 lights are out I have to call in a NOTAM."

"I call in a NOTAM if all the lights are out (i.e. not working)"

"If more than ¾ are burned out I would call in a NOTAM."

60% - Yes, 40% - No **Snow on the runway**

"I call in a NOTAM when I am plowing."

"I call in a NOTAM when there are 3" of snow on the runway."

60% - Yes, 40% - No **Potholes or ruts in the runway**

"The pilots usually call it in."

"In the springtime if it is bad enough, but this runway drains well…I've never had to call one in for ruts."

60% - Yes, 40% - No **Windsock not working**

"I replace it every two years."

20% - Yes, 80% - No **Snow Berms on the runway**

60% - Yes, 40% - No **Snow removal operations ongoing**

"I don't call in a NOTAM for snow removal operations, I just plow it."
"I call in when I start plowing and when I stop."
"I call in when I begin plowing and again when I am finished."

40% - Yes, 60% - No **Flooding on the runway**

**D6. How often do you inspect the runway during the summer?**
Answers ranged from "daily" to "nobody ever really inspects daily".

**D7. How often do you inspect the runway during the winter?**
Answers ranged from "daily" to "nobody ever really inspects daily".

**D8. What do you look for when you inspect the runway?**
"Burned out lights, donuts in the gravel."

**D9. What airport maintenance problems are the hardest to fix?**
"Windsock lights don't work. Our windsock is in a bad place, I can't even see it from the air." (Circle City)

**D10. When you need supplies from DOT to fix reflective cones, wind socks, lights, etc. do you have any trouble getting them?**
0% - Yes 100% - No

"DOT is great about sending parts out to me."
"I have had trouble getting threshold markers."

**D11. Do you have a radio from DOT for your equipment?** 40% - YES 60% - NO

"I didn't want one."
"I need one and want one."

**D12. Is vandalism of the airport property a problem?** 20% - YES 80% - NO

**OTHER REMARKS**

"Runway soft on far end of runway 34." (Birch Creek)

"I need a brushwacker/hydroaxe to take down brush. It grows too fast. When they built the runway they seeded it with an AG plane and grass has been growing on the runway ever since." (Circle City)

"I need a brushcutter or hydroaxe once a summer. My airport has no beacon. We are only getting mail every other day. (Stevens Village.)

# APPENDIX B

# Commercial Pilot Survey

## SECTION A
## GENERAL INFORMATION

**A1. Which company are you currently flying for? (Circle One)**
Indicates the number of pilots responding to this survey from each company.

| | | |
|---|---|---|
| ____ Air Cargo Express | _1_ Frontier Flying Service | _2_ Tanana Air Service |
| _3_ Arctic Circle Air | ____ Hageland Avn Services | _3_ Tatonduck Flying Service |
| ____ Alaska Central Exp | _3_ Larry's Flying Service | _1_ Warbelows Air Ventures |
| _3_ Bell Air | ____ Lynden Air Cargo | _2_ Wright Air Service |
| ____ Cape Smythe Air | _1_ Northern Air Cargo | |
| ____ Forty Mile Air | ____ Reno Air | |

**A2. This survey asks your opinion about rural airstrips in Interior Alaska. Please "X" those airstrips that you have personally flown to regularly within the last year. In other words, if you feel comfortable answering questions about runway maintenance, weather conditions and availability of weather information at the airstrip, "X" it.**

As a group, pilots responding to survey fly to all airports checked below.

| | | |
|---|---|---|
| _X__ Allakaket | _X__ Bettles | _X__ Central |
| _X__ Beaver | _X__ Birch Creek | _X__ Chandalar Lake |

| | | |
|---|---|---|
| _X__ Chandalar Shelf | _X__ Galena | ____ Northway |
| _X__ Chalkyitsik | _X__ Hughes | _X__ Nulato |
| ____ Chicken | _X__ Huslia | _X__ Rampart |
| _X__ Circle City | _X__ Kaltag | _X__ Ruby |
| _X__ Clear | _X__ Koyukuk | _X__ Stevens Village |
| _X__ Coldfoot | _X__ Manley Hot Springs | _X__ Tanana |
| _X__ Eagle | _X__ Minchumina | _X__ Venetie |
| _X__ Fort Yukon | _X__ Minto | |

**A3. Approximately how many times per week are you currently flying to the following locations?**

Not compiled.

## SECTION B
## B - RUNWAY MAINTENANCE

*The Alaska Department of Transportation and Public Facilities often contracts with local villagers or the city council to maintain rural airports. Answer these questions regarding the general quality of that maintenance for the airports with which you are familiar (those checked in Question #A2).*

**C - Please answer the following questions using the scale below. Circle the number that applies. Add remarks as needed to clarify your answer.**

| Strongly Agree | Agree | No Opinion Or Don't Know | Disagree | Strongly Disagree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

### D - Winter (Snow on the Ground)

**B1. Airstrips are normally plowed within a reasonable time after a snowfall:**

1 – 0%  2 – 72%  3 – 11%  4 – 17%  5 – 0%

"Most of them are (plowed), places like Arctic Village and Venetie are not."

"Except for Venetie and Arctic Village."

"Reasonable would be well cleared 0700 – 2100 Local."

"Except for Stevens Village."

"Except Arctic Village and Venetie."

**B2. The quality of snow clearing is sufficient to safely operate my aircraft:**

1 – 0%   2 – 67%   3 – 11%   4 – 22%   5 – 0%

"It depends, some are very good, others are not."

"Too many berms to catch wheels and wings during snow."

"Too much snow removed for ski operations."

"Stevens Village is marginal."

**E - B3. Contract maintenance workers know how to operate graders and dozers well enough to clear snow for safe aircraft operations:**

1 – 0%   2 – 56%   3 – 22%   4 – 22%   5 – 0%

"Check to see if Stevens Village even has a grader or dozer."

"Center area is usually plowed but lights are covered."

**F - B4. During the last year I have often had to land my aircraft on a rural airstrip which was plowed poorly.**

1 – 11%   2 – 17%   3 – 33%   4 – 33%   5 – 6%

"Most problems with Allakaket."

"Service overall good, except Venetie, Arctic Village are poor and Fort Yukon is fair."

**B5. In general, winter runway maintenance is excellent.**

1 – 6%   2 – 33%   3 – 22%   4 – 39%   5 – 0%

"Far from excellent! Adequate is a better word."

"Good!"

"Winter runway maintenance is good."

## G - Spring (Daily Freeze/Thaw Cycle)

**H - B6. Airstrips are normally maintained free of dangerous ruts, potholes and obstructions:**

1 – 5%    2 – 26%    3 – 21%    4 – 32%    5 – 16%

"Except Venetie, Arctic Village."
"Not the case at private (airports) i.e. Venetie."
"Except for Stevens Village."
"Except Arctic Village and Venetie."
"Stevens Village is free of ruts, potholes and obstructions but runway is not level…makes for rough landings and takeoffs."

**B7. Glare ice is controlled well at airstrips:**

1 – 0%    2 – 39%    3 – 22%    4 – 33%    5 – 6%

"Haven't seen any in the Interior in the past two years."
"Kaltag and Tanana, I don't believe they have a grader with scarifier."

**B8. In general, spring runway maintenance is excellent.**

1 – 0%    2 – 37%    3 – 11%    4 – 47%    5 – 5%

"Adequate."
"Dependeing on strip. Venetie always bad. (private strip) Stevens usually bad."
"For unimproved Arctic Strips it is."
"It's good not excellent."

| Strongly Agree | Agree | No Opinion Or Don't Know | Disagree | Strongly Disagree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

I -

## J - Summer (No Snow)

**K - B9. Airstrip irregularities which develop over the winter and during break-up are normally repaired quickly: (Potholes, ruts, washouts etc.)**

| | | | | |
|---|---|---|---|---|
| 1 – 6% | 2 – 50% | 3 – 6% | 4 – 28% | 5 – 11% |

"Often takes too long."
"Except Venetie and Stevens."
"Generally, but depends on locations."
"Quickly would mean no one hits them."
"Stevens Village has never received repairs on the ruts that develop on the runway from using the dozer to clear snow."
"Except Venetie and Arctic Village."

**L - B10. Growth of vegetation is controlled well so that it does not hinder the safe operation of my aircraft:**

| | | | | |
|---|---|---|---|---|
| 1 – 11% | 2 – 58% | 3 – 16% | 4 – 16% | 5 – 0% |

"Can't see traffic on mid runway trail at Beaver due to vegetation."

**B11. In general, summer runway maintenance is excellent:**

| | | | | |
|---|---|---|---|---|
| 1 – 11% | 2 – 42% | 3 – 21% | 4 – 21% | 5 – 5% |

"It's adequate."
"Except Venetie and Stevens."
"Again, Stevens village is uneven and rough."

## M - General

**B12. Runway markers are generally well-maintained throughout the year:**

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 53% | 3 – 21% | 4 – 21% | 5 – 5% |

"Many are broken or missing."

**B13. Runway lighting systems are generally well-maintained throughout the year:**

1 – 0%  2 – 44%  3 – 22%  4 – 22%  5 – 11%

"Except for Arctic Village."

"Depends on location."

**B14. Wind socks are generally well-maintained throughout the year:**

1 – 0%  2 – 37%  3 – 26%  4 – 32%  5 – 5%

"Except Anaktuvuk Pass where it's hard to locate."

"Except Rampart where its rusted and barely moves."

"Windsocks will freeze into one position."

**B15. Rotating beacons are generally well-maintained throughout the year:**

1 – 0%  2 – 74%  3 – 21%  4 – 5%  5 – 0%

"Most are low power, can see town/village lights first."

## SECTION C
## N - RUNWAY CONDITION REPORTING

*Contract maintenance workers are required to call in Notices to Airmen (NOTAMs) to the Flight Service Station (FSS) when conditions dictate. Answer the following question regarding NOTAM reporting at the airports with which you are familiar.*

**O - Use the scale below. Circle the number that applies.**

| Strongly Agree | Agree | No Opinion Or Don't Know | Disagree | Strongly Disagree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

**C1. I have confidence that the NOTAM reports which I get from the Flight Service**

**Station are accurate:**

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 44% | 3 – 11% | 4 – 28% | 5 – 17% |

"FSS and the contract workers offer a very large margin for error."

"Insofar as the FSS is kept up to date."

"NOTAM L's often missed in distant jurisdictions."

**C2. Problems with the NOTAM system include:**

***a. Village contractors don't know what to report:***

| | | | | |
|---|---|---|---|---|
| 1 – 17% | 2 – 33% | 3 – 39% | 4 – 11% | 5 – 0% |

"Some exceptions, but usually OK."

"...or don't care."

"Some do, some don't."

"Especially Venetie, Rampart and Fort Yukon."

"Pilot report is better information."

***b. Village contractors don't regularly inspect their runways and therefore don't know when a reportable condition arises:***

| | | | | |
|---|---|---|---|---|
| 1 – 22% | 2 – 22% | 3 – 39% | 4 – 17% | 5 – 0% |

"Usually, they do OK."

"...or don't care."

"Yes!!!"

"Most runway condition reports come from pilots."

"Don't know how often they inspect."

"Especially Venetie, Rampart and Fort Yukon."

"Airports I go to the operators are good."

***c. Village contractors don't take the time to call in the NOTAM:***

| | | | | |
|---|---|---|---|---|
| 1 – 22% | 2 – 28% | 3 – 39% | 4 – 11% | 5 – 0% |

"Usually, OK."

"...or don't care."

"Yes!!!"

"Some do, some don't."

*d. NOTAMs called in don't get entered into the FSS System:*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 6% | 3 – 78% | 4 – 6% | 5 – 11% |

"FSS does not have the "cream of the crop" here in Alaska."

"No, getting rid of old outdated ones is a problem."

"Exception: PIREPs of AWOS/ASOS anomalies often lost in shuffle.

*e. NOTAMs don't stay in the FSS system long enough:*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 6% | 3 – 56% | 4 – 22% | 5 – 17% |

"NOTAM-R not disseminated well enough."

"Seldom do they offer runway NOTAMS unless you request them."

"They usually stay in too long."

"They stay in the system until they are changed, dated or manually cancelled."

"They should be corroborated monthly."

*f. FSS briefers don't offer NOTAMs to pilots unless requested:*

| | | | | |
|---|---|---|---|---|
| 1 – 11% | 2 – 21% | 3 – 11% | 4 – 47% | 5 – 11% |

"Always. FSS NOTAM reporting system is dangerous at best!!!"

"...and seldom give the pertinent NOTAMS."

"I get told almost all the time."

"Only if you do not get a standard briefing, get an Aeronautical Information Manual and read it."

**C3. When getting a pilot briefing from FSS I always ask for NOTAM information at destination airports if the briefer does not give it to me:**

| | | | | |
|---|---|---|---|---|
| 1 – 32% | 2 – 47% | 3 – 5% | 4 – 16% | 5 – 0% |

"And then I may not get all available."

"Seldom ask anymore as the info given isn't pertinent."

"I'm usually given them anyway."

**C4. When I get NOTAM information from the FSS it is specific and complete enough to be helpful:**

| | | | | |
|---|---|---|---|---|
| 1 – 21% | 2 – 47% | 3 – 16% | 4 – 5% | 5 – 11% |

"Only if I ask specific questions."
"Generally very good."
"They're not hard to understand."

**C5. When I get NOTAM information from the FSS it is accurate:**

| | | | | |
|---|---|---|---|---|
| 1 – 12% | 2 – 41% | 3 – 18% | 4 – 12% | 5 – 18% |

"Usually it's semi-accurate."
"Only if I ask specific questions. Pilot must know what to ask."
"Seldom."
"If any are available they are usually outdated and irrelevant."
"Oftentimes the NOTAMs are old and do not get dropped."
"As accurate as the information has been given to FSS."

**P - Please answer the following questions using the scale below:**

| Very Often | Often | Sometimes | Rarely | Never |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

**C6. How often in the last year would you say you have flown to a remote airstrip and chosen NOT to land due to one of the following poor runway conditions which SHOULD have been on a NOTAM but was NOT:**
"Not often, I can't make money if I don't land."

***a. Unplowed snow***

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 0% | 3 – 19% | 4 – 38% | 5 – 44% |

*b. Poorly plowed snow*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 6% | 3 – 44% | 4 – 13% | 5 – 38% |

*c. Obstructions on the runway (above runway level)*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 0% | 3 – 25% | 4 – 25% | 5 – 50% |

*d. Potholes, ruts, (below runway level)*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 6% | 3 – 50% | 4 – 15% | 5 – 25% |

*e. Vegetation encroaching on the runway:*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 0% | 3 – 19% | 4 – 19% | 5 – 63% |

*f. Flooding:*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 6% | 3 – 35% | 4 – 24% | 5 – 35% |

"Allakaket, late NOTAM which closed runway."

*g. Inoperative or insufficient runway lighting:*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 12% | 3 – 29% | 4 – 29% | 5 – 29% |

*h. Other (write it in) ________________________ :*

| | | | | |
|---|---|---|---|---|
| 1 – 20% | 2 – 0% | 3 – 40% | 4 – 0% | 5 – 40% |

"Deep mud and water filled pot holes."

"I landed in Arctic Village last winter. Maybe I shouldn't have. It was uneventful but wasn't enjoyable – deep snow berms."

"Snow removal to the point skis not usable."

"Planned NAVAID outages during IFR WX, making legal compliance impossible."

"I don't rely on NOTAMs..."

"Gigantic holes in Venetie. It's bad."

**Please "X" any airports where you believe poor NOTAM reporting is a particular problem:**

| | | |
|---|---|---|
| __1_ Allakaket | ____ Beaver | ____ Birch Creek |
| __1_ Arctic Village | ____ Bettles | ____ Central |

| | | |
|---|---|---|
| _1_ Chandalar Lake | _2_ Fort Yukon | ____ Minto |
| _1_ Chandalar Shelf | ____ Galena | ____ Northway |
| ____ Chalkyitsik | ____ Hughes | ____ Nulato |
| _1_ Chicken | _3_ Huslia | _1_ Rampart |
| ____ Circle City | _1_ Kaltag | _1_ Ruby |
| ____ Clear | _2_ Koyukuk | _6_ Stevens Village |
| ____ Coldfoot | _2_ Manley Hot Springs | ____ Tanana |
| ____ Eagle | ____ Minchumina | _3_ Venetie |

"Only airports we have a regular problem with are Venetie and Arctic Village."

**Nenana**

"Treacherous."

**Venetie**

"Treacherous."

"Bad."

**Stevens Village**

"Bad."

**Q - Please answer the following questions using the scale below:**

| Very Often | Often | Sometimes | Rarely | Never |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

**C7. How often in the last year would you say you have elected NOT TO FLY to a remote airstrip primarily because a NOTAM indicated that there was:**

***a. Unplowed snow on the runway***

1 – 0% 2 – 0% 3 – 19% 4 – 31% 5 – 50%

***b. Potholes or ruts on the runway***

1 – 0% 2 – 0% 3 – 6% 4 – 35% 5 – 59%

*c. Berms or obstructions on the runway*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 0% | 3 – 6% | 4 – 41% | 5 – 53% |

*d. Inoperative runway lighting*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 0% | 3 – 24% | 4 – 35% | 5 – 41% |

*e. Inoperative wind sock*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 0% | 3 – 0% | 4 – 6% | 5 – 94% |

"Allakaket was flooded this year so we didn't go."

"Venetie is bad."

"Venetie runway lights not installed or inoperative, but still need MEDEVAC service."

**C8. When you anticipate poor runway conditions at a rural airstrip, how often do you call someone in the village to determine actual conditions?**

| | | | | |
|---|---|---|---|---|
| 1 – 28% | 2 – 28% | 3 – 28% | 4 – 6% | 5 – 11% |

"Almost always."

"All the time."

**C9. When you anticipate poor weather conditions at a rural airstrip, how often do you call someone in the village to determine actual conditions?**

| | | | | |
|---|---|---|---|---|
| 1 – 39% | 2 – 39% | 3 – 17% | 4 – 0% | 5 – 6% |

"Almost always."

"All the time."

## SECTION D
## WEATHER CONDITION REPORTING

**R - Please use the scale below. Circle the number that applies.**

| Strongly Agree | Agree | No Opinion Or Don't Know | Disagree | Strongly Disagree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

**D1. I have confidence in the accuracy of the following data provided by AWOS/ASOS:**

***a. Temperature/Dew Point***

1 – 22% 2 – 67% 3 – 11% 4 – 0% 5 – 0%

***b. Visibility***

1 – 0% 2 – 22% 3 – 11% 4 – 39% 5 – 28%

***c. Sky Conditions (Ceilings, Obscuration etc.)***

1 – 0% 2 – 22% 3 – 11% 4 – 33% 5 – 33%

***d. Wind Direction***

1 – 17% 2 – 67% 3 – 6% 4 – 6% 5 – 6%

***e. Wind Speed***

1 – 17% 2 – 61% 3 – 11% 4 – 6% 5 – 6%

***f. Altimeter***

1 – 17% 2 – 78% 3 – 0% 4 – 0% 5 – 6%

**D2. I get AWOS/ASOS info while enroute to airports that have ASOS/AWOS.**

1 – 47% 2 – 47% 3 – 6% 4 – 0% 5 – 0%

"It's a CYA measure in controlled airspace."

"Always!"

"Fort Yukon and many other AWOS/ASOS reporting systems are unable to accurately report visibility and ceiling in winter conditions."

"I use what is there."

**D3. I would normally cancel a flight to a non-instrumented remote airport based solely on an AWOS/ASOS report of IFR conditions.**

1 – 6%　　2 – 33%　　3 – 6%　　4 – 28%　　5 – 28%

"Never."

"Hold for weather sometimes – depends on factors (PIREPS etc.)"

"Machines on the ground cannot determine flight visibility from the cockpit."

"Need more info to cancel flight."

"AWOS/ASOS is bad."

**D4. I would rather have ASOS/AWOS than a human weather observer at remote airports to which I fly.**

1 – 6%　　2 – 11%　　3 – 6%　　4 – 11%　　5 – 67%

"Never – as long as observer is trained."

"Never – the only good thing about AWOS is it operates 24 hours a day. People aren't always staffed 24 hours."

"I want people there."

"We do not have the technology as yet to remove the human weather observer."

"They are unreliable and cost the air carriers big bucks in cancelled flights."

**D5. Please rank order the following (1 thru 7) in terms of their relative importance to you when flying VFR to rural airstrips. ("1" is most important, "7" is least important).**

These have been rank ordered based on pilot response from most important to least important.

| | |
|---|---|
| 1 - Visibility | 100% of pilots rated this as #1 or #2. (94% as #1, 6% as #2) |
| 2 - Sky Conditions | 94% of pilots rated this as #1 or #2. (6% as #1, 88% as #2) |
| 3 - Wind Speed | |
| 4 - Wind Direction | |
| 5 - Altimeter | |
| 6 - Temperature | |
| 7 - Dew Point | |

## SECTION E
## USE OF CLOSED CIRCUIT TELEVISION

*It is technically feasible to install Closed Circuit TV (CCTV) cameras at remote airports which could provide near real-time still images of the runway and/or terrain off the ends of the runways. Pilots could access this information over the Internet to help confirm actual conditions at remote airstrips during flight planning. Answer the following questions regarding this technology.*

| Strongly Agree | Agree | No Opinion Or Don't Know | Disagree | Strongly Disagree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

**E1. I currently have access to the Internet at work:**

1 – 24% 2 – 47% 3 – 6% 4 – 6% 5 – 18%

**E2. I expect to have Internet access at work within the next 12 months.**

1 – 14% 2 – 21% 3 – 43% 4 – 14% 5 – 7%

**E3. CCTV images would provide helpful information in flight planning:**

1 – 41% 2 – 24% 3 – 29% 4 – 6% 5 – 0%

"If cameras can be protected it would be OK."
"If the images give a referenced datum for evaluation of actual cloud heights and visibility."
"It does not provide anything more than what it is when you look at it, not what it will be when you get there."
"Depends on image quality."

**E4. I would take the time to access CCTV images from the Internet during my flight planning if Internet access was available to me:**

1 – 59% 2 – 18% 3 – 18% 4 – 0% 5 – 6%

"I would access anything that would give me real time images."
"I use what(ever) is there."

**E5. I would be very interested in using CCTV for:**

*a. Weather Information*

| | | | | |
|---|---|---|---|---|
| 1 – 56% | 2 – 19% | 3 – 25% | 4 – 0% | 5 – 0% |

*b. Runway Condition Information*

| | | | | |
|---|---|---|---|---|
| 1 – 56% | 2 – 19% | 3 – 25% | 4 – 0% | 5 – 0% |

"Not interested in CCTV."

**S - Please answer the following questions using the scale below:**

| Very Often | Often | Sometimes | Rarely | Never |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

**E6. How often in the last year would you say you have flown to a remote airstrip and been surprised to find one of the following weather conditions which you did not anticipate prior to arrival at the airstrip:**

*a. Poor Visibility*

| | | | | |
|---|---|---|---|---|
| 1 – 19% | 2 – 19% | 3 – 31% | 4 – 25% | 5 – 6% |

*b. Low ceiling*

| | | | | |
|---|---|---|---|---|
| 1 – 13% | 2 – 25% | 3 – 31% | 4 – 25% | 5 – 6% |

*c. Thunderstorms or heavy precipitation*

| | | | | |
|---|---|---|---|---|
| 1 – 13% | 2 – 6% | 3 – 38% | 4 – 25% | 5 – 19% |

*d. High wind*

| | | | | |
|---|---|---|---|---|
| 1 – 0% | 2 – 19% | 3 – 38% | 4 – 25% | 5 – 19% |

"I always expect these conditions."

**E7. How often in the last year would you say you have flown to a remote**

**airstrip and chosen NOT to land due to one of the following weather conditions which you were not aware of prior to arrival at the airstrip:**

*a. Poor Visibility*

1 – 0%    2 – 31%    3 – 19%    4 – 25%    5 – 25%

*b. Low ceiling*

1 – 0%    2 – 31%    3 – 19%    4 – 31%    5 – 19%

*c. Thunderstorms or heavy precipitation*

1 – 0%    2 – 13%    3 – 6%    4 – 38%    5 – 44%

*d. High wind*

1 – 0%    2 – 19%    3 – 6%    4 – 44%    5 – 31%

**E8. Of the airports listed below, please rank order the top three that you believe would benefit from improved *weather condition* reporting through the use of CCTV accessed over the Internet. Put a "1" in your first choice, a "2" in the second and a "3" in the third.**

Numbers indicate how many times pilots selected the airport on surveys.

__3_ Allakaket
__2_ Anaktuvuk Pass
____ Beaver
__1_ Bettles
____ Birch Creek
__1_ Central
__1_ Chandalar Lake
____ Chandalar Shelf
____ Chalkyitsik
____ Chicken
____ Circle City
____ Clear
____ Coldfoot
__2_ Eagle
__4_ Fort Yukon
____ Galena
__1_ Hughes
__1_ Huslia
__4_ Kaltag
____ Koyukuk
__1_ Manley Hot Springs
__1_ Minchumina
__2_ Minto
____ Northway
__3_ Nulato
__6_ Rampart
__5_ Ruby
__3_ Stevens Village
__1_ Tanana

**Explain why you chose these three.**

**Fort Yukon**

"AWOS usually reports low ceiling/visibility with any type of obscuration."

"Often inaccurate AWOS."

"Fort Yukon during the winter months is completely unreliable."

"AWOS is no good."

**Chandalar Lake**

"...between very high mountains, accurate weather needed."

**Rampart**

"Also lies between tall mountains."

"Weather has caused me problems."

"Down in a hole."

"No one qualified to observe."

**Minchumina**

"Has no local reporting station close enough to get a weather picture."

**Anaktuvuk Pass**

"When the village can be seen greater than 5 miles."

"Weather can be very different from the rest of the flight. Long trip to find out at the last minute that you can't get in."

**Ruby**

"Ruby sits higher than most strips and is at a bottle neck of rising terrain which causes frequent difficulties with flight planning."

"Weather not reported and Tanana/Galena doesn't always depict what is happening in between."

"Ruby's weather is so completely different than any other place along the Yukon that reports weather."

"Runway much higher than Galena."

"This is also a low weather spot."

**Kaltag**

"Often AWOS is not accurate."

"Down river weather."

"Kaltag has terrain it would be nice to see if it is obscured."

**Nulato**

"Has no weather reporting."

"Nulato has terrain it would be nice to see if it is obscured."

**Allakaket**

"No weather reports."

"My opinion is that this technology would be too fragile to operate properly especially during the winter, also I can only imagine the cost for installation and maintenance would be very high. I would rather see the money used to train someone in the village to observe weather and runway conditions and then report them to FSS."

**Koyukuk**

"Runway conditions not recorded well."

**Allakaket**

"Runway conditions vary greatly and reported rarely and no weather available and Bettles isn't always accurate depictions of Allakaket."

**Stevens Village**

"Stevens has absolutely no report on any condition weather or runway."

"This is where the weather is lowest between Fairbanks and Bettles."

**Eagle**

"We go there twice a day."

"Because of the high mountains around the airport."

**Hughes**

"Hughes has terrain it would be nice to see if it is obscured."

**Huslia**

"AWOS notoriously unreliable after first snow."

**Central**

"They decommissioned our only NAVAID, we need all the help we can get."

**E9. Of the airports listed below, please rank order the top three that you believe would benefit from improved *runway condition* reporting through the use of CCTV accessed over the Internet. Put a "1" in your first choice, a "2" in the second and a "3" in the third.**

Numbers indicate how many times pilots selected the airport on surveys.

| | | |
|---|---|---|
| __3_ Allakaket | ____ Clear | ____ Minchumina |
| __1_ Beaver | ____ Coldfoot | __1_ Minto |
| ____ Bettles | ____ Eagle | ____ Northway |
| ____ Birch Creek | __1_ Fort Yukon | __3_ Nulato |
| ____ Central | ____ Galena | ____ Rampart |
| ____ Chandalar Lake | ____ Hughes | ____ Ruby |
| ____ Chandalar Shelf | __2_ Huslia | __6_ Stevens Village |
| ____ Chalkyitsik | __2_ Kaltag | __1_ Tanana |
| ____ Chicken | __2_ Koyukuk | __1_ Venetie |
| ____ Circle City | __2_ Manley Hot Springs | |

"Pilots are best source of runway info."

"Bring back the FSS's and trash the AWOS.

**Venetie**

"Worst strip."

"It's bad."

**Stevens Village**

"Worst strip."

"Only this one because it is the shortest runway in both the Yukon and Tanana Valleys."

"Stevens may or may not plow their snow."

"It's bad."

"This is the poorest runway."

**Huslia**

"Worst strip."

**Allakaket**

"Runway conditions at Allakaket poor on occasion and NOTAMS inaccurate."

"Unreliable info."

**Koyukuk**

"Camera may help."

"Soft runway ruts."

**Huslia**

"Like Koyukuk runway short and doesn't accept moisture well."

**Kaltag**

"Kaltag has a real problem with slick ice build-ups."

**Nulato**

"Nulato because the wind and snow pack may affect the aircraft's ability to even land on the runway because of its slope."

**Manley Hot Springs**

"Too Narrow."

**Tanana -**

"Ruts."

**Minto**

"Runway is maintained from Manley and sometimes they don't get to Minto as soon as they'd like."

**Rampart**

"So far from town no one ever knows current conditions."

**Fort Yukon**

"Never can believe NOTAMs, hard to know if plowed, often not.

# APPENDIX C

# Economic Analysis of Three Alternatives for Improving Supervision of AKDOT Contract Maintenance Personnel in Rural Alaskan Villages

The AKDOT is responsible for the development, maintenance and operation of its public airport system. As such, AKDOT owns and operates 266 of the 286 public airports throughout the state. Most of these airports service small, remote villages that are otherwise inaccessible by road. Air carriers provide movement of mail, supplies and people into and out of most of these airstrips on a daily basis.

During the winter months, snow removal is critical to the safe, consistent operation of air carriers into these small villages. The state contracts a single individual or the city council at these villages to conduct snow removal and other airport maintenance throughout the year. The AKDOT maintains a road grader, a bulldozer, a small structure and miscellaneous equipment at nearly 80% of these airstrips. This equipment provides the contractor a means for conducting required maintenance. The need for competent, trustworthy individuals in these positions is critical to the safe operation of aircraft at these runways.

The AKDOT is concerned about the level of service provided by these contracted personnel. Contracts normally run for five years and the state is required to hire the lowest bidder. There is some interest at AKDOT in affecting improvements in the conduct of contracted maintenance personnel whose performance is often below that required in the contract. Additionally, research has provided strong incentive to increase the level of supervision of contract maintenance personnel as a measure in improving the quality of service in both runway maintenance and runway condition reporting.

This appendix addresses the issue of introducing a formal AKDOT inspection program at remote airports throughout the Northern Region of Alaska. It specifically attempts to itemize the incremental benefits and cost savings that would accrue to the AKDOT if they were to institute such a program. Such an initiative would not be without some new incremental cost. Therefore, the attached study compares costs, savings and benefits to determine the best alternative for providing such oversight. A major portion of the paper addresses itself to formulating, and deducing reasonable estimates of these benefits, savings and costs so that a realistic analysis may be accomplished.

The report concludes with recommendations to the AKDOT to assist them in pursuing a sound solution. This paper will be provided to the Northern Region AKDOT for their perusal.

## C.1 - Background

It has been accurately stated that Alaska is "the flyingest place in the world". This state has six times as many pilots and sixteen times as many aircraft per capita as the rest of the United States [25]. There are 1112 airports, seaplane bases and other aircraft landing sites for general aviation aircraft in the 586,000 square miles that comprise the "Great Land". There are 286 public use airports in the State. They stretch from Barrow on the cold bleak north coast, 700 miles south to Anchorage on the Cook Inlet. They spread from Wales in the west, a mere sixty miles from Russia, eastward over 750 miles to Northway near the border of the Yukon Territory in Canada.

The majority of the 286 public use airports are rural airstrips in "The Bush". These small airports could more appropriately be called "airstrips", as they are usually little more than a remote, state-owned, unimproved runway with an adjacent building or two. The typical airstrip is 2500 feet long, 75 feet wide and is constructed of compacted gravel hauled or barged from some distant location. The airstrip is cleared of vegetation on all sides that would interfere with the safe operation of aircraft during approach, departure and low-level maneuvering. It serves a small village or community that is absolutely dependent upon regular air traffic to survive. Over 80% of these airports are inaccessible by road, which accounts for the community's vital need for air service. Most airports have a small State-owned maintenance building called a Snow Removal Equipment Building (SREB) where equipment is stored and maintained.

Almost without exception, each of these airports requires significant seasonal maintenance to support the regular and necessary daily flow of air traffic. The one universal maintenance requirement is that of snow removal which affects every airport in the state system. Snow removal, as well as additional airport maintenance requirements, is normally contracted out to an independent contractor managed by the AKDOT. Approximately 90% of these airports are maintained by a single individual, or by the city under contract. The remaining airstrips are maintained by State workers who also maintain the road transportation network in the vicinity of the airport.

Users of Airstrips

Those who operate aircraft at these rural airstrips fall into one of four broad categories:

1. Air Carriers – These firms normally operate daily, scheduled flights to rural airstrips in Alaska to facilitate necessary commerce to these villages. They deliver mail, five to seven days a week, to nearly every rural village and town in the state. As many as seventeen different air carriers are contracted to carry the mail [47]. Often a village will receive several mail flights a day from different air carriers. The air carriers also move passengers between villages as well as to and from larger cities. They also carry cargo to rural Alaskans ranging from necessary food and supplies to convenience and luxury items.

2. Air Taxis – In much the same way as a New York City taxi cab provides for the immediate transportation needs of the paying public, the Air Taxi's provide unscheduled air service within Alaska. These flights accommodate emergencies, immediate business needs and custom-fit recreational outings.

3. State Agencies – The Department of Fish and Game, the Department of Transportation, law enforcement agencies and others use these airstrips as en route refueling stops, and terminal points to provide their services throughout Alaska.

4. General Aviation – Sightseeing, hunting and fishing throughout rural Alaska often necessitates air transportation to the site. Individual aircraft owners use the geographically dispersed web of airports to facilitate recreational trips throughout the state. In addition, some aircraft owners conduct business using their personal aircraft and are dependent upon Alaska's public airports for safe, convenient travel.

Those contracted by AKDOT to perform regular maintenance of airstrips normally live in the village adjacent to the airstrip. This is almost necessitated by the geographical immensity of the state and the huge dispersion of airports. It would be infeasible for an individual contractor, living away from the airstrip, to commit to providing snow removal on the very airstrip he is dependent upon to access the village.

Contractor Responsibilities

The duties of each contractor vary slightly between locations based on the airport infrastructure at that particular location. The primary requirements of the contract are listed below. A statement establishing the AKDOT perspective on how well the contractor is performing that task follows each requirement.

1. Requirement: Conduct a daily inspection of the airport paying particular attention to the condition of the runway and the runway lighting system. Rutting of the airstrip, potholes, snow cover, and glare ice form the core list of discrepancies that must be discovered and corrected by the contractor.

Performance: In general, contractors frequent their airstrips often enough to discover glaring deficiencies. However, thorough daily inspections are not being conducted in the spirit of the contract. Thus, a myriad of small deficiencies tends to stack up delaying needed maintenance and increasing risk to airport users. AN AKDOT representative could offset this tendency with regular inspections.

2. Requirement: Keep the runway clear of snow, 365 days a year and 24 hours a day. This is critical because most air carriers prefer to operate twin-engine, high performance aircraft that do not utilize skis. Thus, they anticipate landing on a surface free of loose snow and void of glare ice throughout the winter season. Contractors at most airports are provided with state-owned heavy equipment to conduct this snow clearing. A road grader with snowplow attachment and a bulldozer are typical of the heavy equipment package.

Performance: This requirement is performed well by most contractors. However, AKDOT is concerned that many contractors will ignore their duties when faced with conflicting opportunities to go hunting, fishing, or engage in recreational activities which may remove them from oversight of the airstrip for days at a time. This concern could also be mitigated by unannounced visits to the airport by AKDOT personnel. The anticipation of such visits would encourage contractors to be more conscientious in their duties.

3. Requirement: Maintain runway lighting and wind cones. This includes runway and taxiway lights; threshold lights; the rotating beacon and the lighted wind cone. Nearly every rural airport has runway lights that are controlled by an approaching pilot through an aircraft radio. The proper operation of these lights is a critical safety issue for pilots using the airstrip in hours of darkness. Since darkness dominates the winter months, maintenance of runway lights is critical.

Performance: Maintenance of airport lighting varies greatly depending upon the contractor. To the extent that burned-out lights are not detected and replaced daily, risk to aircraft may be dramatically increased. For example, a rotating beacon is a primary means of locating an airport in marginal weather conditions. If the beacon is out, the level of safety afforded incoming pilots is greatly diminished. Regular inspections by AKDOT personnel would improve contractor reliability in correcting deficiencies in a timely manner.

4. Requirement: Report Notices to Airmen (NOTAMs) as required. A NOTAM is an advisory message distributed to airport users by the FAA regarding airport conditions that may be hazardous. An airport contractor may formally enter a NOTAM into the Federal Aviation Administration (FAA) computer reporting system with a toll-free phone call. A pilot will be informed of all NOTAMs applicable to his route of flight when he receives his pre-flight briefing from the FAA Flight Service Station. Airport contract maintenance personnel should call in a NOTAM every time the airport is at a reduced level of operational capability. Snow cover, glare ice, ongoing snow removal operations and reduced airport lighting are all conditions that should generate a NOTAM.

Performance: Contractors do not do well reporting NOTAMs affecting their airstrips. The value of the NOTAM is not well appreciated by the contractors. Thus they often do not make the effort to make the report. This has a huge detrimental affect on all air traffic arriving at the airstrip. A pilot arriving after a two-hour flight, only to find that the runway has 6 inches of unplowed new snow may have to abort the flight and turn back. Contractor sensitivity to the importance of NOTAM submission could be raised through more frequent contact with an AKDOT representative on site.

5. Requirement: Use two-way Radio to Communicate with Airborne Pilots. Contractors have recently been provided with modern, two-way radios that are mounted in their snow removal equipment. They are required by contract to transmit their intentions to occupy the runway to plow snow.

Performance: There is concern that contractors may not embrace this contractual responsibility for the long term. Consistent AKDOT oversight and inspections would be helpful in reinforcing the contractor's duties in this task.

6. Requirement: Maintain state-owned Equipment. The contractor is required to conduct preventive maintenance on all equipment provided to him by AKDOT. This includes checking, filling and replacing all fluids as well as lubricating, inspecting and cleaning equipment according to manufacturer specifications.

Performance: Much of this maintenance is not performed regularly due to a lack of direct supervision. This will have a deleterious effect over the long term as equipment ages more quickly and breaks down more often. Regular oversight by AKDOT personnel would correct this problem.

DOT Responsibilities

DOT has direct responsibility and oversight for individuals contracted by the state to perform airport maintenance. AKDOTs primary responsibilities follow:

1. Provide regular oversight and supervision of the contractor.

This is not currently being done with any regularity. For the most part, airports are visited when there is a stated need. As such, face-to-face meetings between an AKDOT representative and the contractor are irregular. This is perhaps the largest single problem associated with airport maintenance. As noted in the prior section, regular inspections or visits by AKDOT personnel on site at airports would help mitigate the concerns held by the state. They would serve to improve both the reliability and performance of airport contractors.

2. Provide all parts, materials, and items needed for the Contractor's use when performing work under the terms of the contract. These include fuel, oil, antifreeze, filters and other required lubricants.

The expedient distribution of these parts and supplies is not controlled by any rigorous system. Lack of dedicated personnel to fill this need may result in contractors not performing required maintenance regularly.

3. Provide contractor training commensurate with developing needs and requirements.

Training topics range from use of heavy equipment to plow snow, to operation and use of a new piece of equipment. There are currently no standard, documented training outlines to meet these needs. In rare instances, AKDOT sends a heavy equipment operator to the outlying village to give a new untrained contractor a quick half-day course on the operation and maintenance of heavy equipment. While contractors are required to attend centralized training sessions required by AKDOT, it is not uncommon for them not to show up. Lack of training incurs both near term and far term costs to AKDOT. An individual performing regular visits to airports could provide more frequent on-the-job training.

The Need

The shortfalls articulated above lead to the following general conclusion. The AKDOT needs to increase supervision by providing regular, thorough visits to remote airstrips to ensure that contractors are executing the terms of the contract more conscientiously. This single initiative would address the primary concerns AKDOT has with contractor performance.

This inspection/visitation program needs to be designed and written. The following primary components of such a program would serve to offset the major problems:

1. Conduct quarterly visits to airstrips where an individual or the city holds the contract. The primary areas to be inspected include the runway; state-owned equipment; airport grounds; the maintenance facility and contractor records.
2. Conduct annual visits to airstrips that are state maintained.
3. Conduct contractor training concurrent with visits to the airport.
4. Inspect leased areas on airports. The AKDOT generates some income by leasing portions of airport property to firms or villages for other uses. These leased areas must be inspected to control encroachments and protect the State's investments.

Scope

This appendix will focus on a subset of Alaska's public airports consisting of twenty airports in the Interior which fall under the direct responsibility of the Regional Aviation Manager at the AKDOT in Fairbanks. This paper will use the conclusions from a study of these "Interior 20" to make recommendations that could be expanded to cover all of AKDOTs 266 public airports in Alaska. The 20 airports are shown in Figure C.1.

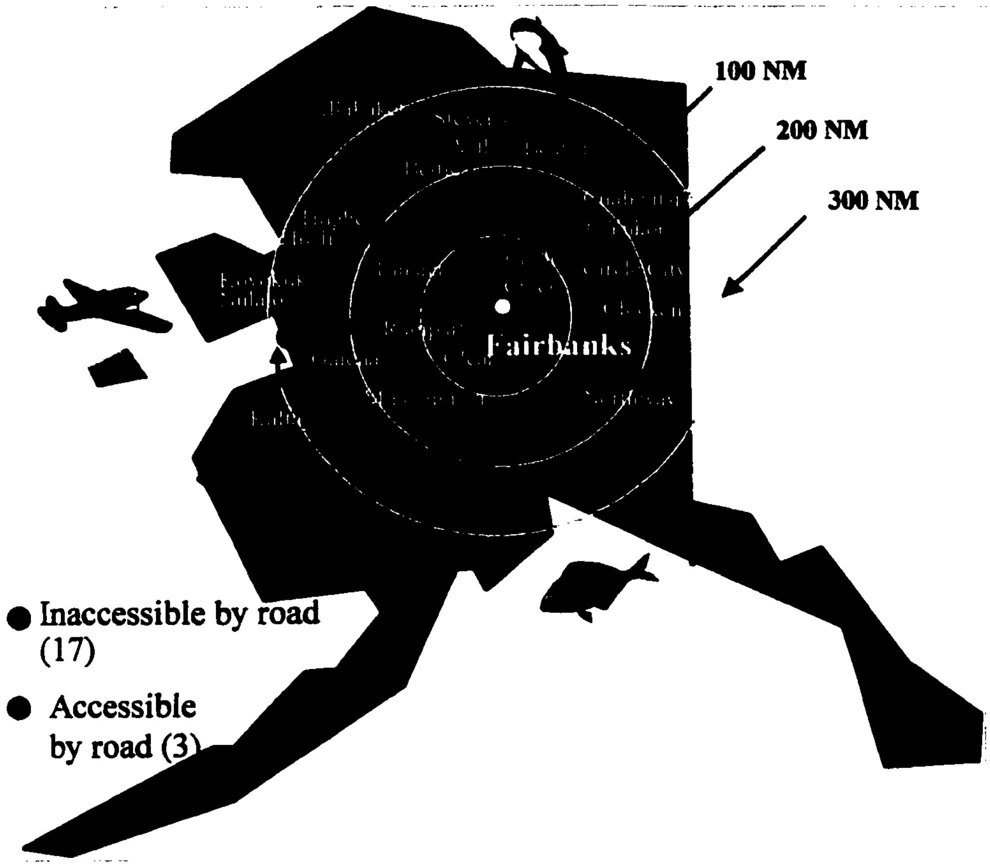


**Figure C.1** - The Interior 20 Rural Airports in the Northern Region of Alaska

## *C.2 - Development of Alternatives*

Three alternatives have been suggested to address the need for more frequent and consistent inspections of rural airports. These are mutually exclusive alternatives in that only one may be selected. Each is discussed below.

Alternative 1 - Do Nothing

The Regional Aviation Manager at AKDOT on Peger Road in Fairbanks, Alaska held that job for 9 years. He retired on 31 December 1999. When he was hired he had direct responsibility for the oversight of 18 rural airports. Initially, he planned and executed a program to conduct quarterly inspections of these airports. Over the last nine years his responsibilities increased tremendously. While he still had direct oversight for the 18 (plus an additional two bringing it to 20), he was been given supervisory oversight for all 101 public airports in the Northern Region of Alaska. In addition, he was directly responsible for the security and certification of the six certificated airports in the region: Barrow; Nome; Kotzebue; Valdez; Cordova and Deadhorse. His title changed from Rural Airport Manager to Regional Aviation Manager with the change in duties. Consequently, the Regional Manager no longer has time to conduct visits with the frequency he believes is required.

*Advantages*

1. No new cost to AKDOT
2. No new position to justify and create

*Disadvantages*

1. Quarterly visits to all airports will not be conducted
2. Existing problems due to lack of oversight will continue and the integrity of airport and equipment maintenance as well as NOTAM reporting will continue to deteriorate

Alternative 2 - Hire a New AKDOT Employee

A new AKDOT position could be justified and created to work as a deputy to the current Regional Aviation Manager. This position was actually filled in 1999 subsequent to this study. However with the retirement of the Regional Aviation Manager, the deputy moved up and the deputy position is again empty. He would be a full-time AKDOT employee paid salary and benefits. His compensation package would be valued at approximately $60K.

*Advantages*

1. He could perform regular quarterly inspections of all 20 airports.
2. The new employee would be "in-house" and immediately available to the Regional Aviation Manager.
3. The new employee would be able to assume duties other than inspections.
4. He could design and write the inspection program from the ground up.
5. He could maintain inspection files at AKDOT to be used to justify disciplinary actions against contractors failing in their duties.

*Disadvantages*

1. Must compete with other offices in AKDOT to justify a new position

Alternative 3 – Hire an Independent Contractor

This option would involve hiring an independent contractor to conduct inspections of airports as an AKDOT representative. The contract would be opened for bid and the low bidder would be hired.

*Advantages*

1. Compensation for the contractor would probably be less than that for a new AKDOT employee as no benefits would have to be paid.
2. Decision process to justify a contractor is much less rigorous than hiring a new employee.
3. Contractor will not be overcome by new responsibilities that could ultimately preclude him from his primary responsibility of conducting inspections.

*Disadvantages*

1. Contractor would have less loyalty to the AKDOT than a regular employee
2. Contract is less flexible than having an employee. Changes to inspection requirements are harder to implement with a contractor.

## *C.3 - Comparison of Alternatives*

General Discussion

It is important to establish that there is inherent value in increasing AKDOTs level of supervision over contractors. That is, we anticipate that an incremental increase in AKDOTs supervision of contractors will produce a requisite improvement in contractor performance.

The annual cost of airport maintenance contracts for the twenty interior airports in question are difficult to control directly. The graph below establishes how these costs have changes since 1981.

The blue, total cost line is in current year dollars. The red line is in 1981 dollars adjusted by the

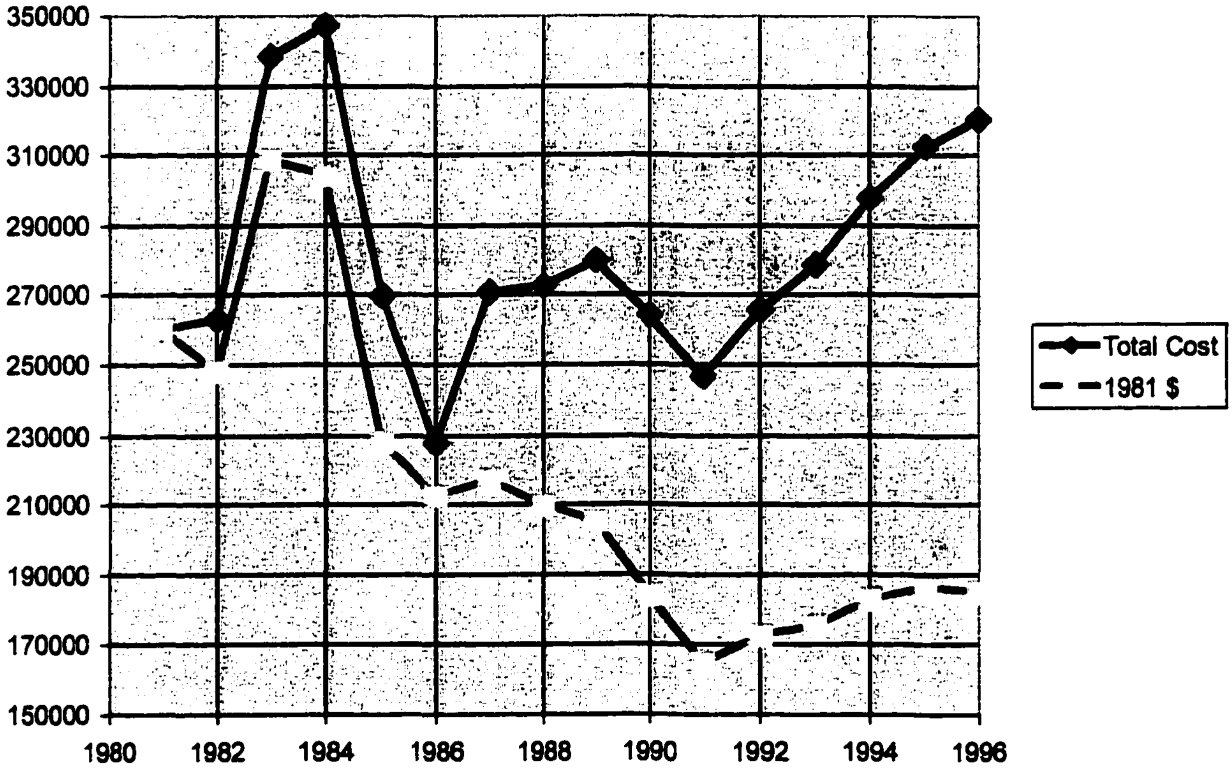


**Figure C.2** - Cost in $ of Contracts for Airport Maintenance for 20 Interior Airports from 1980 - 1996

Consumer Price Index. This graph indicates that the real value of maintenance dollars spent on contractors has been decreasing over the years. Currently, spending is still below what it was during the period 1981 – 1990.

Since the requirements of the contract have not decreased, but in fact increased somewhat over the years, this would appear to be a success story. What is not seen is that the benefits, which should accrue from contractor execution of the terms of the contract, have also decreased over recent years. This decline can be attributed directly to a lack of oversight at the airports as has been discussed. Another way to view this is that contractors are effectively making less money at this business than they used to...and they may sense that decline and expend less effort in executing the terms of the contract. The ultimate effect is that AKDOT can greatly improve the current Benefit-Cost ratio (or Bang for the Buck) not by decreasing the costs, but by improving the benefits! However, the tool used to increase the benefits (additional oversight) will incur a new cost.

Figure C.3 is simply a theoretical statement of the relationship between level of supervision, contractor performance and cost of supervision. The effect of increasing supervision is to increase contractor performance. At some point of diminishing returns, increased supervision only serves to frustrate the process such that contractor performance deteriorates. On the other hand, as level of supervision increases, the cost of supervision continues to increase. We anticipate that we can enter this graph at a point where the incremental increase in performance is greater than the incremental increase in cost.

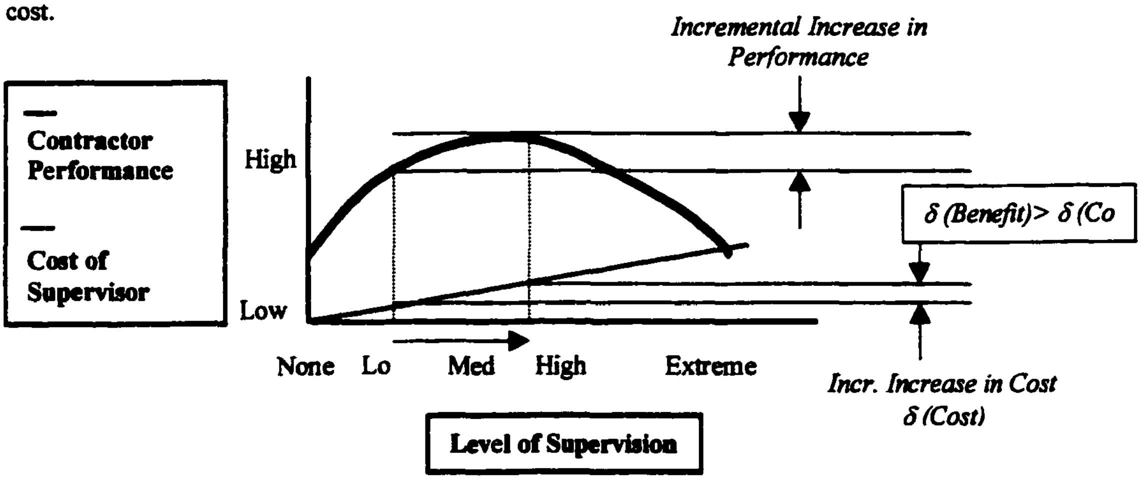


**Figure C.3** - Relationship between Level of Supervision, Contractor Performance and Cost of Supervision

Figure C.4 is a theoretical description of the relationship between level of supervision and the B/C ratio. Since the incremental benefit increases faster than the incremental cost of hiring a supervisor, the B/C ratio is greater than 1. As the increase in benefits equals the increase in costs, the B/C = 1 Finally, as benefits increase more slowly than costs, the B/C drops below 1. This continues until the benefit begins to decrease, while costs continue to rise wherein the B/C becomes negative.

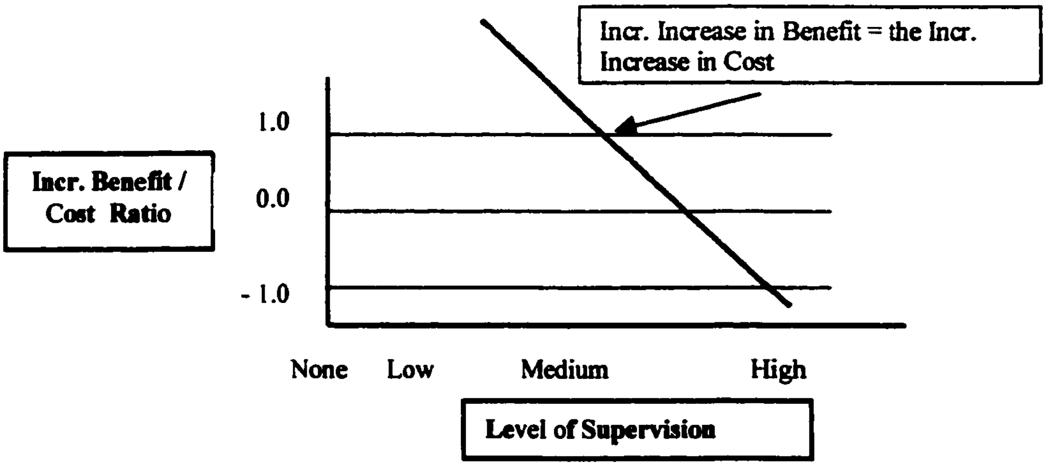


**Figure C.4** - Theoretical Relationship Between Level of Supervision and the Benefit/Cost Ratio

Having established that an increase in level of supervision will produce an incremental Benefit/ Cost ratio greater than 1.0 at some point, we will proceed to investigate the incremental benefits and costs involved in stepping up the level (frequency) of direct supervision of airport contractors. Our goal is simply to establish whether the incremental benefit/cost ratio associated with any of our three alternatives is greater than 1.0. Having done that, we will compare Benefits – Costs (B-C) to determine which of the three alternatives has the greatest Equivalent Annual Cash Flow (EACF).

## C.3.1 - Development of Incremental Benefits to the Public

The incremental benefits, which accrue as a result of additional oversight, consist primarily of entities that reduce risk to the flying public. As such these benefits are very hard to convert into monetary values which are easily appreciated. While they are not totally irreducible, they are difficult to quantify and equate to dollars. Four primary safety related benefits manifest themselves in this problem;

1. The reduced risk to the flying public due to better airstrip maintenance.

a. Winter runway maintenance is performed more quickly and in a more conscientious fashion due to frequent feedback from the AKDOT inspector in the form of quarterly inspections.

1) The amount of soft snow on the runway at any particular point in time is minimized.
2) The existence of snow berms on or adjacent to the runway (such that they increase the likelihood of contact with a landing or departing plane) is minimized.
3) Contractors are proactive in dealing with glare ice during spring breakup such that it is removed, or its affects mitigated sooner than when maintenance is haphazard.
4) Cases:

- Report of an aircraft incident on 3 March 1992 at Selawik, Alaska where glare ice covering two-thirds of the runway contributed to the aircraft's running off the end of the runway and onto a frozen river. One individual was injured.

- Report of an aircraft accident on 25 December 1991 at Tatitlek, Alaska where ice and water on a runway contributed to an aircraft running off the departure end of the runway. Three individuals were injured.

- Report of an aircraft accident on 14 March 1985 at Nulato, Alaska where snow on a runway contributed to a pilot continuing off the end of a runway and substantially damaging his aircraft.

b. Summer runway maintenance is performed more quickly and in a more conscientious fashion due to frequent feedback from the AKDOT inspector in the form of quarterly inspections.

1) Rutting of runways is repaired more quickly.
2) Soft spots in runways are discovered and repaired more quickly.
3) Frost heave, bulges and other runway inconsistencies are discovered and repaired more quickly.
4) Cases:

- Report of an aircraft accident on 26 August 1996 at Northway, Alaska where the plane hit a grass clump and uneven portion of the runway contributing to the pilot losing control of the aircraft and hitting a tree.
- Report of an aircraft accident that occurred on 10 July 1983 at Bettles, Alaska where an aircraft hit a frost heave on the runway during landing, cutting the tire and causing the two occupants serious injury.
- Report of an aircraft accident on 25 May 1993 at Kivalina, Alaska where a soft spot in the runway caused the collapse of an aircraft's nose gear and subsequent aircraft accident.

2. The reduced risk to the flying public due to better maintenance of airstrip lighting.

a. Burned-out runway lights are discovered and replaced within 24 hours.

1) Runway lights enable a pilot to maintain proper runway alignment during takeoff and landing. Runway lights are absolutely critical during periods of darkness which predominate during the winter months. Regular air carrier traffic continues throughout this time of extended darkness and safe operation of the aircraft is heavily dependent upon sound runway lighting.

2) Case: Report of an aircraft accident on 7 May 1994 at Allakaket, Alaska where poorly maintained runway lighting contributed to a pilot's inability to maintain proper runway alignment during landing.

b. Burned-out threshold lights are discovered and replaced within 24 hours. Threshold lights enable a pilot to discern the point at which he has crossed the end of the runway during landing. They, like runway lights are critical during periods of extended darkness.

c. Burned-out windsock lights are discovered and replaced within 24 hours. Windsocks enable a pilot to discern wind direction from the air prior to landing. Since most remote runways are not monitored, pilots must determine wind direction by observation from the air prior to landing. If windsocks lights are out, wind direction is impossible to determine at night which increases risk in landing.

d. Burned-out rotating beacon lights are discovered and replaced within 24 hours. The rotating beacon at an airport provides the pilot with a visual means of locating the airport in poor weather conditions. The flashing green and white light can be recognized in poor visibility and help lead the pilot to find the runway. The absence of this light, especially in periods of darkness and reduced visibility could spell disaster if the pilot was unable to locate his destination and did not have sufficient fuel to return to his departure point or an alternate airport.

3. Frequency of Reporting of NOTAMs increases.

a. Airport contractor reports poor runway conditions more consistently. A report of an aircraft accident at Tatitlek, Alaska was found where the contractor had not reported a NOTAM as he should have. Three people were injured in the incident.

b. Airport contractor reports periods when heavy equipment will be on the runway with more regularity. A report of an aircraft accident on 7 February 1985 at Koyuk, Alaska was found where a pilot purposely landed short to avoid snow removal equipment at the other end of the runway. Upon landing short, the aircraft hit a snowmobile driver and killed him. If a NOTAM had been issued that snow removal equipment was to be on the runway, the pilot may have delayed the flight and thus been able to perform a normal landing.

4. Frequency of use of two-way radio to communicate with inbound pilots increases. Airport contractor would regularly report his intention to occupy the runway with snow removal equipment. These transmissions would provide inbound pilots with additional information about conditions on the runway prior to landing. This could reduce potential accidents between pilots and heavy equipment on the runway.

Establishing a probability of occurrence of accidents related to these issues at rural airports is difficult. All accidents and fatalities at the 20 interior airports since 1981 were reviewed. Those related to issues listed above were extracted. The results are summarized below:

| Date | Location | Contributing Cause | Type Injury | Cost of Injury | Airframe | Cost of |
|---|---|---|---|---|---|---|
| | | | | | Damage | Damage |
| | | | | | | |
| 10-Jul-83 | Bettles, AK | Rough, uneven airstrip | 2 Serious | 2 x .2 x VL = .4 VL | Substantial | $30,000 |
| 7-Feb-85 | Koyuk, AK | Heavy Equipment on Runway | 1 Fatality | 1 x VL | Minor | $8,000 |
| 14-Mar-85 | Nulato, AK | Snow covered runway, snow berm | None | | Substantial | $30,000 |
| 7-May-94 | Allakaket, AK | Burned-Out Landing Lights | None | | Substantial | $30,000 |
| 26-Aug-96 | Northway, AK | Rough, uneven airstrip | None | | Substantial | $30,000 |
| | | | | | | |
| | | | TOTAL | 1.4 x VL* | | $128,000 |

**Table C.1** - Accidents Related to Runway Conditions or Reporting at 20 Interior Airports Since 1981

- VL represents the dollar value of a human life.

Given that these accidents occurred over a 13 year period, we establish the probability of occurrence as 1/13 = .0769 = 7.69%. Based on these five accidents, it is estimated the potential annual benefit to the flying public of improving contractor performance at the 20 interior airports is as follows:

Dollar Value of Potential Annual Benefit = .0769 (128,000 + 1.4 VL) (See Annex 1)

Where:

- VL represents the dollar value of a human life
- .0769 = 7.69 % represents the current probability of an incident of this type in any year.
- The assumption at this point is that all accidents of this type could be eliminated. We will modify that assumption shortly.

At this point we apply these findings to define the benefits for each alternative.

Alternative 1 – Do Nothing

Since this alternative involves no change in the existing structure, no new benefits will accrue. This option has no incremental costs.

Alternative 2 – Hire a New AKDOT Employee

From the discussion above, we establish the standard monetary benefit as .0769 ($128,000 + $1.4VL) where VL= the monetary value placed on a human life and .0769 (7.69%) represents the probability of this level of damage or injury in a year.

We now add a modifying factor to this equation to account for the fact that supervision of contractors will not eliminate all accidents, but serve to reduce them by some percentage. We will establish this modifying variable as $\lambda$. $\lambda$ then represents the effectiveness of the inspector in improving contractor performance, thereby reducing accidents. It is a percentage applied to the potential benefits, to yield actual benefits. Our modified benefit equation becomes:

$ Benefit from Accident Reduction = .0769 $\lambda$ ($128,000 + $1.4VL)

We anticipate that given an AKDOT employee focused on improving contractor oversight, that his influence could reduce runway condition accidents by 30%. Thus $\lambda = .30$ and our equations reads:

$ Benefit from Accident Reduction = .0769 * .30 * ($128,000 + $1.4VL)

This may be simplified to:

$ Benefit from Accident Reduction = $2,953 + .0323 VL

Alternative 3 - Hire an Independent Contractor

Following from the discussion above, we will establish a $\lambda$ for the contractor. Since he is not working full time at AKDOT, we anticipate that he will not be able to monitor the reporting of NOTAMs with the same fervor that the AKDOT employee would. That is, he will devote less time to administrative work and therefore have less impact in enforcing the prompt reporting of NOTAMs than the AKDOT employee. This implies that his impact at reducing the frequency of accidents will be somewhat less than the AKDOT employee's.

We therefore establish a $\lambda$ value of .20 that takes this into account. Following from above, our equation now reads:

$ Benefit from Accident Reduction = .0769 * .20 * ($128,000 + $1.4VL)

This may be simplified to:

**$ Benefit from Accident Reduction = $1969 + .02153 VL**

## C.3.2 - Development of Incremental Costs to AKDOT

The primary incremental costs associated with each alternative are tangible and measurable. They are delineated below by alternative.

Alternative 1 – Do Nothing

Since this alternative involves no change in the existing structure, there will be no additional cost.

Alternative 2 – Hire a New AKDOT Employee

The cost of a new AKDOT employee for planning purposes is shown below.

| C - Item | D - Cost | E - Reference |
|---|---|---|
| Value of Salary and Benefits of New AKDOT Employee | $ 60.0K | From AKDOT |
| Value of Per Diem for trips to conduct Qtrly Inspections | $ 1.3K | From Annex 2 (Same as for Contr.) |
| **TOTAL COST** | **$ 61.3K** | |

Alternative 3 – Hire an Independent Contractor

The cost of contracting an individual to conduct inspections is calculated in Annex 2.

| F - Item | G - Cost | H - Reference |
|---|---|---|
| Cost of Plane Travel | $ 16.7K | Annex 2 |
| Wage for Contractor | $ 19.4K | Annex 2 |
| Unforeseen Flying Costs | $ 1.7K | Annex 2 |
| Per Diem for Trips | $ 1.3K | Annex 2 |
| **TOTAL COST** | **$ 37.7K** | |

## C.3.3 - Development of Incremental Savings to AKDOT

Savings to AKDOT will be subtracted from costs in our Benefit / Cost Analysis. As such we need to establish monetary savings for each alternative. These are discussed below with reference to Annex 3 where all calculations are documented.

Alternative 1 – Do Nothing

Since this alternative involves no change in the existing structure, there will be no new savings.

Alternative 2 – Hire a New AKDOT Employee

Six areas of savings will accrue to the AKDOT upon hiring a new employee. Two of these areas are peculiar to hiring an AKDOT employee. The other four would accrue to AKDOT if either of Alternatives 2 or 3 were chosen. All six are discussed here.

- Reduction in workload for Regional Aviation Manager – The new AKDOT employee would work directly for the current Regional Aviation Manager (RAM). The RAM estimates that the new employee would embrace tasks that would save him two hours per day. In essence, that means that AKDOT would receive two additional hours per day of effort out of the RAM towards items that currently need more attention. Annex 3 establishes this annual saving as $15,840.
- Better tracking of repair and replacement parts – The new AKDOT employee would spend a portion of his time tracking movement of repair and replacement parts for rural airport maintenance. Currently, AKDOT estimates they spend over $5K annually correcting the mismanagement of these parts. The estimated annual savings to AKDOT is therefore $5,000.

The following areas are savings to both Alternative 2 and Alternative 3:

- Payments Withheld due to Failed Inspections – The terms of the contract permit AKDOT to withhold pay from a contractor commensurate with his poor performance or failure to meet up to the terms of the contract. This tool is rarely used, in part because there is little feedback about contractor performance. The introduction of a regular inspection program would provide the means to justify withholding payments as required. The lost revenue to the contractor may be interpreted as a saving to AKDOT. Annex 3 establishes this amount as $1,268 annually.

- Grounds Maintenance Savings – The terms of the contract require the contractor to control vegetation on each end, as well as the sides of the runway. This vegetation control reduces the potential for aircraft damage if an airplane veers off the runway during departure or landing. Some contractors do not keep up with this maintenance. As a result, the AKDOT ends up setting aside funds for brushcutting at various airstrips when the vegetation impinges on the safe operation of the airstrip. Regular oversight of the contractors would provide the requisite incentive for them to control vegetation growth. Annex 3 calculates the annual savings to AKDOT at $6,000.

- Remediation Savings due to proper disposal of Hazardous Waste – Contractors inevitably fail to dispose of hazardous wastes properly at remote airstrips. Waste oil, fuel, brake fluid and other hazardous waste is often stored or disposed of improperly. Once discovered, the remediation of improperly handled waste is manifested as a cost to AKDOT. Annex 3 estimates this annual savings at $5,000.

- Increased Tool Accountability – AKDOT provides each airport contractor with simple tools to conduct maintenance on State owned equipment and grounds. The value of these tools at each airport is approximately $600. Currently there is no formal procedure for maintaining accountability of these tools. If quarterly inspections included a tool inventory, and lost tools were paid for by the contractor, savings are estimated at $1,140 annually. See Annex 3.

Alternative 3 – Hire an Independent Contractor

Five areas of savings will accrue to the AKDOT upon hiring an independent contractor to conduct inspections. One of these areas is peculiar to hiring an independent contractor. The other four would accrue to AKDOT if either of Alternatives 2 or 3 were chosen and have already been discussed above.

- Reduction in Number of Hours Plane is Leased per year by AKDOT – Currently AKDOT contracts with a local flying service to lease a plane from them for 90 hours per year. AKDOT guarantees a minimum usage of 90 hours for which the flying service receives approximately $19,200. If inspections are conducted by an independent contractor who is providing his own air travel, AKDOT can reduce the number of hours required for the annual lease from 90 to approximately 30. Annex 3 establishes this annual savings as $12,000.

## C.3.4 - Benefit - Cost Comparison

Having discussed Benefits, Costs and Savings of both primary alternatives, we now turn our attention to calculating B/C ratios, and B – C amounts. In our analysis, we have assumed annual amounts for both costs and benefits, thus no rate of return is required, and no discounting need be done.

Since we have not defined a value for VL (Value of a Human Life), we will leave it as a variable and use it to perform a break-even or sensitivity analysis later. This analysis will help us determine at what value of VL, any particular alternative becomes viable, or exceeds the other alternative in relative worth.

First we tabulate Benefits, Costs and Savings for each alternative. These values are transcribed from Annex 4.

| Alternative | Area | $ Value |
|---|---|---|
| | | |
| **1 - Do Nothing** | Benefits | None |
| | Costs | None |
| | Savings | None |
| | | |
| **2 - Hire AKDOT Employee** | Benefits | $2,953 + .0323 VL |
| | Costs | $61,300 |
| | Savings | $34,248 |
| | | |
| **3 - Hire Independent Contractor** | Benefits | $1,969 + .02153 VL |
| | Costs | $39,014 |
| | Savings | $25,408 |

**Table C.2** - Tabulation of Benefits, Costs and Savings for Each Alternative

The final Benefit Cost Ratio for each alternative may now be developed. We will use the following definition of B/C.

$$\frac{B}{C} = \frac{\textbf{(Benefits to the Public – Disbenefits to the Public)}}{\textbf{(Costs to the AKDOT – Cost Savings to the AKDOT)}}$$

The Equation for B – C is:

B – C = (Ben. to the Public – Disben. to the Public) – (Costs to the AKDOT – Cost Savings to the AKDOT)

Which may be rewritten as:

B – C = (Ben. to the Pub.) – (Disben. to the Pub.) – (Costs to the AKDOT) + (Cost Savings to the AKDOT)

We now substitute figures from the table above into the equations developed here to arrive at an equation for each of the primary alternatives which calculates either B/C or B-C as it varies with the Value of a Human Life (VL).

Alternative 1 – Do Nothing – No equations required.

Alternative 2 - Hire a New AKDOT Employee

From Annex 5:

$B/C_2 = (2953 + .0323\ VL) / 27052 \longrightarrow B/C_2 = 1\ @\ VL = \$746{,}099$

$(B - C)_2 = .0323\ VL - 24099 \longrightarrow (B - C)_2 = 0\ @\ VL = \$746{,}099$

Alternative 3 – Hire an Independent Contractor

From Annex 5:

$B/C_3 = (1969 = .02153\ VL) / 13606 \longrightarrow B/C_3 = 1\ @\ VL = 540{,}501$

$(B - C)_3 = .02153\ VL - 11637 \longrightarrow (B - C)_3 = @\ VL = 540{,}501$

$$(B - C)_2 = (B - C)_3\ @\ VL = \$1{,}157{,}103$$

These equations are now plotted to determine the sensitivity of B/C and B – C to VL.

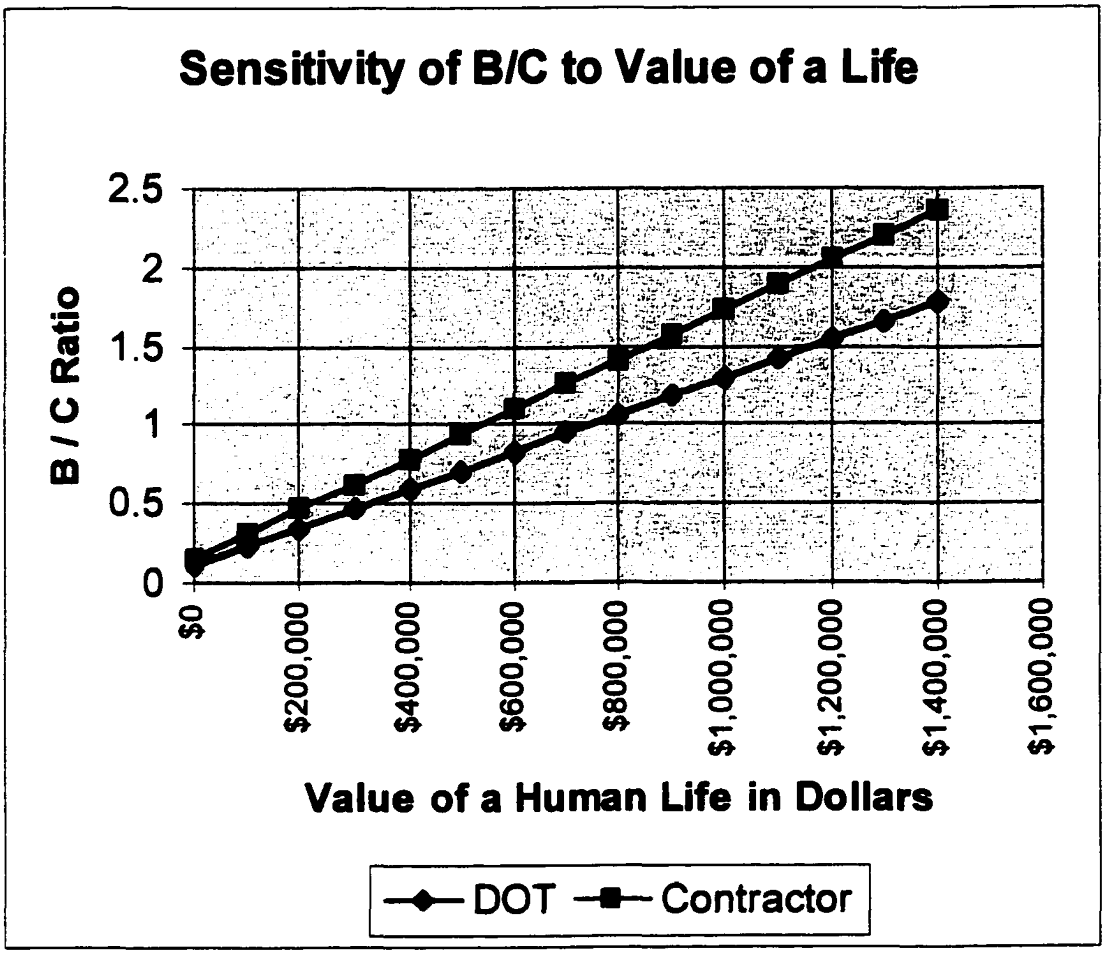


**Figure C.5** - Sensitivity of Benefit/Cost to Value of a Human Life

- The graph establishes that Alternative 1 (Do Nothing) is the best choice if the value of a life is less than $540,501.
- This graph demonstrates that Alternative 3 (Hire Independent Contractor) is viable (B/C > 1.0) if the value of a human life is greater than $540,501.
- It shows that Alternative 2 (Hire AKDOT Employee) is viable (B/C > 1.0) if the value of a human life is greater than $746,099.

Therefore, if the value of a human life is greater than $540,501, either Alternative 2 or Alternative 3 is economically feasible. In order to determine which is better at any given value of VL, we must turn to the B-C graph.

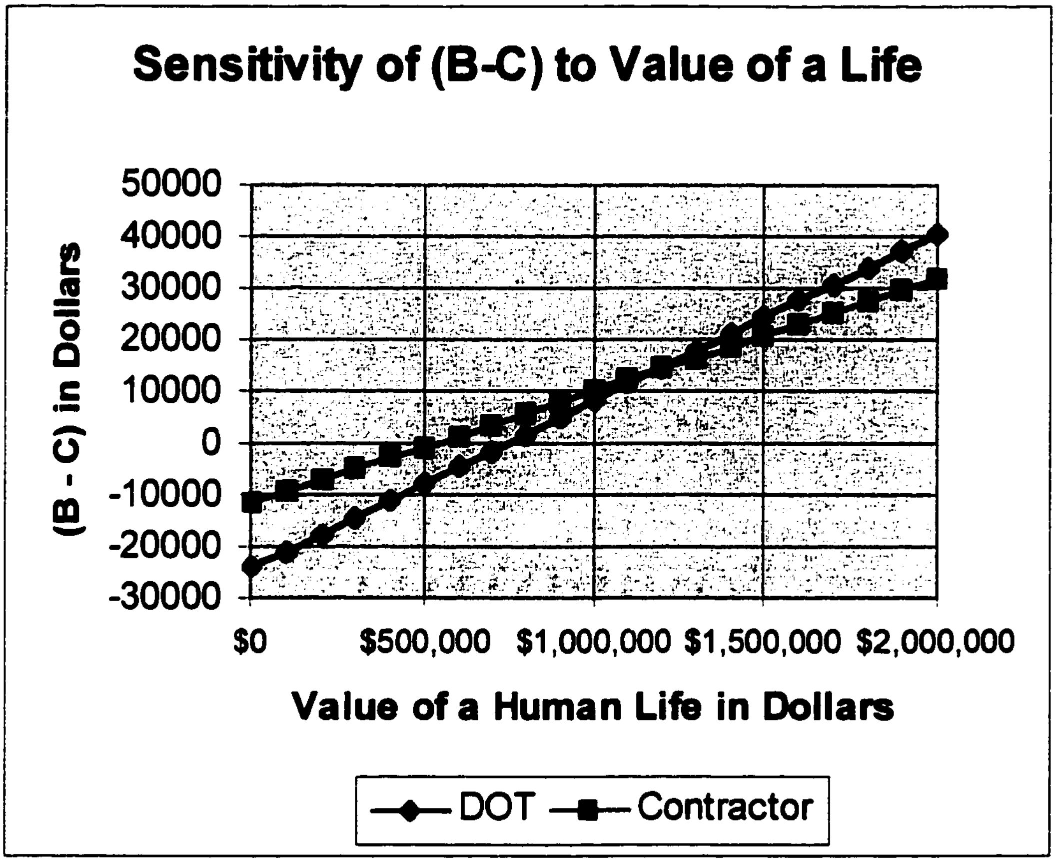


**Figure C.6** - Sensitivity of (Benefit - Cost) to Value of a Human Life

This graph verifies the B/C graph in demonstrating that at a value of life less than $540,501, only Alternative 1 (Do Nothing) is economically feasible because all values of B-C are less than zero.

In addition, it demonstrates that hiring a contractor is more cost effective than hiring a new AKDOT employee as long as the value of a human life is less than $1,157,103. Either is economically feasible as demonstrated in the last graph if the value of a life is greater than $746,099, but the contractor is a better deal.

If the value of a human life is greater than $1,157,103 then hiring a new AKDOT employee is better. The contractor line has a greater slope than does the AKDOT line because the value of lambda is greater. This demonstrates graphically that since the AKDOT employee can better oversee NOTAM implementation, then he will eventually justify his position (over that of a contractor) as the value of a human life increases since he will save more lives!

Additional graphs could be constructed by changing the value of lambda. Since lambda is a measure of the success of the oversight program at reducing aircraft accidents at the airport, it would affect the slope of the lines in both graphs. A change in slope will dictate a change in the point at which different alternatives become viable (or superior) as a function of the value of human life.

We have now completed our analysis and move on to draw some succinct conclusions.

## *C.4 - Conclusions*

1. All three mutually exclusive alternatives have significance and none should be discarded.

2. The three primary components used to determine the cost effectiveness of these alternatives are:

   a. Benefits which accrue to the flying public – These consist mainly of the reduction of risk to pilots during takeoff and landing which manifests itself in fewer fatalities, fewer injuries, and less damage to airframes. These benefits are very difficult to convert to monetary values and they are very sensitive to the following:

      1) The established monetary value of a human life
      2) The degree of success that a new inspector has on reducing accidents ($\lambda$)

   b. Cost savings which accrue to the AKDOT – These are composed of various items for which the AKDOT currently spends more than it would if there were better supervision over it's contracted airport managers. These savings convert readily to monetary values, but are based on estimates that could vary greatly.

   c. Costs which accrue to the AKDOT – These consist primarily of salary, benefits and contract costs depending on the alternative being considered. Of the three components, one may place the highest degree of confidence in the value of these costs.

3. The best alternative from an economic standpoint switches from Alternative 1 (Do Nothing) to Alternative 3 (Hire an Independent Contractor) to Alternative 2 (Hire a new AKDOT Employee) as the established value of a human life increases from 0 to $1.16 M.

## C.5 - Recommendations

1. Verify that the value used for lambda (λ) is reasonable. Consider trying other values.
2. Establish the monetary value of a human life that AKDOT management considers appropriate for air transportation in Interior Alaska.
3. Pursue the appropriate alternative based on the value of a life and the table shown below:

| Value of a Life | Alternative |
|---|---|
| | |
| Less than $540,501 | #1 – Do Nothing |
| Between $540,501 and $1,157,103 | #2 – Hire an Independent Contractor |
| Greater than $1,157,103 | #3 – Hire a new AKDOT Employee |

**Annex 1 to Appendix C** - Accident Frequency Calculations and Development of Benefit Equation

***Assumptions***

1. Benefit to the public of a saved human life is undetermined and established as a variable VL (Value of Life)
2. Benefit to the public of a prevented human injury is estimated as a percentage of VL as follows:

| Type Injury | Value (% of VL) | Example: If VL = 1,000,000, then Then Cost = |
|---|---|---|
| None | 0.0% | $0 |
| Minor | 0.2% | $2,000 |
| Serious | 10.0% | $100,000 |
| Fatality | 100.0% | $1,000,000 |

Percentages are estimated.

3. Airframe Damage is estimated as follows:

| | | |
|---|---|---|
| None | $0 | |
| Minor | $8,000 | Landing Gear, Propeller, Underbelly damage. |
| Substantial | $30,000 | Engine destroyed, wing, fuselage, elevator, tail damage |
| Total | $90,000 | Airplane totaled and not repairable |

| Date | Location | Contributing Cause | Type Injury | Cost of Injury | Airframe Damage | Cost of Damage |
|---|---|---|---|---|---|---|
| 10-Jul-83 | Betties, AK | Rough, uneven airstrip | 2 Serious | 2 x .2 x VL | Substantial | $30,000 |
| 07-Feb-85 | Koyuk, AK | Heavy Equipment on Runway | 1 Fatality | VL | Minor | $8,000 |
| 14-Mar-85 | Nulato, AK | Snow covered runway, snow berm | None | | Substantial | $30,000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 07-May-94 | Allakaket, AK | Burned-Out Landing Lights | None | | Substantial | $30,000 |
| 26-Aug-96 | Northway, AK | Rough, uneven airstrip | None | | Substantial | $30,000 |
| | | | TOTAL | 1.4 x VL | | $128,000 |

**Conclusions:**

Over a 13 year period from July 83 to Aug 96, the following damages occurred:

| | | | | |
|---|---|---|---|---|
| Airframe | $128,000 | Total for 13 Years | Risk of Damage/Year | 7.69% |
| Injuries | 1.4 VL | Total for 13 Years | Risk of Injury/Year | 7.69% |

Therefore, the total dollar value of damages in any one year is 7.69% of $128K +1.4 VL

Dollar Value of Damages for One Year = .0769 (128,000 + 1.4 VL) or ($9843.2 + .10766 VL)

**Annex 2 to Appendix C** - Calculation of Contractor Costs

***Assumptions***

1. Operating expenses for contractor's plane (rented or owned) are $125/hr
2. Contractor's plane cruises at 95 knots (105 MPH)
3. Weather and other issues will add 10% to the contractors flying costs
    a. Weather systems may require rerouting which extends trip length
    b. Weather may preclude pilot from landing requiring he return later
    c. Contractor may not show up at inspection requiring contractor return later
4. Contractor will inspect an average three airports each trip
5. Contractor will conduct quarterly inspections of airports with individual or city contracts
6. Contractor will conduct annual inspections of airports with state maintenance.
7. Prevailing wage for contractor should be about $30/hr
8. Inspections will be conducted in six, two-day trips to cover all 20 airports.
9 Average mileage for each trip is 500 miles
10. Average speed of plane including takeoffs and landings is 90 MPH

***Givens***

| | | |
|---|---|---|
| Airplane Cost/Hr | $125.00 | per hour |
| Number of Trips/Qtr | 6 | trips/qtr |
| Number of Qtrs/Year | 4 | qtrs/yr |
| Number of Days/Trip | 2 | days/trip |
| Number of Miles/Trip | 500 | miles/trip |
| Avg speed of plane | 90 | MPH |
| Prev. Wage for Contr. | $30.00 | per hour |
| Insp Hrs per trip | 13.33 | Insp hrs/trip |
| Admin hrs per trip | 8 | Admin hrs/trip |

***Calculated Values***

| | | | | |
|---|---|---|---|---|
| **Cost of Plane Travel (Annually)** | | | **$16,666.67** | **per year** |
| Avg Flying Hours/Trip | 5.56 | Hrs/trip | | |
| Airplane cost per trip | $694.44 | per trip | | |
| Airplane cost per qtr | $4,166.67 | per qtr | | |
| **Wage for Contractor (Annually)** | | | **$19,360.00** | **per year** |
| Admin Wage per trip | $240.00 | per trip | | |
| Insp Wage per trip | $400.00 | per trip | | |
| Flying Wage per trip | $166.67 | per trip | | |
| Total Wage per trip | $806.67 | per trip | | |
| Total Wage per Qtr | $4,840.00 | per qtr | | |
| **Unforeseen Flying Costs** | | | **$1,666.67** | **per year** |
| **Per Diem for Food and Lodging** | | | **$1,320.00** | |

| | |
|---|---|
| Lodging per night | 35 |
| # Nts per trip | 1 |
| # Nts per qtr | 6 |
| # Nts per year | 24 |
| Total Lodging Cost/yr | 840 |
| # Meals/Trip | 4 |
| # Meals/Qtr | 24 |
| Avg Cost of Meal | 5 |
| # Meals/Yr | 96 |
| Total Meal Cost/yr | 480 |

**TOTAL ESTIMATED CONTRACTOR COST** **$39,013.33 per year**

## Annex 3 to Appendix C - Calculation of Savings to DOT

***Alternative 2 - Hire new DOT Employee***

1. Reduction in Workload for Regional Aviation Manager

| | | |
|---|---|---|
| Hrs Saved/Day | 2 | hrs/day |
| Wage | $30 | $/hr |
| Work Days/Month | 22 | days/month |
| Months/Yr | 12 | months/yr |
| **TOTAL Annual Savings** | **$15,840** | |

2. Better tracking of Repair and Replacement Parts

| | | |
|---|---|---|
| **TOTAL Annual Savings** | **$5,000** | DOT Estimate |

***Alternative 3 - Hire an Independent Contractor***

1. Reduction in Number of Hours Plane is leased per year by DOT.

| | | | |
|---|---|---|---|
| Current hours leased | 90 | hours | From DOT |
| Current hourly rate | $200 | per hour | From DOT |
| Number flying hrs/trip | 3.5 | hrs/trip | |
| Number trips/qtr | 5 | trips/qtr | |
| Number qtrs/yr | 4 | qtrs/yr | |
| Number flt hrs/qtr | 70 | Hours for Inspections no longer required. | |
| Hours Remaining | 20 | Hours Remaining for Admin Flights | |

Assume Contract is only for 30 hours per year at $200/hr

| | |
|---|---|
| Cost of New Contract | 6000 |
| Cost of Old Contract | $18,000 |
| **TOTAL Savings** | **$12,000** |

***Savings for Both Alternative 2 and Alternative 3***

1. Payments Withheld due to failed Inspections

| | |
|---|---|
| Current cost of contracts | $320,288 |
| Average cost per airport | $16,014 |
| Average cost per airport per month | $1,335 |

Assume major failure of quarterly inspection costs the contractor 25% of one months pay.
Assume 20% of contractors fail 1 inspection per year

| | |
|---|---|
| Total Number of Contractors | 19 |
| % of contractors failing 1 insp. per yea | 0.2 |
| Amount of one months pay withheld | 0.25 |
| Number of contractors failing per yr | 3.8 |
| **Amount of pay withheld per year** | **$1,267.81** |

2. Grounds maintenance Savings

| | |
|---|---|
| Current cost of deferred maint $ for brush cutting | $105,000 |
| % of Brush Cutting Required due to contractor | 0.23 |
| Current cost of contractor incurred brush cutting | $24,150 |
| Number of Years deferred maintenance has accrued | 4 |
| **Anticipated annual savings due to oversight** | **$6,038** |

3. Remediation Savings due to proper disposal of Haz. Waste **$5,000** DOT Estimate

4. Savings due to increased tool accountability

| | |
|---|---|
| Value of tools at each airport | $600 |
| Total Value at all airports | $11,400 |
| % of tools lost annually | 0.1 |
| Value of tools lost annually and replaced by DOT | $1,140 |
| | |
| **Estimated annual tool savings** | **$1,140** |

**Annex 4 to Appendix C** - Tabulations of Benefits, Costs and Savings

**1 - Do Nothing** No Benefits Costs or Savings

**2 - Hire DOT Employee**

| | | |
|---|---|---|
| *Total Benefits* | | $2,953 + .0323 VL |
| *Total Costs* | | $61,300 |
| Salary and Benefits | $60,000 | |
| Per Diem for Trips | $1,300 | |
| *Total Savings* | | $34,248 |
| RAM Workload Reduction | $15,840 | |
| Parts Tracking | $5,000 | |
| Contractor Payments Withheld | $1,268 | |
| Grounds Maintenance | $6,000 | |
| Remediation | $5,000 | |
| Tool Accountability | $1,140 | |

**3 - Hire Independent Contractor**

| | | |
|---|---|---|
| *Total Benefits* | | $1,969 + .02153 VL |
| *Total Costs* | | $39,014 |
| Plane Travel | $16,667 | |
| Wage | $19,360 | |
| Unforeseen Flying Costs | $1,667 | |
| Per Diem for Trips | $1,320 | |
| *Total Savings* | | $25,408 |
| Reduction in Plane Lease | $12,000 | |
| Contractor Payments Withheld | $1,268 | |
| Grounds Maintenance | $6,000 | |
| Remediation | $5,000 | |
| Tool Accountability | $1,140 | |

**Condensed Table of Costs, Benefits and Savings**

| Alternative | Area | $ Value |
|---|---|---|
| 1 - Do Nothing | Benefits | None |
| | Costs | None |
| | Savings | None |
| 2 - Hire DOT Employee | Benefits | $2,953 + .0323 VL |
| | Costs | $61,300 |
| | Savings | $34,248 |
| 3 - Hire Independent Contractor | Benefits | $1,969 + .02153 VL |
| | Costs | $39,014 |
| | Savings | $25,408 |

Annex 5 to Appendix C - B/C Ratio and (B-C) Calculations

***Alternative 2 - Hire new DOT Employee***

| | |
|---|---|
| Benefit | 2953 + .0323 VL |
| Costs - Cost Savings | 27052 |

Benefits - Costs + Cost Savings =.0323 VL - -24099

***Alternative 3 - Hire an Independent Contractor***

| | |
|---|---|
| Benefits | 1969 + .02153 VL |
| Costs - Cost Savings | 13606 |

Benefits - Costs + Cost Savings = .02135 VL - -11637

**Data for Plots**

Benefit = Lambda * .0769 * (128000 + 1.4 VL)

| | |
|---|---|
| Lambda for DOT Employee | 0.3 |
| Lambda for Indep. Contractor | 0.2 |

**B/C Calc. As function of VL**

| VL | DOT | Contractor |
|---|---|---|
| 0 | 0.10915866 | 0.1446891 |
| 100000 | 0.22855094 | 0.3029428 |
| 200000 | 0.34794322 | 0.4611965 |
| 300000 | 0.4673355 | 0.6194502 |
| 400000 | 0.58672778 | 0.777704 |
| 500000 | 0.70612007 | 0.9359577 |
| 600000 | 0.82551235 | 1.0942114 |
| 700000 | 0.94490463 | 1.2524651 |
| 800000 | 1.06429691 | 1.4107188 |
| 900000 | 1.18368919 | 1.5689725 |
| 1000000 | 1.30308147 | 1.7272262 |
| 1100000 | 1.42247375 | 1.8854799 |
| 1200000 | 1.54186604 | 2.0437336 |
| 1300000 | 1.66125832 | 2.2019874 |
| 1400000 | 1.7806506 | 2.3602411 |

**(B-C) Calcs. As Function of VL**

| VL | DOT | Contractor |
|---|---|---|
| 0 | -24099.04 | -11637.36 |
| 100000 | -20869.24 | -9484.16 |
| 200000 | -17639.44 | -7330.96 |
| 300000 | -14409.64 | -5177.76 |
| 400000 | -11179.84 | -3024.56 |
| 500000 | -7950.04 | -871.36 |
| 600000 | -4720.24 | 1281.84 |
| 700000 | -1490.44 | 3435.04 |
| 800000 | 1739.36 | 5588.24 |
| 900000 | 4969.16 | 7741.44 |
| 1000000 | 8198.96 | 9894.64 |
| 1100000 | 11428.76 | 12047.84 |
| 1200000 | 14658.56 | 14201.04 |
| 1300000 | 17888.36 | 16354.24 |
| 1400000 | 21118.16 | 18507.44 |
| 1500000 | 24347.96 | 20660.64 |
| 1600000 | 27577.76 | 22813.84 |
| 1700000 | 30807.56 | 24967.04 |
| 1800000 | 34037.36 | 27120.24 |
| 1900000 | 37267.16 | 29273.44 |
| 2000000 | 40496.96 | 31426.64 |

# APPENDIX D

# Training Plan for AKDOT Contract Maintenance Personnel

AKDOT is responsible for the development, maintenance and operation of its public airport system. As such, AKDOT owns and operates 266 of the 286 public airports throughout the state. Most of these airports service small, remote villages that are otherwise inaccessible by road. Air carriers provide movement of mail, supplies and people into and out of most of these airstrips on a daily basis.

In order to accommodate this wide variation of traffic, airstrips require cyclic maintenance throughout the year, but especially during periods of high snowfall. Snow removal is critical to the safe, regular operation of air carriers into these small villages. Since most airstrips are inaccessible by road, AKDOT road crews cannot provide this maintenance. Therefore, at each village, the state contracts a single individual or the city council to conduct snow removal and other airport maintenance throughout the year. Contracts are annual, but renewable for up to 5 years, based on the mutual agreement of both AKDOT and the contractor. The AKDOT maintains a road grader, a bulldozer or bucket loader, a small structure and miscellaneous equipment at nearly 80% of these airstrips. This equipment provides the contractor a means for conducting required maintenance. The need for competent, trustworthy, trained individuals in these positions has been highlighted in the basic document.

This appendix addresses the issue of introducing a formal AKDOT training program for maintenance contractors at rural airports throughout the Northern Region of Alaska. Figure 4.2 demonstrates how the benefits of training impact on the larger topic of improving runway maintenance and runway condition reporting information at rural airstrips. The bottom left hand corner of this figure articulates factors that help mitigate the substandard condition of a rural runway or airport. One of these primary factors is the level of training of the maintenance contractor (operator). If this contractor is well-trained and doing his job correctly, then the need for reporting of poor runway conditions is reduced...simply because the contractor has recognized and corrected the problem quickly enough to preclude the need for a formal report. Therefore good training ultimately reduces the burden on the runway condition reporting system, which minimizes the need to report runway discrepancies. Ultimately, this results in safer, more efficient aviation operations.

In drafting a training plan, we have employed aspects of I.L. Goldstein's training model. This model establishes three phases of a training system: 1) The assessment phase, 2) The implementation phase and 3) The evaluation phase. This paper provides a focus on phases 1 and 2 with primary emphasis on assessing the need.

## *D.1 - Assessing the Need*

We first establish the specific requirements of the contract so that we might compare them to contractor performance thus assessing shortfalls to discover training needs. The duties of each contractor vary slightly between locations based on the airport infrastructure at that particular location. The primary requirements of the contract are listed below. A statement establishing the AKDOT perspective on how well the contractor is performing that task follows each requirement. Instead of assessing the needs of a particular contractor, we have generalized based on discussions with the Regional Airport Manager at AKDOT and his assessment of average contractor performance. A good training program would tailor the training needs of particular contractors to established requirements.

<u>Task #1 - Daily Inspection</u>

1. Requirement - Conduct a daily inspection of the airport paying particular attention to the condition of the runway and the runway lighting system. Rutting of the airstrip, potholes, snow cover, and glare ice form the core list of discrepancies that must be discovered and corrected by the contractor.

2. Assessment - In general, contractors frequent their airstrips often enough to discover glaring deficiencies. However, thorough daily inspections are not being conducted in the spirit of the contract. Thus, a myriad of small deficiencies tends to stack up delaying needed maintenance and increasing risk to airport users.

3. Training Needs

a. Specific procedure for conducting runway inspection

b. Identification of deficiencies which should be corrected

- Burned out runway lights or malfunctioning lighting system
- Snow on the runway
- Wind sock needing replacement
- Vegetation overgrowth
- Burned out or malfunctioning beacon

c. Identification of deficiencies which should not be corrected unless the contractor is trained to perform specified maintenance

- Rutting of gravel runway surface
- Potholes
- Any maintenance requiring grading of the runway surface

Task #2 - Keep Runway Clear of Snow

1. Requirement - Keep the runway clear of snow, 365 days a year and 24 hours a day. This is critical because most air carriers prefer to operate twin-engine, high performance aircraft that do not utilize skis. Thus, they anticipate landing on a surface free of loose snow and void of glare ice throughout the winter season. Contractors at most airports are provided with state-owned heavy equipment to conduct this snow clearing. A road grader with snowplow attachment and a bulldozer are typical of the heavy equipment package.

2. Assessment - This requirement is performed well by most contractors once they have been at it for awhile. Unfortunately, very little formal training is provided by AKDOT regarding methods for plowing snow. There are conflicts between AKDOT standards and air carrier preferences. Air carriers prefer that all snow be scraped off the runway. AKDOT desires that a small, compact layer of snow remain so that contractors don't remove the top layer of gravel throughout the plowing season. Thus contractors are often faced with competing demands, a dilemma and some frustration in trying to please everyone. Recurrent training would help answer these questions and reinforce the "right way" to do things. AKDOT is concerned that many contractors will ignore their duties when faced with conflicting opportunities to go hunting, fishing, or engage in recreational activities which may remove them from oversight of the airstrip for days at a time.

This concern could also be mitigated somewhat by a training program which emphasizes the important part that contractors play in aviation safety and service.

3. Training Needs

a. Standards for clearing snow
b. Methods for clearing snow
c. Methods for clearing ice
d. Safety in snow clearing operations (e.g. plowing an active runway)
e. The importance of snow clearing to aviation operations (case studies perhaps)

Task #3 - Maintain Airport Systems

1. Requirement - Maintain airport lighting, wind cones, and markers. This includes runway and taxiway lights; threshold lights; the rotating beacon and the lighted wind cone. Nearly every rural airport has runway lights that are controlled by an approaching pilot through an aircraft radio. The proper operation of these lights is a critical safety issue for pilots using the airstrip in hours of darkness. Since darkness dominates the winter months, maintenance of runway lights and airport systems is critical.

2. Assessment - Maintenance of airport lighting varies greatly depending upon the contractor. To the extent that burned-out lights are not detected and replaced daily, risk to aircraft may be dramatically increased. For example, a rotating beacon is a primary means of locating an airport in marginal weather conditions and especially during periods of darkness. If the beacon is out, the level of safety afforded incoming pilots is greatly diminished. Initial and recurring training would improve contractor reliability in correcting deficiencies in a timely and professional manner.

3. Training Needs

a. Replacement of runway lights (threshold, taxiway and runway alignment)
b. Replacement of beacon lights
c. Replacement of wind cone lights
d. Replacement of wind socks
e. Repair/replacement of broken runway light fixtures
f. Importance of timeliness in conducting repairs

Task #4 - Report Notices to Airmen

1. Requirement - Report NOTAMs as required. A NOTAM is an advisory message distributed to airport users by the FAA regarding airport conditions that may be hazardous. An airport contractor may formally enter a NOTAM into the FAA computer reporting system with a toll-free phone call. A pilot will be informed of all NOTAMS applicable to his route of flight when he receives his pre-flight briefing from the FAA FSS. Airport contract maintenance personnel should call in a NOTAM every time the airport is at a reduced level of operational capability. Snow cover, glare ice, ongoing snow removal operations and reduced airport lighting are all conditions that should generate a NOTAM.

2. Assessment - Contractors do not do well reporting NOTAMs affecting their airstrips. The value of the NOTAM is not well appreciated by the contractors. Thus they often do not make the effort to make the report. This has a huge detrimental affect on all air traffic arriving at the airstrip. A pilot arriving after a two-hour flight, only to find that the runway has 6 inches of unplowed new snow may have to abort the flight and turn back. Part of the difficulty is lack of specific knowledge among contractors about what constitutes a reportable discrepancy. Contractor sensitivity to the importance of NOTAM submission could be raised through annual training.

3. Training Needs

a. Identification of deficiencies which should be reported

- Flooding of runway
- Vandalism
- Destruction of airport property through natural causes
- Runway being plowed
- Snow on the runway
- Potholes or ruts in the gravel surface of the runway
- Runway lighting inoperative
- Runway beacon inoperative
- Encroachment of vegetation on runway

Task #5 - Use Two-Way Radio

1. Requirement - Use two-way Radio to Communicate with Airborne Pilots - Contractors were provided with modern, two-way radios mounted in their snow removal equipment during the winter of 1997-1998. They are required by contract to transmit their intentions to occupy the runway to plow snow thereby reducing the probability of runway incursions between maintenance equipment and aircraft.

2. Assessment - There is concern that contractors may not embrace this contractual responsibility for the long term. Recurrent AKDOT training in the required use of this communication equipment would help ensure contractor involvement.

3. Training Needs

   a. Technical operation of the radio
   b. Accountability of communication equipment
   c. Required use of the radio
   d. Option use of the radio
   e. Radio communication procedures with air traffic
   f. Maintenance of radio

Task #6 - Maintain State-Owned Equipment

1. Requirement - Maintain state-owned Equipment. The contractor is required to conduct preventive and scheduled maintenance on all equipment provided to him by AKDOT. This includes checking, filling and replacing all fluids as well as lubricating, inspecting and cleaning equipment according to manufacturer specifications.

2. Assessment - Much of this maintenance is not performed regularly due to a lack of both training and supervision by AKDOT representatives. This has a deleterious effect over the long term as equipment ages more quickly and breaks down more often. Initial and recurrent training in equipment maintenance is imperative.

3. Training Needs

a. Scheduled Maintenance
b. Breakdown Maintenance
c. Preventative Maintenance
d. Frequency of Maintenance (Chart)

Task #7 - Know and Understand AKDOT Policies and Expectations

1. Requirement - Although contractors are not AKDOT employees, they represent the agency and the State of Alaska and as such should be instructed in AKDOT policies. Contractors should make a good faith effort to abide by such policies and represent the department well.

2. Assessment - In general, contractors do not feel tremendous loyalty to abide by the expectations of AKDOT. Contract amounts vary greatly among airports and contractor loyalty is a function of individual character, degree of supervision, cultural pressures and institutional knowledge. Contractors often do not conduct their daily inspection, relying instead upon air carrier pilots to inform them of airport maintenance needs. Better initial and recurrent training could mitigate some of these concerns and encourage contractors to abide more fully by the terms of their contract.

3. Training Needs

a. Unauthorized use of AKDOT equipment
b. Unauthorized use of AKDOT property and structures
c. Accountability of AKDOT equipment and tools
d. Requesting repair parts
e. Requesting expendable items
f. Maintenance standards for AKDOT buildings

## D.2 - Implementation of the Plan

Goldstein breaks this phase into selecting, arranging, conducting and monitoring training. We will address each step in turn.

Select Training Methods - Training is complicated by the geographical distances involved between trainer and trainee. Two primary methods are appropriate for training the maintenance contractors: On-the-Job Training, and Classroom Training. Due to the remote nature of each job site, a specific form of OJT, called Job Instruction Training (JIT) is most appropriate. Standard OJT is not practicable because the trainee (contractor) has no day-to-day contact with the trainer (AKDOT representative or experienced contractor). Instead, JIT should be performed on an abbreviated time scale to maximize the transfer of knowledge and skills. JIT involves preparing the learners, presenting the information and having trainees practice the job. The last step in JIT, follow-up, will be difficult to perform with any frequency, but will have to be greatly pared down to meet AKDOT budgetary and resource constraints. Classroom training provides the opportunity for contractors to receive specific knowledge in a controlled environment to assist them in new or recurring responsibilities of the job.

Arrange for Training - Part of the contract requires maintenance personnel to attend mandated AKDOT training sessions at the contractors expense. In reality, this rarely happens. In order to encourage the attendance of contractors who often feel little to no obligation to meet this contract requirement, AKDOT has resorted to paying transportation, lodging and per diem to contractors as an incentive to come. While this is not the best way to conduct efficient, cost-effective training, it will be hard to retract as contractors have become accustomed to this practice. The conduct of training is important enough to safety and efficiency of airport maintenance operations, that AKDOT should continue an approach that will encourage participation.

Conduct and Monitor Training - The following template is suggested as an appropriate start to initiating a more regular and thorough training program for maintenance contractors. Bear in mind that most contractors desire to keep their contracts for the full five-year option if AKDOT is agreeable.

*Initial Training (Orientation)* - When a new bidder wins a contract for airport maintenance operations in his village or community, he will undergo orientation. It will be conducted in two phases, the Fairbanks Phase and the Village Phase.

Fairbanks Phase - Training will be conducted in Fairbanks at the AKDOT on Peger Road. The Regional Aviation Manager (RAM) or his assistant will be the primary trainer with assistance from other AKDOT personnel. The initial welcome and introduction will be presented by the AKDOT Chief of Maintenance and Operations (M&O). The following topics will be covered in a classroom/office setting in two days. The Fairbanks Phase will be conducted within 15 days of any contract that is let between 1 Apr and 1 Sep. It will be conducted within 7 days of any contract let between 1 Sep and 1 Apr to ensure timely training during the busiest maintenance season (winter).

| SUBJECT | TRAINER |
| --- | --- |
| • Initial Welcome | Chief, M&O |
| • DOT Policies and Procedures | RAM |
| • Specific contract responsibilities | RAM |
| • Safety | RAM |
|   • Daily Inspection of the Airport | |
|   • Daily Building and Equipment Checks | |
| • Airport Security | RAM |
| • Mobile Equipment | AKDOT M&O |
|   • Maintenance and Repair | |
|   • Operation - Safety | |
|   • Equipment Records | |
| • Airfield Maintenance | AKDOT M&O |
|   • Summer | |
|   • Pre-Winter | |
|   • Winter | |
| • Airfield Lighting Maintenance | AKDOT M&O |
|   • Runway Lights | |
|   • Beacons | |
|   • Wind Cone Lights | |
| • Airfield Marker Maintenance | AKDOT M&O |
|   • Edge Markers | |
|   • Threshold/Approach | |
| • Building Maintenance | AKDOT M&O |
| • NOTAM Reporting | RAM |
|   • Reportable Conditions | |
| • How to report a NOTAM | AKDOT M&O |
| • Conclusion | Chief, M&O |

A single hardcopy booklet will be used throughout instruction. The booklet will be given to the contractor at the end of training and will serve as his primary reference for all material covered throughout the contract period. Currently, no such reference exists. The compilation of such a training aid/reference would be invaluable to contractor and AKDOT both as it would eliminate much confusion during the first year while the contractor is becoming familiar with his duties. Such a booklet has been developed for Canadian rural airports and is an excellent resource for contract maintenance workers.

Before returning to his community, the contractor will be provided with the date and time of the next phase of his training, the Village Phase.

Village Phase - The village phase will be conducted at the contractor's home community. The primary trainer will again be the Regional Airport Manager or his assistant, accompanied by an AKDOT M&O technician and an experienced contractor from another rural airport. The RAM will only attend the morning of the first day. This training period will last 2 days and will consist almost exclusively of hands-on instruction (JIT) in the field. This phase will be scheduled for as soon as practicable after the Fairbanks Phase. It will cover the following topics.

| SUBJECT | TRAINER |
|---|---|
| DAY 1 | |
| • Airport Orientation | RAM |
| • Joint Equipment Inventory | RAM |
| • Inventory of Repair Parts | RAM |
| • Airport Inspection Walk-Thru | RAM |
|   • Building cleanliness standards | |
|   • Runway standards | |
|   • Grounds standards | |
|   • Vehicle cleanliness standards | |
| • Hands-On Demonstrations of the following | DOT M&O |
|   • Wind Sock Replacement | |
|   • Runway Light Replacement | |
|   • Runway Fixture Replacement | |
|   • Beacon Light Replacement | |

DAY 2

| | |
|---|---|
| • Heavy Equipment Orientation | DOT M&O |
| • Hands-On Equipment Operation | DOT M&O |
| • Hands-On Equipment Maintenance | DOT M&O |
|     • Oil Changes | |
|     • Blade Edge Replacement | |
|     • Belt Changes | |
|     • Hydraulic Hose Replacement | |
|     • Air Filter Replacement | |

If the village phase occurs during summer (no snow cover) months, then an experienced contractor will conduct a one-day equipment operations session with the new contractor after there is permanent snow cover on the ground at his village. This will provide the new contractor an opportunity to learn efficient methods of plowing the runway when real snow can be moved.

*Recurrent Training* - Since geographical separation precludes frequent follow-up during the contractors first year, annual, recurrent training will be presented for all contractors each summer. This training will be conducted in Fairbanks and will be required attendance for all contractors. A make-up date will be provided for those contractors who cannot resolve conflicts with the scheduled date. This training will last one day and will occur in a classroom setting. The RAM will be the primary trainer. The following topics will be covered:

| | |
|---|---|
| • Welcome | Chief, M&O |
| • Review the Year | RAM |
|     • Aviation accidents at airports in the region | |
|     • NOTAMs reported during the year | |
|     • Airport upgrades | |
|     • Equipment upgrades | |
|     • Equipment accidents at airports in the region | |
| • The Year to Come | RAM |
|     • Airport upgrades | |
|     • Equipment upgrades | |
|     • Contracts to be renewed | |

- Problem Session — RAM
    - Equipment Issues
    - Maintenance Issues
    - Parts Issues
    - Pay Issues
- Awards Presentations (Gifts/Bonuses) — Chief, M&O
    - Best AKDOT Maintenance Building
    - Best Maintained Airport
    - Best Maintained Equipment

## D.3 - Training Evaluation

This is the final phase of Goldstein's model and I will just touch upon a few pertinent issues. Perhaps the primary problem with maintenance contractors is that they have no regular, on-site supervision. The remoteness issue strikes again. The RAM simply cannot conduct frequent visits to all of his 23 airports and simultaneously fulfill the rest of his job responsibilities. If the RAM has an assistant his primary responsibility should be to conduct quarterly visits to all airports in the region to provide direct feedback and oversight to the airport contractors. During these visits, the fruit of his training labors, or the lack of the contractors loyalty will be obvious. These visits would provide an opportunity to conduct announced and unannounced inspections of the airport from which awards could be generated in the annual refresher training as outlined above. This would also provide an opportunity for the RAM to get direct feedback from first year contractors as to deficiencies in his training...from which the RAM could design training program improvements.

## D.4 - Conclusion

While there are certainly costs incurred in running a training program such as that suggested above, the benefits can be enormous. The opportunity to bring some cohesion to an otherwise fragmented group of physically separated contractors will have some powerful side effects. Not the least of these will be a strong incentive to excel in their work. This training program template should be adjusted to meet the specific needs and constraints of the RAM. A good training program, combined with regular oversight by the Regional Aviation Manager will serve to overcome many of the difficulties currently experienced with maintenance contractor operations.

# APPENDIX E

# Original Project Schedule

This appendix contains the original project schedule that was provided to ASTF in the FlightCam project proposal. This schedule served as a good planning template throughout the conduct of the project. The schedule was produced using Microsoft Project 98, registered by the Microsoft Corporation.

The following is a brief description of the pages that follow:

Legend - A legend is provided on page four of the schedule which defines the various graphics in the schedule.

Page Layout - Each page is broken into columns. Each column is explained below:

*Column 1 - ID* - This column lists the task identification number for purposes of constructing the schedule.

*Column 2* - No significance

*Column 3 - Task Name* - This column indicates the name of the task that was to be conducted. It includes the 5 major benchmarks in the project, the last of which marks project completion.

*Columns 4 and 5* - This is the main part of the schedule which indicates the start date, end date, and duration of each task.

## Appendix E - Project Schedule Page 1 of 4

| ID | ⓘ | Task Name | Half 1, 1999 / Half 2, 1999 (Dec–Dec) |
|---|---|---|---|
| 1 | ▣ | ASTF Board Meeting and Approval | ◆ ASTF Board Meeting and Approval |
| 2 | ✓ | Grant Negotiations | 0 21 days |
| 3 | ✓ | Initiate Purchases | ◆ Initiate Purchases |
| 4 | ✓ | **PURCHASE EQUIPMENT** | PURCHASE EQUIPMENT |
| 5 | ✓ | Local purchase of hub computer | 01/05 1 day |
| 6 | ✓ | Local purchase web site software | 01/05 1 day |
| 7 | ✓ | Order and Receive Field Hardware | 01/05 21 days |
| 8 | ✓ | Order and Receive Hub Comp. Software | 01/05 21 days |
| 9 | ✓ | Construct Website | 01/05 21 days |
| 10 | ✓ | Visit top 5 villages to determine 3 best | 01/11 5 days |
| 11 | ✓ | Planning Day with DOT&PF | 01/17 1 day |
| 12 | ✓ | Visit top 3 sites to finalize selection | 01/25 3 days |
| 13 | ✓ | All hardware/software on hand | ◆ All hardware/software on hand |
| 14 | ✓ | Rehearsal Day with DOT&PF | 02/02 1 day |
| 15 | ✓ | **HOME BASE TEST** | HOME BASE TEST |
| 16 | ✓ | Set up and test equipment at hub location | 02/03 14 days |
| 17 | ✓ | DOT Fabricates platforms for cameras | 02/03 6 days |
| 18 | ✓ | ***BENCHMARK 1 - SUCCESSFUL HOME BASE TI*** | 02/20 ★ BENCHMARK 1 - SUCCESSFUL HOME BASE TEST |
| 19 | ✓ | **FIELD INSTALLATIONS** | FIELD INSTALLATIONS |

Timeline columns: Half 1, 1999: Dec, Jan, Feb, Mar, Apr, May, Jun; Half 2, 1999: Jul, Aug, Sep, Oct, Nov, Dec

## Appendix E - Project Schedule Page 2 of 4

| ID | | Task Name | Half 1, 1999 / Half 2, 1999 (Dec–Dec) |
|---|---|---|---|
| 20 | ✓ | Install System at Village #1 | 02/20 2 days |
| 21 | ✓ | Install System at Village #2 | 02/23 2 days |
| 22 | ✓ | Install System at Village #3 | 03/26 1 day |
| 23 | | **TROUBLESHOOT TOTAL SYSTEM** | TROUBLESHOOT TOTAL SYSTEM |
| 24 | | Visits to each site for troubleshooting | 03/27 3 days |
| 25 | | ***BENCHMARK 2 - SUCCESSFUL FIELD TES*** | 03/29 ★ BENCHMARK 2 - SUCCESSFUL FIELD TEST |
| 26 | | Begin Test | 04/01 ◆ Begin Test |
| 27 | | **CONDUCT TEST** | CONDUCT TEST |
| 28 | | Maintenance Visit to all 3 sites | 04/05 2 days |
| 29 | | Maintenance Visit to all 3 sites | 04/12 2 days |
| 30 | | Maintenance Visit to all 3 sites | 04/19 2 days |
| 31 | | Maintenance Visit to all 3 sites | 04/26 2 days |
| 32 | | Collect Feedback from Users | 05/03 3 days |
| 33 | | Maintenance Visit to all 3 sites | 05/10 2 days |
| 34 | | Maintenance Visit to all 3 sites | 05/10 2 days |
| 35 | | Maintenance Visit to all 3 sites | 05/24 2 days |
| 36 | | Collect Feedback from Users | 05/31 3 days |
| 37 | | Maintenance Visit to all 3 sites | 06/07 2 days |
| 38 | | Maintenance Visit to all 3 sites | 06/21 2 days |

## Appendix E - Project Schedule Page 3 of 4

Timeline: Dec (1998); Half 1, 1999: Jan, Feb, Mar, Apr, May, Jun; Half 2, 1999: Jul, Aug, Sep, Oct, Nov, Dec

| ID | Task Name | Schedule |
|---|---|---|
| 39 | Collect Feedback from Users | 06/28 3 days |
| 40 | *BENCHMARK 3 - 50% COMPLETION OF 6 I* | 07/01 ★ BENCHMARK 3 - 50% COMPLETION OF 6 |
| 41 | Maintenance Visit to all 3 sites | 07/05 2 days |
| 42 | Maintenance Visit to all 3 sites | 07/19 2 days |
| 43 | Collect Feedback from Users | 07/26 3 days |
| 44 | Maintenance Visit to all 3 sites | 08/02 2 days |
| 45 | Maintenance Visit to all 3 sites | 08/16 2 days |
| 46 | Collect Feedback from Users | 08/23 3 days |
| 47 | Maintenance Visit to all 3 sites | 08/30 2 days |
| 48 | Maintenance Visit to all 3 sites | 09/13 2 days |
| 49 | Collect Feedback from Users | 09/20 2 days |
| 50 | Maintenance Visit to all 3 sites | 09/27 2 days |
| 51 | *BENCHMARK 4 - 100% COMPLETION OF 6* | 10/01 ★ BENCHMARK 4 - 10 |
| 52 | **UNINSTALL EQUIPMENT** | UNINSTALL EQUIPMENT 10/13 |
| 53 | Uninstall Equipment at Village #1 | 10/04 2 days |
| 54 | Uninstall Equipment at Village #2 | 10/07 2 days |
| 55 | Uninstall Equipment at Village #3 | 10/11 2 days |
| 56 | **PREPARE REPORT TO END-USERS** | PREPARE REPORT TO END-USERS 11/28 |
| 57 | Collect Final Feedback from Users | 10/13 7 days |

**Appendix E** - Project Schedule Page 1 of 4

| ID | Task Name | Schedule (Dec 1998 – Dec 1999; Half 1, 1999: Jan–Jun; Half 2, 1999: Jul–Dec) |
|---|---|---|
| 56 | **PREPARE REPORT TO END-USERS** | PREPARE REPORT TO END-USERS 11/28 |
| 57 | Collect Final Feedback from Users | 10/13 7 days |
| 58 | Analyze feedback and test results | 10/22 14 days |
| 59 | Write Report | 11/08 14 days |
| 60 | Briefback to Users | 11/26 1 day |
| 61 | Disseminate Report | 11/27 1 day |
| 62 | **COMPLETE REPORT TO ASTF** | COMPLETE REPORT TO ASTF 12/ |
| 63 | Conduct Audit | 11/28 3 days |
| 64 | Prepare Written Report | 11/28 5 day |
| 65 | Forward Written Report | 12/05 2 da |
| 66 | ***BENCHMARK 5 - PROJECT COMPLETE*** | BENCHMARK 5 - PROJECT COMPLETE ★ 12/ |

Project:Remote Video at Rural Airports
Date: 03/25/00

| Legend | | |
|---|---|---|
| Task | Rolled Up Critical Task |
| Critical Task | Rolled Up Milestone |
| Progress | Rolled Up Progress |
| Milestone | Split |
| Summary | External Tasks |
| Rolled Up Task | Project Summary |

# APPENDIX F

# Final On-Line Survey

The following survey was provided online on the FlightCam website in January 2000.

FlightCam has been providing images from Ruby, Kaltag and Anaktuvuk Pass Alaska updated every 30 minutes on the Internet since March, 1999. The project was undertaken to try to improve upon current weather and runway condition reporting systems in Interior Alaska. The project is expected to continue until at least May 1, 2000. An online survey has been used to capture data about the capabilities of the system. Over 3000 responses have been gathered since July 1, 1999. Each set of images has been accessed over 50,000 times. FlightCam has been received very well by the aviation community nationwide, and embraced by those who use it in Interior Alaska.

The purpose of this new survey is to gather information about the benefits of FlightCam images for aviation use from those who have used the system for operational purposes (flying, weather forecasting, etc.) The responses will be compiled and generalized into specific comments about the capabilities of remote video to improve upon current weather and runway condition reporting systems. Your name, company and e-mail are requested (but totally optional) to enable me to contact you if I have additional questions about any of your responses. Personal identity will be kept confidential. Your input is very important to the process of documenting the benefits of the system and encouraging nationwide implementation. Thank you for your help!

There are 29 questions. A couple questions have sub-parts. The survey will take about 10 minutes. THANKS!

Directions:

- Take this survey only one time
- Use the comment block at the end of the survey to add detail to your feedback.
- For these questions, assume use of FlightCam during daylight hours (when it wasn't dark)

Your Name (Optional) ______________________________

Your E-mail (Optional) ______________________________

1. In what capacity primarily were you acting when you used FlightCam images?

   a. Pilot working for commercial air carrier or other agency (e.g. Fish and Game, BLM etc.)
   b. Support of pilots in a. above (working in operations, management etc.)
   c. Private Pilot
   d. NWS Employee (Go to Question 3)
   e. FAA Employee (Go to Question 3)
   f. AKDOT Employee (Go to Question 3)
   g. Other (please specify)

2. What company or agency do you work for (e.g. Tanana Air, Frontier, Fish and Game etc.)

3. When you used FlightCam images did you normally access the images yourself, or get the information from someone else in your agency or company?

   a. I normally accessed the images myself on the Internet 96%
   b. I normally got information about the images from someone else in my company or agency. 4%

Indicate the degree to which you AGREE or DISAGREE with the following statements according to the following scale.

1-Strongly Agree 2 - Agree 3 - Neutral or Don't Know 4 - Disagree 5 - Strongly Disagree

4. The FlightCam system was reliable (images were available when I needed them).

| | |
|---|---|
| 1 - Strongly Agree | 45% |
| 2 – Agree | 38% |
| 3 - Neutral or don't know | 16% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

5. The quality of the images was sufficient to discern operational information.

| | |
|---|---|
| 1 - Strongly Agree | 47% |
| 2 – Agree | 40% |
| 3 - Neutral or don't know | 12% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

6. The clear-day image helps me interpret the current image.

| | |
|---|---|
| 1 - Strongly Agree | 70% |
| 2 – Agree | 24% |
| 3 - Neutral or don't know | 6% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

7. The elevation information on the clear-day image is helpful to me.

| | |
|---|---|
| 1 - Strongly Agree | 53% |
| 2 – Agree | 36% |
| 3 - Neutral or don't know | 11% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

8. The distance information on the clear-day image is helpful to me.

| | |
|---|---|
| 1 - Strongly Agree | 55% |
| 2 – Agree | 37% |
| 3 - Neutral or don't know | 8% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

9. Magnetic directional information on the clear-day image is helpful to me.

| | |
|---|---|
| 1 - Strongly Agree | 41% |
| 2 – Agree | 42% |
| 3 - Neutral or don't know | 16% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

10. Annotation of man-made features on the clear-day image is helpful to me (buildings, villages)

| | |
|---|---|
| 1 - Strongly Agree | 35% |
| 2 – Agree | 51% |
| 3 - Neutral or don't know | 13% |
| 4 – Disagree | 1% |
| 5 - Strongly Disagree | 0% |

11. Annotation of airport environment information is helpful to me (windsock, taxiway, runway etc.).

| | |
|---|---|
| 1 - Strongly Agree | 40% |
| 2 – Agree | 45% |
| 3 - Neutral or don't know | 14% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

12. Annotation of natural features on the clear-day image is helpful to me (rivers, mountains)

| | |
|---|---|
| 1 - Strongly Agree | 56% |
| 2 – Agree | 34% |
| 3 - Neutral or don't know | 11% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

13. If I had to choose between AWOS/ASOS visibility information and FlightCam images, I would rather have the FlightCam image during pre-flight for a VFR flight.

| | |
|---|---|
| 1 - Strongly Agree | 45% |
| 2 – Agree | 32% |
| 3 - Neutral or don't know | 21% |
| 4 – Disagree | 2% |
| 5 - Strongly Disagree | 0% |

14. If I had to choose between AWOS/ASOS ceiling information and FlightCam images, I would rather have the image for a VFR flight.

| | |
|---|---|
| 1 - Strongly Agree | 34% |
| 2 – Agree | 32% |
| 3 - Neutral or don't know | 25% |
| 4 – Disagree | 8% |
| 5 - Strongly Disagree | 0% |

15. FlightCam images are valuable as a stand-alone weather collection resource (Ruby for example)

| | |
|---|---|
| 1 - Strongly Agree | 36% |
| 2 – Agree | 31% |
| 3 - Neutral or don't know | 23% |
| 4 – Disagree | 8% |
| 5 - Strongly Disagree | 2% |

16. FlightCam images help me verify the accuracy or inaccuracy of AWOS/ASOS information.

| | |
|---|---|
| 1 - Strongly Agree | 48% |
| 2 – Agree | 34% |
| 3 - Neutral or don't know | 17% |
| 4 – Disagree | 1% |
| 5 - Strongly Disagree | 0% |

17. FlightCam images would be a good enhancement to ASOS/AWOS.

| | |
|---|---|
| 1 - Strongly Agree | 69% |
| 2 – Agree | 21% |
| 3 - Neutral or don't know | 8% |
| 4 – Disagree | 1% |
| 5 - Strongly Disagree | 0% |

18. If images were updated every minute, my company would use them to help track the status of flights (you could see your plane on the ground at Anaktuvuk Pass for example)

| | |
|---|---|
| 1 - Strongly Agree | 22% |
| 2 – Agree | 18% |
| 3 - Neutral or don't know | 54% |
| 4 – Disagree | 5% |
| 5 - Strongly Disagree | 1% |

19. If employed on a large scale (more airports) FlightCam images would accomplish the following:

a. Improve aviation safety in Alaska for commercial carriers

| | |
|---|---|
| 1 - Strongly Agree | 50% |
| 2 – Agree | 36% |
| 3 - Neutral or don't know | 14% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

b. Improve aviation safety in Alaska for general aviation pilots

| | |
|---|---|
| 1 - Strongly Agree | 63% |
| 2 – Agree | 25% |
| 3 - Neutral or don't know | 12% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

c. Improve the level of service air carriers provide to passengers (better able to determine if a flight can be completed given the weather at the destination)

| | |
|---|---|
| 1 - Strongly Agree | 42% |
| 2 – Agree | 39% |
| 3 - Neutral or don't know | 17% |
| 4 – Disagree | 2% |
| 5 - Strongly Disagree | 0% |

d. Improve the efficiency of air carrier operations (save money due to fewer turnbacks and a higher mission completion rate)

| | |
|---|---|
| 1 - Strongly Agree | 34% |
| 2 – Agree | 50% |
| 3 - Neutral or don't know | 16% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

20. If employed on a large scale (more airports):

a. I would use FlightCam regularly during pre-flight to determine conditions at my destination

| | |
|---|---|
| 1 - Strongly Agree | 61% |
| 2 – Agree | 30% |
| 3 - Neutral or don't know | 10% |
| 4 – Disagree | 0% |
| 5 - Strongly Disagree | 0% |

b. I would use FlightCam regularly during pre-flight to determine conditions along my route of flight

| | |
|---|---|
| 1 - Strongly Agree | 55% |
| 2 – Agree | 30% |
| 3 - Neutral or don't know | 13% |
| 4 – Disagree | 2% |
| 5 - Strongly Disagree | 0% |

21. Information from FlightCam images should be available through the FAA Flight Service Station

| | |
|---|---|
| 1 - Strongly Agree | 56% |
| 2 – Agree | 31% |
| 3 - Neutral or don't know | 11% |
| 4 – Disagree | 2% |
| 5 - Strongly Disagree | 0% |

22. If the in-flight desk at the FSS had access to FlightCam images, it would assist me during flight in making decisions prior to landing (e.g. you could divert if conditions were bad)

| | |
|---|---|
| 1 - Strongly Agree | 40% |
| 2 – Agree | 42% |
| 3 - Neutral or don't know | 15% |
| 4 – Disagree | 2% |
| 5 - Strongly Disagree | 1% |

23. If FlightCam images were available through an uplink to a multifunction display in my aircraft, it would assist me in in-flight decision-making.

| | |
|---|---|
| 1 - Strongly Agree | 43% |
| 2 – Agree | 30% |
| 3 - Neutral or don't know | 25% |
| 4 – Disagree | 1% |
| 5 - Strongly Disagree | 0% |

24. I have personally CANCELLED a flight primarily because of weather information I received through FlightCam images. (1-Yes 5-No)

| | |
|---|---|
| 1 - Yes, 5 or more times | 10% |
| 2 - Yes, less than 5 times | 21% |
| 3 – No | 69% |

25. I have personally DELAYED a flight primarily because of weather information I received through FlightCam images.

| | |
|---|---|
| 1 - Yes, 5 or more times | 20% |
| 2 - Yes, less than 5 times | 16% |
| 3 – No | 64% |

26. I have personally LAUNCHED a flight based on information from FlightCam images when I might otherwise have cancelled the flight based on information from other weather collection resources (ASOS, satellite, FSS etc.)

| | |
|---|---|
| 1 - Yes, 5 or more times | 12% |
| 2 - Yes, less than 5 times | 26% |
| 3 – No | 62% |

27. FlightCam images can assist in assessing wind conditions (e.g. windsock is in runway view at Kaltag)

| | |
|---|---|
| 1 - Strongly Agree | 16% |
| 2 – Agree | 54% |
| 3 - Neutral or don't know | 27% |
| 4 – Disagree | 3% |
| 5 - Strongly Disagree | 0% |

28. FlightCam images can assist in determining runway conditions (snow on runway/taxiway, flooding, runway obstructions, construction etc.)

| | |
|---|---|
| 1 - Strongly Agree | 22% |
| 2 – Agree | 50% |
| 3 - Neutral or don't know | 18% |
| 4 – Disagree | 9% |
| 5 - Strongly Disagree | 1% |

29. My overall impression with the FlightCam system is

| | |
|---|---|
| 1 – Excellent | 75% |
| 2 – Good | 18% |
| 3 - Neutral, Medium or don't know | 6% |
| 4 – Poor | 1% |
| 5 - Very Poor | 0% |

General Comments (Use this block for comments EXCEPT suggestions for improvement

Suggestions (Use this block for suggestions for improvement or deployment of FlightCam)

# APPENDIX G

# Miscellaneous Supporting Documentation

The following supporting documents are attached:

**Letters of Support for ASTF Proposal**



**ASTF Grant-Related Letters**



**Patent Document**

**DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES**

*NORTHEERN REGION MAINTENANCE AND OPERATIONS*

**TONY KNOWLES, GOVERNOR**
*2301 PEGER ROAD*
*FAIRBANKS, ALASKA 99709-5399*
*FAX (907) 451-2220*
*PHONE (907) 451-5217*
*TDD (907) 451-2363*

October 30, 1998

Members of the Board
Alaska Science and Technology Foundation
4500 Diplomacy Drive, Suite 515
Anchorage, AK 99508-5918

SUBJECT: Alaska DOT&PF Commitment to Remote Video Project

1. This letter provides specific delineation of cash and in-kind support, which the Alaska Department of Transportation, Northern Region will provide to James M. Buckingham. This support is to assist with the conduct of a six-month test of the feasibility and applicability of using remote video technology to collect runway and weather information at rural airports in Interior Alaska. The DOT&PF has been briefed on the specific aspects of this project and strongly endorses its execution.

2. DOT will provide the following contingent upon ASTF approval of the stated proposal:

   a. In-Kind Support

      1) Use of DOT structures at rural airports upon which to mount video camera hardware.
      2) Donation of electrical power to operate hardware at selected sites.
      3) Use of DOT&PF personnel (electrician) subject to availability to assist with the installation, mechanical and electrical troubleshooting of hardware installed on DOT structures.
      4) Assistance of DOT&PF contract maintenance personnel at rural villages to provide access to DOT&PF owned structures.
      5) Provision of Mr. Dean Owen, Northern Region Aviation Manager, as a co-applicant and primary end-user of knowledge gained from this project.
      6) Transportation to rural sites on a space-available basis for the project manager when flights are already scheduled for that location.

   b. Cash Support - $10K to assist with cash requirements for project. These funds are contingent upon the Northern Region Highways and Aviation ending the 1999 State Fiscal Year (June 30 1999) with a budget surplus. The project manager will determine specific application of these funds.

ITEM 1

Members of the Board -2- October 29, 1998
Alaska Science and Technology Foundation

3. While the DOT cannot provide firm commitment that the knowledge gained from this project will be used to fund capital investments in remote video technology, the agency is firmly committed to evaluating any potential opportunity which can increase the safety, efficiency and service of public transportation systems. In this light, the results of the project will be carefully considered and DOT will actively participate in dialogue that would consider the potential for widespread application of this technology throughout the Northern Region of Alaska.

Sincerely,

Ralph Swarthout, P.E.
Director M&O Northern Region

University of Alaska Anchorage
**THE LEADING EDGE**
of Aviation Education on the Last Frontier

PROFESSIONAL PILOTING
AVIATION ADMINISTRATION
AIR TRAFFIC CONTROL
AVIATION MAINTENANCE TECHNOLOGY

October 28. 1998

Members of the Board
Alaska Science and Technology Foundation
4500 Diplomacy Drive, Suite 515
Anchorage, AK 99508-5918

Dear Members:

This letter is written in support of a proposal submitted by James M. Buckingham, **Use of Remote Video for collecting Runway and Weather Information at Rural Airstrips in Interior Alaska.** Mr. Buckingham accomplished a research project for me this past summer, a pilot project evaluating characteristics of airports as precursor to the above proposal. The report he submitted was finite in detail, providing information which has already been incorporated by the Alaska Statewide Airports Division. This report far exceeded expectations, due to Mr. Buckingham's ability to maximize efforts and control expenditures.

The remote video project was a recommendation of the National Transportation Safety Board. The use of remote video at rural airstrips has the potential for significantly enhancing safety of flight in Alaska. The Federal Aviation Administration is seeking funding for such a project, but the project envisioned by Mr. Buckingham exceeds the parameters of the FAA program, offering evaluation of the use of video in a shorter time span. Such research is critical to the establishment of a solid data point concerning benefits which could accrue to Alaska from technological advances.

The Aviation Technology Division has a keen interest in the results of this project as they would apply to our Professional Piloting program and Experimental Weather Forecasting Facility. I feel this project could provide the seed for continued research in this area so vitally important to the safety of Alaska's aviation industry.

I strongly urge you to fund this project. This Division will provide any support possible through use of our technical expertise and simulation capabilities. I am personally working with Mr. Buckingham as he pursues his Ph.D. on a topic of such vital importance. Thank you for your consideration. If you have questions, please call me at (907) 264-7411.

Sincerely,

James E. Crehan
Chair, Aviation Technology Division

ITEM 2

2811 Merrill Field Drive • Anchorage, Alaska 99501 • (907) 264-7400 • Fax (907) 264-7444
E-mail: ayflyhi@uaa.alaska.edu • WWW: http://www.uaa.alaska.edu/aviation/

**TANANA AIR SERVICE**
**P.O. Box 60713**
**Fairbanks, Alaska 99706**

October 27, 1998

Members of the Board
Alaska Science and Technology Foundation
4500 Diplomacy Drive, Suite 515
Anchorage, AK 99508-5918

Dear Board Members:

Tanana Air Service is a small commuter carrier servicing the interior of Alaska with scheduled passenger and cargo flights. We fly more then eight thousand (8,000) hours per year, year round. Most of our forty-six (46) destinations are small villages without adequate navigational aides or weather reporting to fly except under visual flight conditions. Each weekday morning Tanana Air Service flies from Fairbanks to Tanana, Ruby, Galena, Koyukuk, Nulato, and Kaltag. The flight departs at 7:00 a.m., after receiving a weather briefing from the FAA Flight Service Station on weather conditions at Fairbanks, Tanana, and Galena. (Fairbanks and Galena has observations 24 hours a day with Tanana observations starting at 6:00 a.m. until 9:30 p.m. daily.) Eight (8) other carriers fly the same route from Fairbanks during the morning.

The National Transportation Safety Board has published two reports on aviation safety in Alaska. Each study addressed the enormous shortfall in weather reporting throughout the state. The National Weather Service and the Federal Aviation Administration has installed Automated Weather Observation Systems in selected locations that report the weather directly above these locations by machinery, but does not report what is on the horizon that a human can see or a video system could transmit. After the disaster in Valdez, remote videos were installed showing the shipping lanes into and out of the harbor. If a system were installed that could provide a pilot information about what is going on around an observation point, then the pilot would be better informed to assess safe flying conditions. On our flight from Fairbanks to Galena each morning, we have no idea what is happening in the Yukon valley between Tanana and Ruby where the river cuts through the rising terrain. There have been many times when the flight is expected to be flown without encountering any adverse weather, only having to return to Tanana because of deteriorating weather conditions between Tanana and Ruby. The distance between these villages is eighty-nine (89) nautical miles.

The remote video system that LTC James Buckingham, PHD candidate at the University of Alaska, is trying to prove will greatly enhance aviation safety in the areas that he is allowed to install the system. Tanana Air Service will provide, without charge, any transportation that is within our ability, size, and weight to and from Ruby. We will also provide said service to other scheduled locations, if there is room on the aircraft. We are willing to support this endeavor by

ITEM 3

**Fairbanks 474-0301 Aniak 675-4258 Galena 656-1834 McGrath 524-3330**

providing input and air transportation.

We will be able to reduce the cost of transporting the mail by not having to return to base due to deteriorating weather conditions. The potential to save lives throughout the state with the installation of such a system cannot be estimated. You read weekly about pilots flying into the terrain because of bad weather. Pilots do not take off to crash. If they knew the weather conditions at their destinations and along the route of flights, many would not depart until the conditions improved. If only three (3) systems are funded and tested, then three(3) locations will be safer for flying. We are killing too many good Alaskans because we expect and demand the federal government to provide a system that will enhance our safety. You now have the opportunity to improve the safety of the flying Alaskans by funding this system and proving how it will work.

As a board member of the Alaska Air Carriers' Association, I have obtained their support for this endeavor. If I can be of any further assistance in this matter, please contact me at 907-474-0301.

Sincerely,

Fred H. Ciarlo
General Manager

U.S. Department of Transportation
Federal Aviation Administration

3811 University Ave
Fairbanks, AK 99709

October 30, 1998

Members of the Board
Alaska Science and Technology Foundation
4500 Diplomacy Drive, Suite 515
Anchorage, Alaska 99508-5918

Dear Sirs:

I am the Manager for Fairbanks Automated Flight Service Station (AFSS). I am also a member of the Northern Alaska Aviation Users Group (NAAUG). Mr. James Buckingham attended our last NAAUG meeting and explained his proposal to test remote videos at rural airports in the Interior. Those videos will provide visual images of weather and runway conditions and will be of great value for planning a flight to any of these airports. At this time, the FAA and National Weather Service utilize either automated weather observations or weather observers at remote locations, both with varying degrees of reliability. If the concept Mr. Buckingham is testing is successful in relaying accurate data to pilots, it will be enhance aircraft safety.

I have made a commitment to Mr. Buckingham to have our staff check his airport sights on a regular basis during the six-month test period and provide feedback to him. We cannot use this information for briefing pilots at this time, but we can determine how effective this information would be if it were available for briefings.

If you have any questions, please contact me at 907-474-0388.

Bette L. VanManen

Bette L. VanManen

ITEM 4

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE
ALASKA REGION
222 W. 7th Avenue, #23
Anchorage, Alaska 99513-7575

October 30, 1998

Board Members
Alaska Science and Technology Foundation
4500 Diplomacy Drive, Suite 515
Anchorage, Alaska 99508-5918

Dear Sirs:

The National Weather Service (NWS) is working together with the Federal Aviation Administration in Alaska to explore and demonstrate the impact of video cameras on aviation operations in Alaska. Our hypothesis is that these cameras can provide useful and sometimes critical information which can benefit flight operations in Alaska. There are, of course, many challenging elements to safe flying in Alaska. If video cameras can alert pilots to any of these challenging elements, they will have provided a valuable service.

LTC James M. Buckingham is proposing a research project involving the use of remote video at rural Alaskan airports. The application of this technology in the collection of runway and waather condition information at rural locations opens a tremendous opportunity to improve aviation safety and bolster the quality of service and operating efficiency of the aviation community throughout Alaska. The results from this project will help us assess the validity of our hypothesis.

The NWS is not currently in a position to provide any funding for LTC Buckingham's research. We do, however, wish to provide strong endorsement for the project.

Sincerely,

James E. Kemper
Chief, Environmental and
Scientific Services

ITEM 5

AASF
ALASKAN AVIATION SAFETY FOUNDATION

COPY FOR YOUR INFORMATION

October 29, 1998

Dr. Robert Chaney
Alaska Science and Technology Foundation
4500 Diplomacy Drive, Suite 515

Dear Dr. Chaney:

Time and accurate weather and runway information are critically important to aviation safety in Alaska. The development to date of automated weather systems does not yet match the requirements of the aviation community. We believe that video technology could be a valuable source of information to help fill the gap left by the present automated weather systems.

The Alaskan Aviation Safety Foundation supports the prototyping project to install and operate remote video cameras at four interior Alaska airports, proposed by Mr. James Buckingham as part of his Ph.D. program at the University of Alaska Fairbanks. We understand that he is working with the Alaska Department of Transportation, the Federal Aviation Administration and the National Weather Service to conduct an operational test of video data collection and dissemination during this coming year. A project of this nature would be an important step toward exploring and integrating new technologies to improve the aviation infrastructure which is relied on by the public when they travel by air.

Sincerely,

Thomas H. Wardleigh

Thomas H. Wardleigh, Chairman
Board of Directors

ITEM 6

[illegible]
[illegible], Alaska [illegible]

TOTAL P.02

**ALASKA SCIENCE & TECHNOLOGY FOUNDATION**
**— Putting Innovation to Work for Alaska —**

*December 14, 1998*

*Lt. James Buckingham*
*Lieutenant Colonel*
*6958 No Name Lane*
*Fairbanks, AK 99712*

*Dear Lt. Buckingham:*

*SUBJECT: 98-4-119*
*Use of Remote Video to Collect Runway and Weather Condition Information at Rural Airstrips in Interior Alaska*

*The ASTF Board of Directors met December 10, and selected the above-referenced proposal as a project it wishes to fund, contingent upon successful negotiation of specific grant provisions. In order to complete the grant agreement, we will need the following information:*

1. *Complete and retum the enclosed Grant Information Sheet*
2. *Provide a Certificate of Insurance*
3. *We would like you to include with your final report a plan for placing remote video systems at other rural airstrips that the FAA consider.*

*Because the Foundation retains 10% of the grant until the Board has taken action on the final report and audit, we will adjust the payment schedule accordingly. You will not need to revise Budget Form E, as the payment schedule will appear on Appendix D.*

*"When Your Proposal is Funded" contains information conceming detailed material we may need unless you have already provided it.*

*So that you can review the general terms, I am furnishing a generic grant agreement. We will, of course, customize it to your particular project. The proposal becomes Appendix B, with any changes going into the Revisions and Addenda section, Appendix C. Appendix D will lay out the interim report and payment schedules we agree to for your grant.*

*You do not need to fill in any blanks except those on the Info Sheet for Grant Agreement Preparation. We would appreciate your retuming this or bringing it with you when we meet. As soon as we have all the necessary information, we will fill in the rest of the blanks and prepare the final grant agreement documents.*

ITEM 7

*4500 Diplomacy Dnve. Suite 515. Anchorage. Alaska 99508-5918*

*Telephone: (907) 272-4333*
*Fax: (907) 274-6228*

*December 14, 1998*
*Page 2*

*Congratulations on your successful application. Would you please call to arrange a convenient time to get together and discuss the grant agreement, either in person or by phone. I look forward to working with you in this endeavor.*

*Sincerely,*

*James F. Palin*
*Grants Administrator*

*JFP:JLF*
*984113.ltr*

*Enc:* *Info Sheet for Grant Preparation*
*Blank Grant Agreement*
*Sample Appendix D*
*When Your Proposal is Funded*
*Confidentiality Policy*

**ALASKA SCIENCE & TECHNOLOGY FOUNDATION**
***—Putting Innovation to Work for Alaska—***

# Grant Agreement
## 98-4-119 (Buckingham)

**between**

## Alaska Science & Technology Foundation
***An instrumentality of the State of Alaska***

**and**

## James M. Buckingham

**Effective**

**December 30, 1998**

ITEM 8

7. Notices to Grantee.

Until notified otherwise in writing, the address of the Grantee to which ASTF shall send all notices to the Grantee that are required under this Agreement or applicable law is as follows:

James M. Buckingham, PE
6958 No Name Lane
Fairbanks, AK 99712

8. Insurance.

Notwithstanding the requirements of Section 55 of the Grant Agreement Standard Terms and Conditions attached as Appendix A, the insurance coverage amount required to be provided by the Grantee shall be that shown in Appendix C of this agreement.

**FOR ASTF:**

ALASKA SCIENCE & TECHNOLOGY FOUNDATION
An Instrumentality of the State of Alaska
By: James Kenworthy, Executive Director

James Kenworthy
Signature

Dated: 12/30/98

Address: 4500 Diplomacy, Ste 515
Anchorage, AK 99508-5918

**FOR GRANTEE:**

By: James M. Buckingham, PE
Project Manager

James M. Buckingham
Signature

Dated: 26 Dec 1998

**ALASKA SCIENCE & TECHNOLOGY FOUNDATION**
**— Putting Innovation to Work for Alaska —**

*December 17, 1999*

*James Buckingham*
*Lieutenant Colonel*
*6958 No Name Lane*
*Fairbanks, AK 99712*

*Dear Lt. Colonel Buckingham:*

*SUBJECT: 98-4-119*
*Use of Remote Video to Collect Runway and Weather Condition Information at Rural Airstrips in Interior Alaska*

*As you are aware, at its December 8 meeting, the ASTF Board of Directors approved your budget revision request and a change from a knowledge project to a technology project with a repayment condition. Enclosed is Amendment No. 1 to your grant agreement for your signature. The changes include the following:*

1. *Increased the grant amount to $113,552.*
2. *Reinstated Section 4 - Grant Repayment*
3. *Changed the project completion date to June 30, 2000*
4. *Reinstated three sections in Appendix A, Article IV, Sections:*
   - *25 - Intellectual Property, Technology, and Commercialization*
   - *26 - Gross Receipts*
   - *27 - Transfer of and Security Interest in Intellectual Property*

*Please sign both copies of the amendment and return them to us. After the Executive Director has signed them, I will send you a copy for your records.*

*If you have any questions, please give me a call.*

*Sincerely,*

*James F. Palin*
*Grants Administrator*

*Enclosure*
*cc: Dave Moran*
*JFP:JLF*
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ITEM 9

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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

**Certificate Of Mailing**

I hereby certify that the enclosed twenty-six page application with eight sheets of drawings, declaration, power of attorney, claim for small entity status, return post card and the filing fee of $345.00 are being deposited with the United States Postal Service with sufficient postage as express mail in an envelope addressed to:

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

Express mail number EJ353093183US
on January 12, 2000

Michael Tavella
(Name of person making deposit)

(Signature)
1/12/00
(Date)

IN RE: The application of James Buckingham

TITLE OF THE INVENTION

System For Collection, Dissemination And Presentation Of Near Real-Time Images Of Weather And Runway Conditions At Distant Locations

**Michael Tavella**
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# APPENDIX H

# Media Releases/Publications

The following media releases and publications are attached:

Fairbanks Daily News-Miner

LOCAL

Section B

Wednesday, April 21, 1999

# Bush cameras show weather status on Web

By SEAN COCKERHAM
Staff Writer

Planning on flying to a remote village and wish a crystal ball could show you the faraway weather firsthand?

Through cameras set up at some villages, Fairbanks pilots and anyone else can now eyeball the conditions simply by logging onto the Internet.

"It's an enormous asset," said Fred Ciarlo, general manager and director of operations at Tanana Air Service. "I'd like to see it continue and spread to other locations."

Two Web sites have recently started offering the service. One—featuring Anaktuvuk Pass, Kaltag and Ruby—is run by an Army officer using it for his doctoral research at the University of Alaska Fairbanks.

The other is from the Federal Aviation Administration—showing Dillingham, Haines and Summit airport near Windy Pass. The FAA plans to expand soon to at least three other locations, including Fort Yukon.

Both Web sites show images of the area, from several directions, that are updated every half-hour. They feature a "current image," contrasted with a "clear-day image,"—which displays the altitude of local terrain landmarks and their distance from the runway.

Lt. Col. James Buckingham set up his Interior village cameras for his UAF research in engineering management. Next spring, he will teach at the U.S. Military Academy in West Point, N.Y.

Buckingham launched his project with a $62,000 grant from the Alaska Science and Technology Foundation and the donated services of local air carriers, GCI, Mosquitonet and others. His project began April 1 and will run through Oct. 1 and is designed to see how much the Web-cams can benefit aviators.

Ciarlo, of Tanana Air, likes the cameras so much he is considering taking over the service in some fashion when Buckingham's project ends.

"Anytime (Buckingham) needs to go out that way he's got a ride with us," Ciarlo said. "Space required, not space available... it's that important to us."

Ruby does not have any other good weather information, and the FAA's Automated Weather Observing System in Anaktuvuk Pass is not always on-target, aviation companies said.

The AWOS has a laser that beams straight up to measure cloud layers, Buckingham said. "It can't give any information on what's happening to the north, to the south, to the west."

Both Buckingham's and the FAA's camera Web sites bear disclaimers stating that the images are not meant to replace official weather information and are provided only as a supplement. Both also invite feedback from users.

Buckingham's site is at www.flight-cam.net. The FAA's Alaska camera site is www.akweathercams.com.

THE NATION'S NEWSPAPER www.usatoday.com

By Nancy Palmen for USA TODAY

**Touch of Europe:** Marcello is a Providence River gondolier.

## A renaissance for Providence

The waterfront city of Providence, R.I., has been discovered by Hollywood and by an influx of young people who are building a vibrant cultural scene.

**Tomorrow in Destinations & Diversions**

USA TODAY Life

THURSDAY, AUGUST 5, 1999

# Around the globe in a click with Webcams

By Elizabeth Weise
USA TODAY

Can't make it to Paris? Click www.tf1.fr/livecam/index.html and see the Eiffel Tower from the top of French television's office building.

Need something serene when you've just missed an important FedEx pickup? Nothing beats five minutes on a snowy pass staring out at Mount Everest, courtesy of www.m.chiba-u.ac.jp/class/respir/eye_e.htm.

And if you're a bush pilot in Alaska (or just in need of a view from your cubicle), check runway conditions in Anaktuvuk Pass at www.flightcam.net/anaktuvi.htm.

Webcams — cameras that post continuous pictures on Web pages — are booming. Although no one keeps an authoritative count, the directory Earthcam.com lists more than 5,000 sites; the listings have been doubling annually the past three years.

Webcams are put up by tourist boards, bored programmers, traffic authorities, TV stations and anyone else with a digital camera and a 24-hour Internet connection.

There's something compelling about sitting in front of a computer and seeing a place halfway around the globe at exactly the same time. The pictures may be fuzzy and may change only once every 10 minutes, but they offer the closest thing possible to instant travel.

"It's enormously more than not having anything better to do," says Nico Spinelli, a computer science professor at the University of Massachusetts Amherst. These images "expand our consciousness; they expand our range of vision."

From the Earthcam directory you can click through to see shots of the makeshift memorial in front of John F. Kennedy Jr.'s New York apartment or a broadcast from the southeast window of the sixth floor of the Texas School Book Depository at Dallas' Dealey Plaza, where his father died 36 years ago.

For a broader view, visit www.fourmilab.ch/cgi-bin/uncgi/Earth, where a Webcam on a satellite shows the simple image of Earth.

"On that blue stuff there are boats with people, on the brown stuff there are millions and millions of people, and we're all invisible," Spinelli says. "It gives you pause."

WX WATCH

# Eyes on the sky

## More ways the Web can put you on the scene

**BY THOMAS A. HORNE**

Ever since automated weather observations made their debut, pilots have complained about the problems associated with the observations' lack of a human element. ASOS (automated surface observation system) and AWOS (automated weather observation system), for example, use laser beam ceilometers (LBCs) to determine the height of any clouds or cloud layers above the observing stations. The LBC shoots an extremely narrow beam directly upward to make these observations. If there's a 500-foot overcast, then the LBC will faithfully record the cloud height and report it over the ASOS or AWOS frequency (and, in many cases, over a published telephone number, too). That's great when clouds cover, more or less, the entire sky.

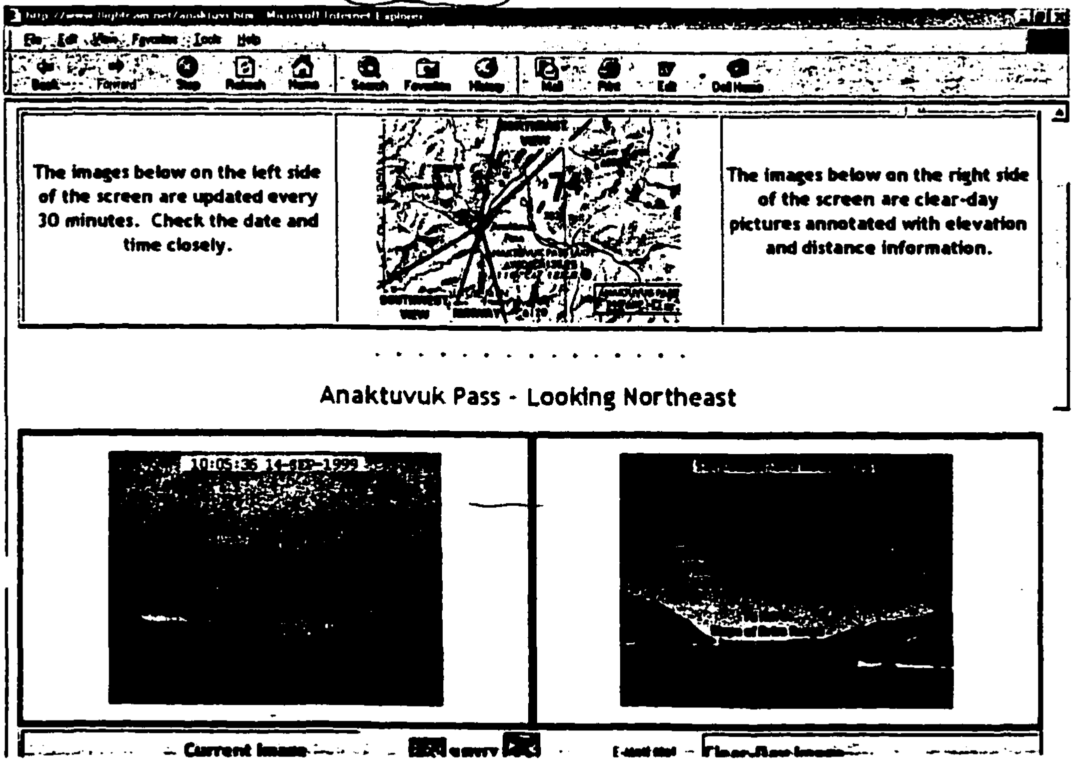
But the LBC doesn't distinguish between a lonely fair-weather cumulus cloud and a massive thunderstorm. It only "sees" the sky directly above it. And ASOS technology hasn't developed to the point where thunderstorm activity can be reliably located and reported by today's observation methods. (This technology is now being introduced, however.) So pilots face a problem: How do we know if the cloud-base information from an ASOS or AWOS observation is really indicative of the prevailing weather at or near the site?

That's one of the issues at the heart of anti-ASOS/AWOS sentiments. "You need a human observer at the airport," critics say. "That's the only way we'll know that a huge thunderstorm is just out of range of an automated site's LBC."

Other criticisms center on precipitation observations and measurements, although ASOS equipment does in fact report precipitation type. Some ASOS sensors also report the presence of freezing rain. Even so, it would be nice to have an actual human telling you whether the rain came from a monster microburst or an isolated, passing shower.

None of this is to suggest that we turn back the clock and revert to rolls of yellow newsprint ratch-

*Alaska's flightcams provide vital weather information at three remote airports. Is Anaktuvuk Pass open? A look at the flightcam Web page is worth a thousand words.*



eting out of clattering teletype machines. I'm no Luddite, and besides, automated weather does give us accurate vital information (altimeter settings, wind information, density altitude) at more airports than ever before. The equipment works day and night, and it allows more instrument approaches (with lower descent minimums) at more airports. Moreover, many ASOS and AWOS sites *do* have observers who augment automated reports with their own observations. Reports from these sites won't have the AUTO or AO prefixes at the beginning; any human observations that back up or augment any automated information will appear in the "remarks" section of a METAR.

*The Tropical Prediction Center's Web site has a wealth of hurricane imagery. In this infrared image, it's September 13, and Hurricane Floyd is set to pounce on the Bahamas.*

## The Web lets you download flights in a hurricane, and gives new views of icing conditions.

### Alaska's flightcams

That said, let's agree that more weather information is always better. A program now being used in Alaska goes today's automated weather one better by posting imagery from airport cameras on the Internet (www.flightcam.net). This program is supported by the Alaska Science and Technology Foundation (funded with the help of the FAA and regional airlines) and now serves three airports in the Alaskan interior—Anaktuvuk Pass, Ruby, and Kaltag.

These airports don't have instrument approaches and are near high terrain and mountain passes. Weather changes quickly in these remote areas, and Ruby and Kaltag don't even have AWOS equipment. Before flightcams, pilots had to fly to these villages not knowing what to expect. Sure, other pilots could relay their own observations, but how reliable would those be after a few hours had gone by?

The flightcam imagery is updated every 30 minutes. Views are shown for various directions from the camera sites. Actually, there are two views for each camera angle. One shows the nearby scenery on a severe-clear, VFR day, and includes terrain features labeled with their heights and ranges. The one next to it shows the current conditions. By comparing the two images, you can see (or not see, as the case may be) just how bad the weather is. Flightcams lend truth to the sayings "What you don't see can definitely hurt you" and "A picture's worth a thousand words."

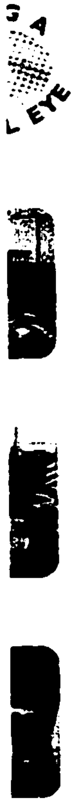
Alaska's flightcam project began with a $61,000 grant to Army Lt. Col. James Buckingham. More support came from the FAA, the National Weather Service, the Alaska Aviation Safety Foundation, Mosquitonet (an Internet service provider), GCI (a long-distance carrier), the Alaska Department of Transportation, and Alaskan charter firms such as Frontier Flying Service, Tanana Air Service, Larry's Flying Service, and others.

The program began in April. Buckingham would like to continue the flightcam project past its six-month initial period. "I am going to try to continue the service until the FAA can take over the sites later this year [1999]," he said.

"This project has been strongly embraced by the local flying community," Buckingham added. "Air carriers in particular are ecstatic....They trust AWOS for everything but ceiling and visibility. Therefore the cameras fill a much-needed gap in information, especially with the demise of the AFSSs around the state."

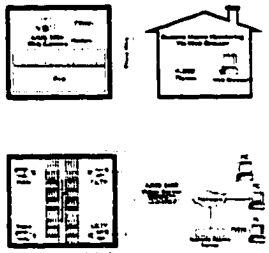
Plans are to expand the program to include cameras at the Dillingham, Haines, and Summit airports. Pilot support will help preserve, sustain, and

# Catch It On Camera.



## Axis Communications Helps Monitor Weather In Rural Alaskan Villages

Pilots flying into remote Alaskan villages no longer have to guess the weather. They simply log on to the Internet at www.flightcam.net and can view live images of airport conditions immediately. "Seeing the extent and shape of the clouds really helps me get a feel for the weather—way beyond what the FAA's automated sensor tells about cloud height and extent" says Tom George, pilot and Regional Representative, Alaskan Aviation Safety Foundation.



At the heart of the FlightCam system, developed by James Buckingham for his Ph.D. thesis at the University of Alaska at Fairbanks, an Axis camera server controls remote digital cameras providing three different views of the sky and runway. These images are communicated to the Web site to help pilots determine weather conditions and cloud ceiling before taking off.

## Just Imagine If The Web Had Eyes

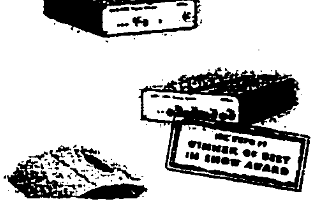
You could increase your Web traffic by featuring live images from anywhere in the world. Keep watch over secure areas of your business. Or monitor your remote manufacturing facilities.

You don't need any extra hardware or software—just a standard browser and a network or modem connection. Simply plug in Axis' ThinServer™ Technology-based camera server, assign an IP address, and you're ready to take, display and view live pictures, right over the Web.

And whatever the demands of your application, Axis camera servers make it easy, reliable and affordable.

## An Eye For Your Application

The Axis camera and video server family fits a variety of business applications.



The AXIS 2400/2401 video server surveillance solutions can transmit high quality Motion-JPEG images at up to 30 frames per second. They provide single-box solutions for video transmission over LAN or WAN networks, such as the Internet.

The AXIS 200+ Web camera is the world's first self-contained Web server and network camera. The AXIS 200+ includes everything you need to capture live images and deliver them

## Science

James Buckingham
FlightCam creator

James Barker photography

In March 1999, Lieutenant Colonel Jim Buckingham set up remote color video cameras at three rural village runways – Anaktuvuk Pass, Ruby and Kaltag. None of these three runways has the capability for instrument approaches, so pilots have to fly according to visual flight rules (VFR).

Buckingham's FlightCam System presents three current images from each location, which are then available via a public web site at www.flightcam.net. The real-time image is placed on the screen against a clear-day image of the same view with distance and elevation information about the visible terrain noted as well. Pilots can then compare and contrast current conditions against ideal conditions and directly assess the current weather for themselves.

Buckingham's ASTF-supported project is making a difference in the lives of people who live and work in some of Alaska's Interior villages. An active duty Army Officer, Buckingham returned to Alaska to get his Ph.D., and will return to the U.S. Military Academy at West Point in 2000 as an instructor. His enjoyment of flying, combined with his academic goals, gave him the perfect opportunity to devise the FlightCam System to improve runway and weather condition information at rural sites.

Buckingham estimates that 400 people per day are accessing his website, and the feedback he has received from those users is overwhelmingly positive. When AvWeb, an Internet-based aviation news agency, published his web site on September 13, Buckingham received more than 10,000 hits in a 24-hour period. Media coverage in USA Today, AOPA Pilot Magazine and a number of smaller publications have contributed to widespread interest in the project. Air carriers and general aviation pilots in the Interior are no longer wasting time flying all the way to a village, then turning around and coming back because weather conditions are too poor for landing. With the new FlightCam System, they are accessing the images and making GO/NO GO decisions based on the current view, saving the company money and providing better, safer service to passengers.