

# INDEX OF NAFEC TECHNICAL REPORTS, 1967-1969

National Aviation Facilities Experimental Center  
Atlantic City, New Jersey 08405



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FINAL REPORT

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Prepared for

**FEDERAL AVIATION ADMINISTRATION**  
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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 1969. 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 free to qualified users from the Defense Documentation Center, and to others from The Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151. Most reports from The Clearinghouse are sold at \$3.00 each for full size hard copy, and .65 cents for microfiche copy.

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, AD, Project and Contract numbers. The subject headings, with few exceptions, were taken from the FAA Thesaurus of Descriptors, 3rd edition.



NA-67-1

AN ANALYSIS OF THE HELICOPTER HEIGHT VELOCITY 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 lack 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. 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 +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 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, Int. 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 effect 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 659 796).

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.



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  $\frac{1}{2}$  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  $2\frac{2}{3}^{\circ}$  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 outline vs. the hatched display. No differences were found between displays in number of vectors issued or time under control. The  $2\frac{2}{3}^{\circ}$  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  $8^{\circ}$ .

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 Journeyman 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  $0.03^{\circ}$  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  $0.01^{\circ}$  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 HC<sub>2</sub> 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- $\gamma$  -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 a 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. Voysls. 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

FRICION 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 alkyl-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- $\frac{1}{2}$  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 (C20N), 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 (C20N) 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  $1.32^{\circ}$  and  $-1.84^{\circ}$  (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 120.49  $\mu\text{A}$  deflection with a standard deflection (90  $\mu\text{A}$ ) signal applied, and +6.65 and -6.55  $\mu\text{A}$  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  $\mu\text{A}$  deflection with a standard deflection (78  $\mu\text{A}$ ) signal applied, and +4.85 and -5.43  $\mu\text{A}$  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.

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 stickshaker 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 than 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).

A simulation study was conducted at the National Aviation Facilities 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).

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.

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