NASA Contractor Report 3214

1979 Current Research on Aviation Weather (Bibliography)

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CONTRACT NAS8-32692
JANUARY 1980

NASA

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Prepared for
Marshall Space Flight Center
under Contract NAS8-32692

NASA
National Aeronautics
and Space Administration

**Scientific and Technical
Information Office**

1980

AUTHORS' ACKNOWLEDGMENTS

The work reported herein was supported by the National Aeronautics and Space Administration, Marshall Space Flight Center, Space Sciences Laboratory, Atmospheric Sciences Division, under Contract No. NAS8-32692.

The authors are indebted to Messrs. John H. Enders and Solomon Weiss of Aviation Safety, Office of Aeronautics and Space Technology (OAST), NASA/Headquarters, Washington, DC, for their support of this research. Special thanks also go to Mr. Dennis W. Camp of the Atmospheric Sciences Division, Space Sciences Laboratory, NASA/Marshall Space Flight Center, who was the scientific monitor of the program.

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I. INTRODUCTION

This aviation weather bibliography was written as an update to Current Research on Aviation Weather (Bibliography), NASA CR-3076, December 1978. The majority of the literature survey includes reports and references dating from 1977 to 1979.

The format of the bibliography is as follows: reports are summarized in chapters under the headings of Advanced Meteorological Instruments, Forecasting, Icing, Lightning, Visibility, Fog, Low Level Wind Shear, Storm Hazards/Severe Storms, Turbulence, and Training. Appendix A is a tabulation of the major aviation meteorological research programs being carried out by government agencies in the areas of Advanced Meteorological Instruments, Forecasting, Icing, Lightning, Visibility, Low Level Wind Shear, Storm Hazards/Severe Storms, and Turbulence. Appendix B is a supplementary listing of pertinent references recommended by the various research personnel. Appendix C is a compilation of useful acronyms.

II. ADVANCED METEOROLOGICAL INSTRUMENTS

Meteorological instruments have been operationally tested for determining wind profiles and measuring vertical motion and velocity components. Additional instrument systems were tested for precipitation area identification and visibility and atmospheric electricity measurement.

Warnock (1978) compared wind profile measurements made with Doppler radar and rawinsonde balloons, the balloons passing within 25 km of the radar. He found that below 6 km MSL the measurements made by both systems did not agree due to orographic effects, but above 6 km, sixteen measurements by each correlated with a coefficient of 0.96. A radar system for measuring wind profiles was presented by Rosenberg (1976). A low power solid state x-band radar was used to track a balloon-borne corner reflector and measure wind velocity and direction, with a possible range of 10 km. A vertical motion sensor to measure vertical velocities greater than 10 cm/sec carried by radiosonde balloon and released at a given altitude was described by Hill and Woffinden (1977). Carbone (1977) discussed a radar with tetrahedral scan capability for computing direct horizontal divergence from its sample volume and thus computing vertical motion. Existing systems today must perform tetrahedral scan with a software link-up. Kalafus (1978) detailed the use of a hybrid CW/pulsed laser for providing advanced warning for frontal and synoptic wind shear conditions. Sal'man et al. (1976) discussed problems associated with automated radar observation systems that process and present data. Kaimal and Haugen (1977) operated an acoustic Doppler wind sensor at an airport under fog and light rain conditions. Their observed boundary layer wind profiles showed good agreement with an instrumented

150 m tower. The system performed poorly during periods of moderate-heavy rainfall and at times when aircraft passed over the sounder. Lading et al (1978) compared mean wind velocity measurements by a 70 m range laser anemometer with those by a cup anemometer; agreement was within 10%.

Renger and Ruppersberg (1977) described the lidar operations of the instrumented platform aboard a meteorological research aircraft. Earnshaw and Keebaugh (1977) reported on an experimental laser weather identification instrument which can be used to identify areas of precipitation and other obscurations to visiblity. Johnson (1978) examined atmospheric moisture measurement systems with regard to accuracy, response, advantages and disadvantages. He also surveyed moisture measurement systems mounted on balloons and installed in aircraft.

Maxwell (1979) discussed an in-flight system to measure the electromagnetic characteristics and other effects of lightning. The system, composed of electric and magnetic field sensors, current sensors and a mini-computer, was flown through eight thunderstorms. The feasibility of this system was proven and measurements revealed that near miss lightning strikes were not a hazard to aluminum aircraft that did not contain electronic flight control systems. Browning (1978) surveyed the many meteorological applications of radar, including severe storm warnings, identification and tracking of storm cells, precipitation area identification, wind measurements, and spotting of turbulent and wind shear instances.

III. FORECASTING

Timely and accurate aviation-oriented weather forecasts have long been in demand by the aviation community. Techniques and models have been developed for forecasting precipitation, severe storms and wind shear, and methods have been formulated for improved aviation weather forecasting. The aviation community's needs for accurate forecasts of winds and wind shear; icing and frost; atmospheric electrical hazards; fog, visibility and ceilings; and turbulence were outlined at the Third Annual Workshop on Meteorological and Environmental Inputs to Aviation Systems (Camp and Frost, 1979). Participating in the conference were meteorologists specializing in the aforementioned fields and members of the aviation community involved in training, flight operations, accident investigation, air traffic control, and airport management. Results and conclusions of the 1977, 1978, and 1979 Workshops on Meteorological and Environmental Inputs to Aviation Systems are summarized in Frost, Camp, Enders, Sowar and Connolly (1979).

A nonparametric technique based on a pattern recognition algorithm was used by Paegle et al. (1977) to forecast precipitation probabilities for 42 western U.S. stations. Bellon and Austin (1978) described the use of a short-term (0-3 hour) precipitation forecasting method in which digital weather radar data were utilized along with a pattern recognition procedure.

Schnee (1977) discussed the effect of satellites and numerical weather prediction on storm warning forecasting accuracy. He stated the need for good systems for disseminating weather information that would make satellites and numerical prediction most useful. Alaka, Charba and Elvander (1977) reported on methods for 0-2 hour thunderstorm prediction for aviation using 10 and 30 minute radar data sequences to produce 10, 30, 60 and 90 minute forecasts. Classical and model output statistics plus probability forecasts were used to develop 2-6 hour thunderstorm forecasts for the U.S. east of the Rockies.

Steinberg (1978) described a system installed in a Pan Am 747 to obtain automated meteorological data from a commercial aircraft to earth via satellite. Data recorded by the aircraft include wind direction and wind speed, temperature, altitude, and position versus time. He explains how this system may be used for airline route forecasting. Aids and methods for forecasting meteorological conditions and special weather events for aviation were given by Petrenko (1977). Crisci (1978) discussed needs and methods for improving en route and terminal aviation weather forecasts in the 0-4 hour range and for weather specifically affecting aviation.

Richwein and McLeod (1978) provided low level wind shear advisories for 3 hour periods at seven East Coast airports. They were to be used when a 10° surface temperature difference existed across a front and/or when a front had a speed greater than 30 kts. The advisories were sent to pilots via the Federal Aviation Administration. Limited success was achieved in forecasting warm frontal shear and no success was realized for cold frontal shear. They recommended better shear advisory dissemination and forecasting methods.

Bristor (1978) considered currently operating weather satellites and projected usage of weather satellites into the 1980's, looking at the needs of very short-range weather forecasting, as well as needs for better display and dissemination. Long et al. (1978) reported on the Technique Development Laboratory Boundary Layer Model which produces 24 hour daily forecasts for wind, temperature and humidity within a 2 kilometer boundary layer. Forecasts can be made for the United States east of the Rocky Mountains with the initial wind, temperature and humidity data supplied by 65 radiosonde stations.

IV. ICING

Aviation icing research has centered on engine, airframe and airfoil accretion and protection. Helicopter icing has also been studied and in-cloud measurements have been taken. The Aircraft Icing Workshop (1979) sponsored by NASA and the FAA at Lewis Research Center, Cleveland, Ohio, July 19-21, 1978, addressed fixed wind and rotorcraft operation in an icing environment, icing research facility requirements, improvements in icing forecasts, and instrumentation development.

Ice measurements were made by Hallett et al. (1978) flying an instrumented aircraft just below the tops of cumuli in temperatures of -4°C to -9°C. It was found that fresh growing towers with high updraft velocities contained lower concentrations of graupel than older, low updraft towers. The presence of cloud drops of diameter larger than 25 μm in concentrations of 10-100 cm^{-3} between -4°C and -6°C was verified, these being the conditions at which secondary ice crystal production by riming of graupel may occur.

The problems of aircraft engine ice protection were examined by Pfeifer and Maier (1977) with regard to areas of icing phenomena which can be realistically simulated by experimental methods and regarding areas of icing that require additional research. Stallabrass (1978) measured snow concentration in the air by visibility estimation for use in the design of aircraft engine intake systems operating under heavy snow conditions. Pfeifer (1978) detailed icing effects on aircraft engines and discussed icing simulation methods and designs for engine ice prevention.

Methods to determine the effect of ice accretion on the aerodynamics of unprotected components on an Airbus A300 were studied by Laschka and Jesse (1978). They also looked at ice shedding trajectory prediction theory. Wilder (1978) also studied ice accretion effects and shedding characteristics of jet transport airfoils. His tests showed that ice accretion depends on airfoil shape, specifically leading edge radius and camber, and on angle of attack. An aircraft performance loss and landing weight penalty analysis was also carried out. A computer model was developed by Dietenberger, Kumar and Luers (1979) to predict frost formation on a flat plate in terms of frost surface temperature, density and thickness. Environmental variations in ambient humidity, temperature and convective flow properties were used to test the model, which showed good agreement with experimental results.

Ryder (1978) noted the role of the meteorologist in the prevention of helicopter icing. He stressed a need for knowledge of the physics of icing problems, not the improvement of forecasting conditions to determine when icing will occur. Icing detection problems in helicopters were addressed by Stallabrass (1978). He stated the need for high sensitivity detectors and described a detector that measures icing rate and liquid water content. Tulloch et al. (1978) reported on their tests of ice phobic coatings on UH-1H helicopter rotor blades. Materials tested were General Electric G697 and Dow Corning E2460-40-1, and results indicated that both aided in shedding helicopter rotor ice.

V. LIGHTNING

Lightning represents a serious hazard to aircraft both in flight and on the ground. Major studies have been directed toward atmospheric electricity measurement and lightning modeling. Research has also been carried out on aviation systems protection. The Workshop on The Need for Lightning Observations from Space; Christensen, Frost and Vaughan (1979); summarizes the views of the many disciplines, i.e., researchers, operators and engineers, on problems related to lightning and the potential to analyze these from space.

Nanevicz (1977) used an instrumented aircraft equipped with four electric field meters and an analog data processing system for measurement and determination of the effects of lightning internal and external to aircraft. Perala (1979) used an aircraft coated with 6 mil aluminum flame spray to study lightning-induced cable run currents and voltages. He determined that direct strokes induced the largest currents and that the induction effects of indirect (near) strokes were not negligible. Selvam et al. (1977) examined sferics data from four types of rain conditions in India. These included pre-monsoon thunderstorms, light intermittent rain, heavy continuous rain and post-monsoon thunderstorms. Measured parameters from these storms were raindrop charge, rain intensity, cloud thickness and electric fields. A chaff seeding experiment by Rust and Krehbiel (1977), using a microwave radiometer and 10 cm chaff, revealed that a corona discharge and discharge current flow could be produced in a thunderstorm. Corona currents were also induced by Weber and Few (1978) using radiosonde balloons in clouds. They measured charge distribution in the clouds as well as recording altitude and temperature from the radiosonde. Turman (1978) analyzed sferics data from 10,000 lightning flashes recorded by a lightning detector on board the Defense Meteorological Satellite Program Satellite. This detector viewed a 700 x 700 km area of the earth's surface. LeVine (1978) examined the 3-300 MHz RF band radiation in lightning and noted that strong radiation from return strokes occurred 20 μsec after the initial stroke. He also found the radiation from subsequent return strokes to be associated with cloud processes preceding the flash. MacClement and Murty (1978) studied the VHF direction finder as an instrument to locate lightning discharges. Six hundred discharges could be measured per second, and the instrument was found to be accurate to ±5° for direction and ±3 ms for time.

Lefferts (1978) used a Bruce-Golde lightning return stroke model to simulate the generation of atmospherics. This statistical model simulation compared well with experimental investigations of return strokes. A phenomenological model to simulate induction charging due to drop interactions was used by Colgate et al. (1977). They noted that when a two-peaked drop diameter distribution of 20 μm and 150-200 μm occurred, the polarization induction charging produced was sufficiently large to overcome charge reduction processes. McRae et al. (1978) used a computer program to determine the spatial distribution from the leader head location to the final strike location. They used their results to examine the aspects of shielding against negative downward lightning flashes. LeVine and Meneghine (1978) used a Monte Carlo simulation to study the effects of tortuosity on fields radiated by lightning return strokes.

The problems of using high alloy, thin, light airplane skins while considering the danger of pitting and puncture by lightning strikes were examined by Dobbing et al. (1978). They determined through laboratory experiments that 2 mm thick aluminum alloy skins sufficiently resisted puncture by lightning. Corbin (1979) discussed the methods of protecting aircraft frames and electronics systems against lightning by external structural and circuit design and by equipment and cable shielding. Corn (1979) defined the hazards, causes, and criticalities of direct lightning strokes to aviation, including pitting and burning of metallic structures, skin puncture, damage to unprotected non-metallic components, fuel ignition and human safety in the aircraft. Indirect and nearby lightning discharges are also defined as hazards which induce voltages affecting aircraft electrical or electronic subsystems. Corn also stressed a need for more in-flight data on lightning electrical parameters, lightning detection systems, general aviation lightning data, better protection systems, more pilot lightning reports and better training procedures for flight in lightning environments.

VI. VISIBILITY

Research in visibility has addressed airport and aviation systems operations. Visibility models have been devised, measurements have been made and analyzed, and the effects of precipitation on visibility have been noted.

Pradhan et al. (1977) studied the effects of air pollution and weather at the Bombay Airport. They found that visibility improved after storm activity since dust and other aerosols were washed out. Muench and Brown (1977) studied the effects of snowfall on visibility and radar reflectivity. They verified a relationship between extinction coefficient and snowfall rate.

In a study of contrast, Zhadanovskii and Krylov (1977) derived equations for apparent contrast in terms of object and background luminosities. They determined that detection and recognition visibility can be in varying degrees of error, depending upon the degree of atmospheric haze between the observer and the object. Kreiss et al. (1977) used an optical long path laser transmissometer to determine visual range by measuring the atmospheric extinction coefficient over the propagation path. The problems of interpreting lidar return signals from inhomogeneous atmospheric dispersions and determination of attenuation coefficient along the lidar beam were examined by Kohl (1978).

As there is no known stated requirement for slant visual range (SVR) in the United States, Lewis and Schlatter (1977) performed studies to determine a relationship between SVR and runway visual range (RVR) during fog. Vertical fog profiling was accomplished using six transmissometers mounted from heights of 5 ft to 155 ft. They determined

That by using fog profile measurements, SVR could be determined from RVR. Additional information on surface temperature, wind speed and atmospheric stability may help in determining SVR from RVR in denser fog conditions. The application of lidar to SVR is discussed by Kohl (1979).

VII. FOG

Fog has been one of the greatest incapacitators to aviation operations on the ground and in the approach and takeoff phases of aircraft operation. Fog modeling and measurement studies have been made along with experiments testing fog dispersal/suppression methods.

A warm fog dispersal system described by Klein (1977) featured momentum-driven ground-based heat sources with the jets blowing in the opposite direction to the ambient wind as a counterflowing system. Kunkel (1979) looked at thermo-kinetic warm fog dispersal systems designed for airport use and performed passive heat tests and subscale heat/momentum tests. Also examined were single full-scale runway and approach zone combusters and co-flowing (with ambient wind) and counterflowing jets. Kunkel also explored the effectiveness of the system under the three visibility categories and the volumes to be cleared to make for safe aviation operations under the three category conditions. Christensen (1979) investigated charged particle warm fog dispersal in comparison with seeding, helicopter downwash and thermal techniques. He stated the need for experimental studies of particle mobility and charge density.

Chemical fog suppression research was carried out by McFadden and Collins (1978) using a hexadecanol film over a power plant cooling pond for prevention of water vapor fog at -14°C. Subsequent tests used films of hexadecanol, hex/octadecanol and ethylene glycol monobutyl ether (EGME) with the aid of reinforcing grids also placed in the pond. The films spread over the pond allowed some evaporation but the ice fog formed was less frequent, thinner, and easier to disperse.

Pinnick et al. (1978) used a balloon-borne light scattering particle counter to measure particle numbers, areas, volume distributions and extinction properties, and liquid water content and to determine the vertical structure of fog and haze. Their study revealed that little vertical variations existed in haze and vertical increases in concentrations of drops with radii greater than 4 μm were present in fog. Liquid water content ranged from 10^{-4} to .45 gm^{-3} and a correlation between particle extinction and liquid water content, independent of particle size distribution, was carried out. Deepak and Vaughan (1978) investigated a method for measuring artificial fog particle size distributions without altering the natural state of the fog. Unlike present-day particle size counters, the fog drops settled in a quiet chamber and optical depth versus time was measured. An analytic function was fit to the optical depth-time decay curve and then inverted to yield particle size distribution. Fog and haze drop size distributions and visibility measurements were carried out by Lala, Meyer and Jiusto (1978) using scattered light recorders and optical particle counters. Data was also collected on soil and air temperatures, wind speed and direction, vertical wind speed, net radiation, soil moisture content and dew deposition rate in deriving a relationship between droplet concentration and visual range.

VIII. LOW LEVEL WIND SHEAR

A large proportion of research in aviation weather has focused on the effects of low level wind shear (LLWS) on aviation systems. Studies have been carried out to determine the best methods for sensing and detecting wind shear around airports and in-flight. Work has also been undertaken concerning wind shear modeling and measurement, along with a number of aircraft flight simulations through wind shear.

Hardesty et al.(1977) utilized a dual acoustic Doppler-microwave radar system at Dulles Airport, Washington, DC, to obtain vertical wind profiles in 30 m increments from the surface to 510 m. In this wind shear detection system, the acoustic radar operated during clear air conditions, while the microwave radar took over during periods of precipitation. Also being tested at Dulles Airport is the system of pressure jump sensors, described by Bedard, Hooke and Beran (1977). These sensors surround the airport and detect local high pressure changes from the cold air outflow associated with thunderstorm gust fronts. The design characteristics of these pressure jump detectors were examined by Bedard and Meade (1977). They determined that a pressure switch having a 0.5 mb threshold, high pass filter and 3 minute time constant was adequate for the detection of rapid pressure changes. Mandics (1977) discussed improvements in an acoustic Doppler LLWS detection system possessing a higher signal-to-noise ratio and better signal processing. A 10 cm radar used by Chadwick et al. (1978) for a period of 12 months proved to be a good instrument for providing LLWS warning at airports. Chadwick et al. also considered the problems of low angle operation and suggested a method of airport clutter suppression.

Caracena and Kuhn (1978) reported on an on-board infrared low altitude wind shear detection system (IRLAWS) for providing real-time warnings of changing shear conditions. The system used a forward view infrared sensor with a 10-20 km range to detect sharp temperature gradients across a gust front 1-2 minutes in advance of an encounter. The forward sensor compared its readings with an on-board ambient infrared temperature sensor to yield the temperature gradient. Tinsley, Coons and Wood (1978) described the Federal Aviation Administration Wind Shear Program's possible solutions to the wind shear hazard. The first is a ground-based LLWS alert system (LLWSAS) installed at 60 U.S. airports for detection and tracking of thunderstorm gust fronts. In compares winds measured by remote field anemometers with the wind measured by a central-field anemometer and displays any large vector differences to the controllers. Also developed by the Federal Aviation Administration with the National Weather Service was a Hazardous Wind Shear Advisory Service to alert pilots of forthcoming shear conditions. The 2-3 hour advisories are received by pilots using the Automatic Terminal Information Service (ATIS). Lastly, simulations were carried out to determine the best on-board wind shear hazard displays for pilots. The airspeed/ground speed comparison instruments were most preferred by the pilots.

Ramsdell (1978) performed statistical analyses on wind measurements in the lowest 50 meters one mile downwind of an urban area. The purpose was to determine the short-term fluctuations of vertical and lateral shear of the longitudinal wind component in a slightly to moderately unstable atmosphere. Thunderstorm gust fronts were studied by Greene et al. (1977) using an instrumented tower, acoustic echo sounder and pressure sensors. Their results indicated a relationship between gust front speed and maximum shear. Lewellen, Teske and Segur (1978) developed a model of turbulent atmospheric boundary layer flow for LLWS from thunderstorm gust fronts and warm fronts. They looked at gust front sensitivity to five dimensionless parameters and noted conditions causing shears dangerous to aviation. Frost, Camp and Wang (1979) developed a thunderstorm gust front model for use in terminal area aircraft flight simulations in wind shear environments. The model is two-dimensional, giving the three components of wind speed in horizontal and vertical coordinates. A stable boundary layer wind shear model was developed by Frost, Wang and Camp (1978) for use in terminal area wind shear hazard flight simulation studies.

Goff (1978) reviewed the major meteorological factors which produce wind shear and offered methods to define and classify shear in terms of its effects on aircraft. He also discussed problems of sensor location, scan geometry, range, resolution and averaging periods, as well as other problems related to LLWS detection.

Beaulieu (1978) discussed the meteorological and aircraft considerations of wind shear. He also studied through 100 simulated approaches the dynamic response of the aircraft/pilot system in strong wind shear environments. Displays and control systems for controlled airspeed and flight path flight, as well as the advantages, disadvantages and limits of ground-based and airborne sensors, were examined. A pilot/vehicle model was used by Levison (1978) for comparison with a real-time simulation study to examine the approach task in a wind shear environment. Lehman, Heffley and Clement (1977) simulated approach and take-off in wind shear for four passenger aircraft ranging from STOL to jumbo jet, using pilot models appropriate to the four aircraft. They looked at flight operations and propulsion and found no correspondence between shear hazard and aircraft size or type. Factors determined to be sensitive to shear were airspeed, flight path regulation and airspeed regulation. Frost and Reddy (1978) digitally simulated approach and landing for DC-8 and DHC-6 aircraft in gust and shear environments induced by thunderstorms and bluff geometries. They used a two-dimensional model of aircraft motion with fixed and automatic controls. Deviations from glide path and touchdown were studied and the necessary added controls to keep the simulated aircraft on glideslope were calculated. Frost, Crosby and Camp (1979) simulated aircraft landings through thunderstorm gust fronts using a three-degree-of-freedom nonlinear aircraft motion model. The aircraft entered the tabulated wind fields at a given position in a given trim condition and the flight paths and trajectory control inputs were analyzed for the fixed and automatic control landings. Aircraft-measured winds were used by McCarthy and Blick (1979) to numerically simulate aircraft response in a thunderstorm environment. They examined the feasibility of accurately measuring the winds near the earth's surface, developing a model which uses real wind profiles in determining whether an approach is safe and developing a real-time detection and warning system. Frost, Reddy, Crosby and Camp (1979) simulated the fixed stick and automatic landing system flight of a DC-8 and DHC-6 through wind fields induced by block geometries. They used a two-dimensional aircraft motion model and examined the terms in the equations of motion which were affected by wind shear.

IX. STORM HAZARDS/SEVERE STORMS

The aviation community is concerned with the identification and tracking of storm cells and their associated hazards, precipitation and electricity. Various storm models have been derived along with measurements and observations of storm parameters. One parameter studied was cloud top height and its relation to storm severity.

Sassen (1977) used polarization diversity lidar to study high plains thunderstorm precipitation. Bright bands in the reflectivity returns were indicators of the occurrence of ice phase precipitation processes. Ice particle types could be identified by using depolarization profiles from CW laser scattering measurements. Sassen observed the presence of graupel during the developing stages and melting snowflakes in the mature stage. Zabolotskaya and Muchnik (1976) concluded from their observations of sudden intensifications in shower and thunderstorm rainfall that they were not caused by lightning discharge, but rather by the passing of the most intense area over the observing point. Hailstones were grown in a vertical icing tunnel by Thwaites, Carras and Macklin (1977) and the aerodynamics of the stones were studied.

Thunderstorm climatology around airports was investigated by Prasad and Kundra (1977) who studied thunderstorms occurring at Ozar Airfield at Nasik, India. Data was taken for the years 1968-1973 to derive hourly and monthly thunderstorm distributions as well as seasonal variations, synoptic features and orographic effects from the surrounding area.

Schlesinger (1978) three-dimensionally modeled the mature stage of an isolated convective storm (precipitation and turbulence included) and studied the effects of different shear environments. Winn et al (1978) sent an instrumented balloon through a thunderstorm and measured electric field, echo structure and wind profiles as the balloon ascended. Algorithms for severe storm description from single Doppler weather radar data were developed by Crane (1977). The resulting descriptive information included small convective cells, large echo areas, estimates of wind profile and reflectivity profile, and regions of high tangential shear, as well as the development and motion of severe storms. Caracena (1978) compared and described two scales of thunderstorm downburst cells, termed supercell downburst and microburst respectively. The two cases were classified according to damage pattern, magnitude and lifetime. The maximum wind speed and the radius of the Stillwater, Oklahoma, tornado on June 13, 1975, were determined by a least squares fit of pulse Doppler radar data and vortex model velocity spectra carried out by Zrinic, Doviak and Burgess (1977). The results revealed a wind speed of 92 m/s at 630 m altitude and 85 m/s at an altitude of 1.5 km.

Wang and Burns (1976), through time series analysis and pattern recognition techniques, developed a computerized severe weather forecasting and warning system by measuring the rate of occurrence of electrical disturbances in the atmosphere. Freeman (1977) performed statistical studies on the distribution of thunderstorm days and lightning discharges. He found that the occurrence of lightning discharge followed the sun poleward from January to July and receded toward the equator from July to December. It was determined that for the Northern Hemisphere the average incidence of lightning discharge was 0.000042/km^2/sec. Zavoli (1977) studied atmospherics from thunderstorms forecast as severe by the National Severe Storms Forecast Center. Using a directional

HF antenna, he noted a distinct class of atmospherics which differed from those observed during normal thunderstorms. A correlation between reception of these impulses and occurrence of severe weather was statistically significant. The possible use of satellites to determine the relationship between the air motions associated with thunderstorms and electrification and discharge rates was examined by Dodge (1979). The satellites, having the capability of observing the moisture influx patterns, air motions and atmospheric temperature structure and lightning characteristics could be used to determine if a relationship exists between lightning activity and storm severity. The Lightning Detection and Ranging Display (LDAR) described by Poehler (1978) agreed with radar precipitation echoes and visual observations of lightning. LDAR correlated with aircraft measurements of turbulence and updrafts and proved to be a useful tool for thunderstorm warning and detection.

The use of a conventional weather radar to detect three-dimensional storm motion by analyzing radar reflectivity data was reported by Rinehart and Garvey (1978). Peslen (1979) derived wind vectors from satellite tracks of clouds and analyzed the divergence fields associated with these vectors to describe conditions preceding severe storm development.

Adler (1977) used infrared radiation data from a geostationary satellite to examine thunderstorm top growths and relate them to severe weather occurrence on the ground. Both growth rate and maximum height of the tops were considered for detection of severe storms. Darrah (1978) looked at the characteristics of severe storms according to their tops as indicated by radar. In cases of tropopause penetration, he found that hailstorms extended highest into the stratosphere since the most severe storms have high updraft velocities and therefore attain the greatest heights.

X. TURBULENCE

Atmospheric turbulence, in one form or another, affects all aircraft during every flight. Turbulence models have been formulated and measurements have been taken. In addition, specific studies of turbulence effects on aviation systems operation have also been undertaken, as well as studies of the effects of mountain wave and clear air turbulence (CAT) phenomena.

Bowen and Lindley (1977) performed wind tunnel studies of flow over two-dimensional forward-facing escarpments to examine the wind close to the ground. They assumed a neutrally stable boundary layer and studied the extent and magnitude of turbulence. A computer program was developed by Bilanin et al. (1978) to study vortex decay affected by the ground and various atmospheric parameters such as shear, convective turbulence and stratification. Ehernberger (1978) reported on an airborne gust velocity measurement system to measure turbulence in a supersonic environment using a YF-12 aircraft. Because of the resulting airframe flexibility, the fixed flow vane sensors must have good amplitude resolution as well as phase matching capabilities and must also be able to withstand the effects of heating. A method for determining bias errors in winds measured from airborne Doppler radar and inertial navigation systems was devised by Grossman (1977). The method uses measured wind component and true aircraft heading before and after a change in heading. Lee (1977) examined the potential for Doppler radar use in determining the mean velocity spectrum width for locating areas of turbulence. He compared aircraft recorded turbulence and Doppler data for a given volume of air.

Polge and Bilbro (1978) used Doppler lidar and spectral analysis to determine velocity flow field variations to be utilized for weather forecasting and airport management. Williamson, Lewellen and Teske (1977) looked at flight data recorders from aircraft accidents to assess the feasibility of predicting conditions under which wind and turbulence environments hazardous to aviation operations exist. They used a model of turbulent flow in the atmospheric boundary layer. Jewell, Stapleford and Heffley (1977) computed aircraft responses in different flight conditions through turbulence and wind shear. A flexible atmospheric turbulence model for use in aircraft flight simulations was developed by Jewell and Heffley (1978). The effect of turbulence on powered-lift aircraft handling was studied by Jewell et al. (1979). They used a helicopter on approach and a simulator, using actual turbulence wind profiles and a Dryden spectrum of turbulence.

The effects of mountain wave-induced turbulence and associated hazards to aircraft were discussed by Lilly (1978). He studied the case of the January 1972 downslope windstorm in Colorado and noted that conditions preceding the event were detectable from soundings 12-24 hours in advance and 1,000 km downstream. An airborne infrared radiometer system that can be used for detection of CAT described by Kuhn (1978) can detect turbulence from 1.5-6.0 minutes ahead of the encounter by the aircraft. Hopkins (1977) descussed the aeronautical implications of CAT referring to the effects of CAT and the necessary accuracy of CAT forecasts. He examined the causes of CAT and different forecasting methods for predicting different types of CAT. An instrumented B-57B aircraft was flown in a CAT study by Davis, Champine and Ehernberger (1979). Forty-six missions were flown through mountain waves, jet streams, upper level fronts and troughs, and low level mechanically and thermally induced turbulence. The encountered turbulence intensities ranged from slight to severe.

XI. TRAINING

Aviation meteorology research regarding pilot training has primarily focused on the problems of flying through low level wind shear on both approach and take-off phases of operation. Additional studies were made on the effects of precipitation and visibility on pilot performance.

Gartner and McTee (1977) ran flight simulations with pilots to determine better cockpit displays and procedures for pilots encountering low level wind shear. It was concluded that current flight instruments and procedures were insufficient and that an airspeed/ground speed indicator (most preferred by the pilots in the tests) may be an adequate instrument for safer flight through shear. Gartner et al (1977) simulated a DC-10 landing in CAT I visibility conditions and Instrument Landing System (ILS) guidance with inversion-layer, frontal, thunderstorm and no shear wind conditions. Constant monitored ground speed approaches by a jet transport in moderate and severe wind shear environments were simulated by Kelley (1979). He determined that the constant ground speed approach was better for shear negotiation and led to predictable and acceptable touchdown. It was noted that higher airspeeds on constant ground speed approaches gave added stall margin in situations where tail shear was encountered. Continental Airlines (1978) stressed a need for pilots to be aware of low level wind shear on approach and take-off. Continental noted that use of the Inertial Navigation System (INS) gave a pilot the capability to compare winds at the approach altitude to those at the surface, thus analyzing shear conditions. The airline stated that pilot reports (PIREPS) should be used and reported more frequently and be made more specific with respect to altitude, location, type of aircraft flown and effects of shear on airspeed fluctuations so that the next pilot will know what to expect and do. Simulations by Kunciw (1978) revealed that an aircraft on approach flying from 510 ft above ground level (AGL) to 10 ft AGL through a headwind decreasing logarithmically from 30 kts to 0 kts sank at a rate of 6.2 ft/sec and landed 721 ft short of the runway. He designed a flare control law which enables an aircraft on automatic approach in wind shear to achieve the smallest possible sink rate and closest touchdown distance.

The effects of precipitation on a runway were studied by Kibbee (1978) who developed a DC-9/10 runway directional control simulator. Fourteen pilots from government agencies and airlines evaluated the simulator, making 818 runs including landings, rejected take-offs and ground maneuvers. The pilots gave the simulator a good rating as an instrument for training pilots on adverse runway conditions.

Johnson (1978) discussed the modeling of fog and low visibility for realistic use in simulators. He studied shallow fogs and fogs with marked vertical density gradients. Improvements in atmospheric environmental simulation for flight simulators are also offered by Allsopp (1978).

The importance of meteorological education in general aviation pilot training was stressed by Colomy (1979). He noted that an understanding of the effects of meteorological phenomena on the pilot/aircraft system would make pilots safer. Training must come from experience (both simulated and real) and from professional aviation educators (with a meteorological background) teaching from an aviation instructor curriculum.

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APPENDICES

APPENDIX A

TABULATION OF NASA, NOAA AND FAA RESEARCH

I. ADVANCED METEOROLOGICAL INSTRUMENTS

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Automated Weather Observation Systems (AWOS) Jack Dorman (202)426-8427 Project #III 153-451-06	DOT/FAA	NWS/Systems Development Office, Equipment Development Laboratory	James A. Cunningham	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.
Discrete Address Beacon System (DABS) Data Link Winds Eric Mandel (202)426-8427	DOT/FAA	DOT/FAA	R. Craig Goff	Real-time three-dimensional wind field in terminal area.
Automation of Weather Observation Facilities Raymond Colao (202)426-8427 Project #153-451	DOT/FAA	Transportation Systems Center	William Wood Ed Spitzer	To automate weather observations at airports and towers and to use solid state technology for replacement of old equipment.
Airborne Doppler Weather Radar James Muncy (202)426-8427 Project #152-462-08	DOT/FAA	NOAA/ERL	Bobbie Trotter R. Strauch	Prove operational utility of Doppler weather radar for airborne commercial aviation.
Evaluation of Ryan Stormscope James Muncy (202)426-8427 Project #152-462-03	DOT/FAA	USAF/AFFDL, Wright Patterson AFB, OH	I. Mangold	Compare airborne weather radar with Ryan Stormscope.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Development of Ground Doppler Weather Radar James Muncy (202)426-8427 Project #152-462-06	DOT/FAA	NOAA/NSSL	E. Kessler and Staff	Develop and demonstrate operational utility of ground Doppler weather radar.
Radar Echoes by Size and Intensity James Muncy (202)426-8427 Project #152-462	DOT/FAA	NOAA/NCC	R. Baldwin	Look at films of five radar echoes and obtain quantitative data on reflectivity, intensity and geographic extent of these echoes. Applies to airborne or ground weather radar at any frequency one chooses.
Automated Low-Cost Weather Observing System (ALWOS) Richard R. Reynolds (301)427-7815 Project #RD590714	DOT/FAA	NWS/System Development Office, Equipment Development Lab	Richard R. Reynolds	To develop a low-cost automatic weather station and sensor for the FAA. This station will be a limited alternative to AV-AWOS. Only one ceiling and one visibility sensor will be used instead of three. Algorithms will be limited initially to a 3,000 ft ceiling and 1/4 through 7 miles visibility. The Wind, Altimeter, Voice Equipment (WAVE) System is a computerized system which automatically records wind speed and direction and current altimeter setting and reports this information to pilots in the vicinity of an airport over a VOR voice channel. Also, there is a device to allow airport personnel to indicate a favored runway.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Automatic Weather Observing System (AV-AWOS) James A. Cunningham (301)427-7809 Project #RD590713	DOT/FAA	NWS/Systems Development Office, Equipment Development Laboratory	James A. Cunningham	To enhance the design of AV-AWOS by adding and evaluating an improved thunderstorm detector and a laser present weather system. AV-AWOS was designed to be an automatic weather station capable of providing aviation weather observations of the same quality as now provided by human observers.
Stratospheric Measurements A. J. Broderick	DOT/FAA	NRL	H. J. Mastenbrook	Develop a capability for stratospheric water vapor measurements through the development of instrumentation for commercial production. Also to provide reference measurements for the assessment of climatic impact of pollutants in the stratosphere.
Aviation Operations Safety Technology - Lidar Applications E. A. Weaver (205)453-1597 FTS 872-1597	NASA	Optics Branch, Electronics and Control Laboratory, MSFC, AL	Optics Branch Environmental Branch Raytheon Company Sudbury, MA M&S Computing, Inc. Huntsville, AL Computer Science Corp. Huntsville, AL UT Space Institute Tullahoma, TN Alabama A&M University Huntsville, AL	Electro-optic sensors using lasers will be developed for application to aircraft operations and safety problems. The primary objective will be the evaluation of Doppler lidar test data and the development of rational requirements and specifications for a lidar CAT detection system. Remote measuring of atmospheric flow systems will use infrared lasers. Other coherent light frequencies will be used as defined by the systems analysis studies of a specific problem. System engineering studies will identify the research hardware design specifications for use in building the required feasibility demonstration sensor systems. CW and pulsed Doppler lidars will be investigated.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Automated Pilot Advisory System Loyd Parker	Research Triangle Institute	NASA/WFC	J. Parks	To demonstrate systems feasibility of utilizing advanced low-cost digital systems technology to provide: automatic voice airport advisory information and automatic voice air traffic and conflict alert advisories at uncontrolled airports. To develop an experimental system for feasibility evaluation and concept demonstrations.
Electro Optics Meteorology R. J. Richter	Naval Ocean Systems Center	NRL	H. E. Gerber	To provide instruments and methods to give real-time support on clouds, aerosol, water vapor and turbulence.
Doppler Radar Project in Advanced Techniques	DOC/NOAA	NSSL	R. J. Doviak D. S. Zrnic	Measurement of shear and turbulence in the planetary boundary layer.
Aviation Weather Sustaining Engineering Raymond Colao (202)426-8427 Project #151-451	DOC/NOAA	NWS/Systems Development Office, Equipment Development Laboratory	Bob Strickler Doug Downen	Technical data package recommendation to Operating Services resulting in improved availability and more cost-effective operations and maintenance for such systems as: transmissometers, RVR signal data converters, wind measurement devices, ceilometers, ASI, temperature equipment.
Radar Kenneth Shreeve (301)427-7815 Project #8AA830	DOC/NOAA	NWS/Systems Development Office, Equipment Development Laboratory	Kenneth Shreeve	To continue development of signal processing, data processing and display equipment to improve NWS-weather radar facilities and operational techniques.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Automatic Data Acquisition Richard R. Reynolds (301)427-7815	DOC/NOAA	NWS/Systems Development Office, Equipment Development Laboratory	Richard R. Reynolds	To develop automatic weather stations such as the Sensor Processor and Display (SPAD-AMOS VI), the Automated Low-Cost Weather Observing System (ALWOS), and the Shipboard Environmental Data Acquisition System (SEAS).
Sensor Development for Basic Surface Observations Donald T. Acheson (301)427-7815 Project #8AA810	DOC/NOAA	NWS/Systems Development Office, Equipment Development Laboratory	Donald T. Acheson Charles F. Lambert James O. Abernathy Anthony W. Cheek	To develop observing technniques and to design sensors and preprocessing systems for future NWS observing systems. Sensors will be developed to measure clouds, visibility, winds, humidity, temperature and pressure.
Dual Channel Microwave Radiometer D. C. Hogg	DOC/NOAA	WPL/ERL	F. O. Guiraud	Operational - measures continuously cloud liquid and precipitation water vapor at WSFO, Denver; observes super-cooled liquid that causes aircraft icing.
Microwave Satellite (COMSTAR) Beacon Receiver and Radiometer D. C. Hogg	DOC/NOAA	WPL/ERL	J. B. Snider	Operational - measures continuously line integral of liquid water in clouds.
Microwave Continuous Profiler System (PROFS) D. C. Hogg	DOC/NOAA	WPL/ERL	M. T. Decker R. G. Strauch F. O. Guiraud	To measure continuously precipitable vapor and liquid, and temperature and wind profiles.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Icing Photoinstrumentation System Phyllis F. Kitchens (804)878-2071/2306 AUTOVON 927/2071/2306	Department of the Army Applied Technology Laboratory, Fort Eustis, VA	Contract (competitive)		To develop a rotor blade photo-instrumentation system to record ice accretion and shedding from the lower surface of helicopter main rotor blades. The photoinstrumentation system will be used on an ice-protected JUH-1H helicopter in the 1979-1980 winter test season to evaluate the effectiveness of rotor blade ice-phobic coatings in natural icing flight tests.
Icing Severity Level Display (Unfunded) Richard I. Adams (804)878-2071/2306 AUTOVON 972-2071/2306	Department of the Army Applied Technology Laboratory, Fort Eustis, VA	Leigh Instruments, Ltd. Rosemount, Inc.		In separate unfunded efforts the two manufacturers of ice detectors used during a series of JUH-1H helicopter icing flight-test programs will design and fabricate new icing severity level displays (ISLD) for use in the 1979-1980 test program on an Army helicopter. In a previous test, a display of cloud liquid water content was judged to be unsuitable for operational use. The purpose of the ISLD program is to determine an optimum display of the cumulative effect of flight through icing conditions on the capability of the helicopter to safely continue flight.
Icing Nozzle Element Optimization and Rain Nozzle Calibration W. V. Tracy, Jr. (805)277-3068 AUTOVON 350-3068	4950th Test Wing Wright Patterson AFB,OH AFGL/LYC Hanscom AFB, MA	6510th Test Wing/TEEES Edwards AFB, CA	W. V. Tracy, Jr.	For objectives see Icing.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Palletized System Improvements W. V. Tracy, Jr. (805)277-3068 AUTOVON 350-3068		6510th Test Wing/TEEES Edwards AFB, CA	W. V. Tracy, Jr.	For objectives see Icing.
Hygrometer Modification W. V. Tracy, Jr. (805)277-3068 AUTOVON 350-3068	4950th Test Wing/FFM Wright Patterson, AFB, OH	6510th Test Wing/TEEES Edwards AFB, CA	W. V. Tracy, Jr.	For objectives see Icing.
Lightning Sensor Mapper Wayne Wagnon (205)453-4623	Auburn University	NASA/MSFC	Wayne Wagnon Warren Harper (microwave) Tom Barnes (optical)	For objectives see Lightning.
Portable Visioceilometer Jagir S. Randhawa	U.S. Army/DARCOM	U.S. Army/ERADCOM	Robert S. Bonner William J. Lentz	For objectives see Visibility.
Airport Low Level Wind Shear Alert System Field Test Guice Tinsley (202)426-9350 Project #150-451-160	DOT/FAA	NAFEC	R. Craig Goff	For objectives see Low Level Wind Shear.
Evaluation of the Pulsed Doppler Wind Shear Sensing System at Dulles International Airport Guice Tinsley (202)426-9350 Project #154-451-130	DOT/FAA	NAFEC	Peter V. Versage Augusto M. Ferrara Final Report No. FAA-RD-78-158	For objectives see Low Level Wind Shear.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Thunderstorm Gust Front Detection System Evaluation Guice Tinsley (202)426-9350 Project #154-451-250	DOT/FAA	NAFEC	Augusto M. Ferrara	For objectives see Low Level Wind Shear.
Wind Shear/Pulse Doppler Radar Effort R. G. Strauch	FAA(ARD-243) Washington, DC DOT-FA76WAI-622 I. D. Goldman	NOAA/WPL/ERL	R. G. Strauch 499-1000 x6385 FTS 323-6385	For objectives see Low Level Wind Shear.
Low Level Wind Shear: Aviation Safety Technology In-flight Detection and Prediction of Low Level Wind Shear P. M. Kuhn, NOAA/APCL	NASA NOAA	NASA NOAA	P. M. Kuhn L. P. Stearns F. Caracena	For objectives see Low Level Wind Shear.
Aviation Safety Technology Wind Shear Detection L. Parker, WFC		NASA/WFC	W. Brence, WFC R. Snyder, WFC	For objectives see Low Level Wind Shear.
FM-CW Doppler Radar Wind Shear Detector R. B. Chadwick	USAF/AFGL Hanscom AFB, MA	NOAA/WPL/ERL	R. B. Chadwick	For objectives see Low Level Wind Shear.
Clear Air Turbulence: Aviation Safety Technology, In-flight Detection and Prediction of CAT P. M. Kuhn, NOAA/APCL	NASA NOAA	NASA NOAA	P. M. Kuhn L. P. Stearns	For objectives see Turbulence.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research D. W. Camp (205)453-2087 RTOP #505-08-19	NASA/MSFC	Space Sciences Laboratory, Fluid Dynamics Branch, NASA/MSFC	For investigators and objectives see Turbulence.	
Knowledge of Atmosphere - Advanced Measurement Techniques L. C. Parker, WFC	NASA/KSC	Virginia Polytechnic Institute and State University University of Dayton, Ohio NASA/WFC	H. W. Tielemen, VPI&SU F. J. Schmidlin, WFC J. K. Luers, U.D. W. E. Melson, Jr., WFC W. D. Gunter J. H. Scott J. F. Andrews, WFC W. D. Gunter, WFC D. LeVine, GSFC N. L. Crabill, LaRC	For objectives see Storm Hazards.

II. FORECASTING

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Doppler Weather Radar Program (NEX RAD) John W. Hinkleman (202)426-8427 Project #152-462-05	DOT/FAA	NOAA/ERL NOAA/NSSL	K. Wilk J. Lee D Zrnic	Provide an improved national weather radar system with improved severe weather detection capability.
Improved Terminal Area Weather Service Program (PROFS) John W. Hinkleman (202)426-8427 Project #152-462-06	DOT/FAA	NOAA/ERL (PROFS Program)	D. Beran D. Haughan	Improve weather services to terminal area operations.
Interpretation of Weather Echoes on ATC Radars James Muncy (202)426-8427 Project #152-462-06	DOT/FAA	NOAA/NSSL	K. Wilk D. Zittel J. Dooley	Prepare rules for interpretation of weather echoes on en route and terminal radars.
Severe Weather Tracking and Prediction John W. Hinkleman (202)426-8427 Project #152-462-04	DOT/FAA	ERT	Robert Crane	Computer techniques for presenting current radar severe weather data and forecast position information for en route and terminal ATC operations.
Improved Aviation Weather Forecasting Frank Melewicz (202)426-8427 Project #152-461-01	DOT/FAA	NWS/Techniques Development Laboratory	M. Alaka R. Elvander R. Saffle	Improve the accuracy, timeliness and location of thunderstorm forecasts and associated hazards in the 0-2 hr time range including 0-10, 0-20 and 0-30 minute forecasts.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Integrated Aviation Weather System for the National Airspace System (NAS) John W. Hinkleman (202)426-8427 Project #152-462-01	DOT/FAA	Several contractors Transportation System Center Minority Services, Inc. MITRE	Various investigators Ed Sptizer, TSC R. Johnson, MSI R. Thompson, MITRE	A system engineering program to provide a comprehensive integrated aviation weather system tying all weather program segments together.
Thunderstorm Forecasting for Aviation Mikhail A. Alaka (301)427-7772 Project #RD5901	DOT/FAA	NWS/Systems Development Office, Techniques Development Laboratory	Mikhail A. Alaka Robert C. Elvander Robert E. Saffle	To develop short (0-2 hr) forecasts of convective weather, at or near air terminals, based on digitized radar data.
Terminal Weather Prediction	DOC/NOAA	NWS/Systems Development Office, Techniques Development Laboratory	Robert G. Miller Karl F. Hebenstreit David J. Vercelli	To develop forecasts of weather elements crucial to aviation operations in the terminal area. Emphasis is on cloud amount and height, visibility and nonprecipitation related obstructions to vision. Techniques suitable for short-range (0-6 hr) and medium-range (6-24 hr) prediction are under investigation.
Severe Local Storms Prediction Mikhail A. Alaka (301)427-7772 Project #8C3781	DOC/NOAA	NWS/Systems Development Office, Techniques Development Laboratory	Mikhail A. Alaka Ronald M. Reap Jerome P. Charba James E. Kemper Paul E. Long Wilson E. Shaffer Robert C. Elvander Robert E. Saffle	To develop automated forecasts of thunderstorms and severe local storms in the 0-2 hr, 2-6 hr and 12-48 hr time ranges.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
AFOS Forecast Applications Dale A. Lowry (301)427-8066 Project #8C2702	DOC/NOAA	NWS/Systems Development Office, Techniques Development Laboratory	David J. Vercelli	To monitor NWS predictions and warnings; to supply guidance to the forecasters in the same form as the final product; to introduce worthwhile new products (either guidance material or final products) into the NWS expanded services program. One aviation-related task under this project is <u>Local Monitoring and Updating</u>: To develop an automated procedure for the AFOS systems at WSFO's which will monitor all surface aviation observations (SAO) and terminal forecasts (FT) within each WSFO's area of responsibility and alert the forecaster when a problem or potential problem arises with the FT and provide objective guidance for preparing FT's.
Public Weather Prediction Surface Wind Forecasting Robert G. Miller (30-)427-7768 Project #8C298004	DOC/NOAA	"	Gary M. Carter	To develop techniques for the automated prediction of surface winds in the U.S. These forecasts may be used as guidance for NWS forecasters or may be issued directly to the public.
Systems Development and Experimentation - Forecaster Aids and Applications Hugh M. O'Neil (301)427-7778 Project #8C27037	DOC/NOAA	"	Thomas Laufer D. Richardson Decker Mary C. Newton	To enhance the capability of forecasters at NWS operational sites through the use of new or improved products and the extended use of automation to provide these products. One aviation-related task is the <u>Automated Route Forecast</u>: A joint FAA/NWS project for the development of an automated route forecast (ARF) program.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Prototype Regional Observation and Forecasting Service (PROFS) Donald W. Beran	NOAA/ERL.	PROFS Program Office	Donald W. Beran Duane A. Haugen David George	Mesoscale weather service using satellite data, radar data and surface observations. Local data acquisition display systems for airport weather conditions.
Aviation Meteorology Research - Severe Storms	NASA	NASA/LaRC	Norman L. Crabill (804)827-3274	For objectives see Storm Hazards.

III. ICING

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Ice Phobic Coating Flight Tests Richard I. Adams Phyllis F. Kitchens (804)878-2071/2306 AUTOVON 927-2071/2306	Department of the Army Applied Technology Laboratory, Fort Eustis, VA	US Army Aviation Engineering Flight Activity, Edwards AFB, CA		In the 1979-1980 winter test season, both simulated and natural icing flight tests will be performed to evaluate the effectiveness of candidate rotor blade ice phobic coatings. Natural icing tests, using the modified JUH-1H helicopter with an electrothermal blade deicing system as a backup, will be performed with the Dow Chemical Co. coating E2978-46. This coating was previously subjected to simulated icing using the Helicopter Icing Spray System (HISS) under USAAEFA Project #77-30, Jan-Feb 78. Using a second, standard UH-1H, simulated icing tests will be performed in the Ottawa Spray Rig with several new candidate coatings which have been identified in laboratory tests. One of the main thrusts of this program will be to determine the effects of rain erosion on coating life; a rain simulator will be constructed for use during this test.
Prevention and Control of Ice Adhesion George D. Ashton (603)643-3200 x258 FTS 834-7585	Department of the Army	US Army CRREL	Stephen F. Ackley Kazuhiko Itagaki L. David Minsk	Develop methods of control, prevention and alleviation of accretion and adhesion of ice on current and future Army helicopters and other materiel where ice accretion interferes with all-weather operational capability. Included is a numerical simulation of the ice accretion process and the investigation of effectiveness and durability of ice phobic coatings.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aircraft Icing Research R. W. Luidens (216)433-400 x6376 FTS 294-6376 RTOP #505-08-12	NASA	NASA/LeRC, Wind Tunnel and Flight Division, Low Speed Aerodynamics Branch, Icing Research Section	R. W. Luidens, Branch Chief, x6376 J. J. Reinmann, Section Head, x5542 B. J. Blaha, x6122 P. L. Evanich, " W. A. Olsen, " R. J. Shaw, "	The objective of this program is to update and advance the basic fundamentals and the technology for safe and efficient operation of aircraft under atmospheric icing conditions. The program encompasses both analytical and experimental research and is conducted both in-house and with industry and university contracts. It is a coordinated effort among the aircraft/industry users, government agencies and the military. NASA will serve as a focal point for assembling and disseminating a wide range of data. During FY 1981, the following icing programs will be conducted: 1) Contract with industry to define state of the art and future research and technology needs in aircraft icing. One study each for rotorcraft, CTOL and general aviation. 2) Procure computer codes for calculating water droplet trajectories about 3-D bodies, 2-D airfoils with lift, and engine inlets. 3) Evaluate selected ice phobics for the USAF. 4) Develop and test a microwave deicer system. 5) Evaluate inflatable boot deicers for helicopters. 6) Develop a non-intrusive laser interferrometer for measuring water droplet velocity and size distributions. 7) Perform helicopter inlet studies. 8) Acquire and evaluate ice accretion computer codes.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Investigation of Passive Anti-Icing Techniques	US Army CRREL NASA LeRC	USAF/AFFDL	Capt Jackson (513)255-6626	To identify test methods to make comparative studies of off-the-shelf anti-icing coatings and to identify existing candidates for such use.
Air Force Aircraft Icing Needs	---	USAF/AFFDL	Capt Jackson (513)255-6626	To outline a roadmap or plan of action to satisfy the Air Force's needs with regard to icing. A workshop was held with ten USAF operational and R&D organizations represented. The recommendations have been summarized in AFFDL Technical Memorandum AFFDL-TM-79-59-WE, May 1979.
Helicopter Icing Environment for Airworthiness Standards Certification Arthur Hilsenrod (202)426-8427 Project #152-463-01	DOT/FAA	NRL	L. Ruhnke R. K. Jeck R. Ruskins	To obtain icing conditions below 5,000 ft, especially of the northeast coast of the U.S. where icing data below 5,000 ft is lacking. The data obtained will be in the form of liquid water content, drop size, distribution and outside air temperature.
Icing Nozzle Element Optimization and Rain Nozzle Calibration W. V. Tracy, Jr. (805)277-3068 AUTOVON 350-3068	4950th Test Wing Wright-Patterson AFB, OH AFGL/LYC Hanscom AFB, MA	6510th Test Wing/TEEES Edwards AFB, OA	W. V. Tracy, Jr.	Feasibility study to investigate if small droplets can be produced in-flight with the AFFTC water spray system. (This has been accomplished and the mean effective drop diameters are 19 to 29 microns.) Calibrate the rain nozzle to obtain accurate drop diameters and liquid water contents for artificial in-flight rain or water ingestion tests.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Palletized System Improvements W. V. Tracy, Jr. (805)277-3068 AUTOVON 350-3068		6510th Test Wing/TEEES Edwards AFB, CA	W. V. Tracy, Jr.	Refurbish the water spray system pallet that can be installed on C-130's for artificial in-flight icing and rain tests.
Hygrometer Modification W. V. Tracy, Jr. (805)277-3068 AUTOVON 350-3068	4950th Test Wing/FFM Wright-Patterson AFB,OH	"	W. V. Tracy, Jr.	Modify the NKC-135, which has the AFFTC water spray system, to include a hygrometer for use in artificial in-flight icing and rain tests.
F-16 Ground Environment Induced Icing Evaluation LTC T. McAttee (805)277-2555 AUTOVON 350-2555		6510th Test Wing/TEVF Edwards AFB, CA	W. V. Tracy, Jr.	Natural environment and climatic laboratory evaluation of the parameters that contribute to ground icing of the F-16 weapon system. Investigate methods to negate the ice accretion experienced by the F-16 weapon system while operating on the ground.
F-16 Artificial In-flight Icing and Rain Evaluation LTC T. McAttee (805)277-2555 AUTOVON 350-2555		"	W. V. Tracy, Jr.	Determine the clearance for the F-16 weapon system to fly in icing and rain conditions.
A-10 Icing Test LTC T. Zang (805)277-3797 AUTOVON 350-3797		6510th Test Wing/TEVA Edwards AFB, CA	W. V. Tracy, Jr.	Determine the areas on the A-10 weapon system which, when they shed ice, induce the most significant engine damage. Use ice phobic materials to isolate certain areas on the A-10 weapon system during ice accretion.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
F-16 Adverse Weather Test LTC T. McAttee (805)277-2555 AUTOVON 350-2555		6510th Test Wing/TEVF Edwards AFB, CA	T. Nasal (805)277-3068 AUTOVON 350-3068	Determine the effects of adverse weather on F-16 weapon system operation in the natural environment.
Dual Channel Microwave Radiometer D. C. Hogg	NOAA	NOAA/WPL/ERL	F. O. Guiraud	For objectives see Advanced Instruments.
Microwave Satellite (COMSTAR) Beacon Receiver and Radiometer D. C. Hogg	NOAA	NOAA/WPL/ERL	J. B. Snider	For objectives see Advanced Instruments.
Microwave Continuous Profiler System (PROFS) D. C. Hogg	NOAA	NOAA/WPL/ERL	M. T. Decker R. G. Strauch F. O. Guiraud	For objectives see Advanced Instruments.
Icing Photoinstrumentation System Phyllis F. Kitchens (804)878-2071/2306 AUTOVON 927-2071/2306	Department of the Army Applied Technology Laboratory, Fort Eustis, VA	Contract (competitive)		For objectives see Advanced Instruments.
Icing Severity Level Display (unfunded) Richard I. Adams (804)878-2071/2306 AUTOVON 927-2071/2306	"	Leigh Instruments, Ltd. Rosemount, Inc.		For objectives see Advanced Instruments.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research - Severe Storms A. W. Hall (804)827-3274 RTOP #505-08-13	NASA	NASA/LaRC	Norman L. Crabill (804)827-3274	For objectives see Storm Hazards.
Aviation Meteorology Research D. W. Camp (205)453-2087 RTOP #505-08-19	NASA/MSFC	Space Sciences Laboratory, Fluid Dynamics Branch, NASA/MSFC	For investigators and objectives see Turbulence.	
Knowledge of High Altitude Atmospheric Processes T. R. Sisk (805)258-3311 x379 L. J. Ehrenberger (805)258-3311 x154 RTOP #505-08-14	NASA/OAST	NASA/DFRC	UCLA NOAA/NCC SRI International	For objectives see Turbulence.

IV. LIGHTNING

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Lightning Detection System F. Sakate (202)426-6593 Eric Mandel (202)426-8427	DOT/FAA	Atlantic Scientific Corp.	Rodney Bent	Lightning (thunderstorm) detection and tracking system.
Lightning Sensor Mapper Wayne Wagnon (205)453-4623	Auburn University	NASA/MSFC	Wayne Wagnon Warren Harper (microwave) Tom Barnes (optical)	Design and development of a sensor system to detect and measure specific characteristics of lightning from a geostationary platform.
Research on Atmospheric Electricity R. R. Rojas	NRL	NRL	R. V. Anderson J. C. Willett	Provide new and improved capability to the Navy in its military functions of predicting and/or modifying atmospheric conditions which produce electrical hazards, severe weather, fog and CAT.
Aviation Meteorology Research - Severe Storms A. W. Hall (804)827-3274 RTOP #505-08-13	NASA	NASA/LaRC	Norman L. Crabill (804)827-3274	For objectives see Storm Hazards.
Knowledge of Atmosphere-Advanced Measurement Techniques L. Parker, WFC	NASA/KSC	Virginia Polytechnic Institute and State University University of Dayton, Ohio NASA/WFC	For investigators and objectives see Storm Hazards.	

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research D. W. Camp (205)453-2087 RTOP #505-08-19	NASA/MSFC	Space Sciences Laboratory, Fluid Dynamics Branch, NASA/MSFC	For investigators and objectives see Turbulence.	
Aviation Safety Technology-Flight Safety A. W. Hall (804)827-3274 RTOP #505-08-23	NASA	NASA/LaRC	R. E. Dunham, Jr. (804)827-3274	For objectives see Turbulence.

V. VISIBILITY

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Evaluation of Visibility Systems for CAT IIIB John Simeroth, ARD-432 (202)426-8454 Project #151-462-03	DOT/FAA	Humboldt County Arcata, CA	Jim Wilkerson	Test dual baseline RVR system for the measurement of RVR to 150 ft, the minimum of CAT IIIB.
Portable Visioceilometer Jagir S. Randhawa	US Army/DARCOM	US Army/ERADCOM	Robert S. Bonner William J. Lentz	Develop a hand portable lidar with a capability to measure visibility or cloud height. Length of Sample Volume for visibility = 1 km max. Maximum cloud height measurement = 3 km.
Meteorological Processes M. Schefer	Naval Air Systems Command	NRL	W. A. Hoppel J. W. Fitzgerald S. G. Gathmon	Provide new and improved capabilities to predict and modify fog and rainfall, achieve a better understanding of cloud and fog dynamics, glaciation, condensation nuclei and electrification and their role in clouds and marine fog.
Automated Weather Observation Systems Jack Dorman (202)426-8427 Project #III 153-451-06	DOT/FAA	NWS/Systems Development Office, Equipment Development Laboratory	James A. Cunningham	For objectives see Advanced Instruments.
Automated Low-Cost Weather Observing System (ALWOS) Richard R. Reynolds (301)427-7815 Project #RD590714	DOT/FAA	"	Richard R. Reynolds	For objectives see Advanced Instruments.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Terminal Weather Prediction Robert G. Miller (301)427-7768 Project #8D5905	DOC/NOAA	NWS/Systems Development Office/TDL	Robert G. Miller Karl F. Hebenstreit David J. Vercelli	For objectives see Forecasting.
Knowledge of Atmosphere - Advanced Measurement Techniques L. Parker, WFC	NASA/KSC	Virginia Polytechnic Institute and State University University of Dayton, Ohio NASA/WFC	For investigators and objectives see Storm Hazards.	
Aviation Meteorology Research D. W. Camp (205)453-2087 RTOP #505-08-19	NASA/MSFC	Space Sciences Laboratory, Fluid Dynamics Branch, NASA/MSFC	For investigators and objectives see Turbulence.	
Aviation Safety Technology-Flight Safety A. W. Hall (804)827-3274 RTOP #505-08-23	NASA	NASA/LaRC	R. E. Dunham, Jr. (804)827-3274	For objectives see Turbulence.

VI. LOW LEVEL WIND SHEAR

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Wind Shear Data Management Guice Tinsley (202)426-9350 Project #154-451-120	DOT/FAA	NAFEC	R. Craig Goff	To implement and maintain a wind shear data base using available computer facilities. Accept meteorological data on magnetic tapes and in written form from multi-sources, process these data and derive correlations linking recognized meteorological events and synoptic features with the occurrence of significant wind shears. Develop procedures for the dissemination of base data or processed data to technical users upon request.
Airport Low Level Wind Shear Alert System (LLWAS) Field Test Program Guice Tinsley (202)426-9350 Project #154-451-160	DOT/FAA	NAFEC	R. Craig Goff	To determine, via a field test program at seven airports, the suitability of a prototype anemometer sensor system for the reporting of representative airport surface wind that would include detection of hazardous horizontal wind shear during thunderstorm and strong cold front conditions.
Evaluation of the Pulsed Doppler Wind Shear Sensing System at Dulles International Airport Guice Tinsley (202)426-9350 Project #154-451-130	DOT/FAA	NAFEC	Peter V. Versage Augusto M. Ferrara Final Report No. FAA-RD-78-158	Evaluation of a pulsed acoustic Doppler wind shear sensing system to determine if the system could accurately and continuously sense windspeed and wind direction at 30-meter intervals between a range of 30 and 510 meters above ground level.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Thunderstorm Gust Front Detection System Evaluation Guice Tinsley (202)426-9350 Project #154-451-250	DOT/FAA	NAFEC	Augusto M. Ferrara	To establish methodology and evaluate the feasibility of combining sensors of the Gust Front Warning System (pressure Jump) and the Low-Level Wind Shear Alert System (anemometers) to provide pilots additional warning time when significant wind shear is present in the airport terminal area.
Wind Shear/Pulse Doppler Radar Effort R. G. Strauch 499-1000 x6385 FTS 323-6385	FAA (ARD-243) DOT-FA76WAI-622 I. D. Goldman	NOAA/WPL/ERL	R. G. Strauch	Demonstrate wind shear warning capability of FAA ATC radar (ASR-8) equipped with suitable antenna and data processing.
Low Level Wind Shear: Aviation Safety Technology In-flight Detection and Prediction of Low Level Wind Shear P. M. Kuhn	NASA NOAA	NASA NOAA	P. M. Kuhn L. P. Stearns F. Caracena	To improve aviation safety by improving inboard detectors of upstream low level wind shear.
Aviation Safety Technology-Wind Shear Detection Loyd Parker		NASA/WFC	W. Brence, WFC R. Synder, WFC	Evaluation of state-of-the-art radar technology as means of wind shear detection on approach to landing.
FM-CW Doppler Radar Wind Shear Detector R. B. Chadwick	USAF/AFGL Hanscom AFB	NOAA/WPL/ERL	R. B. Chadwick	Develop clear-air radar capable of measuring wind shear under all-weather conditions.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Doppler Radar Projection Advanced Techniques	DOC/NOAA	NOAA/NSSL	R. J. Doviak D. S. Zrnic	For objectives see Advanced Instruments.
Aviation Meteorology Research - Severe Storms A. W. Hall (804)827-3274 RTOP #505-08-13	NASA	NASA/LaRC	Norman L. Crabill (804)827-3274	For objectives see Storm Hazards.
Knowledge of Atmosphere - Advanced Measurement Techniques L. Parker, WFC	NASA/KSC	Virginia Polytechnic Institute and State University University of Dayton, Ohio NASA/WFC	For investigators and objectives see Storm Hazards.	
Aviation Meteorology Research D. W. Camp (205)453-2087 RTOP #505-08-19	NASA/MSFC	Space Sciences Laboratory, Fluid Dynamics Branch, NASA/MSFC	For investigators and objectives see Turbulence.	
Aviation Safety Technology-Flight Safety A. W. Hall (804)827-3274 RTOP #505-08-23	NASA	NASA/LaRC	R. E. Dunham, Jr. (804)827-3274	For objectives see Turbulence.

VII. STORM HAZARDS/SEVERE STORMS

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research - Severe Storms A. W. Hall (804)827-3274 RTOP #505-08-13	NASA	NASA/LaRC	Norman L. Crabill (804)827-3274	A technology base will be developed to improve the knowledge and understanding of atmospheric processes as they affect the design and safe and efficient operation of aircraft and aircraft systems. This will be accomplished by experimental and analytical programs aimed at providing an understanding of the predictability and the detectability and avoidance of hazards of severe storms to aircraft operations. These hazards include wind shear, turbulence, lightning, precipitation, and icing. Protection against direct lightning strikes will be studied.
Knowledge of Atmosphere - Advanced Measurement Techniques L. C. Parker, WFC	NASA/KSC	Virginia Polytechnic Institute and State University	H. W. Tielemen, VPI&SU F. J. Schmidlin, WFC	Measurement and definition of the characteristics of an internal boundary layer which develops during southeasterly wind conditions at the NASA/WFC facility.
		University of Dayton,	J. K. Luers, U.D. W. E. Melson, Jr., WFC	Study of the effects of heavy rain on aircraft aerodynamics.
		NASA/WFC	W. D. Gunter J. H. Scott	Evaluation of digitized TV as prevailing visibility sensor.
			J. F. Andrews, WFC	Analysis of wind shear profiles from existing data files 1961 to present.
			W. D. Gunter, WFC D. LeVine, GSFC N. L. Crabill, LaRC	Lightning measurements and correlation with severe storm events using LDAR System.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Automatic Weather Observing System (AV-AWOS) James A. Cunningham (301)427-7809 Project #RD590713	DOT/FAA	NWS/Systems Development Office, Equipment Development Laboratory	James A. Cunningham	For objectives see Advanced Instruments.
Doppler Weather Radar Program (NEX RAD) John W. Hinkleman (202)426-8427 Project #152-462-05	DOT/FAA	NOAA/ERL/NSSL	K. Wilk J. Lee D. Zrnic	For objectives see Forecasting.
Severe Weather Tracking and Prediction John W. Hinkleman (202)426-8427 Project #152-462-04	DOT/FAA	ERT	Robert Crane	For objectives see Forecasting.
Improved Aviation Weather Forecasting Frank Melewicz (202)426-8427 Project #152-461-01	DOT/FAA	NWS/TDL	M. Alaka R. Elvander R. Saffle	For objectives see Forecasting.
Thunderstorm Forecasting for Aviation Mikhail A. Alaka (301)427-7792 Project #RD5901	DOT/FAA	NWS/Sytems Development Office/TDL	Mikhail A. Alaka Robert C. Elvander Robert E. Saffle	For objectives see Forecasting.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Severe Local Storms Prediction Mikhail A. Alaka (301)427-7772 Project #8C3781	DOC/NOAA	NWS/Systems Development Office/TDL	For investigators and objectives see Forecasting.	
Lightning Detection System F. Sakate (202)426-6593 Eric Mandel (202)426-8427	DOT/FAA	Atlantic Scientific Corp.	Rodney Bent	For objectives see Lightning.
Research on Atmospheric Electricity R. R. Rojas	NRL	NRL	R. V. Anderson J. C. Willett	For objectives see Lightning.
Aviation Meteorology Research D. W. Camp (205)453-2087 RTOP #505-08-19	NASA/MSFC	Space Sciences Laboratory, Fluid Dynamics Branch, NASA/MSFC	For investigators and objectives see Turbulence.	
Aviation Safety Technology-Flight Safety A. W. Hall (804)827-3274 RTOP #505-08-23	NASA	NASA/LaRC	R. E. Dunham, Jr. (804)827-3274	For objectives see Turbulence.

VIII. TURBULENCE

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Correlation of Reflectivity and Gusts Measured by Probing Aircraft J. Muncy (202)426-8427 Project #152-462-06	DOT/FAA	NOAA/NSSL	Jean T. Lee	Establish relationship between radar reflectivity and aircraft measured turbulence.
Measurement of Atmospheric Turbulence (MAT Project) H. N. Murrow (804)827-3527 RTOP #517-53-13	NASA	Structures and Dynamics Division, Flight Loads Office, NASA/LaRC	Richard H. Rhyne Richard E. Davis Wm. Mark Bolt, Beranek and Newman Cambridge, MA Geo. Trevino Del Mar College Corpus, Christi, TX	Measurement of CAT in various meteorological conditions with emphasis on accurate power spectral estimates at long wavelengths sufficient to identify appropriate value of L, the integral scale value. Altitudes covered are sea level to 65,000 ft. Derive appropriate model to handle nonstationary aspects and study effects on aircraft response.
Aviation Safety Technology-Flight Safety A. W. Hall (804)827-3274 RTOP #505-08-23	NASA	NASA/LaRC	R. E. Dunham, Jr. (804)827-3274	A technology base will be developed which can be used to reduce the number of aviation accident opportunities and to minimize the fatalities and damage resulting from accidents. This will be accomplished by programs aimed at providing a data base for continued knowledge of the usage of various types of general aviation and transport aircraft relative to their original design criteria. Research on equipment and systems will be undertaken to improve the accuracy and reliability of operational information relative to visibility and meteorological phenomena. Research will also be conducted to provide improved protection of the aircraft and its systems from hazards such as lightning, turbulence and wind shear.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Wake Vortex Minimization A. W. Hall (804)827-3274 RTOP #514-52-03	NASA	NASA/LaRC	R. E. Dunham, Jr. (804)827-3274	The objective of this effort is to reduce the hazard potential of wake vortices shed by transport aircraft through aerodynamic means without significant detrimental effects on aircraft performance. This objective will be met by developing experimental techniques and theoretical numerical methods to enhance the understanding of the fundamental flow mechanisms associated with the generation of multiple vortex wakes, their interaction, and turbulence decay. A detailed understanding of the relationship of aircraft span-load distribution and turbulence effects will be obtained.
Clear Air Turbulence: Aviation Safety Technology; In-flight Detection and Prediction of Clear-Air-Turbulence. P. M. Kuhn, NOAA/APCL	NASA NOAA	NASA NOAA	P. M. Kuhn L. P. Stearns	To improve aviation safety by providing inboard detectors of upstream CAT.
Knowledge of High Altitude Atmospheric Processes T. R. Sisk (805)258-3311 x379 L. J. Ehernberger (805)258-3311 x154 RTOP #505-08-14	NASA/OAST	NASA/DFRC	UCLA NOAA/NCC SRI International	The areas studied include the measurement of high altitude turbulence, the definition of associated atmospheric structure and icing meteorology. Specific tasks include: 1) The improvement of flight test procedures, 2) Development of objective mesoscale upper-air analysis techniques, 3) Climatology of maximum wind shears and temperature gradients, and 4) Numerical simulation of gravity wave motion associated with turbulence.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research D. W. Camp (205)453-2087 RTOP #505-08-19	NASA/MSFC	Space Sciences Laboratory, Fluid Dynamics Branch, NASA MSFC	Space Sciences Laboratory, MSFC Margaret B. Alexander Dennis W. Camp George H. Fichtl Charles Schafer Otha H. Vaughan University of Tennessee Space Institute, Tullahoma, TN Walter Frost Ronald Kohl C. F. Shieh Barry Turkel S. T. Wang University of Dayton Research Institute, Dayton, OH Mark Dietenberger John Keller Prem Kumar James K. Luers University of Oklahoma, Norman, OK Edward Blick John McCarthy University of Alabama, Huntsville, Huntsville, AL R. J. Hung	To define, investigate and model those atmospheric conditions adverse to aircraft operations and possibly conducive to aircraft mishaps. To conduct research relative to development of techniques, procedures and the need for new and/or improved meteorological instrumentation whereby acquired knowledge of the natural environment can be better utilized for safe operation of aeronautical systems. The approach will be to continue to: 1) Measure and anlayze atmospheric data, 2) Develop models of atmospheric boundary layer properties and the conditions which lead to or intensify them, 3) Perform analytical, laboratory and field tests relative to investigation of warm fog, and 4) Develop and/or modify instrumentation as needed to meet the requirements of this approach. Individual tasks will be: 1) Correlation of lateral and longitudinal gusts and their effects on aeronautical systems and conducting an aviation meteorology workshop. 2) Atmospheric dynamics process definition as related to aeronautical system operations. 3) Warm fog investigative studies relative to life cycle, modification and dispersion. 4) Investigation into buildup and dissipation of frost on the surface of an aircraft and conducting a field test program of frost effects on aeronautical systems. 5) Development of new or improved instrumentation for safer operation of aeronautical systems. 6) Identify and

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research (D. W. Camp) (continued)			FWG Associates, Inc. Tullahoma, TN Larry Christensen Sidney Steely Walter Frost Arizona State University Jungfo Chang Earl Logan	develop the necessary natural environment technology to understand and specify the physical processes that produce charge flow and separation in the atmosphere in such a way that determinations can be made of causal relationships between electrical activity and measurable physical atmospheric parameters.
Categorization of Atmospheric Turbulence in Terms of Aircraft Response for Use in Turbulence Reports and Forecasts E. W. Turner	USAF/AWS	USAF/AFFDL	Lt Jackie C. Sims (513)255-6626	To relate the effects of atmospheric turbulence on one aircraft to other types of aircraft based on the "Gusts Loads Formula."
Aviation Operations Safety Technology - Lidar Applications E. A. Weaver (205)453-1597 FTS 872-1597	NASA	Optics Branch, Electronics Control Laboratory, NASA/MSFC	For investigators and objectives see Advanced Instruments.	
Electro-Optics Meteorology R. J. Richter	Naval Ocean Systems Center	NRL	H. E. Gerber	For objectives see Advanced Instruments.
Doppler Radar Project in Advanced Techniques	DOC/NOAA	NOAA/NSSL	R. J. Doviak D. S. Zrnic	For objectives see Advanced Instruments.
Research on Atmospheric Electricity R. R. Rojas	NRL	NRL	R. V. Anderson J. C. Willett	For objectives see Lightning.

PROJECT TITLE AND MANAGER	SUPPORTING ORGANIZATION	PERFORMING ORGANIZATION	INVESTIGATOR(S)	OBJECTIVES
Aviation Meteorology Research - Severe Storms A. W. Hall (804)827-3274 RTOP #505-08-13	NASA	NASA/LaRC	Norman L. Crabill (804)827-3274	For objectives see Storm Hazards.

APPENDIX B

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BIBLIOGRAPHY

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APPENDIX C

LIST OF ACRONYMS

LIST OF ACRONYMS

ACRREL	ARMY COLD REGIONS RESEARCH AND ENGINEERING LAB
AFFDL	AIR FORCE FLIGHT DYNAMICS LAB
AFFTC	AIR FORCE FLIGHT TEST CENTER
AFGL	AIR FORCE GEOPHYSICS LAB
AFOS	AUTOMATION OF FIELD OBSERVATIONS AND SERVICES
AGARD	ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT
AGL	ABOVE GROUND LEVEL
AIAA	AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS
ALWOS	AUTOMATED LOW-COST WEATHER OBSERVING SYSTEM
AMS	AMERICAN METEOROLOGICAL SOCIETY
ARF	AUTOMATED ROUTE FORECAST
ATC	AIR TRAFFIC CONTROL
ATIS	AUTOMATIC TERMINAL INFORMATION SERVICE
AV-AWOS	AVIATION AUTOMATED WEATHER OBSERVING SYSTEM
AWS	AIR WEATHER SERVICE
CAT	CLEAR AIR TURBULENCE
CRREL	COLD REGIONS RESEARCH AND ENGINEERING LAB
CTOL	CONVENTIONAL TAKE-OFF AND LANDING AIRCRAFT
CW	CONTINUOUS WAVE
DARCOM	DEVELOPMENT AND READINESS COMMAND
DRFC	DRYDEN FLIGHT RESEARCH CENTER
DOC	DEPARTMENT OF COMMERCE
DOT	DEPARTMENT OF TRANSPORTATION
ERADCOM	ELECTRONICS RESEARCH AND DEVELOPMENT COMMAND
ERL	ENVIRONMENTAL RESEARCH LAB

ERT	ENVIRONMENTAL RESEARCH TECHNOLOGY
FAA	FEDERAL AVIATION ADMINISTRATION
FT	TERMINAL FORECAST
HF	HIGH FREQUENCY
HISS	HELICOPTER ICING SPRAY SYSTEM
IEE	INSTITUTION OF ELECTRICAL ENGINEERS
IEEE	INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS
INS	INERTIAL NAVIGATION SYSTEM
IRLAWS	INFRARED LOW ALTITUDE WIND SHEAR
ISLD	ICING SEVERITY LEVEL DISPLAYS
LaRC	LANGLEY RESEARCH CENTER
LeRC	LEWIS RESEARCH CENTER
LLWS	LOW LEVEL WIND SHEAR
LLWSAS	LOW LEVEL WIND SHEAR ALERT SYSTEM
LTC	LIEUTENANT COLONEL
MAT	MEASUREMENT OF ATMOSPHERIC TURBULENCE
MSFC	MARSHALL SPACE FLIGHT CENTER
NAFEC	NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
NASA	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NCC	NATIONAL CLIMATIC CENTER
NOAA	NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NRL	NAVAL RESEARCH LAB
NSSL	NATIONAL SEVERE STORMS LAB
NWS	NATIONAL WEATHER SERVICE
OAST	OFFICE OF AVIATION SAFETY TECHNOLOGY
PIREPS	PILOT REPORTS
PROFS	PROTOTYPE REGIONAL OBSERVATION AND FORECASTING SERVICE

RVR	RUNWAY VISUAL RANGE
SAO	SURFACE AVIATION OBSERVATION
SRI	STANFORD RESEARCH INSTITUTE
SVR	SLANT VISUAL RANGE
TDL	TECHNIQUES DEVELOPMENT LAB
UCLA	UNIVERSITY OF CALIFORNIA AT LOS ANGELES
US	UNITED STATES
USAF	UNITED STATES AIR FORCE
VHF	VERY HIGH FREQUENCY
VOR	VHF OMNI-DIRECTIONAL RANGE
WAVE	WIND, ALTIMETER, VOICE EQUIPMENT
WFC	WALLOPS FLIGHT CENTER
WMO	WORLD METEOROLOGICAL ORGANIZATION
WPL	WAVE PROPAGATION LAB

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
NASA CR-3214		

4. TITLE AND SUBTITLE	5. REPORT DATE
1979 Current Research on Aviation Weather (Bibliography)	January 1980
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Barry S. Turkel and Walter Frost	8. PERFORMING ORGANIZATION REPORT #
9. PERFORMING ORGANIZATION NAME AND ADDRESS The University of Tennessee Space Institute Tullahoma, Tennessee	10. WORK UNIT NO. M-292
	11. CONTRACT OR GRANT NO. NAS8-32692
	13. TYPE OF REPORT & PERIOD COVERED Contractor
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, DC 20546	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Prepared under the technical monitorship of the Atmospheric Sciences Division Space Sciences Laboratory, NASA/Marshall Space Flight Center, Alabama.

16. ABSTRACT

The purpose of this study was to assemble an updated, readily usable reference of basic and applied research programs related to a wide range of areas of aviation meteorology. Major government agencies involved in aviation meteorology and related research areas have provided a list of current research project titles and managers, supporting organizations, performing organizations, investigators and objectives of the research. These are tabulated and cross-referenced under the titles of: Advanced Meteorological Instruments, Forecasting, Icing, Lightning, Visibility, Low Level Wind Shear, Storm Hazards/Severe Storms and Turbulence. Additionally, a literature search was conducted which surveyed the major abstract publications such as the International Aerospace Abstracts, the Meteorological and Geoastrophysical Abstracts, and the Scientific and Technical Aerospace Reports. For ease of reading these are summarized under headings similar to the tabulated research. NASA and DOT computer literature searches were run and are also summarized. Finally, a list of pertinent reference material produced through the above tabulated research activities is given.

The acquired information assembled in bibliography form provides a readily available source of information in the area of aviation meteorology.

17. KEY WORDS		18. DISTRIBUTION STATEMENT
Aviation Safety	Wind Shear	Category 47
Aviation Weather	Severe Storms	
Fog	Turbulence	
Icing	Training	
Lightning		
Visibility		

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	91	$6.00

*For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA-Langley, 1980