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Information Systems Management concept for military aircraft in combat operations

Douglas Rhea Schueler
University of Tennessee

To the Graduate Council:

I am submitting herewith a thesis written by Douglas Rhea Schueler entitled "Information Systems Management concept for military aircraft in combat operations." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Aviation Systems.

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We have read this thesis and recommend its acceptance:

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Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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INFORMATION SYSTEMS MANAGEMENT CONCEPT FOR MILITARY AIRCRAFT IN COMBAT OPERATIONS

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Douglas Rhea Schueler
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ABSTRACT

In the 100 years since the first successful heavier than air powered flight, aircraft specifically designed for military applications have proliferated in two overlapping phases. The first phase could be considered the development and evolution of aircraft aerodynamic and power plant performance; basically the ability of an aircraft to fly higher, faster and be more maneuverable. As this first phase reached a plateau in the last 30 years, the second phase, development of on-board systems, (i.e. radar, FLIR, sensors, countermeasures, etc.), rose to the forefront of aircraft evolution. This second phase enabled aircraft with dated performance characteristics to gain the advantage in a combat scenario due to its superior ability to detect military targets of interest or remain undetected itself. The purpose of this thesis is to describe the next phase in military aircraft evolution: the integration of military aviation assets via data links to accomplish a network-centric plan for sharing and passing critical information between aircraft and ground stations. This thesis proposes an Information Systems Management concept for military aircraft to ensure that aircraft conducting specific missions maximize their effectiveness by receiving or transmitting the appropriate information focused towards the overall success of the military operation. Discussion begins with current and future military aviation mission requirements. Concepts are developed for connectivity and interface requirements to include human factors involved with aircrew to system interface as well as discussion of appropriate frequency spectrum and transmission bandwidth. Finally the acquisition strategy and program management requirements to enable such a concept to come to fruition are reviewed. Research for this concept is based on analyzing military mission requirements, review of current aircraft and systems capabilities, and projection of future mission requirements and technologies available.

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LIST OF ABBREVIATIONS

CAS	Close Air Support
C2	Command and Control
C4I	Command, Control, Communications, Computers and Intelligence
COTS	Commercial Off the Shelf
DCA	Defensive Counter Air
DSS	Decision Support System
EHF	Extremely High Frequency
HF	High Frequency
HMD	Helmet Mounted Display
HUD	Heads-up Display
JTRS	Joint Tactical Radio System
LAN	Local Area Network
LOS	Line of Sight
MFD	Multi-function Display
OCA	Offensive Counter Air
OTH	Over the Horizon
SOCOM	Special Operations Command
TTP	Tactics, Techniques and Procedures
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequency
VHF	Very High Frequency

CHAPTER I

INTRODUCTION

Since the introduction of airpower into military conflicts, strategists have continued to find more effective ways to utilize aviation assets for the accomplishment of military objectives. Initially through the increase in aircraft performance, then with the advancement of on-board sensors, weapons and survivability equipment, aviation platforms have evolved into the first-line weapon of choice in most modern day conflicts. In recent military operations ranging from Operation Desert Storm in the Persian Gulf to Operation Enduring Freedom in Afghanistan, airpower has been primary to achieving military success. While gains in aircraft performance and improvements in organic weapons and sensor technology have leveled off in recent years, the networking of aviation assets in a way to achieve maximum synergistic effects of all platforms has yet to be fully developed.

The integration of organic sensors, weapons and survivability equipment first brought a synergistic effect to individual aircraft. The data linking of aircraft within specific mission areas, primarily isolated to the air to air and air to ground missions, has achieved great success recently by closing the "sensor to shooter" loop. However, these isolated success areas have produced limited scope systems rather than an efficient network based information sharing force. Linking *ALL* aviation platforms to each other along with the interface to command and control centers as well as ground and sea based operators will achieve the ultimate synergistic effects of a technologically advanced joint military force.

The concept of linking military platforms is not new, and is part of an overall military transformation plan that has been voiced by leaders of the armed services. When discussing the advantages of using multiple airborne sensors to "build a mosaic" of the battlefield picture, James Roche, the Secretary of the Air Force, said the service recognizes that no one sensor system or platform can provide consistent coverage, "If we try to make any one system solve the problem, it will get phenomenally expensive and I don't know how we do it." He adds: "the challenge is to have an integration of our systems so that we benefit from their contribution to the battlefield."[1] Lieutenant General John Riggs, lead for the Army's modernization effort, says "the challenge of the future isn't building a great infantry carrier or artillery piece, the challenge is building a system that ensures we get the right information to the right place at the right time on the battlefield."[2] Secretary of the Navy, Gordon England, proclaimed, "Networked systems and sensors may be more important today than sheer numbers of weapons platforms." The Navy recently established the Naval Network Warfare Command for the purpose of pursuing a concept that calls for linking ships, aircraft and ground forces in elaborate electronic networks that allow them to share information about the enemy instantly.[3]

Each of the armed services foresees, then, the requirement for a higher level of network integration. This thesis will address this issue by developing a concept for Information Systems Management. The purpose of Information Systems Management is to maximize the

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[1] Michael Sirak, "Interview with James Roche - Secretary of the U.S. Air Force," Jane's Defence Weekly, (January 9, 2002)
[2] Greg Jaffe, "Military Feels Bandwidth Squeeze as the Satellite Industry Sputters," Wall Street Journal, (April 10, 2002)
[3] Matthew Dolan, "Navy Unveils Its Network Command," Norfolk Virginian-Pilot, (July 12, 2002)

effectiveness of aviation platforms in a military theater of operations. This concept would be expected to eventually produce a seamless, end-to-end network comprised of sensors, command and control nodes, and weapons platforms. The outcome of this concept must meet several criteria. First of all it must encompass all airpower missions to be truly effective with further links to ground and maritime platforms or operators. It must not only take advantage of the latest technological systems available, but must be capable of being easily expanded or improved upon as future technologies or mission requirements develop. Finally it must be developed with a Joint Mission Area concept in mind under a Joint Program Office to preclude issues of incompatibility between individual services or users.

While the emphasis of this thesis is to map out a concept for use among military aviation assets, the caveat must be included that linking aviation assets alone is not the complete solution. While airpower, through its evolution and maturity, has achieved great success in recent conflicts, it cannot accomplish military objectives alone. Airpower along with ground and sea forces must work in a combined working relationship. Airpower cannot maneuver in the classical sense, and it cannot prevent reoccupation by enemy ground forces. The connectivity requirement described in this paper must be continued with links to and between ground and maritime forces to ensure the objectives of any future military operation are fully achieved.

CHAPTER II

BACKGROUND

The first use of an aviation platform during a military operation by the United States took place during the Civil War in 1861 when the Union army used a manned balloon to observe Confederate troop locations. Even prior to this, the French had successfully used balloons in campaigns against the Austrians at the end of the 18th century.[4] The Wright brothers made the first successful controlled, powered flight in 1903, and in 1908 the Army signed the world's first contract for the delivery of a military airplane. As time passed, innovative airmen began taking firearms aloft and tossing homemade bombs out of the aircraft. This led to the installation of fixed mounted machine guns and bombsites to improve delivery accuracy, and ultimately to the broad use of airplanes during military operations in World War I. General "Billy" Mitchell, Britain's Lord Trenchard, and the enormously influential Italian General Giulio Douhet were the leading air power advocates who exposed the enormous potential of air power in future battles.[5] New tactics and procedures were developed in parallel with the evolution of aircraft performance capabilities. For example, U.S. Marine Aviators developed the dive-bombing technique during operations in Haiti that led to more accurate ordnance delivery through the dense jungle cover. It was also during this period that the Marines were credited with developing primitive close air support techniques for providing fire support in close proximity to ground

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[4] David A. Anderton, The History of the U.S. Air Force, (New York, Crescent Books, 1981), p. 10.
[5] Bill Gunston, American Warplanes, (New York, Crescent Books, 1986), p. 7-13.

forces.[6] Other developments such as in-flight aerial refueling, "blind flying" cockpit instrumentation and radio direction aids for long range navigation flights further increased the potential for aircraft in combat.[7] World War II saw the proliferation of air power; the final biplanes were phased out and by the end of the war jet-powered aircraft along with the use of radar for tactical advantage opened the doors to the future. In 1944 alone the Department of Defense formally accepted 95,272 airplanes. On 6 August 1945 a B-29 Bomber named Enola Gay dropped the first atomic bomb ever used against an enemy on the Japanese city of Hiroshima, and the world entered a new age of incredible yet dangerous power. "The war was won by all the armed forces of all the Allies, but never again would any sane observer underplay the central role of *air power* in human conflict."[8]

During the post-World War II years, the development of aircraft expanded in several directions and was put to test at war in Korea, Viet Nam, and Southwest Asia. During the Cold War long range, jet engine powered bombers were developed to provide deterrence for the emerging nuclear threat along with aircraft specifically designed for reconnaissance and surveillance. Helicopters were brought into military service and were quickly put to use in the Korean conflict performing combat search and rescue, medical evacuation and troop transport missions. In Viet Nam the helicopter's role expanded to the gunship mission. Jet fighter aircraft pushed the Mach envelope and during the war in Korea, in order to beat the Russian built MiG-15, efforts were made to increase angle and rate of climb, and high altitude maneuverability. The ability to fly faster than sound seemed

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[6] Peter B. Mersky, U.S. Marine Corps Aviation 1912 to the Present, (Annapolis, MD, Nautical & Aviation Publishing Company of America, 1983), p. 20.
[7] Gunston, p. 12.
[8] Ibid., p. 16-19.

to lead naturally to supersonic warplanes, designed to reach speeds in the 3-5 Mach range. However, much of this development failed to progress due to structural and human constraints. While an airplane can travel very fast or maneuver, it cannot do both at the same time. The development of on-board systems to effectively give aircrews the tactical advantage rapidly took center stage in the evolution of military aviation platforms. One early example was the F-86 Sabre, which became the world's first automatic radar-directed all-weather interceptor. It could salvo rockets under computer control towards a box of sky where the computer predicted the enemy would be when the rockets arrived.[9] Today's modern fighters are judged not only on their ability to out perform adversaries through maneuverability or speed, but also on the performance capability of its weapons systems along with its radar and sensor equipment. The ability to remain undetected (or "stealth technology") through either active or passive means has also become a major design criterion. As early as 1936 the "Father of Radar", Sir Robert Watson Watt pointed out that in an electronic world, survivability will increasingly depend less upon speed or altitude, and more upon trying to remain unseen. "Unseen" in this context means invisible to the eye, undetected by radar or infrared, and not heard.[10] More and more on-board systems have been added to aircraft to increase their combat effectiveness. Aircraft are tied in with other aircraft and ground stations through tactical data links, which further increase the information flow to the cockpit. These data links enable aircraft to be much more capable than were the original aircraft acting by itself. However, because many of the data link networks only serve a

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[9] Ibid., p. 21-25.
[10] Ibid., p. 26.

single service or mission area, only a limited portion of the U.S. air forces are able to take advantage of the available information.

In a seemingly total separate development, the 1950s marked a monumental transition in the United States from the industrial era to the information era. It was during this period that the number of employees whose jobs were to primarily handle information surpassed the number of industrial workers, and by the 1970s information workers exceeded 50 percent of the entire work force.[11] As the flow of information increased and information overload led to many operations coming to a standstill, organizations were forced to develop an information systems management plan to sort out and prioritize data. In the same sense, the need to develop a focused plan for interoperability and management of all military aircraft platforms under a single information systems management concept would unleash immense potential not otherwise realized.

While the evolution of air power in a relatively short period of time is somewhat of a phenomenon in terms of military weapons, the lack of interoperability and compatibility has also caused severe shortcomings. Several of these shortcomings involved the communications and network compatibility between aircraft and with ground units. During the 1991 Gulf War an Air Force AC-130 Gunship was shot down resulting in the death of 14 airmen on board. The AC-130, which normally provided close air fire support to special operations forces, attempted to provide support to conventional ground forces. During the delay in linking communications between the ground force and the aircraft, the AC-130 was unnecessarily exposed to enemy surface to

[11] Barbara C. McNurlin and Ralph H. Sprague, Jr., Information Systems Management in Practice, Fourth Edition (Upper Saddle River, New Jersey, Prentice Hall, 1998), p. 2.

air missile fire and shot down. In 1994 Air Force fighters on a combat air patrol shot down two Army UH-60 Blackhawk helicopters killing all 26 on board in the northern no-fly zone of Iraq, partially due to ineffective combat identification equipment and the inability of either the fighters or airborne early warning command and control aircrew to identify the existence of friendly helicopters in the area. Each of these incidents, while tragic, builds a stronger case for a common information systems management concept among combat aircraft in the U.S. armed forces to provide not only combat identification for prevention of fratricide, but a common tactical picture for more effective and efficient execution of air power missions. In the fast pace of modern warfare, the need for platforms to be on a common network of communications cannot be overstated. The time has arrived for such a common information systems management concept.

CHAPTER III

METHODOLGY

This thesis was initiated on the ideal that a modernized method of communications and information flow among various military aircraft platforms could unleash a potential not yet realized. The highly successful modernization of information systems management within organizations in the private sector gave birth to the idea that the process in military aviation could be immensely improved. Research began by analyzing various missions performed or supported by military aircraft. While critical battlefield information from various sources often exists, getting it to the right platform or user at the right time to achieve undeniable mission success falls short in many instances.

After a basic concept for information systems management for military aviation operations was developed by the author, a variety of reference materials were explored to further refine and optimize the original concept. Initially, military doctrinal publications were reviewed to present an overall understanding of *how* the military expects to operate its aviation assets to achieve tactical success. Several books focused on military aviation history were reviewed to fulfill a perspective on where military aviation has progressed since its inception. Next, periodicals were searched for reviews of the performance during recent and current military operations, along with individual armed service proposals of projected modernization requirements to include acquisition strategies. In order to inject a viewpoint with "best corporate practices" in mind, several modern

Information Systems Management textbooks were reviewed. These provided an "out of the box" perspective for military improvements based on modern business practices. Periodicals were vital for reviewing current industry standards due the fact that computers, communications, network capabilities, etc. are such a fast growing and changing sector.

The following subjects, while intricately related to such a project, are considered beyond the scope of this research and were therefore not discussed:

- Cost of project development and implementation
- Military Land and Sea network integration
- Allied/coalition partner integration
- Use of secure/encrypted communications
- Challenges of transitioning to such a concept from current communications networks

The end state of this thesis is a concept from which the framework for an information systems management plan could be drawn. Unknown factors that will undoubtedly arise in the future will force the plan to be flexible and expandable; however, a solid foundation on which the plan is based is required for any hope of success.

CHAPTER IV

OVERVIEW OF INFORMATION SYSTEMS MANAGEMENT CONCEPT

In today's corporate world, the use of technology products is widespread. It is often the management and application of technology that spells the difference between success and failure. This statement equally applies to utilization of information technology resources in military aviation operations. A classic information systems management objective has been to "get the right information to the right person at the right time." This goal was sufficient as early efforts to apply information technology resources were incorporated into operations. However, considering the potential of systems being offered today, goals or objectives such as these are limited and shortsighted, and must be taken a step further. Even "the right information" objective fails to ensure that something useful *results* from the delivery of information. A more appropriate focus for directing the use of information systems in organizations is "to improve the performance of people in organizations through the use of information technology."[12] The ultimate objective is performance improvement; a goal based on outcomes and results rather than merely links or steps in a process. The concept for an information systems management strategy must encompass full spectrum, end to end integration of modern information systems tied through a robust network to all aviation users in the military battlespace with appropriate links to higher headquarters and external supporting agencies.

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[12] Ibid., p. 12.

Before embarking on a concept for management of information in military aviation operations, the basis for using information must be explored. Information serves two primary purposes in military operations: to help create situational awareness as the foundation for decisions and, to direct and coordinate actions in the execution of decisions. Two basic questions must be answered to effectively use information management. The first is, "What information does the organization need?" The second is, "What technology can be used to manage this information?" Unfortunately, both in the corporate world and in the military, the tendency is to focus on the second question while ignoring the first altogether. Technological solutions are often developed and fielded without a clear understanding of the actual "problem" they are supposed to solve. A recent survey by the firm Ernst and Young of over 400 U.S. and European corporate firms concerning the perspectives on information in the organization found that 87 percent saw information as critical to their ability to compete. Even with this understanding, 44 percent of these organizations felt they were poor or very poor at managing information. The top three reasons stated for this assessment were the failure of top leadership to emphasize the importance of information in the organization, a lack of understanding of the organization's information management strategy, and the organization's structure creating an institutional bias against freely sharing information. Military organizations are plagued by many of these same problems.[13]

For military operations in particular, the model for a system which supports information systems management in tactical aviation operations should be based on a Decision Support System (DSS) defined

[13] "Information Management," Marine Corps Gazette, (October 2002), p. 12.

as a "computer based system that helps decision makers confront problems or situations through direct interaction with data and analysis models."[14] Figure 1 illustrates such an information flow model developed as a four-step process.

The first step in this model is the collection of all relevant data and information. The data and information collected may include but is not limited to the following: all known friendly and enemy force information for the theater of operations, operations orders or the Joint Force Commander's framework for achieving military objectives, weather and geographic data for the area of operations. The data and information collected would quickly overload most users; therefore, in the second step it must be processed and directed to the right commanders and staff members for them to assess, make decisions and further direct the course of the conflict. It is also during this

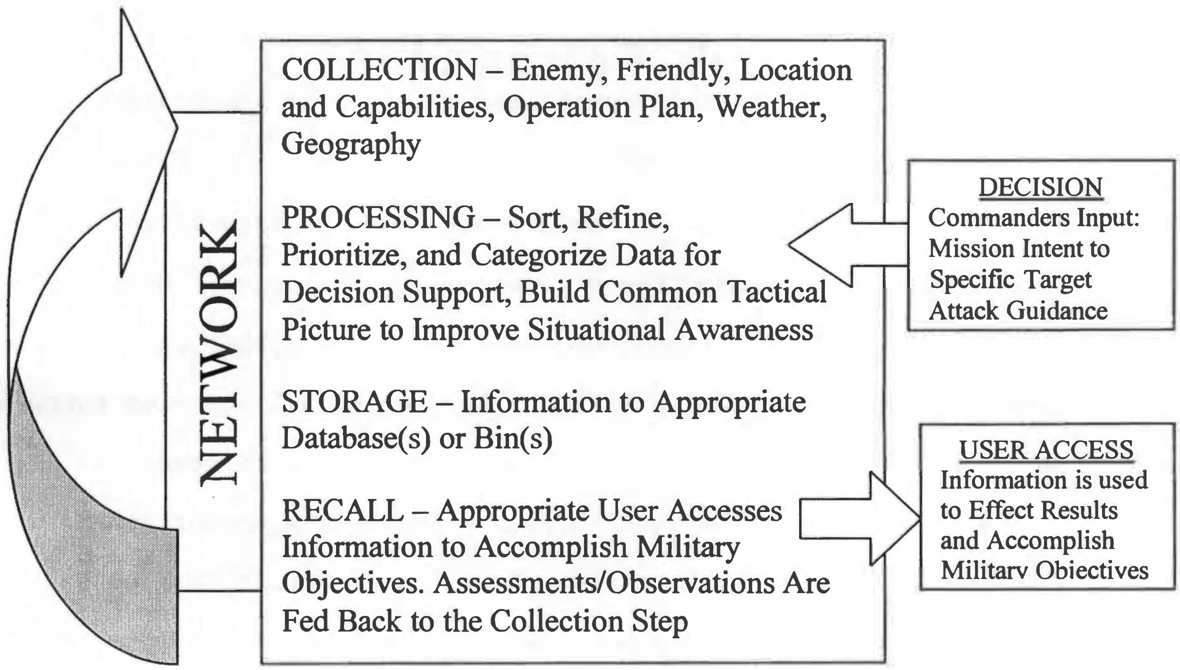

Figure 1

[14]McNurlin and Sprague, p. 368.

step that the processed information is used to expand situational awareness by building a common tactical picture of the battlespace. The processed data and information will be directed to an appropriate storage location for future retrieval in the third step of the model. The method in which data is filed for storage must support retrieval by appropriate aviation users as needed during the execution of their mission, thus completing the fourth step in the process. Finally, battle damage assessments and observations are fed back into the collections step as the process remains in continual motion.

In reviewing lessons learned from current decision support type information management systems, several challenges must be met to achieve the ultimate goal of the system. The first challenge is achieving a common architecture for all users of the network. Each user interface must be viewed as a "window" into the information database. Common dialog architecture will allow access to all information resources available. Just as software for personal computers is written to be compatible with one of the major operating systems, applications on such a network must be compatible for interface with all users on the network from the futuristic jet fighter in the sky to the ground based forward air controller. Secondly, connectivity must be established with all users either participating in operations in a particular military theater or all agencies supporting that particular theater of operations. Connectivity means the ability to connect user workstations through a local area network (LAN) or even wider links such as between LANs through an internet type network. Connectivity also requires a bandwidth or data transfer rate to accommodate the interchange of large files, graphics and figures, digital images, photographs, and video. Thirdly, data storage must be organized in such a way that pertinent information (and only the pertinent information) can be quickly accessed to support a battlefield decision or pushed to an end user or "trigger-puller" to aid or enhance accomplishment of a mission. Whether using a data-pull or data-push concept, sorting the data appropriately and defining the paths for connecting data warehouses to data users is critical to achieving success. The final challenge is the further development and integration of "Expert Systems" to analyze and sort data or solve problems.[15] In the way that a calculator solved for the previous "busy work" performed on a slide rule, expert systems would be able to manage or process the vast amount of data collected and provide succinct answers to define what the data means to the user.

Remembering that the ultimate goal of an information systems management concept is to improve performance through the use of information technology, the first step in developing such a management system must be to identify the information needs of the user. A study of the applicable military aviation missions and data requirements is the starting point in determining the framework for information systems management needs. The following section will introduce the missions and provide an overview of information and interface requirements.

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[15] Ibid., p. 390-391.

CHAPTER V

MILITARY AVIATION MISSIONS AND REQUIREMENTS

In an effects based evaluation process, performance by the end user is often the yardstick by which a system is graded. In order to understand the level of results required, a study of the missions performed by military aviation platforms along with the requirements tied to each mission is warranted. The six missions discussed below are not an inclusive list of all missions which military aviation platforms perform, however, to limit the scope of discussion the list is representative of the most common missions performed and is sufficient to reach the conclusion of this thesis. It is an important distinction that the missions discussed below are not directly linked to specific aviation platforms in the current or future U. S. Military inventory. Each mission is performed by a variety of aircraft while conversely most aircraft are designed or adapted to perform a multiple array of missions. It should also be noted that definitions used for the missions described below come primarily from Joint doctrine. Different services of the U. S. Armed Forces have alterations in the definitions of these missions.

Counter Air

The function of counter air is to facilitate friendly operations against the enemy and protect friendly forces and vital assets by achieving air superiority or control of the air. Air superiority is defined as the degree of dominance permitting friendly aviation operations at a given time and place without prohibitive interference from the enemy.[16] This mission is considered of utmost priority because without air superiority, additional missions involving military aviation assets can not be performed without unacceptable loss of personnel or equipment. Air superiority within a specified theater of operations is defined by both location and timeframe of operations. This mission is conducted through several means ranging from direct attack by either ground or air launched munitions, suppression through electronic warfare or a multiple array of passive measures.

Counter air is directed against enemy forces that directly challenge control of the airspace (airborne fighters, surface to air missiles, etc.) or assets that affect airspace control indirectly (airfields; petroleum, oil and lubricant facilities; production facilities; etc.). Counter air is further broken down into two separate categories: offensive and defensive counter air. Offensive Counter Air (OCA) consists of operations aimed at destroying, disrupting, or limiting enemy air and missile threats. OCA operations include targets such as enemy air defense systems, airfields, sea and air based launch platforms, as well as command, control, communications, computers and intelligence (C4I) nodes. Defensive Counter Air (DCA) is protecting friendly forces and vital interests from enemy air and missile attacks and is synonymous with air defense. DCA consists of active and passive air defense operations including all defensive measures designed to destroy attacking enemy air and missile threats or to nullify or reduce the effectiveness of such attacks.

Information vital to the counter air mission includes location, status, and capabilities of enemy fighter aircraft; location, status

[16] Joint Publication 1-02, Department of Defense Dictionary of Military and Associated Terms, (24 March 1994 ed.)

and capabilities of enemy ground based air defenses; as well as specific details regarding enemy integrated air defense system networks. Because of their speed and ability to create havoc with their organic weapons, location of enemy fighter aircraft must be available near real time. Due to the high mobility of modern ground based air defense systems, update of enemy ground based air defense locations should be maintained within minutes of movement. While friendly air superiority aircraft are equipped with sensors to detect air or ground based threats, they primarily depend on cueing from airborne early warning aircraft or other surveillance assets. Some modern fighter and surveillance aircraft are able to share a common picture through the Joint Tactical Information Distribution System or link 16. However, since not all aircraft or surveillance assets are compatible or able to interoperate with link 16, not all friendly assets are able to share, receive or participate in cooperative engagements. In a fully functioning network any aviation asset, regardless of service or mission being performed, should be able to access the most current tactical picture regarding enemy air threat assets in a given area of operations and use this information while conducting their respective mission. In addition, aircraft performing the OCA mission must be able to receive, in a timely manner, clearance to attack from higher headquarters, especially when rules of engagement are not clearly defined from the issued commander's intent.

Most platforms performing the counter air mission are fixed wing aircraft (fighters and airborne early warning/surveillance assets), which operate at altitude permitting effective use of line of sight (LOS) communications. The current use of Very High Frequency (VHF) and Ultra High Frequency (UHF) frequency bands prove adequate. However, communications with ground or even airborne command and control centers may require an over the horizon (OTH) capability. In this case a requirement to use satellite links or other relay station means becomes a requirement. In tactical application, an airborne early warning platform should be in flight at all times when performing the counter air mission. Maintaining LOS capabilities between the airborne early warning platform and the fighters should be adequate, however, providing an OTH capability between the airborne early warning platforms and both surveillance platforms and ground command and control agencies will be an essential capability.

Ground Attack

Ground attack involves operations conducted to attain and maintain a desired degree of superiority over surface operations by the destruction or neutralization of enemy surface forces. It can be used to directly achieve military objectives through destruction or neutralization of a target, as a preparatory or shaping action for follow on operations, or in concert with friendly ground forces in a fire and maneuver type operation. It is generally broken down into two separate categories, air interdiction and close air support (CAS). Air interdiction encompasses air operations conducted to divert, disrupt, delay or destroy the enemy's surface military potential before it can be used effectively against friendly forces. Air interdiction missions may be conducted with the intent to strike preplanned targets or strike targets of opportunity within a specified area of operations. The second category, CAS, is conducted to achieve the same objectives as air interdiction; however, it is performed within close proximity to friendly forces further requiring the detailed integration of each air mission with fire and movement of friendly forces.[17] For ground attack missions to achieve desired success, they must be coordinated through a single Joint Forces Commander *and* from the impetus of this thesis, be connected to the same information network. Both fixed and rotary wing aircraft perform the ground attack mission.

Information critical to the ground attack mission includes any updates to the location or status of pre-planned targets or identification and targeting details regarding targets of opportunity located by ground forces or surveillance assets. In the latter case, this "sensor to shooter" link has received immense attention during recent military operations and is the focus of many senior airpower officials. The U.S. Air Force has begun efforts to develop a Multi-sensor Command and Control Aircraft to perform the mission now being done by several specialized aircraft. Air Force Chief of Staff, General John P. Jumper recently stated, "The objective is to shorten, as much as possible, the 'find/fix/track/target/engage/and assess' loop, which is our definition of the 'kill chain.' [The goal] is to be able to accomplish the part of this that relies on our sensors and shooters…in less than 10 minutes." If this can be done, he went on to explain, ample time would become available for the commander to devote to the "decision piece" of the engagement cycle-the time that's normally consumed by such related considerations as the rules of engagement in effect for a particular operation and the procedures to limit collateral damage.[18] In addition to the targeting information required to successfully perform a strike mission, information such as current friendly ground force locations to include covert special

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[17] Joint Publication 3-09.3, Joint Tactics, Techniques and Procedures for Close Air Support, (1 December 1995 ed.)
[18] John G. Roos, "Holding the Heading, Interview with USAF Chief of Staff," Armed Forces Journal International, (May 2002), p. 41-42.

operations teams, and fire support coordination measures in effect are essential to be passed to *all* aircraft performing missions within a theater's battle space. Such a goal could only be achieved by fully embracing a common information sharing network concept. A recently published naval document, "Naval Transformation: Roadmap, Power and Access from the Sea. Sea Strike. Sea Shield. Sea Basing." supports proposals for a transformational network concept. This paper states, "One approach being pursued focuses on improving battle space awareness and reducing the time needed to carry out strikes against mobile targets by speeding the flow of information from intelligence and surveillance sensors to tactical controllers. Future sensors will include systems such as the Space Based Radar, Broad Area Maritime Surveillance Unmanned Aerial Vehicles and penetrating 'sensors,' such as the Ground Weapons Locating Radars… all interoperable with the Naval Fires Network and Joint Fires Network."[19]

Many times the spotter or ground forward air controller may not be from the same service branch as the aircraft conducting the ground attack. Interoperable communications equipment is essential to mission success. Long standing CAS tactics, techniques and procedures (TTP) require a standard voice transmission from the ground controller to the CAS aircraft, commonly referred to as the "Nine line brief", for the nine lines of essential information passed. Technology for the information contained in the nine line brief to be passed directly to the CAS aircraft digitally is now available and reaching a mature stage. This technique holds great promise by eliminating the chance for human error that is possible when transferring this information by

[19] Bill Gertz and Rowan Scarborough, "Inside the Ring," Washington Times, (26 July 2002), p. 10.

voice, as well as building situational awareness both on the ground and in the air by displaying additional location, status, and fire support coordination information for both parties. Air Force Chief of Staff, General Jumper, has placed particular emphasis on such a capability. "Ideally, the information that's fed from the ground would be directly entered into the airplane's weapons computer. With that done, a pilot would simply have to confirm the accuracy of the relayed information, rather than enter the information on a keypad aboard the aircraft, as is the case today."[20] Technology will soon take the digital nine line brief technique from the drawing board to the battlefield; however, total success will not be realized unless *all* ground controllers and spotters along with *all* ground attack platforms are equipped with interoperable communications equipment. A recent Department of Defense Joint Test and Evaluation study of CAS techniques reemphasized this point. "A key element in the success of units integrating and applying TTP for Joint CAS is the acquisition by different services of interoperable equipment. It is particularly essential for both voice and data communications."[21] In the ground attack mission, OTH communications among participating platforms is an essential capability. Because time sensitive targets require immediate attention, these OTH capabilities must have the highest availability to ensure mission success.

Air Assault

The air assault mission is the tactical movement of ground combat forces throughout the battle space in conjunction with the ground

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[20] Roos, Armed Forces Journal International, p. 46.
[21] Colonel David R. Brown, USAF, "Rethinking Close Air Support," Armed Forces Journal International, (February 2002), p. 22.

scheme of maneuver. This mission is generally associated with rotary wing assault helicopters but could also be performed by fixed wing aircraft through parachute operations or other aerial delivery techniques. Unlike counter air and ground attack, this is one of the least digitally networked missions today. One reason for this low technology status is the perception that little coordination with other units or surveillance systems is required because the mission merely involves "flying trucks." In reality, these aircraft are just as likely as attack aircraft to have contact with enemy forces as well as the fact that it is essential for all maneuver elements to move in concert with established fire support plans. Once de-barked from the aircraft that delivered them to the battlefront, ground forces must be able to immediately communicate with air assets for CAS and enemy situation updates as necessary. Continuous communications and network updates with such air assets while embarked on assault aircraft is essential to fighting in the single battle concept.

Information critical to assault aircraft serves two purposes. First it updates the aircrews to enemy threats as well as friendly positions and fire support plans in effect. Additionally it is used to continuously feed the ground force commander during his troop movement and provide him the best situational awareness possible the moment he steps off the aircraft. In the reverse aspect, this link in the network would also serve as the combat identification measure to prevent possible fratricide incidents, such as the U.S. Army Blackhawk shoot down in 1994 by friendly combat air patrols in northern Iraq. Information essential to the air assault mission includes enemy ground force and ground based air defense locations, as well enemy aircraft if air superiority has not been achieved. Friendly disposition requirements include ground force locations, fire support coordination measures in effect, and location of friendly air assets for collision avoidance awareness. Since these missions are often flown at night, low level, in black out conditions, it is essential to provide the aircrew with the appropriate situational awareness tools. The low level nature of this mission also requires the capability for OTH communications capability. There are often times when the separation between users or effects of terrain masking prohibits LOS geometry between air assault assets. Additionally, ground force command centers with a high interest in mission status require the capability for continuous progress updates. During many mission scenario situations there will not be airborne radio relay platforms available; therefore an OTH communications capability for the air assault mission will be required.

Surveillance and Reconnaissance

The act of conducting surveillance and reconnaissance is the oldest mission performed by aviation for military purposes. It can be described as the systematic method of obtaining, by visual observation or other detection methods, specific information about the activities and resources of an enemy or potential enemy; or in securing data concerning the meteorological, hydrographical or geographic characteristics of a particular area.[22] While early military reconnaissance missions merely involved flying an airship or airplane within visual sight of an area of interest, today's platforms incorporate some of the most advanced technological systems available. The wide array of platforms being used goes well beyond the single

[22] Joint Publication 3-09.3

piloted airplane and ranges from satellites and unmanned aerial vehicles (UAV) to commercial airline equivalent aircraft with a host of specialized sensor equipment and highly trained aircrew. It is the information gathered by such platforms that feeds a large portion of the national intelligence structure. These platforms are often kept clear of harms way through altitude or stand-off range, or the use of stealth technologies, with the possible exception of UAVs. A secondary or implied mission of all military aircraft, however, is the reporting of any relevant enemy location or activity identified while performing the respective primary mission. A sophisticated network is required to link the information absorbed by the sensors of reconnaissance aircraft (human and electronic) to national reconnaissance sources so that the information can be processed and distributed appropriately. Because of the remote location of sensors or assets performing this mission, OTH communication links are essential and must be thoroughly integrated into the theater communications plan.

Tactical Airlift

Tactical airlift encompasses the logistical movement of personnel and supplies into a theater of military operations or within rear areas of the area of operations. A primary distinction between this mission and air assault is that tactical airlift is merely the logistical staging of personnel or supplies while the air assault plan is embedded in the tactical scheme of maneuver. The importance of logistical movements, however, cannot be underestimated. For without logistical support to military operations, all activities for a given area of operations would come to a screeching halt. Tactical airlift is supported by large military transport aircraft for the deployment and sustainment of personnel, equipment and supplies into a military theater of operations. Intra-theater tactical airlift may be supported by fixed or rotary wing aircraft and involves the redistribution of personnel, equipment and supplies within a theater. Status of logistical build-ups transfers directly to in-theater troop strengths, which may be a determining factor or "trigger point" for commanders to decide when to commence a particular operation or delay. Additionally, logistical sustainment during an operation may dictate the pace at which an operation progresses. Critical decisions by battlefield commanders hinge on knowing the quantity of troops, supplies, and equipment (i.e. manifest or packing list), *where* they are presently, and *when* they are expected to arrive at a particular destination. Present day shipping companies have advanced the capability to provide customers with around the clock status of their shipped goods. The same concept must be applied to airlift into and throughout a military theater of operations in order to provide military commanders and planners with the critical information required to execute plans. The information network is the ideal means to transmit all essential information during tactical airlift. In addition to providing troop manifests, and supply and equipment packing lists, the network could be used to divert or re-prioritize shipments. It could also be used to update troop commanders on board airlift assets, enabling them to receive continuous operational updates to ensure they are ready to hit the ground running upon arrival. The great distance traveled by tactical airlift assets dictates the use of OTH communications.

Command and Control

Command and control (C2) is the battle space management process of planning, directing, coordinating and controlling forces and operations.[23] It may include the management of all forces during a specific mission in an area of operations or it may be limited to the control of aviation assets alone. Command and control of military forces by definition is not a mission, but rather a function performed by military headquarters from strategic down to the tactical level. C2 is addressed with the other mission areas in this section because the platform that often houses the headquarters performing C2 is considered a C2 platform. While the most common C2 headquarters are ground or sea based, for shorter periods of time during a limited scale operation or for C2 of a limited sector of operations, an airborne platform may be utilized. Airborne platforms used for this function may range from commercial airline equivalent aircraft equipped with a complete command center suite to a much smaller aircraft with a single mission commander having voice transmission capabilities alone. Aircraft may also act as the critical relay node for command and control functions where direct line of site communications is not possible.

The most important product of a C2 headquarters is a *decision* intended to create progress towards achievement of a military objective. One goal of incorporating information technology into a C2 system is to achieve increased situational awareness to facilitate the decision making process. A discussion of C2 system elements required to create increased situational awareness can not be complete without detailing the components of a C2 system. For at least 50 years the Department of Defense has defined C2 systems as: "…the facilities,

[23] Joint Publication 3-09.3

equipment, communications, procedures and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the missions assigned." When forming a network designed for communications it is easy to focus on the "hardware" aspects of such an acquisition, i.e. the facilities, equipments and communications from the list given in the definition above. Any effort to create a C2 system that ignores or overlooks the other two critical aspects, procedures and personnel trained in these procedures will have significant problems. Information overload rather than increased situational awareness would be one of the apparent downfalls.[24] Therefore in creating the management concept for networking of C2 systems, the procedures to manage information must be published with the arrival of the hardware which makes up the network. By the same token, personnel trained to carry out the prescribed procedures must be available to run a C2 network. Without all components in place, the potential of a network based C2 system will never be realized and in turn will eventually lead to its failure.

C2 platforms are the "hub" of military operations. They must be able to receive information from a host of sources, ranging from the surveillance and reconnaissance assets providing enemy force disposition and location, friendly positions and status, as well as orders and intent from higher headquarters. Because C2 platforms must be able to communicate globally, a robust OTH communications capability is a must. C2 platforms will also require the largest bandwidth allocations because of the vast data and information they must transmit and receive.

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[24] Lieutenant Colonel Peter Morosoff USMC(Ret.), "Finding the Road Ahead for Information Technology by Looking Into Technology's Rearview Mirror," Marine Corps Gazette, (August 2002), p. 43-45.

Interfaces and Human Factors Considerations

The paramount objectives expected from a well-designed cockpit interface include reducing crew workload associated with weapons engagements, intelligence reporting or mere conduct of the mission along with improving situational awareness for all crewmembers. Crew workload may be described as a state the pilot's or aircrew experience when meeting the demands of tasks imposed by the system, given the limited mental resources that he has available. Flying in combat can often produce either actual or perceived workload to an excessive degree, which can lead to any of the following adverse effects on performance:

- Performance in high workload tasks may degrade
- The pilot or aircrew may "shed" tasks
- The pilot or aircrew may be forced to shift strategies to perform tasks differently[25]

Like workload, situational awareness may be considered an experienced state that cannot be directly measured except on subjective scales, but which has a direct impact on performance. Situational awareness refers to the pilot or aircrew's awareness of the transient changes in the state of the aircraft systems, location, environment or progress of a particular military operation, such that he will be able to react appropriately if unexpected circumstances require a quick response to those states. Situational awareness and workload are often related to each other, in a reciprocal fashion, through the "fulcrum" of automation. That is, automation, which is often designed to reduce

[25] Jon Weimer, Research Techniques in Human Engineering (Englewood Cliffs, New Jersey, Prentice Hall PTR, 1995), p. 117.

workload by requiring the operator to do less, may degrade situational awareness by pulling the operator out to the loop, thereby curtailing an engagement in which the necessary cognitive activity had previously forced the operator to remain current with system states. Reducing workload can also work in a positive manner in that reducing the workload associated with certain tasks may allow the aircrew to more easily absorb information and perform required tasks, thus increasing situational awareness. Whether in the management of aircraft systems and flight paths for the pilot, or in providing assistance and guidance as an air support or terminal aircraft controller, a major design challenge of operator interfaces is to establish ways of reducing workload to appropriate levels, while building vice destroying situational awareness.[26] One example of using advanced technical systems to both reduce workload and enhance situational awareness was the Defense Advance Research Projects Agency's "Pilot Associate" program. This program attempted to integrate computer technology, decision support systems and artificial intelligence into an intelligent interface that could be used by pilots of tactical aircraft to increase operational performance by reducing physical and mental workload while increasing situational awareness.[27] Pursuit of similar designs to achieve an increase in aircrew performance and efficiency will be a primary consideration when enacting an information systems management concept.

Considerations with regard to pilot or operator interface vary with the particular mission being performed, the information being provided, and most importantly the environment within which the user

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[26] Ibid., p. 118.
[27] Ibid., p. 417.

performs his duties. For example, the interface standards and requirements for the pilot of a single seat aircraft vary significantly from a ground based forward air controller. Even the requirements of a systems operator in the cabin of an airborne command and control platform vary significantly from the dynamic needs of the pilot. Regardless of the platform, a few basic requirements must be met.

The gateway for delivering information to a particular platform is a data link capability with the capacity to receive and transmit data at a rate commensurate with providing a common tactical battlespace picture in real time. This common picture should be displayed on a color multi-function display (MFD) of sufficient size to allow readability and avoid fixation by the aircrew under day, night or adverse weather conditions. Most cockpits will require two or more MFD units per aircrew in order to present both the common tactical picture along with aircraft performance status. Various display options should be easily selectable, preferably without requiring aircrew to remove their hands from the primary flight controls.

As augmentation to the MFD, consideration should also be given to incorporating a heads-up display (HUD) or helmet mounted display (HMD) to further provide information, cueing and alerts to the pilot or aircrew while preserving the capability to maintain an outside the cockpit reference scan. HUD devices have long been used in tactical fixed wing aircraft, primarily as a pilotage and targeting reference. HMD devices have been predominantly used in rotary wing aircraft but also more recently in fixed wing aircraft with the advent of off-bore sight weapons capabilities. HMDs typically perform the following functions: 1) display pilotage or gunnery imagery from image intensifier or Forward Looking Infrared sensors, 2) present strategical, tactical, and operational data on demand, and 3) sense eye/head position and motion for the purpose of designating targets, directing sensors and weapons, and activating switches. Well designed HMDs should enhance aircrew situational awareness and increase mission effectiveness.[28]

The final cockpit interface needed to support the information systems management concept is some type of feedback device from the pilot or aircrew back into the network. This is typically done with a cockpit keypad device. Unfortunately, because keypads require a pilot to remove one hand from the primary flight controls along with a heads-down movement, keypads can adversely increase pilot workload in flight. While keypads may not be totally eliminated, emerging technologies should be considered to reduce dependency on them. Such considerations should include but are not limited to hands-on-control interface devices, voice recognition and touch screen technologies.

Ground command and control centers, tactical air direction centers and forward air controllers must also be considered for similar interfaces. Of importance, the personnel on the ground must have the capability to display the same common tactical picture of the battlespace, as well as access other relevant information to perform their duties. The ability to communicate back into the system with a keypad or similar device also applies. This is especially relevant for the forward air controller to send final attack guidance to ground attack assets.

Commonality of pilot and aircrew interface devices throughout military aircraft should be a major acquisition concern. Commonality

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[28] Clarence E. Rash, Helmet-Mounted Displays: Design Issues for Rotary Wing Aircraft (Fort Detrick, Maryland, U.S. Army Medical Research and Materiel Command, 1999), p. 12.

among platforms will not only reduce development costs, but also streamline upgrades and expansion as future technologies emerge. Other military avionics upgrade philosophies which should reduce costs and aid in keeping pace with new technologies include the following: open system architectures that provides maximum flexibility in choosing component suppliers, dual military specification and commercial data busses and input/output systems, maximum use of Commercial Off the Shelf (COTS) technology and computer processors using PC-based architecture.[29]

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[29] Nicholas C. Kernstock, "New Cockpits for a New Threat," Rotor and Wing, (April 2002), p. 18.

CHAPTER VI

INFORMATION PROCESSING AND DECISION MAKING

Information processing is perhaps the most important step in an information management decision support system. Collection assets now have the ability to quickly overload decision-makers and end users, which if not managed properly, can lead to a breakdown in the command and control process. "Overwhelming levels of raw intelligence from a range of sensors could lead to paralysis rather than decisive action. The ability of leaders to assimilate real time combat data and sort out vital information will be critical to success."[30] Developing a plan for the act of processing information is critical to mission success; the goal of which is to provide the decision makers and end users of the information with a complete set of applicable information, yet only the information that is applicable to avoid information overload. To further understand this challenge, the differences between the terms data, information, and knowledge must be defined. Data is comprised of facts. Information is data in context; it's meaning depends on the surrounding circumstances or usage. Knowledge is information with direction or intent; it facilitates a decision or an action.[31] To put these definitions into an applicable context, data may be the raw picture taken by a military surveillance asset. It becomes information when the location of a surface to air missile threat is extracted from the photo. It further becomes knowledge when it is determined that this threat may be in range to shoot down friendly aircraft, therefore it must be defeated before friendly air operations will be permitted in

[30] Barry R. McCaffrey, "Lessons of Desert Strom," Joint Forces Quarterly, (Winter 2000-01), p. 15.
[31] McNurlin and Sprague, p. 197.

that area without the risk of unacceptable losses. The goal of information processing is to decipher data and create information, which supports knowledge.

The actual act of processing information can be very time and manpower intensive. Information management specialists, personnel with both the operational background to decipher the relevance of inbound data and the technological background to divert information to the users who need it, are critical in this function. However, with the amount of data flow now available from advanced surveillance and intelligence gathering sources, the military can not depend on having the manpower to perform this processing function in a timely manner. A solution from the world of information systems management that should be explored is the use of so-called Expert Systems. An Expert System is a term for the real world use of artificial intelligence, a group of technologies that attempts to mimic our senses or emulate certain aspects of human behavior such as reasoning and communicating. An Expert System is a type of analysis or problem-solving model, almost always leveraging computer technology that deals with a problem the way an "expert" does. The solution process involves consulting a base of knowledge or expertise to reason out an answer based on characteristics of the problem. Its purpose is to offer advice or solutions for problems in a particular area. The advice is comparable to that which would be offered by a human expert in that problem area. Some of the specific uses expected from Expert Systems include assisting information management specialists with the flood of data, managing or directing the flow of processed information to users or data storage bins, diagnosing problems and supplying information needed to make decisions.[32] In the rapid pace of modern conflicts, well-designed Expert Systems to process data into useful information will be critical to the success on an information systems management concept.

The ultimate goal of information processing must not be lost while developing high technology decision support or expert systems. The needs of the information users, whether military commanders and decision makers, aircraft controllers, or pilots and aircrew themselves, must remain the primary focus. Information provided to specific users should further enhance execution of a mission or support making decisions. It must be relevant and timely, organized and succinct (i.e. presented so as to not overload the pilot of a single-piloted aircraft), and presented with sufficient background to enable the user to turn information into knowledge. A well-designed information processing solution may even allow for streamlining of the organization of military units and supporting agencies.

[32] McNurlin and Sprague, p. 423, 424, 436.

CHAPTER VII

NETWORK CONNECTIVITY

While exploring the importance of network connectivity, one must consider the significance of Metcalfe's Law, formulated by networking pioneer Robert Metcalfe. Metcalfe's Law: The utility of any network is a square of the number of users attached to it ($Utility = Users^2$).[33] Networks, whether of computers, railroad track, or speakers of a particular language, exert a kind of gravitational pull and the more nodes they have, the stronger the pull. The more members attached to a network, the heartier and more useful it becomes. An example of poor network effects was the early railroads. Early railroads in the United States did not settle on a standard track gauge until the 1880's, making interconnections between lines in the North and South complicated, slow, and expensive. The Internet on the other hand is a shining example of network value. The Internet is the network of the Information Revolution, a growing body of networking standards and other software that allows devices of all kinds to share information, not just data but video, voice, and someday perhaps taste and smell. The network's spread over the last ten years has demonstrated the Internet is the platform on which businesses can be built.[34] While the Internet is obviously not the network on which information management for military aviation can be built, it is a positive example of what direction to take. The network must have a standardized protocol and be accessible to all network users (i.e. *all* military aviation

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[33] Larry Downes, The Strategy Machine (New York, HarperCollins Publishers, Inc, 2002), p. 22.
[34] Ibid., p. 24-25.

platforms and supporting agencies). The more users, the more information will be shared and thus increased utility for all (Metcalfe's Law) as well as increasing efficiency for the senior military commander by ensuring all units under his control share the same information. The network must have the bandwidth to preclude virtual chokepoints or gridlock of information passage. A network system that bogs down and does not allow the timely passage of information is of no use on the fast-paced modern battlefield. The network must also have the continuity to ensure all users are available on the network at any given time through the use of appropriate transmission means and relay stations as required. A breakdown in the availability of any given user's ability to maintain a constant information flow on the network could spell sure disaster and cost lives.

Historical Use of Network-Centric Warfare

The use of networks to enhance the capabilities of military forces is not a new concept. The idea of network-centric warfare relies not only on organic sensors, but on a common tactical picture created by integrating enemy intelligence products and the friendly order of battle. With this picture, operators can synchronize actions without requiring minutely detailed written orders. Given the situational awareness offered by a netted picture, decisions can be made quickly and precisely. During World War II, U.S. and British naval fleets respectively developed combat information centers and action information centers, which gathered tactical pictures using on-board sensors and off-board data. Later, computers were to automate the process of assembling the picture to show more potential targets and the associated digital link make dissemination possible in near real time. Thus computers and data links, a revolution in naval affairs of the 1960s, determined the extent to which ships could cooperate tactically.[35] Digital tactical computers went to sea in the 1960s to receive, display and exploit a shared (netted) tactical picture. British and Dutch navies, in addition to the U.S., developed parallel systems and the tactical picture that ensued was shared by a standardized digital channel called link 11. This enabled dispersed naval formations to operate together in network-synchronized fashion.[36] While creating a common tactical picture generates numerous tactical advantages, it potentially creates additional problems as well when operating with units not tied in to the network. During Operation Desert Storm, only NATO member countries and Australia possessed the link 11 data sharing capabilities and associated tactical doctrines. When operating in the air defense zone of the northern Persian Gulf, other participating coalition warships could not share in the tactical picture, nor could land based U.S. Army Hawk air defense missile batteries. Even mine countermeasure ships were not connected into any computerized tactical picture even though they carried antiaircraft weapons. Fortunately, Iraqi aircraft flew few sorties, and the coalition air force was protected largely by a rigid rule that surface to air weapons were not to be used.[37] For all of the money, personnel and effort dedicated to the air defense mission, much of it stood near useless for fear of shooting down a friendly aircraft. Modern tactical aircraft accomplish a netted common picture through the Joint Tactical Information Distribution System or link 16. While the use of link 16

[35] Norman Friedman, "A Network-Centric Solution, Naval Operations in the Persian Gulf," Joint Forces Quarterly, (Winter 2000-01), p. 24-25.
[36] Ibid., p. 25.
[37] Ibid., p. 26.

is spread across the services to both U.S. Air Force and Naval aircraft, shortcomings still exist because it is limited primarily to tactical jet aircraft therefore still not providing the common tactical picture to all aviation platforms. Lessons learned from the past reveal that achieving true network-centric solutions cannot be realized without a common data network. Because of constantly changing world conditions and the price of doing business, it would be near impossible to provide a common network for all allied partners. However, it is essential to ensure that all U.S. armed forces are able to "log on" and receive the common tactical picture.

Bandwidth

The classic definition of the term bandwidth is "the frequency range occupied by a transmitter signal."[38] With the evolution of information technology and the heavy flow of data among various users by both hard-wired and wireless means, bandwidth has become the coined phrase of choice to describe the amount of data which can flow through a particular pipeline at any given moment. Relating the flow of information to the motor vehicle transportation network, the more lanes provided on a particular information highway, the more data that can be passed in a given period of time. As advanced sensor technology has increased the resolution or definition with which information can be gathered on a particular subject, i.e. a hostile target of interest, the ability to transmit that information to decision makers and end users has become stretched. As an example just one Global Hawk UAV, an advanced unmanned surveillance and reconnaissance platform used in the war on terrorism in Afghanistan, consumes approximately 500 megabits

[38] "Radio," The World Book Encyclopedia (2000 ed.), vol. 16, p. 84.

per second of bandwidth, or about five times the total bandwidth consumed by the entire U.S. military during the Gulf War.[39] One can quickly surmise that while the ability to gather detailed tactical information by a particular sensor is highly significant, without the means to transmit that information to a particular user, the information effectually becomes useless. Even if specific data flows are temporarily shutdown for "time sharing" on the network to allow transmission of only the most time sensitive information at any given moment, delays of other significant information will cost overall combatant theater effort. Additional solutions to conserve or remain within bandwidth limitations lead to degraded capabilities of weapons systems. Military officials have quoted that during the current war on terrorism "Global Hawk controllers have been forced to turn off some of the aircrafts' sensors and transmit fuzzier, lower quality video."[40]

The current mismatch between bandwidth requirements and bandwidth capacity stems from two significant issues. First was the un-forecast increase in demand for bandwidth. "In February 2000, the Defense Science Board, the Pentagon's internal think tank, concluded that the military would need an average of about 16 gigabits per second of bandwidth—the equivalent of about 208,000 simultaneous phone calls—to fight a major war in 2010. Today, the projected requirement, which is classified, is 'significantly higher than what we forecast' says a military official who is heading a study on the Pentagon's communication needs." "Demand for bandwidth continues to grow as the services develop more data intensive weapons systems."[41] The second issue in the dilemma is shortage of satellite capacity to pick up the

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[39] Greg Jaffe, Wall Street Journal.
[40] Ibid.
[41] Ibid.

communications workload. "In the 1990s, the U.S. military bet that by 2005 almost 1,000 new satellites would be available for weapons such as Global Hawk that rely on space-based communications. But the commercial satellite industry, which the Pentagon was counting on to launch those satellites, fell on hard times. Of the 675 launches expected between 1998 and 2002, only 275 satellites reached space." "Fiber-optic cable, which carries huge amounts of information in the form of light beams, ruined the plan. It proved a cheaper and more reliable way of moving gigabits of information around the globe. Scores of companies built fiber-optic networks spanning the world, creating a bandwidth glut that has contributed to the demise of many telecommunications companies. The cable didn't help the military, which needs wireless connections to tanks, planes and ships. But the surge in fiber-optic networks hurt the satellite companies, which have had to cancel, scale back or postpone new satellite launches."[42]

Improvements in bandwidth capacity have progressed with recent demand. The MILSTAR I satellite system launched in 1994-1995 carried a voice only, low data rate (2.4 kilobits per second) capacity, while the next generation MILSTAR II satellites feature a faster medium data rate (1.5 megabits per second) capacity.[43] The following example highlights the practical application of these capabilities: "Two older MILSTAR I satellite versions could take an hour to transmit a 1.1 megabit air-tasking order while the just launched Block II version can do the same job in 5 seconds. Annotated 24 megabit intelligence images, which can take 22.2 hours to transmit on MILSTAR I, can be transmitted in 2

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[42] Ibid.

[43] Glenn W. Goodman, Jr., "Assured Access to Space," Armed Forces Journal International, (July 2002), p. 46.

minutes by the MILSTAR II version, and just 24 second via the Advanced EHF satellite expected to come online in 2006."[44]

The Department of Defense is currently on track with recognizing the need for transformational communications capabilities. "'We are now fighting a different kind of war and our military communications architecture needs to take that into account,' quoted an official at the U.S. Air Force Space and Missile Systems Center. The new warfare 'is with combined U.S. forces, local coalition forces and international forces.' Smooth communications interface is increasingly needed between such divergent units, but not necessarily possible with today's spacecraft and ground terminals. 'A leap in capability is required to meet the rapidly increasing demand for bandwidth and connectivity.'"[45] The major point to be drawn from this discussion is that bandwidth capacity appears to be the weakest link in current information management networks. For any future networks to reach fruition and truly become successful, bandwidth capacity requirements must be met and designed from a global perspective to meet the specifications of all perspective users.

Transmission Media

Radio frequency communications have been the standard transmission means since communications evolved beyond visual or hard-wire communication methods. Aviation platforms have traditionally used the VHF, UHF and High Frequency (HF) bands. HF transmissions have the advantage of providing an over the horizon capability through the use of sky waves where the transmission is reflected off the ionosphere,

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[44] Craig Covault, "U.S. Military Wants Sweeping Satcom Changes," Aviation Week and Space Technology, (January 21, 2002), p. 27.
[45] Ibid., p. 27.

however, this frequency band is also adversely susceptible to atmospheric propagation and disturbances. Amplitude modulated transmissions in the UHF and VHF ranges use ground waves which may extend a short distance beyond the horizon. Frequency modulated transmissions in the VHF range are limited to line of sight capabilities only.[46] Distance limitations and limited frequency band allocations for the number of users has created problems with radio frequency transmissions. As discussed in the previous paragraph on bandwidth, within a defined frequency band, there is only a limited amount of data that can be transmitted or received in a given time period. Radio frequency transmissions will continue to be the backbone of military aviation communications; however, other transmission means will be required to augment a robust information sharing network.

Military aviation platforms and supporting ground systems must be mobile and expeditionary by nature. This is one reason hard-wire communication links between users is not normally an option to connect users such as aircraft, ships or ground vehicles. However, the capabilities of fiber-optic networks are significant and should be examined for use in areas for which a hard-wired network can support operations. Fiber-optic transmissions, which carry huge amounts of data in the form of light beams, can provide significant augmentation to ground based C2 platforms and supporting agencies that do not have the requirement to be highly mobile in a military theater of operations. In concert with the increased bandwidth capacity produced through the use of fiber-optic networks, technology is maturing to allow LASER communications to become the connectivity link between fiber-optic networks and other military users via satellite relay.

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[46] The World Book Encyclopedia, vol. 16, p. 88.

Further development of LASER communication technology has the potential to produce a transmission means, which can carry far more information and data than traditional radio frequency. "Substantially increased development of LASER communications may achieve the capacity of hundreds of gigabits per second."[47] "LASER links are inherently jamming resistant because the beams are small and would be difficult for an adversary to isolate."[48] LASER communications are not immune from additional concerns that must be addressed before the technology is truly mature. "Shooting a LASER beam from space to an orbiting aircraft is fraught with challenges, in part because beams are degraded by moisture in the atmosphere."[49] "Because space-to-ground beams would be susceptible to atmospheric conditions, multiple ground stations would be necessary to mitigate this impact."[50]

The Department of Defense is currently studying proposals to incorporate a robust network by leveraging the increased capabilities of fiber-optic and LASER technologies. A "proposed LASER satellite system, referred to as the transformational communications system (TCS) is designed to increase the bandwidth available to the military by linking ground based fiber-optic cables to space using LASERS to transmit data to and from the ground, and between satellites. A study led by the Defense Department's National Security Space Architect office found that the technology for such a system was mature, technology wise and feasible."[51] The vision of the Department of Defense is emphasized by the Assistant Secretary of Defense for

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[47] Covault, Aviation Week and Space Technology, p. 27.
[48] Michael Sirak, "US DoD Looks To Update MILSATCOM Network," Jane's Defence Weekly, (January 30, 2002).
[49] Jaffe, Wall Street Journal, p. 1.
[50] Sirak, Jane's Defence Weekly, (January 30, 2002).
[51] Sharon Weinberger, "Study Recommends Laser Satellite Communications System, Early End to AEHF," Aerospace Daily, (July 18, 2002).

Command, Control, Communications and Intelligence, Mr. John Stenbit. He stated, "The network changes will comprise three key elements: satellite LASER communication cross-links and down-links; a robust fiber-optic network to connect ground terminals; and 'non-channelized' satellites that no longer divide the electronic spectrum into separate channels via filters, and are, therefore, able to provide more usable bandwidth. The changes will focus on wide-band communications, but will also affect to some extent the extremely high frequency (EHF) and narrow-band ultra high frequency (UHF) satellite systems. The goal is to make a very wide-band, worldwide network, on the one hand, to get information back from sensors, and on the other, to get information out to users that are in the neighborhood of where those sensors were in the first place."[52] If applied for all applicable users, the vision stated above should provide the necessary connectivity to ensure a military aviation information systems management concept that has the available transmission paths to assure mission success.

Relay Stations

One of the severe limitations to communications whether the transmission means is by radio frequency in the VHF band or higher and even LASER transmissions is the requirement for transmitter and receiver stations to maintain LOS geometry. Due to LOS limitations of most radio frequency bands currently used along with LASER transmissions as well, a relay station is often required. Air Force officials propose an additional method of signal relay by use of assets that see near round the clock usage whenever combat aircraft are airborne, aerial refuelers or "tankers." Secretary of the Air Force

[52] Sirak, Jane's Defence Weekly, (January 30, 2002).

James Roche foresees an ancillary mission to aerial refueling whereby 'smart tankers' carry communications relay equipment in addition to other intelligence support gear.[53] With an already over tasked satellite network, Air Force Chief of Staff General John P. Jumper suggests to "take advantage of what's already there," referring to the tanker fleet for the communications relay mission as a substitute for additional satellite constellations.[54] A separate proposal was developed during a Navy and Marine Corps war game scenario at the Naval War College in Newport, Rhode Island. The command and control group for the war game determined that a "tactical communications relay should not require a terrestrially based infrastructure that requires additional manpower and will increase force protection and security requirements. Moreover, the relay capability must not be satellite based. Over reliance on satellites may create an opportunity that a potential adversary might elect to attack. Desirable characteristics include all-weather, manned or unmanned, unattended, tamper resistant, and a 24/7 performance capability." The solution the group came up with was an "UAV-like system with a communications relay payload to extend line of sight communications…"[55]

The aforementioned concepts each address key points that must be considered for any system intended to extend the limitations of LOS communications. Regardless of whether the method to extend communications range is provided by a satellite, tanker, UAV or a combination thereof; it must be robust enough to operate in the tactical environment under all weather conditions, capable of

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[53] Michael Sirak, Jane's Defence Weekly, (January 9, 2002).
[54] Roos, Armed Forces Journal International, p. 42.
[55] Colonel Robert K. Dobson, Jr. USMC (Ret), "Marine Corps C^2 Capability Shortfalls in 2010," Marine Corps Gazette, (August 2002), p. 24-25.

supporting bandwidth requirements, and available on continuous coverage to meet the demands of all forces in the military theater.

CHAPTER VIII

DATA AND INFORMATION STORAGE

In addition to the processing of data into useful information and network connectivity between military aviation users, the storage and organization of data and information for later retrieval is equally important. Information must be organized and stored in a manner from which it can be retrieved quickly and efficiently as needed by the appropriate user. First used during the 1970s in corporate database management systems, the function of Data Administration was created to manage all the computerized data resources of an organization. Data Administration was fashioned out of the necessity for organizations on the verge of or beyond data overload to clean up the data "mess" produced when the inbound flow of information far exceeded the ability to manage it.[56] The function of Data Administration includes not only the broad function of administering databases filled with useful information, it also includes providing compatible data definitions whereby information can be shared across organizational boundaries to all applicable users. The data dictionary is the main tool by which data administrators control standard data definitions. All definitions are entered into the dictionary. Data administrators monitor all new definitions and all requests for changes in definitions to make sure that overall organizational policy is being followed. Data Administration has four main functions to bring order to raw data and information:

- Clean up data definitions

[56] McNurlin and Sprague, p. 198.

- Manage data distribution
- Maintain data quality
- Control shared data [57]

Each of these main functions will be explored further in the context as each applies to data administration within the military aviation information systems management concept.

Information pertaining to military aviation takes many forms. It includes the broad operations orders and air tasking orders, which include the overall commander's intent or guidance down through specific unit assignments. Additionally fragmentary orders update or amend the original orders or further specify direct mission assignments. Information such as friendly and enemy unit locations along with capabilities, strengths, and weaknesses must be maintained for the theater of operations. Targeting information as well as specific mission abort or continue criteria are also critical. Even perishable information such as current weather conditions is important to be properly stored, distributed or removed from the database when it is no longer applicable. Data definitions must support all information and be designed to provide for each user's needs. For example, information relevant to a fighter aircraft conducting the counter air mission at 18,000 feet may include location of enemy fighters and medium altitude surface to air missile launchers, location of friendly aircraft in his engagement zone, weather at altitude for the duration of his patrol, and the commander's current rules of engagement for firing on enemy aircraft. Information relevant to a helicopter gunship conducting the ground attack mission on the other hand, would include targeting details, location of friendly ground forces, location of

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[57] Ibid. p. 199.

enemy low altitude surface to air missile threats, and weather at 500 feet and below. The data administration function of cleaning up data definitions must be responsive for defining which users have the potential for using any particular information and then effectively labeling it in such a way that it can be recalled when necessary.

Management of data distribution presents one of the most significant challenges to the data administrator. There are situations where a data-push process is most relevant and necessary while other situations dictate a data-pull process to avoid an overload of non-critical information in the cockpit. Using the example of the helicopter gunship in the previous paragraph, specific changes to the preplanned target information or emergence of an enemy surface to air missile threat in range of affecting the helicopter should be pushed immediately to the cockpit. On the other hand routine weather updates or movement of friendly forces well outside of his engagement area should only be pulled if the pilot desires. Information distribution on this level would require very detailed data definitions and a complex set of rules governing when information should be pushed versus information that only needs to be ready for distribution if pulled.

Maintenance of data quality ensures only the most accurate information is distributed to the applicable users. Certain perishable information such as weather should be overwritten so that the old data is completely removed. The same applies for enemy or friendly force locations. Some data will be overwritten when updated; others must be completely removed from the database if it is no longer applicable. Data definitions must be flexible enough to allow amendments, even if temporary in nature, such as when a particular anti-air missile unit's capabilities are degraded when its respective search radar stands down for a 2 hour maintenance cycle, yet the amendment must be removed when the temporary condition no longer exists. Whenever information changes, some form of quality control must update the information database. Considering the incredible amount of data and information stored in this database, this will not be a simple task. One possible solution is to ensure the original owner or processor of the information is responsible for updates and revisions (i.e. the weather support agency for weather observations and forecasts), however, data quality control will remain an overall data administrator duty.

The final data administrator function is control of shared data. In the ideal situation all information within a military theater of operations will be based on the same data architecture where data definitions and distribution are defined for all possible users. However considering the many diverse participants in military conflicts, this ideal situation is highly unlikely. With non-Department of Defense national intelligence agencies and foreign coalition partners or allies involved, the requirement to share information with other organizations will definitely exist. To take advantage of all participants' capabilities, whether they are intelligence sources or additional military forces, the ability to share the information produced and stored will be a significant data administration task.

CHAPTER IX

ACQUISITION STRATEGY AND PROGRAM MANAGEMENT

The National Security Act of 1947 paved the way for joint or multi-service operations by formalizing the Joint Chiefs of Staff structure. Until this monumental change in military organization, warfighting responsibilities were delegated directly to Army or Navy representatives. The Goldwater-Nichols Reorganization Act of 1986 clearly established the operational chain of command that runs from the President and Secretary of Defense (the National Command Authority) directly to the Commander in Chief of the joint combatant commands that divide the world into regional warfighting areas of responsibility. "Joint" in this context is a permanent or temporary force structure comprised of more than one military service. The significance of this act was that it effectively removed individual service chiefs from direct warfighting responsibilities and placed these responsibilities with the joint combatant commands. Unfortunately, the complete intent of Goldwater-Nichols has not been realized as envisioned because individual services continue to struggle with "jointness." Individual services tend to "link specific weapons and communication systems to activities regarded as most vital to their missions. Therefore they seek to optimize the integrated performance of systems according to their needs rather than those of the joint community. As a result, as combatant commands attempt to integrate and apply service optimized systems, they discover that service optimization produces sub-optimum performance within the joint operational framework."[58] "Technologies developed since Desert Storm should have decreased decision cycle times and increased the ability to achieve battlefield effects more efficiently and effectively by employing joint capabilities during the 1999 Kosovo air campaign. But joint command and control concepts and procedures did not fundamentally change, and U.S. forces were unable to exploit opportunities offered by new technology."[59]

One reason for the absence of joint effort among the services is the way in which services receive funding for respective weapons and communications systems. Currently funding is given directly to the individual services for them to establish spending priorities and make acquisition decisions for individual programs and platforms. This system has led to a sacrifice in the overall warfighting capability provided to the joint combatant commands. "Current shortfalls in joint interoperability should not be surprising, since warfighting capabilities are still developed, for the most part, in service enclaves with little incentive to integrate them with the capabilities of other services."[60] If more joint control was exerted over service research, development, and acquisition, transformation to new structures for warfighting could occur. "If information superiority and battlespace dominance are the organizing imperatives that can determine how the services will fight in the future, then new joint operational concepts and joint-capable organizations are keys to success."[61]

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[58] Douglas A. MacGregor, "The Joint Force-- A Decade, No Progress," Joint Force Quarterly, (Winter 2001-2002), p. 20.
[59] Ibid. p. 22.
[60] R. Adm. Robert M. Nutwell USN(ret.) and Paul D. Szabados, "Joint Information Interoperability," Armed Forces Journal International, (June 2002), p. 56.
[61] MacGregor, Joint Force Quarterly, p. 23.

Success in the building of an information systems management framework for military aviation can only be achieved if the concept is developed "jointly" from its inception. This begins by assigning the responsibility for development of the concept to a Joint Program Office. While the previous paragraphs have highlighted the negative impact of joint growing pains, the following will provide positive examples and discuss additional concerns for interoperability and open systems architecture.

Joint Program Office

A Joint Program Office, fully in control of its own share of funding, will be a necessary step in further developing an information systems management concept for military aviation operations. The acquisition process required to bring such a concept to fruition must be focused on supporting an overall joint mission area rather than supporting the development of individual aviation platforms. In this way the mandate is to provide a joint capability for the use of air power rather than an improved radio or data link for a particular aircraft. Air Force Chief of Staff, General John Jumper, has recently portrayed this idea for Air Force acquisition programs. He stated, "My contention is that we have too long been program and platform centric. Especially as you get into this advance information technology age, that sort of thinking mitigates against the sort of integrated thinking that you have to have in order to deal with the sophisticated problems we face on the battlefield." Under the general's new approach the first order of business is to write a concept of operations or outline for each mission area. "Deciding how we are going to fight before we go out and decide what we are going to buy to fight with. In the old construct we went program by program and platform by platform, 'higher, faster, farther', but without much consideration of how we were going to integrate with the other services, with coalition partners or allies. So this simply inverts the process… it tries to put the operators into the lead of what we program and buy in our air force."[62] Defining acquisition products based on joint mission area requirements will ensure systems are built to accomplish a defined mission, versus developing advanced systems independently and then letting the warfighters figure out how to operate them on the battlefield to achieve military goals.

The war on terrorism in Afghanistan has provided a success story in the process for which equipment is acquired for special operations forces. "In 1986, Congress consolidated all U.S. special operations forces under the newly created Special Operations Command (SOCOM). The Joint Special Operations Command oversees the Army's Green Berets and Rangers, Navy SEALS, as well as Air Force special tactics units along with other units. Unlike other military units, Congress provides separate research, development and acquisition funding directly to SOCOM to develop equipment uniquely suited to its specialized missions."[63] Using the special operations joint mission area as an independent acquisition focus allowed the forces in Afghanistan to be equipped with the best equipment to accomplish their mission.

A positive example of the Joint Program Office concept is the development of the Joint Tactical Radio System (JTRS). This program is built around the plan to field a revolutionary family of interoperable, multi-band radios to support communication requirements of all four

[62] Michael Sirak, "Interview with General John Jumper: U.S. Air Force Chief of Staff," Jane's Defence Weekly, (September 18, 2002).
[63] William Arkin, "Future Warriors," Wilmington Star News, (August 11, 2002), p. 7E.

military services. JTRS is designed to replace all of the U.S. military's 750,000 tactical radios with a single family of affordable, interoperable radios that will perform their many diverse functions, ranging from battlefield voice and data communications to long distance satellite communications.[64] For decades the principle method to transmit voice over radio wave was to operate similar types of radios on the same frequency. As additional techniques for delivering communications were developed (i.e. encryption for secure communications, frequency-hopping for anti-jam communications, and local area networks for data transfer), interoperability problems were created by scores of proprietary waveforms and the lack of standardization between vendors' software architecture. In 1997 the Assistant Secretary of Defense for Command, Control, Computers and Intelligence chartered an integrated product team to evaluate radio procurements across all of the services. The integrated product team determined that the Department of Defense would achieve a greater economy of scale and joint interoperability with the development of a single family of radios that could meet all the services' operational requirements instead of each service buying individual legacy system replacements. These efforts were the genesis for the development of "a family of digital, modular, software-programmable radios" to be known as the JTRS.[65] While the JTRS program took control of radio procurement out of the hands of individual services and in some cases caused extended delays in the replacement of outdated legacy systems, in the long run all services will be better equipped to interoperate in the joint environment. The JTRS Joint Program Office by design has been

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[64] Glenn W. Goodman, Jr. "Universal Communicator," Armed Forces Journal International, (August 2002), p. 44.
[65] Lieutenant Colonel Jeffery D. Wilson and Major Brian T. Alexander, "Producing the Joint Tactical Radio," Marine Corps Gazette, (August 2002), p. 20-21.

able to leverage rapidly advancing COTS technology which was not possible with the single-function design of legacy systems.[66] The most important concept drawn from the JRTS example is that the system was developed on the joint mission area of battlefield communications, versus an afterthought radio used in a particular aircraft or ground vehicle. JTRS would be an integral component within the overarching information systems management concept for military aviation.

The same Joint Program Office practices that have made JTRS successful up to this point will undoubtedly pave the way for future joint acquisition endeavors. The principles of supporting a joint mission area must be applied to the theme of air power dominance when developing the information systems management concept for military aviation. The vision to procure and sustain a system that supports an entire joint mission area must be met.

Mandated Interoperability

Joint Publication 1-02 defines *interoperability* as "the ability of systems, units or forces to exchange services and… operate effectively together." *Integration* is generally considered to go beyond mere interoperability to involve some degree of functional dependence. For example an *integrated* mission planning system might rely on an external intelligence database for functionality, while *interoperable* systems can function independently. *Compatibility* is something less than interoperability. It means that systems or units do not interfere with each other's functioning, but it does not imply the ability to exchange services. In sum, *interoperability* lies in the middle of an "integration continuum" between *compatibility* and full

[66] Goodman, Armed Forces Journal International, p. 48.

integration.[67] A problem with military hardware is that most of it was never designed with interoperability in mind; in fact for some platforms compatibility was an after thought that required additional engineering modifications and funding to correct. Sometimes, even if compatibility or interoperability was considered in the design phase, it was only carried out within one mission area or military service, leaving a natural firewall between other services of the U.S. Armed Forces or the military forces of allied countries. A prime example of this is combat identification. The Air Force has long had "friend or foe" transponders for its aircraft, and its next generation tactical data link system, link 16, is designed to augment that capability. The Air National Guard, however, which flies alongside Air Force aircraft, has its own program, the Situational Awareness Data Link, which relies on frequency space borrowed from an already clogged Army communications system. The Navy, like the Air Force, has a reliable air-to-air system, but it is not designed to coordinate with ground force systems. In fact, a June 2001 audit performed by the General Accounting Office documented that none of the U.S. services' combat identification equipment is designed to work as an integrated system, nor are the U.S. systems capable of working with those of allies.[68] Interoperability as defined by Joint Publication 1-02 must be a design consideration from the onset for the military aviation information systems management concept. Whether communicating friendly combat identification information or providing a common battlespace picture, interoperability among all users will be mandatory for success.

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[67] Nutwell and Szabados, Armed Forces Journal International, p. 58.
[68] Stephen J. Hedges, "Friendly Fire' Still Haunts U.S. Military," Chicago Tribune, (22 July 2002).

Open Systems Architecture Structure

A discussion of a structure based on an open systems architecture approach first requires a proper definition of these terms with respect to the acquisition process. Architecture is the structure of components, their interrelationships and the principle guidelines governing their design and evolution over time. An open system is one that implements specifications maintained by an open, public consensus process for interfaces, services, and support formats, to enable properly engineered components to be utilized across a wide range of systems with minimal change, to interoperate with other components on local and remote systems, and to interact with users in a manner that facilitates portability.[69] Open systems assure, provide, and are the basis for interoperability; they enable properly engineered components to be utilized across a range of systems. Open systems architecture means the software is portable in the sense that its use is not dependent on specific hardware platforms or operating system software. The major benefits of open system architecture are: (1) costs are reduced through information sharing, interoperability and portability, (2) the possibility of using commercially available software or reusing software developed for other systems is increased, and (3) change is easier to track throughout the software life cycle.[70]

The Department of Defense is already underway with an superb example of the open systems architecture required for the future with the JTRS program. As previously discussed, the need for JTRS stemmed from the incompatibility of the military's current inventory of legacy radios, which could not all talk to each other because of the 33

[69] Glossary of Defense Acquisition Acronyms and Terms, Defense Systems Management College, (Eighth Edition, May 1997), p. B-8, B-79.
[70] "Intermediate Systems Acquisition Course, Student Guide," Defense Systems Management College (Volume 2, July-September 1998), p. SM01-24.

different waveforms and numerous frequencies on which each model relied. To assume an open architecture principle, JTRS will be based around a "software defined" radio, akin to a computer with a radio "front end". Its communications functions are to be based in the radio's software, not in its hardware as with most legacy systems. This open system Software Communications Architecture (SCA) is a set of specifications that details the design rules for JTRS components and their interconnections, essential to effective interface between various radios.[71] Whether a radio's purpose is to provide the communications backbone for an Airborne Command and Control platform, a warship on the high seas or an individual foot soldier, the JTRS program will help ensure unquestioned connectivity in the joint theater.

The open systems architecture example of JTRS must by expanded in use by all facets of warfighter connectivity to ensure network-centric warfare brings forth the synergy of forces that can only be attained through the interoperability of all assets. Open systems architecture will guarantee acquisition of systems from defense contractors remains upgradeable for future increased performance, competitive through its non-proprietary interfaces and protocols, and expandable with industry recognized interfaces and software standards. All of the devices used to form the concept, from cockpit and ground station interfaces to information processing and relay stations must follow suit with an open systems architecture structure. It is one of the critical principles needed to bring the concept of information systems management for military aviation assets to fruition.

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[71] Goodman, Armed Forces Journal International, p. 44.

CHAPTER X

CONCLUSIONS

The objective of this thesis was to develop an information systems management concept that would improve the overall performance of military aviation during combat operations. The information requirements of commanders, decision making staff members, aircrew and aircraft controllers were reviewed for the missions areas of Counter Air, Ground Attack, Air Assault, Surveillance and Reconnaissance, Tactical Airlift, and Command and Control. Considerations for OTH communications requirements were discussed within each mission area. Minimum operator interface requirements included a suitable MFD connected to the network via an on-board data link and a keypad for data input; highly desirable options included a HUD or HMD to supplement the MFD, and a hands-free input device to supplement the keypad. The model in figure 1 of chapter IV proposed the four steps of collection, processing, storage and recall along with decision inputs to the processing step; this model presented the information flow path. Beyond "what" information was required for "who", the "how" and "when" to deliver requisite information determined the baseline as a starting point for this concept.

Stepping outside of typical military planning doctrine, corporate information systems management was reviewed and discussed for relevance to this concept. Decision Support System models with the application of Expert Systems for processing data and information to prevent information overload and organizational paralysis fit well into the concept for military aviation. Lessons learned in the information systems management field showed that a supporting network must be reliable, available, robust and designed with standard protocol for common access. The system must be designed with the bandwidth capacity to support all required voice and data transmissions to avoid network chokepoints and gridlock. Providing connectivity through a combination of radio frequency, LASER, and fiber optic transmissions should satisfy foreseeable requirements. Relay networks to assure OTH communications should take advantage of available resources to include satellites, airborne refueler aircraft, and UAVs. The data administration strategy to manage and store data and information must develop data definitions, which categorize data and define what information pertains to a particular user. This strategy must incorporate a set of rules to apply data-push versus data-pull techniques. Quality control must be exercised over the database to ensure only the most current and relevant data and information is provided to applicable users or stored in the database.

Finally, to bring this concept to reality, an acquisition strategy must be developed for the joint mission area of airpower dominance and supported by a Joint Program Office. This construct will ensure funding is directed towards supporting the joint mission area and not just individual programs or platforms that form military aviation. The JTRS program has shown what can be accomplished when a system is developed with "Joint" operations as a goal from the ground up. Any future system must be interoperable with all U.S. armed forces' aviation platforms, and consideration should be given for a plan to include allies and coalition partners in times of conflict. Open systems architecture is one way to plan for the ability to be expandable; it also ensures maximum competitiveness among vendors to support this system throughout its life cycle.

This concept will require maximum flexibility to adjust as technologies emerge that could better support it. If implemented correctly, the concept holds the potential to unleash a synergistic potential not yet realized by today's most advanced systems. Increased combat effectiveness and efficiency along with a reduced possibility of fratricide through a common network for combat identification make this a concept that will transform future military operations.

CHAPTER XI

RECOMMENDATIONS

The first step towards implementing an information systems management concept for military aviation will be for the Department of Defense to fully embrace the concept at the Joint Chiefs of Staff level. Acceptance at the highest level will be necessary for implementation to affect all military aviation systems. A concept this far-reaching would call for all armed services to be committed to working towards a common vision. Several key elements will be required to bring the foresight of this concept to reality. The following recommendations highlight the major tasks that should be accomplished.

First, a Joint Program Office should be established to manage the development and implementation of the system. This Joint Program Office must be provided with adequate funding and resources to accomplish the entire undertaking. The leverage of the Joint Program Office will ensure all armed services receive a system that is interoperable while meeting the requirements of each combatant commander's warfighting needs. Furthermore, with a mandate from a Joint Program Office, all armed services will be required to design or adapt their respective command and control infrastructure around accepting and supporting such a system, while implementing its use down to the lowest level. A key function will be to ensure the hardware and systems owned by each individual service are interoperable with and support the system developed from this concept.

While not specifically discussed in this thesis, cost will be a significant factor in the outcome of the final product. In order for the final product to be successful, management of the program during the potentially expensive research and development stage must be resourcefully accomplished. The program should capitalize on currently available and maturing COTS technologies that are relevant and transferable. While COTS products will not fulfill all program requirements, their usage will allow the bulk of research and development funding to be focused on program requirements specific to military usage. A final system integrator should ensure both COTS products and those specifically developed for military applications are melded to generate a seamless product.

The final and possibly most critical recommendation is to ensure sufficient "operator" representation on the product development team. The "operator" in this context should be experienced aircrew, decision makers or otherwise end users who are intimately familiar with military aviation mission requirements. These duty experts should represent all facets and mission areas of military aviation. Their participation must go significantly beyond merely providing survey input regarding mission requirements and system performance expectations. The "operators" must work side by side with the designers, engineers and technicians while the system is developed. This is especially true for the development of the Expert Systems required to manage the vast amount of information that will be received and processed. The system has the potential to provide massive quantities of information to various users; information overload will counter-act the entire purpose for providing the system in the first place. An experienced "operator" is essential to describe for the engineer or designer what information is relevant and which excessive information will cause saturation to the point of negative contribution for the heavily engaged aircrew or decision maker. The end product from a well-integrated operator-designer team holds the greatest potential for significant increases in efficiency and performance from modern military aviation assets.

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VITA

Douglas Schueler was born in Clovis, New Mexico on November 20, 1965. At the age of three his family moved to southern Colorado where he attended elementary through high school, graduating from Centauri High School in 1984. He entered the United States Naval Academy in Annapolis, Maryland and graduated in 1988 with a Bachelor of Science degree in Aerospace Engineering. Upon graduation he also received a commission as a Second Lieutenant in the United States Marine Corps. He attended the Basic Officers Course in Quantico, Virginia followed by Naval Flight Training in Pensacola, Florida. Upon completion of training, he received orders to Marine Corps Air Station Kaneohe, Hawaii where he served from 1991 to 1995, flying the CH-46E helicopter in the Hawaiian Island chain and deploying throughout the western Pacific and Far East Theater. In 1996 he transferred to Patuxent River, Maryland for training and subsequent duty as an engineering test pilot with the Naval Test Pilot School and Naval Rotary Wing Aircraft Test Squadron. During this tour he served as project pilot on several developmental flight test programs for the CH-46 and TH-57 helicopters. In 2000 he took assignment as an air liaison officer for the Second Marine Division, Camp Lejeune, North Carolina. During this tour he worked extensively with the integration of both Marine and Joint aviation assets with ground forces. In 2001 he began his current assignment as CH-46E pilot and Squadron Executive Officer at Marine Corps Air Station New River, North Carolina.

He has logged over 3000 flight hours in more than 40 different models of fixed and rotary wing aircraft. He holds every flight designation available as a Marine helicopter pilot as well as civilian Airline Transport Pilot and Certified Flight Instructor ratings.