NASA Contractor Report 3527

1981 Current Research on Aviation Weather (Bibliography)

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I. INTRODUCTION

The purpose of the report is to provide the reader with current available information on major areas of meteorological research related to aviation systems. This study has been conducted as an update to the 1979 Current Research on Aviation Weather (Bibliography) by Turkel and Frost.

National and world demands on air travel require that it is safe and economical under all weather conditions. This has placed requirements upon the industry to improve equipment, on-board and ground based, to provide the highest operational safety and efficiency possible. This includes a continued need for improved weather forecasts and measurement capabilities. This report along with the proceedings from the workshops on Meteorological and Environmental Inputs to Aviation Systems and others will provide information which should be valuable as reference material for researchers in the field.

The bibliography is classified into chapter headings which address Advanced Meteorological Instruments; Forecasting; Icing; Lightning and Atmospheric Electricity; Visibility and Ceilings; Fog; Low Level Wind Shear; Storm Hazards/Severe Storms; Turbulence; Winds; and Ozone and Other Meteorological Parameters.

Appendix A is a tabulation of ongoing research programs being conducted by a number of government agencies. These are referenced under similar headings as the chapter headings. Appendix B is a list of acronyms.

II. ADVANCED METEOROLOGICAL INSTRUMENTS

The following is a brief description of research being conducted in the development and improvement of meteorological instruments. A more detailed description of the instruments and their uses can be found under the individual classifications of weather phenomena.

Radar and lidar are becoming widely used in the measurement and detection of most all classifications of aviation weather.

Various designs and uses of Doppler radar for wind shear detection are being studied by Chadwick, Moran, and Campbell (1979), Offi, et al. (1980), Strauch (1979), Strauch and Moninger (1978), Strauch and Sweezy (1980), and Sweezy, Moniger, and Strauch (1978). A pulsed CO_2 Doppler lidar system for use in wind shear detection is described by Weaver, et al. (1981), Caracena (1980); and Jordon (1980) describes research using wind sensors and pressure sensors in detecting low level wind shear (LLWS). Use of infrared radiometers (IR) is described by Caracena, Kuhn, and Kurkowski (1981) for LLWS detecting and Kurkowski, Kuhn, and Sterns (1981) using IR's in a CAT alerting system.

Harris and Jelalian (1979) describe use of CO_2 laser Doppler for detection of CAT, while Weaver (1980) evaluates a CO_2 pulsed Doppler lidar with radiometers.

A Doppler lidar for wind measurement is discussed by Scoggins, et al. (1980). McCarthy, Blick, and Elmore (1981) conducted a feasibility study of a Doppler radar in wind measurements.

Carr and Gerlach (1981) describe instrumentation systems used in NASA's Storm Hazard Program utilizing the Radar Atmospheric Research Facility (RARF), a WSR-57 radar, a lightning detection and ranging system, and a Ryan Stormscope. Corbin (1980), Fisher and Crabill (1981) review ground-based and airborne lightning locator systems. Trost and Zaepfel (1980) describe use of electromagnetic sensors to measure electric and magnetic fields during a lightning strike.

Werner (1980) emphasizes the use of laser radar systems in determining slant visual range (SVR). A remote tower SVR system is examined by Geisler (1979). Moroz (1979) describes an experimental SVR measuring system.

Saphow, et al. (1979), Bonner and Lentz (1979) report on visiometer/ceilometer and visioceilometer prototypes.

An ultraviolet fluorescence water vapor instrument for aircraft is discussed by Stone (1980). The instrument ducts air at 30 m/s through a 1.5-inch heated intake above the roof of an aircraft. The sensitivity of the instrument is 260 counts per ppmv of water vapor with a standard deviation of plus or minus 15 percent.

Bomar (1979) describes the application of an 8080 microprocessor-based microcomputer to the acquisition and comparison of data from a laser interferometric particle sizing instrument. This is used to determine the relative distribution of water droplet sizes in a wind tunnel for aircraft icing studies. A method for measuring the moisture content in a cloudless atmosphere is described by Rassadovskii (1979). The moisture content is determined by measuring out-going microwave radiation from aircraft.

Abshaev (1980) describes a radar system for the acquisition and display of the cell structure of thunderstorm hail clouds. Musel et al. (1978) measures particle size distributions using a hail spectrometer.

The use of microwave technology in the measurement of liquid water in a cool cloud deck is described by Hogg, Guiraud, and Burton (1980). Microwave power used for fog dispersal is discussed by Klein (1978). Radar as used in forecasting is discussed by Hayes (1979), Strauch (1979), and Holler (1979).

III. FORECASTING

The development of improved methods of providing more real-time information to pilots in short-term (0-2 hours) forecasting is a primary concern in forecasting research. Research to provide controllers with an improved wind shear detector system at and around air terminals is also a critical area of investigation.

Klein (1980) describes some operational and experimental products developed for aviation weather forecasting. These products include surface dew point, obstructions to vision, boundary layer models, computer-worded terminal forecasts, terminal altering procedures, generalized equivalent Markov (GEM) statistics, and radar forecasts (0-2 hours).

The very short range forecasts of visibility and ceiling are discussed by Hilsenrod (1980). Short-range forecasts of one hour or less, immediately after a series of local observations, can be expected to be more accurate. These forecasts can be accomplished through the use of fully automated aviation observation systems and statistical models such as the GEM model.

Alaka, Elvander, and Saffle (1979) developed improved automated techniques for the short-term (0-2 hours) monitoring and forecasting of thunderstorms and severe local convective weather at and around air terminals. An evaluation of a radar data processor system which includes a minicomputer, color graphic and alphanumeric display devices, and communication ports is included. These systems are primarily being developed for air traffic controllers.

Reap and Foster (1979) developed probability equations for a 12-36 hour forecast of severe storms, thunderstorms, and tornado outbreaks. Manually digitized radar (MDR) data and severe storm reports were related to large-scale meteorological predictors obtained from forecast models by applying regression techniques. Verification of these forecasts proved reliable against MDR data and observed thunderstorms during the 1977-1978 convective seasons.

Hilsenrod (1981) discusses the limitation of current weather support to helicopter operations in the Gulf of Mexico. Near-term (to 1986) and long-term (beyond 1986) recommendations are made in the areas of development in observations, forecasts, and communications and others that would improve weather service in the Gulf and other offshore areas. An environmental observation, forecast, and dissemination plan for the northwest gulf scheduled for implementation before the end of 1981 is presented.

An improved method of forecasting CAT is described by Keller (1980). The method is called the Diagnostic Richardson Number Tendency (DRT) technique. The DRT senses the synoptic scale centers of action which provide the energy to the CAT mechanism at the mesoscale level. The DRT algorithm is deterministic rather than statistical, using the hydrodynamic equations relevant to the synoptic scale. This method uses the same input data as currently used by the operational National Meteorological Center prognostic models.

Meteorological satellite programs are discussed by Allison, et al. (1980). The report gives an overview of satellite programs evolving from 1958 to the present and reviews future plans for meteorological and enviornmental satellite programs to be put in service in the 1980's. A summary of the development of the Television and Infra-Red Observation Satellite (TIROS) family of weather satellitesis given,including TIROS, Environmental Satellite Service (ESS), Improved TIROS Operational System/ National Oceanic and Atmospheric Administration (ITOS/NOAA), and the present third generation system, the TIROS-N. The contribution of the Nimbus and Applications Technology Satellite (ATS) technology satellites to the development of the operational polar-orbiting and geostationary satellites is discussed.

Bristor (1978) reviews the capabilities of current operational weather satellites and their potential impact on aviation weather systems in the 1980's. Emphasized is the role of geostationary satellites with discussion of near-term commitments and future developments in the late 1980's.

Monokrovich (1979) evaluates the cost effectiveness of utilizing weather predictions for civil aviation compared to using only actual weather information. It is shown that the cost benefits of weather predictions for civil aviation in the U.S.S.R. exceed the expenses of weather services by two to three times.

Conte, DeSimone, and Finizio (1979) present a physical-statistical method of fog forecasting at the Milano Ginate Airport in Rome, Italy. The method, based on data of ten cold seasons from 1963-1972 and on principles of the perfect prognostic, consists of a particular correlation among 16 predictors and visibility. They found a correlation coefficient of 0.866 and then an accounted variance of 0.750 while citing that an improvement in results is considered probable by introducing dynamic predictors such as upper air divergence, low level convergence, and others which were not used in their study.

Connolly (1980) addresses the developmental status of aviation weather services and the need for a better, more reliable service. The accomplishments of several automatic weather stations are cited.

Milligan and Rosenberg (1979) conducted research to ascertain the compatability of automated weather data with flight service stations. Their results indicated that the automated systems provided suitable information for use in pre-flight and in-flight pilot briefing.

Specific requirements for an improved aviation weather system are reported by Wedan (1980). The need for weather observations at airports with instrument approaches, more accurate and timely radar detection of weather elements-hazardous to aviation, and better methods of timely distribution of both pilot reports and ground weather data were discussed.

Evaluation of the transcribed weather broadcast (TWEB) system and alternatives are discussed by Woodson, Rood, and Barab (1980). A review and appraisal of TWEB and Pilots Automatic Telephone Weather Answering Service (PATWAS) is given. The report provides a set of conclusions and recommendations that may be acted upon at low cost to provide improved short-term operational effectiveness.

Wood (1979) describes the involvement of Atlanta Air Route Traffic Control Centers (ARTCC) distrubution of weather information throughout the system. Developments in meteorological radar for locating and determining the severity of storm cells are discussed along with recommended improvements.

A climatological value of U.S. airports based on climatological data where weather observations are taken is derived from Wyett (1979). The value represents the percentage of time that one could expect to encounter ceilings of less than or equal to 1500 feet and/or visibilities less than or equal to 3 miles in a given year.

Wilson, et al. (1980) discusses the operational application of meteorological Doppler radar. Some weather features that can be identified through color displays include vertical variation of wind with height, widespread precipitation, frontal boundaries, gust fronts, "downbursts", tornadoes, hurricane winds, wind shears dangerous to aircraft, and winds in the boundary layer in clear air. It is concluded that a nationwide network of Doppler radar is justified for weather forecasting.

Wilson and Wilk (1981) report on the many applications of Doppler radar, color displays, and interactive graphical techniques in the nowcasting and short period forecasting of weather phenomena. It is concluded that although significant advances in nowcasting can be made, a combination of man and machine is required to provide the most effective forecast.

Rockwell, Roach, and Griffin (1981) discuss problems involving dissemination of weather information and the use of this information by pilots. Factors such as the ability of the air traffic control (ATC) system to cope with weather-related incidents, the various aspects of pilot behavior, aircraft equipment, and NAVAIDS effects on flights are investigated. The study concludes that skill and training deficiencies of general aviation pilots are not major factors in weather-related occurrences, nor was the lack of aircraft equipment. The major problem causes were identified with timely and easily interpreted weather information, judgement and attitude factors of pilots, and the functioning of the ATC system.

Hayes (1979) describes the newest airport surveillance radar (ASR) system, the ASR-8. Features such as circular polarization which reduce weather signals by up to a factor of 100, and the use of Doppler frequency shift to cancel fixed object returns from moving target indications eliminate weather from the display, thus enhancing aircraft display capabilities. The transmitter and antenna of the ASR-8 will continue to be the source of weather signals, but a separate receiver will be used to tailor the precipitation signal specifically to the weather detection process. Strauch (1979) considers use of Doppler radar for weather surveillance near air terminals. The requirements are discussed and the tasks of an airport Doppler radar are considered.

Holler (1979) discusses problems in the treatment of meteorological radar echoes. A modern system of digital, modular processing of signals obtained from meteorological or ATC radar is presented. Applications of meteorological radar in an ATC system are discussed and a proposed system is indicated.

The National Weather Service (1979) reported the test results of the AV-AWOS. Verification and rationale for the cloud and visibility algorithms are presented; the algorithms for converting sensor data to automated observations of cloud height are specified.

Evaluation of the TWEB system and alternatives are discussed by Woodson, Rood, and Barab (1980). A review and appraisal of TWEB and

PATWAS is given. The report provides a set of conclusions and recommendations that may be acted upon at low cost to provide improved short-term operational effectiveness.

IV. ICING

Research in aviation icing is primarily concerned with ice information on aircraft structures and methods of preventing it and aircraft protection. Because of the additional weight of ice and the altering effect ice has on airfoils and power plants, the aerodynamic efficiency of the aircraft can be reduced to a stage where flight can no longer be achieved. Current research is also directed toward improved forecasting techniques and measurements.

A report by Koegeboehn (1981) outlines the short- and long-range requirements involving commercial aviation icing research programs. A survey of various industry and government agencies, obtaining their views of the needs for commercial aviation ice protection, was conducted. Through those responses, with additional data and Douglas Aircraft icing expertise, an assessment of the state-of-the-art of aircraft icing data and ice protection systems was made.

Breeze and Clark (1981) report on a short-term and long-term icing research and technology program plan drafted for NASA LeRC based on 33 separate research items. Assessment of the current facilities and icing technology was accomplished by presenting summaries of ice-sensitive components and protection methods. Also, assessments of penalty evaluation, the experimental data base, ice accretion prediction methods, research facilities, new protection methods, ice protection requirements, and icing instrumentation are presented. The research plan is intended to determine what icing research requirements NASA LeRC must do or sponsor to provide for increased utilization and safety of light transport and general aviation aircraft.

Newton (1979) presents an overview of the present situation in the field of aircraft icing with respect to certification and operation of non-transport category aircraft. Discussion of problems involving forecasting and measurement of icing intensities, the appropriateness of the present regulatory environment, and the inconsistencies in definitions are discussed. A method for simulating icing conditions on a light twin aircraft is presented by Lawton (1979). Fiberglass to simulate ice shapes on surfaces of the wing, tail surfaces, nose cone, and other parts of the aircraft that were not deiced was installed to confirm handling qualities, stability, and stall characteristics of the aircraft during an icing encounter.

A computer simulation program to evaluate the absolute and relative safety of certain nocturnal frost formations on general aviation and transport-type airfoils is reported on by Dietenberger (1981). A calculation of the frost thickness distribution on an airfoil with time and aerodynamic penalties of the frost layer during takeoff are calculated. Validation of the program was through experiments on an inclined flat plate and by comparisons with documented aerodynamic penalties of an arbitrarily roughened airfoil.

Measurement of liquid water in a cool cloud deck by microwave radiometry is described by Hogg, Guiraud, and Burton (1980). The simultaneous observation of aircraft icing using this system is discussed with possible application of weather modification and warning of icing conditions.

Kitchens (1980) discusses requirements for icing instrumentation. Most suggestions are oriented to rotary wing aircraft, but some of the instrumentation is applicable to general aviation aircraft. Recommendations to adopt a low maintenance anti-ice system and to improve icing weather forecasts are given.

The In Flight Icing Meteorological Surveys Coordination Meeting held at the FAA Technical Center in Atlantic City, New Jersey, on August 6, 1980, discussed key areas in the certification of helicopters into known icing conditions. These areas included icing criteria, test and operational methodology, systems development and evaluation, certification tools, and standards and procedures. Summaries are given of various military and civilian efforts in the area of helicopter icing.

Icing characteristics of low altitude, supercooled layer clouds is discussed by Jeck (1980). During the development of environmental icing criteria for use in certifying helicopters for flight into known icing conditions a limited amount of new data was obtained on the icing environment during the initial airborne measurements. A review of historical data upon which the atmospheric icing standards of Appendix C, FAR-25 is based reveals that data obtained from multidiameter cylinder measurements are subject to significant errors of both signs.

The effects of aircraft icing during low level flights are discussed by Rapp (1979). A crude measure of the potential of aircraft icing near the ground is presented with reasons why icing may hinder low and slow flights. The effects of icing when flying over high terrain are also discussed.

Newman (1980) investigates aircraft accidents involving engine failure due to carburetor ice formation. Prevention techniques such as anti-icing fuel additives, deicing procedures, pilot education, and engine design are discussed.

V. LIGHTNING AND ATMOSPHERIC ELECTRICITY

Research in the area of lightning strikes on aircraft has been primarily concerned with the analysis and development of means of protecting the aircraft structure as well as the system on aluminum skin and composite aircraft. Development of on-board equipment for pilot detection of electrical discharges is a concern.

Corn (1979) presents a ten-year history of USAF lightning incidents along with the problems and hazards it poses to aircraft and their systems. Some of the technical protection needs discussed include (1) in-flight data on lightning electrical parameters; (2) technical base and guidelines for protection of advanced systems and structures; (3) improved laboratory test techniques; (4) analysis techniques for predicting induced effects; (5) lightning strike incident data from general aviation; (6) lightning detection systems; (7) pilot reports on lightning strikes; and (8) better training in lightning awareness.

Alliot and Gall (1980) report on an in-flight program to detect phenomena associated with aircraft and lightning. Parameters included lightning current, skin current at different structural points, external and internal electromagnetic fields, overvoltages on various on-board equipment and circuits, sensing of the characterization of the electric state of the aircraft during the lightning as well as the effects of composite structures.

Lightning measurement and simulation techniques are described by Walko and Seymour (1979). Emphasis is placed on lightning simulation test, and the lightning transient analysis with particular attention given to the use of Moebius loop magnetic sensor, and the use of digital processing equipment. Vaughan (1980) discusses lightning phenomena and lightning measurement techniques with particular reference to aeronautics. Developments in airborne and satellite detection methods are reported. NASA research efforts in design factors and protection, remote optical and radio frequency measurements, in-situ measurements, and space vehicle design are outlined.

Corbin (1980) reviews the operational designs and performance capabilities of ground-based and airborne lightning detection systems. The airborne stormscope system is compared with on-board radar and the lightning detection and ranging system.

A summary of flight tests of an airborne lightning locator system is given by Fisher and Crabill (1981) as compared with ground-based measurements of precipitation and turbulence. Data from the airborne system is compared to storm intensity data obtained by ground-based Doppler radars and the S-band research radars. The lightning locations as measured by the airborne system tended to be further from the aircraft position than the Doppler contours but at the same relative bearing. Results also show that convective storms generate little or no lightning for a significant part of their life cycle, but can produce at least moderate turbulence.

A return stroke model was constructed by Pearlman (1979) to predict the nearby electromagnetic fields (20-200 meters from the channel) as a function of lightning parameters such as return stroke velocity, pulse rise time, and path tortuosity. Path tortuosity was shown to not be a major factor in the nearby induced fields. The electric field near the channel is predominantly electrostatic and proportional to the reciprocal of the wave velocity. The large magnitude of all field components in the vicinity of the channel suggests that a nearby strike could pose a threat to aircraft electrical systems.

Improved test methods for determining lightning-induced voltages in aircraft are described by Crouch and Plumer (1980). A lumped parameter transmission line with a surge impedance matching that of the aircraft and its return lines was evaluated as a replacement for earlier current generators. Return conductor arrangements as well as other circuit changes were also evaluated. The lumped parameter transmission line generates a concave front current wave with the peak di/dt occurring near the peak of the current wave which is more representative of lightning.

Trost and Zaepfel (1980) describe the use of electromagnetic sensors or electrically small antennas installed between the nose boom and fuselage of an F-106 aircraft to measure the electric and magnetic fields and currents during a lightning strike. The sensors were 10 cm in size, producing up to 100v for the estimated lightning fields. The results of the 1979 Severe Environmental Storm and Mesoscale Experiment (SESAME) in Oklahoma involving the effects of lightning strikes on a T-28 aircraft are presented by Musil and Prodan (1980). During two different days of experiments the specially armored and instrumented aircraft intentionally penetrated thunderstorms, resulting in various degrees of damage.

Tests conducted in a specially instrumented F-106B aircraft to investigate the lightning-generated electromagnetic environment affecting aircraft are reported by Pitts and Thomas (1980). Results of simulated lightning ground tests as recorded by the instrumentation system are reviewed and presented.

Clifford (1980) presents evidence that a rapidly moving aircraft charged to high potentials by triboelectric processes can trigger lightning discharges by the passage through freezing precipitation. Results are included along with recommendations that triggering experiments be included in government flight programs now in progress. The problems of protecting aircraft against lightning are discussed by Little (1980). Little analyzed the structure of the electric fields existing in cloud bases. The relative motions of a lightning channel with respect to an aircraft are described along with typical zones on an aircraft. Laboratory simulation and testing are outlined.

Schulte (1980) considers laboratory simulations predicting the response of materials and structures to lightning and defining protective measures. The test accounted for the effect of swept stroke under which an aircraft becomes a part of the lightning arc. Robb and Ta Chen (1980) analyzed the shielding properties of mixed metal and graphite composite structures against lightning strikes. Research conducted with composite structures and the resulting problems of current penetrations are discussed. They find that the true weight savings of composite aircraft can only be evaluated after the introduction of additional weight in the form of cable shields, conductor bonding or external metallization.

During the "Proceedings of the Third Symposium and Technical Exhibition", in Rotterdam, Netherlands, a paper presented by Perala, Cook, and Lee (1979) described the results of lightning-induced cable currents on typical cable runs inside an all composite aircraft. The results of testing an aircraft coated with 6-mil aluminum flame spray are included. The report shows that the direct stroke induces the largest voltages and that the effects of nearby strikes are not negligible. Schneider (1980) discusses the effects of lightning strikes on aircraft structures composed of graphite/epoxy. The common belief that lightning strikes of composite structures would cause heavy damage is rejected. Tests are conducted comparing the effects of lightning strikes on the two basic types of structure, composite, and aluminum.

The future trend of lightning research tends to be in the area of composite structures aircraft,determining the effects and developing means of protecting these light-weight aircraft against lightning strikes. A need for increased pilot awareness of the effects of lightning is indicated.

VI. VISIBILITY AND CEILINGS

The degree of visibility that the pilot of an aircraft can attain during an instrument approach is a significant factor in the completion of the approach to a landing. For this reason research in visibility is highly concentrated in developing more accurate measurement devices and remotely controlled weather observation stations for measurement of visibility and ceiling at uncontrolled airports.

Enders (1980) reports on the technological advances in aviation meteorology research and development with emphasis on the measurement of hazardous weather phenomena. On-board and ground-based equipment is evaluated and methods of alleviating hazards such as fog, low visibility, and ceilings are described

Tombach and Allard (1980) describe a research program which compares standard visibility measurement techniques with visibility related parameters determined by optical instruments. Research utilizing a telephotometer, camera, and integrating nephelometers (INS) to relate visibility to the chemical and physical properties of the atmospheric aerosol was conducted.

A report on efforts by Saphow, et al. (1979) to design, fabricate, and test a combination visiometer/ceilometer based upon laser rangefinding and charge control device technologies demonstrates concept feasibility and offers recommendations for implementation of future generation equipment. Bonner and Lentz (1979) developed a visioceilometer prototype. The hand-held, battery-operated lidar uses the AN/GVS-5 laser rangefinder optics. The visioceilometer can measure cloud height from 50 to 3000 m with a 10 m accuracy and calculates visibility from a sample volume up to 1 kilometer length of the lidar return.

The National Weather Service (1979) reported the test results of the Aviation Automated Weather Observation System (AV-AWOS). Verification and rationale for the cloud and visibility algorithms are presented. The algorithms for converting sensor data to automated observations of cloud height are specified.

Werner (1980) reviews and compares various methods for determining SVR. Discussion of laser radar systems for use in aircraft landing operations is emphasized. A measurement method is proposed for visibility distances up to 1500 m and for altitudes to 100 m. Geisler (1979) reports the demonstrated accuracy of a remote tower SVR system. An examination of short-range predictions revealed that the equivalent Markov technique provides accurate and reliable forecasts of below limit SVR conditions and yields slightly better results than the Markov and REEP techniques. Moroz (1979) describes experimental lidar SVR measuring systems. Information on light scattering by atmospheric particles to determine visibility at airfields is required by the Air Force where during low visibility operations the multiple scattering process is very important.

Severely reduced visibility in nighttime pilot performance is discussed by Lewis and Mertens (1978). Simulated approaches using an aircraft simulator with a computer-generated image were studied in regard to deviations from a 3-degree glide path with altitude and distance flown related to visibility. The relation between flight altitude and flight visibility is discussed by Hoffman (1980). It is noted that for different flight altitudes the degree of turbidity of the atmosphere between the aircraft and target varies; and therefore, the visibility varies. Means of calculating these maximum flight altitudes are discussed and determined experimentally to be represented by a logarithmic function.

Results of simulated approaches using thirteen commercial pilots from four airlines are reported by Haines (1980). Parameters such as wind shear, runway visual range (RVR), ceiling heights, and visibility were tested. Results of mean decision time, pilot performance, the significant effects of wind shear, the day-night and RVR variables are indicated.

The technological advances in aircraft instrument landing systems along with improved approach and runway lightning systems will continue to reduce the visibility requirements at large airports for safe landing operations. However, there is a continued need for improved and less costly ceiling and visibility measurement systems at small airports which cannot provide or afford the expensive lightning and landing systems.

VII. FOG

Fog dispersal continues to be a major problem at commercial air terminals. Even with the technological advances in ground and airborne landing equipment, the occurrence of fog congests aircraft traffic moving in the ramp areas. The primary research is being conducted in the charged particle technique and thermal technique area.

A sensitivity analysis on a one-dimensional mathematical model of ice crystals in supercooled clouds is examined by Dyer (1978) for possible use in fog analysis. Data taken during a stratus seeding field program experiment conducted in northern Michigan in 1977 are compared with model calculations. Critical parameters included seeding rate, cloud depth, temperature, drop size, liquid water content, and updraft velocities. A reasonable agreement between theoretical and observed rates of cloud dissipation is obtained when substituted reasonable values of cloud physics parameters and known values of the seeding rates, minimum temperatures, and cloud depth are used.

A feasibility study to determine the cost effectiveness of using radiant energy for fog dispersal is conducted by Klein (1978). Airborne and ground-based microwave power was considered. In the ground-based method the microwave beam is directed parallel to the ground along the runway, providing a direct source for heating the fog. The airborne method directed the beam perpendicular to the ground, heating the ground and providing infrared power for fog dissipation.

Because of the required power densities that are well above the personal safety limit of 100 W/m^2 and the high cost of electrical energy, the radiant energy methods were found to be cost prohibited.

Fog dispersal at airports using the charged particle technique is investigated and compared with other techniques by Christensen and Frost (1980). This technique of using charged particles for fog dispersal shows potential, but a need for experimental verification of several significant parameters such as particle mobility and charge density is expressed. Thermal systems, seeding and helicopter downwash techniques for fog dispersal are discussed.

The charged particle techniques for dispersing warm fog in the terminal area of commercial airports is reported on by Frost, Collins, and Koepf (1981). The report focuses on features of the techniques which require further study. A description is given of the major verification experiments carried out and the basic physical principles of the techniques. The nozzle characteristics and the fundamentals of its operation are given, including a discussion of the theory of particle charging in the nozzle. Information from extensive literature on electrostatic precipitation relative to environmental pollution control and a description of some preliminary reported analyses of the jet characteristics and interaction with neighboring jets are included. The equation governing the transfer of water substances and of electrical charge is given together with a brief description of several semi-empirical, mathematical expressions necessary for the governing equations. A description of the necessary ingredients of a field experiment to verify the system once a prototype is built is given.

Techniques of dispersing warm fog operationally at commercial airports are reviewed by Frost, et al. (1981). Emphasis is placed on the charged particle technique. A description of experiments and analytical studies previously carried out to prove the charged particle technique is given. An outline of experimental and analytical work required to fully establish the viability to airport operations is included. A cost comparison between the thermal systems and charged particle system is made.

VIII. LOW LEVEL WIND SHEAR

Because of the potential hazards of wind shear, especially during takeoff and landing operations, current research emphasis is in developing on-board and ground-based means of alerting pilots and simulation training of pilots to anticipate wind shear through the use of advanced computer programs which more realistically simulate wind shear.

A computer program developed by Schlickenmaier (1979) simulates the flight dynamics and automatic flight control system of a three-engine jumbo jet on a three-degree glidepath on final approach. This program can represent actual wind shear profiles that the aircraft might encounter. The simulation used autopilot and autothrottle. The results determine when the control forces exceed the limits of the aircraft. This data will help to provide information to pilots of aircraft to avoid and anticipate hazardous wind shear conditions.

Kimball (1980) reports on a simulator comparison of the velocity vector control wheel steering (VCWS) system and a decoupled longitudinal control system. Pilots used the electronic attitude direction indicator (EADI) to capture and maintain a three-degree glide slope and complete a landing in the presence of wind shear. The decoupled system using constant prefilter and feedback gains to provide steady state decoupling of flight path angle, pitch angle, and forward velocity, improved the pilot's ability to control airspeed and flight path angle. The pilots preferred the decoupled control system on a rating scale as much as three to four increments better than the VCWS system.

Ellis and Keenan (1978) present mathematically modeled and measured wind data represented as a function of both aircraft altitude and distance flown with a fast-time computer model piloted by an idealized controller. The wind models were varied with runway position to create a number of different wind profiles. The results of the piloted simulation indicated the severity of the wind shear hazard relative to the runway position and aircraft approach path. It is shown that longitudinal as well as vertical wind shear can produce a hazardous condition.

Turkel and Frost (1980) describe the expansion of a nonlinear aircraft motion and automatic control model to incorporate the human pilot in simulation of aircraft response to wind shear. The human pilot is described by a constant gains lag filter. Fixed-stick, autopilot, and manned computer simulations are made with an aircraft with the characteristics of a small commuter-type flown through longitudinal winds measured by a Doppler radar beamed along the glidescope. The responses of manned aircraft in a thunderstorm environment were measured by simulating the flight of an aircraft through sinusoidal headwinds and tailwind shears at the phugoid frequency.

Frost and Turkel (1981) address some of the problems associated with flight through wind shear. A review of previous studies of wind shear on aircraft performance is given. The dynamic equations of motion are addressed, and additional terms appearing due to variable wind effects are described. Some simple computations are made to illustrate the influence of these terms on typical approach and takeoff through wind shear.

Frost, Turkel, and McCarthy (1982) investigate the excitation of phugoid oscillations of commercial-type aircraft when encountering thunderstorm wind shear. The studies were conducted using computer and manned flight simulators. Sinusoidal winds were also studied at the phugoid frequency and various other frequencies. Manned simulator results although showing similar trends did not fully collaborate the magnitude of the excessive oscillations in flight path amplitude as predicted by computer analysis.

The computer simulation of aircraft landing through thunderstorm gust fronts is discussed by Frost, Crosby, and Camp (1979). The three degree-of-freedom nonlinear equations of aircraft motion for the longitudinal variables containing all two-dimensional wind shear terms are solved numerically. Gust front spatial wind field inputs from experimental data are coupled with a computer table lookup routine to provide the required wind components and shear. Both fixed control and automatic control landings are simulated.

Strauch and Moninger (1978) discuss the use of Doppler radar in the measurement of wind profiles in the lower atmosphere in optically clear air. Because of the requirement for a system capable of operating in all weather regimes, this paper discusses the utility and limitations of the radar system and the application of microwave radar to the wind shear problem.

Strauch and Sweezy (1980) report on a computer program to simulate the measurement of wind profiles and wind shear using a pulse Doppler radar. The simulation using different wind models shows that the radial velocity field of a single Doppler radar depicts wind shear by a change in the orientation of contours of constant velocity.

The effects of a finite antenna beamwidth and the location of the radar on the measurement of LLWS using a computer simulation of radar-measured radial velocity profiles are evaluated by Sweezy, Moninger, and Strauch (1978). The results show that a radar beamwidth of 1.5 degrees provides sufficient spatial resolution to measure low-level wind profiles, but that a fixed beam radar is not sufficient to measure horizontal gradients, headwinds, and tailwinds.

Wilhelm and Marchand (1979) present a method which describes the flight path in analytical form with respect to the flare maneuver of the pilot in wind shear occurrences during landing flare. The influence of direct lift control is shown. It was shown that maintenance of a control function selected by the pilot leads to a reduction in the decay of flight path angle when wind velocity decreases; to achieve touchdown comparable to the undisturbed case, the pilot must vary his control function. A comparison with flight tests shows that a flare path in the form of a fourth order parabola realistically reproduces the actual conditions, and the control function can contain a progressive component in addition to the linear increase in pitch attitude.

Badner (1979) presents theoretical and observational background information on LLWS occurrence. Accidents related to LLWS are cited and forecasting methods are provided.

Bullock (1980) discusses wind shear in three forms, the horizontal plane, the vertical plane, and the horizontal shearing masses in vertical motion. Emphasis is placed on the prediction of CAT. Vertical shear is reported to be the reliable indicator of turbulence. CAT detection equipment such as radiometers and Doppler radar is examined for analyzing the internal structure of thunderstorms.

Weaver, et al. (1981) describes a pulsed CO_2 Doppler lidar system used in demonstration tests of ground-based and airborne flight operations. Used as a ground-based system, the unit permits detection of wind shears in thunderstorm gust fronts to a range of 6 km. The airborne system provides advance warning of CAT. The data provided included turbulence location and intensity, with intensity being indicated by the measured spectral width which is proportional to the wind gust velocity.

Bossi (1980) discusses techniques for designing constant gain estimators. When uncertainties are present in the dynamic model, results of application of these techniques to the design of an estimator for wind shear and thrust loss on a STOL aircraft are presented.

A wind shear detection system designed to operate with the ASR-8 is reported by Offi, et al. (1980). The system is in the second testing phase. The testing compares the radar with aircraft and tower winds measurements, evaluates wind shear measurement capabilities under various weather conditions, and investigates the effectiveness of simple two-azimuth pointing strategy system capabilities and limitations. Results show the system to operate satisfactory and to be compatible with the ASR-8. Recommendations were made to continue testing to provide information for possible development of a prototype model.

The design and preliminary tests of an IR-airborne LLWS remote sensing system are presented by Caracena, Kuhn, and Kurkowski (1981). The 13-15 micron portion of the CO_2 molecular spectrum can be used to remote sense LLWS in and around thunderstorms. A radiometer, with a designed "look-distance" of about 10 km, remotely senses an average air temperature along a forward looking horizontal path. However, this system is not feasible at the present with noncooled detectors which require a major design improvement.

McCarthy, Blick, and Elmore (1981) conducted a feasibility study to determine whether ground-based Doppler radar could measure the wind along the path of an approaching aircraft sufficiently accurately to predict aircraft performance. Sixteen of 43 precision-approach radar-controlled approaches were examined in detail. In approximately 75 percent of the cases studied the Doppler measurements of longitudinal winds were in acceptable agreement with aircraft wind measurements. It was determined that a ground-based Doppler radar operating in optically clear air provides the appropriate longitudinal winds along an aircraft's intended flight path.

The design of a wind shear detection radar by Chadwick, Moran, and Campbell (1979) is treated in two steps. Statistical results are given from a field experiment conducted to determine the strength of the return signal. These results were used to develop a clear air radar for shear detection. The tradeoff between wavelengths, transmitted power, and antenna size is shown.

Results of simulated approaches using thirteen commercial pilots from four airlines are reported by Haines (1980). Parameters such as wind shear, runway visual range (RVR), ceiling heights, and visibility were tested. Results of mean decision times, pilot performance, the significant effects of wind shear, the day-night and RVR variables are indicated. Foy and Gartner (1979) describe the fourth in a series of piloted DC-10 flight simulation exercises conducted to develop and test airborne techniques designed to aid the pilot in detecting and coping with low level wind shear. The reported exercise simulated approach and landing sequences using manual control with the aid of a flight director. Techniques developed from previous exercises were tested, but no one airborne means of coping with LLWS was recommended. Foy (1979) describes the development and testing of airborne displays, instrumentation, and procedures for use in aiding airline pilots to cope with wind shear and turbulence during takeoff approach and landing operations in all weather conditions. This involved the development of a set of candidate standard wind shear models. Tests were conducted using moving base simulators and instrument aiding systems in wide-bodied (DC-10) and nonwide-bodied (727) aircraft. The study emphasizes the role of head-up displays during flight operations.

Koenig and Krauspe (1980a) describe phenomena closely related to wind shear. Consideration is given to hazards to aircraft operations using conventional cockpit instruments. Current and future state-of-the-art methods for wind shear detection are evaluated as well as comments on ground-based wind shear warning systems. The effects of wind shear are analyzed and are shown to differ on aircraft in takeoff and waveoff situations as described by Koenig and Krauspe (1980b). Proposals are made which compensate for wind shear in these modes of flight.

Wilhelm and Marchand (1979) calculate the effect of wind shear on the arrested landing of conventional and short takeoff and landing (STOL) aircraft. The function of wind speed and pilot aircraft controls upon the aircraft trajectory during the approach is analyzed. Recommendations for pilot control during landing are included. Knorr and Wilhelm (1979) studied the relation between landing flare and the specific dynamic characteristics of an aircraft. Conventional flare maneuver operations and coupled control operations as well as the effects of wind shear are investigated.

Glazunov (1979) examines vertical wind shear data in the atmospheric surface layer at 8 and 25 m levels. An analysis of shear data in the range of 2 to 60 minutes is presented with a range of values in which the shear often exceeds a specified "intense" value in short-term pulsations. The analysis shows that maximum values of shear during short-term intensification can attain values of up to 18 m/s near the surface in the 30 m layer.

Alexander and Camp (1981) discuss the magnitude and frequency of wind speed shears from 3 to 150 m. Results from NASA's 150 m ground winds tower facility with algebraically derived values of magnitude and frequency are included. The study supports the need for short-term wind measurement accuracy in detecting wind shear with the most vital need for information below 150 m and possibly more important below 60 m. Vertical wind speed is shown to decrease with altitude.

Fujita (1981c) examines a wide range of horizontal dimensions of airflow in a series of five scales beginning at the planet's equator, being the maximum dimension of mesoscale and decreasing by two orders of magnitude per scale. Various motion classified into these scales led to a conclusion that extreme winds induced by thunderstorms are associated with misoscale and mososcale airflow spawned by the parent, mesoscale disturbances. These five scales of airflow are associated by Fujita and Wakimoto (1981) with a series of destructive windstorms on July 16, 1980, which caused an estimated $500 million in damage. The windstorms which covered a zone from Chicago to Detroit were confirmed to be downbursts and microbursts with their horizontal dimensions extending tens of meters to hundreds of kilometers.

Frost and Camp (1980) discuss the effects of aviation meteorology on terminal operations. Data on turbulence and wind shear from airport terminals are summarized. Emphasis is placed on obtaining more real-time wind and temperature data. Methods to indicate wind differences at altitude and touchdown are reported.

Pilot response to wind shear once encountered is a critical factor; and, therefore, we see a continued effort in the development of means of alerting and training of pilots in corrective actions to be taken.

IX. STORM HAZARDS/SEVERE STORMS

The relatively high number of aircraft accidents that are related to some type of severe storm or thunderstorm prompts researchers to developing improved means of identifying, tracking, and measuring intensities to provide pilots and controllers with better means of coping with these hazards. Increased research in microburst and downburst studies is being conducted.

In a study conducted by Dayton University Research Institute (1980) on the effect of severe rainfall upon an aircraft, it was found that the aircraft can be affected aerodynamically in at least four ways: (1) raindrops striking the fuselage and wings impart a downward momentum to the aircraft; (2) increased drag results from the aircraft striking the raindrops head on; (3) at any instant in time the aircraft will contain a thin layer of water over most of its surfaces which will give additional mass to the aircraft; (4) the water on the airfoil will result in a roughened airfoil surface that could produce significant aerodynamic penalties. The effects of each of these factors were calculated and modeled, with the results that they could cause significant penalties to performance.

Measurements of hail particle size distributions determined by Musel, et al. (1978) with a laser hail spectrometer mounted aboard a T-28 aircraft and flown through thunderstorm cells correlated with surface measurements of hail made by aluminum foil hail pads. Although these samples indicated an agreement between the two measurements, there were found to be greater proportions of both the larger and smaller hail particles with the airborne distribution. Improvements to the airborne sensor system are suggested.

Caracena (1980) describes the phenomenology of one class of thunderstorm downdrafts--the microbursts. Several aircraft accidents involving microbursts are analyzed, and a concept for an early warning wind shear sensor is presented.

Microbursts are discussed by Fujita (1981d) in relation to aviation wind shear hazards and thunderstorm hazards. Recent commercial accidents or near-miss cases are discussed as related to downbursts. Plans for future studies and possible use of Doppler radar for detection of microburst are given. Fujita (1980a) reports on downbursts and microbursts in different stages such as descending, contact, outburst, and dissipating. Incidents involving aircraft encountering microbursts or downbursts are examined. An examination of two microbursts as depicted by the Northern Illinois Meteorological Research on Downbursts (NIMROD) network is reported by Fujita (1980b). Jordon (1980) describes the use of high-sensitivity pressure sensors in combination with suitable wind sensors to determine the velocity of thunderstorm vortex flow near the ground where potential flight hazards exist.

Wood (1979) describes the involvement of Atlanta Air Route Traffic Control Centers distribution of weather information throughout the system. Developments in meteorological radar for locating and determining the severity of storm cells are discussed along with recommended improvements.

The computer simulation of aircraft landing through thunderstorm gust fronts is discussed by Frost, Crosby, and Camp (1979). The three degree-of-freedom nonlinear equations of aircraft motion for the longitudinal variables containing all two-dimensional wind shear terms are solved numerically. Gust front spatial wind field inputs from experimental data are coupled with a computer table lookup routine to provide the required wind components and shear. Both fixed control and automatic control landings are simulated.

Abshaev (1980) describes a high-performance radar system for the operational acquisition and display of the cell structure of thunderstorm hail clouds.

Carr and Gerlach (1981) describe some of the instrumentation system used in support of NASA's Storm Hazard Program. The systems include the Radar Atmospheric Research Facility (RARF) with its space range radar and a near real-time display from the National Weather Service WSR-57 radar, a lightning detection and ranging system (LDAR), and a Ryan Stormscope. The RARF can detect, track, and quantify the properties of severe storms. Simultaneous measurements in the UHF (70cm), S (10cm), and C (5cm) bands can be made of clouds and precipitation to deduce particle size and characteristics, including quantitative cross sections of hail storms and raindrops. Relative attenuation at the wavelengths can be used to calculate path integrated rainfall and water content. The LDAR system determines the location of lightning discharges in real time and measures the electric field waveform for further study. The Ryan Stormscope has the capability to range and detect lightning out to 320 kilometers.

X. TURBULENCE

Unexpected turbulence presents a potentially hazardous situation for aircraft and passengers. Current research in this area is focused on improved detection and forecasting techniques of turbulence for in-flight, takeoff, and approach to landing situations. Mountain wave turbulence is also considered.

The status of research into clear air turbulence (CAT) meteorology is discussed by Ehernberger (1980) in terms of forecasting and detection. Basic reference material for gust design criteria is cited. CAT and its relationship to air transportation is documented in cited research reports by Habercom (1980). The occurrence, detection, and aircraft encounters with CAT are investigated. Mauk (1979) presents 121 citations from the International Aerospace Abstracts covering aspects of CAT such as research and analysis, theories and experiments, detection and measurement equipment, simulation modeling, and aircraft accidents involving CAT.

An overview of problems that turbulence poses for aviation is presented by Etkin (1980). Technical issues, especially for design, simulation, and certification are discussed. Review of knowledge of turbulence at altitude and at ground level is stated. The four-point model of the airplane is introduced. Burroughs (1978) discussed the theory of lee wave formation with a view to nowcasting turbulence categories associated with the waves in the Hawaiian chain. Enders (1978) reports NASA's aviation safety technology program examines specific safety problems associated with atmospheric hazards. The report cites unexpected turbulence as being a major factor affecting the well-being of crew and passengers.

The measurement of atmospheric turbulence is discussed by Pocock (1980) in terms of a pilot's viewpoint. Two areas of measurement are considered: frequency and severity of turbulence. Suggestions for helping the pilot solve turbulence problems are given.

An improved method of forecasting CAT is described by Keller (1980). The method is called the DRT Technique. The DRT senses the synoptic scale centers of action which provide the energy to the CAT mechanism at the mesoscale level. The DRT algorithm is deterministic rather than statistical, using the hydrodynamic equations relevant to the synoptic scale. This method uses the same input data as currently used by the National Meteorological Center prognostic models.

Flight tests using infrared radiometers in a clear air turbulence alerting system are discussed by Kurkowski, Kuhn, and Stearns (1981). It is noted that the alert time and reliability depend on the band-pass of the IR filter used and on the altitude of the aircraft. Flight test results indicate a band pass of 20 to 40 microns appears optimal for alerting the aircraft crew to CAT at times of 2 to 9 minutes before encounter. Alert time increases with altitude as the atmospheric absorption determining the horizontal weighting is reduced.

Harris and Jelalian (1979) report on development of CO_2 laser Doppler instrumentation for detection of CAT. Analyses of the mounting and mount support systems of CAT transmitters verify that satisfactory shock and vibration isolation are attained. The mount support structure conforms to flight crash safety requirements with high margins of safety.

A CAT flight test is described by Weaver (1980). The purpose was to evaluate four sensors in the detection of CAT and related meteorological targets. The sensors included the CO_2 pulsed Doppler lidar and three radiometers. The primary types of CAT investigated were mountain wave, jetstream, frontal wind shears, troughs, and ridges as well as in cirrus clouds.

Williamson (1978) presents a power spectral technique for estimating gust loads on aircraft. A two-degree-of-freedom model is employed on the longitudinal and lateral aircraft motions due to atmospheric turbulence. The conclusion was that this method would be a useful design tool to the small aircraft manufacturer with access to a digital computer. Cocquerez and Verbrugge (1978) studied aircraft performance in turbulent airflow such as lateral gusts. Conditions found in low altitude approaches, landings with wind composed of transversal gusts, and stability at high angles of attack at low airspeed were emphasized.

Gary (1981) describes a method and apparatus for indicating the altitude of the tropopause or of an inversion layer in which CAT may occur and the likely severity of any such CAT. A plot of altitude (with respect to an aircraft) versus temperature of the air at that altitude can indicate when an inversion layer is present and can indicate the altitude of the tropopause or of such an inversion layer. The plot can also indicate the severity of any CAT.

Kennedy and Shapiro (1980) discuss a series of aircraft penetrations into clear air turbulence within upper level fronts. Heat and momentum diffusivities are estimated to obtain more realistic parameterizations for numerical models.

Statistical modeling of atmospheric turbulence is discussed by Wang and Frost (1980). The statistical properties of atmospheric turbulence, in particular the probability distribution, the spectra, and the coherence are reviewed. Different turbulence simulation models are reviewed and incorporated into a computer model of aircraft flight dynamics. Computed results of the influence of different turbulence models on the flight path of an aircraft having the characteristics of a DC-8 are given.

XI. WINDS

Scoggins, et al. (1980) discuss the general criteria for a flight test option of a Doppler Lidar Wind Velocity Measurement System. The importance of the requirement for comparison is brought out because of the first year of operation of the system. The uniqueness of the Doppler system preludes any direct comparison, but measurements from tower mounted sensors and two-dimensional fields obtained from radars were found to be useful.

McCarthy, Blick, and Elmore (1981) conducted a feasibility study to determine whether ground-based Doppler radar could measure the wind along the path of an approaching aircraft sufficiently accurately to predict aircraft performance.

XII. OZONE AND OTHER METEOROLOGICAL PARAMETERS

An investigation into ozone levels in commercial airlines began after a series of illnesses were reported from passengers after long endurances at altitude.

Nastrom, Holdeman, and Davis (1981) summarize cloud encounter and particle number density data taken as part of the NASA Global Atmospheric Sampling Program (GASP) aboard commercial Boeing 747 airliners. Summary statistics and variability studies are presented. It is shown that on the average, 15 percent of the 54,164 data samples contained ozone. This value varies with season, latitude, synoptic weather situation, and distance from the tropopause.

A review of GASP data by Holdeman and Nastrom (1981) involving ozone contamination in aircraft cabins is presented. Analysis of the data (1) confirmed the occurrence of high ozone levels in aircraft cabins, documenting the ratio, and the effects of air conditioner modification on that ratio, (2) better define the ozone climatology at airline cruise altitudes, and (3) outlined procedures for estimating the frequency of flights encountering high cabin ozone levels using climatological ambient ozone data.

Perkins, Holdeman, and Nastrom (1979) present data of measurements on two B747 aircraft of cabin and ambient ozone levels.

Rogers (1980) reports on results of ozone studies of aircraft cabins. The procedures used and a description of equipment is included. The conclusions confirm (1) high levels of ozone, (2) excessive ozone exposure in flights at high altitudes and latitudes, and (3) long-range aircraft are more likely to encounter excessive ozone concentrations than short-range aircraft.

XIII. SAFETY

Weather phenomena is a critical factor in the safe operation of aircraft. Since it is not possible to control the weather, means of making air operations as safe as possible must be taken.

Chabod (1980) discusses the ways in which meteorological services can enhance flight safety. The operations of the meteorological center of ROISSY-CHARLES De Gaulle are described with reference to services provided to both general aviation and commercial aviation.

The National Transportation Safety Board (1978) reported all fatal U.S. aircraft accidents involving weather as a cause or factor for 1977. Statistical data includes type of accident, phase of operation, injury index, aircraft damage, pilots certification, injuries and cause or factor. Keul (1978) conducted a study correlating general aviation accidents with meteorological data during 1966-1976 in Austria. The hypothesis that variation of the regional VFR conditions are responsible for the accident distribution is refuted.

Collins (1981) surveys aircraft accidents and analyzes the apparent causes. Avoidance tactics and techniques as an aid in the prevention of weather-related accidents are provided.

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APPENDICES

APPENDIX A

TABULATIONS OF RESEARCH

AGENCY ACRONYMS

AFFTC	AIR FORCE FLIGHT TEST CENTER
AFGL	AIR FORCE GEOPHYSICS LABORATORY
AFOSR	AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
AFSC	AIR FORCE SYSTEM COMMAND
DFRF	DRYDEN FLIGHT RESEARCH FACILITY
DOT	DEPARTMENT OF TRANSPORTATION
ERADCOM	ELECTRONICS RESEARCH AND DEVELOPMENT COMMAND
ERL	ENVIRONMENTAL RESEARCH LABORATORY
FAA	FEDERAL AVIATION ADMINISTRATION
KSC	KENNEDY SPACE CENTER
LaRC	LANGLEY RESEARCH CENTER

LeRC	LEWIS RESEARCH CENTER
MSFC	MARSHALL SPACE FLIGHT CENTER
NCAR	NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
NOAA	NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NRL	NAVAL RESEARCH LABORATORY
NSF	NATIONAL SCIENCE FOUNDATION
NSSL	NATIONAL SEVERE STORMS LABORATORY
NTSB	NATIONAL TRANSPORTATION SAFETY BOARD
NWS	NATIONAL WEATHER SERVICE
OAST	OFFICE OF AERONAUTICAL AND SPACE TECHNOLOGY
ONR	OFFICE OF NAVAL RESEARCH
UCLA	UNIVERSITY OF CALIFORNIA AT LOS ANGELES
USAF	UNITED STATES AIR FORCE
WFC	WALLOPS FLIGHT CENTER

TABLE I. ADVANCED METEOROLOGICAL INSTRUMENTS

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
NEXRAD Radar Terminal Area Coverage Studies Frank Melewicz (202)426-8427 DOT/FAA, NOAA Project #155-410-03W	NOAA/NSSL	Dusan Zrnic (NSSL) FTS 736-4916	Use Doppler Weather Radars to measure turbulence in thunderstorms. Develop Doppler Weather Radar siting criteria for terminal area applications.
LWI Program Richard R. Reynolds National WX SVC Surface Observations Automation Program (W432) 8060 13th Street Silver Spring, MD (301)427-7815	NWS/System Development Office, Advanced Technology Branch (W431)	D. Acheson J. Bradley (703)471-5302 V. Nadolski	Development of a (horizontal) laser systems capable of distinguishing rain from snow; rainfall amounts and infer the presence of fog. Development of algorithms to translate sensor output into an automated observation suitable for aviation use.
Knowledge of High Altitude Atmospheric Processes L. C. Montoya FTS 984-8423 L. J. Ehernberger (805)258-3311, x435 FTS 984-8435 NASA/OAST RTOP #505-44-14	NASA/DFRF UCLA	L. J. Ehernberger (805)258-3311, x435 FTS 984-8435 M.G. Wurtele (213)825-1751	The areas studied include in-flight measurements of atmospheric turbulence, definition of the associated atmospheric structure, and cloud physics effects on aircraft icing. Specific tasks include 1) the improvement of flight test procedures, 2) meteorological analysis techniques, 3) the climatology of vertical temperature gradients and wind shears in the stratosphere, 4) numerical simulation of atmospheric gravity wave motion associated with CAT, and 5) a study of cloud physics effects which significantly influence aircraft icing.

TABLE I. ADVANCED METEOROLOGICAL INSTRUMENTS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Automated Low-Cost Weather Observing System (ALWOS) Richard R. Reynolds (301)427-7815 DOT/FAA Project #RD590714	NWS/Systems Development Office, Equipment Development Laboratory	Wayne Huffman (301)427-7809	Develop a series of automated weather observation systems ranging from systems which provide only wind and altimeter setting to systems which provide a complete aviation surface weather observation, including cloud cover, ceiling, and visibility.
Evaluation of Offshore Weather Observations John Dorman (202)426-8427 DOT/FAA Project #151-412-06	FAA	John Dorman (202)426-8427	Test Automated Weather System in the environment of Offshore Oil Platform.
Joint Airport Weather Studies (JAWS) Arthur Hilsenrod (202)426-8427 NSF, DOT/FAA, NOAA, and NASA Project #156-410-04W	NCAR University of Chicago	John McCarthy FTS 322-7651 James Wilson FTS 322-7651 T. T. Fujita University of Chicago (312)753-8112	Detailed study of thunderstorms using Doppler radars, instrumented aircraft and mesonet of surface sensors.
Weather Radar Meteorological Techniques Development Frank Melewicz (202)426-8427 DOT/FAA, NOAA/NWS Project #156-410-01W	Environmental Research and Technology, Inc. and Dartmouth College	R. Crane (603)646-3843	Develop algorithms to provide automatic cell detection, tracking, and prediction with conventional and Doppler weather radar data.

TABLE I. ADVANCED METEOROLOGICAL INSTRUMENTS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Center Weather Service Unit (CWSU) Development Eric Mandel (202)426-8427 DOT/FAA Project #151-413-01W	FAA, Washington, DC FAA Technical Center Atlantic City, NJ	Eric Mandel (202)426-8427 Craig Goff FTS 346-2130	Develop automated CWSU workstation.
Automated Weather Observation Systems (AWOS) John Dorman (202)426-8427 DOT/FAA Project #153-451-06	NWS/Systems Development Office, Equipment Development Laboratory	Wayne Huffman (301)427-7809	Develop a series of automated weather observation systems ranging from systems which provide only wind and altimeter setting to systems which provide a complete aviation surface weather observation, including cloud cover, ceiling, and visiblity.
Evaluation of Visibility Systems for CAT IIIB John Dorman (202)426-8427 DOT/FAA Project #151-451-03	Humboldt County Arcata, CA	Jim Wilkerson	Test dual baseline RVR system for the measurement of RVR to 150 ft, the minimum of CAT IIIB.
Automated Weather Observation Systems John Dorman (202)426-8427 DOT/FAA Project #153-451-06	NWS/Systems Development Office, Equipment Development Laboratory	Wayne Huffman (301)427-7809	Develop a series of automated weather observation systems ranging from systems which provide only wind and altimeter setting to systems which provide a complete aviation surface weather observation, including cloud cover, ceiling, and visibility.

TABLE I. ADVANCED METEOROLOGICAL INSTRUMENTS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Satellite Sounding Techniques Jean King (617)861-2976 AFSC	AFGL/Satellite Meteorology Branch/(LYP)	J. Bunting V. Falcone F. Valovcin R. Hawkins	To obtain the maximum information on atmospheric parameters such as temperature and moisture distribution from remotely sensed DMSP Satellite data.
Atmospheric Hazards Donald Fitzgerald (617)861-4405 AFSC	AFGL/Ground-Based Remote Sensing Branch/LYR	A. Bohne C. Bjerkaas K. Glover	To develop improved techniques for the detection, interpretation, and prediction of atmospheric hazards to Air Force personnel, equipments and facilities, both airborne and ground-based, utilizing remote sensing measurements from locations on or near the earth's surface.
Aviation Operations Safety Technology-Lidar Applications E. A. Weaver (205)453-1597 FTS 872-1597 NASA/Marshall Space Flight Center Huntsville, Alabama	Optics Branch Electronics & Control Laboratory Marshall Space Flight Center, AL 35812 Raytheon Company Sudbury, MA Lassen Research Manton, CA Applied Research, Inc. Huntsville, AL Alabama A&M University Huntsville, AL	J.W. Bilbro W.D. Jones S.C. Johnson J.W. Wright C.E. Harris C.A. Dimarzio R.W. Lee H.B. Jefferys L.Z. Kennedy S.S.R. Murty	Electro-optic sensors using coherent light will be developed for application to aircraft operations and safety problems with primary emphasis on Doppler lidar systems. Factors that affect CO_2 lidar performance in the atmosphere will be investigated. Developed sensors to be used in measurement of winds, wind shears, turbulence, etc. Investigate use of CO_2 Pulsed Doppler Lidar to measure global winds from satellite.
Aviation Safety Technology N.L. Crabill NASA/Langley Research Center Hampton, VA (804)827-3274 RTOP #505-4423	NASA/Langley Research Center	L.D. Staton (804)827-3631	Determine effective radar techniques for thunderstorm turbulence and wind shear detection with flight tests of an experimental Doppler weather radar. Comparisons will be made with penetration aircraft winds and turbulence and with ground-based Doppler weather radar.

TABLE I. ADVANCED METEOROLOGICAL INSTRUMENTS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research - Investigation into the Use and Development of New or Improved Methods and/or Instrumentation to Enhance Safety and Efficiency of Aeronautical Systems Dennis W. Camp ES82/Atmospheric Sciences Division NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-2087 RTOP #505-44-19	NASA/MSFC Atmospheric Sciences	Dennis W. Camp (205)453-2087	To develop new and/or to improve present meteorological instrumentation in support of this project and to investigate the use of meteorological satellite data relative to enhancing the safety and efficiency of aeronautical systems.
Aircraft Meteorological Data Relay (AMDAR) Jim Giraytys Physical Scientist Department of Commerce NOAA 6010 Executive Blvd. Room 804 Rockville, Maryland 20852 (301)443-8811	NOAA/Office of Oceanic and Atmospheric Services, Washington, DC NWS/Office of Meteorology and Oceanography, OA/W116 Washington, DC NWS/Office of Technical Services, OA/W513 Washington, DC	Jim Giraytys (301)443-8811 Richardson Decker George J. Smidt	To develop and equip a fleet of commercial or other aircraft with a device (AMDAR) to automatically transmit wind and temperature observations taken every 7-1/2 minutes. Reports are sent directly to ground stations via VHF radio or by means of a geosynchronous satellite. Increasing the observation rate allows vertical profiles to be taken. System designed to increase observations from data-sparse parts of world and for mesoscale forecasting.
Quantitative Visibility Measurements for E-O Characterization E.H. Holt ERADCOM	DELAS-AS-T Atmospheric Science Lab White Sands Missile Range, NM	W. J. Lentz (505)678-1761	Construct and test hand-held slant visual range and cloud ceiling height measuring Lidar. Integrate system into Remote Automatic Weather Station (RAWS).

TABLE I. ADVANCED METEOROLOGICAL INSTRUMENTS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Wind Shear Detection With Pulse Doppler Radar I.D. Goldman FAA ARD-231 Washington, DC	NOAA/ERL/WPL	R. G. Strauch W. B. Sweezy	Investigate use of Doppler radar for detecting wind shear in the terminal area. (Project concluded.)
Radar Studies of Vortices R. B. Chadwick R45x6 NOAA/DOC/ERL Boulder, Colorado DOT/FAA	NOAA/ERL	R.B. Chadwick FTS 320-6318	Determine feasibility for detecting hazardous wake effects with FM-CW radar.
ALWOS (Automated Low-Cost Weather Observation System) Ray Calao ARD-451 FAA Kenneth Shreeve OA/W411 NWS	NWS Integrated Systems Lab Test & Evaluation Division	Wayne Huffman (301)427-7809 Steve Imbembo	Evaluate the overall system performance of a microprocessor - based automated weather observation system including sensors and processing algorithms. (At Dulles International Airport)
Cloud Physics Model and Instrumentation Development Mr. Vernon Plank (617)861-2942 AFSC	AFGL/LYC	M. Glass R. Berthel E. Georgian D. McLeod	To develop better methods and models for determining the microphysical properties of clouds and precipitation for particular locales or along specific atmospheric paths.

TABLE I. ADVANCED METEOROLOGICAL INSTRUMENTS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
CHI/Visibility Program Richard R. Reynolds National WX SVC Surface Observations Automation Program (W432) 8060 13th Street Silver Spring, MD	NWS, T&ED RD 1, Box 105 Sterling, VA	J. Bradley (703)471-5302 R. Lewis	Evaluation of current sensors used on cloud height indicators (CHI) or as visibility sensors. Development of specifications for cloud and visibility sensors to be used in an automated observing system. Development of algorithms to include proper sampling time, network spacing and processing schemes to output an observation of cloud condition and visibility suitable for use in an automated observation.
Severe Storms & Local Weather James C. Dodge NASA Headquarters (202)755-8596 NASA/OSTA	NASA/Marshall Space Flight Center Huntsville, AL	F.W. Wagnon (205)453-4623 T.G. Barnes (205)453-1574	Measurement and analysis of optical emissions from lightning discharges to determine feasibility of lightning detection from a satellite-based system.
Severe Storms & Local Weather James C. Dodge NASA Headquarters (202)755-8596 NASA/OSTA	NASA/Marshall Space Flight Center Huntsville, AL	F.W. Wagnon (205)453-4623 T.G. Barnes (205)453-1574	Measurement and analysis of radio-frequency emissions from lightning discharges to determine feasibility of lightning detection from a satellite-based system.
Airborne Field Mill D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644	NASA/KSC (Design Eng. & Technical Support Planning Research Corp.	Don Stubbs (305)867-9167 J. Stahman (305)867-3407 Ron Wojtasinski (305)867-4020	Design Field Mill System for aircraft use.
Ground Field Mill D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644 KSC Technical Support	NASA/KSC Vehicle Operations	Ron Wojtasinski (305)867-4020	Provide electric field determination for potential lightning discharges.

TABLE I. ADVANCED METEOROLOGICAL INSTRUMENTS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Hazards From Fields Aloft D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644	NASA/KSC (Design and Support Engineering) Coulotron, Inc.	Ron Wojtasinski (305)867-4020 Richard Dietz (305)867-9406	Develop software techniques to integrate data sources of lightning and fields aloft.
Winds D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644	NASA/KSC/NOAA Weather Support	Jim Nicholson	Determine presence of conditions supportive by winds convergence instrumentation that will produce local storm buildup in early stages.
Cockpit Weather Display James Muncy (202)426-8427 DOT/FAA Project #151-412-02W	Mitre Corporation McLean, VA University of Ohio	J. Kelly (703)827-6940 R. McFarland (614)594-5746	Develop low-cost relay of NWS weather radar to general aviation aircraft. Conduct flight evaluation of Cockpit Weather Display.
Weather Radar Data Processing and Exploratory Display Development Glenn Glassburn (202)426-8427 DOT/FAA Project #156-410-03W	Mitre Corporation McLean, VA	T. Garceau (614)827-6701	To demonstrate an automated method to contour and display weather radar data for en route air traffic control support.

TABLE I. ADVANCED METEOROLOGICAL INSTRUMENTS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Wave Propagation Laboratory C. Gordon Little Department of Commerce/NOAA/ERL Boulder, CO (303)497-6261	WPL/NOAA/ERL	C. Gordon Little	To improve the nation's geophysical research and services through creation and application of new remote measurement systems. Essential functions include: a) Wave propagation studies, b) Technique development, c) Geophysical research, d) Technology transfer.
Optical Sensor Development Robert S. Lawrence Department of Commerce/NOAA/ERL Boulder, CO (303)497-6353	WPL/NOAA/ERL	Robert S. Lawrence	Investigate basic problems of optical propagation in the atmosphere, and use the results of these studies to develop new optical techniques for remotely measuring the atmosphere. Quantities to be measured include average values, structure parameters, spectra, and fluxes of velocity, temperature, and water vapor.
Infrared Doppler Lidar Freeman F. Hall Department of Commerce/NOAA/ERL Boulder, CO (303)497-6312	WPL/NOAA/ERL	Freeman F. Hall	To develop and exploit remote sensors based on CW and pulsed coherent lasers for the measurement of atmospheric winds, turbulence, and diffusion, and for measuring the concentration of optically absorbing species of vapors and gases in the atmosphere by differential absorption lidar (DIAL) methods.
WINDS D. C. Moja NASA/Kennedy Space Center, FL (305)867-3644 NOAA	KSC/NOAA Weather Support	Jim Nicholson	Determine presence of conditions supportive by winds convergence instrumentation that will produce local storm buildup in early stages.

TABLE I. ADVANCED METEOROLOGICAL INSTRUMENTS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Environment Radiometry David C. Hogg Department of Commerce/NOAA/ERL Boulder, CO (303)497-6375	WPL/NOAA/ERL	David C. Hogg	Realization of microwave systems, primarily radiometric, for continuous, remote measurement of atmospheric temperature, water vapor, liquid water, and wind for use by the weather services, in weather modification programs, and in atmospheric research.
Meteorological Radar Earl E. Gossard Department of Commerce/NOAA/ERL Boulder, CO (303)407-6239	WPL/NOAA/ERL	Earl E. Gossard	To increase the understanding of the dynamical and microphysical processes controlling local weather by creating and using a multi-station, transportable Doppler radar facility capable of measuring three-dimensional wind fields, an FM-CW radar of the atmospheric under all weather conditions, and a coherent 8 mm cloud-sensing radar system that detects microphysical changes in cloud systems.
Atmospheric Studies Chandran J. Kaimal Department of Commerce/NOAA/ERL Boulder, CO (303)497-6263	WPL/NOAA/ERL	Chandran J. Kaimal	To increase national understanding of the atmosphere by carring out fundamental investigations in atmospheric dynamics and acoustic remote sensing, and by working with WPL program areas and outside groups to apply remote sensors to atmospheric research. The group also maintains and operates the Boulder Atmospheric Observatory (BAO) in support of this goal.
Icing Instrument Comparison Test in the NASA Lewis Icing Research Tunnel W. A. Olsen NASA/Lewis Research Center (216)433-4000, x6122 *and* Air Force (AFFTC)	NASA Air Force	W. A. Olsen T. Tibbals	To compare the liquid water and/or drop size distribution measured by several icing cloud instruments (both old and modern) for a given cloud condition in the Icing Research Tunnel.

TABLE II. FORECASTING

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Automated Weather Observation Systems John Dorman (202)426-8427 DOT/FAA Project #153-451-06	NWS/Systems Development Office, Equipment Development Laboratory	Wayne Huffman (301)427-7809	Develop a series of automated weather observation systems ranging from systems which provide only wind and altimeter setting to systems which provide a complete aviation surface weather observation, including cloud cover, ceiling, and visibility.
Automated Low-Cost Weather Observing System (ALWOS) Richard R. Reynolds (301)427-7815 DOT/FAA Project #RD590714	NWS/Systems Development Office, Equipment Development Laboratory	Wayne Huffman (301)427-7809	Develop a series of automated weather observation systems ranging from systems which provide only wind and altimeter setting to systems which provide a complete aviation surface weather observation, including cloud cover, ceiling, and visibility.
Evaluation of Offshore Weather Observations John Dorman (202)426-8427 DOT/FAA Project #151-412-06	FAA	John Dorman (202)426-8427	Test Automated Weather System in the environment of Offshore Oil Platform.
Terminal Area Weather Support Arthur Hilsenrod (202)426-8427 DOT/FAA Project #152-410-02W	NOAA/Prototype Regional Observing and Forecasting System	Don Beran FTS 320-6894 (303)499-1000, x6765	Improve very short range forecasts of aviation weather.

TABLE II. FORECASTING (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Cockpit Weather Display James Muncy (202)426-8427 DOT/FAA Project #151-412-02W	Mitre Corporation McLean, VA University of Ohio	J. Kelly (703)827-6940 R. McFarland (614)594-5746	Develop low-cost relay of NWS weather radar to general aviation aircraft. Conduct flight evaluation of Cockpit Weather Display.
Weather Radar Data Processing and Exploratory Display Development Glenn Glassburn (202)426-8427 DOT/FAA Project #156-410-03W	Mitre Corporation McLean, VA	T. Garceau (703)827-6701	To demonstrate an automated method to contour and display weather radar data for en route air traffic control support.
Center Weather Service Unit (CWSU) Development Eric Mandel (202)426-8427 DOT/FAA Project #151-413-01W	FAA, Washington, DC FAA Technical Center Atlantic City, NJ	Eric Mandel (202)426-8427 Craig Goff FTS 346-2130 (609)641-3200, x2284	Develop automated CWSU workstation.
Automated Weather Observation Systems (AWOS) John Dorman (202)426-8427 DOT/FAA Project #153-451-06	NWS/Systems Development Office, Equipment Development Laboratory	Wayne Huffman (301)427-7809	Develop a series of automated weather observation systems ranging from systems which provide only wind and altimeter setting to systems which provide a complete aviation surface weather observation, including cloud cover, ceiling and visibility.

TABLE II. FORECASTING (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Present Weather Richard R. Reynolds National WX SVC Surface Observations Automation Program (W432) 8060 13th Street Silver Spring, MD	NWS, T&ED RD 1, Box 105 Sterling, VA	S. Imbembo	Evaluation of current sensors suitable for the automatic detection and reporting of lightning, freezing rain, or hail. Development of specification for sensors to detect lightning, freezing rain, or hail to be used in future automated systems. Development of algorithms to process sensor data and report in current aviation format.
Fog Forecasting by Atmospheric Electrical Conductivity R.V. Anderson Office of Naval Research Washington, DC Code 4325 (202)767-3350	NRL	R.V. Anderson J.C. Willett	Study the physical mechanism of the observed precursor behavior of atmospheric conductivity using apparatus and techniques not in existence when the phenomenon was initially observed.
LLP (Lightning Location Protection) D.C. Moja (305)867-3644 NASA/Kennedy Space Center, FL USAF	NASA/KSC Vehicle Operations	W. Jafferis M.C. Forsyth	Evaluate the advantage of lightning detection for storm hazards forecasting. U.S. Air Force evaluation of system provided by KSC.
Weather Prediction Technology D.C. Moja (305)867-3644 NASA/Kennedy Space Center, FL and NASA/Langley Research Center NASA/Goddard Space Flight Center	NASA/KSC Technical Support NASA/LaRC	Carl Lennon (305)867-4068 N. Crabill (804)827-3274	Develop model of fine mesh with KSC parochial requirements for weather prediction using LaRC/GSFC model being developed.

TABLE II. FORECASTING (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Severe Storms (ONR)	TRW Los Angeles, California	F. Fendell (213)536-2438	To improve weather forecasts.
(ONR)	Jackson State Jackson, Mississippi	P. Feteris (601)968-2566	
(NEPRF)	Colorado State	W. M. Grey (303)491-8681	
(ONR)	Systems Control California	F.H. Nicholson (408)649-8495	
(ONR/NEPRF)	MIT Cambridge, Massachusetts	F. Sanders (617)253-2286	
(ONR)	University of Lowell	W. Tang (617)862-3615	
W. Martin Office of Naval Research 800 North Quincy Street Arlington, Virginia 22217 (202)696-4123			
Pilot Report Program Improvement Edward M. Gross NOAA/NWS 8060 13th Street Silver Springs, MD 20910 (301)427-7858 DOC/NOAA DOT/FAA	NWS/Office of Meteorology and Oceanography, OA/W116 Washington, DC FAA/Systems Research and Development Service, ARD/452 Washington, DC	Michael A. Tomlinson Eric Mandel (202)426-8427	1) To eliminate the procedural and systematic deficiencies of the pilot report program, as currently operated, through the development and implementation of procedures, formats, and necessary supportive equipment. 2) To utilize the output of this improved program in developing real-time graphics and specialized data collectives to improve pilot and pilot briefer weather intelligence; and in direct input and/or interaction with current numerical models to improve initial outputs and to provide real-time updating/amendment capabilities.

TABLE II. FORECASTING (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Atmospheric Dynamic Models Chien-hsiung Yang (617)861-2878 AFOSR	AFGL/Atmospheric Prediction Branch/LYP	S. Brenner S. Yee	To improve weather prediction by the development of an improved numerical-dynamical model of the atmosphere on a global scale. The model is to serve as a vehicle of research with which the dynamics of the earth's atmosphere may be studied and better methods of simulating and predicting the state of the atmosphere may be developed.
Climatological Techniques Arthur Kantor (617)861-5956 AFSC	AFGL/Tropospheric Structure (LYT)	I. Gringorten P. Tattelman E. Bertoni D. Grantham	To improve techniques for obtaining climatic information for use in design, operation, and evaluation of Air Force systems. Improved techniques include development of mathematical and physical models to better describe the atmosphere and its effect on AF operations.
Mesoscale Weather Forecasting H. Stuart Muench (617)861-2982 AFSC	AFGL/LYP	D. Chisholm H. Brown A. Jackson	To develop and evaluate improved techniques for automated and man-interactive forecasts of operationally significant local weather events and to develop techniques for the integrated utilization of satellite, radar, and conventional data into mesoscale (0-9 hr) forecasts.
Atmospheric Morphology Ralph Donaldson (617)861-4405 AFSC	AFGL/LYR	E. Moroz G. Armstrong	To develop improved techniques for observing, modeling, and predicting the time varying three dimensional structure of operationally significant meteorological phenomena.
Battlefield Weather Systems Michael Kraus (617)861-2473 AFSC	AFGL/LYP	F. Brousaides	To develop weather observation systems and forecasting techniques for use in uncontrolled or enemy-controlled battle areas and airspace.

TABLE II. FORECASTING (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Experimental Automated Route Forecast (ARF) Evaluation Frank Melewicz (202)426-8427 DOT/FAA, NOAA/NWS Project #132-403-030	FAA NWS Mitre Corporation McLean, VA	Frank Melewicz (202)426-8427 Ed Gross (301)427-7698 T. Mitchell (703)827-6815	Provide automated route-oriented aviation weather forecasts and other flight planning data for pilot self-briefing.
Environment Radiometry David C. Hogg Department of Commerce/NOAA/ERL Boulder, CO (303)497-6375	WPL/NOAA/ERL	David C. Hogg	Realization of microwave systems, primarily radiometric, for continuous, remote measurement of atmospheric temperature, water vapor, liquid water, and wind for use by the weather services, in weather modification programs, and in atmospheric research
Meteorological Radar Earl E. Gossard Department of Commerce/NOAA/ERL Boulder, CO (303)497-6239	WPL/NOAA/ERL	Earl E. Gossard	To increase the understanding of the dynamical and microphysical processes controlling local weather by creating and using a multi-station, transportable Doppler radar facility capable of measuring three-dimensional wind fields, and FM-CW radar of the atmosphere under all weather conditions, and a coherent 8 mm cloud-sensing radar system that detects microphysical changes in cloud systems.
Atmospheric Studies Chandran J. Kaimal Department of Commerce/NOAA/ERL Boulder, CO (303)497-6263	WPL/NOAA/ERL	Chandran J. Kaimal	To increase national understanding of the atmosphere by carrying out fundamental investigations in atmospheric dynamics and acoustic remote sensing, and by working with WPL program areas and outside groups to apply remote sensors to atmospheric research. The group also maintains and operates the Boulder Atmospheric Observatory (BAO) in support of this goal.

TABLE II. FORECASTING (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
WINDS D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644 and NOAA	KSC/NOAA Weather Support	Jim Nicholson	Determine presence of conditions supportive by winds convergence instrumentation that will produce local storm buildup in early stages.

TABLE III. ICING

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Pressure Icing Rate Meter (PIRM) P.J. Perkins NASA/Lewis Research Center Cleveland, OH (216)444-4000, x5535	NASA/Lewis Research Center	P.J. Perkins (216)433-4000, x5535	To modernize a low-cost instrument developed by the NACA to measure liquid water content and ice accretion rate, by incorporating a micro-processor and digital readouts.
Microwave Ice Accretion Measurement Instrument (MIAMI) R.F. Ide NASA/Lewis Research Center Cleveland, OH	Ideal Research, Inc. 1182 Coakley Circle Rockville, MD	B. Magenheim	To develop a flush-mounted surface waveguide instrument to detect ice, and measure ice thickness and growth rate.
Anti-Freeze Fluid Ice Protection Systems R.J. Shaw NASA/Lewis Research Center Cleveland, OH (216)433-4000, x367	University of Kansas Center for Research, Inc.	D.L. Kohlman	To update the design data base for glycol-exuding porous leading edge ice protection systems. To develop a light-weight, low cost porous leading edge fluid distributon made from a composite material.
Electrothermal Deicers for Rotor Blades R.J. Shaw NASA/Lewis Research Center Cleveland, OH (216)433-4000, x367	NASA/Lewis Research Center B.F. Goodrich, Inc. 500 S. Main St. Akron, OH	R.J. Shaw (216)433-4000, x367 N.A. Weisend (216)379-0765	To install an electrothermal deicer system on a helicopter main rotor blade for testing in the Icing Research Tunnel. The deicer will be heav-ily instrumented with thermocouples to obtain heat transfer data for comparison wiht 1-D and 2-D transient conduction codes being developed by NASA.
Icephobics Research H. Schmidt NASA/Lewis Research Center Cleveland, OH (216)433-4000, x5165	Clarkson College of Technology	H. Jellinick	Attempt to develop a material that will reduce ice adhesion sufficiently to cause self-shedding from fixed wings and rotor blades.

TABLE III. ICING (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Ice Accretion Studies on General Aviation Wings R.J. Shaw NASA/Lewis Research Center Cleveland, OH (216)433-4000, x367	NASA/Lewis Research Center Ohio State University	R.J. Shaw (216)433-4000, x267 M.B. Bragg	To test general aviation airfoils in the NASA Lewis Icing Research Tunnel. To obtain ice shapes and measure aerodynamic performance change due to ice. To compare results with analytical predictions. To make artificial ice shapes, and to compare the aerodynamic performance at a wing with artificial ice attached with the results for real ice.
Icing Scaling Law Verification R.J. Shaw NASA/Lewis Research Center Cleveland, OH (216)433-4000, x367 and Air Force (AEDC and AFFTC)	NASA/Lewis Research Center Air Force/AEDC Air Force/AFFTC	W.A. Olsen J.D. Hung T. Tibbals	To test the validity of published icing scaling laws using the NASA Lewis Icing Research Tunnel and the AEDC High Speed Icing Test Facility.
Upgrading of NASA Lewis Icing Research Tunnel G.P. Richter NASA/Lewis Research Center Cleveland, OH	NASA/Lewis Research Center	G.P. Richter W.A. Olsen (216)433-4000, x6122	To expand the ranges of liquid water content and cloud water droplet size available in the NASA Lewis Icing Research Tunnel to cover more of the FAR-25 envelopes.
Improved Capability for Helicopter Icing Research in the NASA Lewis Icing Research Tunnel W.A. Olsen NASA/Lewis Research Center Cleveland, OH (216)433-4000, x6122	NASA/Lewis Research Center	W.A. Olsen (216)433-4000, 6122	To install an OH-58 tail rotor (rotating blade test rig) in the Icing Research Tunnel (IRT). To install an oscillating blade test rig in the IRT.
Icing Instrument Comparison Test in the NASA Lewis Icing Research Tunnel W.A. Olsen NASA/Lewis Research Center and Air Force (AFFTC)	NASA/Lewis Research Center Air Force Meteorology Research, Inc.	W.A. Olsen T. Tibbals M.E. Humbert	To compare the liquid water and/or drop size distribution measured by several icing cloud instruments (both old and modern) for a given cloud condition in the IRT.

TABLE III. ICING (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Three-Dimensional Water Droplet Trajectory Code R.J. Shaw NASA/Lewis Research Center Cleveland, OH	Atmospheric Sciences Associates	H.G. Norment	To publish a computer code to calculate water droplet trajectories about 3-D lifting bodies.
Ice Accretion Modeling Code R.J. Shaw NASA/Lewis Research Center Cleveland, OH	University of Dayton Research Institute	J.K. Luers (513)229-3921	To develop a computer code to predict ice accretion shapes on lifting and non-lifting 2-D bodies.
Transient Heat Conduction Code for Deicer Analysis R.J. Shaw NASA/Lewis Research Center Cleveland, OH	University of Toledo	K. Dewitt	To develop 1-D and 2-D transient heat conduction codes to analyze thermal deicer systems.
Icing Scaling Analysis R.J. Shaw NASA/Lewis Research Center Cleveland, OH	University of Tennessee	K.G. Keshock (615)974-4118	To develop key dimensionless variables to allow icing tests on sub-scale models.
Water Droplet Collection Efficiency and Limits of Impingement for Modern Airfoils R.J. Shaw NASA/Lewis Research Center Cleveland, OH (216)433-4000, x367	Ohio State University	M.B. Bragg G.M. Gregorek	To calculate, tabulate, and plot results of calculations for water droplet collection characteristics of 30 modern airfoils.

TABLE III. ICING (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorological Research - Study of Frost Buildup and Dissipation on Aeronautical Surfaces Dennis W. Camp ES82/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-2087 RTOP #505-44-19	University of Dayton Research Institute Dayton, Ohio FWG Associates, Inc. Tullahoma, Tennessee	James K. Luers Mark Dietenberger (513)229-3921 Walter Frost Prem Kumar (615)455-1982	To investigate the onset, buildup, and dissipation of frost on the surface of an airfoil and to conduct a field test program relative to frost effects on aeronautical systems.
Aerodynamic Performance Penalties Due to Icing R.J. Shaw NASA/Lewis Research Center Cleveland, OH (216)433-4000, x367	Ohio State University	M.B. Bragg G.M. Gregorek	To analytically predict (and experimentally verify) the degradation in airfoil performance in icing conditions.
Prop/Rotor Performance Penalties Due to Icing R.J. Shaw NASA/Lewis Research Center Cleveland, OH (216)433-4000, x367	Ohio State University	K.D. Korkan	To analytically predict changes in aerodynamic performance of propellers or helicopter rotors in icing conditions.
Two-Dimensional Water Droplet Trajectory Code R.J. Shaw NASA/Lewis Research Center Cleveland, OH (216)433-4000, x367	FWG Associates, Inc. Tullahoma, TN	W. Frost (615)455-1982	To publish a computer code to calculate water droplet trajectories about 2-D lifting airfoils and through 2-D inlets.

TABLE III. ICING (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Electromagnetic Impulse Deicer System H.W. Schmidt NASA/Lewis Research Center Cleveland, OH and others	NASA and others	H.W. Schmidt (216)433-4000, x5165	To encourage companies to test electro-impulse systems on models installed in the Lewis Icing Research Tunnel. From these test results identify necessary R&D for further development of the electro-impulse system.
Pneumatic Deicer Boots for Helicopters NASA/Ames Research Center and Army (AVRADCOM & AEEFA)	NASA ARMY	L. Haslim	To flight test a helicopter equipped with deicer boots on the main rotor blades.

TABLE IV. LIGHTNING AND ATMOSPHERIC ELECTRICITY

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aircraft Atmospheric Electricity Instrumentation R.V. Anderson NRL, Code 4325 Office of Naval Research (202)767-3350	NRL	R.V. Anderson J.C. Willett	NRL's 30 year experience in aircaft instrumentation is employed to instrument a long range aircraft for measurements of electric field, aircraft change, conductivity, and fast field changes.
Severe Storms & Local Weather James C. Dodge NASA Headquarters (202)755-8596 NASA/OAST	NASA/Marshall Space Flight Center Huntsville, AL	F.W. Wagnon (205)453-4623 J.W. Harper	Measurement and analysis of radio-frequency emissions from lightning discharges to determine feasibility of lightning detection from a satellite-based system.
Severe Storms & Local Weather James C. Dodge NASA Headquarters (202)755-8596 NASA/OAST	NASA/Marshall Space Flight Center Huntsville, AL	F.W. Wagnon (205)453-4623 T.G. Barnes (205)453-1574	Measurement and analysis of optical emmissions from lightning discharges to determine feasibility of lightning detection from a satellite-based system.
Airborne Field Mill D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644	NASA/KSC (Design Eng. and Technical Support) Planning Research Corp.	Don Stubbs (305)867-9167 J. Stahman (305)867-3407 Ron Wojtasinski (305)867-4020	Design Field Mill System for aircraft use.
Ground Field Mill D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644	NASA/KSC Vehicle Operations and Technical Support	Ron Wojtasinski (305)867-4020	Provide electric field determination for potential lightning discharges.

TABLE IV. LIGHTNING AND ATMOSPHERIC ELECTRICITY (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
LLP (Lightning Location Protection) D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644	NASA/KSC Vehicle Operations	Bill Jafferis (305)867-2261 M.C. Forsyth	Evaluate the advantage of lightning detection for storm hazards forecasting. U.S. Air Force evaluation of system provided by KSC.
Determination and Measurement of Lightning Characteristics D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644	NASA/KSC (Design and Support Engineering) University of Florida	Ron Wojtasinski (305)867-4020 Richard Dietz (305)867-9406	Ascertain characteristics and electrical effects of cloud to ground strokes occurring at KSC.
Integrated Meteorological Processing and Display System D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644	NASA/KSC (Design and Support Engineering) University of Arizona	Ron Wojtasinski (305)867-4020	Determine actual locations in thunderstorm of cells that produce cloud-to-ground lightning.
Hazards From Fields Aloft D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644	NASA/KSC (Design and Support Engineering) Coulotron, Inc.	Ron Wojtasinski (305)867-4020 Richard Dietz (305)867-9406	Develop software techniques to integrate data sources of lightning and fields aloft.
Lightning Channels in an Unusual Flash at Kennedy Space Center D.C. Moja NASA/Kennedy Space Center (305)867-3644	NASA/KSC Support Engineering University of Florida	Carl Lennon (305)867-4068 Pete Rustan M.A. Uman W.H. Beasley D.J. Childers	Computer processing of electromagnet data yields locations of lightning inside a thunder cloud.

TABLE IV. LIGHTNING AND ATMOSPHERIC ELECTRICITY (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Severe Storms and Local Weather Research Program - Applied Research in Lightning - Research Associates William W. Vaughan ES81/Atmospheric Sciences Division Spaces Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Atmospheric Sciences Div. Marshall Space Flight Center Universities Space Research Association Columbia, Maryland	H. J. Christian (205)453-2463 M. H. Davis (303)449-3414	To develop and implement digital data handling and compression techniques to be used for lightning data handling aboard the NASA U-2; to correlate studies of the electrical properties of severe storms, this effort includes comparing lightning sferic location data with cloud tops, radar returns, field charges, GOES imagery, etc.; to analyze electrical activity in hurricanes using cross base line phase linear inferometers, to investigate alternate lightning mapper sensor designs; and to analyze U-2 lightning data.
Severe Storms and Local Weather Research Program - Lightning Mapper Technology William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Atmospheric Sciences Div. Marshall Space Flight Center Optical & R. F. Systems Division Marshall Space Flight Center	H. J. Christian (205)453-2463 T. Barnes (205)453-1574	The goal of this investigation is to develop a sensor capable of mapping lightning occurrences and locations from geostationary orbit. The approach is: (1) Conduct a comprehensive in-house research effort to quantify the characteristics of lightning emissions as measured from the ground and from above cloud tops. (2) Incorporate this data into the design of the lightning mapper sensor in order to optimize the sensor capabilities.
Lightning Storm Climatology R.V. Anderson NRL, Code 4325 Office of Naval Research (202)767-3350	NRL	R.V. Anderson J.C. Willett	Utilize instrumented long range aircraft to develop a lightning climatology and strike probability over both ocean and land areas.

TABLE IV. LIGHTNING AND ATMOSPHERIC ELECTRICITY (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Lightning Physics Jim Hughes Office of Naval Research ONR-465 800 North Quincy Street Arlington, VA 22217 (202)696-4123	State University of New York Atlantic Scientific Melbourne, Florida Hill Research California University of Arizona Tucson, Arizona University of Florida Gainesville, Florida NASA Marshall Space Flight Center Huntsville, Alabama	Barreto/Vonnegut (518)457-4930/4607 R. Bent (305)725-8000 R. Hill (805)969-3759 P. Krider (602)626-1329 M. Uman (904)392-0940 W. Vaughan (205)453-3100	1) Safety of naval operations. 2) General environmental support of Naval operations. 3) Improvement of Naval weather forecasts.
Storm Electricity J.T. Lee National Severe Storms Lab Norman, OK (405)360-3620 and NASA, Navy	NSSL Norman, OK	William Taylor David Rust FTS 736-4916 (405)231-4916	1) Characterization and location of lightning leading to possible prediction of intensity and location of lightning. 2) Determine lightning's role in storm dynamics.
Circuit Damage Produced by Lightning Currents R.V. Anderson, NRL Code 4325 (202)767-3350 NAVAIR	NRL	R.V. Anderson	Damage and malfunction in microcircuits is observed in the total absence of any electrical contact. Study hardening requirements. NRL Memorandum RPT. 3268.

TABLE IV. LIGHTNING AND ATMOSPHERIC ELECTRICITY (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research - Atmospheric Electricity as Related to Safe Operations of Aeronautics Systems Dennis W. Camp ES82/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-2087 RTOP #505-44-19	Atmospheric Sciences Div. Marshall Space Flight Center Desert Research Institute Atmospheric Sciences Center Reno, Nevada	Hugh Christian (205)453-2463 John Hallett Rick Purcell (702)972-1676	To study the electrical properties of thunderstorms in order to better identify spatial and temporal characteristics that can be used in both hazard identification/avoidance applications and to improve our fundamental understanding of cloud electrification processes. This study of thunderstorm electrification processes will attempt to determine characteristics of the thunderstorm electrical field structure and the associated size, location, and concentrations of the major charge centers. In addition, the electrical properties of the thunderclouds will be correlated with other fundamental state variables such as temperature, wind structure, liquid water content, hydrometer size and concentration, etc. The ability of various remote sensing techniques to indicate potential thunderstorm hazards will be evaluated by comparisons with in situ measurements.
Severe Storms and Local Weather Research Program - Lightning Observations/Research and Data Analysis William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Division NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Atmospheric Sciences Div. Marshall Space Flight Center Research Foundation of the State University of N.Y. Albany, New York New Mexico Institute of Mining & Technology Socorro, New Mexico	O. H. Vaughan (205)453-5218 B. Vonnegut (518)457-4607 M. Brook (505-835-5611	To simultaneously record pictures of thunderstorms with a 16 mm moving picture camera and the optical and electronic signatures of lightning on a sound tape recorder in an instrument carried aboard the Space Shuttle and operated by the crew. Correlate visual storm data with lightning intensity.

TABLE IV. LIGHTNING AND ATMOSPHERIC ELECTRICITY (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Severe Storms and Local Weather Research Program - U-2 Flight Costs William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Application Aircraft and Future Programs Office Ames Research Center Moffett Field, California	J. Arvesen (405)965-5379	To use U-2 aircraft to obtain quantitative data needed for the development of a lightning mapper sensor and to acquire lightning from above thunderstorms in coordination with ground-truth measurements in order to assist in the interpretation of NSSL data.
Severe Storms and Local Weather Research Program - Lightning Studies in Severe Storms William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Research Foundation of State University of New York Albany, New York	R. E. Orville (518)457-3985	This investigation includes studies of the spectral emissions of lightning, analysis of all available DMSP lightning data over a one-year period, collaboration in coordinated U-2 and ground based measurements of lightning, and studies of severe storm lightning properties.
Severe Storms and Local Weather Research - Severe Storm Electricity William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Atmospheric Sciences Div. Marshall Space Flight Center NOAA National Severe Storms Laboratory Norman, Oklahoma	H. J. Christian (205)453-2463 W. D. Rust (405)360-3620	This investigation is primarily focused on providing ground truth measurements in conjunction with the NASA U-2 thunderstorm over-flights. Additional investigations include ELF system development and the correlation of electrical activity with storm observables.

TABLE IV. LIGHTNING AND ATMOSPHERIC ELECTRICITY (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
LDAR Observations of Developing Thunderstorms Correlated with Field Mill, Ground Strike Location, and Weather Data D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644	NASA/KSC Support Engineering RCA Service Co.	Carl Lennon (305)867-4068 Horst Poehler	This was an experiment designed to observe and measure a thunderstorm prior to, during, and after its development over KSC.

TABLE V. FOG, VISIBILITY, AND CEILINGS

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research - Warm Fog Dispersal Studies Dennis W. Camp ES82/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-2087 RTOP #505-44-19	Atmospheric Sciences Div. Marshall Space Flight Center FWG Associates, Inc. Tullahoma, Tennessee	Dennis W. Camp (205)453-2087 Otha H. Vaughan (205)453-5218 Hugh Christian (205)453-2463 Walter Frost Frank Collins (615)455-1982	To investigate various fog dispersal techniques and operational procedures and to study the charged particle concept for warm fog dispersal. This will entail the possibility of a field test program for fog dispersal.
Severe Storms and Local Weather Research Program - Cloud Microphysical Processes William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Atmospheric Sciences Div. Marshall Space Flight Center	B. J. Anderson (205)453-5218	To perform laboratory, theoretical and KC-135 flight experiment studies to obtain information on cloud microphysical processes. Emphasis is on development of experimental methods which utilize the low gravity environment.
Boundary Layer Meteorology Bruce Kunkel (617)861-2972 AFSC	AFGL/LYT	J. Morrissey R. Dyer O. Cote	To develop improved techniques for the detection of meteorological parameters in the planetary boundary layer that affect Air Force systems and operations. Such parameters include mean and turbulent refractivity structure, turbulence intensity and length scales, fog and precipitation

TABLE V. FOG, VISIBILITY, AND CEILINGS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Evaluation of Visibility Systems for CAT IIIB John Dorman (202)426-8427 DOT/FAA Project #151-451-03	Humboldt County Arcata, CA	Jim Wilkerson	Test dual baseline RVR system for the measurement of RVR to 150 ft, the minimum of CAT IIIB.
Aviation Safety Technology-Operational Problem and Fire Worthiness (NTSB Accident Investigation Assistant, HUD, IFR Operation Safety for DTOL and rotorcraft, on-board CAT, and wind shear detectors, fire resistant materials, anti-misting fuels, and fire material resistance R.L. Kurkowski/D.A. Kourtides (415)965-6219/(415)965-5226 NASA/Ames Research Center Moffett Field, CA 94035 RTOP #5005-44-21	Ames Research Center Moffett Field, CA (415)965-5000 Northrop Services, Inc. Moffett Field, CA	Rodney Wingrove Ralph Bach Richard Bray John Bull Dave Anderson Demetrius Kourtides Pete Kuhn	The first objective is to improve aviation safety by a) increasing the understanding of the cause of accidents, and b) developing systems technology and piloting techniques for avoiding hazards. Research on post-accidents analysis techniques is a cooperative program with the NTSB Bureau of Aviation Safety. Simulation in flight investigations will be conducted on the affectiveness of integrated head-up displays (HUD) on reducing hazards associated with wind shear and low visibility. Research will also be conducted in new technology to enhance the operational safety of IFR operations for civil and military rotorcraft in BFOD/STOL aircraft. In-flight study will be conducted on the use of the IR radiometer to detect and alert to low altitude wind shear associated with downburst phenomena and to clear air turbulence during cruise conditions. A second objective of this RTOP is to improve aircraft cabin safety in post-crash fires.

TABLE VI. LOW LEVEL WIND SHEAR

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Low Level Wind Shear J.T. Lee National Severe Storms Lab Norman, OK (405)360-3620 FTS 736-4916 and FAA, NASA	NSSL Norman, OK	J.T. Lee Richard Doviak	1) Determine a characteristic Doppler radar signature of gust fronts and the best utilization of Doppler radar to measure clear air wind shear. 2) Determine lifetime of wind shear events and associated turbulence. 3) Determine predictability of wind shear events.
Knowledge of High Altitude Atmospheric Processes L. C. Montoya FTS 984-8423 L. J. Ehernberger (805)258-3311, x435 FTS 984-8435 NASA/OAST RTOP #505-44-14	NASA/DFRF UCLA	L. J. Ehernberger (805)258-3311, x435 M.G. Wurtele (213)825-1751	The area studied include in-flight measurements of atmospheric turbulence, definition of the associated atmospheric structure, and cloud physics effects on aircraft icing. Specific tasks include 1) the improvement of flight test procedures, 2) meteorological analysis techniques, 3) the climatology of vertical temperature gradients and wind shears in the stratosphere, 4) numerical simulation of atmospheric gravity wave motion associated with CAT, and 5) a study of cloud physics effects which significantly influence aircraft icing.

TABLE VI. LOW LEVEL WIND SHEAR (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research - Atmospheric Dynamics Processes Definition as Related to Aeronautical System Operation Dennis W. Camp ES82/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-2087 RTOP #505-44-19	Atmospheric Sciences Div. Marshall Space Flight Center FWG Associates, Inc. Tullahoma, Tennessee National Center for Atmospheric Research Boulder, Colorado	Margaret B. Alexander (205)453-2087 Dennis W. Camp (205)453-2087 Warren Campbell (205)453-1886 Hugh Christian (205)453-2463 Walter Frost (615)455-1982 John McCarthy (303)494-5151	To acquire, develop, and summarize basic information (experimental and theoretical) on atmospheric dynamics processes for direct application to safe operation of aeronautical systems. This will entail the analysis of wind data from towers, balloons, Doppler radar, etc. relative to wind shear studies.
Wind Shear Detection With Pulse Doppler Radar I. D. Goldman FAA ARD-231 Washington, DC	NOAA/ERL/WPL	R. G. Strauch W. B. Sweezy	Investigate use of Doppler radar for detecting wind shear in the terminal area. (Project concluded.)
FM-CW Radar Wind Shear Detector R.B. Chadwick, R45x6 U.S. Department of Commerce NOAA Environmental Research Laboratories Boulder, Colorado 80303 FTS 320-6318	NOAA/ERL	Dr. R. B. Chadwick	Develop a radar technique for detecting low level wind shear at airport.

TABLE VI. LOW LEVEL WIND SHEAR (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Safety Technology-Operational Problem and Fire Worthiness (NTSB Accident Investigation Assistant, HUD, IFR Operation Safety for DTOL and rotorcraft, on-board CAT, and wind shear detectors, fire resistant materials, anti-misting fuels, and fire material resistance. R.L. Kurkowski/D.A. Kourtides (415)965-6219/(415)965-5226 NASA/Ames Research Center Moffett Field, CA	NASA/Ames Research Center Moffett Field, CA (415)965-5000 Northrop Services, Inc Ames Research Center Moffett Field, CA	Rodney Wingrove Ralph Bach Richard Bray John Bull Dave Anderson Demetrius Kourtides ,Pete Kuhn	To improve aviation safety by increasing the understanding of the cause of accidents and by developing systems technology and piloting techniques is a cooperative program with the NTSB Bureau of Aviation Safety. Simulation in-flight investigations will be conducted on the affectiveness of integrated head-up display on reducing hazards associated with wind shear and low visibility. To improve in new technology to enhance the operational safety of IFR operations for civil and military rotorcraft in BFOD/STOL aircraft. In-flight study will be conducted on the use of the IR radiometer to detect and alert to low altitude wind shear associated with downburst phenomena and ,CAT during cruise conditions.

TABLE VII. STORM HAZARDS/SEVERE STORMS

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Joint Airport Weather Studies (JAWS) Arthur Hilsenrod (202)426-8427 NSF, DOT/FAA, NOAA, NASA Project #156-410-04W	NCAR University of Chicago	John McCarthy FTS 322-7651 James Wilson FTS 322-7651 T.T. Fujita (312)753-8112	Detailed study of thunderstorms using Doppler radars, instrumented aircraft and mesonet of surface sensors.
Weather Radar Meteorological Techniques Development Frank Melewicz (202)426-8427 DOT/FAA, NOAA/NWS Project #156-410-01W	Environmental Research and Technology, Inc. and Dartmouth College	R. Crane (603)646-3843	Develop algorithms to provide automatic cell detection, tracking and prediction with conventional and Doppler weather radar data.

TABLE VII. STORM HAZARDS/SEVERE STORMS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Severe Storms and Local Weather Research Program - McIDAS Terminal and Inhouse Anlaysis William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Atmospheric Sciences Div. Marshall Space Flight Center	G. S. Wilson (205)453-2570	An integral part of the Mesoscale And Severe Storm (MASS) research effort involves the direct use of satellite imagery and soundings in combination with many other data types to provide an improved understanding and predictive skill for severe storms and local weather. To assist both the contractor and inhouse MASS research team, a Man Computer Interactive Data Access System (McIDAS) was considered an essential tool needed to perform state-of-the-art storms research and space technology development. A McIDAS system, of special configuration, was needed to support the current and planned MASS research involving improved understanding of storms, data interpretation development, forecast model development, and technology transfer requirements. Extensive utilization of this system will provide MASS scientists with database management, computer power, and software/display capabilities that enhance our current capabilities and resources to support severe storm and local weather research.
LDAR Observations of a Developing Thunderstorm Correlated with Field Mill, Ground Strike Location, and Weather Data D.C. Moja (305)867-3644 NASA/Kennedy Space Center, FL	NASA/KSC Support Engineering RCA Service Co.	Carl Lennon (305)867-4068 Horst Poehler	This was an experiment designed to observe and measure a thunderstorm prior to, during, and after its development over KSC.

TABLE VII. STORM HAZARDS/SEVERE STORMS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Severe Storms and Local Weather Research Program - VAS Ground Truth Field Experiment William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Texas A&M University College Station, Texas	J. R. Scoggins (713)845-7671	To establish the accuracy and representativeness of satellite measurements of mesoscale and storm-scale atmospheric phenomena, as revealed by ground-based data, a VAS Ground Truth Experiment will be conducted. In order to evaluate the VAS data from the point ofview of individual variables as well as characteristics of systems from synoptic to mesoscale in size, it will be necessary to set up a mesoscale network capable of resolving characteristics of systems that range in size from those that can be detected from the existing rawinsonde network down to systems approaching thunderstorm size. A field program designed to accomplish the above has been planned for a geographical area where large contrasts in air masses occur and the moisture, temperature, wind fields, and cloud conditions are highly variable. Plans include 24 NWS and 12 remote upper air stations located in the Southwest and Southeastern part of the United States.
Storm Hazards/Severe Storms and Turbulence J.T. Lee NSSL Norman, OK (405)360-3620 FTS 736-4916 and FAA, NASA, USAF(AWS)	NSSL	J.T. Lee Dusan Zrinc	1) Determine characteristics of turbulence and other storm hazards (hail, vortices, etc.), their lifetime, detection and predictability. 2) Apply Doppler radar's potential to improve flight safety in severe storm environment. 3) Develop displays of hazardous weather as observed by remote sensors.

TABLE VII. STORM HAZARDS/SEVERE STORMS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Severe Storms and Local Weather Research Program - Application of the AVE-SASAME Data Sets to Mesoscale Studies William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Space Sciences & Engineering Center University of Wisconsin at Madison Madison, Wisconsin	D. Suchman (608)262-5772	To investigate the quantitative application of GOES data, complemented by conventional data, in the investigation of the structure and dynamics of severe local storms and convective outbreaks: (1) using the '79 SESAME-AVE storm-scale rawinsonde and radar data, improve the methods whereby rapid-scan satellite imagery can be combined with conventional meteorological observations to produce more useful data sets--this includes improved mesoscale wind fields for at least three levels, and combined satellite and digital radar maps of convection and small-scale thunderstorm features, (2) improve means whereby satellite brightness data can be used both to isolate deep convection and to detect severe weather in its incipient stages, and (3) complete more cases of investigating small-scale thunderstorm characteristics, and combine digital satellite and radar data to relate the occurrence of cold domes and overshooting tops to severe weather at the surface.
Severe Storms and Local Weather Research Program - Lightning Observations/Research and Data Analysis William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Atmospheric Sciences Div. Marshall Spaces Flight Center Research Foundation of the State University of N.Y. Albany, New York New Mexico Institute of Mining & Technology Socorro, New Mexico	O. H. Vaughan (205)453-5218 B. Vonnegut (518)457-4607 M. Brook (505)835-5611	To simultaneously record pictures of thunderstorms with a 16 mm moving picture camera and the optical and electronic signatures of lightning on a sound tape recorder in an instrument carried aboard the Space Shuttle and operated by the crew. Correlate visual storm data with lightning intensity.

TABLE VII. STORM HAZARDS/SEVERE STORMS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Severe Storms and Local Weather Research Program - Objective Wind Determination from GOES Satellite Measurements and Replacement of IDAPS Disk William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Atmospheric Sciences Div. Marshall Space Flight Center	G. S. Wilson (205)453-2570	Cloud motions, as observed from multi-spectral geostationary satellite imagery, have been used successfully to approximate winds in the atmosphere for about 10 years. This success in combination with larger and faster computers, has led to a re-examination of the time-comsuming methods by which cloud motions have previously been manually determined from image processing. This research will lead to the development of an objective technique for multi-spectral image processing to yield rapid, accurate, and reproducible cloud motions and winds for use in research and eventually in an operational environment. Validation of the results is determined by an objective comparison between satellite winds and (1) surface winds, (2) radiosonde winds, and (3) manually determined cloud winds using severe storm case studies from the AVE/SESAME program.
Aviation Operations Safety Technology-Lidar Applications E.A. Weaver (205)453-1597 FTS 872-1597 NASA/Marshall Space Flight Center Huntsville, Alabama	Optics Branch Electronics & Control Lab Marshall Space Flight Center, AL Raytheon Company Sudbury, MA Lassen Research Manton, CA Applied Research, Inc. Huntsville, AL Alabama A&M University Huntsville, AL	J.W. Bilbro (205)453-1597 W.D. Jones S.C. Johnson J.W. Wright C.E. Harris C.A. Dimarzio R.W. Lee H.B. Jefferys L.Z. Kennedy S.S.R. Murty	Severe storms and local weather - using airborne CO_2 Pulsed Doppler Lidar to measure velocities in the nonprecipitous regions surrounding thunderstorms. Meteorological Observing System Development.

TABLE VIII. TURBULENCE

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Spanwise Gradient Measurement of Atmospheric Turbulence Allan R. Tobiason NASA Headquarters (202)755-3003	Cooperative Effort: NASA/Langley, Dryden, Marshall, and Ames Centers	H.N. Murrow NASA/Langley Research Center Warren Campbell NASA/Marshall Space Flight Center	Obtain time histories, power spectra, and cross spectra of three components of atmospheric turbulence and perform statistical analyses and meteorological correlations. Data will be obtained in lower 2,000 feet of atmosphere and principally apply to terminal conditions of flight.
Aviation Safety Technology N.L. Crabill NASA/Langley Research Center Hampton, VA (804)827-3274 RTOP #505-44-23	NASA/Langley Research Center	H.N. Murrow (804)827-3527	Measure spanwise gradients of atmospheric turbulence in terminal area operations. A large rigid-wing aircraft will be instrumented at both wing tips and the nose to measure atmospheric turbulence in low altitude holding, approach, and landing.
Storm Hazards/Severe Storms and Turbulence J.T. Lee NSSL Norman, OK FTS 736-4916 (405)360-3620 and FAA, NASA, USAF(AWS)	NSSL	J.T. Lee Dusan Zrinc	1) Determine characteristics of turbulence and other storm hazards (hail, vortices, etc.), their lifetime, detection and predictability. 2) Apply Doppler radar's potential to improve flight safety in severe storm environment. 3) Develop displays of hazardous weather as observed by remote sensors.
NEXRAD Radar Terminal Area Coverage Studies Frank Melewicz (202)426-8427 DOT/FAA, NOAA Project #155-410-03W	NOAA/NSSL	Dusan Zrinc FTS 736-4916	Use Doppler Weather Radars to measure turbulence in thunderstorms. Develop Doppler Weather Radar siting criteria for terminal area applications.

TABLE VIII. TURBULENCE (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research - Correlation of Lateral and Longitudinal Gusts Dennis W. Camp ES82/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-2087 RTOP #505-44-19	Atmospheric Sciences Div. Marshall Space Flight Center Arizona State University Tempe, Arizona FWG Associates, Inc. Tullahoma, Tennessee University of Tennessee Space Institute Tullahoma, Tennessee	Margaret B. Alexander (205)453-2087 Dennis W. Camp (205)453-2087 Warren Campbell (205)453-2087 Earl Logan (602)965-3291 Walter Frost (615)455-1982 S. T. Wang (205)533-7590 Walter Frost Luke Gilchrist Ming-Chung Lin (615)455-0631	To measure wind gust gradients across the span of an aircraft wing and over the fuselage of an aircraft, to analyze the data, and to develop appropriate turbulence simulation models which can be used in aeronautical design and operations. To plan the annual workshop on meteorological and environmental inputs to aviation systems. To assemble a bibliography relative to aviation meteorology.
Boundary Layer Meteorology Bruce Kunkel (617)861-2972 AFSC	AFGL/LYT	J. Morrissey R. Dyer O. Cote	To develop improved techniques for the detection of meteorological parameters in the planetary boundary layer that affect Air Force systems and operations. Such parameters include mean and turbulent refractivity structure, turbulence intensity and length scales, fog and precipitation.
Measurement of Atmospheric Turbulence (MAT) H.N. Murrow NASA/Langley Research Center Hampton, VA (804)827-3527	NASA/Langley Research Center Bolt Beranek & Newman Cambridge, MA	H.N. Murrow (804)827-3527 William Mark (617)491-1850, x527	Detailed measurement of clear-air atmospheric turbulence to wavelengths greater than 30,000 feet in various meteorological conditions and to altitudes above 30,000 feet. Derive models appropriate for nonstationary aspects.

TABLE VIII. TURBULENCE (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Knowledge of High Altitude Atmospheric Processes L. C. Montoya FTS 984-8423 L. J. Ehernberger (805)258-3311, x435 FTS 984-8435 NASA/OAST RTOP #505-44-14	NASA/DFRF UCLA	L. J. Ehernberger (805)258-3311, x435 FTS 984-8435 M.G. Wurtele (213)825-1751	The areas studied include in-flight measurements of atmospheric turbulence, definition of the associated atmospheric structure, and cloud physics effects on aircraft icing. Specific tasks include 1) the improvement of flight test procedures, 2) meteorological analysis techniques, 3) the climatology of vertical temperature gradients and wind shears in the stratosphere, 4) numerical simulation of atmospheric gravity wave motion associated with CAT, and 4) a study of cloud physics effects which significantly influence aircraft icing.
Infrared Doppler Lidar Freeman F. Hall Department of Commerce/NOAA/ERL Boulder, CO (303)497-6312	WPL/NOAA/ERL	Freeman F. Hall	To develop and exploit remote sensors based on CW and pulsed coherent lasers for the measurement of atmospheric winds, turbulence, and diffusion, and formeasuring the concentration of optically absorbing species of vapors and gases in the atmosphere by differential absorption lidar (DIAL) methods.
Aviation Safety Technology-Operational Problem and Fire Worthiness (NTSB Accident Investigation Assistant, HUD, IFR Operation Safety for DTOL and rotorcraft, on-board CAT, and wind shear detectors, fire resistant materials, anti-misting fuels, and fire material resistance R.L. Kurkowski/D.A. Kourtides (415)965-6219/(415)965-5226 NASA/Ames Research Center Moffett Field, CA	NASA/Ames Research Center Moffett Field, CA (415)965-5000 Northrop Services, Inc. Ames Research Center Moffett Field, CA	Rodney Wingrove Ralph Bach Richard Bray John Bull Dave Anderson Demetrius Kourtides Pete Kuhn	To improve aviation safety by increasing the understanding of the cause of accidents and by developing systems technology and piloting techniques is a cooperative program with the NTSB Bureau of Aviation Safety. Simulation in-flight investigations will be conducted on the affectiveness of integrated head-up display on reducing hazards associated with wind shear and low visibility. To improve in new technology to enhance the operational safety of IFR operations for civil and military rotorcraft in BFOD/STOL aircraft. In-flight study will be conducted on the use of the IR radiometer to detect and alert to low altitude wind shear associated with downburst phenomena and to CAT during cruise conditions.

TABLE IX. WINDS

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Severe Storms and Local Weather Research Program - Software and Algorithm Development William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Atmospheric Sciences Div. Marshall Space Flight Center Optical & R. F. Systems Division Marshall Space Flight Center	Margaret B. Alexander (205)453-2087 Daniel Fitzjarrald (205)453-0946 J. J. Wright (205)453-1596	To develop new and improve existing software and algorithms for real-time, fast processing, and display relative to the analysis and handling of wind flow field data reviewed from MSFC's Doppler Lidar System.
Severe Storms and Local Weather Research Program - Scientific Data Analysis and Evaluation William W. Vaughan ES81/Atmospheric Sciences Division Space Sciences Laboratory NASA Marshall Space Flight Center Huntsville, Alabama 35812 (205)453-3100 RTOP #146-50-02	Atmospheric Sciences Div. Marshall Space Flight Center	Daniel Fitzjarrald (205)453-0946 George H. Fichtl (205)453-0875 John Kaufman (205)453-3104 Margaret B. Alexander (205)453-2087	This research is aimed at utilizing the MSFC Doppler Lidar System (DLS) to satisfy OSTA Severe Storms and Local Weather Research Program goals. The effort involves planning and performance of ground-based and airborne experiments to assess the capability of the MSFC/DLS. These tests will be performed in conjunction with other data acquisition systems (rawinsondes, radar, mesonetworks, meteorological towers) to develop comprehensive data sets which provide "ground truth" for DLS capability assessment and the accomplishment of meaningful scientific research.
Surface Wind Program Richard R. Reynolds National WX SVC Surface Observations Automation Program (W432) 8060 13th Street Silver Spring, MD	NWS, T&ED RD 1, Box 105 Sterling, VA	R. Stone V. Nadolski	Evaluation of current wind sensors considered suitable for automation. Development of specifications for wind sensors to be used in future automated observing systems. Development of algorithms for processing sensor data to include proper sampling and averaging times for wind speed and gusts applicable for aviation use.

TABLE IX. WINDS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Optical Sensor Development Robert S. Lawrence Department of Commerce/NOAA/ERL Boulder, CO (303)407-6353	WPL/NOAA/ERL	Robert S. Lawrence	Investigate basic problems of optical propagation in the atmosphere, and use the results of these studies to develop new optical techniques for remotely measuring the atmosphere. Quantities to be measured include average values, structure parameters, spectra, and fluxes of velocity, temperature,and water vapor.
Infrared Doppler Lidar Freeman F. Hall Department of Commerce/NOAA/ERL Boulder, CO (303)497-6312	WPL/NOAA/ERL	Freeman F. Hall	To develop and exploit remote sensors based on CW and pulsed coherent lasers for the measurement of atmospheric winds, turbulence, and diffusion, and for measuring the concentration of optically absorbing species of vapors and gases in the atmosphere by differential absorption lidar (DIAL) methods.
Environmental Radiometry David C. Hogg Department of Commerce/NOAA/ERL Boulder, CO (303)497-6375	WPL/NOAA/ERL	David S. Hogg	Realization of microwave systems, primarily radiometric, for continuous, remote measurement of atmospheric temperature, water vapor, liquid water, and wind for use by the weather services, in weather modification programs, and in atmospheric research.

TABLE IX. WINDS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Meteorological Radar Earl E. Gossard Department of Commerce/NOAA/ERL Boulder, CO (303)497-6239	WPL/NOAA/ERL	Earl E. Gossard	To increase the understanding of the dynamical and microphysical processes controlling local weather by creating and using a multi-station, transportable Doppler radar facility capable of measuring three-dimensional wind fields, and FM-CW radar of the atmosphere under all weather conditions, and a coherent 8 mm cloud-sensing radar system that detects microphysical changes in cloud systems.
Atmospheric Studies Chandran J. Kaimal Department of Commerce/NOAA/ERL Boulder, CO (303)497-6263	WPL/NOAA/ERL	Chandran J. Kaimal	To increase national understanding of the atmosphere by carrying out fundamental investigations in atmospheric dynamics and acoustic remote sensings, and by working with WPL program areas and outside groups to apply remote sensors to atmospheric research. The group also maintains and operates the Boulder Atmospheric Observatory (BAO) in support of this goal.

TABLE X. OZONE AND OTHER METEOROLOGICAL PARAMETERS

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Atmosphere Profile of Ozone-Lidar V. Nicolai Office of Naval Research 800 North Quincy Street Arlington, Virginia 22217	University of Arizona Tucson, Arizona	R. Schotland (602)626-2447	To understand the role ozone plays in the chemistry and physics of the atmosphere.
Atmosphere Profile of Ozone & Dust W. Martin Office of Naval Research 800 North Quincy Street Arlington, Virginia 22217	University of Wyoming	T. Pepin (307)766-4323	To understand the role ozone plays in the chemistry and physics of the atmosphere.
Balloon Soundings of Ozone & Dust W. Martin Office of Naval Research 800 North Quincy Street Arlington, Virginia 22217	University of Wyoming	David. J. Hofmann (307)766-4323	To understand the role ozone plays in the chemistry and physics of the atmosphere.
Balloon Soundings of Ozone J. Hughes Office of Naval Research 800 North Quincy Street Arlington, Virginai 22217	Physikalisch-Bioklimatische Forschungsstelle, West Germany	R. Reiter 49-8821-51056	To understand the role ozone plays in the chemistry and physics of the atmosphere.
Cloud Physics Arnold A. Barnes, Jr. (617)861-2939 Air Force Office of Scientific Research (AFOSR)	AFGL/Cloud Physics Branch/LYC	M. Glass V. Plank I. Cohen B. Main R. Schaller	To develop and test comprehensive models of the physical processes occurring within clouds and precipitation systems.

TABLE X. OZONE AND OTHER METEOROLOGICAL PARAMETERS (Cont.)

PROJECT TITLE, MANAGER, AND SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
"BEST" (Baseline Environmental Study Test D.C. Moja NASA/Kennedy Space Center, FL (305)867-3644	NASA/KSC (Design Engineering, Vehicle Operations, and Medical Program Office) University of Central Florida Orlando, FL	R. Rudolph	Determine environment - natural and manmade involving ozone, etc.

APPENDIX B

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APPENDIX C

LIST OF ACRONYMS

ARTCC	AIR ROUTE TRAFFIC CONTROL CENTER
ASR	AIRPORT SURVEILLANCE RADAR
ATC	AIR TRAFFIC CONTROL
ATS	APPLICATIONS TECHNOLOGY SATELLITE
AV-AWOS	AVIATION AUTOMATED WEATHER OBSERVATION CENTER
CAT	CLEAR AIR TURBULENCE
DRT	DIAGNOSTIC RICHARDSON NUMBER TENDENCY
EADI	ELECTRONIC ATTUTUDE DIRECTION INDICATOR
ESS	ENVIRONMENTAL SATELLITE SERVICE
GASP	GLOBAL ATMOSPHERIC SAMPLING PROGRAM
GEM	GENERALIZED EQUIVALENT MARKOV
INS	INTEGRATING NEPHELOMETERS
IR	INFRARED RADIOMETERS
ITOS	IMPROVED TIROS OPERATIONAL SYSTEM
LDAR	LIGHTNING DETECTION AND RANGING
LLWS	LOW LEVEL WIND SHEAR
MDR	MANUALLY DIGITIZED RADAR
NAVAIDS	NAVIGATIONAL ADIS
NIMROD	NORTHERN ILLINOIS METEOROLOGICAL RESEARCH ON DOWNBURSTS
PAR	PRECISION APPROACH RADAR
PATWAS	PILOTS AUTOMATIC TELEPHONE WEATHER ANSWERING SERVICE
RARF	RADAR ATMOSPHERIC RESEARCH FACILITY
RVR	RUNWAY VISUAL RANGE

SESAME	SEVERE ENVIRONMENTAL STORM AND MESOSCALE EXPERIMENT
STOL	SHORT TAKEOFF AND LANDING
SVR	SLANT VISUAL RANGE
TIROS	TELEVISION AND INFRARED OBSERVATION SATELLITE
TWEB	TRANSCRIBED WEATHER BROADCAST
VCWS	VECTOR CONTROL WHEEL STEERING
VFR	VISUAL FLIGHT RULES
WPL	WAVE PROPAGATION LABORATORY

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16. ABSTRACT

The purpose of this study was to provide an updated reference of current and ongoing research programs related to various areas of aviation meteorology. Literature searches of major abstract publications, such as the Scientific and Technical Aerospace Reports, the International Aerospace Abstracts, and the Meteorological and Geoastrophysical Abstracts, were conducted. Research project managers of various government agencies involved in aviation meteorology research provided a list of current research project titles and managers, supporting organizations, performing organizations, the principal investigators, and the objectives. These are tabulated under the headings of Advanced Meteorological Instruments; Forecasting; Icing; Lightning and Atmospheric Electricity; Fog, Visibility, and Ceilings; Low Level Wind Shear; Storm Hazards/Severe Storms; Turbulence; Winds; and Ozone and Other Meteorological Parameters.

This information was reviewed and assembled into a bibliography providing a current readily useable source of information in the area of aviation meteorology.

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