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National Aviation Facilities Experimental Center
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FINAL REPORT

Prepared for

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
National Aviation Facilities Experimental Center
Atlantic City, New Jersey 08405

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The National Aviation Facilities Experimental Center maintains laboratories, facilities, skills and services to support FAA research, development and implementation programs through analysis, experimentation and evaluation of aviation concepts, procedures, systems and equipment.

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16. Abstract

This report is an index of all technical reports which were assigned NA numbers and published by NAFEC during the period 1967 through 1971. Entries are arranged by NA number and include titles, authors and full abstracts. Separate sections contain indexes by subject, author, RD number, DS number, project number, and contract number.

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INTRODUCTION

The practice of assigning NA numbers to technical reports published by the National Aviation Facilities Experimental Center was begun during the autumn of 1967. This index includes all such reports which were issued from that time through 1971. Because assigned numbers are sometimes changed or discarded during the reports preparation process, missing numbers are not indicative of missing reports. All published reports are listed.

The arrangement in this listing is by the NA number. Each entry includes the title, author, date, number of pages, and a full abstract. Where appropriate, other bibliographic information is also included such as Aircraft Development Service (DS) and Systems Research and Development Service (RD) numbers, and AD numbers. The AD number indicates that the report is available from the National Technical Information Service, Springfield, Virginia 22151. Reports in the NTIS collection are available indefinitely. Prices are set by NTIS and are subject to change.

There are a few reports listed without AD numbers. Application for copies of these should be made to the Director of the FAA service which sponsored the report.

FAA personnel will find copies of NAFEC reports in the libraries in Regions, Centers, and The Departmental Library in Washington.

The indexes at the end of this report provide access to the abstracts by subject, author, RD, DS, NS, Project and Contract numbers. The subject headings, with some exceptions, were taken from the FAA Thesaurus of Descriptors, 3rd edition.

NA-67-1
AN ANALYSIS OF THE HELICOPTER HEIGHT VEOLCITY DIAGRAM INCLUDING A PRACTICAL METHOD FOR ITS DETERMINATION, by W. J. Hanley and G. DeVore, Feb. 1968. 34p. (DS-67-23) (AD 669 481).

A composite summary analysis was made of the height-velocity (H-V) diagram test data obtained from the flight testing of three single engine, single rotor helicopters of varying design characteristics and basic parameters. The purpose of this analysis was to ascertain if a practical method for the determination of the H-V diagram could be evolved, as well as a means to determine the effects of aircraft weight and altitude on the H-V diagram. Analysis disclosed that H-V diagrams can be developed for any conventional single rotor helicopter by the flight test determination of a singular maximum performance critical speed (V_{cr}) point in conjunction with the use of a nondimensional curve and the solution of specific key point ratios which are set forth in the report. An evaluation of the H-V diagram key point relationships is presented followed by a discussion of the observed factors affecting autorotative landing following power failure. A suggested step by step procedure for deriving average pilot H-V diagrams is also presented.

NA-67-10
WEATHER EFFECTS ON VORTAC FACILITIES VOR MONITOR DETECTOR TESTS, by J. A. Muller. Final report, Dec. 1967. 32p. (RD-66-86) (AD 664 491).

On this phase of the project the effects of various ice and/or snow conditions on four different monitor detectors, with five different detector covers, were investigated to determine action to be taken in the field to eliminate or reduce VOR outages. Tests were conducted at the NAFEC Experimental VORTAC and the NAFEC Environmental Laboratory. Field and laboratory tests results indicated action to be taken in the field as follows:

1. All adjustable antenna end-loading discs should be set at 2 inches from the ends of the standard cover.

2. If outages still persist after implementation of recommendation #1, or if insufficient signal is provided to the monitor, then the standard cover should be replaced with one 24 inches in length. This extended cover must also be provided with a bottom cover.

3. The VOR Antenna Shelter Type-3 should be provided with a counterpoise mounting base and installed at VOR sites that report the 24-inch cover is not adequate due to extreme weather conditions.

NA-67-13
EVALUATION OF ECONOMICAL VISUAL APPROACH INDICATORS, by D. M. Brandewie. Final report, Dec. 1967. 18p. (RD-67-50) (AD 664 246).

An evaluation was conducted to determine the feasibility of a variety of "low-cost" visual approach slope techniques intended to aid pilots in establishing a suitable glide path prior to landing. The techniques included three-color and two-color types. Assessing the suitability of the hardware was not essential to the evaluation. Emphasis was placed on determining photometric characteristics, effects of humidity and temperature upon beam structure, and usefulness as seen in flight. They were compared in flight tests to a two-box "abbreviated" version of the U. S. Standard twelve-box Visual Approach Slope Indicator (VASI). Except for the two-box VASI, (1) all could produce misleading and possibly hazardous information when condensation or ice formed on the glass face-plates, and (2) none had a useful daytime range. Due to lact of boldness of presentation, all the three-color units were difficult to distinguish from runway edge and obstruction lighting.

It was recommended that (1) tri-color techniques not be approved for operational use, (2) any technique which produces a false signal be excluded from the national airspace system, (3) investigations be continued to reduce cost of the Standard and Abbreviated VASI's and (4) criteria be adopted for Abbreviated VASI's.

NA-67-16
RLT/FM BROADCAST INTERFERENCE STUDY, by D. L. Fehr and H. E. Scozzafava. Final report, Dec. 1967. 12p. (RD-67-44) (AD 665 028).

Interference signal ratios were measured by laboratory tests to determine: (1) the level of VOR test signal at 108.0 MHz that could be tolerated in various FM broadcast receivers without audible interference, and (2) the level of FM broadcast signal at 107.7 and 107.9 MHz that could be tolerated in various VOR airborne receivers without causing an indicated course shift greater than $\pm$0.5 degree or a change in course sensitivity greater than 10 percent. The degree of interference was sufficient to recommend that the data be used to establish geographical separation criteria be-between Radio-navigation Land Test (RLT) stations and FM broadcast stations for frequency assignments.

NA-68-1
TEST AND EVALUATION OF VHF/UHF ANTENNAS, by J. G. Dong. Final report, Nov. 1968. 80p. (RD-67-60) (AD 681 023).

This report presents results of tests performed at the National Aviation Facilities Experimental Center (NAFEC) to obtain standard reference antenna patterns for existing Federal Aviation Administration (FAA) and selected prototype VHF and UHF air-ground communication antennas, and associated investigations to determine the effects of antenna configuration, siting, polarization, mutual coupling, and antenna deicing. Because the transmission line is a primary auxiliary to an antenna system, characteristics

of foam dielectric cable were investigated for use in field facilities. Results of the test effort provided standard reference patterns for the antennas investigated. In addition, it was determined that the siting environment was the predominant influence on antenna radiation patterns; dissimilar circular polarized antennas could be vertically stacked to provide the needed decoupling where space limitation was a constraint; antenna heaters were feasible for deicing antenna; and foam dielectric cable reduced transmission line losses. It was recommended that dissimilar polarized antennas, heated antennas (where applicable), and foam dielectric cable be used at field facilities.

NA-68-2
EVALUATION OF AUTOMATED TRACON FUNCTIONS, by D. O. Brown, D. W. Connolly, and J. J. Maurer. Final report, April 1968. 74p. (RD-67-61)

A dynamic simulation study was conducted to evaluate the relative merits of various functional levels of automation as applied to a terminal area radar facility. Data were collected on various system performance and controller workload measures in a simulated present-day environment and compared with data collected when building block packages of functional levels of automated capability were incorporated. System performance measures (i.e., Operations Rates, Time in System, and Delays) for the most part indicated that the Modular Packages were neither better nor worse than the present-day Manual System, nor, based on those measures, was there any distinction between the Modular Packages. However, certain controller workload measures favorably distinguished the package containing Radar Beacon Numeric Decoding (TRACON A) over the Manual System, and further discrimination was noted in favor of the Modular Packages which contained Radar Beacon Alpha Numeric Decoding (TRACON's B, C, and D). It was also found that efficient data entry devices were critical in the use of automated functions. It was recommended that further testing of the automated TRACON functions be done using a high density terminal area and an improved ATC Simulation Laboratory. It was also recommended that Radar Beacon Alpha Numeric Decoding be favorably considered over Radar Beacon Numeric Decoding and that a high degree of importance be given to the study and development of an efficient data entry system.

NA-68-4
REDUCTION OF STALL/SPIN ACCIDENTS RELATED TO TAKE-OFF, DEPARTURE AND LANDING, by J. Grambart, Interim report, Feb. 1968. 20p.

Despite the use of stall warners, stalls and spins cause more fatalities and serious injuries than any other type of General Aviation accident except inadvertent VFR flight into IFR weather. One probable cause is inability of a weak stall warning signal to penetrate pilot fixation on outside visual cues during critical flight phases. A major weakness of stall warning systems is the use of the comparatively inefficient continuous signal. Angle of attack sensors and various alternative signals are discussed, and a method of evaluating signal effectiveness is detailed.

NA-68-6
INVESTIGATION OF TURBOPROP ENGINE CHARACTERISTICS DURING BIRD INGESTION, by D. M. Millar. Final report, April 1968. 23p. (DS-68-4) (AD 668 834).

Tests were conducted to determine specific reactions to the ingestion of small birds by a free turbine turboprop engine. Transient and steady-state engine performance was monitored and recorded during and following ingestion sequences. In general, a deterioration in engine performance was indicated upon ingestion of birds or portions thereof. Subsequent engine recovery and stabilization to operating levels below preingestion values were attained in periods from 2 to 4 seconds. Operating levels were reduced as much as 50 percent and were in general a function of the quantity of starlings which entered the inlet duct. Following multiple bird ingestion tests, the degree of inlet blockage prevented preingestion power levels from being attained. No evidence of engine flameout was recorded during any of the 16 test runs conducted, nor was any autofeathering signal indicated. There was no visible damage sustained by the engine which could be attributed to bird impact.

NA-68-7
UNDERWATER LOCATOR BEACON DETECTION RANGES FOR FUSELAGE ENCAPSULATED RECORDERS, by R. B. Fisher and P. M. Rich. Final report, July 1968. 22p. (DS-68-9) (AD 672 545).

An acoustic locator beacon was developed and tested in an underwater environment simulating the conditions that might exist when an aircraft crashed into water. The beacons were self-contained, battery powered, and produced a 10 to 20 millisecond pulse of 35-40 kilohertz at a rate of 1 to 4 pulses per second. The locator beacons were designed to be attached to airborne flight data recorders to assist in investigations following a crash. The crash environmental tests were conducted using a section of an aircraft fuselage that still contained the cabin pressure bulkhead. The beacons tested were placed in two different representative locations; (1) inside the cabin pressure area and (2) aft of the pressure bulkhead in the unpressurized area. The fuselage section was lowered into sea water at depths of 50, 100, and 200 feet, off the coast of the Florida Keys. Search runs were made using a motor powered craft equipped with an acoustic locator receiver. The results indicate that the signals of a fuselage encapsulated locator beacon can be detected at reasonable surface distances (up to 3000 yards) and at depths as low as 200 feet.

NA-68-8
INVESTIGATION AND EVALUATION OF ASR/ARSR PERFORMANCE MONITOR, by W. F. Herget and D. L. Offi, April 1968. 10p. (RD-68-24) (AD 670 595).

An FA-5170 Radar Performance Analyzer was investigated to determine causes for poor field operation and its suitability as a basis for development of a new ASR/ARSR Radar Performance Monitor.

Some of the circuitry and techniques employed in the Radar Performance Analyzer are satisfactory, while others are inadequate or require redesign. It was recommended that a proposed model, as described in this report, form the basis for a new Performance Monitor.

NA-68-9
AN EVALUATION OF AN ALL-WEATHER LANDING PANEL DISPLAY, by R. H. Pursel. Final report, Aug. 1968. 43p. (RD-68-21) (AD 673 261).

A flight test evaluation of an instrument panel display for monitoring automatic landings was performed at the National Aviation Facilities Experimental Center (NAFEC). A Federal Aviation Administration DC-7 aircraft equipped with a single-channel Automatic Landing System was utilized. Over 700 automatic approaches were conducted under simulated Category III conditions. Intentional ILS path deviations or sensor failures were inserted on many of these approaches. The results of this test program have been very beneficial in that solutions to problems encountered with the particular equipments have led to improved instrument layout and design. Valuable inputs also have been provided to all-weather landing system developments now in the test and evaluation stage.

NA-68-10
AN EXPLORATORY TEST OF DATA TRANSFER BY VHF TO AIRCRAFT OVER THE OCEAN IN A TROPOSPHERIC PROPAGATION ENVIRONMENT, by J. J. Scavullo. Interim report, June 1968. 46p. (RD-68-27) (AD 671 057).

Two very high frequency (VHF) troposcatter antennas, each with 16 colinear dipoles in a vertical array, were installed about 80 wavelengths apart at a site near the coast at Avalon, New Jersey. These antennas had flat, broad, high-gain radiation patterns directed in parallel toward the horizon. Exploratory tests were conducted while transmitting test signals, in a controlled sequence, between the site and a project aircraft operating over the ocean. In the sequence of test signals, a period of no modulation was followed by a calibrated audio tone, teletype messages and voice messages. Each sequence was repeated so that performance during phase modulation of the VHF transmitter could be compared with performance during amplitude modulation. The test site, test experience, and data are described as guidance for further experimentation in the same environment.

The majority of the comparative data was collected during shuttle maneuvers by the aircraft across the down-range threshold of reception. Communication distances, often two- to three-hundred miles beyond the radio horizon, were about the same regardless of modulation mode. The test indicated that simple substitution of low-speed data modulation for voice modulation, or of phase modulation for amplitude modulation, would not produce a substantial change of performance in a system designed for voice communications. The report recommends a test to determine probable operational coverage of these troposcatter antennas.

NA-68-12
TESTING MONSANTO CHEMICAL DE-ICER ID-1352B, by C. B. Phillips, Interim report, Mar. 1968. 11p. (RD-67-19) (AD 835 129).

Tests were performed with a recently developed de-icer mixture to determine what advantages, if any, it might have over other de-icers previously investigated. This de-icer mixture is designated as Monsanto ID-1352B. The United States Air Force contracted with the Royal Canadian Air Force to perform the tests at the Canadian Forces Base at Rockcliffe. These tests were conducted during the winter of 1965 and 1966. The results of this investigation indicated that urea as a de-icer is superior to Monsanto ID-1352B.

NA-68-13
FLIGHT SIMULATION STUDY OF AIR-TO-AIR RANGING DISPLAYS FOR SEPARATION ASSURANCE, by R. M. Spangler and R. L. Sulzer. Feb. 1968. 20p. (RD-66-83) (AD 666 620).

Three flight simulation tests have assessed the operational value for separation assurance of cockpit display of: (a) warning that another aircraft has intruded within 60 miles, plus constant display of intruder range; (b) the same warning and present range, plus pilot-to-pilot communications; and (c) the warning and present range, plus relative bearing of the intruder, without communications. All three added displays were adequate for overtaking intrusions with no one method very superior to the others. Head-on and beam intrusions produced less assurance. Potentially serious errors of interpretation occurred with all three displays in high closure rate head-ons.

NA-68-14
SIMULATION AND ANALYSIS OF OVER-OCEAN SEPARATION ASSURANCE PROCEDURES AND DISPLAYS, by W. Crook and R. Sulzer. Final report, Feb. 1968. 72p. (RD-67-43) (AD 666 829).

After an analysis of operational characteristics in North Atlantic air traffic and the Air Traffic Control system, standard operating procedures (SOP) for pilot use of air-derived separation information were developed and tested in flight simulators. Three individual system types were simulated: Air-to-Air Distance Measuring Equipment (DME), Airborne Beacon Range/Altitude Monitor, and Airborne Time/Frequency Range/Altitude Monitor (T/F). The capabilities and limitations of each system display (in its initial form) and pilot preferences were determined through exercise in a wide diversity of aircraft intrusion situations. Horizontal and vertical evasive maneuvers, as required by the SOP, were employed in all the test runs which included slow and fast closing, as well as head-on encounters. Altitude probing before a vertical maneuver was tested. With immediate and assured communications, and with the tested SOP, the displays were all adequate to insure separation. Pilot preferences were for the simplest displays and controls.

Densities above three conflicting aircraft were not tested nor were reception problems due to multipath or other physical sources of signal error included. Flight tests of some of the equipment simulated will be described in a report expected to be available by April 1968.

NA-68-15
GRAPHIC SIMULATION STUDY OF SITES FOR A THIRD CHICAGO METROPOLITAN AIRPORT, by S. B. Rossiter, Final report, Aug. 1968. 66p. (RD-68-41) (AD 681 876).

A graphic simulation study was made of the Chicago terminal area to provide comparisons between two proposed sites for a third Chicago Metropolitan Airport. Terminal area air traffic control procedural plans were developed incorporating each new site. Through the use of a questionnaire, developed around factors that significantly affect an air traffic control subsystem, each site was evaluated by a panel of 12 Air Traffic Control Specialists. The results of this evaluation indicated that Site A was preferred over Site D. The predominant reasons for this choice were the lesser degree of interaction of arrival traffic in the final approach area to the three major airports and the availability of less restrictive airspace to support areas of independent operations. In addition, Site A would permit future expansion of both Site A and O'Hare airports with the least impact on the other.

NA-68-16
NIMBUS II VHF MULTIPATH INVESTIGATIONS, by T. H. Barton and F. W. Jefferson. Final report, May 1968. 38p. (RD-68-30) (AD 669 796).

The Federal Aviation Administration conducted an over ocean and limited over land flight test program to obtain data on performance degradation of VHF radio frequency satellite-to-aircraft communication links resulting primarily from multipath propagation fade effects. The Nimbus II satellite was used to provide a signal source for the measurements which were made in an instrumented aircraft equipped with a conventional VHF blade antenna and a special design circularly polarized satellite communications antenna. In addition to the acquisition of multipath data, the aircraft received a real time printout of Nimbus Automatic Picture Transmission System weather pictures. Data were obtained for varying satellite azimuth angles with the elevation angles ranging from near grazing to 90 degrees. The special airborne satcom antenna was used in both the low and high elevation angle operation modes with results indicating only minor fades of 1 dB or less in the high angle mode. For the low angle mode, below 40 degrees, the measurements showed that multipath propagation can be a significant source of satellite-to-aircraft link performance degradation. Results of the tests indicated that for 98 percent of the data samples fade degradation was less than 8 dB. The average fade depth measured was 4 dB and the maximum was 10 dB.

NA-68-17
CLEAR AIR TURBULENCE, A BIBLIOGRAPHY, 1950 - 1967, by D. E. Bulford, March 1968. 76p. (AD 667 731).

Clear air turbulence encounters can occur unexpectedly without any visual evidence or warning. As operations of higher altitude aircraft increase, the phenomenon is encountered more often. CLEAR AIR TURBULENCE is defined as "all turbulence in the free atmosphere of interest in aerospace operations that is not in or adjacent to visible convective activity (this includes turbulence found in cirrus clouds not in or adjacent to visible convective activity)." This bibliography consists of 578 references to technical reports, articles in periodicals, and books published during the past 17 years. References about other forms of turbulence such as that occurring with storms and airplane wake vortices are not included.

NA-68-19
LOW-COST RUNWAY GUIDANCE (VORLOC II), by F. W. Marschall. Final report, July 1968. 16p. (RD-68-31) (AD 672 197).

The Waddell Dynamics Corporation of San Diego, California, developed a simple low cost approach aid called VORLOC II. The Federal Aviation Administration (FAA) performed some limited flight tests on this equipment at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey. The results of the tests conducted indicate that the quality of the course line of VORLOC II is susceptible to its siting. The course line had an average 95% course path bend amplitude of 0.41° with extremes of 0.17° and 0.63°. The equipment did not provide clearance throughout 360°. The maximum range at 2,000 feet altitude varied from 12.5 miles to 17 miles depending on the course width. The vertical polarization for a 20° bank either way had an average value of 18 microamperes. The equipment had temperature instability. During a period of heavy rainfall, the course line shifted 50 microamperes in 5 hours.

NA-68-20
AN INVESTIGATION OF A TECHNIQUE FOR PREDICTING DEMAND AND SERVICE AT THE TERMINAL FACILITY, by G. D. Jolitz. Final report, Aug. 1968. 42p. (RD-68-44) (AD 673 667).

The concept of the flow control function as a part of the Air Traffic Control (ATC) system includes a requirement for information about the volume of air traffic demand on the ATC system relative to the system's capacity for servicing such a demand. Furthermore, the information is needed sufficiently far in future time to permit action to be taken when a serious imbalance is predicted. The demand prediction process described in this report was based on two related hypotheses: (a) air traffic demand on an airport is repetitive in nature such that historical operations data would be useful as a predictor; and (b) operations information known to the Air Traffic Control (ATC) system would be a

useful predictor. A computer program was developed which permitted joint use of the two predictors and, using sample data from a test case (Washington National) airport, the prediction model was evaluated. A companion program which was designed to provide service predictions took into account such environmental factors as weather and runway configuration. The criterion against which the model's prediction were tested was a count of actual operations. It was concluded that demand predictions were not highly correlated with the criterion and that errors in prediction appeared to be normally distributed and random with time. It was recommended that future efforts consider other predictors and/or prediction processes than those used in this experiment.

NA-68-21
VTOL AND STOL SIMULATION STUDY, by R. Conway. Final report, April 1968. 48p. (RD-67-68) (AD 670 006).

A simulation study to determine the effect on air traffic control when both Vertical and Short Takeoff and Landing aircraft are introduced into a terminal air traffic control environment was conducted at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey. The simulation was conducted using the Model B Dynamic Air Traffic Control Simulator. Several approach conditions, various glide slope angles, and separation criteria were investigated to determine the effect on a terminal environment. It was concluded that Vertical and Short Takeoff and Landing aircraft could be accommodated in the terminal area using present operational procedures as contained in the Terminal Air Traffic Control Manual 7110.8. However, when Vertical and Short Takeoff and Landing aircraft reduced from terminal area speed, difficulties were encountered in providing not only the desired spacing between these aircraft but between these aircraft and conventional aircraft in the sequence to and on the final approach course. These problems did not exist when Vertical and Short Takeoff and Landing aircraft used a final approach speed compatible with that of conventional aircraft. It was recommended that in the planning future Vertical and Short Takeoff and Landing aircraft ports consideration be given to the location and runway alignment in order that the traffic flow of this airport be compatible with that of other traffic in the terminal area. It was also recommended that flight tests be conducted under simulated instrument Flight Rule conditions to determine the most favorable relationship between glide slope angle, rate of descent and approach speed for both Vertical and Short Takeoff and Landing aircraft. It was further recommended that the feasibility of non-standard separation be examined in a live environment.

NA-68-22
METALLURGICAL EVALUATION OF AIRCRAFT EXHAUST SYSTEM COMPONENTS FAILED DURING GROUND TEST PROGRAM, by J. R. Kaye, T. J. Hogland, and H. P. Weinberg,. Final report, April 1968. 72p. (DS-68-10) (AD 672 034).

Twenty samples from small aircraft engine exhaust systems were investigated metallurgically to determine the differences, if any, between

failures produced in a ground test program and failures from operating aircraft as described in Technical Report ADS-28. The work included samples fabricated from a new material (nickel-chromium alloy) recommended as an improvement for applications such as exhaust systems. The purpose also requested further information regarding the metallurgical cause of failure of conventional stainless steel exhaust system components. The test failures and samples involving AISI 321 and 347 stainless steels were similar to the previously evaluated failures from operational aircraft. The samples showed the effects of high temperature corrosion, carburization, sigma phase and delta ferrite. In most cases, these conditions were similar to those exhibited by the components from operational aircraft. Crack-type failures were attributed to a type of fatigue, which was also the conclusion drawn by the investigation of the components which failed on aircraft. Test results disclosed that a material composed of 21 percent chromium and 32 per cent nickel was far superior to AISI 321 or 347 stainless steel in regard to high-temperature oxidation or corrosion in exhaust systems. Those failures resulting from oxidations could be significantly reduced or eliminated by incorporation of this material.

NA-68-23
EVALUATION OF DIGITAL CHECK CHARACTER GENERATORS USED IN TELETYPEWRITERS, by C. G. Santora. Final report, July 1968. 32p. (AD 686 382).

This report deals with two preproduction digital check character generator (DCCG) models installed in the teletypewriters of the NAS En Route Stage A System Support Facility at the National Aviation Facilities Experimental Center (NAFEC). The purpose of this effort was to determine compliance with the applicable specification and provide technical information on installation, operation, test procedures, and measured characteristics of these models and the required changes to be made in the production units. The models tested proved satisfactory except in minor respects and recommendations are made to employ the teletypewriter power switch and to facilitate detachment of the DCCG.

NA-68-24
EVALUATION OF EXPERIMENTAL FLIGHT DATA RECORDERS IN AN AIRCRAFT CRASH ENVIRONMENT, by P. M. Rich. Final report, Nov. 1968. 29p. (DS-68-23) (AD 677 781).

Two types of experimental 20-channel flight data recorders were evaluated to determine their resistance to an aircraft crash environment. This crash environment was simulated by a series of four tests: a shock test, a crushing test, a penetration test, and a fire test. The first flight data recorder tested was an oscillographic recorder enveloped in a 1/2 ATR (Air Transport Radio) case; the recording medium being stainless steel tape. This recorder survived all the tests except the shock test in the longitudinal direction. A minor modification to the recorder would correct this fault. The second type of recorder was a magnetic tape recorder. This recorder was also destroyed in the longitudinal shock test. A major redesign would be required for this recorder to survive this test. It was concluded that the series of four crash survivability tests are poorly defined and recommendations are made herein to correct this problem.

NA-68-25
DEVELOPMENT AND APPLICATION OF A TERMINAL SPACING SYSTEM, by D. A. Martin and F. M. Willett, Jr. Final report, Aug. 1968. 43p. (RD-68-16) (AD 673 262).

This report describes the results of laboratory and field tests of a NAFEC-developed computer system which provided aircraft rate control and spacing assistance to the air traffic controllers in a terminal area. A general purpose digital computer was used to provide heading, speed and turn information, in symbolic and numeric form, on an ASR-4 radar display used by the final approach controller. Additionally, an input/output device at the flight data location indicated which aircraft should depart which outer fix at a given time, in order to establish and maintain a consistent, first-come, first-served traffic flow in the final spacing area (metering). Initial testing was conducted at NAFEC.

The system was subsequently relocated to the J. F. Kennedy Terminal Radar Control (TRACON) for further evaluation in an operational environment. In a comparison with the manual control system, use of the final spacing function of the computer system resulted in more consistent and accurate landing intervals which would proportionately increase the arrival rate. Other expected benefits could not be properly assessed during the field appraisal due to operational, environmental and other constraints resulting from the heavy J. F. Kennedy traffic. It was not possible, for example, to measure computer system performance and to form an opinion of its usefulness when the computer system is operated by controllers with less radar experience than those TRACON controllers who ultimately operated the final approach spacing function. However, the computer system as configured and installed was not favorably accepted by the controllers due to an increase in workload. Favorable results were obtained with the metering function of the computer system during simulation tests at NAFEC; however, limited work space and related problems did not permit use of this function in the J. F. Kennedy TRACON.

NA-68-26
EVALUATION OF HIGH-SPEED TELEPRINTER EQUIPMENT, by T. F. Edwards. Interim report, Sept. 1968. 44p. (RD-68-42) (AD 839 810L).

A comparative Engineering Evaluation and limited Field Trial were conducted to assess the suitability of commercially available off-the-shelf high-speed teleprinters for agency short and long term applications. One each of two generic types of impact and non-impact teleprinters were installed, operated, tested, and evaluated in a laboratory test environment at the National Aviation Facilities Experimental Center (NAFEC) for applications on Service "A" Weather Data Interchange System and the proposed Modernized Weather Teletypewriter Communication System. Results indicated that existent off-the-shelf commercially available teleprinters do not fully satisfy agency application requirements without incorporation of major design modifications. It was recommended that the VS-249 Inktronics Printer and DCI-150 High-Speed Teleprinter not be procured and production prototype equipment specifications be prepared and utilized for procurement of a test model teleprinter.

NA-68-27
RECIPROCATING ENGINE AND EXHAUST VIBRATION AND TEMPERATURE LEVELS IN GENERAL AVIATION AIRCRAFT, by G. R. Slusher. June 1968. 37p. (DS-68-8) (AD 671 894).

The engine and exhaust system vibration and exhaust gas and metal temperature levels were determined for flight and ground conditions on several single-engine aircraft for purposes of establishing exhaust system and heat exchanger design and test criteria. The temperature data were presented as a function of engine compression ratio and the vibration data were plotted against engine horsepower to foster the general utilization of the information. Method of data presentation permits the estimation of exhaust gas temperatures for horizontally-opposed, reciprocating engines. Temperature measurements indicated uneven heating of the muffler outer wall (heat exchanger surface) reflecting uneven flow of the exhaust gases through and around the baffles and diffusers probably producing thermal stresses and contributing to failures. Baffles and diffusers within the mufflers of engines with compression ratios of 8.5:1 or higher are exposed to exhaust gas temperature levels under which standard construction materials (AISI 321 and AISI 347 stainless steels) become marginal with respect to high-temperature oxidation, carburization, and attack by lead compounds. Vibration of general aviation aircraft engines was noted to increase with increased power rating and reached maximum intensities under takeoff conditions. The acceleration level of mufflers on engines of high power compared favorably with the MIL-STD-810A Vibration Test Specification for equipment mounted directly on aircraft engines. Recommended procedure for development of new exhaust system designs involved random vibration testing under operating thermal conditions.

NA-68-28
EVALUATION OF A PICTORIAL TURN AND BANK INDICATOR, by G. E. Skelton. Final report, Aug, 1968. 16p. (DS-68-14) (AD 675 778).

A subjective evaluation was conducted of a pictorial turn indicator as a replacement for the conventional turn and bank indicator. Results showed that a pictorial turn indicator can replace the turn and bank indicator without any adverse effect, and that the novice VFR pilot or a current IFR pilot can use a pictorial turn indicator alone without confusing it with any other flight instrument. Operationally, all pilot subjects were able to fly the required IFR basic air maneuvers proficiently in both smooth and turbulent air. There were no unusual responses to the unusual maneuvers when the outside-in presentation of a pictorial turn indicator was mixed with the inside-out presentation of the conventional attitude indicator. The low-time VFR pilot, flying solely by instruments, demonstrated an ability to perform timed turns with confidence and greater accuracy than when using the conventional turn needle.

NA-68-29
DISPLAY OF WEATHER CONTOURS, by D. W. Connolly. Interim report, Aug. 1968. 25p. (AD 673 417).

The Weather Outline Contour Generator outlines areas of weather clutter at different intensity levels. Three experiments and several additional tests were performed to investigate two principal problem areas regarding the human factors aspects of the display of such data. The first problem concerned resolution -- the level of detail or continuity required for reasonably complete and accurate representation of the shape and extent of the area of precipitation. This was tested by a recognition procedure. Twenty-three controllers correctly recognized, over 90 percent of the time, which of four actual weather patterns was represented by an outline made up of symbols spaced radially approximately 2 2/3° apart. Doubling or quadrupling the resolution improved recognition slightly while increasing the certainty of recognition to a greater degree. Almost exactly the same results were obtained from a second sample of 20 controllers when the display was made up of radial-hatched lines (i.e., lines connecting positions of symbols at the same azimuth instead of the symbols). The second general question concerned usefulness, for vectoring, of the symbolic outine vs. the hatched display. No differences were found between displays in number of vectors issued or time under control. The 2 2/3° resolution was used in both cases and vectoring performance using either outline did not differ from that where the raw, broadband weather was used. However, the radial-hatched contours were found to be more visible in clutter and other symbology, and to result in slightly better weather avoidance. The radial-hatched contour is recommended for operational use, with a transmission interval of not greater than 8°.

NA-68-30
FLAMING AND SELF-EXTINGUISHING CHARACTERISTICS OF AIRCRAFT CABIN INTERIOR MATERIALS, by J. F. Marcy and R. Johnson. Final report, July 1968. 44p. (DS-68-13) (AD 673 084).

A study was made of the burning characteristics of some 140 different materials for the purpose of obtaining technical data and criteria needed to support current efforts to improve existing Federal Air Regulations governing the use of cabin interior materials in aviation. Comparative tests were conducted on two groups of materials, one consisting of materials now in use in air transport, and the second materials proposed for future use with superior fire resistance. Measurements were made of ignition time, burn and char lengths, flame-out time, burn rate, heat of combustion, flame-spread index, etc. Two standard laboratory test methods were employed; namely, (1) Federal Standard CCC-T-191b, Test Method 5902, Vertical Burning Apparatus, and (2) Federal Standard 00136b (ASTM E-162), Radiant Panel Apparatus.

Results of the tests were analyzed to indicate major flammability trends for different material classifications. Practical allowable flammability limits based on available materials technology were recommended for increasing the present fire protection requirements of interior materials.

NA-68-31
FRICTION EFFECTS OF RUNWAY GROOVES, RUNWAY 18-36, WASHINGTON NATIONAL AIRPORT, by W. A. Hiering and C. R. Grisel. Final report, Dec. 1968. 19p. (DS-68-21) (AD 678 645).

Wet and dry runway friction tests were conducted on bituminous concrete Runway 18-36 at Washington National Airport using a Fixed Slip Runway Friction Tester. These tests were conducted to determine if significant friction changes were generated as a result of grooving the runway surface with 1/8- by 1/8-inch-transverse groovers spaced on 1-inch centers. Data analysis indicates that at test speeds of 10 to 60 mph, no appreciable increase or decrease in overall runway friction values were obtained for this series of tests. The treatment of the runway surface, however, by the cutting of uniformly spaced grooves markedly smoothed the resultant wet friction values. It is hypothesized that these smoother wet runway friction values result in a surface that affords more efficient operation of aircraft antiskid braking devices and more effective manual braking.

NA-68-32
AIR TRAFFIC CONTROL SYSTEM ERROR DATA FOR 1965 AND 1966 AS RELATED TO AGE, WORKLOAD, AND TIME-ON-SHIFT OF INVOLVED CONTROLLER PERSONNEL, by A. Kershner. Final report, Nov. 1968. 12p.

System Error Data from 181 reports for 1965 and 144 for 1966 were examined to ascertain if (1) older controllers made proportionately more errors, (2) errors increased with increased workload, and (3) errors increased in proportion to increased time-on-shift. A hypothesized relationship, namely, that system-error-involved controller personnel would increase with increases in age, was not supported. A second hypothesized relationship, that the number of system-error-involved personnel would be greatest for heavy traffic conditions and least for light traffic conditions, received only equivocal support. A third hypothesis, that system errors or system-error-involved personnel would increase as time-on-shift increased, was not supported. On the contrary, the evidence shows greater involvement in errors and more errors during the first quarter of the shift with successive decreases for each succeeding quarter at a high level of statistical significance. It is recommended that methods be instituted to acclimate traffic controllers coming on duty more rapidly and effectively to the full thrust of traffic control demands. A continuing investigation of the workload-error relationship is suggested, and that publication of monthly or at least quarterly age distributions for Journeymen and Facility Supervisors will permit a more definitive analysis of the age-error as well as other relationships.

NA-68-33
ILS FLIGHT INSPECTION POSITIONING SYSTEM TEST AND EVALUATION, by G. D. Adams. Final report, Sept. 1968. 33p. (RD-68-35) (AD 674 413).

Technique Feasibility hardware for an Instrument Landing System (ILS) Flight Inspection Positioning System (FIPS), developed by Westinghouse, Inc., Baltimore, Maryland, for the Federal Aviation Administration, has been tested at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, and at Pittsburgh, Pennsylvania. Positioning accuracy data show that the two standard deviation measures of dispersion were 0.03° in the initial part of the ILS approach. In the near area of the approach, the FIPS performance may have exceeded the capability of the measurement instrumentation. Static tests near the threshold produced a two standard deviation measure of dispersion of 0.01° and less. The flight inspection aircraft, measuring for effects on the commissioned ILS, report that the FIPS installation has no measurable influence on the ILS. With respect to providing guidance for flight inspection use, the FIPS produces courses, flyable simultaneously by a pilot when used in conjunction with a standard ILS. The conclusion is reached that the interferometer technique used is feasible as an accurate measurement system. Some redesign and improvements to the feasibility hardware are suggested.

NA-68-34
FOAM AND DRY CHEMICAL APPLICATION EXPERIMENTS, by G. B. Geyer. Interim report, Dec. 1968. 34p. (RD-68-55) (AD 680 068).

Full-scale tests were conducted under fixed fire conditions employing air-aspirating foam and dry powder dispensing equipment in which six different foam agents and three different dry chemical powders were evaluated, both alone and in combination. The time required to control circular pool fires of 40, 60, and 80 feet in diameter, containing an obstacle and a three-dimensional fire, was determined.

NA-68-36
SMOKE AND GASES PRODUCED BY BURNING AIRCRAFT INTERIOR MATERIALS, by D. Gross, J. J. Loftus, T. G. Lee, and V. E. Gray. Final report, June 1968. 43p. (DS-68-16) (AD 675 513).

Measurements are reported of the smoke produced during both flaming and smoldering exposures on 141 aircraft interior materials. Smoke is reported in terms of specific optical density, a dimensionless attenuation coefficient which defines the photometric obscuration produced by a quantity of smoke accumulated from a specimen of given thickness and unit surface area within a chamber of unit volume. A very wide range in the maximum specific optical density was observed. For the majority of materials, more smoke was produced during the flaming exposure test. However, certain materials produced significantly more smoke in the absence of open flaming. During the smoke chamber tests, indications of the maximum concentrations of CO, HCℓ, HCN and other selected potentially toxic combustion products were obtained

using commercial colorimetric detector tubes. A study was made of the operation, accuracy and limitations of the detector tubes used. Measurements of the concentrations of HCℓ were also made using specific ion electrode techniques. The elevated temperature thermal degradation of selected materials was studied in a number of ways including thermogravimetry and differential scanning calorimetry. Qualitative identification of the major components of the original test materials was accomplished primarily by infrared absorption spectrophotometry. Of the materials tested, a number were found to possess good heat stability properties, and did not generate large quantities of smoke or high concentrations of the combustion products selected for analysis.

NA-68-37
EVALUATION OF LOW-COST COLLISION AVOIDANCE GROUND TRAINING EQUIPMENT, by R. L. Sulzer and W. G. Crook. Final report, Nov. 1968. 22p. (DS-68-22) (AD 680 253).

The purpose of this project was to determine the effectiveness of a system of low cost aids in improving visual search and in providing practice in search technique during simulated cross-country flight. Twelve private/commercial and three student pilots having widely varied amounts of flight time were given practice in dividing their time between in-cockpit flight duties and external visual search. This "time-sharing" practice was conducted in a general aviation-type ground trainer using low-cost slide equipment to project images of intruder aircraft on possible collision courses. Results indicate marked improvement in target detection throughout the 10 sessions flown, with no corresponding deterioration of flight control performance or detection of instrument warnings. Total logged flight time was not a good predictor of individual scan/search performance. Further measurement of the development of time-sharing skills, using similar low-cost ground training equipment, is recommended at an approved flight school to validate the concept. Additional possible uses of the equipment and procedures include proficiency testing and practice in division of duties in two-man crews.

NA-68-38
TEST AND EVALUATION OF OVER-OCEAN SEPARATION ASSURANCE SYSTEMS, by A. D. Bradley and R. S. Bassford. Sept. 1968. 58p. (RD-68-47) (AD 676 525).

Three airborne air-to-air ranging systems were evaluated to determine their capability to provide aircraft separation information in an over-ocean airspace environment, and to verify the technical characteristics of each system. The systems evaluated were: (1) TACAN Navigational Set AN/ARN-52(V); (2) Airborne Beacon Range/Altitude Monitor; and (3) Airborne Time/Frequency Range/Altitude Monitor. Flight tests confirmed the results obtained during the simulation effort (Report No. RD-67-43) which established the operational procedures for each system. The technical tests indicated that all three systems were suitable for operation in an over-ocean environment, but

improvement should be made in the antenna coverage of the Airborne Beacon Range/Altitude Monitor and the synchronization of the Airborne Time/Frequency Range/Altitude Monitor employing a dual antenna feed configuration. It was recommended that the air-to-air ranging concept of the TACAN Navigational Set AN/ARN-52(V) be considered for incorporation into civilian distance measuring equipment (DME), and that the Airborne Beacon Range/Altitude Monitor concept be considered provided the antenna coverage is omni-directional. In addition, further testing of the Airborne Time/Frequency Range/Altitude Monitor was recommended utilizing the equipment to investigate the concept applied to a full collision avoidance system configuration.

NA-68-39
PRELIMINARY INVESTIGATION OF THE NAS STAGE A BACKUP CHANNEL AS RELATED TO THE RESOLUTION AND DETECTION OF AIRCRAFT, by C. Chapman. Final report, Oct. 1968. 29p. (AD 675 779).

A preliminary investigation of the backup channel of the National Airspace System (NAS) at the Air Route Traffic Control Center (ARTCC) in Jacksonville, Florida, was performed to obtain advance information relative to the resolution characteristics and the target-detection-in-clutter capability of the backup channel. Equipment comprising the backup channel were the radar/beacon/common digitizer facility at Valdosta, Georgia, the modems and telephone data lines, and the data filter group/bright display equipment at the ARTCC. Test data were collected concurrently on the backup channel and the broadband radar system to permit a comparison between the two systems. The overall system resolution capability of the backup channel for radar, beacon and radar/beacon was comparable to that of the broadband radar system in that the two test aircraft were resolved 50 percent of the time, on both systems, when the aircraft were separated by approximately 1.5 miles. Target-detection-in-clutter (blip/scan ratio) for the broadband radar system was approximately 10 percent greater than that of the backup channel, but investigation revealed that the Air Traffic Control (ATC) Specialists had difficulty in distinguishing aircraft targets from weather-clutter targets on the backup channel. It is recommended that investigation by ATC Specialists be performed to determine the training and/or operating procedures necessary to obtain maximum performance of the backup channel in the detection, recognition, resolution and/or interpretation of display targets.

NA-68-43
EVALUATION OF UTILITY OF ANNOTATED WEATHER OUTLINES, by Lt. Col. W. Lewis. Interim report, Nov. 1968. 15p. (RD-68-54) (AD 677 461).

Simulations were carried out using two methods of presenting the NAS En Route Stage A Model 1 Weather Outline (WOG) radar weather contours on air traffic controllers' displays. The first was the televising of a series of manually prepared displays consisting of annotated dot (outer) and X (inner) WOG contours. The annotations consisted of simulated reports of storm heights, turbulence and hail. The second

was through digital recordings of the digital radar channel method of presenting contours wherein three radar antenna sweeps build up the dotted outline, three the X outline and so on cyclically. Using rules based on severe storm research, 17 controllers vectored aircraft around the televised weather displays during simulations. Eleven of the controllers observed the radar channel three-sweep display but did not use it for vectoring. Most controllers stated that the dark televised display provided sufficient definition for vectoring and was an improvement over conventional CP "punch-through." However, most also felt that it would conflict somewhat with other information on the scope, if bright. Of the 11 controllers who viewed the radar channel three-sweep display, opinion was equally divided between those who felt it provided sufficient definition for vectoring and was an improvement over CP "punch-through" and those who thought the reverse. However, most felt it conflicted with other information on the scope. In regard to the annotations, all controllers (17) stated that those shown (storm heights, turbulence and hail) would be helpful in vectoring aircraft. It was recommended that additional simulations be carried out providing for the measurement of the effect of the weather on air traffic control activities versus non-weather situations.

NA-68-45
LIGHTING AND MARKING OF OBSTRUCTIONS TO AIR NAVIGATION, by R. Sulzer. Final report, October 1968. 22p. (RD-68-38) (AD 676 526).

Three classes of obstructions present hazards to VFR flight: tall towers encroach navigable airspace, catenaries obstruct the paths of low flying aircraft, and structures near airfields endanger terminal area traffic. Study of the first class, tall towers, has produced recommendations for very bright, flashing white lights and wide bands of black and white paint to enhance detection. Objection has been taken to revision of the marking standard for tall towers only, because the importance of retaining simplicity in the international standard requires all three classes of obstructions to be considered together. Additional analysis reveals that orange and white bands and checkerboards, and lesser red obstruction lights are valuable as hazard identification signs, if detection is otherwise assured. Under marginal VFR conditions, however, there is reason to predict superior detection of both tall towers and catenaries if brightness contrast rather than color contrast is given priority. Relatively, addition of very bright flashing lights offers more increase in detection range than any painting scheme, but painting remains important for correct interpretation of what is detected.

NA-68-48
GENERAL AVIATION COCKPIT DISPLAY AND CONTROL SIMULATION, by R. J. Ontiveros. Final report, Oct. 1968. 76p. (DS-68-17) (AD 680 054).

An experiment was conducted to evaluate, by use of a general aviation simulator and airplane, typical versus experimental concepts of general aviation cockpit environments in an effort to reduce pilot workload and

training time to operate an airplane in today's IFR environment and to meet the flight skills required for the instrument rating flight test (FAR 61.37). Phase I of the experiment examined the flight performance of a group of noninstrument-rated subjects utilizing a cockpit environment typical of aircraft used for single engine instrument flight training. The results, in terms of flight training time, provided baseline data of pilot performance in all aspects of instrument flight. Phase II of the experiment examined the instrument flight performance of a similar group of pilots. Flight training was accomplished in an experimental cockpit environment, consisting of improved cockpit displays, controls and instruments to provide maximum assistance to the pilot. Project results indicated a reduced pilot workload and training time to operate an aircraft in an IFR environment. An experimental flight training syllabus was utilized with both pilot groups. Phase III of the experiment examined the flight performance of the Phase II group in a conventional cockpit environment. A determination was made of the effects of Phase II training in reducing the training time needed to achieve the flight skills required by the instrument rating flight test (FAR 61.37 and AC 61.17A). Project results indicated that the use of improved cockpit controls and displays at an early stage of IFR pilot training is beneficial to the noninstrument-rated in aiding him to achieve the aforementioned flight skills. The report also describes pilot performance and problem areas encountered during training and check flights in both the typical and experimental cockpit environments of the simulator and airplane.

NA-68-54
COLLISION AVOIDANCE, A BIBLIOGRAPHY, 1955 - September 1968, compiled by D. E. Bulford. November 1968. 166p. (AD 677 942).

The Federal Aviation Administration is dedicated to providing a safe and efficient system for the utilization of national airspace. The prevention of mid-air collisions is a highly important aspect of overall FAA efforts. To assist both Government and the aviation industry in their study of collision avoidance matters, this bibliography, containing 1013 titles, has been compiled. It was in 1955 that the Air Transport Association requested industry proposals on collision avoidance systems. The year 1955 has been selected as the year to begin this list of references. A preliminary CAS bibliography was published in May 1967 to meet the immediate needs at NAFEC. This new and much enlarged bibliography contains a subject index and replaces the previous edition (identified as AD 652 606 in DDC).

NA-69-1
EVALUATION OF EXPERIMENTAL SAFETY FUELS IN A CONVENTIONAL GAS TURBINE COMBUSTION SYSTEM, by A. J. Atkinson. Final report, April 1969. 25p. (DS-68-27) (AD 686 840).

Performance evaluation of a typical gas turbine engine combustion system was conducted to determine the combustion characteristics of two gelled Jet A fuels (JetA plus 1.5% N-coco-γ -hydroxybutyramide, and Jet-A plus 2% of a styrene type polymer). Testing of an emulsified fuel was terminated due to separation of the emulsion by the shearing action of the boost

pump in the system. The conclusions reached: (1) indicate the feasibility of employing gelled fuels from a combustion standpoint and, (2) demonstrate filtration, atomization, and deposition problems.

NA-69-2
FLIGHT TEST AND EVALUATION OF HELIPORT LIGHTING FOR VFR, by R. Sulzer and T. Paprocki. Final report, March 1969. 47p. (RD-68-61) (AD 683 680).

The guidance value of heliport lighting system components was tested under VFR conditions in a joint FAA/U.S. Army effort. The overall system included lighting to identify and locate the heliport and support the approach and landing of helicopters. Forty-six civil and military pilots flew on 11 nights at Tipton Army Airfield, Fort Meade, Maryland, producing the following conclusions: The heliport beacon, flashing green-yellow-white, had adequate range and distinctiveness but could be improved by a change in flash rate: the yellow pad perimeter lighting met all requirements; the white approach direction and yellow landing direction lighting components were satisfactory; both pad surface floodlighting and pad inset lights were used satisfactorily, and all pilots who were shown the painted maltese cross marking rated it as an aid at night; the lighted wind sock provided adequate wind direction information if overflown first, but neither the lighted wind sock nor the lighted wind tee tested were adequate to provide this information to a pilot on the approach path at one-half mile from the pad. A minimum VFR heliport lighting system is recommended to include the beacon for location information, the perimeter lights and painted marking for pad identification, and the lighted wind sock to provide wind information. Other components are recommended for installation when required by special conditions.

NA-69-3
EVALUATION OF A PICTORIAL NAVIGATION DISPLAY AS AN INSTRUMENT PILOT TRAINING AID, by G. E. Skelton. Final report, May 1969. 20p. (DS-69-4) (AD 687 405).

A study was conducted to evaluate the effectiveness of a Pictorial Navigation Display (PND) as a conceptual training aid for instrument flight training. The PND was capable of providing Heading-Up and North-Up information to the pilots. Results showed that the PND was generally superior to the conventional very high frequency omnirange (VOR) navigation instrument when used alone, and proved to be an asset to the instrument student pilot. A comparative evaluation revealed that the North-Up mode of the PND was favored over that of the Heading-Up mode. Operationally, all subject pilots were able to meet the navigation requirements of the Instrument Flight Rules (IFR) syllabus proficiently with the PND. There were no unusual responses with either the North-Up or the Heading-Up modes of the display. The training

times and the pilots' comments showed greater confidence and better accuracy when using the North-Up mode of the PND. The effectiveness of the PND as a conceptual training aid was confirmed by observing and documenting the performance of pilots flying an aircraft in simulated IFR environment without the assistance of the PND.

NA-69-4
TEST AND EVALUATE TAKE-OFF AND GO-AROUND SYSTEM, by R. W. Cleary. Final report, February 1969. 26p. (RD-69-1) (AD 682 542).

Automatic throttles, take-off information displayed on the flight director, and go-around information displayed on the flight director, all using angle-of-attack as the primary control reference, were evaluated in DC-7 aircraft. Phototheodolite position data and oscillograph recordings from on-board recorder were used to measure performance. It was concluded that the automatic throttles were compatible with flight director approaches and with landings performed with the aircraft automatic landing system. The go-around information was used to perform go-around without reference to attitude or airspeed. Four engine and three engine take-offs were performed with conventional instruments and with the flight director. Performance was more consistent when the flight director was used.

NA-69-5
DYNAMIC TEST CRITERIA FOR AIRCRAFT SEATS, by D. W. Voyls. Final report, October 1969. 50p. (DS-69-10) (AD 696 963).

A series of static and dynamic tests of representative aircraft passenger seats was conducted. The static tests utilized the procedures of Technical Standard Orders C-22 and C-39 which embody the test standards for certifying passenger seats for commercial aircraft. The dynamic tests utilized, in part, test procedures developed specifically for this project and, in part, test procedures developed from experience in the testing of Navy aircrew seats. A significant difference between static and dynamic test results was found, thus warranting further investigation of the validity of utilizing static tests alone for the type certification of aircraft passenger seats for a dynamic or crash load requirement. The fact that static test results, in themselves, cannot be related to crash environments is demonstrated and cited as a definite limitation of static tests. Dynamic test results are demonstrated as having the capability of being related to crash environments and are considered to be the more meaningful in defining the behavior of seat/occupant systems when subjected to crash phenomena. Dynamic test criteria for the type certification of aircraft seats were established and used to analyze the static and dynamic test results. A relationship between the static and dynamic test load conditions was devised as part of the criteria. Relatively simple methods for dynamic testing are suggested, and the procedure of analyzing test results is presented.

NA-69-6
TEST AND EVALUATION OF DECRAB DISPLAY SYSTEM, by R. H. Pursel. Final report, April 1969. 33p. (RD-69-11) (AD 684 808).

A flight test evaluation, under simulated Category III conditions, was conducted on a three-axis attitude indicator. Heading error was presented on the third axis to be used in executing the decrab maneuver. The indicator was installed in a Federal Aviation Administration DC-7 aircraft and flight tests were conducted using four FAA flight test pilots. Data associated with the landing maneuver were collected and compared to similar data obtained from a previous evaluation of a decrab display which had been considered unsatisfactory. It was concluded that the new indicator offered no significant advantage over the previous indicator. It is recommended that investigation be made into the use of the pilot's peripheral vision channel to convey the decrab information.

NA-69-7
TEST AND EVALUATE RUNWAY ALIGNMENT INDICATOR LIGHT (RAIL) FOR APPROACH GUIDANCE, by B. Weinstein. Final report, March 1969. 32p. (RD-69-8). (AD 684 088).

An evaluation has been completed at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey comparing the Runway Alignment Indicator Lights (RAIL) with the Medium Intensity Approach Light System (MALS) for effectiveness in providing identification and guidance as visual approach aids. The two aids were flown alternately in each available weather condition to permit comparison. The results obtained from pilot questionnaires and radar data during day and night IFR/VFR operations with weather minimums down to 3/4-mile visibility indicated the following: While the RAIL provided earlier identification and displacement information than did the MALS, the glare from the RAIL was so distracting during VFR night operations that pilots considered the RAIL unacceptable. On the other hand, the MALS was acceptable during day and night IFR/VFR operations and was rated the better approach aid during VFR night operations. It was recommended that RAIL not be approved for operational use.

NA-69-8
FRICTION EFFECTS OF RUNWAY GROOVES, RUNWAY 4R-22L, JOHN F. KENNEDY INTERNATIONAL AIRPORT, by W. A. Hiering and C. R. Grisel. Final report, July 1969. 14p. (DS-69-3) (AD 692 075).

Wet and dry runway friction tests were conducted on concrete Runway 4R-22L at John F. Kennedy International Airport, New York City, using a Fixed Slip Runway Friction Tester. These tests were conducted to determine if significant friction increases or decreases were generated as a result of transversely grooving the runway surface with 3/8-inch-wide, 45°, V-shaped grooves, having a 1 3/8-inch pitch. Data analysis indicates that at the test speeds of 50 and especially 60 mi/h,

an appreciable increase in overall wet runway friction values due to grooving was obtained for these series of tests. In addition, the treatment of the runway surface by the cutting of uniformly spaced grooves markedly smoothed the resultant wet runway friction values. The chemical removal of rubber from the touchdown area of the 22 end of the ungrooved runway substantially improved the friction values of this end compared to those of the untreated 4 end.

NA-69-9
SIMULATION TEST OF THE ARCATA, CALIFORNIA, DIAMOND RUNWAY CENTERLINE by G. S. Brown and R. L. Sulzer. Interim report, Aug. 1969. 13p. (RD-69-35) (AD 691 721).

The guidance value of the Arcata diamond runway centerline paint markings was tested by comparison with the U. S. standard centerline markings in the Dalto/P-3 visual simulation facility. Twenty experienced pilots participated in the testing. Results generally favored the U. S. standard centerline consisting of a 3-foot-wide interrupted stripe with 120-foot painted length and 80-foot gaps, as opposed to the 10-foot maximum width diamonds with 75-foot length and spacing. The only exception was that the diamonds were seen farther away prior to touchdown, a result that is attributed to the one-third larger total painted area.

NA-69-10
INVESTIGATION OF MODIFIED TURBINE FUELS FOR REDUCTION OF CRASH FIRE HAZARD, by K. Posey, Jr. Final report, May 1969. 26p. (DS-69-1) (AD 694 008).

Fifty-five modified fuels were tested and rated for their ability to reduce aircraft post-crash fires. The candidate fuels were subjected to a seven-part rating scheme in which combustion and physical properties were examined under both static and dynamic conditions. Measurements were made of flash point, rate of vapor release, burn rate, surface flame propagation rate and fuel spread rate (ignited), as well as fireball size under impact conditions (drop test) and fireball size with sample propelled by a catapult device. Fuels gelled with either alkl-hydroxybutyramides, amine diisocyanates Al-2-ethylhexanoate (aluminum octoate) or a styrene-type polymer as well as an emulsified fuel were found to provide marked safety benefits. The alkyl-hydroxybutyramide gels, the amine diisocyanates, and the emulsion had a firm, or stiff, consistency which would present a serious tank feed-down problem in present aircraft. The polymer gel was pourable but contained harmful sodium and required a relatively high polymer concentration, and the polymer was not compatible with the de-icer contained in JP-4. The aluminum octoate gel was selected as the best of the candidate fuels tested. It was pourable, provided marked safety benefits, required only a low concentration (1%), was stable, noncorrosive and was easily prepared.

NA-69-11
NORTH ATLANTIC DATA COLLECTION INSTRUMENTATION AND PROCESSING, by J. E. Blazej. Final report, May 1969. 48p. (RD-69-19) (AD 687 721).

This project involved the collection and processing of aircraft positional data of air traffic over the North Atlantic Ocean for the purpose of assessing the navigational accuracy of this traffic. The concept, specifications, and broad systems design of the Automatic Beacon/Loran Digitizer System (Processor) were developed at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey. The Processor was part of a data collection system that also included ancillary antenna and radar beacon systems and Loran navigation systems. Acceptance testing of the Processor was accomplished at the factory, at NAFEC, and in field locations. Data collection system installations were made at Gander, Newfoundland, Kilkee, Ireland, and on three United States Coast Guard cutters stationed at various locations in the North Atlantic Ocean. The radar data collection program, conducted over a period of 6-1/2 months, was managed from NAFEC. All resulting data were processed at NAFEC and forwarded to the Royal Aircraft Establishment (RAE) at Farnborough, England, for analysis. It was concluded that the technical and operational approaches to the data collection and processing requirements were generally sound. It was recommended that the Processor be made available for use in other data collection programs.

NA-69-12
EVALUATION OF LOW-COST VIDEO TAPE RECORDER, by R. W. Delaney and H. L. McFann. Final report, May 1969. 10p. (RD-69-17) (AD 687 406).

A low-cost (less than $1500) television type video tape recorder system was tested at the National Aviation Facilities Experimental Center (NAFEC) to determine whether the system could provide a recording of radar targets suitable for use in recreating air traffic situations. The equipment was evaluated in two modes of operation: (1) camera recording of the radar video from a scan-converted display; and (2) on-line recording of the radar video from the signal bus of a high-resolution scan converter. Although the mechanical performance of the system was adequate, its narrow bandwidth significantly degraded the resolution of the recorded display. Certain operational features were identified as further limiting factors. These features included tape running time, audio track capability, and automatic switchover features. In view of these limitations, it was concluded that the performance of the system was marginal for its intended use. It was recommended that the low-cost system not be adopted.

NA-69-13
SYSTEM SHAKEDOWN TESTS (C2ON), NAS EN ROUTE STAGE A MODEL 1, FUNCTIONAL PACKAGE A (Flight Data Processing), by G. P. Boschert. Final report, August 1969. 11p. (AD 691 722).

System Shakedown Tests (C2ON) of the National Airspace System Functional Package A (FP-A) were conducted at NAFEC during the period April through June 1968. Some of the original plans, which required a stable, representative ATC operational system, were abandoned in favor of Program Shakedown (Category B) type activity, when it became apparent that the system was not ready for more sophisticated tests. Planned investigations were conducted despite many system failure interruptions. Valuable information was obtained which expedited shakedown activities. Data collection, data reduction and test conduct methods for application to future First Article Center (Jacksonville ARTCC) testing were examined. Reaction and impact of planned equipment failures upon system operation were also scrutinized. The test results produced the most suitable method for conduct of tests at the Jacksonville Center (ZJX), the most acceptable method of data collection and reduction, and the conditions and circumstances under which failures of specific system components had an adverse impact upon system operations. At the conclusion of testing, it was determined that many discrepancies in system performance, and some deficiencies in system design, remained to be resolved.

NA-69-14
IN-SERVICE IMPROVEMENTS TO USAF TOWER CABS, by J. R. Bradley, Jr. and H. D. Milligan. Final report, April 1969. 39p. (RD-69-13) (AD 684 807).

This project was conducted to design, fabricate, test, and recommend design criteria for air traffic control tower cab consoles. Considerations were given to human factor aspects to ensure that the console design would provide ease of coordination, economy of motion, and accessibility of controls and displays for the controllers. Supplementary areas of investigation included: tower cab light systems, controller chairs, and a recently developed interphone keying system. Recommendations include: specifications for a highly versatile tower console of modular design, tower cab illumination criteria, a scientifically designed work station chair, and details on a compact, modular interphone keying system.

NA-69-15
INERTIAL NAVIGATION SUPPORT, PHASE II, by R. Braff and R. H. Mayer. Final report, May 1969. 48p. (AD 852 583L).

Flight tests were performed in the civil air environment, primarily over the North Atlantic Ocean, during which a type LN-12 Inertial Navigation System was coupled to the aircraft control system through a BANC 461 analogue computer and was the primary navigation system. The flight

testing was performed in a Pan American Airways Douglas DC-8 aircraft. Quantitative and qualitative navigational errors were measured and treated statistically. Data thus treated showed that the equipment under test met the present-day accuracy requirements. No equipment or human errors were made during these tests; thus, it was not determined whether such errors (blunders) could be detected by ordinary cockpit procedures.

NA-69-16
RETRACTABLE PENDANT CABLE SUPPORT SYSTEM FOR BAK-9 EMERGENCY ARRESTING SYSTEM, by H. P. Scheuerman. Final report, October 1969. 11p. (RD-69-24) (AD 694 957).

A retractable pendant cable support system for the BAK-9 Emergency Arresting System was designed and installed adjacent to the BAK-9 at both ends of Runway 13-31 at the Atlantic City Airport, National Aviation Facilities Experimental Center, Atlantic City, New Jersey.

It was found that the pendant cable, which retracts into a slot in the runway, reduces the maintenance requirement on the system and eliminates damage to aircraft previously caused by bouncing of the cable on landing and takeoff roll-overs. Tests were conducted using the F-100, F-106, A4D and various light aircraft. The military aircraft were arrested successfully and the light aircraft showed no indication of being damaged by the cable when in the retracted position. The system is capable of being operated both from the control tower and the pit near the runway.

NA-69-17
CRASH FIRE HAZARD RATING SYSTEM FOR CONTROLLED FLAMMABILITY FUELS, by J. M. Kuchta, A. L. Furno, G. H. Martindill, and A. C. Imhof. Final report, March 1969. 17p. (DS-68-25) (AD 684 089).

A method for rating the potential crash fire hazard of gelled and emulsified hydrocarbon fuels was developed at the request of the Federal Aviation Administration since the use of thickened aircraft fuels may provide a significant reduction in the crash fire hazard. The rating system is designed primarily for screening candidate thickened fuels with respect to their overall flammability hazard under laboratory-scale conditions. The fuel properties included in the rating system are minimum autoignition temperature, flash point, volatility rate, self spread rate, regression or burning rate, flame spread rate, and fire ball size under impact conditions; methods for determining these fuel properties are also described in the report. Experimental data on such fuel properties are presented for JP-4 and JP-5 or Jet A thickened fuels that were formulated with an emulsifying agent or with one of three different gelling agents submitted for evaluation. The results of these determinations and the numerical ratings derived for each fuel composition are discussed.

NA-69-18
AN EVALUATION OF THE C-141 CATEGORY III ALL-WEATHER LANDING SYSTEM, by Lt. Colonel L. B. Marshall. Final report, October 1969. 76p. (RD-69-34) (AD 695 804).

A flight test evaluation of a C-141 All-Weather Landing System (AWLS) proposed for use in Category IIIB landing weather minima was conducted under an FAA-USAF Inter-Agency Agreement at the National Aviation Facilities Experimental Center (NAFEC). Over 300 approaches were conducted under simulated Category III conditions. The primary area of interest was decrab, touchdown and rollout to full stop since the basic AWLS was already certified for operation in Category II landing weather minima. Based on evaluation of the data collected, it was determined that: (1) With appropriate restrictions Category IIIB operations can be accomplished with a system of the type tested in the C-141; (2) When ILS guidance signals are maintained with suitable precision, the C-141 AWLS is satisfactory in the automatic mode for landing in Category IIIB weather; (3) Effective operational restrictions must be defined and enforced to preclude the occurrence of ILS signal disturbances which can be hazardous during the final stages of Category III landing; (4) The C-141 AWLS is satisfactory in the manual mode for monitoring an automatic landing, for go-around from any height, and for rollout on the runway; (5) Although most manual landings were successful, the percentage of success was not the very high level deemed necessary for safety; consequently, the manual mode of the C-141 AWLS is not satisfactory for landing in Category III weather; (6) Intense pilot concentration on the flight director during manual landing seriously affected pilots' ability to assess performance, particularly lateral deviation and drift, in the final stages of landing; (7) Further development of flight directors is required for manual instrument landing; (8) Improvements can be made in various elements of the C-141 AWLS to improve marginal acceptability of those elements.

NA-69-19
EVALUATION OF PROTOTYPE DOPPLER VOR SIDEBAND ANTENNA MONITOR, by V. E. Willey. Final report, June 1969. 99p. (RD-69-27) (AD 689 361).

This report presents the results of evaluation tests of a prototype Doppler VOR sideband antenna monitor. The monitor utilizes a bandpass spectrum analysis technique, as recommended in report No. RD-66-49, for the detection of a faulty sideband antenna. The ability to detect a sideband antenna fault deletes the requirement of two of the three VOR monitors presently used in the monitoring of a Doppler VOR navigational facility.

NA-69-20
EVALUATION OF THE ASDE BRIGHT DISPLAY, by R. L. Tarr. Final report, April 1969. 16p. (RD-69-15) (AD 691 187).

Field tests were conducted at Chicago O'Hare Airport to evaluate the operational use of a bright display for presentation of Airport Surface Detection Equipment (ASDE) radar information in a control tower cab and to determine the effect of the addition of the solid state duplexer on the maintainability and reliability of the radar.

The ASDE Bright Display was fabricated by personnel of the Engineering Design Section, National Aviation Facilities Experimental Center. It consisted of a vidicon camera pickup of the ASDE presentation from a modified ASDE-2 indicator in the tower equipment room and transmission of this information via closed circuitry to a bright display located in the tower cab.

Tests were conducted using both a 12" and a 16" bright display. The air traffic control personnel at Chicago O'Hare International Airport Control Tower functioned as test subjects during the evaluation.

Controller opinion indicated that the ASDE Bright Display was a desirable control tool. This was attributed to the fact that (1) the display presentation was usable in all ambient light conditions and (2) to the smaller cabinet size of the TV monitor for a given screen diameter as compared to the conventional ASDE-2 console. It was recommended that the ASDE Bright Display be adopted for use in airport control towers.

NA-69-21
EFFECTS OF SELECTIVE SYSTEM PARAMETERS ON COMMUNICATIONS INTELLIGIBILITY, by P. J. O'Brien and A. C. Busch. Final report, March 1969. 34p. (RD-68-59) (AD 849 465L).

The communications frequency study was made to facilitate spectrum planning by Federal Aviation Administration Frequency Management personnel. The study relates communications intelligibility to frequency channel spacing, bandwidth, modulation type, and signal-to-interference ratio. The overall approach was to conduct talker/listener intelligibility tests, voice communications equipment tests, and digital communications equipment tests. The test procedure subjected the Speech Communications Index Meter (SCIM) simulated speech signals, the Air Traffic Control (ATC) messages, and the Modified Rhyme Tests (MRTs) to specific levels of interference. The SCIM signal was first applied to the SCIM analyzer for computation and display of articulation index (AI). The ATC messages and MRTs were then recorded at the configuration which produced these discrete values of AIs. These recordings were subsequently used to perform subjective intelligibility testing. Talker/listener intelligibility tests were conducted to determine the particular values of AI required

for communications links within the ATC system using both ATC and MRT vocabularies. Voice and digital communications tests were conducted to obtain data pertaining to channel assignments for various configurations of conventional and proposed operational modes. The calculated AI scores predicted subjective test scores very closely, thus indicating the validity of AI. It has been shown that the project test results may be used as a guide for evaluating channel spacing criteria with respect to signal level, modulation scheme, receiver performance characteristics and intelligibility for many types of fixed and mobile communications systems.

NA-69-22
ANALYSIS OF VORTAC SYSTEM ERROR ACCURACY OF STANDARDS USED BY RADIO (AVIONICS) REPAIR STATIONS, by J. A. Muller. Final report, June 1969. 42p. (RD-69-26) (AD 693 084).

This report covers a survey which was conducted at 103 radio (avionics) repair stations throughout the United States on various models of signal generators used for the calibration of VOR localizer, and glide slope airborne navigation receivers. The survey includes data from four different models of VOR signal generators, four different models of localizer signal generators, and four different models of glide slope signal generators. A statistical analysis is presented which enables prediction of error distributions for radio navigation test equipment used in radio repair stations. The 97 VOR signal generators tested were within the limits of 1.32° and -1.84° (95 percent probability) when results were based on a statistical analysis. The 100 localizer signal generators tested were within the limits of 71.18 and 120.49μA deflection with a standard deflection (90 μA) signal applied, and +6.65 and -6.55 μA on centering when results were based on a 95 percent probability statistical analysis. The 71 glide slope signal generators tested were within 62.85 and 97.17 μA deflection with a standard deflection (78 μA) signal applied, and +4.85 and -5.43 μA on centering when results were based on a 95 percent probability statistical analysis. The report contains a description of the survey, discussion of the results, and recommends possible action to improve present avionics test equipment calibration methods used in the radio repair stations.

NA-69-23
AIRCRAFT PROPELLER VIBRATION MEASUREMENT SYSTEM, by R. C. Dorshimer. Final report, September 1969. 85p. (DS-69-5) (AD 694 009).

A slip ringless propeller-mounted data system has been designed, fabricated and tested for the measurement of propeller blade strain during flight and ground operation of an instrument aircraft. This data system is self-powered through the rotary motion of the test propeller, employs a 16 channel constant bandwidth Frequency Modulated (FM) Multiplex and signals are capacitively coupled from the propeller to the aircraft. The FM Multiplex consists of 17 channels of information including propeller rpm and 16 strain gage channels containing information from dc to 1kHz. An

environmentally protected strain gage installation has also been a consideration of this program.

The FM Multiplex is split into four groups of signals with a frequency translation process in order to conserve bandwidth and/or recording time on an airborne tape recorder. Seven additional data channels are provided on board the aircraft for inclusion of parameters needed to define the aircraft operating condition.

The data system was demonstrated for a period of 50 hours on an engine test stand during which the demodulated signals were observed and additional data were obtained relative to the system stability.

NA-69-24
FLIGHT EVALUATION OF SEAL GLIDE-SLOPE RECEIVER, by J. E. Blazej. Final report, March 1969. 9p. (RD-69-2) (AD 684 090).

Flight tests of two Signal Evaluation Airborne Laboratory (SEAL) glide-slope sensors (receivers) were conducted to evaluate the performance in a real world flight inspection environment. Output data were compared with that of two standard flight inspection glide-slope receivers. The quality of the SEAL data was determined to be higher than that of the flight inspection receivers. It was concluded that the SEAL receivers would perform satisfactorily in the SEAL System. Integration into the System was recommended.

NA-69-25
RETRO-REFLECTIVE MARKERS AS TAXIWAY VISUAL AIDS, by C. B. Phillips. Interim report, June 1969. 30p. (RD-69-29) (AD 689 794).

An investigation was conducted to determine the usefulness of retro-reflective markers to aid pilots in identifying the edges of taxiways. Retro-reflective markers were installed on the edges of two intersecting taxiways and the corresponding fillets. Field observations were made for comparisons among a variety of retro-reflective markers. Laboratory measurements of brightness were made of a number of selected markers. A questionnaire was used to collect pilot observations during operational tests. While intensity of the aircraft light and height of the observer above the surface were factors in the observed brightness of retro-reflective markers, the major factor was the angle formed by the light source, the reflector, and the observer's eye. The smaller the angle the brighter the reflector appeared. It was determined that on a VFR night, blue retro-reflectors were usable to distances of 1,000 feet and more, when illuminated by typical landing lights at typical locations on the aircraft. A study was recommended to optimize location of the aircraft landing and taxi lights. Greatly improved operational use of retro-reflectors could result.

NA-69-26
AN INVESTIGATION OF IN-FLIGHT FIRE PROTECTION WITH A TURBOFAN POWERPLANT INSTALLATION, by E. P. Klueg and J. E. Demaree. Final report, April 1969. 126p. (DS-68-26) (AD 686 045).

The potential explosive and fire hazards and methods of detecting and controlling in-flight fires on modern aircraft powerplant installations were investigated under full-scale simulated low altitude flight conditions. Modifications were made to the pod-mounted turbofan engine test article to extend the program scope beyond the normal range of variables present on the installation. The test program consisted of five studies: (1) environmental conditions producing thermal ignition of combustible mixtures and ignition characteristics, (2) characteristics of nacelle fires, (3) system performance and installation requirements for fire and overheat detection, (4) requirements for extinguishing and controlling fires, and (5) effects of fires and explosions on the powerplant installation. The results of this program are presented as fire safety design criteria and engineering data. The effects of environmental conditions and thermal ignition and the characteristics of ignition are reported as a function of the amount, location, and type of fluid leakage. The size, intensity, radiation level, and propagation rate of nacelle fires are related to flight condition, fluid-type, and fluid leakage characteristics. Fire detection requirements and the feasibility of abbreviated and remotely located sensors are presented as a function of detector operating characteristics. Fire extinguishing requirements are related to the location, size, intensity, and duration of the fires, flight conditions, nacelle ventilation, and the type extinguishing agent and container. The resistance of the nacelle and engine components to fire and explosive damage and means of controlling and preventing the spread of fire are reported.

NA-69-27
A COMPARISON OF NATURAL LIGHTNING AND THE LONG LABORATORY SPARK WITH APPLICATION TO LIGHTNING TESTING, by M. A. Uman. Final report, August 1970. 19p. (AD 712 308).

Laboratory sparks of a few meters length can be used to simulate lightning current rates-of-rise and peak values and to simulate some of the temporal characteristics of the lightning channel temperature. Long-spark generators are inadequate for producing a simulation of the continuing current phase of lightning. Long sparks cannot be used to produce a simulation of the shock wave due to lightning except in that the spark data can be scaled by theory to predict the characteristics of the lightning shock wave. A short discussion is given of the several types of lightning which might be encountered by an aircraft. The validity of long-spark testing in determining the likely points of strike of a lightning discharge to an aircraft or other structure is briefly considered.

NA-69-28
ATCBI-3 ALTITUDE AND IDENTITY READOUT MODIFICATION, by G. H. Mahnken. March 1969. 16p. (RD-69-5) (AD 684 805).

This report deals with technical aspects of the design, development implementation and performance of low-cost equipment modification providing 4096 radar beacon identity code decoding and altitude readout capabilities. It was designed at the National Aviation Facilities Experimental Center (NAFEC) for installation and operational test at Richmond, Virginia, Radar Approach Control Facility. The modification and addition to expand the capabilities of the Air Traffic Control Radar Beacon System (ATCBI-3) to provide 4096 beacon identity code decoding and altitude readout is described. The technical test results indicated that, for the most part, the equipment performed as technically designed, and consistently presented correct identity and altitude readouts. Some equipment problems were uncovered, but were not considered serious in nature or uncorrectable.

NA-69-29
AN EVALUATION OF THE VOR/DME OMNITRAC 1a AREA NAVIGATION SYSTEM, by B. V. Dinerman. Final report, June 1969. 67p. (RD-69-30) (AD 689 360).

Laboratory and flight tests of an area navigation system designated as the VOR/DME Omnitrac 1A were performed at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, and in the air traffic control environment. The flight tests in a Federal Aviation Administration Gulfstream aircraft (N-376) were divided into operational tests between Washington, D. C., and Atlanta, Georgia, and engineering tests between Atlantic City, New Jersey, and Washington, D. C. Subjective and engineering data were obtained. Based on the evaluation of the data collected, it was determined that: (1) Enroute area navigation accuracies were within present airway widths. (2) Flight technical error was the major contributing factor to the total navigation error. (3) The total electronics navigation error, which included the error contribution of the Omnitrac, was small in comparison to the flight technical and total navigation errors. (4) Navigation with the Omnitrac was preferred by the subject pilots over conventional navigation due to the increased operational options associated with area navigation. (5) Control of an aircraft equipped with area navigation equipment minimizes the need for radar vectoring, permits direct and parallel routings, and reduces the communication workload.

NA-69-32
STUDY OF FLAME PROPAGATION THROUGH AIRCRAFT VENT SYSTEMS, by J. P. Gillis. Final report, August 1969. 107p. (DS-68-20) (AD 692 463).

A study was made of flame propagation in a simulated aircraft vent system to provide design criteria for future vent system installations in aircraft. Determinations were made of flame speeds in various sections of the vent system under conditions of ascent, descent and

aircraft-on-ground. Temperature and altitude effect on flame speed were also investigated.

The geometric configuration of the simulated vent system caused momentary flame speeds in excess of 1000 feet per second and the associated pressures developed in some instances exceeded the structural limitations of typical aircraft vent ducts.

Conclusions indicate methods of reducing flame propagation speed in aircraft vent systems.

NA-69-33
EVALUATION OF UNITED STATES AIR FORCE PORTABLE AIRFIELD LIGHTING SYSTEM, by R. F. Gates. Final report, August 1969. 33p. (AD 692 076).

An evaluation of a prototype portable airfield lighting system was conducted for the United States Air Force by the Federal Aviation Administration at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey. The system was designed to provide both day and night visual guidance in VFR and IFR weather straight-in and circling approaches and landings. The system was installed in the approach light system designed to a minimum configuration based on previous tests at NAFEC on simple approach light systems. Comparative tests were conducted using Precision Approach Radar (PAR) in weather conditions of approximately 1/2-mile visibility. Motion picture film was taken of the segment ahead of the aircraft and the PAR scope was photographed three times a second to obtain data on approach light system effectiveness. A post-flight questionnaire also was used to obtain pilot reaction to the effectiveness of the visual guidance received. Data were obtained on circling and straight-in approach guidance in VFR weather conditions. Integrity and reliability data were obtained by USAF personnel stationed at NAFEC but were not included in the report by the Federal Aviation Administration. The very limited weather data obtained in the six-week test period indicated that both systems would provide minimum acceptable visual guidance in 3/4-mile visibility conditions with the alternate approach light system preferred in 1/2-mile visibility conditions primarily due to the additional length of 900 feet (2400 feet versus 1500 feet). The runway edge lighting used in the portable approach light system provided adequate straight-in guidance, but circling guidance was inadequate for both day and night conditions. Several recommendations were made concerning the design of the brightness control, interlocking of system through the console, and the method of supporting the approach and runway edge lighting fixtures.

NA-69-35
EXPERIMENTATION AND EVALUATION OF IMPROVED STALL WARNING EQUIPMENTS, by R. J. Ontiveros. Final report, December 1969. 22p. (DS-69-15). (AD 697 941).

A flight simulation project was conducted at the FAA's National Aviation Facilities Experimental Center at Atlantic City, New Jersey, to determine the relative alerting efficacy of aural and tactile warning signals for

alerting pilots to an impending stall condition. Five pilots with current private flying experience participated as subjects in the evaluation of a continuous warning horn signal, an interrupted warning horn signal, and tactile stickshakers with and without an aural (clacker-type) signal. While performing an intricate in-flight pattern task in a flight simulator, pilots were required to respond to aural and tactile warning signals if and when they were detected. The results show that a stick-shaker warning signal is the most effective means of alerting a pilot (99 percent effective) followed by an interrupted horn (84 percent effective). The continuous or steady horn, currently used in most aircraft, was only 64 percent effective in alerting a pilot. The results also show that aural signals are least detected when the in-cockpit task or workload requires a high degree of pilot attention.

NA-69-36
EXPERIMENTATION AND ANALYSIS OF SITING CRITERIA, by G. F. Spingler. Final report, September 1969. 99p. (RD-69-43) (AD 693 541).

Experimentation and analysis were performed at the National Aviation Facilities Experimental Center (NAFEC), to develop criteria for siting future radar beacons and minimizing reflection problems at existing sites. Reflection study calculations were made to determine the intensity of signals reflected from a standard flat plate. From these computations, nomographs were developed which predicted the maximum range of a reflection and the signal intensity at various ranges from the reflector. At the completion of the reflection study, a number of tests, with practical propagation models, were performed to confirm the theory. The results of the tests at NAFEC showed that the Improved 3-Pulse Side Lobe Suppression (SLS) System effectively reduced reflected replies, provided the reflecting surface was at least 750 feet from the directional antenna. Reflected replies were also reduced appreciably when the signals from the reflector were made to impinge on the surface of the terrain, adjacent to the reflector, at the Brewster Angle of the particular type of terrain. Moderate reductions in the intensity of reflections were provided by modifying a flat plate reflector to a curved, scattering-surface reflector. Means of reducing vertical lobing and reflection problems at future radar beacon sites are presented as well as precautions to be observed in the installation of the transmitter site omni-directional antenna. Two methods of calculating were developed, one for the range to a reflector along the reflection azimuth, and the other for the orientation of the reflector. Also developed was the manner in which reflected replies can be distinguished from ring-around, near-synchronous fruit, and second-time-around targets. Recommendations were made that all future radar beacon sites incorporate Improved 3-Pulse SLS and that the procedures outlined in this report be followed when siting future radar beacon sites.

NA-69-37
EFFECT OF GROUND CRASH FIRE ON AIRCRAFT FUSELAGE INTEGRITY, by G. B. Geyer. Interim report, December 1969. 35p. (RD-69-46) (AD 698 806).

A mathematical model was formulated which permits a calculation to be made of the time required for damage to occur to the aluminum skin covering in aircraft fuselage when it is exposed to maximum spill fire conditions. The damage time was defined as the time required for the aluminum skin to melt. The model was developed through consideration of the heat transfer rates by convection and radiation across a simplified aircraft fuselage configuration. The resulting differential equation was solved using a numerical technique. The results indicate that the minimum time required for skin damage to occur to the largest commercial aircraft now in service is less that 40 seconds. The fuselage damage time predictions, made through the use of the mathematical model, correspond closely with measurements made on simulated aircraft skin configurations employing a 40-foot, stainless-steel-covered section of a four-engine jet aircraft fuselage.

NA-69-38
EVALUATION OF TALL-TOWER LIGHTING, by C. T. Johnson. Final report, June 1969. 23p. (RD-68-53) (AD 691 723).

A prototype of high-intensity rotating obstruction lighting was installed on the KOCO-TV tower at Oklahoma City, Oklahoma, during the period between November 1965 and February 1966. Testing began in March 1966 to optimize the system and obtain operational parameters that would satisfy the requirement of providing obstruction identification for at least 3 miles during 3-mile meteorological visibility conditions. Numerous failures or deficiencies interrupted the tests and extensive system changes were required in design or engineering of the hardware involved. Tests were resumed in September 1966. The variable parameters of the obstruction lighting system were evaluated and selection of the preferred operational characteristics was completed in December 1966. It was recommended that white light be used in a minimum of three beacons for each tower providing 40 flashes per minute in a synchronous mode of operation. Such lighting, along with existing tower marking, was considered adequate for protection of associated guy wires as well as the main tower structure.

NA-69-40
A COMPARATIVE ANALYSIS OF INDIVIDUAL AND SYSTEM PERFORMANCE INDICES FOR THE AIR TRAFFIC CONTROL SYSTEM, by E. P. Buckley, W. F. O'Connor, T. Beebe. Final report, September 1969. 49p. (RD-69-50). (AD 710 795).

A simulation study was conducted at the National Aviation Facility Experimental Center (NAFEC) to examine the relationships of several field facility air traffic controller performance indices with simulation-developed system performance measures. Thirty-six air traffic controllers

ranging in age from 31 to 45, from four Air Route Traffic Control centers served as test subjects. The study encompassed performance criteria developed within two distinct environments; namely, the controller's home facility where he controlled live traffic, and a specifically designed micro-system or "one-man ATC system" in a dynamic simulation environment at NAFEC. Thus, the experiment represented a comparative examination of several quantitative measures of system functioning derived from air traffic control simulation and, simultaneously, an investigation of these measures as indices for the objective evaluation of the individual air traffic controller. The study presents estimates of the relationship between various performance measures and evaluation indices. Data from the micro-system model suggested a new system performance criterion which was found sensitive to system load differences.

NA-69-42
VISUAL ILLUSION PROBLEMS, by G. E. Rowland and J. F. Snyder. Final report, September 1970. 43p. (RD-69-49) (AD 711 766).

A literature search was made concerning purely visual illusions which might originate from lighting or marking of aircraft and which might induce pilots to become involved in near-misses or collisions. (The study specifically avoided vestibular-induced illusions.)

A number of areas have been identified as potentially capable of causing illusions to pilots. These have included the geometrical illusion; after-effects with particular reference to figural after-effects; hypnogogic hallucinations; expectancy (or mental set) and unexpected events; interactions between kinesthetic and visual stimuli; personality variables in response to after-effects and illusions. Recommendations are made for a wide variety of researches but specific attention is drawn to making improvements in the way pilots are taught to utilize their visual sense and research on after-images and figural after-effects. These two effects have received little aviation-related research but hold some likelihood of being a serious source of illusory perception to pilots. In general, further research in illusions should be quite limited since the effects they create are probably not causing much trouble. A small research program on figural after-effects appears warranted at this time and is recommended.

NA-69-43
AN ENGINEERING INVESTIGATION AND ANALYSIS OF CRASH-FIRE RESISTANT FUEL TANKS, by M. M. Yancey and R. T. Headrick. Final report, June 1970. 54p. (DS-69-7) (AD 709 846).

Techniques investigated apply to integral tanks and bladder cells as well. General contributions include prevention of original penetration, containment of penetration, maintenance of fuel integrity even with failure of above two systems; change in characteristics of fuel expulsion from major wound to non-vapor, low flow liquid leak; flame and explosion

suppression and surge attenuation. Proper selection of "building blocks" to optimize desired performance characteristics indicates a major contribution is available with slight, almost unmeasurable displacement of usable fuel and addition of weight. Structures so protected may be inspected.

NA-69-44
BEACON NUMERICS ON RBDE-5 DISPLAY, by J. J. Scavullo. Final report, December 1969. 66p. (RD-69-54) (AD 702 089).

The Air Traffic Control Radar Beacon System (ATCRBS) was modified so as to expand the decoding capability at the indicator site of Air Traffic Control Radar Beacon Interrogator (ATCBI-3) to 4096 discrete identity codes. An Altitude Code Processor was developed to process transponder replies to Mode C interrogations. Radar Bright Display Equipment (RBDE-5) was augmented with Numerics Display Generators. The resulting Beacon Numerics Display System was implemented at Air Route Traffic Control Centers (ARTCC) at Atlanta, Georgia, and at Indianapolis, Indiana, as a tool for use in evaluating the operational utility of beacon numerics on the RBDE-5 displays.

During engineering tests and flight checks with transponder-equipped aircraft, the System performed all its processing and display functions reliably. Visual formats containing the identity codes and processed altitude data were generated in real time concurrently with scan conversion of beacon video so that the numerics were synchronous with the TV raster. Altitude data in the formats were well within tolerances for correspondence prescribed for air traffic control. Although the pilot model did not have sufficient capacity to serve as a prototype, it was concluded to be technically feasible to implement reliable real-time decoding of 4096 beacon identity codes, processing of altitude replies, and presentation of beacon numerics near the corresponding discrete targets on RBDE-5 displays. It was recommended that a plan be established to implement beacon numerics in operational facilities, and to continue operation of the pilot models for further development of procedures. A study also was recommended to determine whether beacon identity codes could be assigned as primary aircraft identifiers in place of flight numbers or registration numbers.

NA-69-47
A METHOD FOR COMPUTER SIMULATION OF AIRPORT SURFACE TRAFFIC, by E. J. Dowe. Final report, October 1969. 55p. (AD 694 958).

A method of simulating airport surface traffic using a fast-time digital simulation technique is presented in this report. The control process that regulates airport traffic (both aircraft and ground vehicles) is described, and it is proposed that the airport surface environment be handled by taxiway and terminal subsystems. A method of approach is described for generation of the traffic samples, route selection, conducting the simulation, and validation of its results. It was concluded that

digital simulation methods are feasible to produce quantitative improvements in the use of the airport surface. A bibliography of references is included.

NA-69-50
TEST AND EVALUATE DUAL DIVERSITY FOR AIRPORT SURVEILLANCE RADARS (ASR), by D. L. Offi. Final report, December 1969. 37p. (RD-69-56) (AD 698 807).

A frequency diversity modification was developed for the National Aviation Facilities Experimental Center (NAFEC) Airport Surveillance Radar -5 (ASR-5) test bed. The modified system was evaluated to determine the extent of performance improvements realized with this technique. Radar system tests indicated the modification had little effect on normal single channel maintainability, and resulted in an improvement in reliability because of an increase in available radar service. Detection capability tests showed a significant increase in probability of detection for both the analog system, and for the Radar Video Data Processor (RVDP) operating in conjunction with the ASR-5. It was recommended that a prototype frequency diversity modification, similar to that employed in these tests, be considered for field implementation.

NA-70-1
OPERATIONAL TEST AND EVALUATION OF DAIR, by R. L. Tarr and R. J. Sule, Capt. USAF. Final report, April 1970. 66p. (RD-70-5) (AD 704 828).

This report describes operational testing conducted to evaluate the functional capability, operational utility, and system reliability of the Direct Altitude and Identity Readout (DAIR) beacon numeric decoding and display system. Operational testing was essentially a dynamic simulation effort, using a representative terminal facility/geographic air traffic control environment. Project activity was a joint effort between Federal Aviation Administration (FAA) and Department of Defense (DOD), with civilian and military personnel participating at all levels.

Test data were obtained from recordings of measurable controller workloads, system performance, and subjective comment from all project participants. Comparative tests were conducted between present-day FAA and DOD passive beacon decoding systems and the DAIR system active readout. Quantitative results were statistically analyzed to obtain any significant differences between the systems tested. Controller comments and opinions were recorded and summarized for presentation as subjective results. Special tests were conducted to obtain controller opinion regarding the use of the DAIR-derived center mark as a separation resolution factor, and the effect of the DAIR presentation with regard to certain secondary radar phenomena. Comments and opinions expressed during the special tests were recorded and summarized for subjective presentation. Limited live testing was conducted to confirm that the simulated inputs and displayed information were reasonably representative of the live radar environment.

Results of the operational testing indicated that the DAIR system was functionally sound. Operational utility and application of the active beacon numeric readout were desirable and enhanced operations in the tested environment. Reliability of the DAIR equipment during operational testing was very good. DAIR center mark did not provide better separation resolution capability. Effects of secondary radar phenomena, though noticeable, were neither distracting nor detrimental to control functions.

NA-70-2
INVESTIGATION OF ICE ACCRETION CHARACTERISTICS OF HYDROPHOBIC MATERIALS, by D. M. Millar. Final report, May 1970. 20p. (DS-70-11) (AD 712 712)

To determine their effectiveness as anti-icing agents, 23 hydrophobic materials were evaluated in a dynamic icing environment. Each substance was examined in a manner that would determine its ice accretion characteristics and ice release properties. No attempt was made to stimulate ice release by either thermal or mechanical means during individual test runs. Ice formed on all the materials which were investigated at the same rate as on the untreated aluminum wing section which was utilized as a test bed. There was no observed release of ice due to aerodynamic forces associated with the test velocities (110 to 150 knots). The minimum ice adhesion force of any product evaluated was 1.8 pounds per square inch, with maximum values in excess of 40 pounds per square inch.

NA-70-3
EVALUATION OF AREA NAVIGATION IN THE NORTHEAST CORRIDOR, by B. V. Dinerman. Final report, January 1970. 111p. (RD-69-53) (AD 699 183).

The Federal Aviation Administration, Eastern Airlines, and two area navigation equipment manufacturers participated in an area navigation evaluation in the northeast corridor. Area navigation equipment was installed in two Eastern Airlines DC-9 aircraft assigned to commercial shuttle flights between La Guardia Airport, New York; National Airport, Washington; and Logan Airport, Boston. Special area navigation routes, operational procedures, and an evaluation plan were developed.

To support operational conclusions, aircraft space position data were collected during flights over area navigation routes and conventional victor airways. The prime measurement source was the New York Air Route Traffic Control Center surveillance radar and secondary beacon radar with a beacon video digitizer output to a specially developed magnetic tape recorder. The final format of the measurement data analysis consisted of statistical computations of the lateral deviations of the aircraft from the desired course. Measurements were made during a total of 223 flights on four area navigation routes and a total of 117 flights on four conventional routes. The measurements of the conventional navigation flights on the preferred victor airways were made for comparison purposes.

Based on the evaluation of the data collected, it was determined that:

1. The total navigation errors from area navigation and conventional navigation flights over the test routes were similar.

2. The total navigation errors from the area navigation flights over the test routes were essentially well within the amount of airspace normally protected for the corresponding conventional routes.

NA-70-4
EVALUATION OF A CHEMOSENSOR FOR DETECTING DYNAMITE ABOARD AIRCRAFT, by S. V. Zinn, Jr. Interim report, March 1970. 25p. (DS-70-5)

Tests were performed to determine acceptance and/or operational limitations of a laboratory device designed to detect dynamite by odor. The function of the machine is to combat bombing sabotage of aircraft by sampling air vapors within an aircraft prior to takeoff and signaling the presence of dynamite. The tests proved that the machine was very reliable in detecting exposed sticks of dynamite in an enclosed room, but detection was questionable when the dynamite was confined in a container. The conclusions indicate that the Chemosensor represents a substantial step in the direction of a workable production device, but considerable further research will still be required to attain that goal.

Distribution of this report is controlled. Application for copies may be made to FAA Headquarters in Washington, D. C., attention RD-700.

NA-70-5
DEVELOPMENT OF A BASIC METHODOLOGY FOR PREDICTING AIRCRAFT STOPPING DISTANCE ON A WET RUNWAY, by O. W. Preston, Dr. G. W. Kibbee, R. H. Muroyama and R. A. Storley. Final report, March 1971. 116p. (RD-70-62) (AD 721 165).

Studies and tests were conducted to develop a basic methodology for predicting the test aircraft stopping distance on a wet runway. Development consisted of a series of wet and dry runway tests utilizing the FAA Variable Slip Runway Friction Tester and an instrumented non-flyable test aircraft followed by an analysis of the test results using an analog computer simulation of the aircraft. A relationship was established between wet runway friction measured by the friction tester and friction available to the braking wheels of the test aircraft. The methodology consists of using this relationship and an analog computer aircraft simulation, incorporating actual anti-skid and braking system hardware, to prepare a nomograph showing aircraft stopping distance as a function of the runway friction measured by the FAA Variable Slip Runway Friction Tester. Correlation exists between friction measured by the friction tester and friction available to the tires of the test aircraft when normalized with respect

to theoretical hydroplaning velocities. The relationship is that μ $MAX_{A/C}$ equals 0.59 times μ MAX_T when the ratio between aircraft and friction tester velocities was equal to the ratio between their respective theoretical hydroplaning velocities.

NA-70-6
STUDY OF TURBINE ENGINE OPERATION WITH GELLED FUELS, by R. F. Salmon. Interim Report, May 1970. 25p. (DS-70-6) (AD 711 765).

Three types of gelled Jet A-1 fuels were tested to determine the compatibility of the thickened fuels with typical turbojet engines. The three fuels were: (1) Gel A, a 2-percent concentration of a styrene polymer additive in Jet A-1, (2) Gel B, a 2-percent concentration of a sodium-free styrene polymer additive in Jet A-1, and (3) Gel C, an aluminum octoate gel in Jet A-1, concentrations ranging from 0.2 to 1.0 percent. The two polymer gels had a 13,000-centipoise reading on the Brookfield Viscometer, RVT model, and the aluminum octoate ranged from 2,800 to 13,000 centipoises. Spray pattern tests were run with the fuels and a 1-hour engine test was conducted on a J47 engine. Comparison of engine performance when using regular JP-4 and polymer gelled Jet A-1 fuels indicated that the gel did not markedly affect the engine performance in the power range from 70 to 95 percent of rated engine r/min. The polymer gels, however, could not be used from engine light-off to idle power in the J47 engine since they required higher fuel manifold pressures for vaporization than the engine could produce during the starting sequence. A 15-minute test using Gel A was conducted on a J57 engine. When operating the J57 engine, the Gel A was used from light-off to maximum power, and no difficulty was experienced in running the unmodified engine with this fuel. Gel C could not be used successfully in the J47 engine even when providing fuel manifold pressures of 250 psi, corresponding with 82 percent of rated engine rotor speed. Combustion could not be maintained and a relight could not be effected when switching back to JP-4 fuel. Preliminary chemical analysis of a combustion can, after 1 hour of engine operation using the sodium-free polymer Gel B, indicated no corrosive effects or excessive carbon buildup in the combustion chamber.

NA-70-7
EVALUATION OF LORAN-C/D AIRBORNE SYSTEMS, by G. H. Quinn. Final report, April 1970. 81p. (RD-70-10) (AD 705 507).

The performance of three Loran-C airborne receiver/computer systems was investigated during flights in the U. S. Northeast Corridor to determine the feasibility of using Loran-C signals and equipment to navigate V/STOL vehicles in that area. Flight tests were conducted in a C-130 and DC-6 fixed wing aircraft, and a CH-47C Helicopter. Tracking radar was used on several of the flights to determine the airborne Loran-C equipment accuracy. Oscilloscope photographs of the received signals and strip

chart recordings of the received 50 kHz to 150 kHz spectrum were used to establish the Loran-C signal, noise, and interference conditions throughout the Northeast Corridor. Test results showed that existing Loran-C signals and the systems did establish aircraft positions from the ground to operating altitudes in the Northeast Corridor. However, the equipment interfering signal rejection ability and reliability were not adequate for immediate operational use.

NA-70-8
AN EVALUATION OF THE VECTOR ANALOG COMPUTER, MODEL 5A, AREA NAVIGATION EQUIPMENT, by J. J. Wojciechowicz and R. J. McFadden. Final report, May 1970. 96p. (RD-70-11) (AD 705 991).

Laboratory and flight tests were conducted at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, on a Vector Analog Computer, Model 5A, Area Navigation Equipment. Based on the test results, it was concluded that: (1) The area navigation equipment input bearing processor minimizes the effect of certain VOR and TACAN azimuth signal perturbations. A bearing lag is introduced, however, that is proportional to the aircraft radial crossing rate; (2) The area navigation equipment permits navigation with accuracies generally equal to or better than those provided by conventional navigation equipment; (3) The area navigation equipment permits locating an airport within "line-of-sight" distances of the guidance VORTAC and, under certain conditions, completing straight-in approaches to non-instrumented runways; (4) Linear display of lateral deviation, with appropriate scale sensitivities, is generally more desirable than an angular display of deviation, especially at longer ranges.

NA-70-9
EVALUATION OF TAXIWAY GUIDANCE SIGNS, by R. F. Gates and C. B. Phillips. Interim report, January 1970. 31p. (RD-69-60) (AD 699 914).

Taxiway guidance signs, 3 feet high and 4 feet wide of a type similar to those used on highways, were evaluated for airport use by means of simulation and actual field trials. Retro-reflective sheeting of red, yellow and green colors was evaluated for color coding application in a taxiway guidance system. Legends, 18 inches in height, were prepared from white enamel and silver retro-reflective sheeting on a red background, black paint on a yellow background and white enamel on a green background. Retro-reflective discs also were used on the legends for the red and green signs. The discs provided excellent long-range targets but legibility deteriorated as the signs were viewed at distances of 500 to 600 feet and less due to the increased angle from the aircraft light to the sign and the pilot eye, coupled with the white paint appearing black to the observer at these ranges. Tests also were conducted on sign illumination provided by a light source located ahead and below the signs. Test results showed that the signs would provide additional advantageous cues to pilots through means

of color coding with (1) red used on the more critical areas such as runway crossings and Category II restricted movement areas, (2) yellow used on all movement areas not requiring red, and (3) green used on and in the vicinity of the apron for informational type guidance such as gate positions and destination identification.

NA-70-10
AN INVESTIGATION OF THE CHARACTERISTICS OF THE NAFEC PHOTOTHEODOLITE SYSTEM UNDER CONDITIONS OF HIGH-ALTITUDE, CLOSE-IN TRACKING, by V. J. Luciani. Final report, January 1970. 17p.

A flight test was conducted to acquire phototheodolite positioning data under conditions of high-altitude, close-in tracking for the purpose of evaluating the characteristics of high-altitude phototheodolite information. Comparison was made of phototheodolite height information from test flights at 5000 feet altitude and 20,000 feet altitude. The standard deviation of height data at the lower altitude was 9.2 feet as compared to a standard deviation of 26.7 feet at the higher altitude.

NA-70-11
A STUDY OF THE COMPATIBILITY OF A FOUR ENGINE COMMERCIAL JET TRANSPORT AIRCRAFT FUEL SYSTEM WITH GELLED AND EMULSIFIED FUELS, by A. T. Peacock, R. F. Hazelton, L. S. Gresko and L. D. Christensen. Final report, April 1970. 183p. (DS-70-1) (AD 714 030).

The rheological and physical properties of four gelled and three emulsified turbine fuels were evaluated. One gelled and one emulsified fuel were selected for further test and analysis in a compatibility study with a four engine commercial jet transport aircraft fuel system. Full scale testing of system components was performed. Penalties and problem areas associated with using the fuels were identified by an analysis of the fuel system. A full-scale ground test program to evaluate an aircraft fuel system's performance on thickened fuels was outlined. Results show significant decreases in available fuel and large increases in system weights are associated with the use of the thickened fuels described. Substantial fuel development is indicated before application to commercial aircraft.

NA-70-12
LET-DOWN GUIDANCE SYSTEM, By G. D. Adams. Final report, April 1970. 45p. (RD-70-6) (AD 704 476).

A small airborne analog computer which converts distance and barometric altitude inputs into vertical guidance signals is described. The output of the computer is presented on a conventional crosspointer instrument

for use by a pilot. The guidance function may be a two-segment approach to land for noise abatement, a one-segment approach to land where no groundbased instrument landing system (ILS) exists, an altitude hold signal, or a climb to a preassigned altitude and distance. Limited accuracy tests have been conducted and an operational field evaluation is underway. Engineering design changes and improvements continue in support of the field evaluation.

NA-70-13
TECHNICAL EVALUATION OF INTERROGATOR SET AN/TPX-42 TYPE III AND TYPE IV SYSTEMS (DIRECT ALTITUDE AND IDENTITY READOUT), by A. D. Bradley. Final report, May 1970. 145p. (RD-70-14) (AD 705 992).

The AN/TPX-42 Direct Altitude and Identity Readout (DAIR) equipments, Type III, Department of Defense (DOD) Radar Approach Control Centers (RAPCON's) and Radar Air Traffic Control Centers (RATCC's) and Type IV, Federal Aviation Administration (FAA) Low Density Terminal Radar Control (TRACON) Systems, were evaluated to determine their capability of extracting and decoding beacon identity and altitude replies and displaying them, in an acceptable form, on a plan position indicator (PPI) presentation. The technical tests included preparatory measurements of the radar site parameters and fruit environment. Both the Type III and Type IV Systems were subjected to tests involving pulse, reply, target, and code processing. Range and azimuth resolution and accuracy tests were performed in addition to an examination of the display processor functions. The maintainability aspects of both systems were investigated during the entire evaluation period. Flight tests were conducted on both systems to investigate the ability of the DAIR equipment to perform its functions in a controlled, live environment. The results of the tests demonstrated that the AN/TPX-42, Type III and Type IV Systems, effectively perform the designed functions of decoding, processing, and displaying beacon identity and altitude replies. The systems are technically acceptable for use in an Air Traffic Control (ATC) terminal environment, and are compatible with their associated radar and beacon systems. The systems are maintainable and, with additional troubleshooting aids, the time required to restore the equipment to operation after a failure can be reduced.

NA-70-14
ENGINEERING SURVEY AND ANALYSIS OF EN ROUTE ATC RADAR/DISPLAY SYSTEM ERRORS by R. H. Holliday. Final report, October 1970. 44p. (RD-70-46) (AD 713 011).

En route radar (primary and secondary) range and azimuth accuracy data were collected from other projects and analyzed, along with theoretical considerations, to determine if the available accuracy data were adequate for assessing the position measuring performance of en route, Air Traffic Control Radar/Display Systems.

NA-70-15
NEW YORK AIR TRAFFIC CAPACITY STUDY, by H. F. Slattery. Final report, February 1970. 112p. (RD-70-7) (AD 702 779).

A simulation study to determine the operational benefits resulting from a plan designed to increase airspace and airport capacity in the New York Area was conducted at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey.

The study included terminal area operations and two different segments of the en route environment. The operational plan submitted for evaluation used area-navigation as the prime method of aircraft guidance, assumed that additional runways were available at Newark and Kennedy Airports, and the aircraft would be metered into the terminal area.

It was concluded that features of the operational plan increased the operation rate of the entire New York Terminal Area by more than 50 percent, the departure operation rate of the en route area by 140 percent, and the arrival operation rate of the en route area by 97 percent. It was further concluded that the increased terminal capacity was due more to the additional runways at Newark and Kennedy than to the terminal track system associated with the area-navigation. However, the area-navigation and track system concept contributed greatly to the increase in operations rates within the en route area.

NA-70-16
CHARACTERISTICS OF FIRE IN LARGE CARGO AIRCRAFT (PHASE II), by J. J. Gassmann. Final report Sept. 1970. 21p. (RD-70-42) (AD 713 914).

The degree to which fire in large cargo compartments may be suppressed by shutoff of ventilation was investigated. Results of the tests indicated that this action alone would not protect the fuselage of large cargo aircraft from severe fire damage.

Peak air temperatures occurring during fire increased significantly with increasing compartment size from 1,000 to 2,000 cubic feet and were similar with further increase in size to 5,000 cubic feet. Temperatures in the order of 1,800°F were reached in these larger compartments.

An increase in percent loading resulted in a more severe fire condition for compartment volumes of all the sizes used in this program.

A single cargo fire test indicated the use of bromotrifluoromethane at the time of detection and ventilation shutoff may be an effective means of greatly reducing peak temperatures and pressures and providing a longer control time.

NA-70-17
CRITERIA FOR AIRCRAFT INSTALLATION AND UTILIZATION OF AN EXTINGUISHING AGENT CONCENTRATION RECORDER, by G. Chamberlain. Final report, March 1970. 74p. (DS-70-3) (AD 712 191).

For a number of years, the Federal Aviation Administration (FAA) has been active in the field of testing and evaluation of aircraft powerplant fire-extinguishing systems. In this area, the FAA has supplied the specialized test equipment and experienced personnel necessary for such testing and has been, essentially, the sole organization providing these services within the United States. This report describes the specialized test equipment, provides criteria for the installation and operation of this equipment, and provides the guidelines for utilization of the equipment for the conduct of meaningful test programs.

The extinguishing agent concentration recorder, as specialized gas analyzer test equipment, and its operational principle are described. Guidelines are presented for the location and installation of extinguishing agent concentration sampling probes within the test article. Also included in the report are sections concerning importance of agent distribution system conformity; factors which influence agent distribution and concentration; suggested flight and ground test procedures; the relative importance of flight tests and ground tests with and without supplemental airflow; and test data form, reduction, interpretation, and presentation. The value and recognition of the utilization of the gas analyzer test equipment as the most effective means of determining the performance of an aircraft extinguishing system are also discussed.

NA-70-18
EVALUATION OF A LOW-COST VISUAL APPROACH SLOPE INDICATOR (VASI) AS A PILOT TRAINING AID, by W. G. Crook. Final report, May 1970. 47p. (DS-70-4) (AD 707 040).

The purpose of this project was to determine the effectiveness of a simple low-cost Visual Approach Slope Indicator (VASI) in developing and reenforcing proper aircraft control technique during approach and landing under actual pilot training conditions. A simplified two-box, single-lamp system was evaluated at two pilot training schools which summarized the results of training given to comparable groups of student pilots instructed with and without the use of the abbreviated VASI.

Results showed that the simplified VASI made flight instruction easier enabling the students to quickly grasp the fundamentals of final approach glide path control. VASI-trained students made better, safer approaches earlier in their training than the regular students trained without it and had no trouble subsequently landing without benefit of the system during daylight or nighttime approaches.

The system provided reliable visual guidance and good sensitivity for glide path control within its design capability of 1 to 1.5 miles. Maximum benefit

of the system appeared to be derived during night approaches where judgement of altitude is difficult.

NA-70-19
ALTIMETRY - A Literature Review and Bibliography, by J. J. Shrager. Final report (Phase I), September 1970. 106p. (RD-70-52) (AD 713 010).

The Federal Aviation Administration is interested in disseminating information which could be used by the aviation community to promote safety and economy. This document has been prepared to assist both government and the aviation industry in the design, maintainability and reliability of altimeter systems.

NA-70-20
FEASIBILITY STUDY AND INITIATING SYSTEM DEVELOPMENT OF THE EXPLOSIVE EXIT CONCEPT FOR CIVIL TRANSPORT AIRCRAFT, by J. J. Jaglowski, Jr. Final report, April 1970. 50p. (DS-70-8) (AD 704 477).

This feasibility study and system development demonstrated the use of liquid explosives to provide emergency exits in commercial transport aircraft. During the course of the study, linear-shaped tubing systems of various designs and materials were fabricated and tested in an attempt to obtain the best cutting efficiency with a minimum of explosive charge. Energy-absorbent shields molded from liminated fiberglas-reinforced plastics were fabricated and evaluated. The purpose of the shield was to provide protection against overpressures and fragments produced as the result of the detonation of the linear-shaped charge. A system to automatically mix the two components while simultaneously pumping them into the linear-shaped tube loop and to initiate the charge was designed fabricated, and tested.

NA-70-21
SIMULATION OF A CONTINUOUS RUNWAY CENTERLINE MARKING, by G. S. Brown and R. L. Sulzer. Interim report, August 1970. 32p. (RD-70-40) (AD 711 254).

A simulation study was conducted to compare a continuous runway paint marking with the U. S. standard broken centerline stripe under low-visibility conditions. Overall results showed no strong preference for the guidance value of the continuous centerline. Despite this, the most experienced pilots reported advantages in the continuous mark in that it could be seen farther in reduced visibility and gave slightly better guidance; however, they indicated only a moderate strength of preference. Highlighting one advantage of an interrupted certerline marking, pilots stated the need for speed information. A strong chance was noted that the location of the markings could be confused if the present standard system were revised by exchanging the locations of interrupted and continuous markings. Pilots also reported that VFR as well as instrument runways need to have a common marking. The preferences and comments of the most experienced subject pilots suggest that the present centerline could be improved for low-visibility

operations by reducing the length of the gap, without giving up the benefits of speed information, while retaining the broken centerline concept.

NA-70-22
ATS-1 VHF COMMUNICATIONS EXPERIMENTATION, by F. W. Jefferson. Final report, June 1970. 87p. (RD-70-12) (AD 707 446).

Eight flight tests were conducted utilizing the Applications Technology Satellite-1 (ATS-1) to obtain characteristic data of VHF communications links via satellite relay for use in over-ocean air traffic control subsystem design studies. Measurements of signal level, signal plus noise-to-noise ratio, multipath propagation, voice intelligibility, adjacent channel interference, and 75, 1200, and 2400 bits-per-second digital communications performance were obtained. Results of the tests are discussed in the report and reviewed in the "Summary of Results" section. In general, overall communications reliability using the ATS-1 link was considered marginal.

NA-70-23
ACCELERATED TESTING OF GENERAL AVIATION ENGINE EXHAUST SYSTEMS, by G. Slusher. Final report, February 1970. 34p. (DS-70-2) (AD 701 759).

An accelerated test procedure was developed for possible use to enhance and demonstrate the airworthiness of exhaust systems of single-engine aircraft incorporating exhaust gas-to-air heat exchangers. The exhaust systems of seven aircraft were endurance tested on engine stands to determine if the types and times of failures occurring during the tests were similar to failures occurring in aircraft and to identify design features for minimizing hazards. Evaluation of an exhaust system fabricated of a more corrosion-resistant material was included. Testing was conducted either until failure occurred or 600 test hours were accumulated.

The accelerated test schedule and procedure produced failures comparable to those occurring in aircraft with 1 hour of testing equivalent on the average to 3.8 hours of operation in aircraft. It was concluded that the utilization of more corrosion-resistant, nickel-iron-chromium material would significantly reduce or eliminate those exhaust system failures resulting from high-temperature oxidation or corrosion, and that muffler failures and related carbon monoxide hazards could be minimized by the design and construction of airtight cabin ventilating systems in conjunction with the incorporation of muffler designs of the axial flow through type fabricated of a more corrosion-resistant material.

NA-70-24
INERTIAL NAVIGATION SUPPORT, PHASE III, by R. H. Mayer. Final report, March 1970. 72p. (RD-70-3) (AD 702 090).

This report considers several aspects of the use of inertial navigation and guidance in the U. S. Domestic Air Traffic environment. It presents flight

test data taken on regular scheduled commercial cargo jet aircraft flights of the Sperry SGN-10 Inertial Navigation system (INS). It further presents an operational study of inertial guidance as compared with the present VORTAC system of navigation.

The results of the data analysis and the study indicate that it is feasible to use inertial navigation during the en route portion of the flight and that benefits can thereby be obtained. It also shows that very little use of the system could be realized in the terminal areas under the present standard instrument departures (SIDs) and approach procedures. A cost-benefit study showed that the cost of operation and ownership exceeded the benefits derived unless the cost of operation was prorated with some other service, such as international guidance.

NA-70-25
FIRE TEST CRITERIA FOR RECORDERS, by T. Rust, Jr. and P. N. Boris. Final report, July 1970. 49p. (DS-70-16) (AD 708 814).

Tests were conducted to investigate fire test criteria as applied to flight data and cockpit voice recorder systems and material. Studies were made to determine the effect of elevated temperature on various types of recording tapes and highly conspicuous exterior coatings which could be applied to recorder covers. Open flaming and enclosed furnace tests were performed on complete recording units in order to obtain data for formulating improved standardized laboratory test methods suitable for evaluating survivability of flight data and cockpit voice recorders in a crash-fire environment.

NA-70-26
TEST AND EVALUATION OF AN ADVANCED INTEGRATED LANDING SYSTEM FOR ALL-WEATHER LANDING, by V. L. Bencivenga. Final report, August 1970. 150p. (RD-70-28) (AD 714 442).

Test and evaluation of an Advanced Integrated Landing System (AILS) was conducted at the National Aviation Facilities Experimental Center (NAFEC) Atlantic City, New Jersey. The AILS is a microwave, scanning beam system and provides precision azimuth and elevation guidance signals to an aircraft. The system incorporates a distance measuring equipment (DME) function, as well as a radar function for providing precision approach radar (PAR) type monitoring of an approach. During the test program, AILS approaches were made in fixed-wing aircraft, both prop and jet, including short take-off and landing (STOL) aircraft. Based on evaluation of the data collected, it was determined that (1) the AILS is capable of providing air-derived space position information to the following accuracies: DME data to $\pm$100 feet or 1 percent of distance, whichever is greater, azimuth angle data to $\pm$0.05° 1 sigma, and elevation angle data to $\pm$0.03° 1 sigma; (2) the system is not adversely affected by overflying aircraft, and taxing aircraft and/or other vehicles only affect performance when stopped so that they effectively shadow a transmitting antenna; (3) some minor system deficiencies exist. Proposed corrective measures are discussed.

NA-70-27
EVALUATION OF TAXIWAY CENTERLINE LIGHTING FOR RUNWAY EXITS AND TAXIWAY INTERSECTIONS, by C. B. Phillips. Final report, May 1970. 48p. (RD-70-15) (AD 711 764)

An evaluation was conducted on green taxiway centerline lighting to determine the feasibility of its continuance across runways to maintain continuity of taxiway guidance and use in runways on short radius curves leading into taxiways for reducing runway occupancy time. It was determined that green taxiway centerline lighting can be used in the surface of runways to provide (1) exit guidance on short radius curves and (2) continuity of taxiway guidance across runways. By color coding green the three runway centerline lights opposite the "throat" of a taxiway used for exit purposes, a method of providing visual aids for reducing runway occupancy time resulted. Other findings concerned the need for wide beam fixtures adjacent to intersections consisting of straight sections of centerline lighting, a method of determining the minimum number of fixtures on short straight sections, and a hold bar of three yellow lights spaced 5 feet apart as a minimum adequate configuration for providing an imminence of intersection signal--also applicable for holding aircraft clear of intersecting runways and taxiways. Low-profile green reflectors were found effective as a low cost means of marking curved exits from the runway centerlines into the "throats" of taxiways for night operations.

NA-70-28
LORAN-C COMPUTER EVALUATION, by G. H. Quinn. Final report, July 1970. 108p. (RD-70-23) (AD 708 063)

An evaluation has been completed at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, of the AN/AYA-4 airborne, Loran-C hyperbolic coordinate converter, and general Navigation Computer. The AN/AYA-4 Navigation Computer was developed by the instrument division of Lear Siegler, Inc., of Grand Rapids, Michigan, under the provisions of a joint FAA/U. S. Coast Guard contract. The AYA-4 accepted inputs from (1) Loran-C receiver, (2) Doppler navigator, (3) VOR, DME, and TACAN Systems, and (4) dead reckoning information. Laboratory and fflight tests were used in the evaluation. Flights were in a Coast Guard C-130 and an FAA KC-135 aircraft. Flights near NAFEC were tracked by an instrumentation radar unit to provide accuracy figures. A North Atlantic crossing was completed in the KC-135 where the North Atlantic and Norwegian Sea Loran-C chain was used. Test results showed that the AYA-4 Navigation Computer had the capability to provide guidance information to the pilot and to the automatic flight control system. The reliability of the AYA-4 computer needs much improvement before acceptance of the system can be seriously considered.

NA-70-29
BEACON VIDEO DIGITIZER (BVD) STATIC TEST RESULTS, by M. H. Holtz, Interim report, July 1970. 112p. (RD-70-32) (AD 709 161)

This report describes the test methods employed and the results obtained during the test and evaluation of the Beacon Video Digitizer (BVD).

A test bed was established to record BVD Target Reply and Target Report outputs on a digital computer.

Technical tests were conducted to determine the characteristics of the BVD Standardizer, Garble Detection Logic, and Beam Splitting Logic, and establish the function of the Code Validation and Target Detection circuits. Additionally, tests were conducted to determine the capability of the Storage Tube Defruiter to eliminate non-synchronous returns (Fruit) and its effect on target reliability and BVD target code validation.

The test and evaluation program established the base line standards of performance for the Digitizer. Further, the BVD test bed was used in a computer analysis of several Air Traffic Control Radar Beacon Systems (ATCRBS) environments.

It was concluded that the BVD should operate with a Sliding Window size of eight bits and a Lead Edge and Trail Edge Threshold criteria of two hits and one hit, respectively. The Storage Tube Defruiter was determined to be an effective means of eliminating Fruit; however, it decreased the target reliability approximately 15 to 20 percent.

NA-70-30
EVALUATION OF TACAN CW INTERFERENCE MODIFICATION, by G. J. Hartranft and H. Postel. Final report, September 1970. 38p. (RD-70-53) (AD 711 255).

This report presents the results of laboratory and field tests of a NAFEC-developed modification designed to alleviate the CW interference problems that have been suspected of causing outages of GRN-9 and RTB-2 TACAN (transponder) ground systems. Previous investigation (Report No. RD-67-7, Project No. 330-006-04X "TACAN CW Interference" by John E. Walls) concluded that the level of spurious RF CW, radiated by certain airborne interrogators tested, was of sufficient magnitude to cause transfer or shutdown of TACAN equipment used for air navigation when located near taxiways and/or runways of airports. The modification was field-evaluated at four commissioned facility sites and was found successful in preventing equipment transfers or shutdowns of TACAN at ground facilities caused by CW interference.

NA-70-31
SYSTEM SHAKEDOWN TESTS (C30/60N), NAS EN ROUTE STAGE A MODEL 1, FUNCTIONAL PACKAGE B, BY J. Levy, et al. Final report, December 1970. 148p.

The purposes of this project were (1) to conduct such system shakedown tests as were needed to identify and aid in the resolution of hardware and software problems in achieving stable, acceptable, and reliable operation of the NAS En Route Stage A Model 1 System as configured in

the System Support Facility at the FAA's National Aviation Facilities Experimental Center, Atlantic City, New Jersey; (2) to integrate controller, engineering and maintenance personnel into the system identifying and helping to resolve problems in the man/machine interface area; and (3) to provide guidance for the conduct of similar testing on the system at the Jacksonville Air Route Traffic Control Center. Four test phases, identified in total as C30/60 testing, included investigation of (1) computer program functions and operational test procedures, (2) baseline verification of modified operational computer programs, (3) system failure and recovery, and (4) procedures for radar control which would allow either partial or full system testing at Jacksonville while simultaneously controlling live traffic without derogating safety of the operation. Completion of the C30/60 testing effort marked the termination of formal system shakedown at NAFEC.

NA-70-32
INVESTIGATION AND TEST FOR A FUTURE SOLID-STATE TERMINAL VOR FACILITY, By W. O. Mickey, Final report, February 1971. 67p. (RD-70-54) (AD 718 988).

This report provides technical information from the test at NAFEC, FAA, Atlantic City, New Jersey, of an available commercial 10-watt solid-state VOR to assist in preparing specifications for a future type terminal VOR facility. The investigation included low altitude flight tests by NAFEC project aircraft, ground checks, remote receiver monitoring, and the FAA standard SAFE flight inspection system at high altitude. A conclusion was that solid-state is practical and provides stability and reliability with less requirement for maintenance only if special care is given to design of circuits such as in certain areas pointed out in the report.

NA-70-33
EXPERMENTATION WITH THE TERMINAL-CONFIGURED RADAR VIDEO DATA PROCESSOR, by C. Chapman, Final report, July 1970. 58p. (RD-70-33) (AD 708 455)

Experimentation with a Radar Video Data Processor within a terminal-radar environment was accomplished at the National Aviation Facilities Experimental Center to obtain data pertinent to the functional requirements and specifications for terminal-radar digitizers. Test results related to detection, resolution, and position-reporting of aircraft targets were equivalent to design considerations. The limited dynamic range of the radar video precluded optimum operation of the scan-correlated quantizer insofar as reducing the excessive message processing rates that prevailed in areas of heavy precipitation. Specific features that were effective in the selective reduction of the message processing rates were the automatic clutter eliminator, run length discrimination and sensitivity time control functions.

NA-70-34
SIMULATION STUDY OF TWO SITES FOR A THIRD CHICAGO METROPOLITAN AIRPORT, by S. B. Rossiter, Final report, July 1970. 120p. (RD-70-25) (AD 708 635)

A dynamic simulation study to assess the relative merits of two proposed sites for a third major airport in the Chicago Metropolitan Area was conducted at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey.

The study considered the traffic flows of the three major airports, O'Hare, Midway, and either of the proposed sites, under three different landing/takeoff directions, West, Northeast, and Southeast.

It was concluded that on a system vs. system basis, there was no statistical preference for either site when the three wind configurations were considered equal in weight. Both sites were equally efficient in a West Configuration. The Land site system was less efficient than the Lake site system in the arrival operation of the Northeast Configuration. The Lake site system was less efficient than the Land site system in both the arrival and departure operations of the Southeast Configuration. It was further concluded that on a system basis, in all configurations tested, the airspace as employed by both site plans was able to accomodate the amount of traffic which could be generated by the three airports.

NA-70-35
NAS EN ROUTE STAGE A, MODEL 1b, TEST AND EVALUATION OF THE PREPRODUCTION EQUIPMENT AN/FYQ-47, by K. H. Burkard, Final Report Sept. 1970. 48p. (NS-70-2) (AD 711 473).

A joint Federal Aviation Administration/Department of Defense test program was conducted on the AN/FYQ-47 Production Common Digitizer (PCD) to verify its operational capability as an element of the National Airspace System (NAS) En Route Stage A, Model 1b, Jacksonville, and the U. S. Air Force Semi-Automatic Ground Environment (SAGE) System. Based on the test results, it was concluded that the PCD performed its basic function of digitizing primary and secondary radar video inputs. Further adjustments and circuit modifications will improve PCD performance relative to search target split-rates, and radar quantizer operation in the clutter mode. The source of Beacon range (Hit-sharing) splits has not been determined.

NA-70-36
SNOW AND ICE OUTAGES - COMLO FACILITIES TASK NO. 1 SOLID-STATE RADIO BEACON, by J. A. Muller and T. H. Broussard, Final Report Nov. 1970. 29p. (RD-70-38) (AD 715 531).

This report covers the test and evaluation of a low power solid-state radio beacon manufactured by the Southern Avionics Company. It was concluded that, with some minor changes, such as an aluminum housing, lightning protection, and relocation of the antenna feed insulator, the system provides a satisfactory off-the-shelf item that is readily available as a temporary replacement to ensure continuity of compass locator (COMLO) service where outages occur due to snow and ice conditions.

NA-70-37
TEST AND EVALUATION OF THE ACCURACY CAPABILITY OF THE AIRCRAFT SEPARATION MEASUREMENT SYSTEM FOR APPLICATION AS A MEASUREMENT FACILITY, by V. J. Luciani Final Report May 1970. 32p. (AD-735-892).

Basic system accuracy of the Aircraft Separtion Measurement System was evaluated. Two NAFEC aircraft were flown in various flight patterns during which ASMS-derived aircraft separation measurements were recorded in one of the aircraft on a digital printer. Paired phototheodolite stations tracked the aircraft and provided time-correlated aircraft coordinates which were converted into comparable reference aircraft separation data. Comparison of ASMS and Phototheodolite data demonstrated an average ASMS system error of 0.017 nautical miles (103 feet), with standard deviation of 0.026 nautical miles (158 feet).

NA-70-38
LIVE TESTS OF TOWER CAB RADAR APPROACH CONTROL PROCEDURES, by J. R. Bradley, Jr. and H. D. Milligan, Final Report Aug. 1970. 20p (RD-70-31) (AD 710577).

This project was conducted primarily to determine the operational feasibility of using Bright Radar Indicator - Tower Equipment (BRITE-1) as a display to provide all standard radar services from low density control tower cabs and secondarily to delineate BRITE-1 installation and maintenance requirements involved with the tower cab radar approach control operation.

Two BRITE-1 displays were installed in the control tower at Wilkes-Barre, Pa. along with appropriate radio and interphone equipment. The approach control operation was then moved from the terminal radar control (TRACON) room to the tower cab where all radar services were provided, on a test basis, for a 60-day period.

Results indicated that it is feasible, and desirable, to provide all standard radar services from the tower cab, at low density radar facilities, using the BRITE-1 display.

BRITE-1 installation and maintenance requirements involved with the tower cab radar approach control concept were determined and documented.

NA-70-39
AIR TRANSPORT CABIN MOCKUP FIRE EXPERIMENTS, by J. F. Marcy, Final Report Dec. 1970. 45p. (RD-70-81) (AD 717855).
A study was made of the burning characteristics of airplane interior materials ignited inside a 640-cubic-foot cabin mockup enclosure. Test conditions were varied to investigate the effects of a number of factors on the ignition and propagation of flames within enclosures; namely, (1) flammability ratings of the materials as obtained from standard laboratory tests, (2) intensity, duration and type of the ignition source whether flaming or incandescent, (3) ventilation rate as provided by different size openings into the cabin enclosure, (4) partitioning of the cabin space by use of a fire barrier curtain and (5) discharge of bromotrifluoromethane (CF_3Br) into the cabin atmosphere,

both at different rates and total quantities of application before and during a fire occurrence. Comparative tests conducted on flame-retardant (FR) urethane and neoprene foams showed that the flash fire hazard prevalent with the use of regular foam could be greatly reduced by replacement with these two self-extinguishing foams. A high-rate discharge system employing CF_3Br (1301) was shown to be effective in rapidly extinguishing the flames of a foam fire. A curtain divider placed across the ceiling was shown to be useful as a fire barrier to arrest flame propagation. Roof venting of the mockup at a location away from the fire was relatively ineffective in preventing rapid buildup of smoke and flame spread from a flash fire involving urethane foam.

NA-70-40
INVESTIGATION OF JET ENGINE COMBUSTION CHAMBER BURN-THROUGH FIRE, by T. Rust, Jr., Final Report March 1971. 52p. (RD-70-68) (AD 718 755).

The work performed under this project was directed toward establishment of standard test conditions for testing materials which are intended for use as fire barriers for protection against a jet engine combustion chamber burn-through type of failure. The development of such a failure was accomplished on a General Electric J-47 jet engine. The resulting flame was quite severe, penetrating the present standard firewall material in 2 seconds. Studies were made of the flame impingement characteristics, including impingement temperatures and pressures; and various potential firewall materials were tested for effectiveness as fire barriers for protection against such a failure. Most materials tested in this manner failed to provide adequate protection against such an engine failure.

An investigation was conducted toward development of a means of simulating a combustion chamber burn-through failure with the ultimate goal of developing a suitable laboratory test flame for evaluating potential firewall materials. A combustion chamber simulator, which will produce a flame of similar severity to the flame produced in the J-47 engine, was developed. However, more effort is required to further develop this simulator so that exact simulation is possible.

NA-70-41
FIRE PROTECTION TESTS IN A SMALL FUSELAGE-MOUNTED TURBOJET ENGINE AND NACELLE INSTALLATION, by D. E. Sommers, Final Report Nov. 1970. 62p. (RD-70-57) (AD 715 442).

Tests under simulated flight conditions were conducted on a small fuselage-mounted turbojet engine and nacelle installation to investigate the potential explosion and fire hazards and detection and fire control methods.

Hot-surface ignition of flammables did not occur during simulated flight operating conditions until a change to the normal nacelle configuration reduced cooling airflow to the hot section of the engine (Zone I) below 0.15 pound per second.

The installed detection system did not provide for prompt detection of all fires originated in the lower foward portion of the compressor compartment (Zone II). Both the Zone II fire detection and the Zone I overheat detection system, a portion of which traversed the aft inboard section of Zone II, were sensitive to fires originated in the inboard portion of Zone II.

The installed extinguishing system provided rapid extinguishment of all Zone II fires until extensive accumulative damage from fires destroyed the integrity of the zone. Fireproof protection incorporated in the nacelle was very effective in performing its intended function. Most susceptable to damage by fire was the aluminum portion of the nacelle, especially aluminum receptacles for camlock-type fasteners, an aluminum ventilation louver panel in the top aft portion of Zone II, and aluminum ribs, formers, and baffles inside the nacelle in the path of fire. The fire damage to the engine and accessories was insignificant in regard to engine operation.

NA-70-42
NAS EN ROUTE STAGE A, RADAR VIDEO DATA PROCESSOR MODIFICATIONS, by O. D. Carlson, Final Report Aug. 1970. 26p. (NS-70-1).

The Radar Video Data Processors, located at the National Aviation Facilities Experimental Center, and at the Suitland, Maryland, en route surveillance radar site, were tested and evaluated to determine the benefits of contractor-installed modifications. Tests were conducted in controlled radar and beacon environments to enable each modification to be analyzed discretely.

Data were collected to evaluate the modified radar processing functions of run length discrimination, dynamic hit width discrimination, and automatic clutter elimination. Modifications to the beacon sliding window detection and beacon code validation functions were also evaluated.

Test results indicated that the modifications improved the performance of the processor by reducing the number of processed targets resulting from radar clutter and excessive radar reply widths. In addition, the probability of correct beacon code validation was enhanced while the probability of erroneously setting special identity and emergency indicators was diminished.

NA-70-43
EXECUTIVE SUMMARY OF TECHNICAL AND OPERATIONAL EVALUATION OF THE DIRECT ALTITUDE AND IDENTITY READOUT (DAIR) SYSTEM (INTERROGATOR SET AN/TPX-42), by A.D. Bradley and R. L. Tarr, Final Report Aug. 1970. 13p. (RD-70-29) (AD 710 506).

This report presents a summary of both the technical and operational evaluation of the AN/TPX-42 Direct Altitude and Identity Readout (DAIR) equipment. It includes a brief description of the system and a statement of the purpose and specific objectives of the effort. Following a statement of the testing and data collection methods employed during the evaluation, the major conclusions are listed concerning the technical suitability. operational capability, controller utility, maintainability, and reliability of the DAIR System.

NA-70-45
ECONOMIC ANALYSIS ON THE USE OF GELLED FUELS IN JET TRANSPORT AIRCRAFT, by H. D. Whallon, A. T. Peacock, and L. D. Christensen, Final Report July 1970. 67p. (DS-70-13) (AD 708 840).

A previous study described in FAA Final Report No. DS-70-1 examined the technical aspects of using gelled or emulsified fuel in a DC-8-62 commercial jet transport and identified associated problems. This study examined the economics of jet fleet conversion to the use of 2 percent gelled fuel. Based on the technical findings, a DC-8-62 modification program was outlined, costed, and analyzed. Based on the DC-8-62 analysis, it was estimated that conversion and operation for the ten years 1972-81 of all U. S. air carrier jet passenger airplanes would add about four million dollars to their operating costs for the decade. This is approximately a 4.5 percent increase to total operating costs.

NA-70-46
INVESTIGATION OF TWO METHODS FOR IMPROVING THE CRASHWORTHINESS OF INTEGRAL FUEL TANKS, R. H. Ahlers, Final Report Nov. 1970. 21p. (RD-70-56) (AD 715 445).

F-86 droppable fuel tanks, fitted with reticulated polyurethane foam and filled to capacity with JP-4 fuel, were drop tested and catapulted to test the effectiveness of the foam in reducing fuel spray and leakage at impact. Also, structurally reinforced DC-7 integral wing tanks were impacted against an upright beam restrained by a steel shear pin to limit the loads. The forward spar caps were strengthened with aluminum alloy doublers and chord wise stiffeners to determine the effect of structural modifications on the crashworthiness of the structure.

It was determined that the 10 pores per inch and the 60 pores per inch polyurethane foam have little effect on the attenuation of fuel misting and spilling. The addition of a 0.040-inch-thick doubler strip to the upper and lower DC-7 wing skins did not appreciably decrease the vulnerability of the integral tank to leakage, but the front spar rails when reinforced by chordwise structural shapes did increase impact resistance.

NA-70-47
INVESTIGATION OF THE EFFECTS OF RUNWAY GROOVES ON WHEEL SPIN-UP AND TIRE DEGRADATION, by C. R. Grisel, Final Report April 1971. 28p. (RD-71-2) (AD 721 152).

Tests were conducted at three airports having different runway groove configurations. The objective of these tests was to determine if grooves change the rate of wheel spin-up and if they produce cuts in the tires of the test aircraft. Although no evidence of tire cutting was observed, it was found that the wheel spin-up rate for the test aircraft was increased by the runway grooves. The extent of the increase was influenced by the width of the grooves.

NA-70-48
GRAPHIC SIMULATION STUDY OF TWO SITES FOR A SECOND MAJOR AIRPORT IN THE ATLANTA AREA, by S. B. Rossiter, Final Report Oct. 1970. 58p. (RD-70-63) (AD712 713).

A graphic simulation study was made of the Atlanta terminal area to provide comparisons between two proposed sites for a second major airport based on air traffic control considerations. Terminal area air traffic control procedural plans were developed incorporating each new site. Through the use of a questionnaire, developed around factors that comprise an air traffic control subsystem, each site was evaluated by a panel 12 Air Traffic Control Specialists for each of four different wind directions. The results of this evaluation indicated that Site D was significantly preferred for the west, northwest, and east landing directions with Site A being significatly preferred for a southeast direction of operation. Considering all wind directions, Site D was preferred over Site A when the wind directions were weighted based on percentage of occurrence, or when considered equal in weight. The primary reasons for this choice were the lesser interaction with satellite airports, more avialable airspace, fewer areas requiring critical vectoring, less interaction between Site D and the Atlanta airport for north/south departures, less coordination because of less compression of airspace, and no added effect on the satellite airports operations.

NA-70-49
INVESTIGATION OF TRANSPONDER REPLY FADEOUT IN THE VICINITY OF CHICAGO O'HARE AIRPORT, by G. F. Spingler, Interim Report Dec. 1970. 43p. (RD-70-75) (AD 716 944).

Exploratory flight tests were performed approximately 11 nmi south of the Chicago O'Hare ASR-4 Radar Beacon Site to determine why transponder replies were being lost in this area. The report presents a summary of the type of tests that were conducted and results of each test.

Analysis of the flight test data showed that the major cause of the coverage problem centered around the towers of the Remote Transmitter Site No. 1 and propagation vertical lobing. It was concluded that confirmation flight tests should by performed by the FAA Chicago Area Office prior to any site modifications.

NA-70-50
STUDY OF THE PERFORMANCE CHARACTERISTICS OF THE BENDIX TYPE DRA-12 AIRBORNE DOPPLER RADAR SYSTEM, by R. H. Mayer, Final Report Nov. 1970. 22p. (RD-70-73) (AD 715 444).

A study of the performance characteristics of the Bendix Radio type DRA-12 Doppler Navigation System and the General Electric Miniature Heading and Attitude System type A/A24G-26, for the purpose of determining the expected navigation error when flying straight and level, and the expected error as a result of making a standard rate turn at a speed of 200 knots, is reported herein.

A profile of the error, while in staight and level flight, is presented to which each 180° turn error of 184 feet should be added in quadrature to obtain the expected error at any discrete distance from the doppler reference point.

The results of this study are considered useful in determining the extent to which doppler navigation can be applied to the Sabreliner aircraft flight inspection mission.

NA-70-51
VISUAL AIDS FOR SECONDARY AIRPORTS, by T. H. Paprocki, Final Report Sept. 1970. 39p. (RD-70-59) (AD 715 443).

A new type lighting and marking system for use at small general aviation type airports under VFR weather conditions was installed at the municipal airport, Ocean City, New Jersey, for evaluation. The system consisted of fluorescent runway edge and approach lighting systems; an incandescent sequenced flashing light system; a Simplified Abbreviated Visual Approach Slope Indicator (SAVASI) system; painted aiming-point runway markings; and retroreflective centerline and threshold markers. All of these visual aids were evaluated individually, and in addition the fluorescent runway edge lighting fixtures were evaluated in comparison with standard incandescent edge lighting units. It was determined that all of the above mentioned visual systems provided satisfactory guidance under VFR conditions and that the fluorescent type runway edge light fixture can provide excellent VFR lighting with fewer maintenance problems and lower operating costs than the present standard medium-intensity runway edge light fixture.

NA-70-52
EXPERIMENTATION SUPPORT FOR DEVELOPMENT OF LOW-COST TV RADAR REMOTING SYSTEM, by M. Greenberg, Final Report Dec. 1970. 77p. (RD-70-74) (AD 715 446).

Test and experimentation were conducted on an engineering model microwave relay remoting system at NAFEC to obtain data to finalize the system design requirements. Measurements and calculations for received signal levels, fade margins, signal plus noise-to noise ratio, noise figure and others were obtained. Measured values of the signal levels for a dish-to-dish antenna configuration were in

agreement with the theoretical values, whereas the measured values for the periscope antenna configuration used showed a 5 dB discrepancy to the predicted values. An analysis of this discrepancy is covered in the report. In general, the microwave receiver and transmitter characteristics met the equipment procurement specifications.

NA-70-55
HUMAN FACTORS IN THE USE OF TERMINAL RADAR (ANALOGUE) DISPLAY SYSTEMS, by D. W. Connolly and W. R. McCosker, Final Report Nov. 1970. 23p. (RD-70-66) (AD 714 335).

An experiment was performed to measure the accuracy with which observers could estimate the separation (distance apart) of two aircraft targets as displayed by continuous film strips of current operational terminal radar equipment. Experimental materials consisted of scan-by-scan photos of two types of display devices; namely, the ASR-4 plan position indicator (PPI) and the RBDE-5 scan-converted PPI. Two types of target or aircraft radar returns were used--primary radar echoes and beacon transponder (secondary radar) returns. Two types of separation were employed; i.e., aircraft separation mainly in the range dimension and targets separated principally in the azimuth dimension of the display. Eighteen observers with varying degrees of radar experience made approximately 1,600 judgments of target separation. The mean and variable error or discrepancy between judged separation and displayed (not actual) separation were computed for all combinations of conditions. The major variables (equipment type, target mode, dimension of separation and observer experience) did not have statistically significant effects. Nearly all individual judgments fell within plus or minus 1 1/2 miles of the target separation as displayed to the observer. It is also pointed out that the quality of such judgment is unknown where no distance scale (or some scale other than the current concentric range rings) is provided, as might be the case with digital systems.

NA-70-57
NAVAID FLIGHT CHECK CONSOLE, by J. E. Jensen, Final Report Aug. 1970. 32p. (AD 710 576).

A portable receiving, conditioning, and recording system to evaluate the performance of common system en route and terminal aids avigation is described. The receiving equipment and signal conditioning are conventional, as is the presentation of displayed and recorded information. Features to facilitate recorder trace identification and to normalize and ease the operating specialist's workload have been included.

Flight tests have been conducted with the system installed in DC-6B aircraft N-114. The recorded data compared favorably with equivalent data obtained in the same flight period using T-29 aircraft N-247, configured as a standard flight inspection aircraft. All of these flight tests were conducted in accordance with the applicable portions of the "United States Standard Flight Inspection Manual".

The Flight Check Console consists of a single channel self-contained airborne navigation system capable of receiving signals from VOR, TACAN, LOCALIZER, GLIDE SLOPE and MARKER BEACON stations in the various assigned frequency bands. It also provides self-contained VHF Communications and such signal conditioning, recording, control, and display features as to allow the analysis of transmitted signals for the purpose of determining Navaid facility performance.

NA-70-59
VISUAL APPROACH SLOPE INDICATOR (VASI) SYSTEM FOR LONG-BODIED AIRCRAFT, by R. F. Gates, Final Report Dec. 1970.
38p. (RD-70-76) (AD 715 453).

A comparative evaluation was conducted at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, on two methods of modifying the standard VASIS for use for long-bodied aircraft operations. Modification was required due to the greater pilot eye-to-wheel height of the larger aircraft which placed these aircraft in a potential undershoot situation when the on-course signals of standard VASIS were flown. Thirty-four subject pilots flying a variety of aircraft, including the B-747 and C-5A aircraft, participated in the program. The aircraft were tracked with phototheodolite equipment, and the pilots completed questionnaires at the conclusion of each flight. The Three-Bar System, a modification consisting of an addional component of the standard VASIS, was a significantly better aid than the White-Wing System, a modification incorporating the use of white lights only (pilots flew combinations of bright-dim light) adjacent to the upwind bar of the standard VASIS.

NA-70-60
TEST AND EVALUATION OF IMPROVED AZIMUTH PULSE GENERATOR (APG), by O. D. Carlson, Final Report Oct. 1970.
21p. (RD-70-64) (AD 713 718)

Azimuth pulse generators and a digital-to-synchro converter were subject to tests at the National Aviation Facilities Experimental Center to ascertain their compliance with engineering requirements and to determine their performance in supplying antenna azimuth position data to a Radar Video Data Processor (RVDP).

The azimuth pulse generators were installed in the antenna pedestal of the experimental airport surveillance radar (ASR-5) facility, and the digital-to-synchro converter was installed at the radar display subsystem. Utilizing digital computer programs, RVDP output messages were tabulated and analyzed to determine precision in reporting antenna azimuth.

Test results indicated that the azimuth pulse generators and the digital-to-synchro converter performed satisfactorily, and acceptably provided antenna azimuth position data to the RVDP. Difficulties encountered during the tests were related to the type of coupling between the antenna and the azimuth pulse generators,

which resulted in a recommendation to use only a worm-gear method of coupling.

NA-70-62
FIELD TEST AND EVALUATION OF THE NAS EN ROUTE STAGE A MODEL 1b WEATHER SUBSYSTEM, by H. L. McFann, Final Report Mar. 1971. 117p. (AD 719 004)

Four Weather Outline Generators were installed in Jacksonville NAS. En Route Stage A, Model 1b. environment to generate contours around radar weather clutter at two different intensity levels. The contours were processed by the radar video digitizers for transmission to the Air Route Traffic Control Centers as weather map messages. A series of technical and operational tests were run in the field to obtain performance data pertinent to the preparation of specifications for future systems. Calibration methods and trouble shooting aids were established by the test team for use by operating personnel. It was concluded that the generators were capable of producing reliable contours around the periphery of clutter without interference from aircraft signal returns. The dynamic range of the systems, when using logarithmic video inputs, was sufficient to permit contouring of weather cells from 42 to 50 dB above the radar receiver minimum discernible signal levels. Effective control of weather map data rates was achieved by a sampling and interleaving technique that transmitted outer contour data every 8.4° and inner contour data every 2.1°.

NA-70-64
CRASH FIRE HAZARD EVALUATION OF JET FUELS, by A. J. Atkinson and T. I. Eklund, Final Report Jan. 1971. 54p. (RD-70-72) (AD 718 116).

An investigation was conducted to determine the relative crash fire hazards of jet fuels under survivable crash conditions. Kerosene, JP-4, and mixtures of both were evaluated under various release modes (pools, drips, streams and sprays) and in the presence of possible ignition sources (electrical sparks, friction sparks, open flames, and hot surfaces). Wind speed, wind air temperature and fuel temperatures were also varied. The results of this evaluation and the conclusions reached are discussed in the report.

NA-70-67
INDEX OF NAFEC TECHNICAL REPORTS, 1967 - 1969, Final Report Oct. 1970. 58p. (AD 713 176)

This report is an index of all technical reports which were assigned NA numbers and published by NAFEC during the period 1967 through 1969. Entries are arranged by NA number and include titles, authors and full abstracts. Separate sections contain indexes by subject, author, RD number, DS number, project number, contract number and AD number.

NA-71-2
TITANIUM FUSELAGE ENVIRONMENTAL CONDITIONS IN POST-CRASH FIRES, by C. P. Sarkos, Final Report Mar. 1971.
74p. (RD-71-3) (AD 720 026)

A 28-foot titanium fuselage was exposed to a 400-square-foot JP-4 fire for about 2 1/2 minutes. The titanium fuselage remained intact, thus preventing any flames from entering into the cabin. Heating of the cabin pressure sealant and insulation caused these materials to burn. This, in turn, caused significant increases in temperature, smoke, and toxic and combustible gases within the cabin at about 1 minute after fuel ignition and a flash fire at 2 minutes. Theoretical heat transfer calculations were compared with thermocouple data from a section of the fuselage where the insulation did not burn. This comparison indicated that if the insulation and sealant were "inert," habitable conditions would have been maintained within the cabin for at least 5 minutes, and perhaps more.

NA-71-3
EVALUATION OF CRYOGENIC NITROGEN AS A FIRE EXTINGUISHING AGENT FOR AIRCRAFT POWERPLANT INSTALLATIONS, by G. Chamberlain and E. P. Klueg, Final Report Nov. 1971.
148p. (RD-71-58) (AD 732 622).

Proposals have been made to carry relatively large quantities of liquid nitrogen (LN_2) aboard commercial aircraft for the purpose of fuel tank inerting. Secondary uses, such as powerplant fire extinguishment, have been suggested. Testing was conducted at the National Aviation Facilities Experimental Center to determine the feasibility of using LN_2 as an aircraft powerplant fire-extinguishing agent and also to determine the characteristics of LN_2 when used as an extinguishant. These tests were conducted in a fire test facility using a full-scale aircraft turbojet engine and nacelle for subsonic low altitude flight condition simulation and also in a mockup engine/nacelle facility where nacelle volume and airflow could be varied. For all tests, the LN_2 was delivered from a dewar where it was stored under pressure as a saturated liquid. All fire tests were conducted using JP-4 jet fuel which was spray released and spark ignited. In addition to the preliminary feasibility study, this report describes the experimentation conducted to determine the design criteria required for an effective agent quantity, discharge rate, discharge conditions, and distribution system configuration. The report also describes the effects of an inadvertent discharge on engine components, the effects of a damaged cowling, and the cooling of potential reignition sources.

NA-71-4
MINIMIZE SNOW AND WEATHER EFFECTS-VORTAC TASK II TACAN ANTENNA, by G. J. Hartranft, Interim Report Sept. 1971.
27p. (RD-71-56) (AD 728 923).

The report covers the use of various techniques to minimize the effects of snow and ice on the RTA-2 TACAN antenna. The techniques were: (1) a wire-wrapped radome with current flowing through the wires attached to

the external surface of the radome; (2) enlarged radomes; (3) coating existing radome with hydrophobic materials; and (4) providing a polyurethane shroud over the existing radome with movement of the shroud provided by antenna vibration, wind, or air inflation. The polyurethane shroud showed the most promise of all the techniques tested.

NA-71-5
VORLOC II FAR-PART 171 COMPLIANCE TEST, by F. W. Marschall, Final Report Apr. 1971 66p. (RD-71-12) (AD 721 260).

The Cubic Industrial Corporation of San Diego, California, developed a low cost Simplified Directional Approach System (SDAS) called VORLOC II. The National Aviation Facilities Experimental Center (NAFEC) of the Federal Aviation Administration examined this equipment as part of an effort to determine the acceptability of VORLOC II as a non-Federal IFR aid for public use. This examination consisted of performing tests to gather data relative to the requirements of the "Notice of Proposed Rule Making" (NPRM) to Part 171, subpart F - (SDAS) of the Federal Aviation Regulations (FAR.) Test data were also gathered on the effect of environmental factors on elements of the system. This report covers the tests performed and the data obtained.

NA-71-6
AFAPL AIRCRAFT FIRE TEST PROGRAM WITH FAA 1967-1970, by D. E. Sommers, J. H. O'Neill, Final Report June 1971.
114p. (AD 884 744).
A number of aircraft propulsion and fuel system fire protection test programs were conducted.

The NARMCO prototype "Fibercell" Overheat Detector, the Panametrics Inc. Prototype Hazardous Vapor Detector and a McGraw-Edison Co. Ultra-Violet Fire Detection System underwent limited evaluation in a Jet powerplant fire test environment.

The Walter Kidde and Company, Inc. pyrotechnic generated gas discharge fire extinguishing agent container, and the E. W. Bliss Co. high-expansion foam/bromotrifluoromethane extinguishing agent combination fire extinguishing system were evaluated in a simulated aircraft powerplant nacelle.

Fire-resistant tests in a standard 2000°F flame-test environment were conducted on specific stainless-steel tubing as well as various size stainless-steel tubing assemblies with several combinations of stainless steel and aluminum connectors (nut, sleeves, and unions). Some tubing was tested while either fluid or air under pressure was trapped (no pressure relief provided) in the tubing. The tubing assemblies with connectors were tested while fluid either was flowing through or was static in the tube assembly system. Pressure relief for the static fluid condition was provided.

Evaluation of a Fenwal Explosion Suppression System for an aircraft fuel tank was conducted. Testing involved the measurement of relative concentration of an extinguishing agent discharged by the system into the fuel tank cavity to determine agent distribution in the cavity. Specialized gas analyser equipment was used to measure the relative concentration of the agent.

An investigation of the vulnerability of JP-4 and JP-8 fuel, contained in a fuel tank, to ignition by incendiary gunfire was made. Dynamic incendiary gunfire was made. Dynamic incendiary gunfire tests were conducted utilizing either JP-4 or JP-8 fuel and varying the following parameters; (1) standoff distance between the fuel cavity and test article skin, (2) airflow over the test article surface, and (3) ventilation rate in standoff space. A few tests were conducted with JP-4 and JP-8 fuels utilizing porous polyurethane foam in either the fuel cavity portion of the tank or the standoff space portion.

NA-71-7
VHF/UHF GROUND-AIR-GROUND COMMUNICATION SITING CRITERIA, by J. G. Dong, Final report, Nov. 1971. 289p. (RD-71-76) (AD 732 618).

This report presents results of tests accomplished at the National Aviation Facilities Experimental Center (NAFEC) and selected Federal Aviation Administration (FAA) field facilities to determine radio frequency communication problems and equipment performance under Remote Transmitter Receiver (RTR) and Remote Center Air-Ground (RCAG) configuration. Performance characteristics of antennas, transmitters, receivers, transmission lines, and ancillary equipment were investigated to determine the parameters that affect mutual interference when these equipments are combined in FAA system configurations. The results of the investigation were limited to equipment in current use at field sites and equipment recently developed. Data are incorporated in Appendix A of this report for use as a field manual. The field manual was prepared to provide reference and guidance to installation and maintenance personnel on interference aspects in correcting similar problems at existing sites and the application of these principles in establishing new sites.

NA-71-9
PREVENTION OF AIRCRAFT LOSS OF CONTROL USING A SIMPLE HEAD-UP DISPLAY, by G. E. Skelton and R. L. Sulzer, Final report, June 1971. 22p. (RD-71-28) (AD 726 280).

To evaluate the concept of a simple head-up display (HUD) as an aid to noninstrument-rated pilots encountering reduced flight visibility conditions, two versions of such a display were flown by six pilots. The subject pilots were pretested to insure that they could not perform standard maneuvers when outside visual reference and panel attitude instruments were obscured leaving only the altimeter, airspeed indicator,

gyroscopic direction indicator, gyroscopic rate-of-turn/slip-skid indicator, and clock. Given either of the HUD instruments and a partial panel of basic instruments, plus a brief indoctrination in the use of the HUD, the pilots showed marked improvement in preservation of aircraft control. The opinions of expert observers suggest that, with a few hours of additional training, inexperienced pilots would be able to employ a simple HUD with a further improvement of aircraft safety when penetrating adverse weather.

NA-71-11
DEVELOPMENT AND TEST OF THE EXPLOSIVE EXIT CONCEPT FOR CIVIL TRANSPORT AIRCRAFT, by J. J. Jaglowski, Jr., Final report, July 1971. 45p. (RD-71-33) (AD 727 348).

The test program was performed to evaluate the liquid explosive emergency exit system reliability, performance, and hazards to personal safety when exposed to environments which might be encountered before, during, and after a crash. The report includes: (1) A test program to evaluate the liquid explosive emergency exit system when exposed to environment simulating conditions encountered before, during, and after a crash; (2) Results of the tests; (3) Evaluation of a retaining shield in attenuating the sound level and containment of the debris produced by the detonation of the linear-shaped charge; and (4) The feasibility of adapting the liquid explosive emergency exit system for use on civil transport aircraft.

NA-71-12
SMALL-SCALE IMPACT TESTS OF CRASH-SAFE TURBINE FUELS, by R. A. Russell, Jr., Final report, August 1971. 51p. (RD-71-49) (AD 731 461).

A variety of regular and modified hydrocarbon-turbine fuels, one nonhydrocarbon fuel, and reticulated polyurethane foam filled with neat fuel was subjected to small-scale impact tests to determine burning, misting, and splatter characteristics of the fuels. The results of this study conclude that it is entirely feasible to retard the ignitibility, combustibility, and flow characteristics of current hydrocarbon fuels by increasing their apparent viscosity. The study showed that non-Newtonian gelled fuels performed better than other modified fuel candidates and better than the reticulated polyurethane foams filled with neat fuel.

NA-71-13
TASK I, TEST AND EVALUATION OF SOLID-STATE 100-WATT VOR TRANSMITTING EQUIPMENT, by B. S. Brayer, Final report, Sept. 1971. 42p. (RD-71-65) (AD 730 057).

This report discusses the development and tests of a 100-watt solid-state VOR Transmitter at National Aviation Facilities Experimental

Center (NAFEC). The VOR is a major part of the VORTAC System and provides azimuth guidance to enroute aircraft in the National Airspace System. The transmitting system tested herein is used to generate these signals. Results of the tests discussed in this report provide data for establishment of specifications for the next generation of solid-state VOR transmitting equipment.

NA-71-14
OPERATIONAL EVALUATION OF THE BRIGHT RADAR MICROWAVE REMOTING SYSTEM, by E. H. Wright, Final report, Sept. 1971. 26p. (RD-71-48) (AD 729 368).

An operational evaluation to determine the capability of a bright radar microwave remoting system to provide operationally useful radar data in a satellite control tower was conducted in the Tampa/St. Petersburg, Florida, area. The microwave equipment consisted of a 15 GHz microwave transmitter and receiver and two 6-foot parabolic antennas. The St. Petersburg/Clearwater Air Traffic Control Tower used a pre-production model of a BRITE-I display with a 16-inch cathode-ray tube (Bright Radar Indicator Tower Equipment) display for the first half of the evaluation and a BRITE-II display for the last half. A daily log was maintained to record any deterioration of display quality and also to record rain and thunderstorm activity. Air traffic control personnel at the St. Petersburg/Clearwater Tower completed questionnaires during and after the study. It was concluded that the bright radar microwave remoting system is capable of providing operationally useful radar information on BRITE-I/BRITE-II displays in a satellite airport tower and that the system was reliable during the rainfall periods in the Tampa/St. Petersburg area. It was further concluded that the microwaved system was capable of providing radar data in the St. Petersburg/Clearwater Tower Cab equal in quality to that provided by the primary BRITE system in the Tampa Tower.

NA-71-15
1585 MHz GLIDE SLOPE SYSTEM, by J. E. Townsend, Final report, Aug. 1971. 32p. (RD-71-50) (AD 728 212).

Test and evaluation of a glide slope system operating in the 1585 MHz frequency range were conducted at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey. The system designed and built by Airborne Instruments Laboratory (AIL) uses a directional waveguide antenna that forms beams in space that are independent of ground reflections. Tests were performed at NAFEC and also at a problem site, Greater Pittsburgh Airport. Based on the data obtained from the tests performed, it was determined that a glide slope operating in the 1585 MHz frequency range is feasible, but certain improvements are necessary to the present system to make it operational.

NA-71-16
MEASUREMENT AND ANALYSIS OF EN ROUTE ATC DIGITAL RADAR SYSTEM ERRORS, by C. Chapman, Interim report, Sept. 1971. 27p. (RD-71-63) (AD 730 056).

Prior to the conduct of tests pertinent to radar separation standards, a review of previous efforts was accomplished to ascertain the application of existing data towards the establishment of separation criteria within the en route Air Traffic Control National Airspace System, Model 1 complex at Jacksonville, Florida. Data analyses and presentation were directed towards the range and azimuth resolution characteristics and aircraft-separation measurement capability of the secondary-radar/ digitizer subsystem.

NA-71-17
CHEMICAL AND PHYSICAL STUDY OF FUELS GELLED WITH HYDROCARBON RESINS, by R. E. Erickson and R. M. Krajewski, Final report, July 1971. 106p. (RD-71-34) (AD 728 305).

A gelled fuel was modified to achieve low viscosity at low shear while maintaining significant resistance to fire while in the misting condition. The modified gelled fuel has been rheologically profiled using a variety of rheometers. Test data on flowability, rheological characteristics, and simulated crash fire misting hazard are included in the report.

NA-71-18
CHEMICAL AND PHYSICAL STUDY OF FUELS GELLED WITH CARBOHYDRATE RESINS, by J. Teng and J. M. Lucas, Final report, Sept. 1971. 95p. (RD-71-43) (AD 730 513).

A carbohydrate derivative was designed as a gelling agent for turbine fuel. The gelling agent is effective in reducing the fire hazard of the fuel. The free flowing gelled fuel could be adapted readily to existing fuel systems. The rheological profile of this gelled fuel was established over a range of conditions by means of a rotating viscometer, Rotovisco Viscometer, equipped with special measuring heads. Among the rheological parameters which were measured, the viscoelasticity of the gelled fuel appears likely to be a major factor in contributing to the crash-safe character of the fuel.

Pertinent physical properties and microbiological data were also compiled to demonstrate that the fuel gelled with the carbohydrate-based gelling agent is compatible with present aircraft fuel systems.

NA-71-19
AN ACCURACY EVALUATION OF A TAXI SPEED AND DISTANCE MEASURING DEVICE, by R. H. Pursel, Final report, Sept. 1971. 32p. (RD-71-53) (AD 730 096).

A taxi speed and distance measuring device was evaluated for accuracy in tests at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey. The device used a modified skid detector assembly as a sensor. The skid detector assembly was mechanically coupled to the aircraft wheel and thus sensed wheel rotation. Accuracy measurements were made on the device and it was found to meet design accuracy specification for distance measurement. In two cases, speed errors occurred which were in excess of the design specification, but it was felt that this would not degrade the operational usability of the speed measuring equipment. The distance measuring portion of the equipment would require modifications to overcome some limitations before the utility of the distance measuring portion of the device in Category III conditions could be investigated.

NA-71-20
A DYNAMIC SIMULATION STUDY OF AIR TRAFFIC CAPACITY IN THE SAN FRANCISCO BAY TERMINAL AREA, by P. J. O'Brien, Final report, August 1971. 110p. (RD-71-37) (AD 727 756).

A dynamic simulation of air traffic operations in the San Francisco Bay Terminal Area was conducted at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, to determine air traffic capacity estimates when several different airport expansion plans were implemented. Capacity estimates were made for the following separate conditions: first, the present day system slightly modified to accommodate an increased volume of traffic; second, with the operation of an additional runway at San Francisco Airport; third, with the operation of an additional runway at Oakland Airport instead of at San Francisco; and fourth, with the operation of a new multi-parallel runway airport located near the south end of San Francisco Bay and without the expansion to either San Francisco or Oakland Airports. In addition, an estimate was also made of the total system capacity when all airport expansions were implemented. Procedural plans used the area-navigation and two-segment glide slope concepts, and aircraft entered the system at a rate commensurate with system acceptance capabilities. A terminal area capacity of 272 airport operations per hour was attained when the new airport was implemented; however, that rate, although 37 percent greater than the present system, was only 10 percent and 18 percent greater than the capacity when the airport expansions were applied at San Francisco and Oakland Airports, respectively. The capacity of the total system, when all airport expansions were implemented, was estimated to be 332 operations per hour.

NA-71-21
EVALUATION OF FLIGHT PLAN POSITION INFORMATION DISPLAY FOR OCEANIC CONTROL, by A. J. Spingola, W. R. McCosker, and R. L. Sulzer, Final report, July 1971. 54p. (RD-71-38) (AD 728 055).

Tests were conducted using flight data paralleling that entering oceanic sectors to evaluate the concept and measure the accuracy of using computer generated flight plan position information as presented on pictorial and tabular displays for oceanic air traffic control. In Phase I, actual flight progress strip data were tabulated to show the relations among flight plans, estimated times of arrival updated en route, and actual times of arrival over fixes. In Phase II, experienced oceanic controller teams at the Oakland Air Route Traffic Control Center were trained in the use of an interactive graphic display system. In Phase III, questionnaires were administered to controllers who had participated in the Phase II tests. Results of the analysis of flight progress strips indicated that the standard deviation of differences between pilot estimated times at reporting fixes and actual time taken at 515 data points was 3.2 minutes. Based on 17 days of Phase II testing, it was determined that the accuracy of pictorial display symbology was satisfactory for performing the required oceanic control functions and that the tabular display added significantly to the utility of the system. Controller questionnaire responses indicated that the display and processing techniques used in the test system provided a more useful presentation for oceanic air traffic control than the present flight progress strip boards.

NA-71-22
SMALL-SCALE FIRE TESTS OF HIGH-TEMPERATURE CABIN-PRESSURE SEALANT AND INSULATING MATERIALS, by C. P. Sarkos, Final report, Nov. 1971. 37p. (RD-71-67) (AD 731 903)

A 2-foot-square stainless-steel panel was constructed with the same dimensions between the fuselage skin and cabin wall as those of a titanium fuselage previously exposed to an external fuel fire. The panel was subjected to a 2-gallon-per-hour kerosene burner which simulated the heat flux and temperature from a large JP-4 fuel fire, as existed during the titanium fuselage test. The purpose of the panel tests was to determine if the phenomena observed during the titanium fuselage test could be duplicated on a small scale, and also to test various sealant/insulation combinations superior to those used in the titanium fuselage in order to ascertain the degree of improvement in environmental conditions which would result. Testing of the panel utilizing the same materials found in the titanium fuselage caused phenomena and temperature distribution very similar to those observed during the full-scale test, thus giving credence to this test method as being representative of what would occur to a titanium or stainless-steel aircraft during a post-crash fire. The titanium fuselage insulation tested without any cabin pressure sealant caused a flash-fire.

However, two commercially available high-temperature insulations also tested without any sealant maintained survivable conditions for at least 15 minutes. Viton, * a hydrofluorocarbon elastomer, was found not to flame or cause a flash-fire under conditions which silicone did (the titanium fuselage had a silicone cabin pressure sealant). The propensity of the formation of a flash-fire was strongly influenced by the compactness of the insulation and the presence of any voids or passageways between the fuselage skin and cabin wall interface.

NA-71-23
FIRE-EXTINGUISHING METHODS FOR NEW PASSENGER/CARGO AIRCRAFT, by J. J. Gassmann and R. G. Hill, Final Report Nov. 1971. 42p. (RD-71-68) (AD 733 259)

Full-scale fire tests were conducted to determine the degree to which fire in large cargo compartments may be controlled by the use of bromotrifluoromethane as an extinguishing method in conjunction with ventilation shutoff. Results of the tests, using a 10-percent load, indicated that temperature can be kept below 500°F and that a flash fire can be averted for at least 2 hours by the use of as little as 3 percent by volume of bromotrifluoromethane. The rate of agent application was about 3 1/2 pounds per second. During these tests, the normal leakage that occurs while in flight configuration was simulated by providing an airflow of 75 cubic feet per minute. Two tests were conducted to determine the effectiveness of liquid nitrogen as an extinguishing agent. The weights of agent used were 175 pounds and 284 pounds, respectively. The use of liquid nitrogen proved very effective in extinguishing the initial flames, but with the 75 CFM simulated leakage, when the oxygen concentration rose to 12 percent, a flash fire occurred. In both cases the protection lasted just over 30 minutes. The rate of application of the liquid nitrogen was as high as 10 pounds per second.

NA-71-24
STUDY OF VISIBLE EXHAUST SMOKE FROM AIRCRAFT JET ENGINES, by J. Stockham and H. Betz. Final Report June 1971. 75p. (RD-71-22) (AD 726 249).

The objective of this study was to relate the visibility of inflight jet exhaust to the SAE smoke number. A method based on photographic photometry was developed for measuring the optical density of smoke plumes. This method was related to visibility and to the smoke number through transmissometer measurements and visibility theory. A portable transmissometer, capable of operating over a wide range of optical path lengths and under varying ambient light conditions was fabricated for use on this study. The mathematical expression relating the transmission measurements to the smoke number was derived. Liminal visibility requirements of smoke trails, developed from light scattering theory, correlated with actual visual observations

and the transmissometer and photometry measurements. Test results, with the engines investigated, indicate that SAE smoke numbers below 23 were associated with invisible exhaust plumes. Samples of the exhaust smoke showed the particles to be composed of lacy agglomerates. At the nozzle, the geometric median particle diameter was 0.052 m. At a distance of 10 nozzle diameters the geometric median particle diameter was 0.13 m. at cruise condition.

NA-71-26
INERTED FUEL TANK OXYGEN CONCENTRATION REQUIREMENTS, by S. V. Zinn, Jr., Interim Report Aug. 1971. 24p. (RD-71-42) (AD 727 824).

A literature search was conducted to investigate the extent of experimental work and studies that were performed for determining and evaluating safety parameters of jet fuels in aircraft tanks when using nitrogen as an inerting agent. The search revealed that extensive laboratory studies have been made during the past 30 years and that safety zones can be predicted over a wide range of conditions and environments. Except for some very early full-scale tests using aircraft fuel tanks by the Royal Aircraft Establishment, all the studies were made using laboratory equipment.

As a conclusion from this search, it is considered that an oxygen content up to 9 percent in the effluent obtained by nitrogen inerting will produce an incombustible environment.

NA-71-27
SIMULATION STUDY OF CHEVRON MARKINGS FOR AREAS ADJACENT TO RUNWAY THRESHOLDS, by G. S. Brown and R. L. Sulzer, Interim Report July 1971. 20p. (RD-71-40) (AD 726 435).

To determine the minimum system of chevron markings that would give warning of potentially deceptive, nonload-bearing paved areas before a runway threshold, 20 pilots were given systematic exposure in a flight simulator to narrowed and more widely spaced chevron patterns, and also to the present U. S. Standard. The judgments made by these pilots were that both the conventional pattern of full-width chevrons spaced 100 feet apart and a pattern of standard-width chevrons spaced 200 feet apart provided distinct and unambiguous warning of the nonload-bearing surface. Further, they reported that these two patterns were not confusable with other markings such as the runway threshold stripes. Pilot judgments of the two patterns with narrowed chevrons were mixed. While a majority reported the narrowed chevrons not confusable, there was a marked increase in the number reporting absence of distinct and unambiguous guidance particularly when the markings were viewed from a position low on glide slope and offset from the centerline.

NA-71-28
TASK II, TEST AND EVALUATION OF A VOR SOLID-STATE MODULATION ELIMINATOR REPLACEMENT, by B. S. Brayer, Final Report Sept. 1971. 24p. (RD-71-66) (AD 729 733).

This report presents the results of tests conducted on a breadboard solid-state RF Amplifier unit that was designed to replace the power divider and modulation eliminator in a conventional VOR installation. The data obtained from tests on this equipment at the National Aviation Facilities Experimental Center (NAFEC) will be used to provide the basis for specifications of a prototype model.

NA-71-29
INVESTIGATION OF AIRBORNE MARKER BEACON, By L. A. Dvorsky, Final Report Nov. 1971. 100p. (RD-71-80) (AD 732 312).

Ground and airborne tests of flight inspection marker beacon receiving system were made to identify and correct variations in marker pattern measurement from time to time and from aircraft to aircraft. The tests were made with both the T-29 Convair and DC-3 aircraft. Based on the flight test results, new receiver calibration and antenna system ramp calibration procedures have been devised.

NA-71-32
AN INVESTIGATION OF METHODS TO CONTROL POST-CRASH FUEL SPILL FROM INTEGRAL FUEL TANKS, By K. D. Robinson, Final Report Dec. 1971. 70p. (RD-71-75) (AD 733 607).

This study was undertaken to investigate the use of elastomer coatings, curtains and other more novel materials as containment methods to eliminate or control post-crash spill from aircraft integral fuel tanks.

Through use of comparative screening tests, elastomeric liner, curtain, and multilayer liner, and contractor selected boot type liner concepts were selected for evaluation in aircraft wing sections.

Results of aircraft wing section drop tests show that very little improvement was realized with the various systems installed. The structural damage to the wing sections was of such magnitude as to preclude success of any of the systems evaluated.

NA-71-34
CRASH RESISTANT FUEL SYSTEMS DEMONSTRATIONS AND EVALUATION, By H. P. Scheuerman, Final Report Aug. 1971. 31p. (RD-71-27) (AD 728 304).

A crash-resistant bladder fuel tank system incorporating crash actuated valves and crash-resistant bladder material was impact tested in full-scale wing assemblies. The tests were conducted under realistic crash load conditions simulating survivable accidents at approximately 25 mph and 75 mph. Weight and volume changes incurred by the crashworthy features installed are outlined.

NA-71-35
ANALYSIS OF VFR CLOUD CLEARANCE AND VISIBILITY STANDARDS, By G. E. Rowland and C. T. Reichwein, Final Report, Sept. 1971. 113p. (RD-70-48) (AD 730 512).

A three-dimensional vector analysis of a two-aircraft near-miss geometry was developed and used to generate a numerical safety rating scheme for quantifying the degree of hazard associated with aircraft-to-cloud separation minimums and with speed-visibility restrictions. Hazard functions were generated for low, medium, and high-speed aircraft. Based upon the resulting data, proposed new Visual Flight Rules were created. The rationale behind the new rules is discussed. Possible effects of the rules are noted. Numerous inadequacies of the data which were inserted in the limited mathematical model are indicated. Additional research needs are sketched. Concern over the broad impact of the proposed new VFR rules, coupled with reservations about the limited scope of the study and the paucity of hard data to incorporate into and actually test out the validity of the model, cause the authors to suggest the firm necessity of substantial additional technical investigation and broad discussion prior to adoption of the new rules.

NA-71-36
DEVELOPMENT AND EVALUATION OF A DOUBLE SIDEBAND DOPPLER VOR SYSTEM WITH HIGH LEVEL REFERENCE MODULATION, By V. E. Willey, Final Report, June 1971. 178p. (RD-71-25) (AD 724 566).

This report describes the development and evaluation of an improved Doppler VOR System which will provide improvement of receiver compatibility with existing receiving equipment and reduction of station bearing error with some additional reduction of "siting effects" and a reduction of counterpoise size. A new method of providing the 30 Hz amplitude modulation of the carrier, applicable to either the present Single Sideband or the Double Sideband Doppler VOR System for increased carrier power is also described.

NA-71-37
DALLAS-FORT WORTH TOWER CAB DESIGN EVALUATION, By J. R. Bradley, Jr. Final Report, Nov. 1971. 23p. (RD-71-77) (AD 731 961).

This project was conducted to validate the design concept and determine the operational feasibility of an undecagon (11-sided) control tower cab for the new Dallas-Fort Worth Regional Airport. A report was made on position and equipment arrangements, tower console design, and operational factors resulting from the study. A full-scale plywood mockup of the tower cab and consoles was constructed at the National Aviation Facilities Experimental Center (NAFEC) in accordance with specifications provided by the Southwest Region. After installation of equipments and displays, a joint NAFEC/South-west Region 30-day evaluation was conducted. Results indicate that the design concept of the 11-sided tower cab for the Dallas-Forth Worth Regional Airport is valid and that it is highly feasible from an operational aspect. Position arrangements and the console design are considered excellent. An improved equipment arrangement was developed and recommended.

NA-71-39
TECHNICAL EVALUATION OF DUAL INPUT TRANSPONDER, By J. E. Blazej, Final Report, Apr. 1971. 78p. (RD-71-18)

The Dual Input Transponder (DIT) was evaluated to determine if it, in conjunction with upper and lower aircraft antennas, could resolve existing Air Traffic Control Radar Beacon System (ATCRBS) antenna coverage problems by minimizing aircraft antenna shielding phenomena. Flight tests of the DIT and other comparative transponder-antenna configurations were conducted at the National Aviation Facilities Experimental Center (NAFEC), and included several types of maneuvers intended to place the test aircraft in numerous shielding attitudes. Results of the test program indicated that the DIT effectively minimized the loss of transponder replies caused by shielding of the antennas and provided essentially uninterrupted antenna coverage.

A limited number of tests with two independently operated transponders and two antennas indicated that this configuration resulted in less apparent shielding effects than the DIT system.

NA-71-40
FUNCTIONAL ANALYSIS OF PILOT WARNING INSTRUMENT CHARACTERISTICS, By G. E. Rowland and C. T. Reichwein, Final Report, Sept. 1971. 76p. (RD-71-59) (AD 730 516).

The concept of a pilot warning instrument (PWI) is that of a relatively simple and inexpensive device which could be used to aid aviators in the visual detection and evaluation of other aircraft in their vicinity, giving the aviator ample time to select and then make an appropriate collision avoidance maneuver if necessary. Until the present study research on collision avoidance through the use of PWI has focused primarily on hardware development.

The functional analysis of PWI systems that is presented in this report, is intended to disclose the role of the pilot in such systems and to describe the intricate relationships between the pilot, the PWI, and the operational aeronautical environment. Thirteen general functions are defined and illustrated; five performed by the PWI and eight by the pilot. The PWI functions are exemplified by references to hardware systems in use; the pilot functions are described through the use of mathematical models and empirical data.

The general functions of PWI systems are structured into three categories of Pilot-PWI systems. The major independent characteristics of these systems are then used to form system generation matrices. It is shown that over 70,000 different systems can be formed from these matrices. Recognizing the impossibility of dealing with such a number of potential PWI systems, an optimization technique and computer simulation layout are described that could be used in the selection of a limited set of optimal PWI characteristics.

NA-71-42
MODELING AND ANALYSIS OF AIR TRAFFIC CONTROL VOICE COMMUNICATION CHANNEL LOADING, By A. C. Busch, Interim Report, Nov. 1971. 55p. (RD-71-78) (AD 732 619).

This report describes an effort to analyze and model by means of a nonreal-time simulation programming language, in this case GPSS, some of the characteristics of an air traffic control (ATC) air/ground/air voice communications channel. The report describes the functional entities or parameters of the model and the statistical characteristics of these parameters. Furthermore, a comparison is made between the modeling outputs and real field derived measures of system output or performance. The conclusions are that this type of modeling and analysis can be a powerful and efficient tool for ATC simulation and system analysis provided that the model parameters adequately coincide with real system parameters and that real operational data are used to quantify the dependent and independent variables in the model.

NA-71-44
TEST AND EVALUATION OF A DAYTIME COCKPIT FOG SIMULATOR, By M. Ritter, Final Report, Nov. 1971. 31p. (RD-71-82) (AD 732 621).

An evaluation was conducted at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, N.J., to determine the suitability of a Daytime Cockpit Fog Simulator to accurately and realistically simulate Category II and Category III weather conditions to the pilot during flight approaches, Thirteen pilots, using a DC-7 aircraft, participated in the program. The fog simulator was evaluated during atmospheric meteorological visibilities ranging from 1 1/2 to over 12 miles. Technical data, as well as completed pilot questionnaires, comprised the data analyzed. Although the simulator shows merit insofar as projecting realism, a redesign of the unit is necessary to correct deficiencies in various optical, electronic, and mechanical areas.

NA-71-45
ANALYTICAL STUDY OF THE ADEQUACY OF VOR/DME AND DME/DME GUIDANCE SIGNALS FOR V/STOL AREA NAVIGATION IN THE LOS ANGELES AREA, By B. V. Dinerman, Interim Report, Dec. 1971. 152p. (RD-71-96) (AD 735 399).

An analysis was performed by personnel of the National Aviation Facilities Experimental Center (NAFEC) to determine the adequacy of very high frequency omnirange/distance measuring equipment (VOR/DME) guidance signals for vertical/short takeoff and landing (V/STOL) aircraft area navigation (RNAV) in the Los Angeles (LAX) area. Guidance signals were derived from existing VOR/DME and "converted" VOR facilities. It was concluded that: (1) VOR/DME RNAV over seven

approved routes was feasible when using the existing VOR/DME facilities; (2) DME/DME RNAV over the approved routes is feasible when using station-pair combinations from existing VOR/DME facilities and certain converted VOR stations; (3) Except for the last segment of the LAX to Van Nuys (VNY) direct route, VOR/DME RNAV over the hypothetical direct routes was feasible when using existing VOR/DME faciltiies; (4) Except for the last segment of the LAX to VNY direct route, DME/DME RNAV over the direct routes was feasible when using station-pair combinations from existing VOR/DME facilities and certain converted VOR stations; (5) RNAV using DME/DME was potentially more accurate than VOR/DME: and (6) The number of en route station changeovers for VOR/DME and DME/DME RNAV over the approved and direct routes was considered acceptable.

NA-71-54
REACTIONS OF PILOTS TO WARNING SYSTEMS FOR VISUAL COLLISION AVOIDANCE, By P. Rich., Final Report, Dec. 1971. 65p. (RD-71-61) (AD 735 141).

A series of six experiments was conducted that have application to development of Pilot Warning Instruments (PWI). The experiments were concerned with the effect of warning rates on pilot performance, pilot response to imminent collision threats, the evaluation of scanning patterns, the value of warning-only, the effect of relative motion on pilot performance, and the effect of PWI display sector size. The results of these experiments offer a variety of useful data in the area of visual collision avoidance.

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