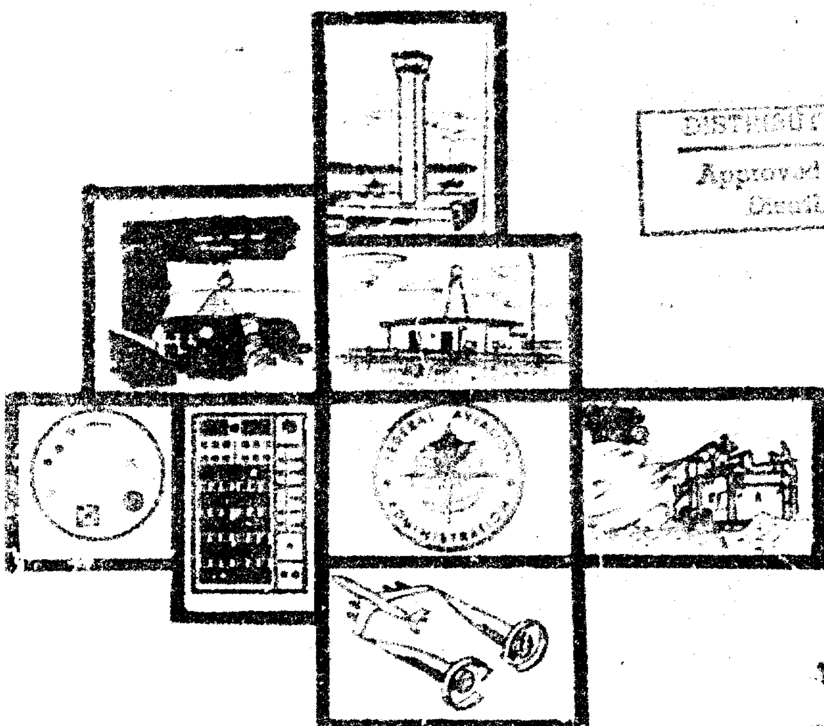
ENGINEERING & DEVELOPMENT PROGRAM

GOALS
ACHIEVEMENTS
TRENDS



1 April 1971 to 31 March 1972

DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

Office of Systems Engineering Management

Washington, D. C. 20591

FOREWORD

This report is intended to serve the needs of FAA top management ~~(i.e.,~~ Administrator, Associate Administrators~~, etc.)~~, DOT, FAA Services, Offices, Regions, Centers, and the aviation community. It covers engineering and development ~~(E&D)~~ progress for the period 1 April 1971 ~~to 31~~ March 1972, and reports on Fiscal Year 1972 E&D Programs~~. These~~ programs include ~~Office of~~ Systems Engineering Management, Systems Research and Development ~~Service,~~* National Airspace System Program Office,* V/STOL Special Projects Office, National Aviation Facilities Experimental Center, Regional, and ~~Aeronautical Center~~ support.

This report covers the following E&D Programs:

01	System	11	Flow Control
02	Radar	12	Enroute Control
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05	PWI/CAS	15	Weather
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08	Runways/Taxiways	18	Aircraft Safety
09	Landside	19	Aviation Medicine**
10	Oceanic	20	Environmental Protection
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Two appendixes are provided covering Completions and Selection Orders.

*SRDS/NASPO to be combined.

**Not included.

Availability is unlimited. Document may be released to the National Technical Information Service, Springfield, Virginia 22151, for sale to the public.

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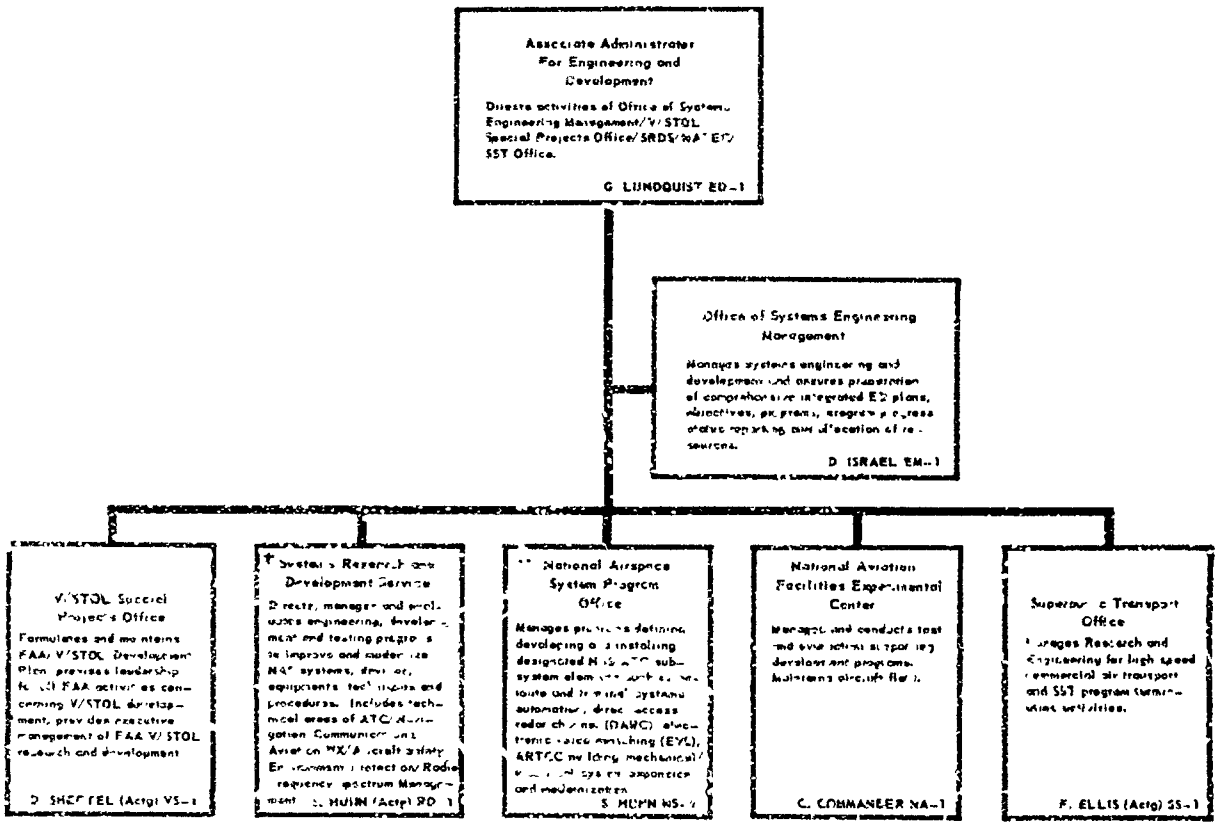
OFFICE OF THE ASSOCIATE ADMINISTRATOR FOR ENGINEERING AND DEVELOPMENT



* SRDS/NASPO to be combined.

01 SYSTEM PROGRAM

GOAL.

The purpose of the System Program is to plan, manage, and define the overall national airspace system design; conduct system simulations, studies, and analyses; and assure establishment of required engineering and development laboratories and test beds.

SCOPE.

These engineering and development efforts are organized under seven Program Elements: 011- System Engineering; 012–Specific Studies; 013–Simulations; 014- R&D Facility; 015–V/STOL System; 016–4th Generation; and 017–New Programs.

In the FY 72 Technical Program, engineering and development efforts include:

012-601 Definition of Functional System Concepts and Design, Program Manager, R.L. Bierman, RD-620.

012-603 System Performance Measures,* Joel E. Erickson, RD-640.

012-604 Capacity Measurement for Air Traffic Performance, Simon Justman, RD-610.

012-605 Measurement and Analysis of Enroute Separation Minima, John Van Dyke, RD-620.

012-607 System Reliability Program,* F. Sakate, RD-650.

012-608 Guidelines for Airport Systems Planning* and New York Offshore Airport Feasibility Study,* Edward W. Schaefer, RD-640.

012-609 System Performance and Cost-Effectiveness Analysis,* James E. Luckman, RD-640.

013-751 NASA AMES System Support, Jack Cayot, RD-540.

013-323 All Weather Landing Simulation, H. Williams, RD-322.

014-241 Radar Beacon Test Bed, M. Natchipolsky, RD-242

015-190 V/STOL Air Traffic Control,* Paul Peterson, RD-150.

015-290 V/STOL Weather Systems,* Arthur Hilsonrod, RD-262.

015-291 V/STOL Surveillance, T. J. Simpson, RD-240.

015-390 V/STOL Joint Program, M Brandewie, RD-326.

015-990 V/STOL System Program Management, James C. Dziuk, VS-10.

015-991 V/STOL System Analysis,* James C. Dziuk, VS-10.

015-992 V/STOL Requirements,* James C. Dziuk, VS-10.

The following selected* major subprograms are highlighted in terms of Background, Progress, and Trend (major milestones scheduled for completion):

SYSTEM PERFORMANCE MEASURES

BACKGROUND.

The purpose of this effort is to develop a data bank of measurements of the performance of the NAS, i.e., Air Traffic Controller Productivity, Airport Capacity, In Flight Delays, In-Flight Separation of Aircraft, Communications, Channel Loading, and NAV Systems. In 1968, SRDS started a research program to measure the efficiency of the ATC system after automation equipment is introduced. Controller workload (per aircraft) was quantified (both voice communications and manual activities workload were measured). This study was designed to establish structured measures of productivity. Subsequently, the project was expanded to address questions of overall system performance. The expanded project constitutes a measurement and performance assessment program designed to periodically provide performance data (including efficiency data) on the NAS or any of its subsystems. The data base created by this program provides support for many different types of analytical efforts ranging from economic feasibility analyses to subsystem design studies, e.g., simulation efforts aimed at assessing the value of proposed improvements.

Preliminary attention focused mainly on the controller and his interaction with a semi-automated environment. Extensive data was collected at FAA facilities. Air/ground/air and interphone voice messages were categorized, and the frequency of occurrence and duration of message types were recorded. Trained observers using paper strip recorders logged and timed the duration of manual activities which are performed by the controller. Statistics, such as the time spent per aircraft by the controller (normalized according to operating procedures), were computed, in addition to a variety of other measures of system efficiency.

PROGRESS.

SRDS initiated a program, including maintenance of a data base. Samples from field facilities were taken at Houston ARTCC and Terminal in March 1971. Samples from Boston Terminal were taken in May 1971, and samples from Boston ARTCC and Atlanta Terminal were taken in October 1971. A second sampling was made in Houston ARTCC in January 1972. NAFEC is reducing the data and storing the data on computer tapes.

SRDS/NAFEC applied methods of comparative analysis using advanced mathematics, as well as mathematical methods of operations research to this data to provide a limited assessment of the performance of the NAS. SRDS/NAFEC completed partial assessment of the performance of airport capacity, in-flight separation of aircraft, etc.

TREND.

The following major milestones are scheduled for completion:

Sampling Completed at Houston Terminal by Contractor or NAFEC–1/73.

Sampling Completed at Boston Terminal by Contractor or NAFEC–10/73.

Sampling Completed at Atlanta Terminal by NAFEC–6/72.

Sampling Completed at Boston ARTCC Contractor or NAFEC–11/73.

Data Collected for Microwave Instrument Landing System Cost/Benefit Analysis by Contractor or NAFEC–4/73.

Data Collected for Low Density Terminal Automation Cost/Benefit Analysis by Contractor or NAFEC–10/72.

Data Collected for ARTS III Add-Ons Cost/Benefit Analysis by Contractor or NAFEC–8/73.

SUBPROGRAM.

System Performance Measures, 012-603.

MANAGER.

Juel E. Erickson, RD-640.

PROJECT MANAGER.

Allen Busch, NA-550.

SYSTEM RELIABILITY ENGINEERING

BACKGROUND.

The purpose of this engineering and development effort is to develop FAA handbook prescribing reliability, maintainability standards. One of our most challenging problems today is the design and development of electronic equipments and systems to provide reliable and failure-free operation to the maximum extent practical. Reliability is the concern of the design and development engineer. The engineer, as well as management, must be concerned with the consequences of equipment failure. A failure may cause air traffic flow problems, i.e., slowing down the process of getting aircraft off the runway or getting aircraft onto the runway. Particularly with the advent of automation in ATC environment, a failure could result not only in severe traffic problems, but significantly decrease the level of safety to the flying public.

Secondly, frequent failures are a source of high maintenance and logistics costs.

Maintainability also is the concern of the design and development engineer. No equipment or system can be guaranteed against failure. Therefore, the equipment or system must provide for a minimum of down time by assuring easy accessability to the failed part or component and/or quick replacement capability.

Logistics is the third factor that must be considered in the operational use of the end product. Logistics can either be high-cost or low-cost and depend on the reliability and maintainability incorporated in the end product.

Thus, the total life cost of an end item will depend on the initial design and development cycle. Has reliability been designed into the equipment? How easy is it to repair? Has equipment maintainability been considered to assure a minimum down time? Will the logistics cost be low?

Agency Order 1110.43, dated January 1969, Subject: "Development of Performance Standards for National Airspace System (NAS) Equipment/System," establishes a requirement for the development of performance standards and the formation of a standing committee with respect to the development of such standards.

Subsequent to the above order, OP-1 letter, dated April 1970, requested DD-1 (ED-1) to establish reliability functions, resulting in the establishment of the Reliability Engineering Branch in SRDS to provide identifiable reliability functions for the agency.

PROGRESS.

1. FAA contract awarded Hughes Aircraft for an FAA Reliability Standard and Handbook. The effort will provide an overall program plan and specification which sets forth the equipment contractor responsibility for achieving reliability requirements. The standard will provide maximum cost-benefits from resources expended on reliability requirements. The handbook will provide procedures and specify acceptable methods for performing reliability program tasks such as reliability prediction, test, design review, etc., for FAA managers and engineers.

2. FAA/RADC (Hqs. USAF Rome Air Development Center) Interagency Agreement executed for RADC/USAF to provide technical support in all reliability/maintainability areas and in-depth failure analysis and special tests necessary to support in-depth physics of failure studies of suspect solid state devices. RADC laboratory facilities and personnel are recognized as one of the nation's best.

TREND.

The following major events are scheduled for completion:

1. FAA Contract Awarded for FAA Printed Circuit Board Evaluation and Standard–3/72.

This effort is based on 9550-1 No. SMS-71-15, dated 18/3/71. This is a comprehensive effort to analyze the present use of printed circuits by the FAA. The agency has a serious maintenance and logistics problem due to proliferation of type sizes, complexity and repair concepts of printed circuit boards. This effort will establish standards for future control and application of printed circuit boards in FAA electronic equipment.

2. FAA Contract Awarded for FAA Grounding, Bonding and Shielding Standard and Handbook–3/72.

This effort is for the development of an FAA standard and handbook. The standard will be the FAA requirement for facility and equipment ground networks to result in personnel safety, lighting and overload protection and reduce equipment interaction of interference.

The handbook will be for use of design engineers and installation technicians to effect equipment and facility design criteria and to permit the establishment of installation and maintenance philosophies of grounding, bonding and shielding standards.

3. FAA Contract Awarded for FAA Maintainability Standard and Handbook–6/72.

This effort will provide a standard which will set forth the equipment contractors responsibility for achieving maintainability requirements. The standard will formulate a maintainability specification that will involve, as a minimum, the maintainability apportionment and prediction in quantative terms as early as possible in the design phase. The standard will cover such areas as maintainability design criteria, maintainability analysis, etc.

The handbook will provide FAA program managers and engineers with procedures for determining realistic maintainability goals.

SUBPROGRAMS.

I 012-607, System Reliability Techniques Development.

I 012-607-016, System Reliability and Maintainability Plans.

I 012-607-026, Reliability Development Support.

I 012-607-036, System Criticality Analysis.

MANAGERS.

F. Sakate, RD-650; R. Barkalow, RD-654; C. Andrasco, RD-653; and E. Bolden, RD-652.

GUIDELINES FOR AIRPORT SYSTEMS PLANNING

BACKGROUND.

The purpose of this effort, responsive to FAAR 5090.1 and 5090.2, is to develop improved methods for measuring traffic at non-tower airports, so as to provide accurate information in evaluating facility improvement criteria and to yield an index of general aviation activities and supply characteristic data necessary for forecasting future conditions This subprogram is divided into two projects (1) techniques for National Airport System Planning (NASP), and (2) Airport Planning Analyses. Techniques for NASP Planning has one contract in force which is to develop methods to estimate traffic at non-tower airports. Within the present definition of airports considered to be essential to the National Airport System Plan, more than 90% are non-tower airports. There are approximately 4,000 airports included within the NASP. About 350 of these have FAA-Operated air traffic control towers which report airport activity. The remaining airports are without adequate or standardized means for reporting operations data. Yet FAA requirements identify the necessity for an annual reporting of operations at each airport in the National Airport Plan. Data concerning annual total, itinerant, and local operations is required to access future as well as current traffic levels so that priorities may be associated with potential airport improvements or new facilities.

The method for estimating traffic at non-towered airports must be statistically valid, comprehensive, number of parameters measured, and economical. Statistical validity is necessary to insure a known and tolerable degree of error. Comprehensiveness is required to satisfy various criteria requirements as well as to provide insight into general aviation activities. For example, at the present, the number of itinerant operations is the criteria used to evaluate an airport's qualifications concerning an FAA control tower. However, it is reasonably contended that enplaned passengers or peak traffic are equally valid criteria. These parameters then, and perhaps others, should also be measured and the traffic estimating method must account for them. Finally, economy is mandatory if the method is to be implemented throughout the large population of non-towered airports. It is evident that statistical sampling is the key to relieving the economic burden. Airport planning analysis has two current contract efforts- one in force, the New York Offshore Airport Study is described elsewhere. The second effort entitled "Apron-Terminal Area Complex Evaluation Criteria," is intended to assist in evaluation of airport planning and design. There is a need to bring together in one volume the best thinking on air transportation "apron-terminal area complex" designs which are within the technical and financial means of most communities. The Systems Research and Development Service has been requested by Airports Service to seek assistance in gathering an adequate amount of information representative of the realities of ground movements of aircraft, air passengers, and cargo, in organizing it in a logical structure, and in developing from it criteria for evaluating "apron-terminal area complexes."

This information will be the basis for the development of criteria for use by mayors of municipalities, airport owners and operators, professional planners and designers, Chambers of Commerce, and other public and private transportation-oriented action groups in evaluating apron-terminal areas complex designers. The criterion developed is to serve in explaining to laymen the logic of planning and constructing a proper size apron-terminal area complex to provide the services intended. In general, these criteria must especially reflect the viewpoints of the air traveler, the cargo container or item, and the aircraft being serviced (on-off). Consideration must also be given to the technical, economic, operational, and aesthetic aspects of accommodating the services provided.

PROGRESS.

FAA contract awarded to Systems Consultants, Inc. for a study of NASP Techniques. The contract is to be accomplished in three phases. The first phase will result in a report that includes the recommendation of five different methods together with trade-off data concerning cost and statistical error. During Phase II, the FAA will review the report and select methods for implementation. The third phase will result in contractor's instruction manual detailing implementation procedures.

In addition to developing new methods, the contractor will analyze, evaluate, and compare 12 alternate survey methods now in use or proposed for determining operations at non-tower airports. These methods are presently used by various FAA regions, state aviation agencies and cities. The contractor will consider any of these methods as candidates for his final recommendations.

SRDS completed a work statement for a proposed contract "Apron-Terminal Complex Evaluation Criteria" to.

1. Bring together all known apron-terminal area concepts.
2. Analyze each concept identifying the advantages and disadvantages of each including a cost benefit analysis.
3. Prepare a narrative report summarizing the work and conclusions.
4. Prepare a handbook outlining the advantages and disadvantages, of each concept. The handbook will be directed toward airport owners, operators and their consultants. Proposals have been evaluated—contract award is pending.

TREND.

The following major milestones are scheduled for completion:

1. FAA handbook issued for estimating traffic in non-tower airports–2/73.
2. FAA handbook issued for airport planners in planning more efficient apron-gate operations–4/73.

SUBPROGRAM.

Guidelines for Airport Systems Planning, 012-608.

SUBPROGRAM MAJOR.

Edward W. Schaefer, RD-640.

NEW YORK OFFSHORE AIRPORT FEASIBILITY STUDY

BACKGROUND.

Operating delays and difficulties at existing airports in New York region combined with increasingly unacceptable noise impact upon nearby populations, traffic congestion caused by inadequate ground access systems, plus other factors, resulted in FAA study regarding feasibility of an off-shore facility serving New York area. Study Contract DOTFA71WA-2626, 25 June 1971 awarded to Saphier, Lerner, Schindler Environetics (SLS), a division of Litton Industries. Requirement for this project is by direction of the Administrator, 1 March 1971. A Study Team was created and headed by Lawrence Lerner who was directly responsible for the concept, creativity, methodology and systems management of the study project. Other Team members are SLS vice-president Marshall A. Graham, a full-time SLS staff crew, and a group of specialized and experienced consultants retained by SLS for assistance in specific segments of the study.

Study prescribed by FAA was divided into two phases:

Phase I. Evaluation of several water locations focusing on determination of their feasibility as sites for an offshore airport.

Phase II. To be carried out if required by FAA, would involve deepening and firming up specific subjects under study as well as answer questions raised by FAA reviewers.

PROGRESS.

Phase I evaluation of water locations was completed by the contractor and findings submitted to FAA on 31 December 1971. Overall findings propose that the Atlantic Ocean, 3 1/2-4 miles off Atlantic Beach provides an economically, technically and socially feasible site (Figures 1 and 2). Aspects of the study implementing this recommendation include: Air Traffic Projections; Air Side Operations; Ground Access System; Offshore Structural Concepts; Airport Configuration; Deep-draft Harbor; Airport Construction; Environmental Protection; Ancillary Functions; Community Impact. The findings developed four plans:

PLAN I. Replace JFK with EWR and LGA remain at 1972 capacity.

PLAN I–A. Replace JFK with EWR and LGA improved technologically on airside.

PLAN II. Offshore as 4th airport.

PLAN III. Offshore as single N.Y. regional airport.

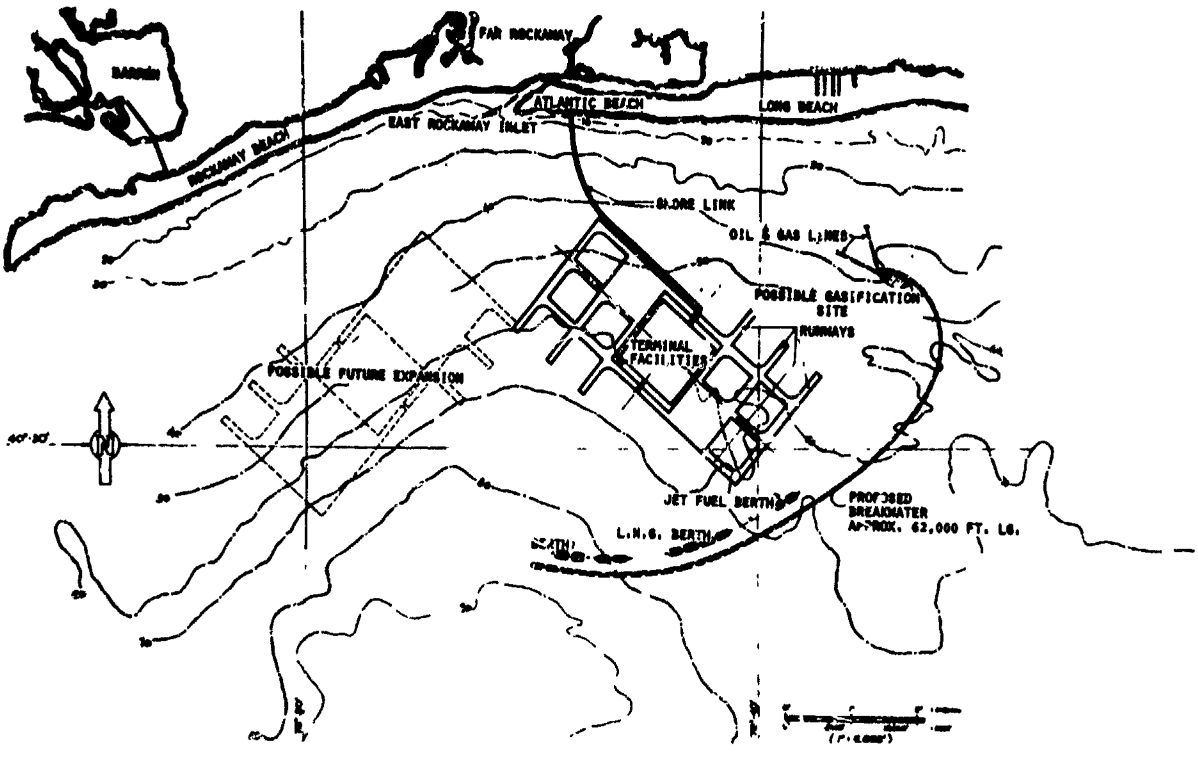


Figure 1. General Site Plan of Proposed New York Offshore Airport.

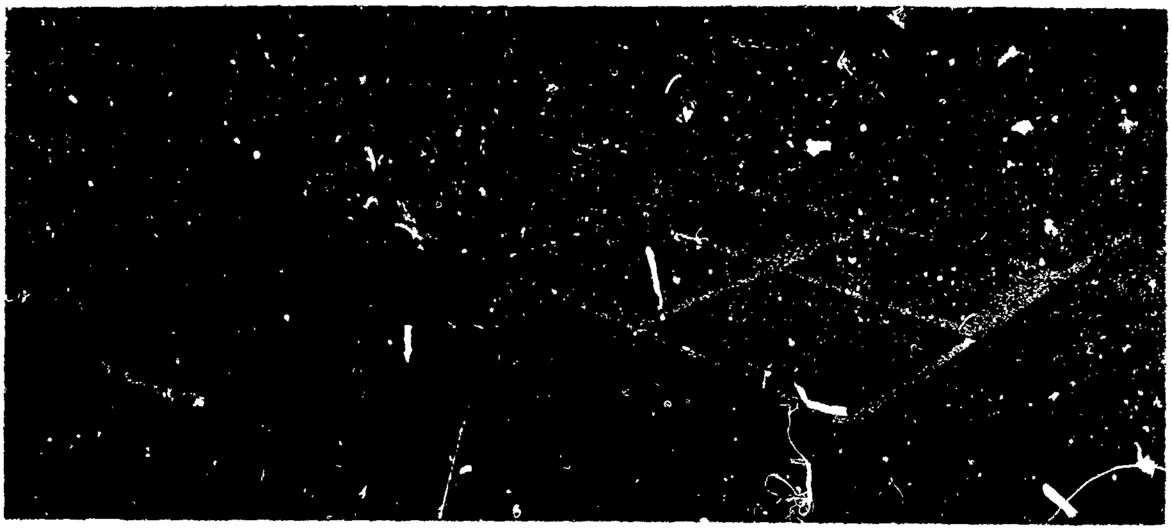


Figure 2. Perspective View of Configuration of Proposed New York Offshore Airport.

The findings arrived at the following projections:

Annual volume for the N.Y. region:

Passengers	1985 = Approximately 120 million
	2000 = Approximately 300 million
Cargo	1985 = 11.6 million tons
	2000 = 17.4 million tons

(Figure 3: Air Operations in Busy Hours--Plan I, Plan II)

The study provides a unidirectional air traffic flow from arrival through the terminal area and then out the opposite side for departure. The flow direction is determined by the wind direction.

The funds concerning airport construction were as follows: If the airport is to be modularly prefabricated at a number of shoreside staging yards, construction could proceed rapidly at many simultaneous locations. As soon as a runway is completed it could be put into operation, first to pick up the expansion the present three airports cannot handle and subsequently to phase out either one or all three. This incremental plan should provide a sound hedge against unpredictable changes in the air traffic volume.

This flexibility and early initial operation capability probably would not be available if a

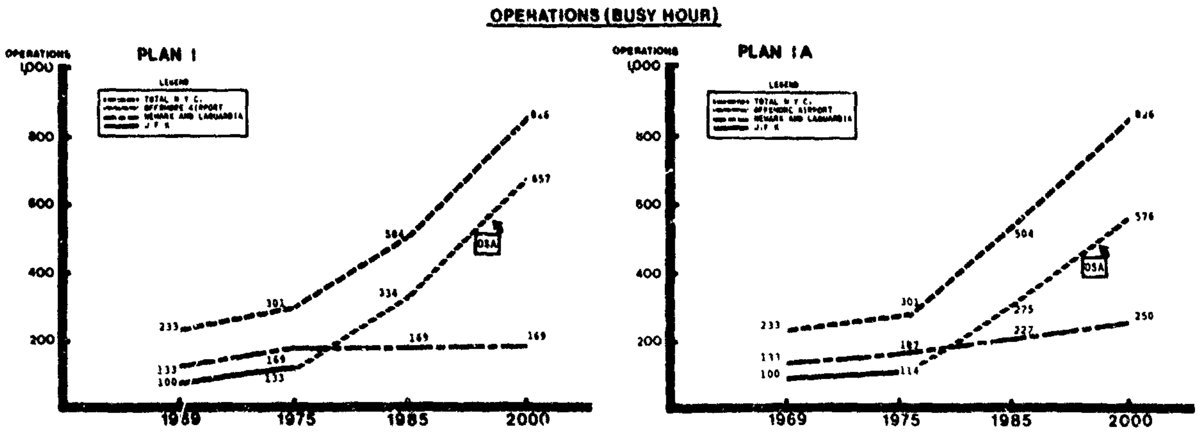


Figure 3. Operations (Busy Hour) New York Offshore Feasibility Study.

Poulder-dyke concept is employed. The ocean bed acreage must be surrounded and isolated to usable dry land before airport construction can begin. In essence it appears at this time in the investigation that it would take as long just to build a dyke as it would to bring a total hybrid system into operation. This particular conclusion bears further study.

TREND.

The following major milestones are scheduled for completion.

Phase II SRDS Report "Financial/Legal/Construction Feasibility of an Offshore Airport for N.Y. issued–4/73.

The Phase I SRDS Report "New York Offshore Feasibility Study" issued–4/72.

SUBPROGRAM.

Guidelines for Airport Systems Planning, 012-608.

MANAGER.

Edward W. Schaefer, RD-640.

SYSTEM PERFORMANCE AND COST-EFFECTIVENESS ANALYSIS

BACKGROUND.

This effort, responsive to a request for R&D support from the FAA Office of Policy and Plans, seeks to conduct system performance and cost effectiveness analysis in support of proposals for and products of development.

PROGRESS.

SRDS completed expansion of Airport Airside Mathematical/Computer Model in February 1972. This model computes aircraft time-in-system for ASR (radar equipped and non-equipped terminals). The model is based upon flight path data obtained from aeronautical charts, aircraft flight profiles, and the recursion relations between flight event histories. Model parameters include: terminal flight geometry, type of approach (ILS, ADF, VOR, DME), enroute airway structure, type of aircraft (flight profile, speed mix, etc.), location of restricted areas, noise abatement procedures, the service demand distribution, and the in-flight separation spacing distribution.

SRDS completed the final report "An Analysis of the Costs and Effectiveness of Airport Surveillance Radars" (012-609-036). This analysis was conducted in response to a request by the Office of Management and Budget and The Office of the Secretary of Transportation as a Special Issue Study on FAA Program Effectiveness and Facility Criteria. This report provides guidance for determining establishment criteria based upon findings which used (1) safety as a measure of effectiveness after extensive analysis of past accidents, near midair collision reports, VFR Radar Advisory Service statistics and Radar Flight Assist Statistics (2) convenience as a measure of effectiveness where convenience is defined as a reduction of mental strain for the air traffic controller, and (3) time saved (reduction in aircraft delays) as a measure of effectiveness based upon estimates provided by applying the Airport Airside Mathematical/Computer Model (described above) to selected airports.

SRDS completed "Cost/Effectiveness Investigation of Automatic Position Reporting." This study was in support of a feasibility study of "Automatic Postion Reporting by Data Link" conducted by Communications Development Division. The Cost/Effectiveness study discusses relative merits of the demonstration data link system operating at Oakland ARTCC and the manual system. Some preliminary cost information is also presented.

NAFEC completed report on "The Development of a Motion Picture Measurement Instrument for Aptitude for Air Traffic Control". This effort was in response to a request from the Associate Administrator for Manpower to R&D for a controller evaluation test which would be used in field validation work scheduled for May 1971. This report describes the test and gives estimates of reliability and validity as obtained from administration of the test to air traffic control specialists.

SRDS completed the final report FAA-RD-71-44-I and -II, entitled "Potential Economic Benefits of Fog Dispersal in the Terminal Area." The report, in two parts, provides estimates of the costs of disruptions of aircraft arrivals associated with a number of Category II and III weather situations, with the emphasis on fog situations, at some of the major air carrier airports in the United States. As such they serve as indicators of the potential economic benefits that would accrue to the airport users as a result of complete elimination of the adverse effects of these weather situations on aircraft landings. Part I of the report carries the subtitle "Estimating Procedure" while Part II is subtitled "Findings." The project (RD-260-001-01R) which resulted in this report was initiated at the request of the Communications Development Division.

SRDS completed report on evaluation of Sampling Methods. In many agency programs, a controller workload analysis is called for wherein the distribution of time spent on various controller tasks is determined. Numerous sampling techniques are employed in developing such data. In this report, the expected accuracy and confidence limits of the various methodologies are explored. Basic data inputs for this study were developed from the NAFEC data bank of observations of performance at field facilities.

SRDS completed report on "Some Estimating Techniques for Traffic Count at Non-Tower Airports." The criteria for the establishment of many FAA services (and for authorizing ADAP funding grants) frequently depend upon the activity level, i.e., operational count, for the location in question. At an airport where no tower exists, traffic count must be estimated. This report examines the expected reliability and validity of several techniques used by various aeronautics groups to obtain estimates of traffic activity at non-tower airports. SRDS completed "Updated Report-Cost-Benefit Analysis of Reflectorized Paints for Runway Markings." The report describes benefits of reflectorized paints for night-time operations, comparative costs of reflectorized versus ordinary paints and the economic value in prevention of accidents.

TREND.

The following major studies will be undertaken in the future:

1. Economic Analysis of Development of ADSA Systems and Devices (Subprogram 052-241) FY73.
2. Cost Benefit Analysis of Radar Weather.
3. Clutter Techniques for Terminal (Subprogram 022-242) FY73.
4. Economic Analysis of Implementing Visual Collision Prevention Systems (Subprogram 051-241) FY73.
5. Cost-Effectiveness and Implementation Criteria for Wake Turbulence Sensing and Display Subsystem in the NAS (Subprogram 214-741) FY73.
6. FAA initiated a support contract to provide cost-benefit/effectiveness analysis of ARTS Expansion, Low Density Terminal Automation and Microwave Landing System (Subprogram 012-609) FY73.

SUBPROGRAM.

System Performance and Cost Effectiveness Analysis, 012-609.

MANAGER.

James E. Luckman, RD-640.

V/STOL AIR TRAFFIC CONTROL

BACKGROUND.

The purpose of this program is to investigate, through dynamic simulator, the effect of STOL performance characteristics on the air traffic control system and the effect of air traffic control system requirements on the efficient operation of STOL aircraft. This is accomplished by tying the NASA Langley Research Center STOL flight simulator into the FAA's digital air traffic control simulator at NAFEC and through real-time simulation, introduce a busy STOL operation into high density terminal area environments.

The first study will provide data on what can be considered the interim period of V/STOL system development (72-76). The study is a three-phase program to examine STOL operations in the air traffic control system. Phase I looks at the impact of a downtown STOLport, Phase II looks at a STOLport on a CTOL airport and Phase III is a combination of I and II. As new information on any part of the system evolves, additional studies will be made to determine system impact.

PROGRESS.

FAA letter report completed on Phase I—"Impact of Downtown STOLport." The report found that because of limited available airspace in high density terminal areas, precise navigation, strict ATC rules and procedures will be required to achieve safe and efficient STOL operation.

TREND.

FAA letter report completed on Phase II—Simulation of STOLport on Conventional Airport (CTOL)—9/72.

FAA final report issued covering Phase I, II, III Simulations—3/73.

NASA final report issued covering Phase I, II, III Simulations—4/73.

SUBPROGRAM.

V/STOL Air Traffic Control, 015-190.

MANAGER.

Paul Peterson, RD-150.

PROJECT MANAGERS.

Herb Slattery, NA-516; Sidney Rossiter, NA-516; and John Maurer, NA-516.

V/STOL WEATHER SYSTEMS

BACKGROUND.

Detailed meteorological information in densely populated metropolitan areas is lacking. Planning and design efforts related to V/STOL vehicles, landing facilities and other system developments are constrained without this information. To obtain this information, the V/STOL SPO initiated a program to investigate the environment at potential metropolitan V/STOL port sites. A determination will be made of the frequency of critical weather parameters such as wind, wind shear, turbulence visibility, icing, etc., which may effect V/STOL design and operation on surface and elevated sites in these built-up areas.

The first phase of the effort will be an analysis to determine significant environmental factors and provide a plan for obtaining the required meteorological information in a form useful for V/STOL vehicle design and operation The information will apply to the design of the stability and control features of V/STOL aircraft, simulation of aircraft operations, location of V/STOL ports, determination of runway orientation, etc.

The second phase will be the actual conduct of a climatology survey at a potential metropolitan V/STOL port site to obtain required data. Specially designed Gill anemometers and sonic anemometers will be used to obtain critical wind information (Figure 4).

The resulting data will also indicate whether or not there is a requirement for a unique V/STOL weather reporting system.

PROGRESS.

This subprogram, supported by the FAA, will be carried out by the Atomic Energy Commission (AEC) program. The AEC has contracted with Battelle Pacific Northwest Laboratory to conduct the analysis and survey.

TREND.

The following major events are scheduled for completion.

Figure 4. Gill Anemometers.

1. Review of draft Analysis Report–6/72.
2. Analysis report released–9/72.
3. Initiation of Climatological Survey–10/72.

SUBPROGRAM.

V/STOL Weather Systems, 015-290.

MANAGER.

Arthur Hilsenrod, RD-262

V/STOL SYSTEM ANALYSIS/REQUIREMENTS

BACKGROUND.

In response to the public need for more efficient and effective short-haul aviation transportation, the Administrator established a V/STOL Special Projects Office (V/STOL SPO) in May 1971. Its purpose is to foster the development of a V/STOL transportation system that is safe and convenient for the passenger, economically profitable to operate, compatible with other segments of aviation, and environmentally acceptable to the public, and to encourage the private sector to develop V/STOL capability on a free enterprise, non-subsidized basis with local authorities establishing needs and planning for their particular areas.

V/STOL development activities are underway in seven program areas. In addition to those described in this section others can be found under 045, 074,081,084,182 and 202 Program Elements.

System elements will be emphasized which are the responsibility of the FAA, i.e., navigation, air traffic control, landing facilities and aircraft/pilot/operational certification.

System analysis will provide those studies and activities needed to plan and define the overall V/STOL Program. This multi-year function requires the formulation of techniques for evaluating the economic viability of STOL and VTOL transport systems and the application of such techniques in actual analytical study programs.

These analyses will take into account the nation's goal in planning the development of short-haul transport systems and provide the agency with a basis for investment decisions concerning the federal, state, local and private sector implementation activities for STOL and VTOL systems. The primary analytical emphasis will be on identifying and quantifying the social costs and benefits as well as the monetary costs and benefits associated with such systems, and conducting trade-off analysis so that the most cost effective plan can be selected for promotion and development.

PROGRESS.

Contracts awarded to Battelle Columbus Laboratories, and Urban Systems Research and Engineering, Inc. for the program definition phase of the FAA's V/STOL Development Plan.

TREND.

The following major milestones are scheduled for completion:

Preliminary Program Plan completed–8/72.
First Program Plan issued–10/72.

SUBPROGRAM.

V/STOL System Analysis, 015-991.
V/STOL System Requirements, 015-992.

MANAGER.

James C. Dziuk, VS-10.

02 RADAR PROGRAM

GOAL.

The purpose of the Radar Program is to improve the performance of the existing radar systems (Airport Surveillance Radars (ASR), and Air Route Surveillance Radars (ARSR) and the associated site detection, digitizing and processing system) in terms of probability of target detection and clutter reduction; and investigate improvements in reliability with advanced radar techniques.

SCOPE.

These engineering and development efforts are organized under three Program Elements: 021–Sustaining Engineering, 022–Improved Subsystems, and 023–New Systems.

In the FY 72 Technical Program, engineering and development efforts include:

021-241 Radar In-Service Improvements,* Ken Coonley, RD-241, Owen E. McIntire, RD-241.

022-241 Improved Radar Design Techniques,* Ken Coonley, RD-241.

022-242 ATC Radar Weather Clutter Control Development,* Ken Coonley, RD-241.

023-241 Next Generation Primary Radar.

The following selected* major subprograms are highlighted in terms of Background, Progress, and Trend (major milestones scheduled for completion):

RADAR IN-SERVICE IMPROVEMENTS

BACKGROUND.

The purpose of this effort is to correct problems in terminal and long range radar facilities. It is responsive to FAARs hereinafter indicated. Specifically, it covers the following two areas of deficiencies:

1. **ASR/ARSR Performance Monitor.** Monitoring radar performance at most FAA facilities is presently conducted by a technician checking facility performance at periodic intervals and by a qualitative observation check of a Plan Position Indicator (PPI) Scope Operator. Slow degradation of performance of the facility could occur between technician checks without being evident on the PPI, causing loss of some small targets. An automatic performance monitor could continuously measure critical radar parameters and provide an alarm when these parameters fall outside specified tolerances. This effort, in response to FAAR 6310.1 (9/7/66), seeks to develop such a monitor for the ASR and the ARSR.

2. **Angel Clutter Reduction Techniques.** "Angel" or "anomalous target" are backscatters which seem to be air-borne targets but exist in numbers far exceeding normal air traffic densities. Previous experiments concluded that these targets vary in size less than a small aircraft to greater than a large aircraft. They usually have a velocity from a few knots up to 60 or 70 knots and are therefore not necessarily eliminated by Moving Target Indicator (MTI) circuitry. Most previous experiments concluded that the majority of these targets are caused by birds. This engineering and development (responsive to FAARs 6310.2 (10/14/66) and 6340.1 (10/2/67)) seeks to reduce the degrading effects of angel clutter from the ASR radar.

PROGRESS.

1. Contract for development of a radar performance monitor awarded to Westinghouse

Technical difficulties were encountered in obtaining an acceptable false alarm rate. Redirection of the program is being considered to provide for computer simulation of a performance monitor prior to actual hardware design.

2. Contract awarded to Johns Hopkins University Applied Physics Laboratory to determine appropriate techniques for incorporation in ASR to reduce the harmful effects of "angel clutter." This study will be accomplished in three steps. The first will be data collection to ascertain the general radar signature characteristics of angel clutter which exists in the air traffic control radar environment. The data will consist of photographs, run length statistics, and ASR wideband video recordings from selected ASR facilities. The second consists of data analysis and experimentation, assembling appropriate instrumentation and operating this equipment in conjunction with an ASR to assess the potential effectiveness of various candidate radar alterations in terms of angel clutter reduction. The third consists of the definition and design of an ASR modification.

TREND.

The following major milestones are scheduled for completion:

ASR/ARSR Performance Monitor.

1. Westinghouse Equipment delivered to NAFEC–6/72.

2. Test and Evaluation completed by NAFEC–11/72.

3. Final Report issued by NAFEC–2/73.

Angel Clutter Reduction Techniques.

1. Report "Recommended Alterations OF The ASR" issued by Johns Hopkins University Applied Physics Lab–7/72.

2. Design of Angel Clutter Fix Completed by Johns Hopkins University Applied Physics Lab–10/72.

3. Final Report issued by Johns Hopkins University Applied Physics Lab–12/72.

4. Retrofit Package Recommendations by Johns Hopkins University Physics Lab–9/73.

SUBPROGRAM.

Radar In-Service Improvements, 021-241.

MANAGERS.

Kenneth E. Coonley, RD-241, and Owen E. McIntire, RD-241.

PROJECT MANAGERS.

William Herget, NA-553, Performance Monitor; Cliff Chapman, NA-532, Angel Clutter Reduction Technique.

IMPROVED RADAR DESIGN TECHNIQUES

BACKGROUND.

1. Passive Horn Development. Significant reduction in angel and ground clutter effects can be obtained by tilting the antenna radiation pattern of a radar upward. This, however, results in loss of low altitude coverage at longer ranges. This engineering and development effort, in response to FARRs 6310.2 (14/10/66) and 6340.1 (2/10/67), seeks to develop a radar antenna with two feedhorns and two radiation patterns. One feedhorn will be used for both transmitting and receiving and will provide the standard radiation pattern. The other feedhorn will be a receive-only or "passive" horn and will provide a tilted-up pattern for reduction of close-in angel and ground clutter. At the beginning of each pulse repetition period, out to a range of several miles, the incoming echo signals will be confined to the tilted-up pattern associated with the passive horn. At the end of this period a high-speed solid state switch transfers the remaining part of the receive period to the standard horn.

2. Small Aircraft Enhancement. The detection and tracking of small aircraft by primary radar is often difficult because of the small radar return from these aircraft. If this return could be increased or "enhanced" then the probability of detection of these small aircraft would also increase. The radar return can be increased by use of a passive enhancement device which returns a large percentage of the intercepted radar energy back to the radar instead of scattering it in all directions, or an active enhancement device which generates a signal in the aircraft. The limitation of a passive device is that the absolutely maximum amount of energy which it can return to the radar is equal to that returned by a flat plate of equal area which is pointed directly toward the radar. This effort, in response to a recommendation of the National Transportation Safety Board, seeks to develop, test, and evaluate radar enhancement devices so that an adequate return from all aspect angles of a small aircraft can be obtained for proper detection and tracking of these targets.

In addition to FAA engineering and development effort there is a continuing need to test promising enhancement devices offered by industry. Vega Precision Laboratories developed an active enhancement system consisting of an airborne unit to be installed in small aircraft and a ground receiver to be interfaced with the ASR and Air Traffic Control Beacon Interrogator (ATCBI). Whenever the airborne unit is hit with an S-band radar signal it returns a pulse on the ATCBI interrogation frequency. The ground receiver is installed in the beacon interrogate path to receive this signal. This return from the aircraft is then processed and displayed on a PPI along with the primary radar and beacon video. The Vega Airborne unit is shown in Figure 5.

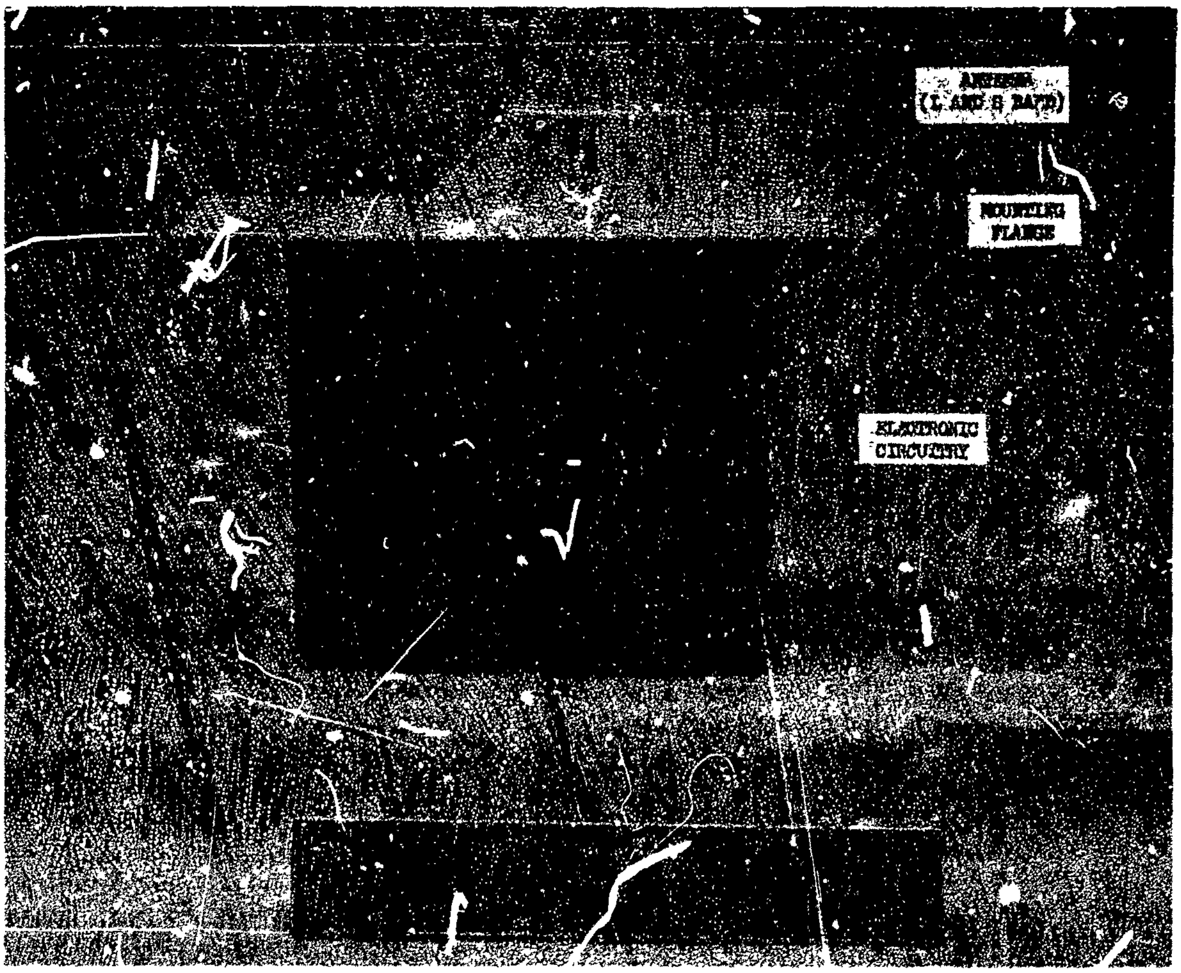


Figure 5. Improved Radar Design Techniques

PROGRESS.

1. Contract for a feasibility model of the passive horn awarded to Raytheon 6/69. Phase I of this contract covering engineering analysis, design and experimental measurements to determine the necessary antenna modifications, optimizations, tilts, etc., completed. Phase II covering design and fabrication of feasibility hardware completed and delivered to NAFEC for test and evaluation, 2/71.

2. A small aircraft enhancement engineering and development program plan is being completed. This plan includes radar cross section measurements to define the magnitude of the problem, the characteristics of an enhancement device, preparation of a procurement specification, generating a request for proposals, evaluation of these proposals, and test and evaluation of several enhancement devices.

Contract awarded to Vega Precision Laboratories for lease of one Vega Airborne Radar Enhancement System for test and evaluation at NAFEC, which is now underway.

Raytheon Pressure Horn Equipment delivered to NAFEC.

Small Aircraft Enhancement Test and Evaluation of Vega Airborne Enhancement completed.

Small Aircraft Enhancement Engineering and Development Program Plan finalized.

TREND.

The following major milestone is scheduled for completion:

Final Report–Pressure Horn issued by NAFEC–10/72

SUBPROGRAM.

Advanced Radar Design Techniques, 022-241.

MANAGER.

Kenneth E. Coonley, RD-241.

PROJECT MANAGER.

D. Offi, NA-533.

ATC RADAR WEATHER CLUTTER CONTROL DEVELOPMENTS

BACKGROUND.

1. **Terminal Radar Weather Clutter Control Development.** Use of circular polarization does not completely eliminate weather clutter from radar displays during moderate and heavy precipitation. A requirement exists to eliminate this weather clutter and improve the signal to clutter (S/C) ratio. However, some indication of hazardous storm conditions must remain on the radar display. Equipment has been developed by Texas Instruments for test and evaluation that may meet the requirements for weather clutter rejection, S/C ratio improvement, and hazardous storm display. The storm display information is in the form of a contour of the storm area. The proposed equipment involves, (1) reduction of the transmitted pulse width from 0.8 usec to 0.4 usec, (2) incorporation of a non-coherent MTI mode, (3) utilization of both radar channels in a dual-frequency diversity operation, and (4) provision of logarithmic amplifier/fast time constant (FTC)/antilog circuitry.

2. **Pulse Compression Development.** The determination of the pulse width in a standard pulsed radar involves tradeoffs between resolution capability and signal to clutter (S/C) ratio and maximum detection range. Higher resolution capability and greater S/C ratio require narrower pulses while greater detection ranges require more energy per pulse and therefore wider pulse widths. In a pulse compression radar a relatively wide pulse is transmitted and the return is then processed and compressed to produce a narrow pulse. One technique used to allow for this pulse compression is to linearly change the carrier frequency during the pulse period. Frequency processing can be used to delay one end of the pulse by a greater amount than the other end. If the amount of delay is a direct function of the original frequency change then the entire pulse can be compressed to a very narrow width. This engineering and development effort, in response to FAAR 6420.1 (11/10/66), seeks to develop a pulse compression radar compatible with circuitry.

PROGRESS.

1. Terminal Radar Weather Clutter Control Development. Test and evaluation of the Radar Weather Clutter Feasibility Equipment at the NAFEC ASR-5 test bed completed and the final report being prepared.

2. Pulse Compression Development. Contract awarded to Texas Instruments 6/71 for the design, fabrication, test and evaluation of a coherent pulse compression/MTI radar for airport surveillance radar. This technique will simultaneously provide increased resolution, better clutter rejection and increased average power for better target detection. The basic pulse compression hardware has been designed and assembled. The remaining period of the contract will be devoted to finalizing and testing the pulse compression radar design.

TREND.

The following major events are scheduled for completion:

Pulse Compression Development

1. Final Design completed by Texas Instruments–6/72.
2. Final Report issued by Texas Instruments–9/72.

SUBPROGRAM.

ATC Radar Weather Clutter Control Developments, 022-242.

MANAGERS.

Kenneth E. Coonley, RD-241, and Dan L. Hopson, RD-241.

PROJECT MANAGER.

Ronald Bassford, NA-533.

03 BEACON PROGRAM

GOAL.

The purpose of the Beacon Program is to improve radar beacon capabilities (accurate, reliable, noise free position, altitude and identity information) for better service to the aviation public and improve the performance and reliability of the air traffic control data acquisition system.

SCOPE.

This engineering and development effort is organized under four Program Elements: 031–Sustaining Engineering; 032–Monitoring and Policing; 033–Improved Systems; and 034–Discrete Address Beacon System.

In the FY 72 Technical Program, engineering and development efforts include:

031-241 Air Traffic Control Radar Beacon System (ATCRBS) Sustaining Engineering,* Subprogram Manager D. Asker, RD-242.

032-315 ATCRBS Flight Inspection Monitor System, R. Vallone, RD-342.

032-601 ATCRBS 4096 Code Employment Plan,* J. Van Dyke, RD-620.

032-602 ATCRBS Long Term Capability, R. L. Biermann, RD-620

033-241 ATCRBS In-Service Improvements,* M. Natchipolsky, RD-242.

034-101 Complete Interface for Advanced ATCRBS, D. Scheffler, RD-123.

034-241 Discrete Address Beacon System (DABS),* K. Wise, RD-242.

The following selected* major subprograms are highlighted in terms of Background, Progress, Trend (major milestones scheduled for completion).

AIR TRAFFIC CONTROL RADAR BEACON SYSTEM (ATCRBS) SUSTAINING ENGINEERING

BACKGROUND.

This engineering and development effort seeks to investigate the performance of the ATCRBS, develop equipment for monitoring the air and ground environments, and promote improvements in the airborne components of the system. Requests from operating facilities for engineering and development assistance in solving system problems are covered in this subprogram.

Operational facilities report weak, broken and false beacon targets. Limited testing by NAFEC and Lincoln Laboratories indicate existence of transponder performance problems, i.e., low power output, poor side lobe suppression, and low receiver sensitivity. NAFEC is developing equipment which will rapidly and automatically analyze transponder performance.

Operating facilities are required to provide full-time, high-quality radar beacon coverage for Air Traffic Control. This requirement for the most part, prevents the site technical personnel from thoroughly analyzing and correcting system problems since the equipment parameters and configuration cannot be varied during ATC operation. SRDS uses its technical expertise and, through NAFEC resources, i.e. aircraft, laboratories, test beds, and instrumentation, to assist the facilities in detecting, analyzing and solving technical problems.

Due to the nature of the subprogram, the specific projects are continuing efforts with project tasks assigned when received or defined. The projects are as follows:

1. **ATCRBS In-Service Improvements.** This effort is in response to formal and informal requests for engineering and development to eliminate system technical problems. Generally, these requests are urgent, and the intent of the project is to respond quickly with technical assistance.

2. **ATCRBS Interference Problems.** This effort seeks to investigate ATCRBS interference problems, and to participate in the activities of the Beacon Interference Problem Subgroup. A

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major task is the development of airborne equipment for monitoring the ATCRBS ground interrogator environment. The monitor will be installed in a dedicated aircraft of the NAFEC fleet and be in future In-Service Improvement projects.

3. Transponder Performance in System Environment. This effort seeks to investigate transponder performance in the system environment. SRDS obtains newly marketed general aviation transponders and NAFEC conducts bench tests against the U.S. National Standard. SRDS/NAFEC developed a ground based monitor to provide quantitative measurements of the performance of operating airborne transponders. This monitor will have the capability of (1) operating independently to interrogate a transponder and receive and analyze the transponder reply, (2) operating synchronously with an ATCRBS facility to determine the quality of received transponder replies, and (3) being used as a laboratory facility for "bench-testing" of transponders.

4. General Aviation Altimeter-Digitizer. This effort seeks to monitor the commercial development of general aviation altimeter-digitizers. SRDS maintains liason with commercial availability of this product. The performance of these altimeter-digitizers will be investigated to foster the production of acceptable equipment for the general aviation market.

PROGRESS.

1. ATCRBS In-Service Improvements. SRDS/NAFEC provided technical assistance to the following commissioned facilities in the investigation of false target and missing reply problems: Trevose, Pa. ARSR-2; McCock, Ill. ARSR-2; Chicago (O'Hare), Ill. ASR-7, and Whitehouse, Fla. FPS-60. SRDS/NAFEC conducted a technical seminar for regional, sector and site personnel to discuss the causes of ATCRBS system problems, the proper investigative techniques, and possible corrective actions.

2. ATCRBS Interference Problems. SRDS plotted the radar beacon over interrogation reports from the semi-automatic flight inspection (SAFI) flights and reported to the Beacon Interference Problem Subgroup. NAFEC procured equipment components for the airborne ground environment monitor. NAFEC completed hardware design and computer software.

3. Transponder Performance in System Environment. SRDS procured several new general aviation transponders. NAFEC bench-tested these. SRDS/NAFEC discussed performance deficiencies with the manufacturers who took corrective action. NAFEC procured equipment components for the ground-based transponder monitor. NAFEC started system assembly and computer programming.

4. General Aviation Altimeter-Digitizer. SRDS procu[illegible] one of the first commercially ava[illegible] low [illegible]ost altimeter-digitizers and NAFEC conducted bench tests. SRDS discussed performance deficiencies with the manufacturer.

TREND.

The following major events are scheduled for completion:

1. In-service improvements are a continuing effort.
2. Airborne Monitor of the ground environment installation by NAFEC in a dedicated aircraft completed–7/72.
3. Shakedown tests of ground-based transponder performance monitor system completed by NAFEC and data collection started–8/72.
4. General Aviation Altimeter-Digitizer effort is a continuing effort.

SUBPPOGRAM.

ATCRBS Sustaining Engineering, I, 031-241.

MANAGER.

Don Aske[illegible]. RD-242.

PROJECT MANAGERS.

Joseph J. Scavullo, NA-533; George F. Spingler, NA-533; and George H. Mahnken, NA-533.

ATCRBS 4096 CODE EMPLOYMENT PLAN

BACKGROUND.

The purpose of this effort is to develop and test various code assignment plans to determine how well they perform in different code environments and at different levels of air traffic activity.

ATCRBS, Mode 3/A, is capable of utilizing 4096 codes. However, except for Automated Radar Terminal Systems (ARTS) at several terminal radar control facilities (Atlanta, New York, Chicago, and others as ARTS-III implementation progresses) and the NAS Enroute Stage A prototype at the Jacksonville ARTCC, the ATCRBS is limited to the use of 64 codes. With the anticipation of automated systems throughout the nation, there is a need for the development of a plan for employment of the 4096 codes. Once such a plan is developed, there is a requirement for the progressive implementation of this plan or development of other plans for use in the interim when many stations have 64 code capability while others have the 4096 code capability. These requirements are expressed in the Air Traffic Service's 9550-1 Request: AT-100-13, 13/5/68.

PROGRESS.

The first task in this subprogram, that of studying plans where 4096 code capability is assumed, has been completed. This study was performed under contract with the National Bureau of Standards (NBS). Copies of the Final Report "Simulation of Air Traffic Control Radar Beacon Code Assignments Plans," FAA-RD-71-13, are available from the National Technical Information Service. This report describes the computer simulation of a peak day's traffic, which consisted of approximately 28,000 flights between 1,100 airports. It describes various code assignment plans and the performance of each plan when adapted to the operating simulation model.

The report shows that under one plan, called the Master Assignment Plan, a total of 547 codes for inter-ARTCC flights is sufficient for today's IFR traffic.

FAA contract awarded NBS for study of Code Plans utilizing 64/4096 codes, 12/71.

TREND.

The following major events are scheduled for completion:

Contractor's final report issued–6/72.

SRDS systems analysis completed–10/72.

SRDS recommendations to Air Traffic Service–10/72.

SUBPROGRAM.

ATCRBS 4096 Code Employment Plan, I, 032-601.

MANAGER.

John Van Dyke, RD-620.

ATCRBS IN-SERVICE IMPROVEMENTS

BACKGROUND.

This research and development effort, responsive to FAARs 6310.2, 14/10/66; 6360.1, 11/10/66; and 9500 SMS-70-15, 18/3/70, seeks to upgrade ATCRBS performance through developing, testing, evaluating, and specifying improved components to replace obsolete, uneconomical equipment.

All radar sites which serve Air Route Traffic Control Centers (ARTCC) and the majority of the Air Traffic Control Towers (ATCT) are equipped with ATCRBS transmitter site equipment. This equipment was built to meet the International Civil Aviation Organization (ICAO) standards of that period and was bought in 1960. ICAO and United States National Standards for the ATCRBS have been revised since 1960, thereby requiring implementation of additional system features. SRDS developed and NAFEC tested modification kits, and production modification kits were procured for all FAA interrogators. These kits have been installed on all type ATCBI-3 interrogators. This modification provides for side lobe suppression (SLS) without the addition of another transmitter and modulator and amplifier as the equipment was originally designed. The modification also provides for three-mods interlace capability for compatibility with the National Airspace System (NAS) requirements.

Improved SLS is a modification of the basic 3-pulse SLS which eliminates false target replies by preventing interrogations due to reflected interrogation pulses. Reflection interrogations and the resultant false target replies are much more prevalent than originally predicted. This increase is attributed to the trend toward construction of large buildings, hangars, and fences in the vicinity of the radar transmitter sites. SRDS developed under contract prototype modification kits which were used effectively at five commissioned ATCRBS facilities. Production modification kits have been procured and installed at all FAA terminal and enroute beacon facilities.

NAFEC established beacon antenna siting criteria to minimize the effects of terrain and buildings upon ATCRBS performance. FAA approved and issued an Agency Order 6360.4 "Siting Criteria for ATCRBS," 1/15/70, which applied the siting criteria standards to all new ATCRBS facilities. The highest priority projects are those which involve equipment improvements for the existing field sites so that the systems will meet the operational requirements of the NAS, such as the following:

1. **Develop ATCRBS Electronic Scan Antenna.** This effort, responsive to FAAR 6310.2, 10/66, "Provide Improved Terminal Radar and Beacon Facilities," seeks to develop and evaluate an electronically scanned array beacon antenna. This type of antenna will be mechanically independent of the primary radar antenna. The design will also permit a larger vertical aperture and shaping of the vertical radiation pattern to minimize ground reflection of radiated energy. It will also attain matched SLS and directional antenna vertical patterns, thus solving the mismatch problems that sometime occur. The antenna will have beam agility so that the beam can be repositioned to any direction within a few microseconds. This feature will permit the introduction of Intermittent Positive Control (IPC) discrete address interrogations and data link to the beacon system. Figure 6 shows approximately what the antenna is expected to look like when installed on the ASR tower. SRDS prepared a specification for a developmental model of a scanned array antenna and solicited technical proposals in December 1970.

2. **Develop ATCRBS Antenna Improvements.** In addition to the development of an electronic-scan antenna, SRDS and TSC initiated studies of methods for improvements to the presently used rotating radar and beacon antenna systems. FAA plans to achieve improved interrogator antenna beam characteristics by use of the primary radar reflector to shape the beacon beam. The larger vertical aperture achievable by use of the radar reflector will permit shaping of the beacon beam underside to reduce the amount of energy radiated into the ground and other low angle reflecting surfaces. Characteristic beam-lobing can be greatly reduced by this means, thereby offering improved beacon coverage. In addition, the reduction of below-the-horizon radiation will reduce the occurance of multipath reflections and the resultant false beacon targets.

3. **Develop ATCRBS Ground Station Monitor.** SRDS procured two prototype ATCRBS performance monitors System Requirement FAAR 6360.1, dated 11/10/66, "Provide Improved Monitoring for ATCRBS," established the requirement for improved monitoring of the ATCRBS facilities The NAS Enroute Stage A description requires that each component subsystem be monitored. The two prototype models were delivered by the contractor and installed by NAFEC in 1970.

4. **Develop Interrogator Frequency Measuring Test Set.** This effort provides for the procurement by SRDS of prototype test sets capable of accurately measuring the RF frequency of the ATCRBS interrogator.

PROGRESS.

1. **Develop ATCRBS Electronic Scan-Antenna.** (a) Contract awarded for antenna development–9/71; (b) Preliminary and Critical Design Reviews completed and approval granted to proceed with fabrication by SRDS.

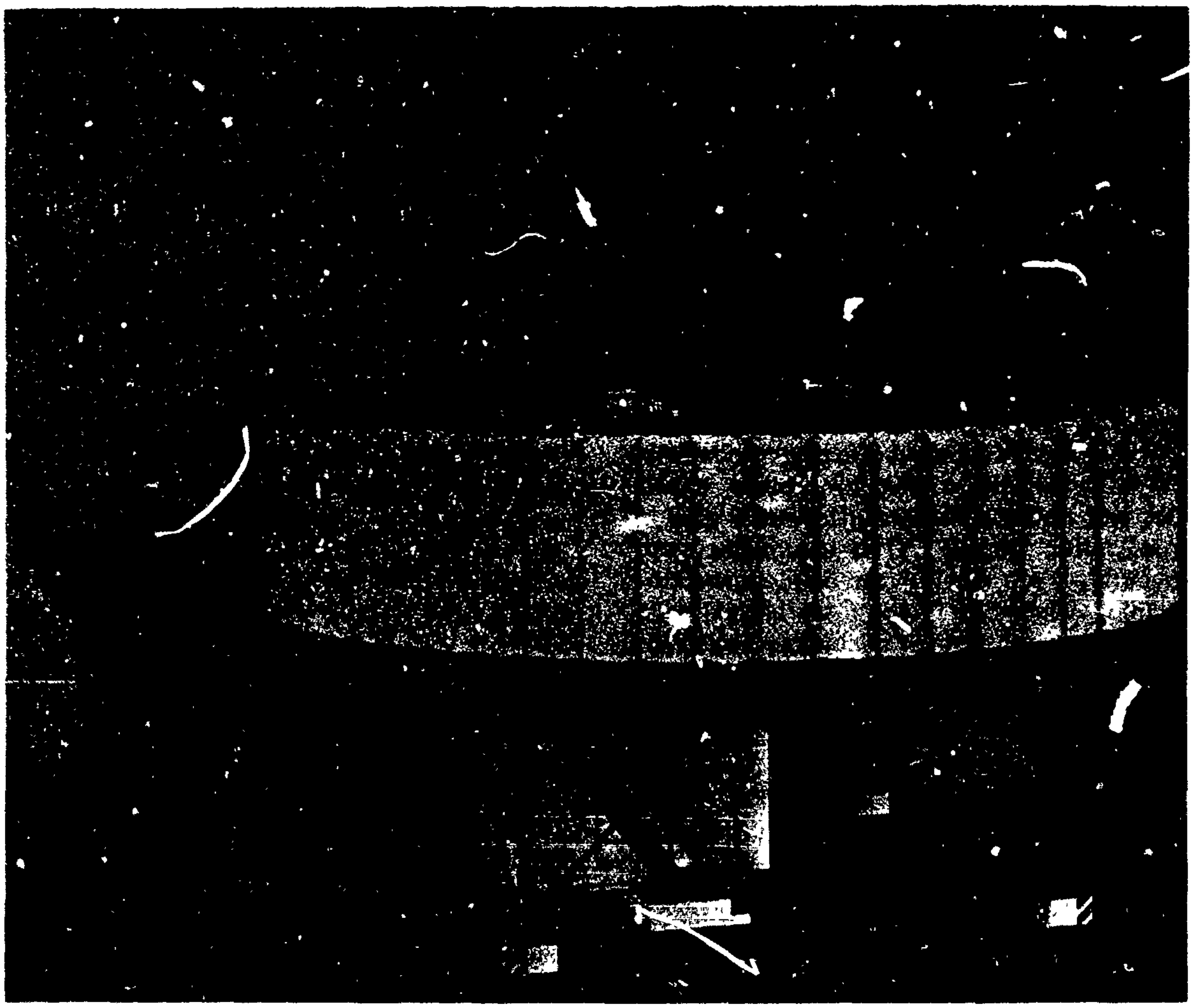

Figure 6 Model of Electronic Scan Antenna.

2. **Develop ATCRBS Antenna Improvements.** TSC issued request for proposals to industry for studies and hardware development antennas.

3. **Develop ATCRBS Ground Station Monitor.** The two prototype units were tested by NAFEC.

4. **Develop Interrogator Frequency Measuring Test Set.** Project has been cancelled by SRDS because it was discovered that commercial test equipment was available. SRDS advised Airway Facilities Service to procure off-the-shelf-equipment.

TREND.

The following major events are scheduled for completion:

1. ATCRBS Electronic Scan Antenna delivered and tested–6/73.

2. Contracts awarded by TSC for study and development of ATCRBS Antenna improvements–6/72.

3. Specification for Facilities and Equipment (F&E) procurement of ATCRBS Ground Station Monitor developed by SRDS–12/72.

SUBPROGRAM.

ATCRBS In-Service Improvements, IB3c, 033-241.

MANAGERS.

Don Asker, RD-242.
(FAAR 6360.1)
(DPP for 6360.1 approved 20/6/67)
Martin Natchipolsky, RD-242.
(FAAR 6310.2)
(DPP for 6310.2 approved 23/8/67)

PROJECT MANAGERS.

George Haroules, TSC; George F. Spingler, NA-533; and Nicholas Talotta, NA-533.

DISCRETE ADDRESS BEACON SYSTEM (DABS)

BACKGROUND.

The requirement for a Discrete Address Beacon System (DABS) was highlighted by the DOT Air Traffic Control Advisory Committee (ATCAC), Report, 12/69, to provide surveillance and ground-air communications in support of air traffic control (ATC) automation. Subsequently, a program for the development of a DABS was included in the FAA 10-year plan. This program represents a major engineering and development effort, affecting all beacon users. Consequently, FAA will coordinate this effort with the Department of Defense and with civilian aircraft interests.

The present ATC system is primarily a manual system with regard to the control and separation of air traffic. This manual system is in the process of transition to the semi-automatic Third Generation System recommended by the Project BeaconTask Force in 1961. The major improvements of the Third Generation System center around the use of computers to reduce the controller's workload and increase his efficiency. The controller is presented with improved displays, with targets automatically identified and tracked by data received from the ATCRBS. Surveillance data are checked automatically against stored flight plans. These improvements are embodied in the NAS Stage A program for enroute ATC centers, and the ARTS II and ARTS III programs for terminal ATC facilities.

Because of the mounting demand on ATC during the late 1960's, the DOT formed in 1968 the ATCAC for the purpose of developing recommendations for an ATC system adequate for 1980's and beyond. The ATCAC task was to provide specific recommendations which would lead to an increase in system capacity, especially in terminal areas, to maintain or improve safety despite the increases in traffic density, and to provide a substantial increase in the traffic handling ability of controllers through extensive system automation.

Based upon its studies, the committee determined that the Third Generation System now being implemented could not be expected to accommodate the forecast traffic loads of the 1970's without significant system improvements. The committee concluded that an evolutionary system plan should be developed to upgrade the Third Generation System and provide a base to extend its useful life into the 1990's. In this regard, several major recommendations were made by ATCAC, including:

a. Air traffic control capacity should be increased by the extension of NAS Enroute Stage A and ARTS to higher levels of control automation, supported by the use of a digital data-link between aircraft and the ground for the transfer of control information.

b. The concept of Intermittent Positive Control (IPC) should be developed and applied in mixed airspace. It is a concept for an automatic ground-based collision avoidance system which issues commands to normally uncontrolled aircraft only when it is necessary to avoid a hazardous midair situation.

c. A new surveillance system should be developed, employing discretely-addressable airborne transponders and incorporating a ground-air-ground data-link. Such a system is required to meet the needs of ATC automation for improved surveillance data quality and reliability, and for a digital communications channel and constitutes the best approach for solving this problem.

The capability of the surveillance and ground-air communication systems pace the performance of air traffic control. The present ATCRBS system is a cooperative radar-beacon system, with interrogators collocated with FAA enroute and terminal radars. It provides position, altitude and identity information on properly equipped aircraft, supplying the necessary inputs for the automation of ATC functions in the NAS Enroute Stage A and ARTS programs.

The ATCRBS has a number of deficiencies which limit its ability to meet the demands presented by the increasing automation of ATC, particularly in an environment of increasing traffic density. Also, there exist inherent limitations on the target capacity, resolution, and ranging accuracy of ATCRBS because of the nature of the system and its signal structure. An ATCRBS transponder replies to essentially all received interrogations, but those from the few interrogators "interested" in that aircraft plus those from the many other interrogators within line-of-sight. In a typical high density terminal area there are many aircraft responding to many interrogators; a high level of interference occurs both at the transponder input and at the interrogator receiver, resulting in lost or garbled replies. Also, replies from aircraft closely spaced in azimuth and slant range overlap, and thus garble each other.

The data acquisition requirements for a highly automated ATC system will exceed that which can be achieved by ATCRBS, particularly when aircraft traffic densities reach the levels predicted for the 1980's and 1990's. To meet these requirements, the ATCAC recommended the development of a DABS to provide garble-free replies, superior data quality, and the means for implementing a digital data-link.

A DABS surveillance system may be thought of as a modified ATCRBS. It is a network of sensors, each measuring range and azimuth on targets within its coverage limits, and obtaining aircraft identify and altitude from coded replies. The chief difference lies in the fact that each interrogation is addressed to a specific aircraft which recognizes its own discrete address and only then replies to the ground. Interrogations may be scheduled in such a way as to prevent garbling of the replies, since target position can be predicted from track data. Provision must, of course, be made to include new targets in the discrete address roll call.

Since aircraft are addressed individually in DABS, the surveillance system automatically provides a natural vehicle for a data-link between ground and aircraft which can be used for ATC tactical control purposes including IPC (Figure 7).

Based on the requirements highlighted in the ATCAC report, and the FAA 10-year plan, a technical development plan (TDP) for a DABS has been prepared and approved. This plan envisions an eight-year development effort of three phases. The first phase starting in January 1972 is for a two-year effort to validate the DABS concept and define system parameters. The second phase is a three-year effort for a prototype system fabrication and testing. The third phase will be devoted to field trials of pre-production equipment which will lead into implementation of field production systems.

PROGRESS.

1. **DABS Technical Development Plan.** In coordination with the Office of Systems Engineering Management (OSEM) a technical development plan by MIT Lincoln Laboratory was completed 10/71 based on studies made by the Laboratory under FAA contract.

2. **DABS Phase I Development Effort.** Subsequent to approval of the DABS TDP in 11/71, an interagency agreement was signed 30/12/71 with MIT Lincoln Laboratory for the first year's development effort under Phase I of the TDP, thus establishing the Lincoln Laboratory as the OSEM contractor for the DABS development effort.

TREND.

The following major events are scheduled for completion:

1. DABS Detailed Characteristics Documented by Lincoln Lab (Phase I)–1/74.
2. DABS Prototype Engineering Model Delivered to NAFEC by Contractor (Phase II)–1/76.
3. DABS Prototype System Evaluated by NAFEC–1/77.
4. DABS Installed in Operation Field Sites by Regions Evaluated–1/79.

SUBPROGRAM.

Discrete Address Beacon System (DABS), I, 034-241.

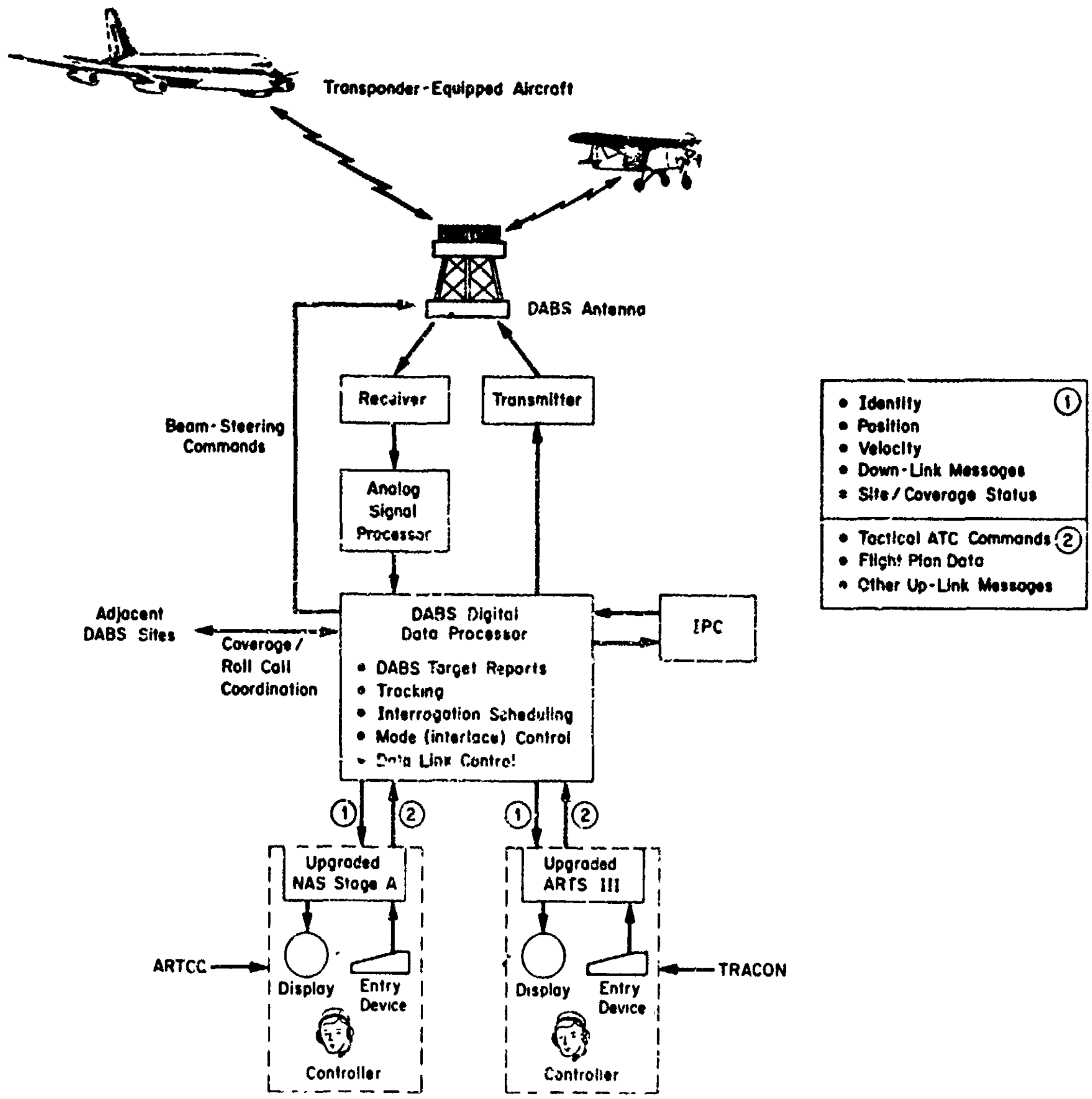

Figure 7. DABS Interrogator and System Data Processing, Functional Block Diagram.

MANAGER.

Kenneth Wise, RD-242.

PROJECT MANAGER.

Anthony Bradley, NA-533.

04 NAVIGATION PROGRAM

GOAL.

The purpose of the Navigation Program is to develop improved VOR, TACAN-DME, COMLO, and Marker facilities siting techniques and less environment-sensitive hardware, in order to meet operational requirements more effectively. It is also the purpose of this program to meet future system needs by implementing area navigation, developing precision VOR and a more precise and higher capacity DME, and providing additional VOR/DME channels.

SCOPE.

This program is organized under four Program Elements: 041–Sustaining Engineering; 042–Improved Subsystems, 043–New Systems; and 044–Oceanic.

In the FY 72 Technical Program, engineering and development efforts include the following subprograms:

041-305 Sustained VOR/COMLO/Marker Engineering, Subprogram Manager, S.R. Anderson, RD-331.

041-306 Sustained TACAN/DME Engineering, A.W. Randall, RD-332.

042-307 Improved VOR Subsystems,* S.R. Anderson, RD-332.

042-308 Improved TACAN/DME Subsystem,* A.W. Randall, RD-332.

043-309 New VOR Systems, A. W. Randall, RD-332.

043-310 New TACAN/DME System, A.W. Randall, RD-332.

043-326 Area Navigation,* M. Brandewie, RD-326.

043-601 VOR-Airway Structure Study, Lloyd Burstein RD-630.

044-304 Oceanic Navigation, W. Faux, RD-340.

045-390 V/STOL Navigation, D.M. Brandewie, RD-326.

The following selected* major subprograms are highlighted in terms of Background, Progress, and Trend (major milestones scheduled for completion):

IMPROVED VOR SUBSYSTEMS

BACKGROUND.

The purpose of this effort is to develop improved VOR equipment to increase operational efficiency, reduce system errors, and reduce operating and construction costs. Improvements include the following:

1. **Conventional VOR Antenna System.** The environment adjacent to a VOR site causes additional errors in the VOR system. This problem may be solved by positioning a VOR on a high tower and by employing an up-tilted pattern. Therefore, the VOR Parasitic Loop Counterpoise Antenna has been mounted atop the NAFEC 75-foot tower to evaluate the site error reduction capability of this technique.

2. **VOR Transmitting Equipment.** Older transmitters require an increase in maintenance and costly replacement parts. Prototype solid state 100 Watt VOR transmitting equipment (except monitor) has been developed by contract and evaluated at NAFEC to improve this situation.

3. **50 KHz VOR Implementation.** There is a critical shortage of frequencies in the VOR/ILS band, with the result that new ILS facilities cannot be implemented in many areas of the U.S. The FAA has announced in Advisory Circular, 170-12 that ground stations will be assigned 50 kHz channels beginning 1/1/73. SRDS initiated a project at the time of that announcement to determine (a) any required ground station modifications and (b) the performance of existing airborne receivers in the 50 kHz environment.

PROGRESS.

1. Tests by the University of Michigan are underway to determine the effects of a mis-tuned receiver on course error when used with DVOR facilities.
2. The VOR parasitic loop antenna has been tested by NAFEC and the University of Michigan with results that compare very well with theory. VOR siting error produced by a reflecting wire system was reduced by a factor of six.
3. Evaluation of a 100-watt solid state VOR system has been completed by NAFEC. FAA Report FAA-RD-71-65, "Task I, Test and Evaluation of Solid State 100 watt VOR Transmitting Equipment" contains details of this effort.
4. Transmitter modifications for all VOR and ILS transmitters have been developed by the FAA Aeronautical Center, Oklahoma City, Oklahoma to provide a frequency accuracy within ±0.002%. Modifications for all VOR transmitter types involved in the initial 50 kHz implementation have been developed. These modifications result in the reduction of 9960 Hz harmonic radiation to acceptable levels. FAA awarded contract to examine the performance of all existing types of airborne VOR and ILS receivers. Also, a study by Kahn Research Lab., Inc., has been completed. The final report is entitled, "Engineering Study of Spurious VOR Sideband Signals and Ways to Minimize or Eliminate the Spurious Signals."

TREND.

The following major events are scheduled for completion:

1. VOR receiver mis-tuning tests completed and report prepared–8/72.
2. NAFEC determination of adequacy of the 100 watt level to support VOR service–8/72.
3. The 50 kHz programs are proceeding satisfactorily and are expected to be completed in time to meet an interim implementation–1/73.

SUBPROGRAM.

Improved VOR Subsystems, 042-307.

MANAGER.

S. R. Anderson, RD-331.

PROJECT MANAGERS.

R. Rea, AC-445, and N. Shanteau, NA-521

IMPROVED TACAN/DME SYSTEM

LOW COST TERMINAL AREA DME

BACKGROUND.

The purpose of this effort is to develop a low cost terminal area DME ground equipment to satisfy System Requirement FAAR 7232.2, "DME at ILS and TVOR Approach Facilities", dated 7/5/69. DME at ILS had been operationally evaluated at several locations in the U. S. and found to provide advantages in improved approach operations. Economy of acquisition and maintenance will allow increased implementation and utility of DME in the terminal area. Reduction of cost can be accomplished by reduction of performance in specific parameters such as power output and eliminating redundant or overlapping functions. However, evaluation of engineering models are required to establish the degree of performance reduction and function elimination that can be tolerated without unduly compromising reliability or coverage of navigation service.

PROGRESS.

SRDS engineering models have been procured from two contractors and installed, evaluated, and flight tested at NAFEC. Both models have been found suitable with minor changes for terminal area use and a NAFEC test report has been written and is in the process of printing.

TREND.

The following major events are scheduled for completion:

1. Release of NAFEC evaluation report on the two engineering models–3/72.
2. FAA award contract for six field test models–6/72.
3. Delivery of field test models–6/73.

SUBPROGRAM.

Improved TACAN/DME System, 042-308.
Terminal Area DME, 042-308,013.

MANAGERS.

A.W. Randall, RD-332.
Carl C. Trout, RD-332 (FAAR 7232.2).

PROJECT MANAGER.

George Hartranft, NA-521.

AREA NAVIGATION

BACKGROUND.

The purpose of this effort, responsive to the Increased Airport/Airway System Capacity Program Plan and 9550.1 Requests for R.D and E support FA-400-69-1, 25/6/69 and FS-60-70-2A, 19/4/71, is to investigate hardware and software techniques to further exploit area navigation in the National Airspace System.

The use of the VOR/DME system for navigation has been confined to flight along VOR radials. Techniques and airborne equipment have been developed; however, to permit VOR/DME area navigation which utilizes the full potential of the system.

In August 1969, the Radio Technical Commission for Aeronautics (RTCA) published its "Minimum Operational Characteristics-Airborne Area Navigation System" and FAA published Advisory Circular 90-45, "Approval of Area Navigation Systems for Use in the U.S. National Airspace System," as guidance to industry and FAA concerning the implementation of two dimensional area navigation techniques. FAA and RTCA are working on amendments to these documents to include criteria for the vertical aspects of area navigation.

In the past, FAA has developed and conducted tests on numerous two dimensional area navigation devices primarily to determine overall system accuracy. In addition, testing has been accomplished on airborne VOR signal processing techniques to improve overall horizontal system performance.

Currently, comprehensive flight tests and simulation experiments are being performed under FAA contract by the University of Illinois, Institute of Aviation, to define the effect of area navigation display characteristics on flight technical error and pilot workload. Flight tests have been accomplished by NAFEC on an analogue three dimensional area navigation system to determine vertical systems errors. Tests at NAFEC on more sophisticated systems are planned.

Contract study efforts are underway by Champlain Technology and Anacapa Sciences to investigate information content requirements for area navigation map displays. Efforts are planned to determine the application of advanced three and four dimensional area navigation techniques to terminal areas including interfacing with the future microwave landing system and automated metering and spacing techniques.

The benefits of these efforts are the substantially increased utilization of the U.S. Standard short range navigation system, increased system capacity and the decreased workload for air traffic controllers and pilots.

PROGRESS.

1. Report FAA-RD-71-3 published describing simulation and flight tests to determine flight technical error for symbolic area navigation displays (University of Illinois, Institute of Aviation).

2. Vertical area navigation flight tests completed at NAFEC.

3. FAA contract award to Hughes Aircraft Company for flexible area navigation CRT simulation.

4. FAA contract award to Champlain Technology and Anacapa Sciences for vertical area navigation error analysis.

TREND.

The following major events are scheduled for completion:

1. Flight technical error report (Phase I)–4/72 (University of Illinois, Institute of Aviation).

2. Map Display information report–5/72 (Champlain Technology and Anacapa Sciences).

3. Vertical area navigation flight test report–6/72 (NAFEC).

4. Flight technical error report (Phase II)–1/73 (University of Illinois, Institute of Aviation).

SUBPROGRAM.

Area Navigation, 043-326.

MANAGER.

D. Michael Brandewie, RD-326

PROJECT MANAGERS.

B. Dinerman, NA-522, H. Sorenson NA-522.

TRAFFIC/AIRWAY/RNAV/VOR CORRELATED NETWORKS

BACKGROUND.

The purpose of this effort is to develop and apply methodologies for systematic computer aided improvement of the networks of airways and ground VORTAC facilities including incorporation of area navigation airway networks. This effort was begun in response to 9550-1 Request: AT-100-15, 4/2/69, "Application of Computer and Simulation Techniques to Review of VOR/VORTAC System." AT-1 letter, 31/10/69, added scope and urgency for High Altitude Area Navigation (High-RNAV). Other FAA documents, and an 18/11/69 letter from the Air Transport Association (ATA) encouraged this type of systematic planning for area navigation.

With nearly 1000 VOR/VORTAC ground stations, FAA plans fewer additions and more relocations, capability modifications, or usage revisions of some VORTACs for the growth and changes in air traffic and its control. Deletions or changes for VORTACs have in the past been suggested, or evaluated by FAA mainly on an individual basis. FAA, in reviewing this work, sought better methodologies that considered more effectively the role of each facility in the network of all VORTACs, their geometrical relationships to conventional and RNAV airways and terminal area procedures, the positional error aspects for RNAV and the relationships of VORTACs and airways to growth and changes in traffic preferences. A major objective is the specific placement of RNAV airways and RNAV terminal area paths to obtain maximum user and ATC benefits–properly integrated with those for non-RNAV aircraft.

The FAA and the aviation industry expect that the VORTAC network and related airways, with expanded capabilities from RNAV, will continue being the principal basis for navigation and air traffic control for at least 20 years. For controllable orderly traffic flow, aircraft with other instrumentation, e.g., inertial navigation, would fly the routes designed primarily for aircraft with VORTAC/DME–RNAV.

Effective consideration of the traffic/airway/VORTAC relationships is now important and urgent to achieve the potential benefits from RNAV equipment in a substantial number of aircraft. To encourage aircraft owners to make this investment, the ATA requested FAA to develop a systematic, integrated national network of RNAV airways and terminal area procedures and indicate what benefits would accrue.

The FAA and OMB recognized the need for better and computer-aided methodologies in analysis and planning, particularly for budgetary justifications. The basic techniques and data developed in this study are primarily for RNAV and other airway/VORTAC networks, but would be helpful for other purposes, such as controller workload sectorization.

PROGRESS.

Coordinated work is being done by a NAFEC project team of several specialities and the contractor, Stanford Research Institute (SRI), who provides methodology/software specialties not available from NAFEC for this effort. Most of the work has been on development of methodologies that will later be incorporated in computer software. Examples of accomplishments are:

1. The NAFEC computer software provided listings of city-to-city traffic demand densities for each time increment and requested flight level, and for their shortest (great-circle) departure direction from sample airports. Some criteria have been developed and used for computer-aided groupings of these threads of directional and other data into "ropes" of "routes-needed" trunks and branchings from these trunks towards each destination. This included methodology to systematically locate trial transition points between enroute and terminal areas. The above are based on traffic demand, independent of existing locations of airways or VORTACs.

2. The SRI provided the software used by a NAFEC computer-fed plotter to draw a routes-needed network for sample criteria an affic demand data. Progressively more capable software packages are being developed for present or forecast traffic demand data, construction of several trial networks per changes in criteria or parameters, evaluations of each network, the relating of routes-needed to existing VORTAC locations, and of any VORTAC relocations to an orderly grid network of enroute VORTACs. Work thus far is virtually all for a national airw network for High-RNAV.

3. The NAFEC analyses concluded that the most efficient total coverage grid pattern for the network of VORTACs is triangular/hexagonal, spaced for a desired minimum altitude. A simple methodology was conceived by SRI for computer-aided orientation of this pattern to best fit the existing locations of VORTACs and thus provide a reference for evaluating any proposed changes of individual VORTAC locations.

4. The NAFEC and SRI have prepared technical notes and briefing materials. Most of these have been on technical segments of the work, but later stage accomplishments of wider interest are beginning to appear. A draft SRI Summary Report on Contract Tasks 2 and 3, High-RNAV Routes-Needed Methodologies and Software, was submitted to NAFEC for comments.

5. The NAFEC technical notes were mainly on math/computer techniques for great-circle paths and the angle/distance relationships for offset locations, and on the coverage advantages of an orderly VORTAC grid being triangular/hexagonal. NAFEC developed mathematical concepts to determine the optimum point for joining RNAV routes when flying offset relative to two VORTACs, methods for initializing High RNAV airways, turnoff angle to an airport offset from a common air route, added travel distance to an airport offset from a common route, and navigational concepts in spherical trig. In addition, NAFEC developed mathematical concepts establishing the orderly relationship between high altitude coverage VORTACs and low altitude VORTACs based on their relative spacing and elevations.

6. SRI developed mathematical concepts to:

a. Test the quality of an airway network based on such factors as angle of crossing of airways, added travel distance due to airways merging, potential conflicts, and controller workload requirements.

b. Investigate assigning altitudes other than the desired one.

c. Determine potential conflicts at air route crossings.

d. Develop other criteria of cost/benefit and quality analysis of airways design.

TREND.

The following major events are scheduled for completion:

1. Draft report from contractor on VORTAC ground facilities support of High-RNAV routes –6/72.

2. Contractor's draft software and its documentation on ground facilities support of High-RNAV routes–6/72.

3. Draft of contractor final report consolidating summary reports for combining airways and supporting facilities in support of High-RNAV routes—7/72.

4. Review revised final report from contractor consolidating the combination of High-RNAV routes and ground support facilities—9/72.

5. NAFEC data/recommendations from the NAFEC/SRI work done for High-RNAV networks—3/73.

6. Plan for further work in FY 73/74, both in response to the 9550-1 request for R&D, and as part of the total program for area navigation. Contract(s) initiated—8/72.

SUBPROGRAM.

Traffic/Airway/RNAV/VORTAC Correlated Networks, II, 043-601.

MANAGER.

Lloyd M. Burstein, RD-630.

PROJECT MANAGER.

Carl M. Russell, NA-510.

INTEGRATED/HYBRID OCEANIC NAVIGATION SYSTEM

BACKGROUND.

The purpose of this effort is to provide a worldwide, ground reference navigation system for civil aviation. Worldwide availability of Omega signals is expected by late 1974. The requirements for this development and evaluation effort by the FAA are found in: (1) the DOT National Plan for Navigation, dated May 1970, (2) a Request for RD and E Effort, Form 9550-1, dated 6 August 1970, (3) an FAA/Navy Agreement of 31 May 1966, and (4) a U.S./U.K. Agreement of September 1963.

FAA Omega Very Low Frequency (VLF) investigations for navigation were established in accordance with the U.S./U.K. agreement (9/63), and include Omega navigation computer development, Omega antenna studies; phase variation signal reception and phase correction studies. The VLF navigation computer development and prediction model studies were defined specifically in accordance with the U.S. Navy agreement (25/5/66). The computer development was an extension of previous digital computer technology developed by the FAA for use in Loran C navigation.

The Navy and U.K. experienced unsatisfactory airborne reception of VLF signals using existing blade and long wire antennas. More scientific knowledge was required regarding field strengths of Omega signals, and phase variations of the signals to resolve lane ambiguities for civil air applications.

Omega transmissions generate sequential CW signals at VLF from stations of remote points around the bloge. At the present, there are four ground stations operating primarily at 10.2, 11.333, and 13.6 kHz. Phase comparisons of the signals from pairs of transmitting stations describe a hyperbolic grid similar to LORAN except that the hyperbolic lines are repeated cyclically and therefore are ambiguous. Consequently, the U.S./U.K. studies were undertaken to determine solutions to both the VLF signal reception, and the conversion and dead reckoning problem for aircraft navigation.

A crossed ferrite loop antenna developed by FAA under a contract to Pickard and Burns Electronics Company was used as the primary antenna system for the airborne Mark III Omega set developed by the Naval Research Laboratory with Lear Siegler Inc., under contract for the navigation computer. This equipment when used in conjunction with the ferrite loop indicated highly satisfactory performance under noisy atmospheric conditions during joint FAA/Navy North Atlantic flights.

Tests of this same Mark III VLF equipment were completed in January 1970 by Strategic Air Command in a USAF RC-135 aircraft utilizing the FAA ferrite loop antenna.

The Navy has developed the AN/ARN-99 Omega Navigation Set under contract with Northrop Inc. This airborne equipment consists of an Omega sensor combined with a sophisticated navigation computer which accomplishes all signal processing and provides digitally displayed position fix and steering information. A commercial version of the ARN-99 was developed by Northrop and has been test flown in a Continental Airlines 707/320 aircraft in the Pacific Ocean area and on a World Airways DC-8 in the North Atlantic. The Pacific flights, completed in January 1970, indicated successful navigational capability when Omega signals were available. Omega coverage in the Pacific is marginal with the present four-station format. An FAA contract with the University of Michigan concerning a "Study and Evaluation of the Omega Navigation System for Transoceanic Navigation by Civil Aviation" was completed in August 1969. This report, FAA-RD-69-39, indicated Omega may become a useful navigation aid provided solutions of potential problems concerning lane resolution, precipitation static, and unpredicted ionospheric disturbances can be found.

PROGRESS.

Omega signal data are being collected by the Canadian government to provide information concerning propagation anomalies and reception of signals in aircraft. Signal monitors in Canada are recording information from the four operating Omega stations for examination of: (1) the 3.4 kHz difference frequency, (2) propagation of the basic Omega frequencies of 10.2 kHz and 13.6 kHz, (3) the effects of solar events on Omega signal propagation, and (4) the effects of the Greenland ice cap or the signals from the Norway Omega transmitter. Omega signal information is being recorded in a DC-6 aircraft by the Hurricane Research Facility of the National Oceanic and Atmospheric Administration (NOAA). The NOAA data will also provide information on the 3.4 kHz difference frequency, but in an aircraft instead of at a fixed ground monitor. NOAA has also evaluated an Omega E-field antenna noise eliminator device produced by Tractor, Inc. The Canadian monitor and NOAA flight recording program are sponsored and funded by the FAA. An evaluation of the Northrop AN/ARN-99 Omega set on a commercial airliner is in progress. The ARN-99 is installed in a World Airways DC-8 aircraft; the equipment will be operated on North Atlantic routes.

Two final reports by Litton Systems, Inc., concerning an inertial/DME/DME system and a map display driven by the system, have been published. These reports are: FAA-RD-70-24, "Flight Evaluation of Inertial/DME/DME System" and FAA-RD-71-46, "Flight Evaluation of Inertial/DME/DME Map Display System."

The FAA has active and planned programs to investigate basic Omega and two variations of Omega. Preliminary equipment design and study work is being done by the Naval Electronics Laboratory Center, San Diego, California. The first variation, Differential Omega, will be examined through the use of airborne and ground equipment that will be designed to include the flexibility needed to observe a number of differential techniques. The second variation, Difference Frequency/Composite Omega, will be evaluated through study and experimentation. Following all preceding Omega work, the FAA will develop an airborne Omega system that will incorporate the best characteristics of both basic Omega and variations of Omega.

TREND.

The following major events are scheduled for completion:

1. ARN-99 operational airline evaluation by Northrop Corporation—10/72.
2. FAA/NOAA Omega signal analysis program—6/72.
3. FAA/Canadian Omega signal monitor program—1/73.
4. Initial differential Omega test program—10/73.
5. Difference Frequency/Composite Omega Test program—9/74.
6. FAA/Civil Omega System—1/77.

SUBPROGRAM.

Integrated/Hybrid Oceanic Navigation System, 044-304.

MANAGER.

George H. Quinn, RD-341.

05 PILOT WARNING INDICATOR (PWI)/COLLISION AVOIDANCE SYSTEM (CAS) PROGRAM

GOAL.

The purpose of this program is to refine operational requirements, develop system description plus hardware and software which will result in an efficient, cost-effective, operationally useful and ATC compatible PWI/CAS airborne hardware and associated ground support equipment.

SCOPE.

This engineering and development effort is organized under two Program Elements: 051-PWI and 052-CAS.

In the FY 72 Technical Program, engineering and development efforts include:

051-241 Visual Collision Prevention Systems, Subprogram Manager, John L. Brennan, RD-241.

052-241 Air Derived Collision Avoidance System,* Subprogram Managers, John E. Reed, RD-241, and Owen McIntire, RD-241.

The following selected* major subprogram is highlighted in terms of Background, Progress, and Trend (major events scheduled for completion):

AIR DERIVED SEPARATION ASSURANCE (ADSA)

BACKGROUND.

Total air traffic in the U.S. is projected to increase fourfold by 1995. It is estimated that this increase could result in a 16-fold increase in the probability of a mid-air collision, since analytical work completed to date strongly supports a quadractic relationship between aircraft population density and mid-air collision. The introduction of aircraft with larger passenger capacity, increased speed capabilities and decreased maneuverability, further aggravates the problem and raises the spector of a major catastrophe. Therefore, methods which are supplementary to and compatible with the basic Air Traffic Control (ATC) Systems must be investigated to reduce or eliminate the danger of mid-air collisions. While the national common civil/military Air Traffic Control and navigation system provides a multiplicity of services such as weather information flight path instruction, separation procedures, and emergency instructions, there is a need for a separate and independent collision avoidance system to augment the primary Air Traffic Control system in the event of a pilot blunder in the air or an Air Traffic Control blunder on the ground. This effort supports Systems Requirement FAAR 9850.1, dated 25/8/67, "Develop Airborne Collision Prevention Systems."

The goal of this program is to develop airborne systems or devices, operating on air derived data, which will significantly reduce or eliminate mid-air collisions in an operationally and economically sound manner. These systems and devices are to be independent of the ground-based ATC system and will serve as a back-up if, for any reason, the ATC system fails to fulfill its role. Two main areas of investigation are Collision Avoidance Systems (CAS) and simple Pilot Warning Instruments (PWI).

A CAS is an all-weather system capable of detecting possible intruders, evaluating the degree of the threat posed, and indicating to the pilot (or actually initiating) a timely, safe evasive maneuver.

A PWI is a system which will increase the probability of a pilot visually acquiring other aircraft in his vicinity, at which time he is responsible for the threat evaluation. Therefore, a PWI is effective only where Visual Flight Rules (VFR) are in effect. A primary objective of the

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subprogram is directed toward establishing system and performance characteristics, and implementation plans to meet the needs of civil/military users.

An Interdepartmental Group on Collision Avoidance and Pilot Warning was formed consisting of members from FAA, DOD, and NASA, and chaired by FAA. The Charter for this group follows:

1. Recommend a joint engineering and development program plan for collision avoidance and pilot warning systems.
2. Undertake the necessary program of work leading to completion of above.
3. Explore the possibility and desirability of establishing national standards in this area.

Undoubtedly, the output of this group will be an expanded and expedited program. Details are not yet available. In the interim, however, FAA is proceeding with its heretofore published plan.

PROGRESS.

NAFEC completed the initial phase of a dynamic CAS/ATC simulation, to determine the extent of the interaction problem and recommended solutions to it. The simulated ATC environment was a high density terminal area which provided for simultaneous approaches to parallel runways. The CAS evaluation and maneuver logic utilized was that formulated by the ATA's CAS Technical Working Group as specified in Revision 10 of ANTC Report 117. The objective was to study the characteristics of ATC/CAS interaction as a function of (1) the location of the CAS switchpoint from full system threat evaluation to landing mode, and (2) variations in controller technique. The NAFEC simulation found that the limit turn feature associated with the tau II coaltitude envelope (full system mode) of the CAS, interacted adversely with ATC in that portion of the area where arrival flights were being sequenced and spaced for final approach. Interaction in other parts of the simulated environment was relatively sparse. When ATC system errors resulted in hazardous encounters, the CAS provided adequate backup. However, due to a feeling of increased workload, controllers reacted unfavorably to CAS in the system. This was not the case, however, in six simulation runs accomplished in the single runway configuration. Controllers felt this traffic environment easily accommodated CAS with little interaction.

A joint program was initiated between the McDonnel-Douglas Corporation and United Airlines and McDonnell-Douglas Corporation and Piedmont Airlines, in which the airlines are flying the McDonnell version of the ATA CAS and a low cost compatible CAS developed by McDonnell in an effort to obtain operational and maintenance data. These programs are being monitored by the FAA.

The Radio Corporation of America (RCA) and Minneapolis-Honeywell are developing CAS/PWI equipment which operates on the interrogate/transpond principle. The FAA is also monitoring these developments.

The Sierra Research Corporation completed an analytical effort under contract to the NASA Langley Research Center whose goal was to develop an effective CAS, compatible with the ATA CAS (or allowing only minor revisions) which would cost $1,500 or less. The results of this study are being reviewed by NASA/SRDS.

Equipment was delivered to NAFEC by Sierra Research Corporation to determine the feasibility of synchronizing airborne clocks by suitably modified DME facilities. This equipment is under evaluation by NAFEC.

The FAA's PWI program main thrust is the investigation of the human factor problems involved so as to better define what the characteristics of a PWI should be or what a PWI should do? Generally, those which are most obvious: i.e., How well can a pilot see and evaluate at flying speeds? How much time does it take? To what degree can a pilot make use of relative bearing information? These and other questions are under investigation. The "Functional Analysis of Pilot Warning Instruments" report by Rowland & Co., Haddonfield, N.J., and the FAA/NAFEC "Reactions of Pilots to Warning Systems for Visual Collision Avoidance" report are contributors in the human factor investigations.

The Control Data Corp., Arlington, Va., "PWI Study" activities are proceeding, with reports on human factor, PWI specifications, and alarm rate analysis to be available in 1972. While pursuing these investigations, SRDS has not ignored the parallel hardware development aspects. The SRDS has been actively coordinating with the NASA and the U.S. Army/ Honeywell hardware activities. In FY 71 and continuing in FY 72, SRDS has project activities with DOT/TSC which continue the optical-IR (Infra Red) component and system development. This included a flight test and evaluation at NAFEC. FAA/TSC plan to continue with selected subsystem optimization during this year, including further flight test to tie down the system specifications. SRDS has procured a radar PWI (developed by Cygned) for future flight test and evaluation by NAFEC. Additionally, SRDS/TSC are preparing an Engineering Requirement for PWI equipment using new techniques and technologies.

TREND.

The following major events are scheduled for completion.

1. Control Data Corp. Reports issued on Human Factors, PWI Specifications, Alarm Rates–3 qrt./72.
2. Rowland & Co. report issued on exterior lighting and marking–4 qrt./72.
3. Time/Frequency ground station contract awarded–4 qrt./72.
4. PWI engineering evaluation equipment contract awarded 4 qrt./72.
5. DOT/TSC horizontal maneuver study contract awarded 4 qrt./72.
6. Visual detection simulations (FAA/TSC) report issued–3 qrt./73.
7. SRDS PWI and CAS recommendations completed–as appropriate.
8. PWI equipment RFP issued, equipment delivered, tested and evaluated at NAFEC and report issued–2 qrt./74.

SUBPROGRAM.

Air Derived Collision Avoidance Systems, 052-241.

Visual Collision Prevention Systems, 051-241.

MANAGERS.

John L. Brennan, RD-241.
John E. Reed, RD-241.
Owen E. McIntire, RD-241.

PROJECT MANAGERS.

Floyd Jones, 052-241-02X; Anthony Bradley, NA-533, 051-241-02X; Paul M. Rich, NA-543, 051-241-03X; Charles Phillips, TSC, 051-241-04M; and Gordon D. Jolitz, NA-516, 052-241-03X.

06 COMMUNICATIONS PROGRAM

GOAL.

The purpose of the Communications Program is to perform engineering and development to improve the performance of the current air/ground and ground/ground communications systems for CONUS enroute and terminal areas and define subsystem requirements and performance characteristics of data links and satellites in the CONUS. It does not include the integral data links of the Discrete Address Beacon System (DABS) and CONUS Satellite Systems.

SCOPE.

This engineering and development effort is organized under four Program Elements: 061–Sustaining Engineering, 062–Improved Voice, 063–New Air/Ground Digital, and 064–Improved Ground/Ground Digital.

In FY 72 Technical Program, engineering and development efforts include:

061-221 Voice Communications Existing RF System, Subprogram Manager James L. Lipscomb, RD-221.

061-222 Short Distance A/G Comms. Backup System,* James L. Lipscomb, RD-221.

062-222 Integrated Total Comms, Sys. Study, Dan J. Hamilton, RD-221.

062-223 Voice Switching and Control System, J.F. Schroeder, RD-222.

062-224 Audio Communication and Control System, Freeman Coble, RD-222.

063-231 Automatic Ground/Air/Ground Digital CONUS Communication, Walter Honea, RD-232.

064-231 Modernization Teletype Writer Networks and Switching Systems,* R. F. Decker, RD-231.

064-232 Low-Medium Speed Data Transfer Equipment, L.P. David, RD-231.

064-233 Development of Low-Cost Broadband and Microwave Remoting System,* C. E. LaRue RD-231.

064-234 Ground/Ground Digital Communications Automated ATC Facilities, W. L. Hyland, RD-232.

BACKUP EMERGENCY COMMUNICATIONS (BUEC)

BACKGROUND.

After a series of catastrophic system communication failures culminating in the loss of 22 circuits for hours at one of the FAA's Air Route Traffic Control Centers (ARTCCs) in 1968, the Administrator directed that immediate action be taken to provide a completely redundant emergency system at all ARTCCs.

The SRDS developed a plan and designed a system to provide reliable automatic selection and operation of remote VHF and UHF air/ground communications. Remote transceiver selection for any of 210 controller stations is done automatically through processor equipment located at the ARTCC. The processor provides each controller 10 possible radio equipments for each band (VHF and UHF) on a predetermined priority basis. The processor, in conjunction with a transceiver control adapter, also tunes the transceiver to the proper frequency, activates the transceiver to the receive mode, and returns a "ready" indication so the controller knows he is in a normal push-to-talk status with operational equipment. The system provides a redundancy in line selection and equipment selection so that individual transceiver or process circuit malfunctions do not cause failure of a controller to obtain a communication channel.

1. **Functional Description.**–The BUEC system includes a fast response processor, status boards, controller stations, and audio transfer panels, located at the ARTCC; and UHF and VHF transceiver, each with an associated control

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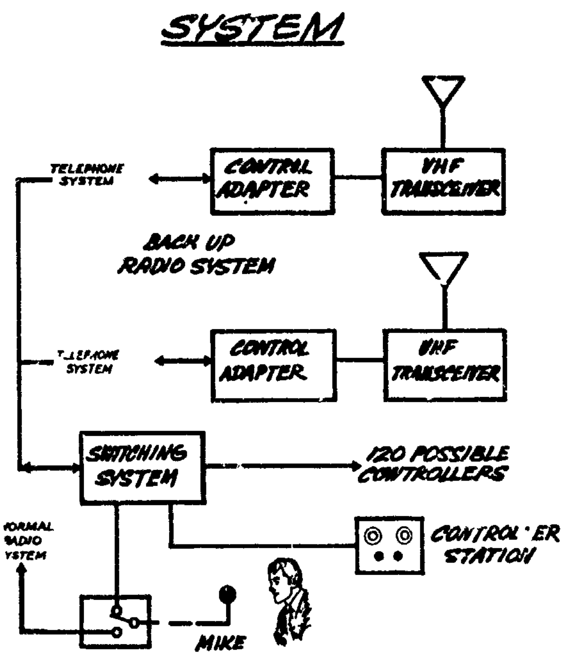
reliable emergency backup system for multichannel communication at ARTCCs. The remote control group (equipments at the ARTCC) will provide complete site and equipment selection, transceiver tuning, push-to-talk and other control and voice functions primarily over the radar microwave link facilities or over regular telephone voice grade lines. Initiations of outlet selection and transceiver tuning functions are preformed at a controller station by momentary actuation of a push-button switch. Changeover of the controller's microphone, headset and keying lines from his normal communication channel to the emergency backup system is automatically controlled by the processor which actuates the audio transfer relay to perform this function. Status panels, one for VHF and one for UHF, provide maintenance personnel with correlation of emergency outlets being used by each of the controllers.



'igure 8. Backup Emergency Communications System.

The control adapter, associated with each ansceiver at the remote site, decodes digital messages from the remote control group and causes activation and tuning of the transceiver, switches the transceiver between receive and transmit mode, provides the UHF and VHF operate.

The transceivers 'Figure 9) are completely solid-state, modular constructed and are capable of 3500 (50 kHz) channels in the UHF and 720 (25 kHz) channels in the VHF band. The nominal carrier output is 20 watts and each is frequency controlled by a solid-state electrical synthesizer. The UHF and VHF transceivers were designed for maximum module commonality with built-in test metering to allow fault isolation to the module level.

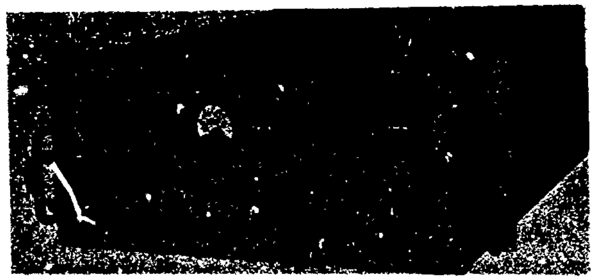


Figure 9. VHF 20 Watt Transceiver.

2. Criteria.

a. Each controller has access to at least two transceivers (and up to as many as 10) capable of operating on his frequency.

b. Should the first transceiver selected be inoperative, the system will automatically switch to the next and be operational in less than one-half of a second.

c. Sufficient backup radios are available to backup a complete remote communications air/ground (RCAG) site.

3. Benefits.

a. Availability of primary communication circuits will be increased from 0.997 to 0.999991 (2.16 hours/month average down time to 24 seconds/month average down time).

b. Provides true redundancy.

(1) Geographically separated path (sometimes two or three redundant paths will be available depending on sector coverage with two to four transceivers per path).

(2) Separate equipment

(3) Redundant sites

c. Allows ease of maintenance on the complete primary channel simultaneously, including the fixed-tuned RCAG transmitters and receivers, the TELCO path, tone control, and switching equipment without disruption in service.

d. Provides advanced state-of-art remotely-tunable transceivers capable of implementing 25 kHz VHF channeling and 50 kHz UHF channeling as the need arises to relieve frequency congestion in the air/ground bands.

PROGRESS.

The contractor, ITT, Aerospace/Optical Division, Fort Wayne, Indiana, started delivery of production equipment in September 1971. Due to budgetary limitations all centers will not be completely equipped with the BUEC system initially. However, to adequately test and evaluate the BUEC system one complete installation is being made at the Oakland, California, ARTCC. This test bed is expected to be fully operational by April 1972 and tests completed by about September 1972.

TREND.

The following major events are scheduled for completion:

1. Installation of a reduced capability at the Chicago and Atlanta ARTCCs by 5/72 and 3/72, respectively.
2. Follow-on procurement of additional transceivers in subsequent years.

SUBPROGRAM.

Development of Modifications to RCAG.
Backup Emergency Communications System (BUEC), 061-222.

MANAGER.

James L. Lipscomb, RD-221.

MODERNIZATION OF TELETYPEWRITER NETWORKS AND SWITCHING SYSTEMS

BACKGROUND.

The FAA manages and operates a variety of digital communication networks across the country with multiple interconnections to foreign countries. Requirements have been established to modernize these networks and introduce programmable computerized switching and control facilities to replace the various electromechanical relay centers of earlier design. These requirements include Selection Order 1010.36, 19/5/66, for the Modernized Weather Teletypewriter Communications System; 9550-1 Request for Research and Development No. AT-30-7, 23/10/68, for the Modernization of Service B Data Interchanges System (BDIS); and a draft FAAR 6180 for the Modernization of FAA Aeronautical Fixed Telecommunications Network (AFTN) Data Switching Systems which is being coordinated.

The networks include teletypewriter services designated as Services A, B, C, O, and the Atlantic and Pacific area Aeronautical Fixed Telecommunications Networks (AFTN). Services A, C, and O carry weather and Notices to Airmen (NOTAM) data. Service B carries traffic control, aircraft movement and other aeronautical operations and administrative traffic within the continental U.S. The AFTN networks provide the links for overseas and foreign exchanges of both weather and aeronautical operation messages.

A major computer controlled switching center as depicted in Figure 10 has just been installed in Kansas City in culmination of a five year development and production program. It is currently phasing into on-line operation for control of the National Weather Communications Services A, C, and O.

It is providing new standards for speed, accuracy and flexibility in handling the tremendous volume of weather data required by the FAA, the National Weather Service, the Military Weather Service, the Airlines, and many other commercial and industrial users.

It serves over 300, 100 words-per-minute circuits with a capacity of up to 500, and provides for approximately three dozen 1000-2000 words-per-minute circuits of which 8 to 10 are being activated during initial operations

The next major project in this area is commencing in FY 72 with a study contract to

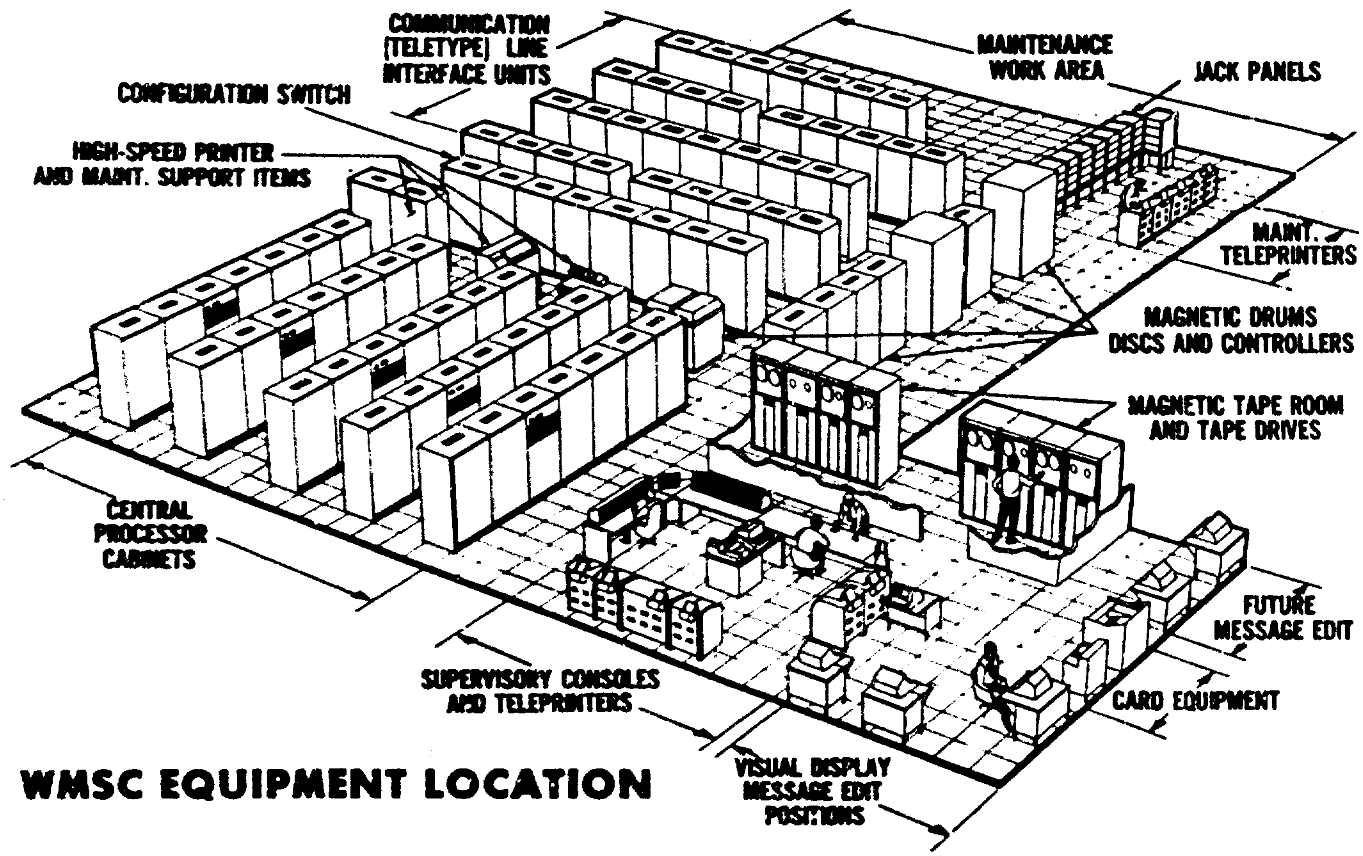


Figure 10. Equipment Layout.

definitize the modernization requirements of Service B. The Service B system consists of four independent message networks. The Primary network is Area B with over 40,000 miles of leased circuits, serving 373 flight service stations and combined station towers 21 air route traffic control centers (ARTCC), and 7 message centers. The Area B network is depicted in Figure 11. The other three networks making up the B system are: Center B, a multipoint, low speed TTY circuit linking the 21 ARTCC's, Air Carrier B and Military B consisting of multipoint TTY circuits from military and airline operation centers to ARTCC's used for direct filing of IFR flight plans.

The modernization study will be conducted in two phases. Phase I will include the characterization of the existing system and a tabulation of known and projected future requirements for the total Service B System for the period 1975-1985. Based on this data, parameters for a modernized system will be developed and candidate systems selected for evaluation. Phase II of the study will provide for the evaluation and selection of an optimized system design to be followed by specification of system hardware and software.

A modernized Service B System will provide much greater flexibility in message handling and routing. Message errors and delays will be reduced. Provision will be made for future expansion and growth and for interface with other digital communication systems. Message format changes, circuit reconfiguration and terminal device upgrading will be simplified.

A further project to be commenced shortly is the modernization of the Pacific Area AFTN networks. The Pacific Area includes Alaska, Hawaii, other U.S. Pacific Islands and extensions to the west coast of the U.S. Centers are located in Anchorage, Honolulu, and San Francisco. This project will follow the general plan of those described above, will include provision for modernization of the Alaskan weather circuits and their control and for alternate or back-up facilities for the U.S. Weather and Atlantic/

AREA B SYSTEM CIRCUIT NETWORK

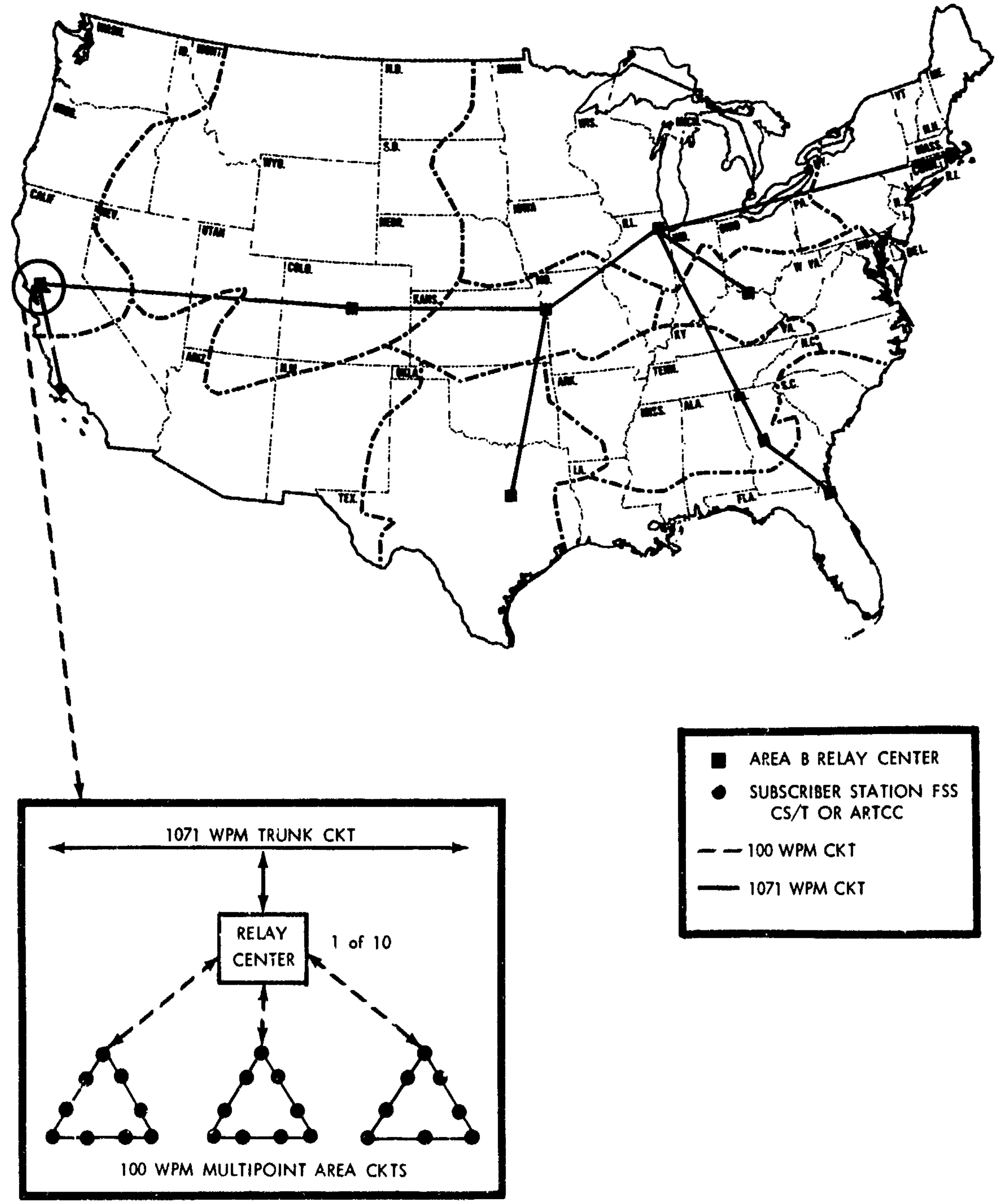


Figure 11. Area B System Circuit Network.

Caribbean AFTN Centers. The Atlantic/Caribbean AFTN Center is collocated with the Weather Center at Kansas City, Modernization of the AFTN Center was completed in 1970 with a major dual-processor switching system and many circuit modifications.

PROGRESS.

1. The Weather Message Switching Center was installed, checked out by the contractor and several dozens of circuits cut-over to new system operation–12/71.

2. A contract for Phase I of the Service B modernization was awarded–10/71.

3. SRDS in-house planning commenced on the Pacific Area AFTN project.

TREND.

The following major events are scheduled for future completion:

1. Phase-over to full, on-line operation of weather switching center completed–10/72.
2. Contract awarded for Phase II of Service B study–9/72.
3. Specification for modernized Service B hardware and software completed–4/73.
4. Pacific Area AFTN Design Study contract awarded–8/72.

SUBPROGRAM.

Modernization of Teletypewriter Networks and Switching Systems 064-231.

MANAGER.

Robert F. Decker, RD-231.

LOW-COST SURVEILLANCE RADAR REMOTING EQUIPMENT

BACKGROUND.

This engineering and development effort seeks to provide tower controllers at satellite airports, with surveillance radar BRITE displays, at high and medium activity terminal area locations, where the satellite airport is within the coverage area of the radar serving the primary terminal. FAAR 6310.3 dated 31 March 1967 "Provide Low-Cost Surveillance Radar Remoting Equipment" documents this requirement. (Figure 12 depicts two basic remoting configurations.) Prior year development effort resulted in the selection of the 14.4 - 15.25 GHz Government frequency band for remoting the TV radar data, and in the procurement, test, and evaluation of an engineering model, wide baseband (15 GHz) microwave transmitter and receiver terminal equipment. These efforts are detailed in FAA Reports: "Experimentation Support for Development of Low Cost TV Radar Remoting System," Report FAA-RD-70-74; "Rain Attenuation Study for 15 GHz Relay Design," Report FAA-RD-70-21; "Propagation Characteristics at 15 GHz on an 18-Km Overwater Relay," Report FAA-RD-71-74.

Although the average direct line distance from most primary airports, to a satellite airport where adequate radar coverage exists is 10 miles, path surveys indicate that over 50% of the locations qualifying for this service will require one or more microwave repeater terminals.

Signal path obstructions and the limitations on tower heights at airport terminals cause the problems. SRDS/NAFEC current effort emphasizes development of an economical, highly reliable, solid state repeater terminal to satisfy this requirement. SRDS determined that the most promising design meeting reliability, maintainability and other specified equipment parameters was a radio frequency (J band) heterodyne, repeater of all solid state constructions, designed for fail-soft operation, requiring minimum support facilities.

PROGRESS.

FAA awarded contract 6/71 for the development of an engineering model repeater having the following main characteristics: Frequency conversion at J band (200 MHz offset, receiver

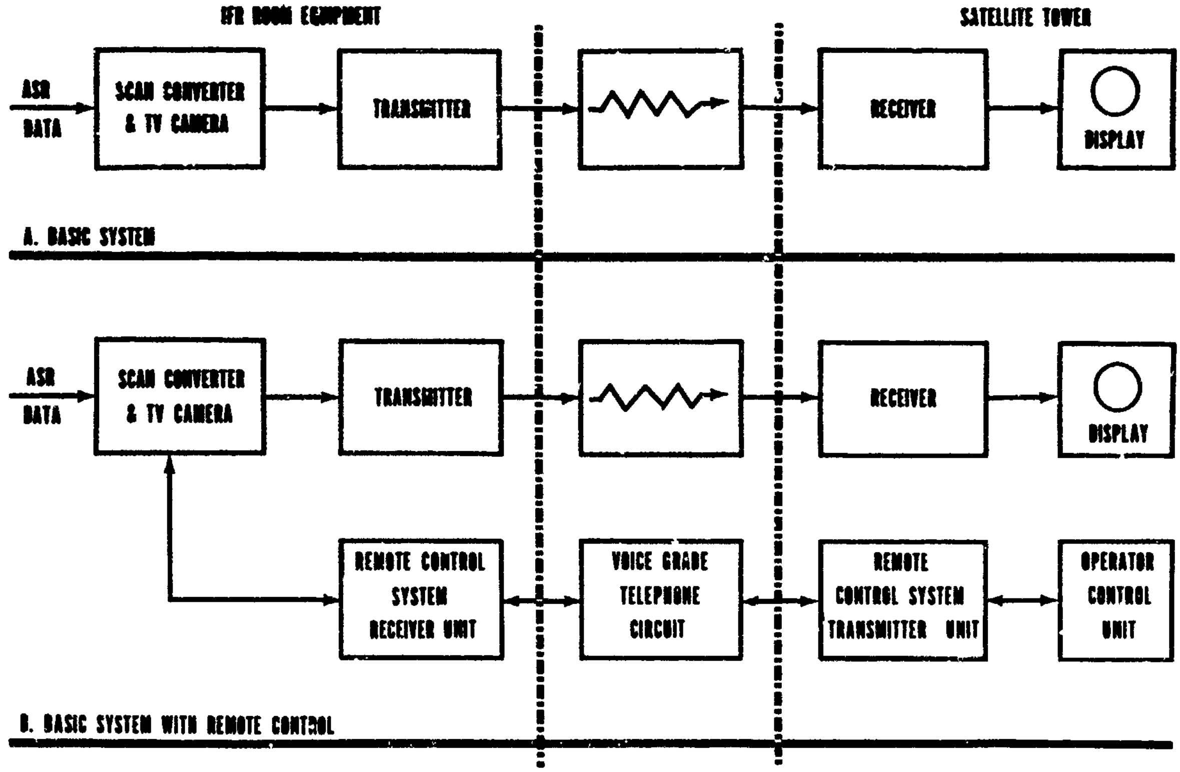


Figure 12. Remoting System Block Diagram.

to transmitter), solid state modular construction throughout, minimum power output of 100 milliwatts. The repeater would be installed in an all weather enclosure for pole or tower mounting adjacent to the antennas. A power supply consisting of a battery and charger would be installed in a separate outdoor enclosure located at ground level. (Figure 13 shows the complete engineering model repeater less antennas and power supply.)

In addition to the repeater, SRDS is developing an engineering model remote control system to allow the controller at the satellite tower location to make adjustments to the BRITE radar scan converter (configuration B of Figure 12).

Figure 13. Engineering Model RF Heterodyne MW Repeater.

TREND.

The following events are scheduled for completion:

1. Test and evaluation of RF repeater at NAFEC completed–5/72.
2. Test and evaluation of Remote Control System at NAFEC completed–10/72.
3. System integration test and evaluation at the FAA, Atlanta, Georgia terminal facility completed–3/73.

SUBPROGRAM.

Development of Low-Cost Broadband Microwave Remoting System 064-233.

MANAGER.

Charles E. LaRue, RD-231.

PROJECT MANAGER.

M. Greenberg–NA-531.

07 LANDING SYSTEM PROGRAM

GOAL.

The purpose of the Landing System Program is to improve the conventional VHF/UHF Instrument Landing System and ground lighting system to meet current operational requirements through CAT IIIA All Weather Landing System and develop a new and improved approach and landing guidance system to meet future operational requirements.

SCOPE.

This program is organized under five Program Elements: 071–Sustaining Engineering; 072–System Improvements; 073–Category III; 074–V/STOL Approach and Landing; 075–Microwave ILS; 076–Approach and Landing Altimetry.

In the FY 72 Technical Program, engineering and development efforts include the following subprograms:

071-312 VFR Visual Guidance-Sustaining Engineering,* Program Manager P.A. Darmody, RD-323.

071-313 Sustained ILS Engineering, H.H. Butts, RD-321.

072-321 ILS Improvements, H.H. Butts, RD-321.

072-324 Low Visibility Visual Guidance, W.C. Fisher, RD-324.

072-741 Two Segment Noise, LTC R. Chubboy, RD-741.

073-316 CAT III Terminal Interface, J.R. Nelson, RD-322.

073-318 CAT III Electronic Guidance,* J.R. Nelson, RD-322.

073-320 Airborne System fo AT III,* J.R. Nelson, RD-322.

073-322 Define and Evaluate CAT III,* J.R. Nelson, RD-322.

073-323 CAT III Visual Guidance* W.C. Fisher, RD-324.

074-390 V/STOL Approach and Landing, W.C. Fisher, RD-324.

075-325 Microwave Landing System,* J.W. Edwards RD-350.

076-311 Approach and Landing Altimetry, J.R. Nelson, RD-322

The following selected* major subprograms are highlighted in terms of Background, Progress, and Trend (major milestones scheduled for completion):

VFR VISUAL GUIDANCE - SUSTAINING ENGINEERING
Improved Airport Beacon

BACKGROUND.

The purpose of this effort, responsive to FAAR 6910.2, dated 31 July 1967, is to improve the present airport beacon which was developed over 25 years ago. The goals are improved vertical guidance, simplicity of design, reduced total cost and reliability.

PROGRESS.

A rotating type beacon with incandescent lamps and a condenser discharge (strobe) beacon, both procured by an R&D contract to meet the above goals, are being evaluated at NAFEC to determine requirements for a procurement specification for an improved beacon. It is anticipated that tests should be completed this fiscal year (1972). Figure 14 shows the rotating beacon and Figure 15 portrays the strobe beacon.

TREND.

The following events are scheduled for completion:

SRDS procurement specification completed for airport beacon–3/73.

FAA Selection Order for airport beacon–3/73.

Figure 14. Structural Incandescent Beacon Strobe Beacon.

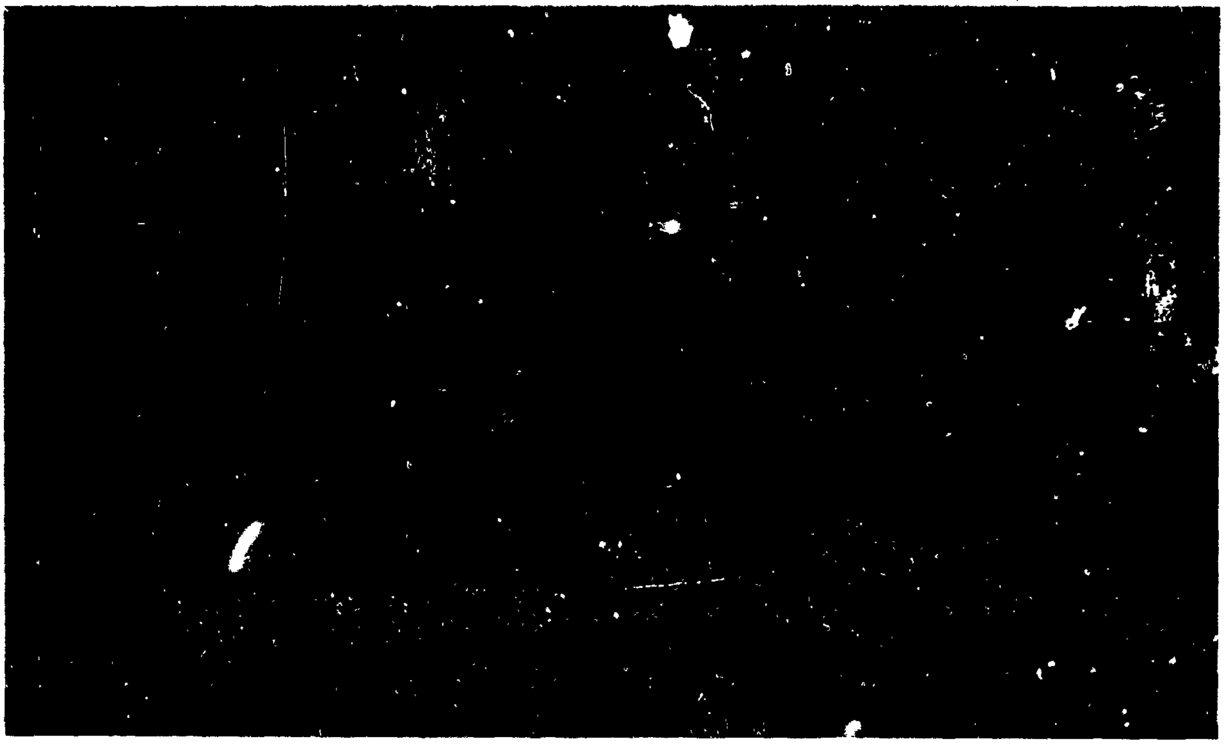


Figure 15. Strobe Beacon.

SUBPROGRAM.

VFR Visual Guidance-Improved Airport Beacon, 071-312-023.

MANAGER.

P.A. Darmody, RD-323.

LOW VISIBILITY VISUAL GUIDANCE
Displaced Threshold Lighting

BACKGROUND.

The purpose of this effort, responsive to SMS 69-13, 10/10/68, is to rectify serious deficiencies in semi-flush approach lighting fixtures operational at that time for displaced threshhold areas.

PROGRESS.

After several phases of development each of which aided in advancing the state-of-the-art, a promising design has emerged for the steady burning fixture. It is being incorporated in NAS as the current operational unit and is identified as "Approach Light, Semi-Flush, Steady Burning, FAA-E-2491." Figure 16 shows complete assembly installed. Figures 17 and 18 illustrate removable light module and its internal optics. FAA awarded development contract for a semi-flush flashing approach light unit. On the basis of prototype tests this unit promises to be the new operational flasher for approach lighting requiring installation in paved areas used by aircraft or vehicles. The flashing unit will include a variable intensity among its many desirable features.

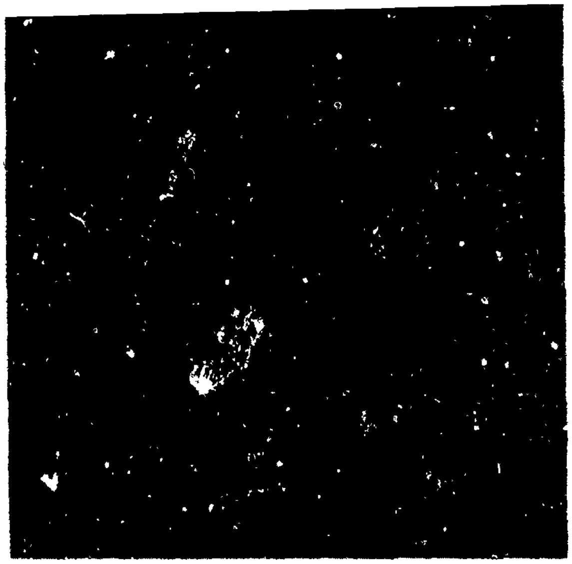


Figure 16. Light Assembly Installed.

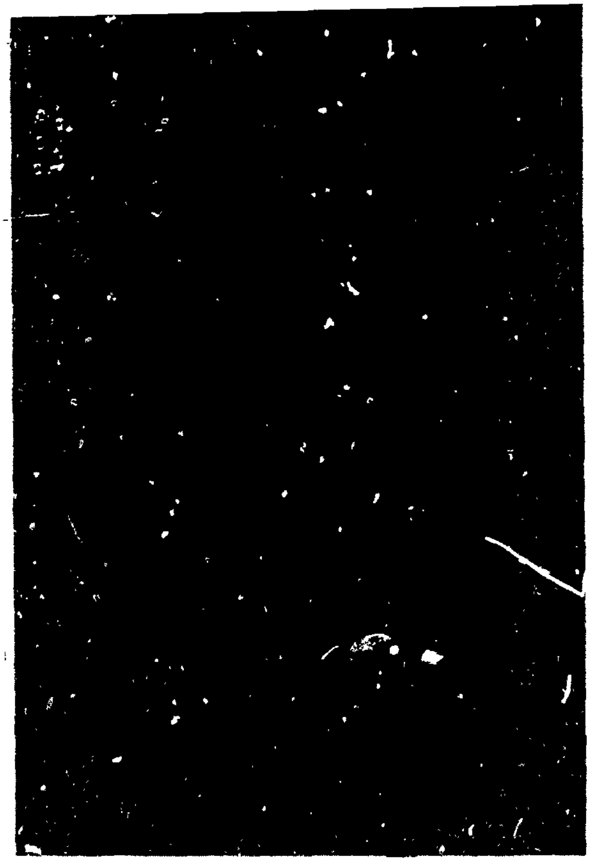


Figure 17. Light Assembly Removed.

TREND.

Selection Order "In-Pavement Lights for Approach Lighting System" issued–10/72.
Selection Order "Semi-Flush Flasher for Approach Lighting System issued–6/73.

SUBPROGRAM.

Low Visibility Visual Guidance–Displaced Threshhold Lighting, 072-324-033.

MANAGER.

W.C. Fisher, RD-324.

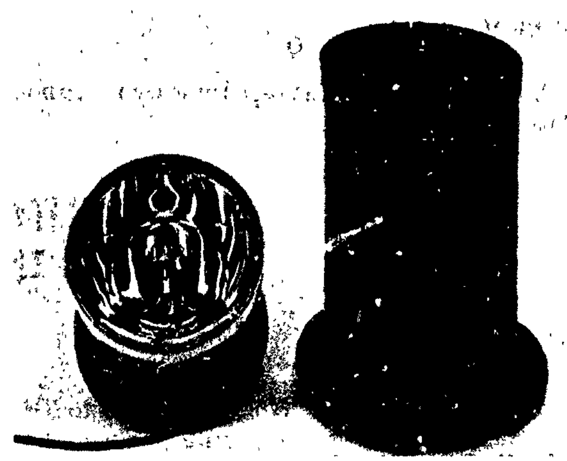


Figure 18. Light Assembly, Internal Optics.

ALL-WEATHER LANDING (AWL)

BACKGROUND.

Instrument Flight Rules flight conditions at airports curtail airborne operations. Restrictions to visibility and cloud ceilings constitute the basic factors in this curtailment. Decision Height (DH) is the term applied as the height at which visual reference must be made during an Instrument Landing System (ILS) approach in order to continue the approach: Runway Visual Range

Currently, most airplanes land under Category I minimums, i.e., when DH is down to 200 feet and RVR is at least 2400 feet.

To conduct landing operations under Category II minimums requires a capability to operate to a DH below 200 feet and down to 1[illegible] feet and RVR is less than 2400 feet and down to 1200 feet.

To conduct landing operations under Category III minimums requires a capability to operate with no DH and the RVR reduced in three steps from Category II minimums to zero.

The purpose of this R&D effort is to develop a capability to meet the demands of safety under all-weather conditions.

and Demonstration. This effort is to define the total Category III system concept (Figure 19) and to demonstrate the capabilities of the system. Improvements may be attained through the development of an independent landing monitor (ILM). One scheme being investigated with possible application as an ILM is a landing system based on nuclear technology which can be redundant to an existing ILS. Another study is being performed examining the use of infrared sensors to see through fog. Activity in this program includes the exercise of Category III air/ground complex during actual weather with approach and landing operations.

2. **Airborne Systems for Category III.** The objective of this effort is to determine the

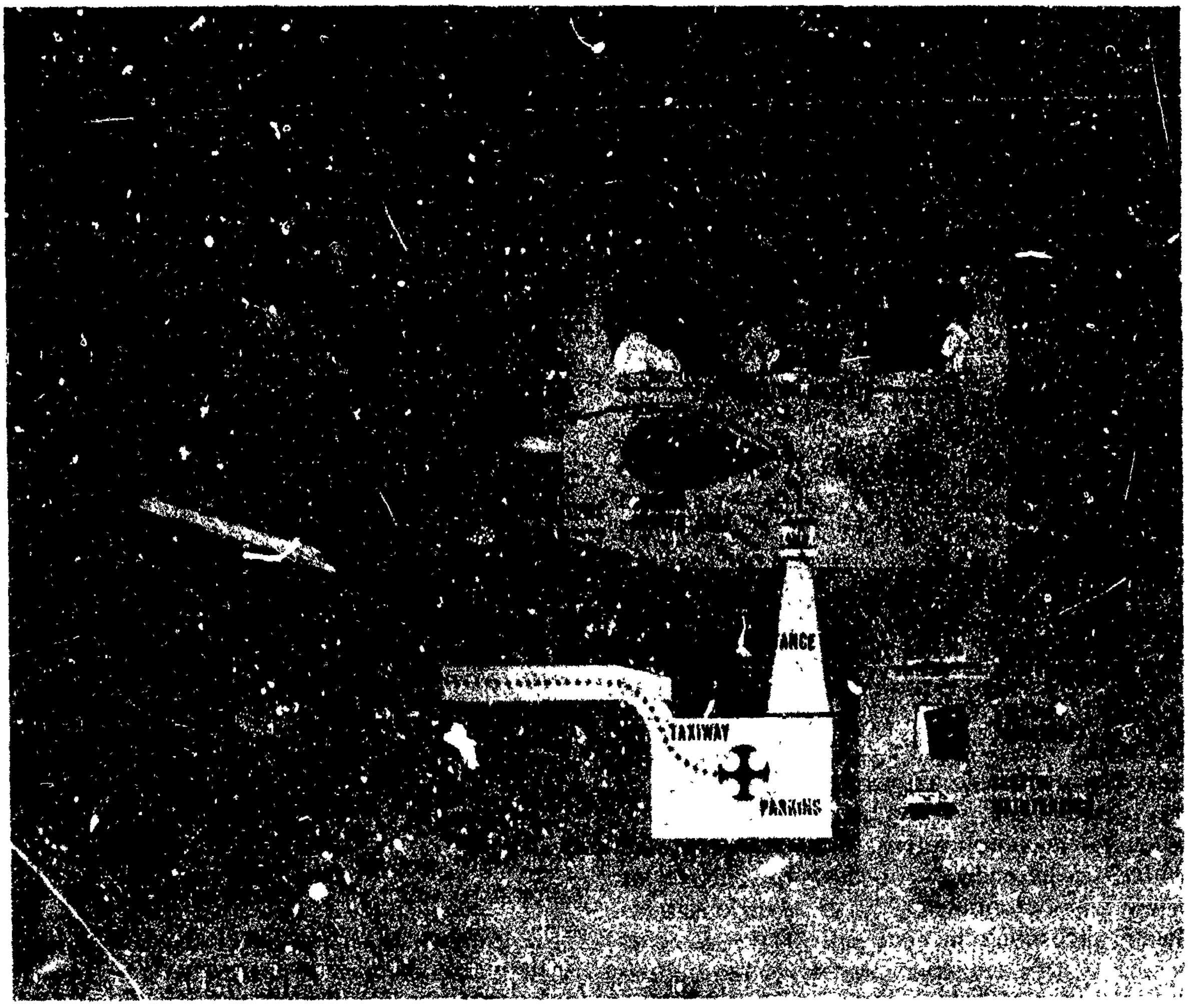


Figure 19 Elements of all Weather Landing System.

... and improve specifications for guidance signal quality; to sponsor and encourage the development of improved airborne systems for Category III. This includes the development, test and evaluation of airborne components required to make an aircraft suitable for operation in Category III weather, to demonstrate compatibility of the ground system with a suitably equipped aircraft, and to demonstrate suitability of the complete air/ground system concept. The FAA system concept envisions a completely automatic landing system with the pilot serving as a monitor and decision maker. He will have fail-safe monitors to inform him how the system is functioning. He will be provided with override capability for manual operation. Emphasis is placed on equipment and systems which will relieve the pilot of portions of his many landing duties such as throttle control and decrab. The safety of approach and landing in Category III weather requires optimum performance and reliability from ground and airborne guidance and control equipment and procedures.

Airborne system developments are being undertaken to (1) permit realistic tests of the complete Category III environment and validate the compatibility of air and ground systems and procedures and (2) develop specific new airborne equipment which may enhance safety and reliability, and reduce cost of or achieve a greater cost/benefit ratio of Category III equipment and operations.

3. **Electronic Guidance.** This effort is directed to developing a ground-based VHF/UHF guidance system for Category III approach and landing. It includes the development, applications engineering, procurement, installation, testing and evaluation of a total non-visual ground based electronic system and components designed to provide Category II and III AWL capabilities. This system transmits electronic signals which a properly equipped aircraft can determine its position with respect to the runway. Information is provided to determine: (a) deviation left or right of the runway centerline extended, (b) deviation above or below a predetermined glide slope angle, and (c) the distance along the glide path. These elements of the system are appropriately monitored so that the traffic control system is advised of the status of the ILS at all times. Provision is made the event of commercial power failure.

This effort includes the development of antenna systems and monitoring systems to improve the performance and reliability of ILS and permit their installation at airports where siting conditions create problems. Mathematical analysis and actual scale modeling is also employed to predict the effect of siting conditions on ILS operation and to plan techniques for overcoming siting problems. The effort also includes development of a new ILS design with special monitoring features for safety in Category III weather.

4. **Visual Guidance for Category III.** This effort is directed toward development of a new lighting system which will result in the modification, extension, and improvement of existing systems to provide the additional visual guidance required for operation of aircraft under Category III conditions.

Because the pilot must rely upon a fully automatic electronic system to flare and land the aircraft in Category III conditions, this effort is confined to providing visual guidance during roll-out on the runway after touchdown, guidance between runways and ramps, and guidance for take-offs. This work is not applicable for the lower end of Category III, where the visibility approaches zero and ground guidance by non-visual means will be provided.

The visual guidance development effort involves Flight Test and Evaluation of Category III Lighting System.

PROGRESS.

1. **Category III System Concept, Definition, and Demonstration.** A Nuclear Instrument Landing System is in the preliminary stages of being installed at the NAFEC to be correlated with results obtained from a Category III ILS to be installed on the same runway.

A joint effort with the U.S. Army evaluating infrared sensors for use in low visibility approach and landing is in the final stages.

2. **Airborne Systems.** An automatic landing system augmented with inertially derived signals is being flight tested by NAFEC in the CV-880 AWL test bed aircraft and in a Boeing 727.

The C-141 aircraft, in a joint FAA/NAFEC and U.S. Air Force program, is continuing in use as a test vehicle for Category III operations.

3. Electronic Guidance. An FAA development contract for two Category III instrument landing systems designed to meet high reliability and integrity standards is now well in progress. One of these systems will be installed at NAFEC where it will become part of a complete Category III facility for continuous experimental and operational testing. The second system is scheduled for installation at San Francisco International Airport where it will undergo extensive field evaluation and reliability demonstrations before acceptance for actual Category III, ILS operation.

A new Category II ILS, together with a promising new localizer antenna will also be evaluated at NAFEC. A STAN 37/38 ILS, on loan from the U.K., has been tested at NAFEC. Now installed at Dulles, this system will undergo an operational evaluation by the Eastern Region.

4. Visual Guidance for Category III. A complete Category III approach and runway lighting system is being installed at NAFEC for operational tests.

A cockpit fog simulator (day version) has been evaluated by NAFEC and related problems have been determined. The manufacturer has proposed changes to upgrade the equipment for field testing.

TREND.

The following major events have been scheduled for completion:

Category III System Concept, Definition and Evaluation.

1. Nuclear ILS installation evaluation by NAFEC–4/73.

2. ILM Infrared sensor study by the U.S. Army under joint agreement–12/72.

3. CV-880 instrument panel modification and general purpose digital computer facility installed by contractor -4/73.

Airborne Systems for Category III.

1. Inertial Augmentation Flight test evaluation completed by NAFEC/TSC of improved couplers/3/72.

2. Initial Phase of Low visibility flight tests completed by NAFEC/USAF–7/72.

3. Actual weather flight tests completed by FAA/Air Force joint C-141 programs–12/72.

4. High-resolution radar procured by FAA–12/72.

5. Head-up Display evaluation plan implemented–12/72.

Electronic Guidance.

1. Installation completed by contractor of prototype Category III ground based guidance system–9/72.

2. Testing and reliability demonstration completed by FAA–6/73.

Visual Guidance for Category III.

1. Category III lighting system tested by NAFEC–3/74.

2. Visual Control and guidance system tested by FAA–6/75.

3. Daytime cockpit fog simulator modification contract awarded by FAA–6/72.

4. Night-time cockpit fog simulator development contract awarded by FAA–3/73.

SUBPROGRAMS.

Definition and Evaluation of Category III Landing Concepts, 073-322.

Airborne Systems for Category III, 073-320.

Electronic Guidance for Category III, 073-318.

MANAGER.

James R. Nelson, RD-320.

SUBPROGRAM.

Category III Visual Guidance, 073-323.

MANAGER.

Walter C. Fisher, RD-324.

MICROWAVE LANDING SYSTEM (MLS)

BACKGROUND.

The purpose of this effort is to develop a MLS in response to the FAA R&D Plan to Increase Airport and Airway System Capacity. A joint DOT/DOD/NASA program, described in "National Plan for Development of the Microwave Landing System," 7/71, has been launched to develop a new, common civil/military aircraft approach and landing system based on recommendations of the Radio Technical Commission for Aeronautics, Special Committee 117 (RTCA SC-117). This system is intended to meet the entire spectrum of civil and military needs at domestic and foreign airports until the year 2000.

The principal approach and landing systems currently in use are the instrument landing system (ILS) for civil aircraft and the ground controlled approach (GCA) system, used largely by military aircraft. Each of these systems has been used essentially unchanged since its introduction in the early 1940's. Over the last few years, the Navy and Air Force have installed, on a limited basis, tactical microwave landing systems to meet urgent military requirements.

The new microwave landing system (MLS) (Figure 20) will provide guidance signals so that closely-spaced parallel runways may be used to accommodate high density air traffic. With airborne processing, the high quality signals will

Figure 20. New Common-Use C. 'Military Microwave Landing System.

permit the derivation of flexible flight paths as an aid to noise abatement and increased capacity in the terminal area. Accurate guidance signals will be furnished that will be relatively insensitive to weather, terrain, structures, and other aircraft. Low cost versions will be available for small airfields. Versions will also be available for vertical and short take-off and landing (V/STOL) operations and for the full spectrum of military applications.

The MLS is an air-derived data system operating at microwave frequencies. Ground stations generate electromagnetic signals that enable airborne units to obtain precision azimuth and elevation angles, and range data, referenced to the ground radiating system runway, which are suitable for display to the pilot and/or for inputs to an automated flight control system. Angular position of an aircraft is measured by reference to ground-generated scanning beams that scan across the coverage sector in both azimuth and elevation. The airborne unit extracts the angle data to obtain the line-of-site angle from the ground antenna. Range measurements are made by airborne interrogation of a ground transponder. The system is capable of providing auxiliary data such as runway identity, equipment status, weather data, and siting geometry, to the airborne units.

THE DOT/DOD/NASA National Plan (Figure 21) includes two major complementary efforts: (1) an industry program designed to produce prototype equipments at the earliest possible date and (2) a series of supporting government programs that will include independent (from the industry program) validation efforts, investigation of subsystem concepts and techniques, and the application of the MLS to the broad range of civil/military aircraft operations.

This plan designated DOT/FAA as the agency for managing the industry development effort. DOD/NASA personnel assigned to FAA will provide additional technical and engineering support. An Interdepartmental Advisory Group, composed of DOD/NASA representatives will also provide support. These supporting efforts will be directed by the participating DOT/DOD/NASA elements and coordinated through FAA-SRDS MLS Program Manager. Problems, such as priorities and funding will be referred for resolution to the FAA Office of Systems Engineering Management. At critical review points, approval at the Secretary/Administrator level of DOT/DOD/NASA will be sought.

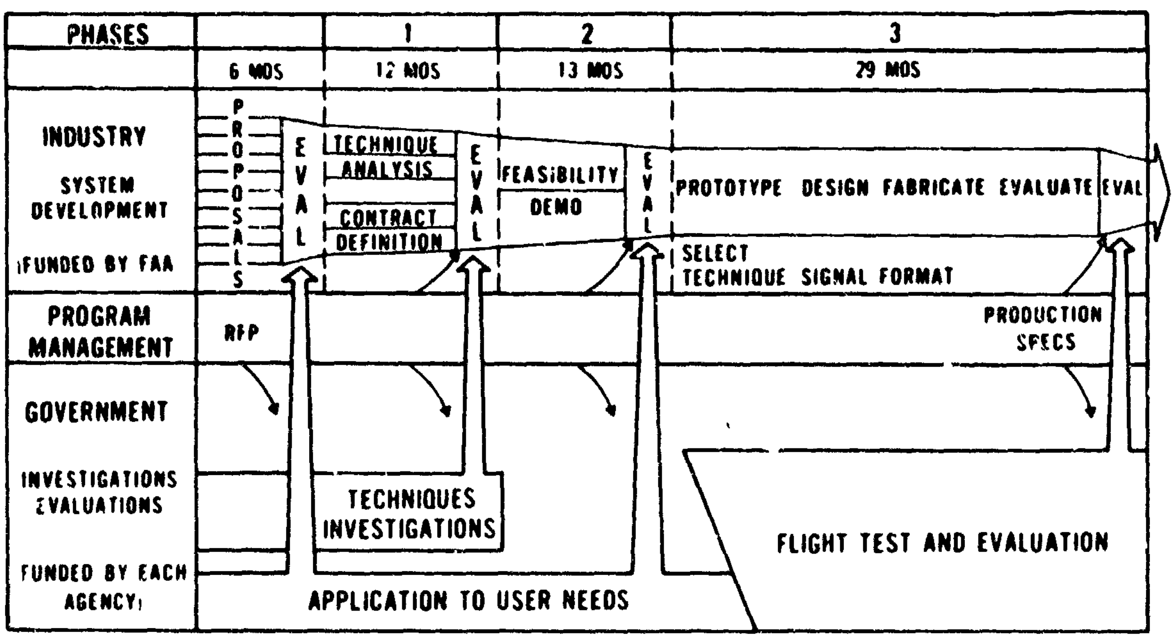


Figure 21. MLS Development Plan.

PROGRESS.

1. RTCA's Special Committee SC-117 published its recommendations in "A New Guidance System for Approach and Landing," DO-148, 18/12/70.
2. DOT/DOD/NASA jointly issued the "National Plan for Development of the Microwave Landing System," July 1971.
3. Six contracts awarded by FAA for the technique analysis and contract definition phase, January 1972.
4. An Interdepartmental Advisory Group, with membership from DOT, U.S. Army, U.S. Navy, U.S. Air Force, and NASA, has been formed.
5. A Program Management Office (MLS Branch–SRDS) has been established in the FAA, with participation from DOD and NASA.
6. A joint agency review of supporting government programs was held in March 1972.

TREND.

The following major milestones are scheduled for completion:

1. Feasibility model development contracts awarded–1/73.
2. Prototype development contracts awarded–2/74.
3. Test evaluation of prototype completed–4/76.
4. Production specs completed–7/76.

SUBPROGRAM.

Microwave Landing System, 075-325.

MANAGER.

Larry Trenary, RD-350.

ASSISTANT PROGRAM MANAGER.

Jack Edwards, RD-350.

ASSOCIATE PROGRAM MANAGERS.

Vincent L. Bencivenga, RD-350; Cloyd J. Combs, RD-350; Seymour Everett, RD-350; Gene Jensen, RD-350 and Albert Stein, RD-325.

08 RUNWAYS/TAXIWAYS PROGRAM

GOAL.

The purpose of the Runways/Taxiways Program is to increase safety and capacity of airport runways/taxiways. It covers engineering and development efforts in pavement design, construction and layout, safety support including fog dispersal, snow/ice removal and fire-fighting systems; and ground surveillance control and guidance.

SCOPE.

This engineering and development effort is organized under three Program Elements: 081–Safety Support; 082–Design/Layout/Construction; and 083–Ground Surveillance and Guidance.

In the FY 72 Technical Program, engineering and development efforts include:

081-261 Fog Dispersal and Prevention,* Subprogram Manager Frank G. Coons, Jr., RD-263.

081-731 Airport/Stolport Safety Support System,* Herman D'Aulerio, RD-733

081-790 STOL Arresting Gear, Herman D'Aulerio, RD-733.

082-120 Airport Design and Surface,* Carl Schulten, RD-161.

082-121 Airport Capacity Determination and Airside Configuration Design,* Roger Pierre, RD-162.

082-122 Advanced Airfield Facility Design,* Roger Pierre, RD-162.

083-123 Airport Blindspot Ground Control Surveillance for Problem Situations,* Louis R. Sneiderman, RD-131.

083-601 Airport Ground Control and Guidance, Terence B. Wendel, RD-620.

084-790 STOLport Design and Testing, J.C. Staples RD-742.

The following selected* major subprograms are highlighted in terms of Background, Progress, and Trend (major milestones scheduled for completion):

FOG DISPERSAL AND PREVENTION

BACKGROUND.

This engineering and development effort is in response to the Increased Airport/Airway System Capacity Program Plan. An essential element of this plan concerns the dispersal of fog at airports and other adverse weather which affect system capacity. This effort seeks to provide means for reducing the effects of adverse weather and environmental conditions at airports.

The widespread dispersal of fog at airports on a routine basis would eliminate many of the flight cancellations, diversions and delays attributed to fog. This loss of time represents a significant aviation problem in such matters as loss of revenue, passenger inconvenience, delays in aircraft checks and rescheduling of aircraft maintenance work. These losses amount to nearly $80 million per year according to the Air Transport Association of America.

The goal of the effort in fog modification is to develop operationally reliable ground-based warm and cold fog dispersal systems which also have a favorable cost/benefit relationship.

SRDS is conducting a study of the meteorological parameters of fog at 39 U.S. airports. The study will define the fog environment in such a way that it can readily be used in engineering calculations.

SRDS made analysis of the terrain effects on the cost of a ground-based fog dispersal system to determine if the system is economically beneficial. Measurement and evaluation of current operational airborne fog dispersal techniques will provide valuable information on the efficiency of various types of fog dispersal agents, rate of fog dissipation, fog physics and cost/benefit ratio analysis.

These studies and others will be the basis of a systems engineering study which will provide industry with FAA requirements for a total warm fog dispersal system and to which industry can respond with the development of prototype ground-based fog dispersal systems. To augment the above effort, the FAA, as "Lead Agency" for the National Fog Modification Project, will develop a plan based on other agencies' requirements for fog dispersal which will include an assessment of:

1. Operational feasibility and evaluation of dispersal concepts.

2. Necessity for supporting engineering and development by other agencies.

3. The role of the Federal Government in fog dispersal.

The goal of this plan is to develop operational fog dispersal systems which meet the requirements of those public and military activities where a favorable cost/benefit relationship can be demonstrated.

To meet these goals, FAA will cooperate with other Federal agencies. Such a coordinated effort by agencies engaged in fog modification can accelerate progress toward operational fog dispersal systems. In this respect, negotiations with the U.S. Air Force for a joint development program are underway way to develop and install an operational cold fog (less than 32°F) dispersal system at an airport which experiences a high incidence of cold fog. This will be a ground-based system which uses propane as the nucleating agent to initiate ice crystal formation in cold fog. The requirement for the installation, test and evaluation of a prototype propane system has been prepared by the FAA.

PROGRESS.

1. A contract has been let to test the efficacy of biodegradable polyhydric compounds for fog dispersal. Tests were carried out in conjunction with the U.S. Naval Weapons Center Project, "Foggy Cloud IV," at Arcata, California, in October-November 1971.

2. A contract was awarded in November 1971 to evaluate the airborne fogseeding techniques used at the Seattle-Tacoma Airport and the Spokane International Airport during the winter fog season from November 1971 through February 1972.

3. Negotiations with the Air Force for a joint-development program of a Ground-based Cold Fog Dispersal System (using propane as the nucleating agent) have been initiated. If successful, a joint development contract will be undertaken with the Air Force. The end-product desired is a demonstrable ground-based propane cold fog dispersal system for a U.S. civil airport which experiences a high incidence of cold fog.

4. SRDS report FAA-RD-71-44-I and II entitled "Potential Economic Benefits of Fog Dispersal in the Terminal Area" was completed in November 1971. This study provides estimates of the costs of disruptions, relays, diversions, number of Category II and III weather situations with the emphasis on fog situations at some of the major air carrier airports in the United States. As such, the report is a measure of the economic benefits which could be realized from modification of these adverse weather effects.

TRENDS.

The following major milestones are scheduled for accomplishment:

1. Polyhydric Fog Dispersal Agents–SRDS/Contractor interim report completed–6/72.

2. Warm Fog Dispersal System Contract Definition awarded SRDS–8/72.

3. Interagency Agreement with USAF to develop a propane cold fog dispersal system completed–8/72.

4. SRDS/Contractor Measurement/Evaluation of Fog Dispersal Techniques at Seattle and Spokane, Washington–final report issued–6/72.

5. Fog Prevention Techniques Contract awarded SRDS–8/72.

6. A contract awarded to evaluated one or two more fog-dispersal techniques, primarily using ground base equipment–9/72.

SUBPROGRAM.

Fog Dispersal and Prevention, 081-261.

MANAGER.

Frank G. Coons, Jr., RD-263

AIRPORT/STOLPORT SAFETY SUPPORT SYSTEM

BACKGROUND.

The engineering and development efforts for Airport/STOLport Safety Support System include aircraft arresting, fire fighting, disabled aircraft, and snow removal systems.

The purpose of the aircraft arresting system effort, in response to 9550.1 Request for Research, Development, and Engineering, AS-570-67-10, is to monitor, study, and report on hookless aircraft arresting system at airports and STOLports. Government facilities at Edwards AFB have been made available by FAA/USAF to industry and dynamic tests of a civil transport type barrier arresting system have been conducted by coordinated efforts of USAF/Aerzur Co./All American Engineering Co. The net erection device for this system and modes of operation are being developed by Aerzur Co./All American Engineering Co. Figure 22 shows a USAF B-52B airplane during an engagement with the emergency arresting barrier net system.

Technical data and reports on these tests have been made available by Aerzur Co./All American Engineering Co. to the FAA and the USAF. Elevated STOLports require an emergency system to prevent aircraft from going over the sides. Arresting systems are being considered as a means of containment.

The purpose of the firefighting effort, in response to 9550.1, AS-570-68-1-1-68, is to develop guidelines and criteria governing firefighting agents, discharge rates, and quantities required for adequate protection to crew and passengers in a crash landing. The solution and discharge rate to control fires varying sizes in a predetermined time interval have been determined. Interim Report FAA-RD-68-55, "Airport Firefighting Equipment and Technique" provides a mathematical model which permits a calculation of the time required for aircraft

Figure 22. USAF B-52B Engages Emergency Arresting Barrier Net System.

fuselage aluminum skin covering to melt when exposed to maximum fuel spillage fire conditions.

Figure 23 shows a helicopter used to extinguish a jet fuel fire. Tests of this nature will be conducted at NAFEC to develop rapid response equipments and techniques to ensure minimum fire control time involving commercial aircraft.

The purpose of the disabled aircraft removal effort, in response to 9550.1, Request AS 570-71-5, 5/11/71, is to develop a system to remove disabled aircraft weighing up to one million pounds from or near runways.

The purpose of the snow removal system effort, responsive to FAAR 5380.1, 1/67, is to investigate, develop, and systemize methods/

Figure 23. Helicopter used to Fight Fires

techniques for removal of snow, ice, slush, and water from runways and establish guidelines to improve effectiveness on snow/ice control on airport pavements. The planning model, showing the cost calculation process for a given airport and associated traffic/snow fall/removal system combination is illustrated in Figure 24.

PROGRESS.

Dynamic tests of an emergency arresting barrier net system using a B-52B airplane weighing 305,000 lbs. and an engagement speed of 112 knots have been completed through cooperative efforts of FAA/USAF/Aerzur Co./All American Engineering Co.

U.S. Navy is conducting tests at Naval Air Test Facility, Lakehurst, N.J. on arresting systems for V/STOL's on elevated STOLports.

Final Report USAF No. SRS-71-1, (FAA-RD-71-57) "Evaluation of Aircraft Firefighting Agents and Techniques" published.

Full scale firefighting experiments performed by NAFEC for FAA/USAF to demonstrate firefighting agent effectiveness and validity of techniques and application rates. FAA initiated Request for Proposal to industry for study of a system to remove disabled aircraft from airport areas.

Hovey-Sores' Limited under contract to FAA completed Final Report FAA-RD-71-20, "An Analysis of Airport Snow Removal and Ice Control".

Field evaluation tests of liquid chemical anti-icer/deicer fluids conducted by USAF, Port of New York Authority, and Canadian Minority of Transport.

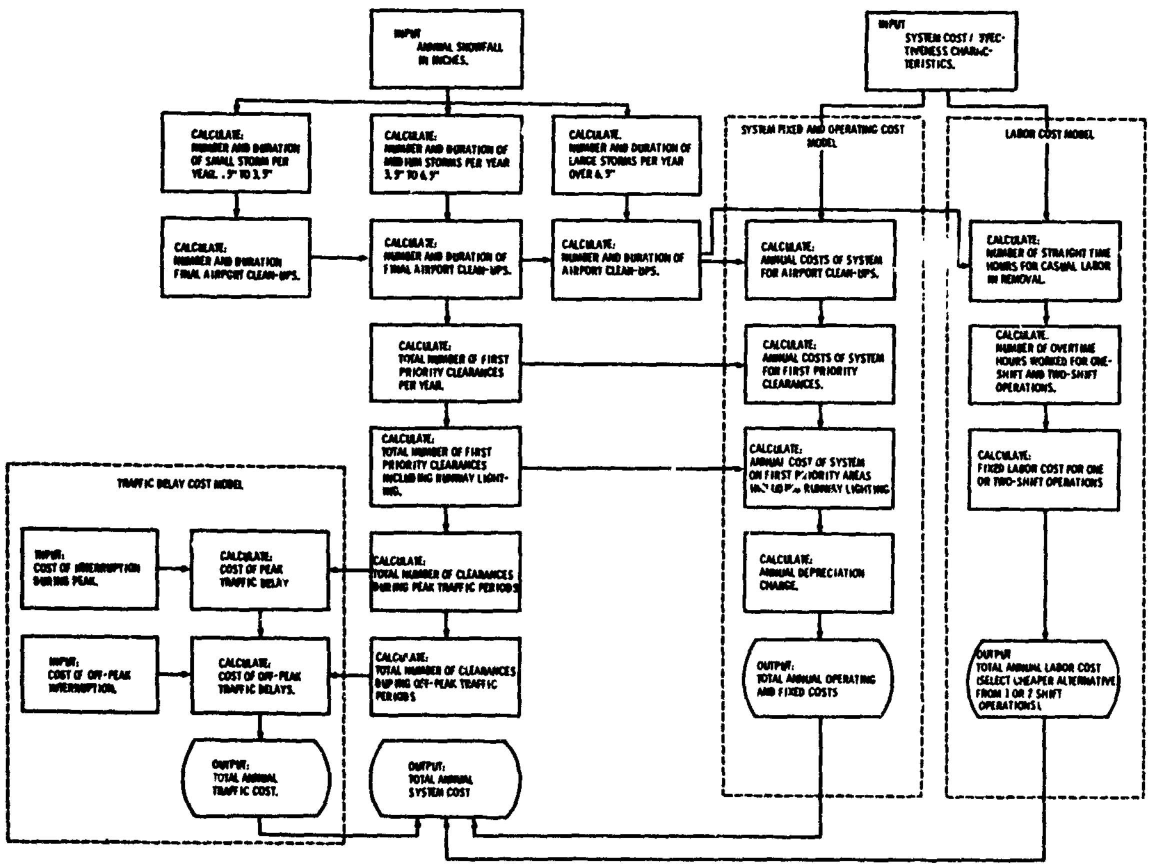


Figure 24. Planning Process Airport Snow Removal and Ice Control.

TREND.

FAA/U.S. Navy negotiated Interagency Agreement for feasibility studies and tests of various arresting systems for elevated STOLports–6/72.

FAA forwarded Request for Proposal to industry to investigate the feasibility of using arresting systems on civil airport runways–3/73.

NAFEC developed firefighting dispensing system using agent–5/73.

FAA forwarded Request for Proposal to industry for development of a rapid response system for firefighting and rescue–12/74.

FAA forwarded Request for Proposal to industry for development of a firefighting and rescue system for elevated STOLports–12/74.

FAA selected and designed aircraft landing system–12/73.

FAA fabricated, tested and evaluated landing system–12/74.

FAA forwarded a Request for Proposal to industry for a feasibility study of thermally deiced/anti-iced runways–4/72.

Contract awarded by FAA to substantiate snow removal planning model–8/72.

Report issued by FAA summarizing results of field tests made by various agencies to evaluate liquid chemical runway deicer/anti-icers–7/72.

SUBPROGRAM.

Airport Safety Support System, 081-731 and 081-790.

SUBPROGRAM MANAGERS.

Herman D'Aulerio, RD-733; R.C. McGuire, RD-733.

PROJECT MANAGER.

G. Geyer, NA-542.

AIRPORT DESIGN AND SURFACE

BACKGROUND.

Recent pavement distress indicates that dynamic stresses may have been underestimated. The continuing increase in aircraft weights and traffic requires the investigation and development of new airfield pavement techniques, materials, and criteria. It is expected that the B-747 and C-5A will be "stretched" resulting in more critical loading and that heavier aircraft, primarily for freight, will come into use during the life of facilities currently being designed.

The purpose of this effort is to:

1. Analyze and validate new pavement materials and techniques to provide necessary criteria for their use. Examples of such new concepts being investigated are: (a) Free draining asphalt runway surfaces that provide a more skid resistant pavement surface under wet conditions, (b) Membrane encased subgrade by sealing off moisture, and (c) Improved design of longitudinal joints in concrete pavement that provides increased strength with a reduction in pavement thickness.

2. Determine significance of dynamic loads on instrument selected pavements (rigid and flexible) on an active airport. Aircraft vertical induced loads and pavement reaction to the moving aircraft will be measured during take-off roll, rotation, landing, etc. Instrumentation will measure pavement, base, subbase and subgrade strains and will be carried to sufficient depth to indicate total pavement reaction.

Concurrent with this investigation, nondestructive testing devices will be correlated with known pavement strength and construction (Figure 25). Also a wheel path distribution study will be conducted. This study is an essential factor in the present design method and has not been verified since the introduction of jet aircraft.

PROGRESS.

An FAA contract awarded for new airport pavement criteria. Prestressed concrete pavement constructed by FAA at Dulles to serve as the access road for Transpo '72. This pavement will be subjected to aircraft type loadings this summer. Traffic tests of several different types of keyed longitudinal joints subjected to C-5A landing gear loads, completed by contractor.

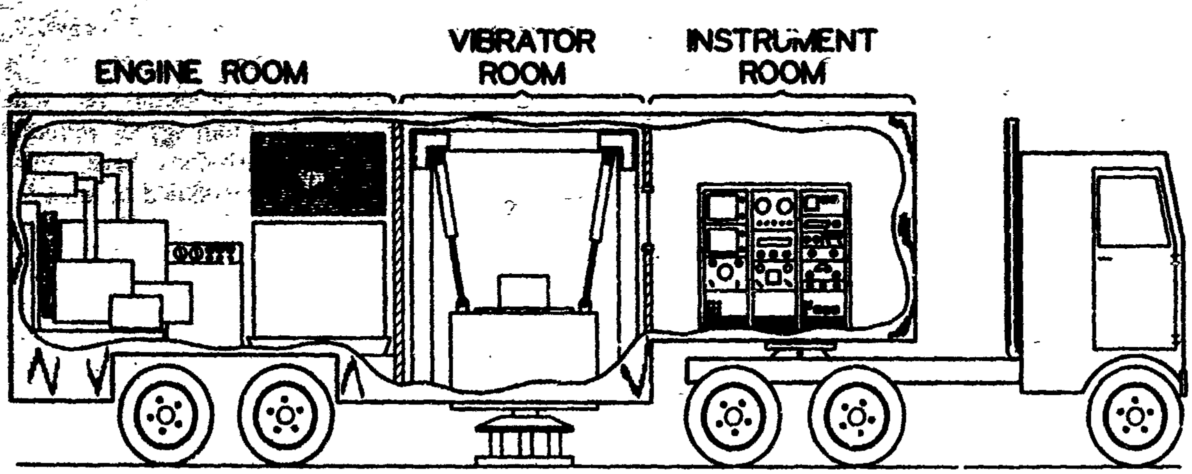


Figure 25. Nondestructive Pavement Testing System.

Planning is in progress for the construction of a free draining asphalt test section and a fibrous reinforced concrete test section at NAFEC.

TREND.

The following major events have been scheduled for completion:

1. Keyed joint draft report for review by contractor–4/72.
2. Dynamic wheel load final report by contractor–1/73.
3. Recommendations to Airports Service by FAA–2/73.
4. New materials and techniques final report by contractor–5/73.
5. Recommendations to Airports Service by FAA–6/71 through 6/73.

SUBPROGRAM.

Airport Design and Surface, 082-120.

MANAGER.

Carl Schulten, RD-161.

PROJECT MANAGER.

A. Segen, NA-523

AIRPORT CAPACITY DETERMINATION AND AIRSIDE CONFIGURATION DESIGN

BACKGROUND.

This effort is responsive to a system requirement, FAAR 5090.2, "Provide a Means for Reducing Airport Congestion," dated 1/10/68; "Air Traffic Control Advisory Committee Report," Volumes I and II dated 12/69; and "R and D Plan to Increase Airport and Airway System Capacity," dated 5/70. The purpose of this effort is to provide airport designers and planners new and improved tools to measure the capacity of airports under a variety of operational and environmental conditions and to show additions or modifications to airport facility layouts that would result in capacity gains. This last goal is particularly desirable in view of the scarcity of new airport sites and in many cases the impossibility of expanding existing airport boundaries.

The major outputs of this effort consist of:

1. Capacity determination models with enough flexibility to measure traffic flow over

the entire airport surface system and to permit the evaluation of contemplated improvements under future operational conditions.

2. Airport capacity determination handbooks that contain a comprehensive listing of typical airport configurations and capacities plus tested design recommendations (Figure 26).

3. An interactive graphics system to simplify and expedite data input and output into the models (1. above).

4. A feasibility/cost benefit study for the development of a real time simulation system distinct from the above in that this system would receive direct human behavior inputs and evaluations from controllers and simulated pilots.

5. Development of a real time simulator based on the above study.

These capabilities will allow indepth assessment of current and proposed airport layouts and ground traffic handling and will provide Airports Service with efficient means to evaluate the benefits of proposed ADAP projects dealing with airport improvement programs.

PROGRESS.

Technical evaluation of proposals received from industry in response to an agency request as well as contract negotiations have been completed by FAA. Work scheduled to start in FY 72.

TREND.

The following major milestones are scheduled for completion by contractor:

1. Capacity model developed–10/72.
2. Handbook No. 1. (current ATC procedures) issued–6/73.
3. Handbook No. 2. (future ATC procedures) issued–12/73.
4. Interactive graphics system delivered–4/74.
5. Real time simulator delivered and commissioned–4/75.

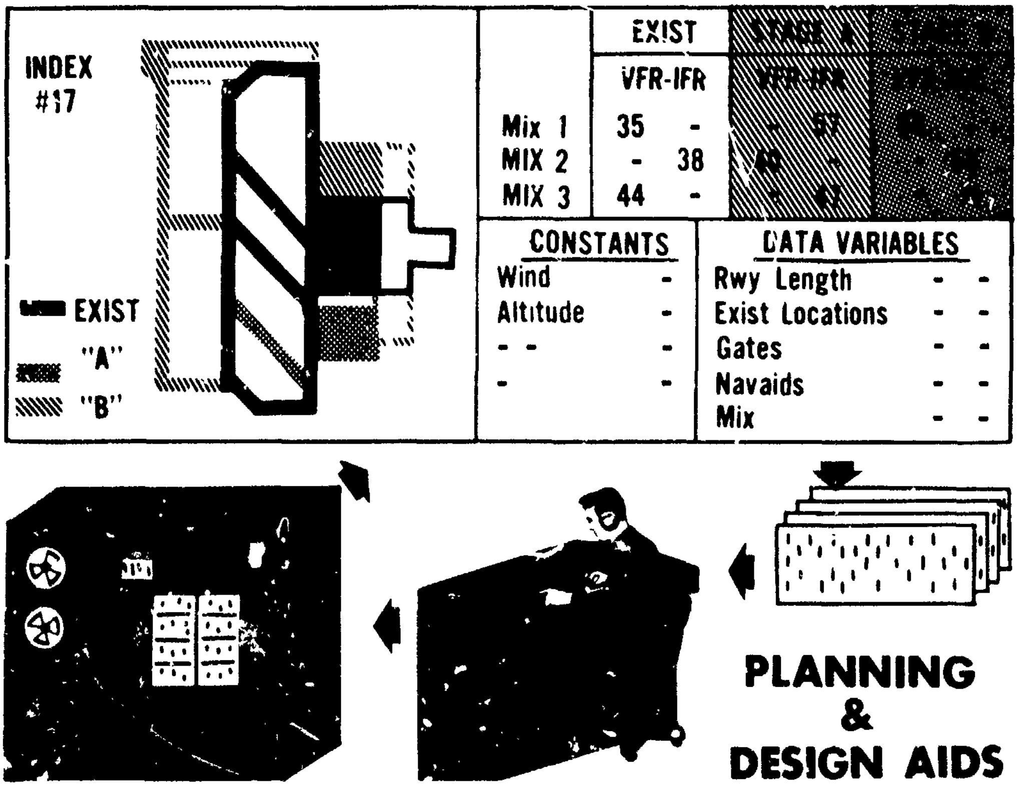


Figure 26. Improved Airport Capacity Determination Technique.

SUBPROGRAM.

Airport Capacity Determination and Airside Configuration Designs, 082-121.

MANAGER.

Roger Pierre, RD-162.

ADVANCED AIRFIELD FACILITY DESIGN

BACKGROUND.

This program is responsive to Airports Service's requested for RD and E Effort (955C 1) AS-560-70-5, 12/22/69; AS-570-71-5, 5/11/71, and P.L. 90-131. The purpose of this effort is to provide means for recovery of disabled aircraft on and in the vicinity of the airport operational area; improve aircraft movement on the apron with improved efficiency; and improve aircraft movement on the airport taxiway system with reduction in air noise pollution.

While the three elements of this project appear to be solving individual problems, they have a common denominator. In each case the aircraft must be moved by other than normal means. Figure 27 shows disabled aircraft recovery using conventional methods. Figure 28 shows one of the proposed methods to be used when serious damage prevents use of gear, and immediate runway clearance is imperative. The work conducted in this project will investigate and catalog the possible alternate ways to move aircraft, up to and including 747, DC-10,

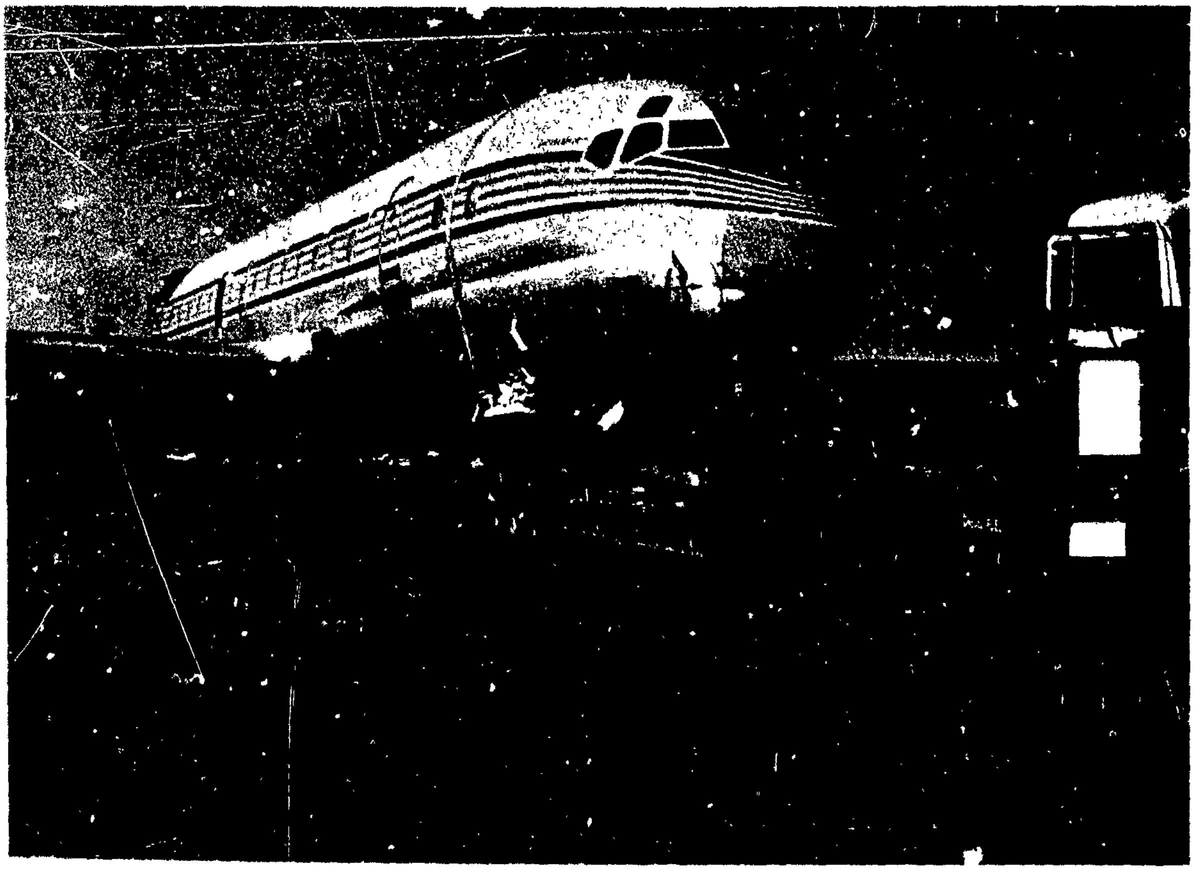


Figure 27. Disabled Aircraft Recovery Using Conventional Methods.

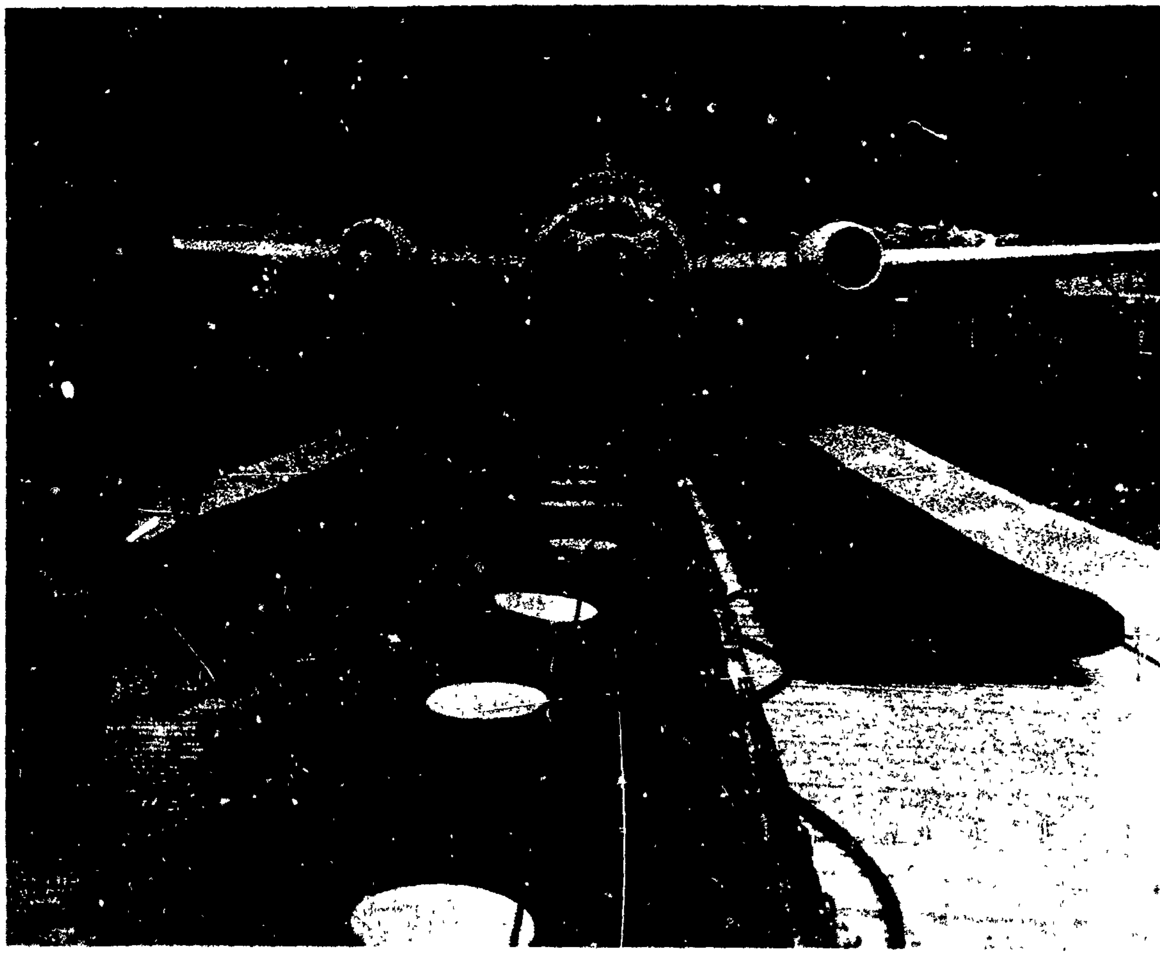


Figure 28. Proposed Methods of Removing Disabled Aircraft From Runway.

L-1011, etc. on the airport surface. It will compare the transporting systems and examine the feasibility of using a single system to accomplish all three objectives, or combinations of any two of them.

Initial designs will be assembled and cost estimates prepared. This information will provide a basis for selection of a system or systems to be used for demonstration. Demonstrations of the latest techniques for recovering disabled aircraft and for moving aircraft on the apron and taxiway using other than prime aircraft power are planned in the final phase of the project.

PROGRESS.

1. A statement of work has been developed which will result in: (a) A feasibility study which defines all systems criteria, (b) Concept definitions, and (c) Development and demonstration of prototype systems.

2. FAA RFP No. WA5R-2-0455 was issued.

TREND.

The following major events are scheduled for completion.

1. FAA awarded contract to determine feasibility and develop concepts to improve operational movement of aircraft on the airport and removal of disabled aircraft–6/72.

2. FAA Contract Phase I including Progress 1a and b above completed–3/73.

3. FAA Contract Phate II development and demonstration completed–2/74.

PROJECT.

System for Transporting Aircraft on the Ground, 082-122-021.

MANAGER.

Carroll Workman, RD-163.

ADVANCED AIRFIELD FACILITY DESIGN DUAL LANE RUNWAY CRITERIA

BACKGROUND.

This effort is responsive to a system requirement. FAAR 5090.2, "Provide a Means for Reducing Airport Congestion," dated 10/1/68; and the "Research and Development Program to Increase Airport/Airway Capacity," dated 23/10/70. Dual lane runways have long been recognized as a means of substantially increasing airfield capacity with a relatively small addition of land. However, the full benefit of this concept has not been achieved because detailed system studies have not been undertaken either to optimize the airfield concrete, i.e., the airfield configuration, or to develop or tailor the ATC rules to promote maximum through put of aircraft. The purpose of this effort is to develop optimum airfield configuration criteria, operational procedures, and capacity estimates based on aircraft mix, configuration features, and ATC procedure parameters.

The primary objective of this program is to increase capacity by specifying the geometry which will allow a decrease of the arrival/departure intervals. A secondary objective is to reduce acreage requirements for runways. In this regard, this program will determine the minimum centerline spacing for dual lane runways serving "heavy jet" traffic.

In determining optimum system configuration, features such as high speed exits, parallel taxiways, staggered threshholds, and holding areas will be simulated to determine the sensitivity of their impact on capacity and operational procedures. In addition, field problems and proposed solutions will be analyzed. A full scale demonstration facility using the geometry resulting from simulated configurations will be constructed at an existing airfield and evaluated to provide concept validation and performance data. Airports Service, Air Traffic Service, and Flight Standards Service will assist in the project guidance and the selection of the final dual lane runway criteria and demonstration site. In addition, liaison with the user pilot community to ensure acceptability will be carried out.

The current criteria for dual lane runway centerline spacing and operational procedures will be reviewed and recommendations made so that they may be revised to account for the new generation of "wide body" aircraft to provide some operational guidelines and capacity increase predictions. The new criteria and information will also provide some basis for making tradeoff decisions during application to specific airports, showing the limits of adjustment and probable impact on operations.

PROGRESS.

An Interagency Agreement between the FAA and USAF has been entered into to fund the TX-2 interactive simulation facility at Lincoln Laboratory. This facility is used to simulate airfield configurations and control procedures. Outputs will become the basis for selection of a configuration for field evaluation. Program logic for generation of arrival and departure operations, runway/taxiway map generation and editing, response to controller commands, aircraft dynamics, and analysis of results has been developed and is running.

The system as now developed can run at real time or fast time. Figure 29 depicts the operation of the interactive simulator. ATC inputs are provided by entering symbolic instructions via a light pen and keyboard. The line at the top of the screen is an extension of the arrival runway centerline. The numbers at the bottom of the screen are identification and dynamic parameters for a queried aircraft.

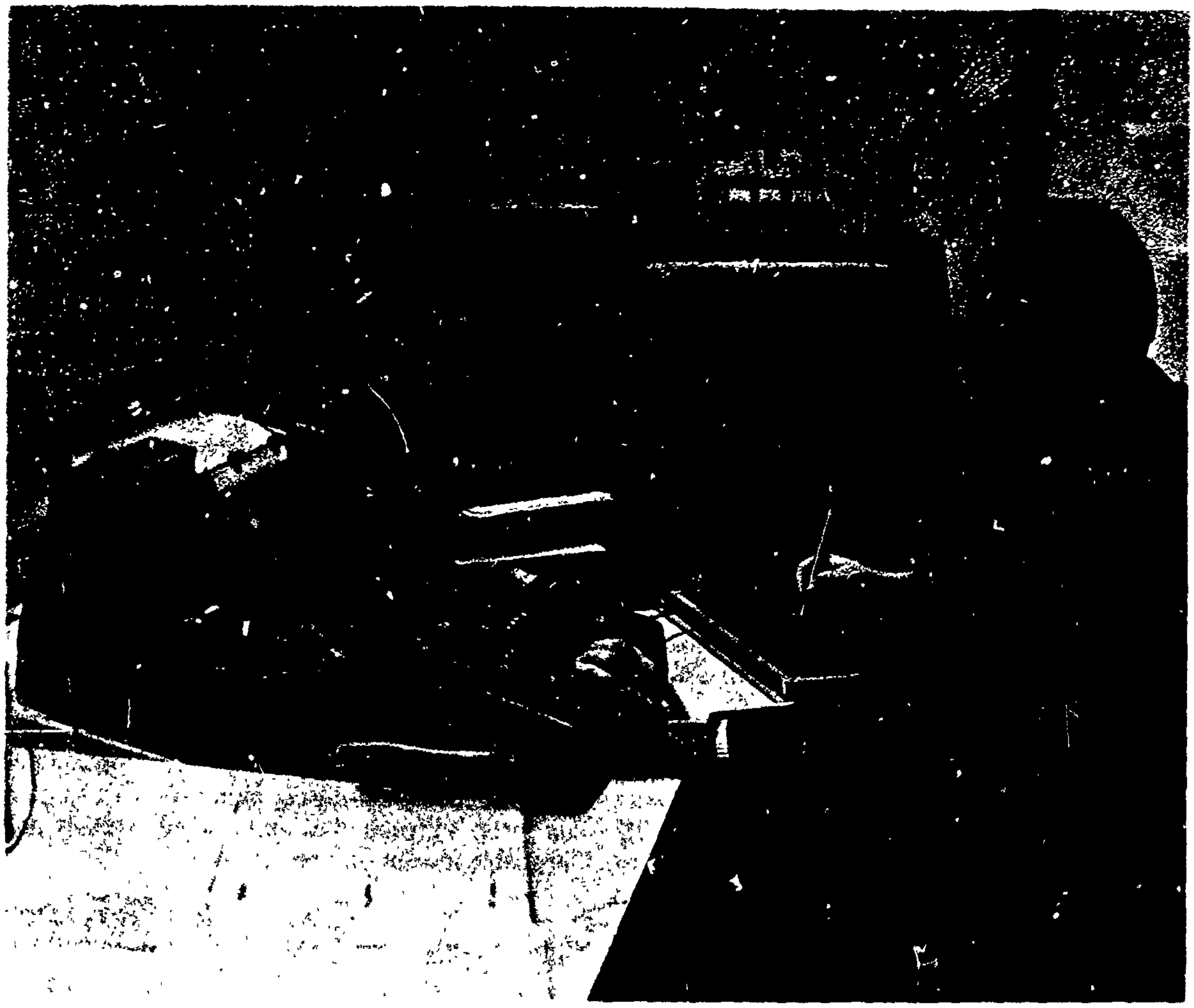


Figure 29. Operation of Interactive Simulator.

TREND.

The following major milestones are scheduled for completion:

1. Preliminary spacing and configuration recommendations completed–3/72.
2. Test site selected–6/73.
3. Test bed established–6/73.
4. Demonstration completed–12/73.

PROJECT.

Dual Lane Runway Criteria, 082-122-041.

MANAGER.

Jack Clark, RD-162.

AIRPORT BLINDSPOT GROUND SURVEILLANCE FOR PROBLEM SITUATIONS

BACKGROUND.

The purpose of this effort is to determine the feasibility, reliability, and modular capability of using sensing devices to detect and display surface traffic in areas that are blind to the controller in the tower. It is responsive to FAAR 5355.1 and 9550-1 Request, AT-100-14, dated 7/4/68.

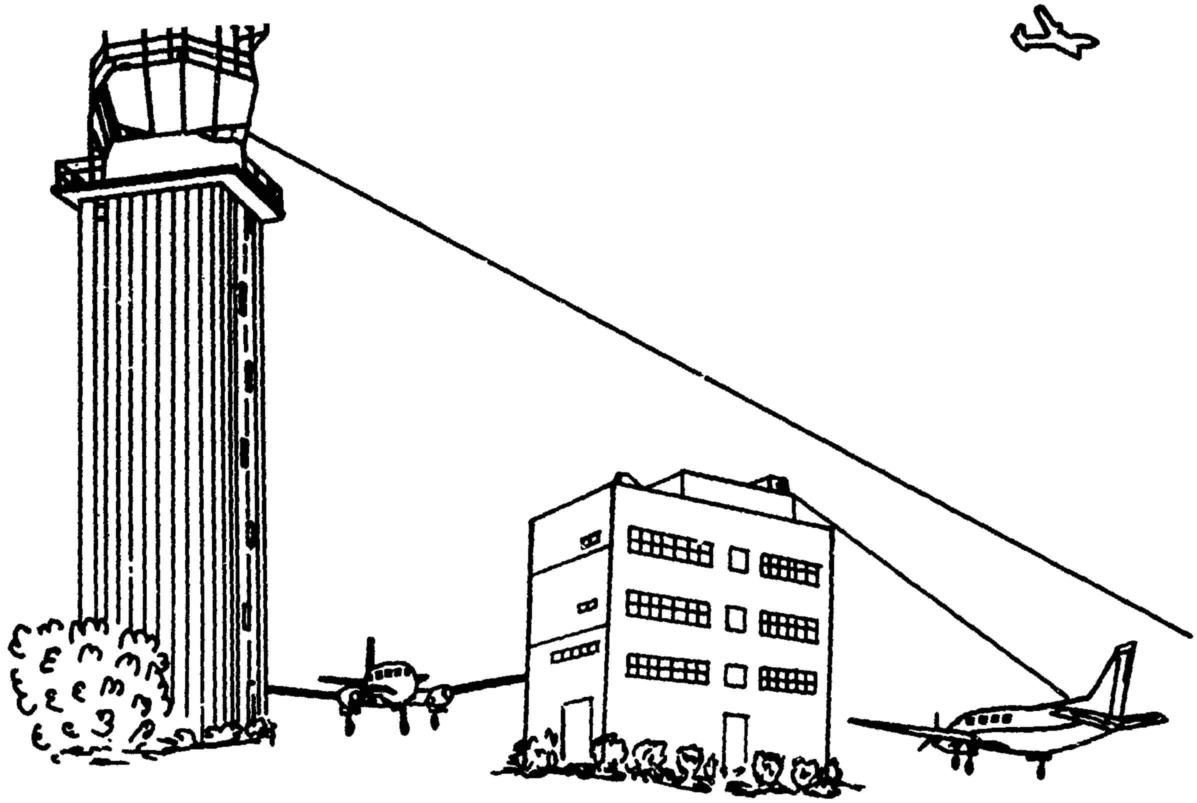


Figure 30. Airport Blindspot Surveillance.

There are areas at airports that are not visible to tower controllers, as shown in Figure 30. As the airport congestion and building expansion programs progress at airports, this problem will become acute and further complicate ground control of aircraft. The addition of Closed Circuit Television (CCTV) systems for extending the viewing areas of controllers will alleviate the problem if a versatile system can be emplaced. The problem is in the varying light conditions expected from aircraft and vehicular traffic at night time, and not solely in the lower light level. The problem of "flashes" of high intensity lights from warning lights, running lights, or turning traffic presents a requirement for shut-down of the camera to prevent damage to the imaging device. In any event, the typical vidicon when exposed to landing lights will bloom, cause severe halation, and require several seconds to recover.

Improvements required to successfully utilize the inherent benefits of CCTV are:

1. A semiportable site survey CCTV system and development of techniques to optimize CCTV capability. Basic characteristics in this semiportable site survey system would be:

a. TV camera with variable focal length lens.

b. Video recorder with programmable sequencer, i.e., cuing capability.

c. Playback monitor compatible with the normal tower controller environment.

2. Techniques that resolve CCTV problems encountered by tower controllers such as:

a. Depth perception limitations inherent in a two dimensional display.

b. Controller orientation in viewing a CCTV monitor to enhance the effect that the tower controller's line-of-sight is extended.

3. High resolution TV camera with day/night compatible characteristics, i.e., does not exhibit blooming or halation characteristics.

4. Control tower environment compatible CCTV monitor, or

5. Interface and switching hardware for operator's selective control and viewing on the BRITE system.

An earlier phase resulted in issuance of Handbook 6171.1, "Closed Circuit Television for Airport Blindspot Surveillance Equipment Establishment Guidelines." This Handbook, issued in November 1968, described interim guideline procedures for use of off-the-shelf CCTV components. In addition, it describes some of the inherent limitations of these CCTV components, e.g., daytime only.

PROGRESS.

Tests were made during July 1970 and August 1971 on off-the-shelf low light level CCTV cameras supplied for FAA tests at no cost to the Government by Westinghouse, Texas Instruments, Sylvania, Singer GPL, and Impossible Electronic Techniques. The cameras furnished for the tests used secondary emission conduction (SEC) vidicon, silicon target vidicon and conventional vidicons with image intensification, automatic iris, automatic gain control and automatic zoom. The tests indicated a distinct improvement over the previously tested off-the-shelf conventional CCTV cameras when used for night-time surveillance of taxiing aircraft. However, the problems of blooming due to landing lights, reflections due to polished lens systems and inadequate day/night dynamic automatic control of output indicates a need for further improvements. Some of the aforementioned camera manufacturers are working on improving their cameras to overcome these deficiencies and are planning to submit their cameras for retesting.

TREND.

The following major milestones are scheduled for completion:

A field evaluation of basic system and assessment of usefulness of off-the-shelf CCTV hardware for blind spot surveillance–11/72.

NAFEC to test commercially available state-of-the-art improvements in the following areas for inclusion into a day/night surveillance system: Improved TV camera tubes, low cost remoting, and an integrated radar/CCTV tower cab display system–CY 72.

NAFEC acquisition of data for updating Handbook 6171.1 to cover a day/night all weather CCTV surveillance system–3/73.

SUBPROGRAM.

Airport Blindspot Ground Surveillance for Problem Situation, 083-123.

MANAGERS.

L.R. Sneiderman, RD-131 and Robert C. Conway, RD-151.

PROJECT MANAGER.

A.V. Lolli–NA-532.

09 LANDSIDE PROGRAM

GOAL.

The purpose of the Landside Program is to conduct: (1) studies of the operational characteristics of the Landside system and subsystems, (2) analyses in order to establish fundamental measurement parameters and points which would yield a measure of service quality to individual units (passenger, cargo parcels, and aircraft), (3) sensitivity analyses to determine critical points yielding large service improvements, and (4) techniques to improve performance at these points or eliminate these points by decentralization, i.e., off-airport consolidation, and (5) demonstrations of improved concepts.

SCOPE.

This engineering and development effort is organized under a single Program Element–091–Terminal/Cargo/Passenger and is included in the FY 72 Technical Program in subprogram 091-601, Landside Terminal Area Design Studies.

10 OCEANIC PROGRAM

GOAL.

The purpose of the Oceanic Program is to conduct engineering and development to upgrade the oceanic ATC system. It includes, developing an automated oceanic ATC system capable of accepting present day communication inputs; expanding the automated oceanic ATC system to provide a pre-operational oceanic satellite service; developing technical characteristics for and implementing the preoperational oceanic satellite system; and determining use of the satellite system in oceanic ATC.

SCOPE.

These engineering and development efforts are organized under two Program Elements: 101–Aerosat and 102–Automation.

In the FY 72 Technical Program, engineering and development efforts include:

101-140 Integration, Subprogram Manager, C. Jones, RD-140.

101-141 Space Segment, D. Spokley, RD-140.

101-142 Ground Segment, F. Carr, RD-140.

101-231 Avionics–Automatic Position Reporting by Data Link,* Thomas Williamson, RD-232.

102-140 Oceanic ATC System,* L. Douglas, RD-150.

102-141 Oceanic-Domestic System Interface, G. Kassing, RD-130.

102-142 Advanced Oceanic Automation, P. DeCara, RD-130.

102-601 Oceanic System Analysis and Design, Chet Dunmire, RD-620.

The following major selected* subprogram is highlighted in terms of Background, Progress, and Trend (major events scheduled for completion):

AVIONICS-AUTOMATIC POSITION REPORTING BY DATA LINK

BACKGROUND.

During the second half of CY 70 and the first quarter of CY 71, a joint U.S. Government-industry sponsored program was conducted to demonstrate the feasibility of enhancing the safety and efficiency of oceanic air traffic control by demonstrating automatic position reporting by data link in the oceanic area. This effort was responsive to 9550.1 request, AT-100-16, for R, D&E, 19/5/69.

The following items were investigated during the demonstration:

1. Techniques to selectively and automatically track and display air traffic information (identification, position, altitude, and any other information which may be considered pertinent to the operation) on a Cathode Ray Tube (CRT) or situation display large enough for two or more people to view.

2. Potential for the reduction of flight data, controller workload, pilot workload, and for increasing the speed, accuracy, and efficiency of depicting flight control operations.

3. Expansion capabilities for meeting future requirements.

4. Reliability of the equipment.

5. Airborne and ground equipment requirements for use of a data link communication system for automatic position reporting.

The Air Route Traffic Control Center (ARTCC) at Oakland was chosen as a suitable environment for the investigation and demonstration effort. Some of the more important reasons for choosing the Oakland center were:

1. Aeronautical Radio, Inc. (ARINC), has an extended-range VHF communication site near San Francisco equipped for data link operations and agreed to furnish data link signals to the Oakland Center for the demonstration.

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2. The first data link-equipped planes for an independent test to be conducted by the airlines were scheduled to fly in the Pacific environment.

3. The Oakland Center oceanic ATC environment covers a large geographic area containing both fixed route and random route air traffic.

4. Personnel at the Oakland Center expressed a keen interest in providing the oceanic controllers with a pictorial-type display. The display system is shown in Figure 31.

EVALUATION RESULTS.

1. The joint U.S. Government-industry experimentation has revealed that automatic position reporting via data link is feasible and represents a vast improvement over the present manual position reporting technique used in the oceanic areas.

2. The data link system is compatible with the FAA's present and future plans for controlling air traffic in the oceanic and non-radar domestic areas. The data link system that was utilized in the experiment is applicable to satellite systems, VHF extended-range (tropospheric scatter) and VHF line-of-sight systems. The display system operated on either manual or automatic inputs.

3. The data link combined with an acceptable display system demonstrated the potential to

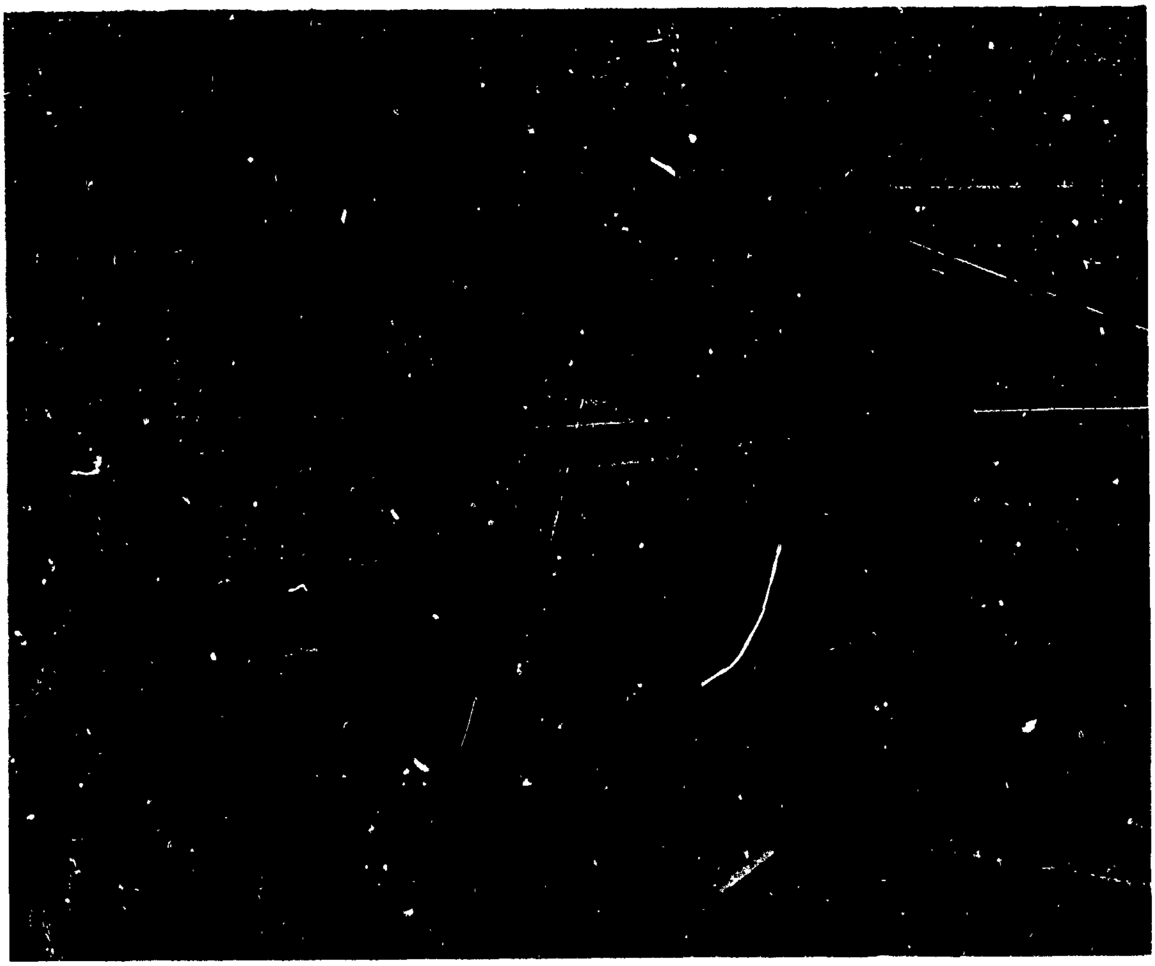

Figure 31. Pictorial-Type Display System.

reduce significantly the routine workload of both the controller and pilot.

4. The data link system demonstrated the capability to enhance flight safety by introducing essentially continuous automatic flight following in the oceanic area.

PROGRESS.

NAFEC Operational and Engineering evaluation completed–7/71.

TREND.

The following major event is scheduled for completion:

SRDS Final Report "Feasibility Study and Demonstration and Automatic Position Reporting Via Data Link" submitted to the Air Traffic Service–5/72.

SUBPROGRAM.

Avionics (Automatic Position Reporting By Data Link), 1, I, 101-231.

MANAGER.

Thomas Williamson, RD-232.

PROJECT MANAGER.

Fred Schneider, NA-531.

OCEANIC ATC DEVELOPMENT

BACKGROUND.

An experimental Oceanic ATC field system is currently undergoing an operational and engineering evaluation at the Oakland Air Route Traffic Control Center (ARTCC). This system is being used as a test vehicle to develop and demonstrate automation capabilities for oceanic sectors and to provide inputs for future system design definitions. The experimental system is composed of airborne terminals, a ground communication/processing terminal, and a processing/display terminal.

The airborne terminals for data link equipped aircraft consist of commercial aircraft equipped with Inertial Navigation Systems (INS) developed in conformance with Aeronautical Radio Incorporated (ARINC) Characteristic 561. The latitude and longitudinal position information of the INS is formatted by experimental airborne data link equipment and transmitted every 32 seconds, after interrogation by the ground station, along with altitude information from the Subsonic Air Data Computer and aircraft identification.

The ground communications and processing terminal is furnished by ARINC facilities in the San Francisco area. The positional information message sent via data link, as mentioned above, is received at the ARINC communication facility and forwarded to the Oakland ARTCC via telephone line for further processing. For non-data link equipped aircraft progress (position) report information is received at ARINC via voice. Progress report information received this way may be entered into the processing/display terminal at the Oakland ARTCC via one of two methods. It is either entered through teletype input from the San Francisco ARINC facility and forwarded via telephone line directly to the processing/display terminal at the Oakland ARTCC for further processing or it is forwarded to the Oakland ARTCC via voice and entered through teletype input at the ARTCC. A schematic of the system terminals is shown in Figure 32.

The processing/display terminal consists of a programmable memory unit, two CRT displays, a teletypewriter which serves as an input-output device, a function keyboard, and a lightpen. As depicted in Figure 33, one of the CRT displays is used as a situation display to show a graphic picture of aircraft positions, identities, and movements while the other CRT is used as a tabular display to show flight plans and flight progress data. The function keyboard and lightpen provide a wide range of display selectivity while the teletypewriter, an ASR-35, provides a means of inputting aircraft flight plans and

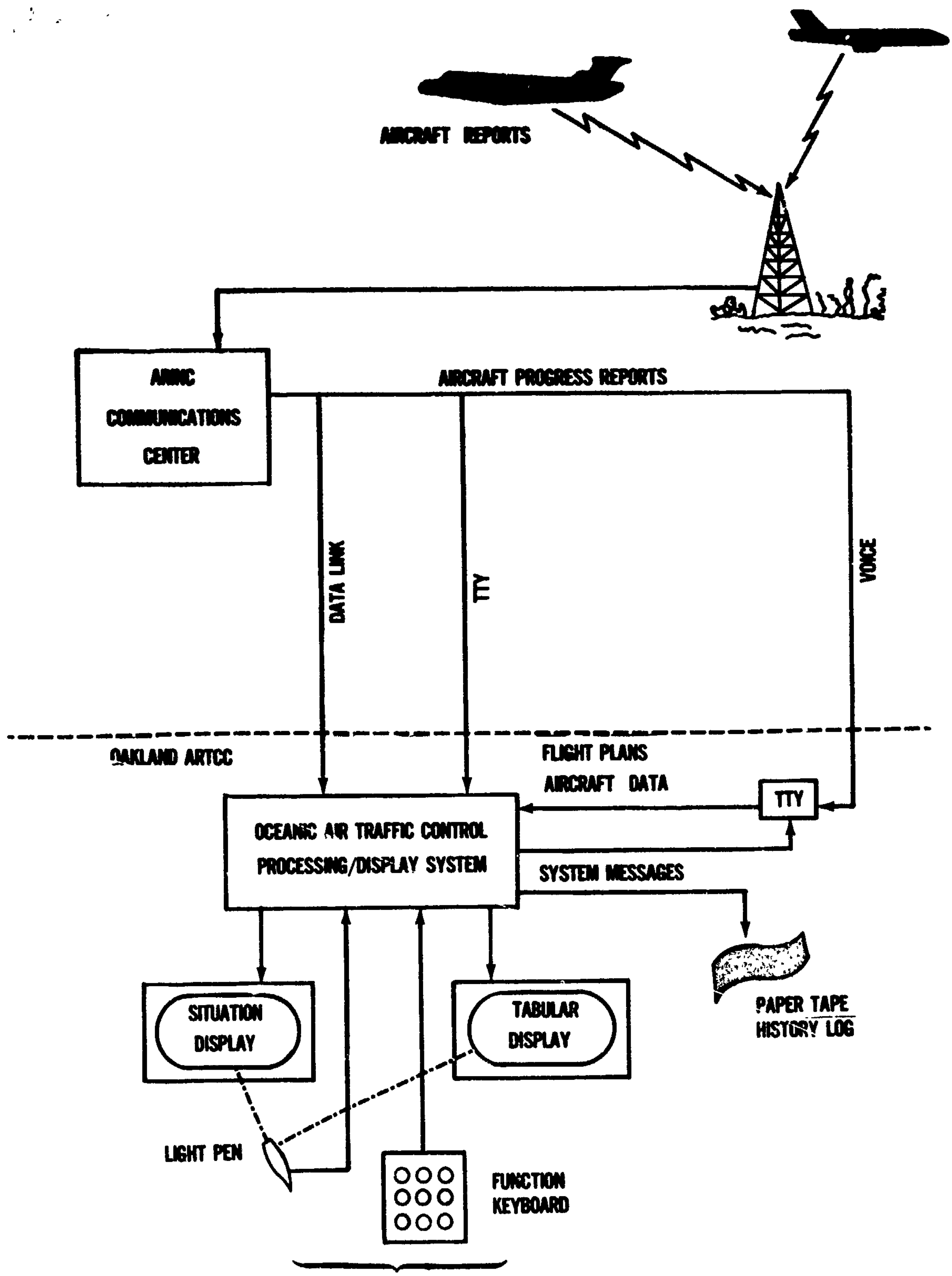

Figure 32. Schematic of System Terminals.

Figure 33. Situation and Tabular Displays.

movement messages in addition to receiving error messages, summary data, etc.

Various background mapping may be selected by the operator for depiction on the situation display. By using the function keyboard and lightpen temporary fixes, routes, and boundaries may be added in addition to varying the geo graphical area of coverage. Data link aircraft target symbology appears on the situation display as a diamond whereas non-data link aircraft target symbology appears as a rectangle. Associated with each is a velocity vector and a data block. The velocity vector indicates the direction of flight of the aircraft and its estimated progress within the succeeding 5, 10, 20, or 40 minute interval as called for by the operator. If the reported altitude differs by more than 500 feet from the assigned altitude on data link equipped aircraft, the reported altitude also will be displayed. To display the position and movement of aircraft not equipped for data link relay flight plan information in the system is activated by inputting a time at a reporting fix. Stored wind aloft information then is applied and target positions are updated at two minute intervals. When routine position (progress) reports received via voice are input to the system the target position is automatically updated to reflect the reported location of the aircraft.

Additional features of the situation display include alerts such as a blinking (1) LATE to indicate that a required progress report is overdue, (2) HAND to indicate that an aircraft is approaching a jurisdictional boundary and that information should be passed to an adjacent sector or facility, (3) CONFLICT to warn of a possible loss of standard separation minimum between aircraft, and (4) V to indicate information in a progress report exceeds established acceptable parameters for position reports, fix times, or altitude. The filed aircraft flight plans route projection can be displayed in solid line format on the situation display by request. In the event two projected routes will cross, a readout of the time each aircraft is estimated to be at the point of crossing can be made. The operator may choose to display only specific aircraft by use of route and/or altitude filtering capabilities.

The tabular display is used to present complete flight plan information or last reported fix data within the selected geographic area and altitudes requested. Last reported fix data is presented in columnar groupings of:

1. The identity of each aircraft.
2. The last reported position (fix) shown in latitude/longitude or by designated fix name.
3. The time the aircraft was over the fix (ATA).
4. The altitude–actual when reported via data link.
5. The identity of the next reporting fix.
6. The computer estimate at the next fix.
7. The pilot estimate at the next fix.
8. Ground speed, continually updated.
9. The present aircraft position in latitude and longitude.

All of the alerts also appear near the top of the tabular display providing the operator with last reported fix information.

PROGRESS.

1. SRDS concept feasibility study completed–5/71.
2. Final Report RD-71-38 Evaluation of Flight Plan Position Information Display for Oceanic Control issued.
3. FAA contract awarded to META Systems, Inc. for experimental oceanic air traffic control software improvements.
4. FAA contract awarded to META Systems, Inc. for oceanic ATC development software improvements.
5. Information survey on Oceanic ATC Facilities completed.
6. FAA contract awarded for Large Screen Display.
7. Technical Development Plan for Oceanic ATC automation completed–3/72.

TREND.

The following milestone is scheduled for completion:

Large Screen Display Test and Evaluation for Oceanic ATC application completed–1/73.

SUBPROGRAM.

Oceanic ATC Development, I, 102-140

MANAGER.

Lauren N. Douglass, Jr., RD-152.

PROJECT MANAGER.

A. Spingola, NA-550.

11 FLOW CONTROL PROGRAM

GOAL.

The purpose of Flow Control Program is to develop a centralized flow control capability which controls and coordinates national air traffic flow. Central Flow Control and Associated Support functions will be provided from the ATC System Command Center (ATCSCC) at FAA Headquarters, Washington, D.C.

SCOPE.

This engineering and development effort is organized under one Program Element: 111–Flow Control-System Improvement. It includes the computers, software, displays, data entry devices, facility layouts and communication interfaces required to assist in the central flow control. Central Flow Control functions to be considered for inclusion are: automatic processing and storage of high density airport reservations, dynamic adjustment of departure release times for aircraft destined to high density airports, rerouting for load balancing and avoidance of problem areas, i.e., hazardous weather, radar failures, etc., enroute slowdown commands to adjust to expected terminal area delays and automatic interface with other ATC facilities.

In the FY 72 Technical Program, the Flow Control Program includes single subprogram: 111-160–Flow Control-System Improvement, Subprogram Manager, T. Armour, RD-152.

This subprogram is highlighted in terms of Background, Progress, and Trend (major milestones scheduled for completion):

FLOW CONTROL – SYSTEM IMPROVEMENT

BACKGROUND.

The existing capability to perform flow control enroute and at terminals is currently being performed with little automation support. The present Central Flow Control Facility (CF^2) operated by the Air Traffic Service (AT 370) is hampered by a lack of data on the ATC system state and the impending traffic demand.

The purpose of this program is to provide the research and development efforts necessary for automation of the required functions of a totally automated enroute/terminal control environment. It includes development of the advanced planning and flow control enroute system functions.

This activity includes development of an advance flow regulation method that will minimize airborne delays while meeting the traffic demands on the airways system. The advanced planning function will be designed to adjust the flow of traffic in accordance with terminal and airway load capabilities. This includes monitoring of traffic densities throughout the ATC system and the utilization of flow regulation procedures to be instituted when densities approach pre-established threshholds. The planning function will vary the density threshhold whenever restrictions to capacity occur such as severe weather occupying portions of the airspace or changes in terminal area acceptance and departure rates. The initial effort will be directed towards automation of the functions performed by the present Central Flow Control Facility (CFCF). Figure 33-1 presents the scope of the ATS Central Flow Control Automation effort.

Beginning with a basic terminal flow control model, the plan is to upgrade the capability as follows:

1. Expand the terminal flow control model to provide high density airport demand/capacity prediction and allocation.
2. Add an automated enroute flow control capability.
3. Integrate the terminal and enroute flow control functions into a unified flow control system.

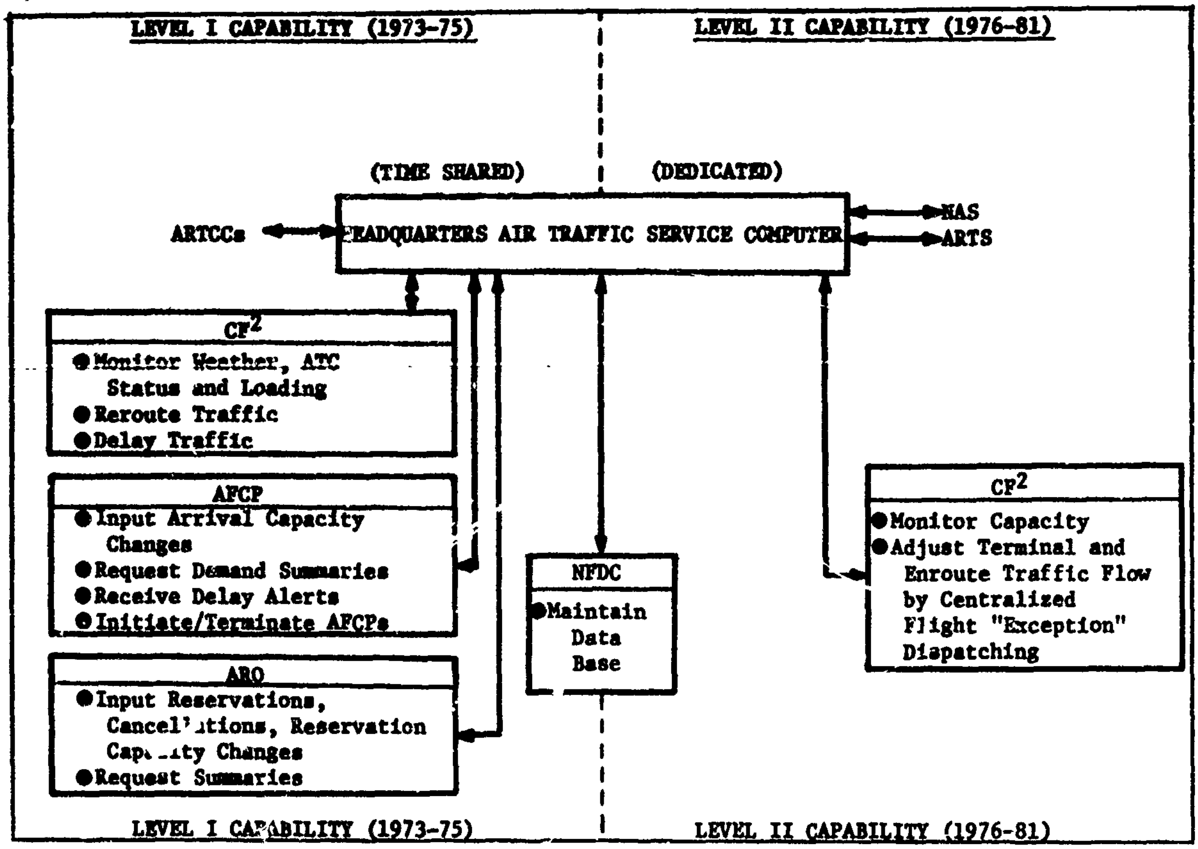

Figure 33-1. Scope of Headquarters ATS Automation.

4. Interface the central flow control facility with the NAS and ARTS air traffic control facilities to provide a unified automated system.

BENEFITS.

Improvement of the existing Flow Control Facility and its related functions is expected to make several contributions to efficiency and savings in the operations of the national airspace system. Dollar savings to airlines and time savings to passengers due to reduced in-flight delays will be significant. For example, it has been estimated that the airlines lost $158M in 1969 due to terminal delays alone. An effective capability to predict and avert even a part of this delay and disruption should produce significant savings.

In addition, the FAA will benefit by having improved information and control during emergency situations, and expanded availability of operational data for system management. Smoothing of local traffic may permit lower levels of future ATC manning.

These benefits, although not quantifiable with any accuracy for future years, do appear to offer savings an order of magnitude greater than the development and operation costs of the control system described in this plan. The total development cost of all the stages of capability through Level II is estimated at about $11.6 million, and the annual operation cost is expected to be about $4 million.

PROGRESS.

A Technical Program Plan has been produced that defines the functions to be automated, the necessary computer hardware and software, the costs that will be incurred, and a schedule for implementation. The plan was developed by a task force of members of the following organization:

1 Office of Systems Engineering Management.

2. The Systems Research and Development Service (SRDS).

3. The National Airspace System Project Office (NASPO).

4. The MITRE Corporation.

TSC has developed a prototype terminal flow control model, utilizing time shared software service, which is being used in the Central Flow Control facility. It is expected that the Advanced Flow Control Procedures for the New York high density airports will be incorporated into this model by the end of FY 72.

A procurement has been initiated for a software contractor to develop the required computer programs for the Central Flow Control facility as described in the Terminal Program Plan issued in August 1971.

TREND.

The following milestones are scheduled for completion:

1. Contract awarded for CF^2 prototype development and evaluation. (Interim Effort)–FY 72.

2. Contract awarded for development of algorithms and software to provide an integrated experimental CF^2 system and experiments conducted to evaluate (quantitatively) Level I software–FY 73 and 74.

3. Contract awarded for procurement, and installation of central flow control facility hardware and software for integrated system (Level II effort)–FY 75 and 76.

SUBPROGRAM.

Flow Control–System Improvement, I, 111-160.

MANAGER.

T. Armour, RD-152.

12 ENROUTE CONTROL PROGRAM

GOAL.

The purpose of the Enroute Control Program is to improve modernize and develop enroute ATC facilities and functions (hardware and software) to reduce the workload of air traffic controllers. It includes development of higher levels of automation in order to enhance controller performance and productivity and safety.

SCOPE.

This program is organized under three Program Elements: 121-Deployment and Implementation Support (NASPO); 122-Experimentation and Development (SRDS/NAFEC); 124–Sustaining Engineering (SRDS/NAFEC).

The engineering and development effort includes computers, software, displays, data entry, devices, facility layouts, new procedures, system testing and implementation support. The FAA National Airspace System Program Office (NASPO) provides engineering support to this program.

In the FY 72 Technical Program, engineering and development efforts include:

121-xxx Deployment and Implementation Support,* Program Manager, Spencer S. Hunn–NS-1.

122-161 NAS Stage A Expansion, Richard Haskin, RD-121.

122-162 Configuration and Procedures, Paul Peterson, RD-152.

122-163 Electronic Tabular Display, John Edgbert, RD-130.

122-164 NAS Conflict Control, J.J. Adair, RD-123.

122-166 Enroute Data Recording, John Egbert, RD-130.

124-160 Enroute Sustaining Engineering, R. C. Conway, RD-151 and R.W. Granville, RD-133.

The following major effort* is highlighted in terms of Background, Progress, and Trend (milestones scheduled for completion):

DEPLOYMENT AND IMPLEMENTATION SUPPORT
NAS ENROUTE STAGE A

BACKGROUND.

The FAA National Airspace System Program Office (NASPO) is implementing the National Airspace System (NAS) Enroute Stage A Program to automatic Air Route Traffic Control Centers (ARTCCs) within the 48 states. This effort is directed by the highest level of the agency and is in accordance with DOT/FAA Order 1800.27, "System Program Plan Enroute Automation."

The Air Traffic Control Automation Program for the enroute and terminal facilities evolved to meet the needs of continuing an air traffic growth. When completed, this program will provide a Flight Data Processing (FDP) and a Radar Data Processing (RDP) Capability at 20 centers and the necessary interface with automated terminal facilities where automation is warranted by traffic density. As an example of IFR aircraft operations at centers, growth in 1960 FAA ARTCC's handled 9.4 million IFR aircraft operations annually and by 1971 this figure had risen to 21.6 million. A slight decrease in the number of operations occurred in 1971 because of slowdown of the economy. However, forecasts indicate that 42.5 million aircraft operations are expected (by FAA centers) by 1981. This automated system has been designed to handle efficiently the expanding forecasted air traffic growth, will enhance safety of the existing air traffic control system, reduce pilot and controller workload.

The NAS Enroute Stage A program when completed (CY 74) will resolve some major problems of the current manual air traffic

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control system. The current system relies heavily on the skill and dedication of air traffic controllers, who use radar for aircraft surveillance, sequency, and voice for communicating with pilots. The NAS Enroute Stage A system will eliminate the lack of precise, automatic, and clear information in the aircraft or on the ground. It will reduce greatly human intervention that results in heavy workloads both in the cockpit and the control centers.

In the NAS Stage A system, primary and secondary radar data are processed in digital form at the radar sites and transmitted to the enroute center where it is fed into the central computer complex for further processing. A computer program correlates the radar returns with flight plan data and feeds them to the display channel which processes and formats the final presentation on the controller's display. The NAS Stage A system is illustrated in Figure 34.

FAA is introducing the NAS Enroute Stage A System in two phases. Phase I provides an automated capability to perform flight data processing. Phase II adds radar data processing. The flight data processing phase is further divided into implementation steps compatible with equipment availability and the requirements for training and proficiency development. There are 16 ARTCC's that have a flight data processing capability. A current status map of the NAS Flight Data Processing Operational Program is provided in Figure 35.

Jacksonville NAS Enroute Stage A Model 1b—Jacksonville was the first field installation of a NAS Enroute Stage A System. This center utilizes a Stage A Central Computer Complex with interim prototype display hardware that differs from that being procured for the national system. Jacksonville is operationally using a Model 1 Flight Data Processing Computer Program complemented with a high altitude beacon

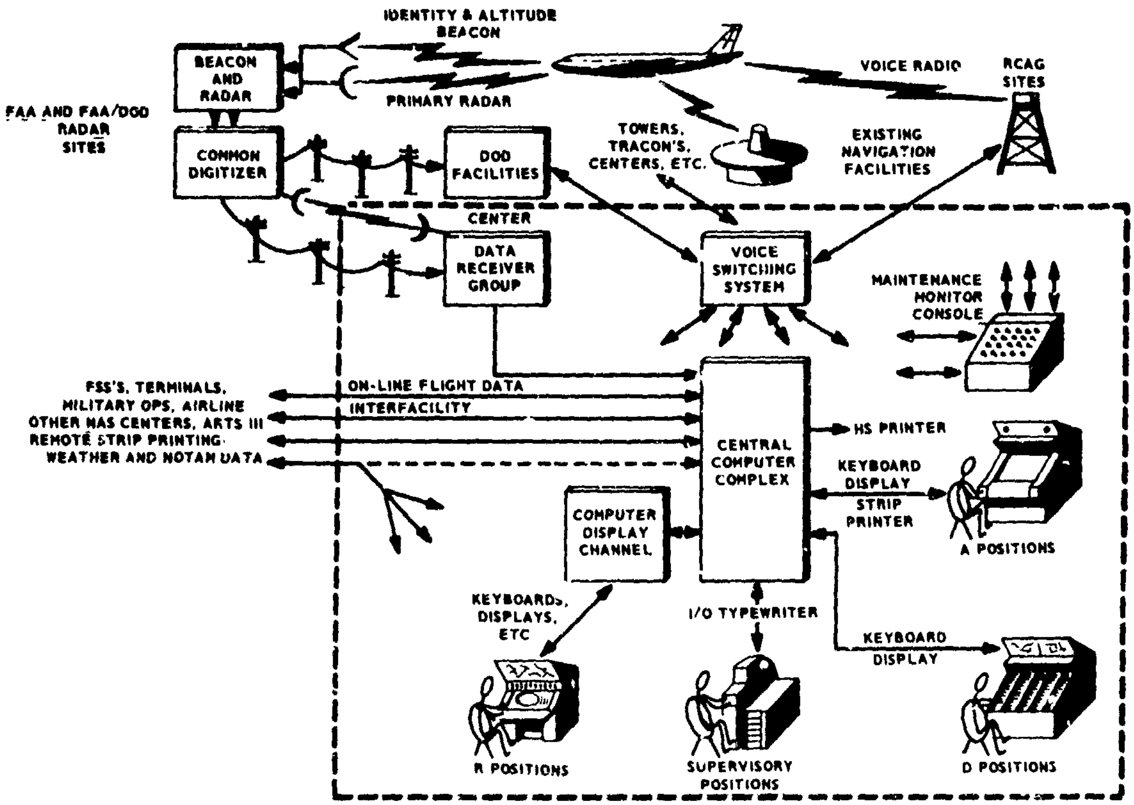

Figure 34. Enroute Stage a System Pictorial Diagram.

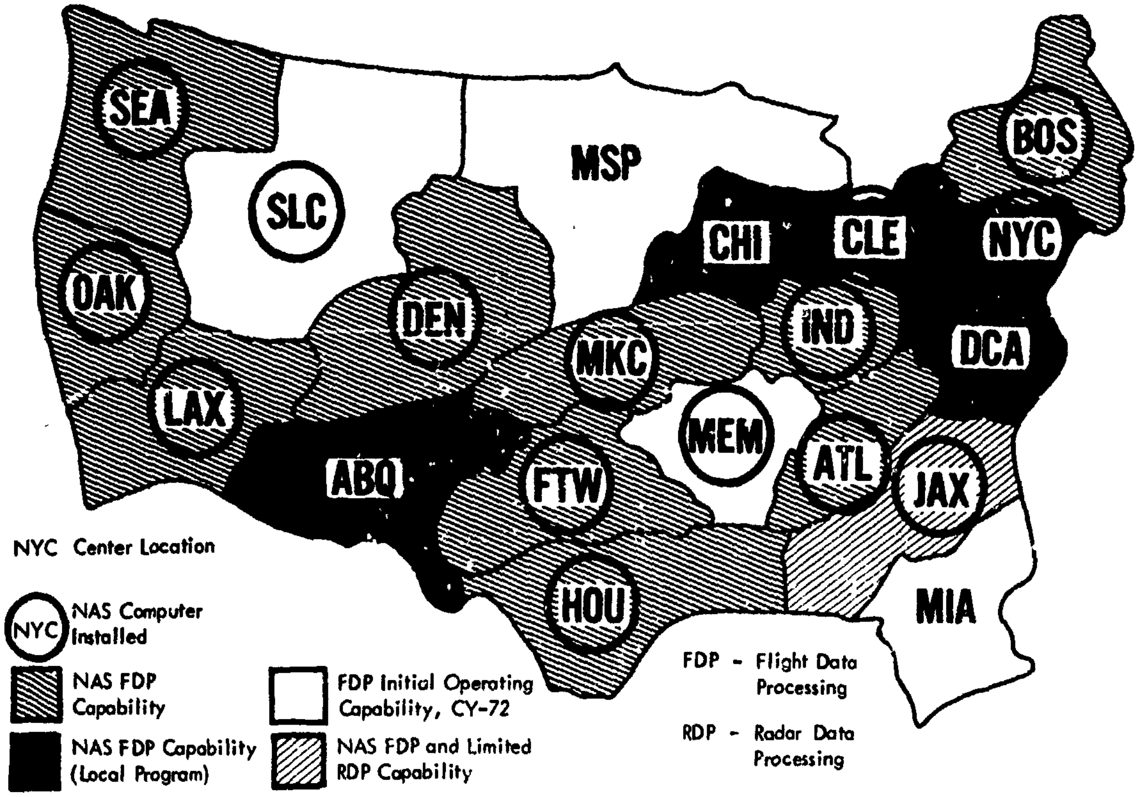

Figure 35. NAS Flight Data Processing Program Operational Status.

tracking level capability. This operational capability is being used 18 hours a day 5 days a week.

Flight Data Processing Model 2 Version 3 With Limited Computer Update Capability–This implementation step followed the initial NAS Model 2 Version 1 Computer Program which primarily processed and distributed flight strips. In addition to the flight data processing function this version provides controllers with a limited capability to update the computer from their control position. This program phase has been implemented at 10 centers.

Flight Data Processing-Local Programs–There are currently five centers operational with locally developed Flight Data Processing Programs. Four of these; Cleveland, Washington, Albuquerque, and Chicago utilize NAS IBM 9020 computers. New York is operating with a local program using pre-NAS Stage A computer equipment. All of these centers except Albuquerque are scheduled to achieve Initial Operating Capability utilizing a NAS Stage A Model 3 Flight Data Processing Program by the end of 1972.

Four centers currently without automation will have a flight data processing capability by the end of calendar year 1972. At that time a flight data processing Phase I capability will have been attained at all 20 centers. Three of these centers; Salt Lake City, Minneapolis, and Miami will initially use local programs while the Memphis facility will be implemented using a NAS Model 3 Computer Program.

Flight Data Processing Program Model 3–FAA developed this version of enroute automation to support an early implementation Model 3d. This program will perform the complete flight data processing functions of the Stage A program. It will be implemented at 20 air route traffic control centers and will provide controllers with a full computer updating capability. Coding of the computer program for this step was completed in FY 71 and the first program was delivered to Los Angeles in November 1971.

Radar Data Processing Program Model 3d—The final step (Phase II) to complete Stage A adds Radar Data Processing (RDP) to the Flight Data Processing Program. In this step the radar data are digitized at the radar sites, transmitted to the center by either microwave link or telephone lines, processed by the Central Computer Complex and displayed to the controllers through the display channel subsystem. Development of the Model 3d computer program began during fiscal year 1971 and it is scheduled for delivery to the first site 15/4/72. Figure 36 is a map showing the NAS Enroute Stage A Initial Operating Capability (IOC).

Equipment Summary. The NAS Enroute Stage A System will consist of three basic configurations:

1. Eleven centers will be equipped with IBM 9020A computers and associated Raytheon Computer Display Channel (CDC) equipment.

2. IBM 9020D Central Computer Complexes will be used in the nine busiest centers; Los Angeles, Kansas City, Washington, Indianapolis, New York, Cleveland, Chicago, Fort Worth, Atlanta, and one for the NAFEC System Support Facility because of the growth in air traffic and the increase in system requirements. The IBM 9020A Central Computer Complex and the Raytheon Computer Display Channel (CDC) would not have adequate speed or capacity to handle the projected growth at the busiest centers. Of these, Washington, New York, Cleveland, Chicago, and Fort Worth will be equipped with an IBM 9020E Display Channel Processor (DCP) to process the data for the radar controllers display. The NAFEC and the Academy will also have 9020E Display Channel Processors for system support and training purposes.

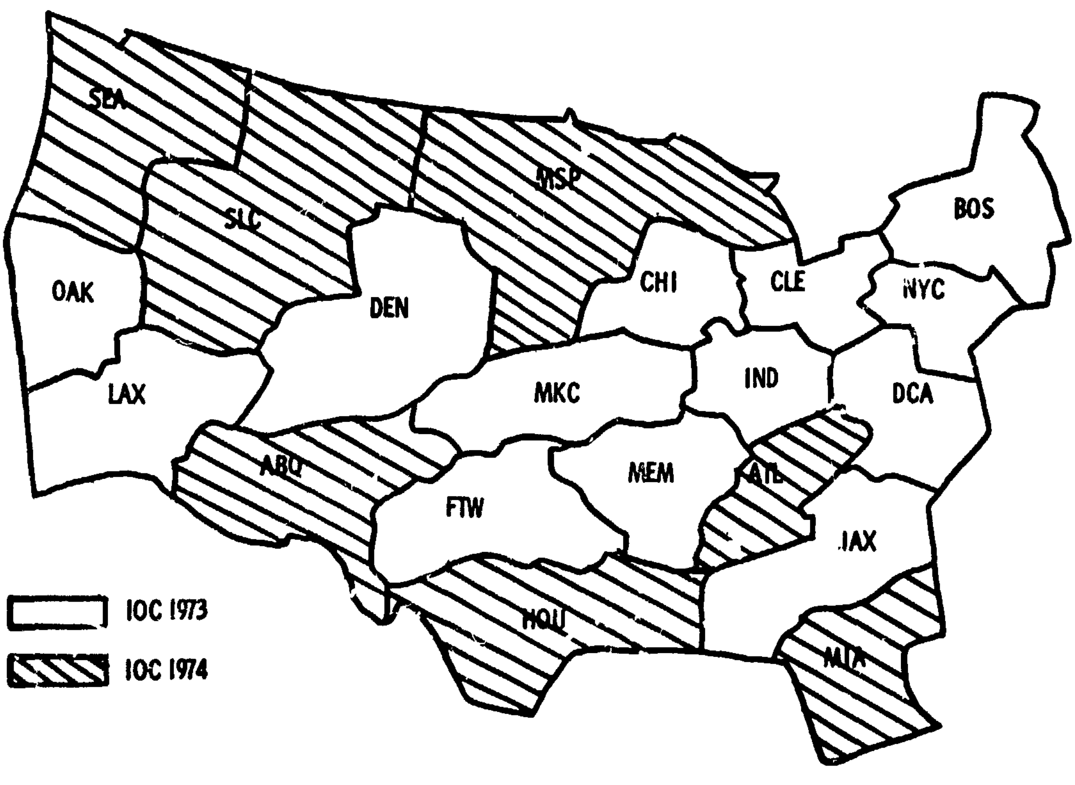

Figure 36. NAS Enroute Stage a Initial Operating Capability.

3. The other four centers; Los Angeles, Kansas City, Indianapolis, and Atlanta will use IBM 9020D computers with Raytheon Computer Display Channel (CDC) equipment.

Five 9020E systems are scheduled for delivery to field locations in 1972. With the Computer Display Channel equipment and Display Channel Processors, new control displays will be installed at all 20 enroute centers. The new plan view displays for the radar controllers positions will display alphanumeric flight data with the aircraft targets. The first Computer Display Channel (CDC) subsystem (with prototype displays) was delivered to the NAFEC in January 1971 to support Stage A computer program development. Los Angeles will be the first operational center to receive a Computer Display Channel subsystem in early 1972 with subsequent subsystems being delivered to air route traffic control center locations at the rate of approximately one every two months.

Direct Access Radar Channel. Preliminary specifications have been prepared for a Direct Access Radar Channel (DARC) subsystem that will be added to the NAS Enroute Stage A centers. This subsystem will permit the display of radar data on the controllers plan view display in the event that a catastrophic failure occurs in the Central Computer Complex Processor or the Display Processor portion of the Computer Display Channel.

Electronic Voice Switching. The agency will also provide Electronic Voice Switching Systems for the centers being automated. A Request for Proposals (RFP) for the Electronic Voice Switching (EVS) Systems was released by FAA on 9/11/71, and mailed to over 135 firms that expressed interest in the procurement program. The closing dates for receipt of technical proposals and cost/price analysis data were 9/3/72 and 31/3/72, respectively.

Air Route Traffic Control Center Building Expansion and Modernization Program. The Air Route Traffic Control Center Expansion and Modernization Program will provide center space, environmental improvements, and electrical and mechanical systems necessary to implement the Enroute Stage A System. The program is being implemented in two phases:

Phase I—will provide space through either an automation wing or bay expansion for the following: central computer complex, display equipment, maintenance functions, data systems staff, air traffic/airway facilities personnel training and briefing rooms, medical clinic, mechanical and electrical services, and miscellaneous support functions. Phase I construction was underway at all locations in 1971 and is scheduled for completion by November 1972. Figure 37 is an artist's rendering of an expanded center with an automation wing.

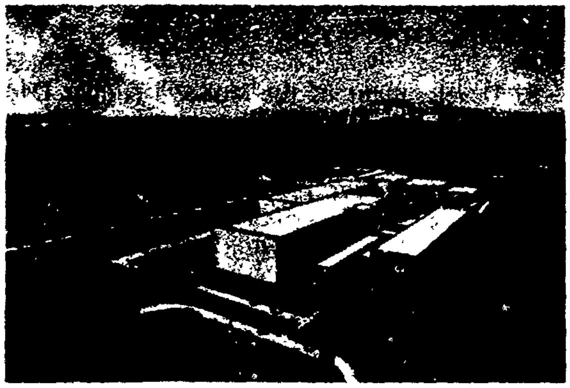

Figure 37. Artist's Rendering of Expanded ARTCC With Automation Wing.

Phase II—will expand and modernize the mechanical and electrical systems, correct environmental deficiencies, and provide additional personnel facilities and administrative space. A detailed breakdown of things to be accomplished by this phase is as follows: electrical and mechanical system expansion and reliability, additional parking, telco and control room space, cafeteria—locker room and toilet area modernization and expansion, modernization of administrative space and general upgrading of facilities. Some advanced Phase II work such as expanding telco/cafeteria areas has been completed at eight centers.

The first Phase II facility construction contract (other than the advanced effort) was awarded in November 1971 and construction started in December. The Phase II program is scheduled for completion by late 1974.

PROGRESS.

1. Seven centers became operational with the Flight Data Processing (FDP) Model 2, Version 3, Program: Oakland, Kansas City, Denver,

Seattle, Houston, Atlanta, And Albuquerque center which is using NAS Enroute Stage A equipment with an interim local computer program.

2. Jacksonville Air Route Traffic Control Center became the first NAS Enroute Stage A facility to conduct an Operational Readiness Demonstration of the high altitude beacon tracking level portion of the Radar Data Processing (RDP) software package. Jacksonville is currently operational with a Model 1 Flight Data Processing capability 18 hours a day 5 days a week.

3. Development of the Model 3 (Flight Data Processing) software program has been completed and delivered to 12 sites for installation. This program provides a NAS Stage A Flight Data Processing system with complete computer update capability.

4. The NAS Stage A Model 3d (Flight Data Processing and Radar Data Processing) program has been developed and is presently in system test at NAFEC, Atlantic City, New Jersey.

5. IBM 9020D Central Computer Complexes. Eight systems were delivered and installed at NAFEC and the following Air Route Traffic Control Centers: Los Angeles, Washington, New York, Cleveland, Chicago, Kansas City, and Indianapolis.

6. IBM 9020A Central Computer Complexes were delivered to the Atlanta, Albuquerque, Memphis, and Salt Lake City Air Route Traffic Control Centers.

7. Computer Update Equipment (CUE). Ten Computer Update Equipment systems were delivered to FAA. This completes delivery of the 22 systems on contract with Raytheon.

8. Common Digitizers. Eighty systems were delivered to FAA, 71 of these have been installed, accepted, and are being maintained by FAA. Production of the remaining systems being provided for the 113 FAA and FAA/USAF joint use radar sites was completed.

9. Final delivery of 120 weather and fixed map units on contract with Tasker Industries was completed.

10. The software program to provide an on line computer interface to exchange flight data between enroute centers and their adjacent ARTS III was developed and tested. This interface is now operational between nine ARTS facilities and their associated enroute centers.

11. Contract modifications to the existing Computer Display Channel (CDC) contract were awarded to the Raytheon Corporation. These modifications include: The Lot 4 Computer Display Channel buy for systems 11 through 17. This concludes all systems to be procured under the provisions of this contract.

12. A contract was awarded to Raytheon Corporation for seven Radar Display Subsystems (RDS), to be used at the five busiest centers with the IBM 9020E Display Channel Processor and in addition, at NAFEC and the FAA Academy for system development and training.

13. A contract was awarded to Raytheon Corporation for the installation of Computer Display Channel systems at the air route traffic control centers.

14. Phase I construction to provide space at 19 centers (automation wing and bay expansion) for the new computer equipment was completed at 16 centers as follows: Chicago, New York, Atlanta, Los Angeles, Cleveland, Albuquerque, Kansas City, Indianapolis, Oakland, Denver, Boston, Fort Worth, Seattle, Memphis, Salt Lake City, and Washington. Construction was underway at the three remaining centers; Minneapolis, Jacksonville, and Miami. The Houston center is not a part of the Phase I construction program.

15. Advanced portions of Phase II construction to provide expanded cafeteria and telco facilities were completed at the following eight centers; Chicago, Atlanta, New York, Jacksonville, Miami, Kansas City, Indianapolis, and Memphis.

16. The first nine Phase II construction contracts in support of the Air Route Traffic Control Center Expansion and Modernization Program were awarded during the reporting period.

17. A contract was awarded for electrical switchgear to the General Electric Corporation. This switchgear will be used at all 20 centers.

18. A contract was awarded to White Motor Company for 24 engine generators.

19. Contracts were awarded to the Johnston Pump Company for condensor water pumps, and to Havens Steel Company for cooling towers to be used at 18 air route traffic control centers.

TREND.

The following major events are planned:

1. NAS Flight Data Processing capability at all 20 centers implemented–12/72.
2. NAS Model 3 Flight Data Processing capability at all 20 centers implemented–12/73.
3. NAS Enroute Stage A Radar Data Processing Model 3d Program at all 20 centers implemented–12/74.
4. Air Traffic Control Center Building Expansion and Modernization Program; Phase I construction completed 12/72 Phase II construction completed–12/74.
5. Contract awarded for Uninterruptible Power System for the 20 NAS Stage A Air Route Traffic Control Center locations.–4/72. All these systems installed and operating–1975.
6. Final Direct Access Radar Channel (DARC) engineering specifications issued–6/72.
7. Engineering model procured–FY 73.
8. A Direct Access Radar Channel System installed at each NAS center–1976.
9. Contract awarded for a preproduction model Electronic Voice Switching (EVS) System for installation at NAFEC–72.
10. Electronic Voice Switching (EVS) Systems purchased for all NAS Stage A centers and the Academy–1978.

PROGRAM MANAGER.

Spencer S. Hunn. NS-1.

13 FLIGHT SERVICE STATION (FSS) PROGRAM

GOAL.

The purpose of this program is to design, fabricate, test and evaluate a modernized FSS; to develop unmanned facilities; and automate weather briefings, flight plan filings, and high density airport reservations.

SCOPE.

This engineering and development effort is organized under a single Program Element: 132 System Improvements.

In the FY 72 Technical Program, the engineering and development effort is covered in one subprogram:

132-221 FSS System Improvements, Subprogram Manager Oscar T. Grann, RD-221.

This subprogram is highlighted in terms of Background, Progress, and Trend (major events scheduled for completion) as follows:

FSS SYSTEM IMPROVEMENTS

BACKGROUND.

This effort is in response to Planning Requirement PL 6490.1 (4/19/71) to provide standards for FSS and 9550-1 Requests for R, D and E Efforts AT-100-18, AT-100-21, and AT-100-6 to achieve FSS improvements.

Recommendations for improving the FSS system were made by the FSS Task Group in December 1966 and the Industry/FAA Working Group which in the spring of 1967. Recommendations included the modernization of electronic equipment, the use of multichannel recorders for briefings, an investigation of methods of improving briefings through the use of visual displays, and an investigation of the feasibility of using automatic data processing to prepare flight profiles.

Standards are required for use in the modernization and relocation of FSS. They provide guidance for projects to renovate old quarters and to establish new stations. They must be flexible enough to encompass considerable variations in operating requirements. They will establish the requirements for a reconfigured system of part-time manned, full-time manned, and unmanned stations. They are required to improve the efficiency of the FSS system. With present operating standards, today's staff of 4,300 specialists would have to be increased to approximately 14,000 by 1981.

The rapid growth of FSS activity has created problems of staff efficiency, high operating costs and inadequate services to pilots. In the past, most of the facilities and much of their equipment have been locally designed and fabricated. There has been no standardization of siting, floor space, parking, equipment design, layout, decor temperature and humidity control, power, lighting or acoustics. Poor staff efficiency results when personnel must move often to accomplish one simple function, from the use of worn out equipment and with the over crowding of old facilities. Flight service stations presently require approximately 18% of the FAA operating budget; this percentage is in danger of increasing dramatically if the configuration of the system is not matched to the demand for services. Briefing services are restricted by inadequate telephone service, poor location of stations, limited air/ground communications, delays in teletype transmissions and the difficulty of extracting desired information from the large volume of available material.

A number of possible improvements to the FSS system are being examined. A reconfiguration of the system to create Type IV full-time manned stations, Type III and II part-time manned stations and Type I unmanned stations

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(Figure 38) can provide a greater number of outlets to service pilots and increase operating efficiency by directing the workload to Type IV stations during periods of minimal demand. Standardization and modernization will provide an efficient operating environment for the FSS specialist, a uniform and efficient system for pilot briefings and facilities that are economical to operate and maintain.

The modernization program includes several efforts. Mock-ups of a Type IV FSS operations (Figure 39) and pilot self-briefing rooms (Figure 40) have been constructed at NAFEC. The objectives of the mockup are to reduce noise, optimize lighting, develop displays for pilot self-briefing, create an efficient operations room layout and to design efficient consoles. A field test model will be constructed consisting of one Type IV, III, II, and three Type I facilities. The objectives of the field test model are to apply and evaluate techniques developed in the mockup, to perfect design of facilities, to evaluate the increase in efficiency of FSS specialists, to establish the basis for system specifications, and to determine the cost of nationwide implementation. A transcribed pilot report broadcast (PIREP) system is presently being evaluated. The objective of this system is to automatically record PIREPs on a dedicated channel and then rebroadcast them at regular intervals on VOR outlets. A project to replace

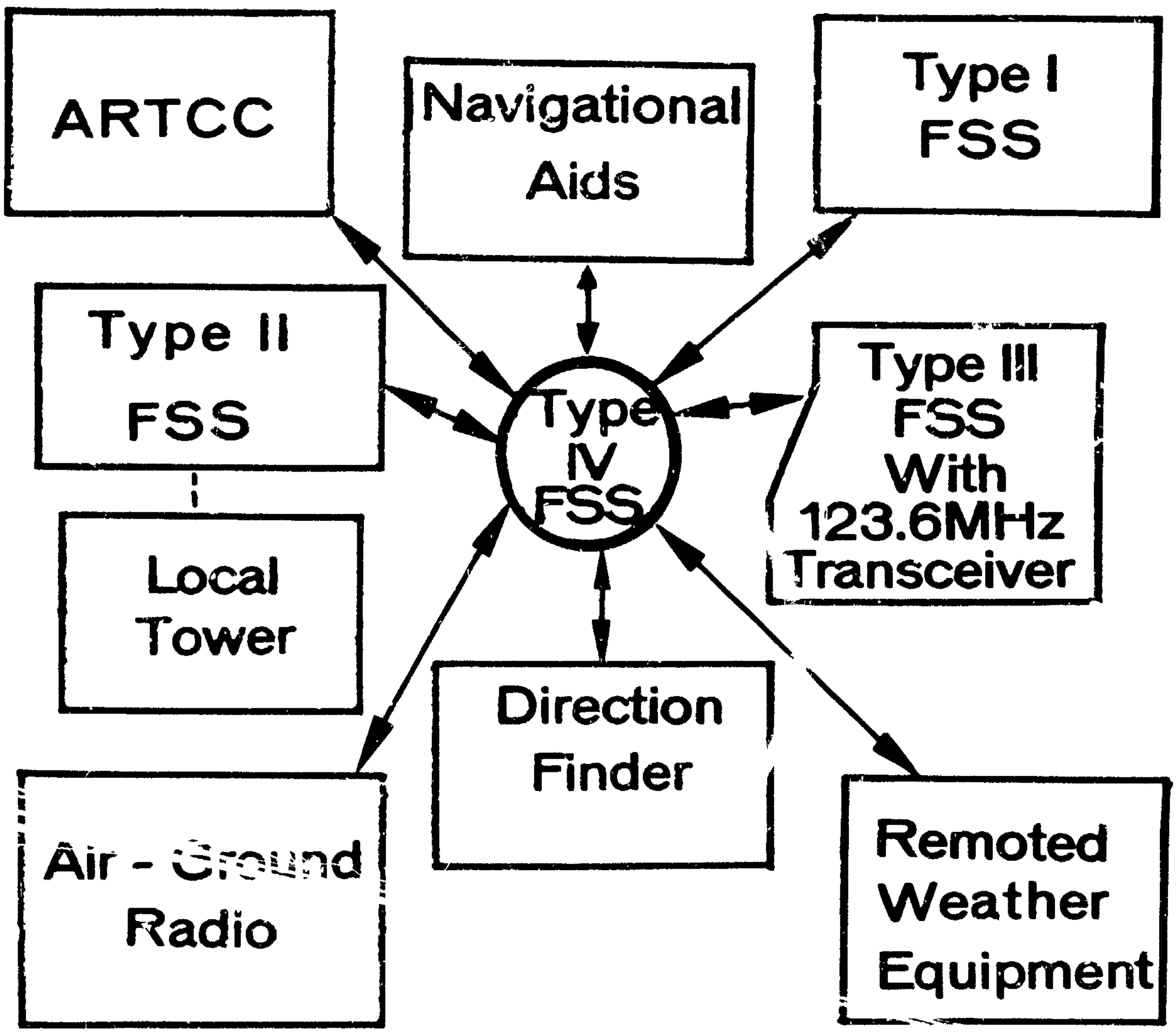

Figure 38. Reconfigured FSS Communications.

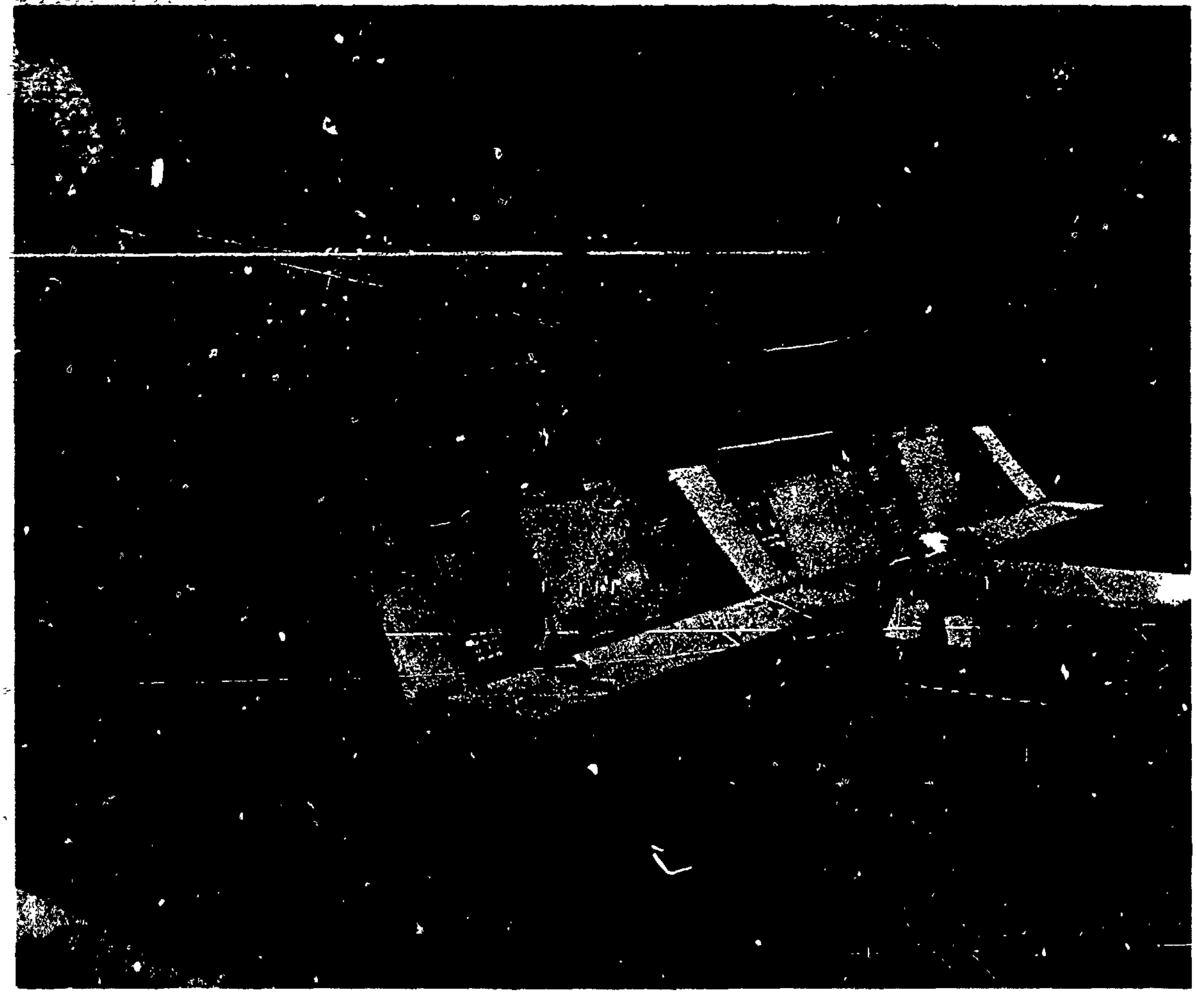

Figure 39. Mock-Up of Operations Room.

and update the present transcribed weather broadcast (TWEB) equipment is also included.

The automation effort consists of three projects. First, a study of various possible techniques of weather data distribution as part of a National Weather Service project is planned. Second, a test of an automated weather data and NOTAM distribution system will be made at the Atlanta, Ga. FSS. Third, a long range project has been established to integrate the automated FSS system with the NAS. This effort will include automatic flight plan filing and the automatic preparation of flight forecasts for pilot self-briefing.

PROGRESS.

1. Mock-ups of operational quarters (Figure 41) and the pilots' pre-briefing counter (Figure 42) of Type IV FSS developed at NAFEC, evaluated by FSS specialist team, recommended changes made and report issued.

2. SRDS procurement request completed for a field test model of Type IV, III, II and I facilities

3. SRDS/NAFEC transcribed pilot report equipment (an automatic recording and playback system) installed at Millville, N.J., Altoona, Pa.; and Charlottesville, Va., FSSs.

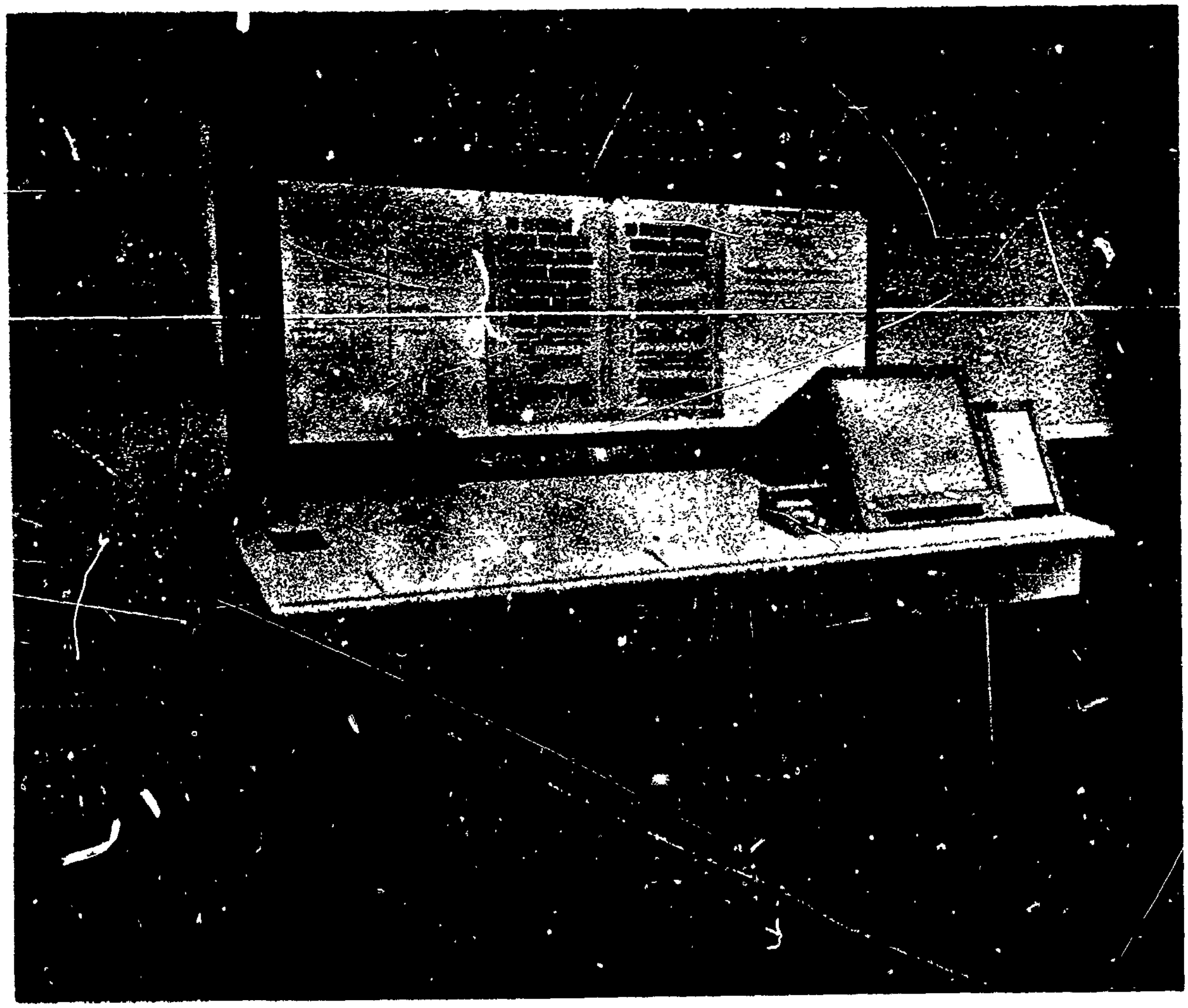

Figure 40. Mock-Up of Pilot Self-Briefing Room.

4. SRDS specification prepared for new transcribed weather broadcast equipment.

5. NAFEC/SRDS Handbook, titled "The Improvement of Operating Conditions at Flight Service Station Facilities" being prepared.

6. SRDS Procurement request completed for an FSS automation feasibility test at Atlanta, Ga.

7. SRDS agreement made with the National Weather Service for the contractual study of FSS weather data dissemination.

8. SRDS engineering requirement prepared for the automated pilot briefing system.

TREND.

The following major events are scheduled for completion:

1. Contract awarded for Phase I design of FSS field test model–5/72.

2. Contract awarded for Phase II construction of the FSS field test model–3/73.

3. Contract awarded for Phase III, evaluation of the FSS field test model–6/74.

4. Award of contract for prototype transcribed weather broadcast equipment–12/72.

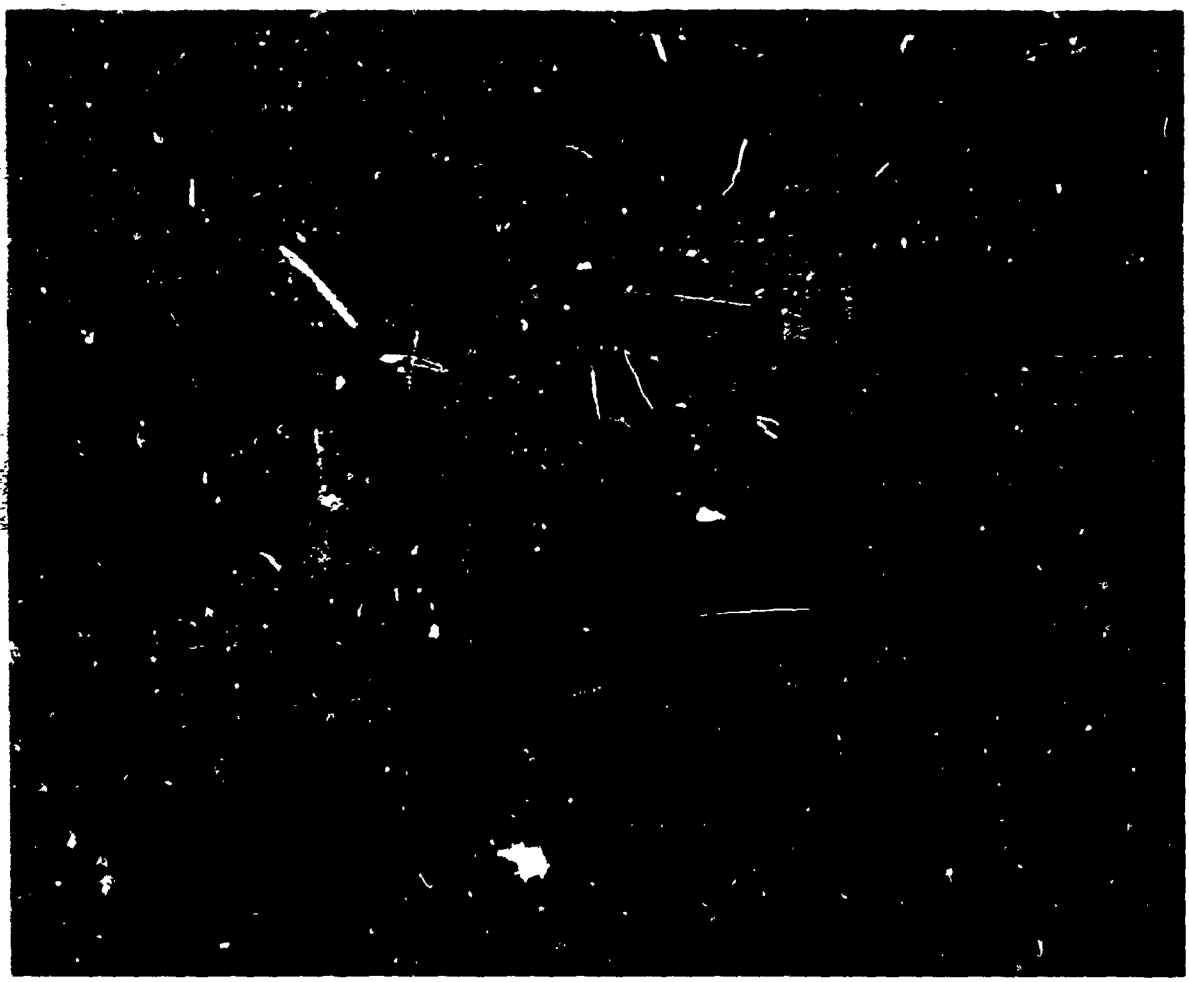

Figure 41. Mock-Up of Operational Quarters.

5. Award of contract for prototype automatic pilot report equipment—9/72.

6. Contract awarded to develop and test an automated weather data storage and retrieval system—6/72.

7. Contract awarded to develop and test an automated flight forecast and pilot briefing system—12/72.

SUBPROGRAM.

Flight Service Station System Improvements, 132-221.

MANAGER.

Oscar T. Grann, RD-221.

PROJECT MANAGERS.

Hugh D. Milligan, NA-516, and James Dong, NA-531.

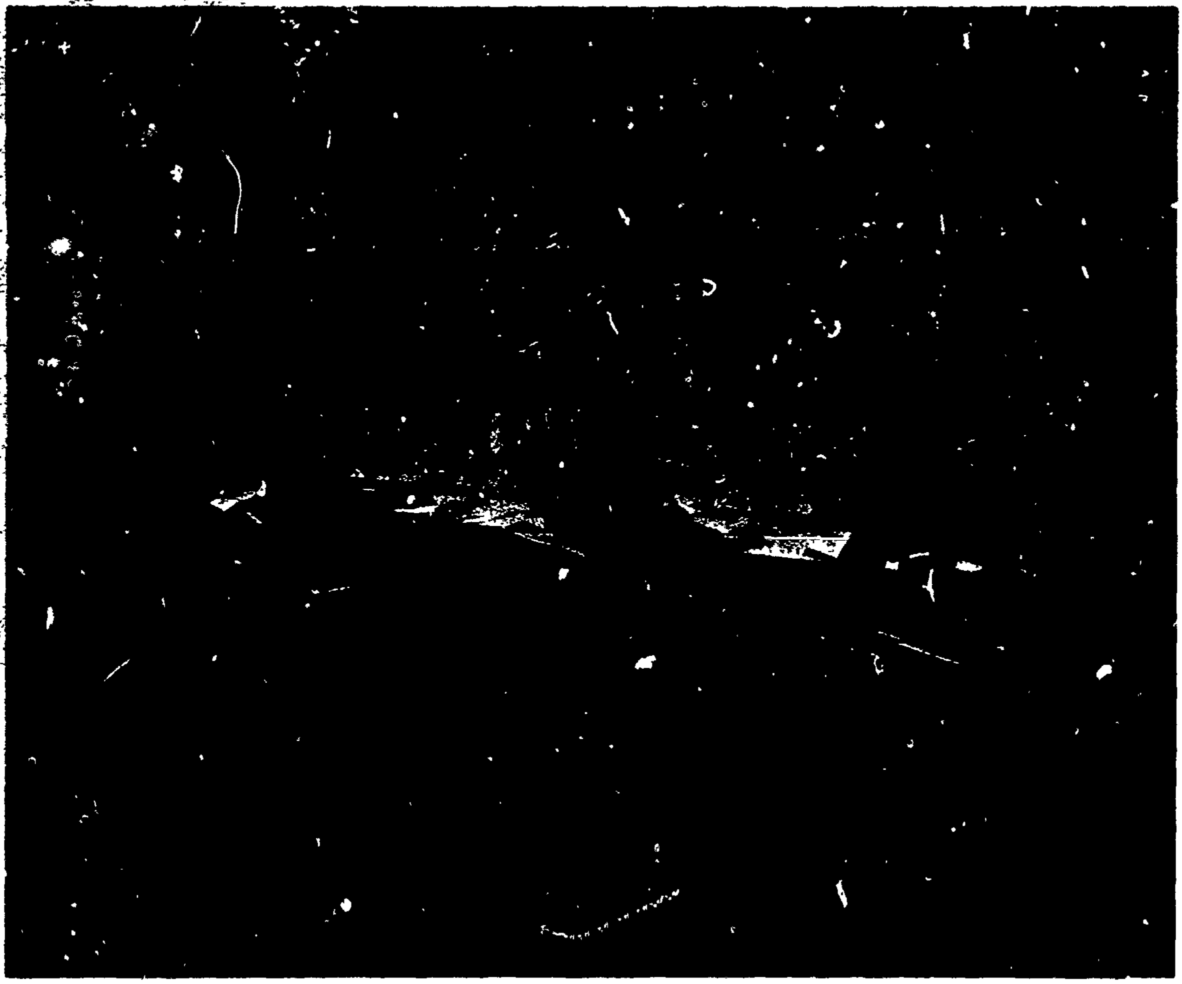

Figure 42. Mock-Up of Pilot Pre-Briefing Counter.

14 TERMINAL TOWER CONTROL PROGRAM

GOAL.

The purpose of this Program is to improve, and modernize existing terminal air traffic control facilities and develop hardware and software in order to reduce air traffic controller work load, increase their productivity, and enhance their performance and increase safety.

SCOPE.

This program is organized under three Program Elements: 141 – Deployment and Implementation Support (NASPO); 142 Experimentation and Development (SRDS/NAFEC); 144 – Sustaining Engineering (SRDS/NAFEC). The engineering and development includes: computers, software, displays, data entry devices, facility layouts, development of new procedures, system testing and implementation support. The FAA NASPO provides engineering support to this program.

In FY 72 Technical Program, engineering and development efforts include:

141-xxx Deployment and Implementation Support,* Program Manager, Spencer S. Hunn, NS-1.

142-717 ARTS Expansion,* H.J. Buck, RD-120.

142-172 Metering and Spacing,* R. Primeau, RD-150.

142-173 Flight Data Distribution System,* J.J. Coeller, RD-123.

142-174 Conflict Control/IPC,* H.A. Wachsman, RD-152.

142-175 Application of Automation to Low-Density Terminal Tower,* Nathan Aronson, RD-122.

142-176 Application of Automation to VFR Towers, Ricardo Cassell, RD-151.

142-177 Airspace Configuration and Procedures. Ricardo Cassell, RD-151.

The following major selected* efforts are highlighted in terms of Background, Progress, Trends (milestones scheduled for completion):

DEVELOPMENT AND IMPLEMENTATION SUPPORT

Terminal Radar Approach Control Automation Program

Automated Radar Terminal System (ARTS III)

BACKGROUND.

The FAA is providing an automation capability at 61 of the busiest airport terminal areas in the United States through implementation of its Automated Radar Terminal System (ARTS III) program. This effort is in response to an agency decision to provide an automated capability at high density terminals. The program is being implemented in accordance with DOT/FAA Order 1800.29, System Program Plan, ARTS III.

The need for ARTS III became apparent at many of the busiest FAA operated towers equipped with terminal radar in the mid-1960's. Even though radar is a significant aid at airports other factors affect the capacity and efficiency in the terminal area. In an effort to increase the capacity, promote efficiency, reduce pilot/controller workload, and to improve safety at these high density terminals, FAA initiated a program to provide an ARTS III level of automation.

The evolutionary events leading to the ARTS III began as early as 1963 when the Advanced Radar Terminal System (ARTS I) was implemented at Atlanta, Ga., and later commissioned there in 1966. The primary purpose of this system initially was to serve as the prototype for future automated terminal systems; and in that role it has been highly successful.

By June 1969, a second automated Air Traffic Control facility was commissioned in New York, the New York Common Instrument Flight Rules Room. The Common Instrument Flight Rules Room system is similar to the ARTS I, except that it offered certain improvements and expanded capabilities, some of which evolved from experience with the ARTS I. Experience gained at these locations provided valuable information and assisted in the development of the FAA's current terminal automated program, ARTS III. In February 1969, the FAA awarded UNIVAC a multi-year contract for the procurement and installation of 64 ARTS III for four years.

The basic ARTS III Beacon Tracking Level System represents an operational capability which can be added to the existing Terminal Radar Approach Control (TRACON) equipment and procedures, utilizing present airport surveillance radar and beacon systems.

The ARTS III provides the terminal facility controller with the capability to automatically track beacon equipped aircraft and display in association with the aircraft track, identification, altitude information (for Mode C equipped aircraft) and computer ground speed. It will also automatically exchange flight data and perform semiautomatic radar handoffs between control positions within the terminal and between the ARTS III equipped terminals and appropriately equipped Enroute Stage A centers.

Because of the modular design of the hardware the ARTS III can be expanded to provide additional capacity and reliability. The ARTS III basic system consists of three subsystems: the Data Acquisition Subsystem (DAS), Data Processing Subsystem (DPS), and the Data Entry and Display Subsystems (DEDS). Figure 43 shows the functional activities performed in each of the subsystems.

The Data Acquisition Subsystem (DAS)–Provides the interfaces between the DPS and the existing secondary radar systems and consists of a beacon digitizer and an azimuth pulse generator.

The Data Processing Subsystem (DPS)–Receives and processes interfacility data from an adjacent Air Route Traffic Control Center (ARTCC), entries from the controller Data Entry and Display Subsystems keyboards, beacon replies, and azimuth and control signals from the DAS.

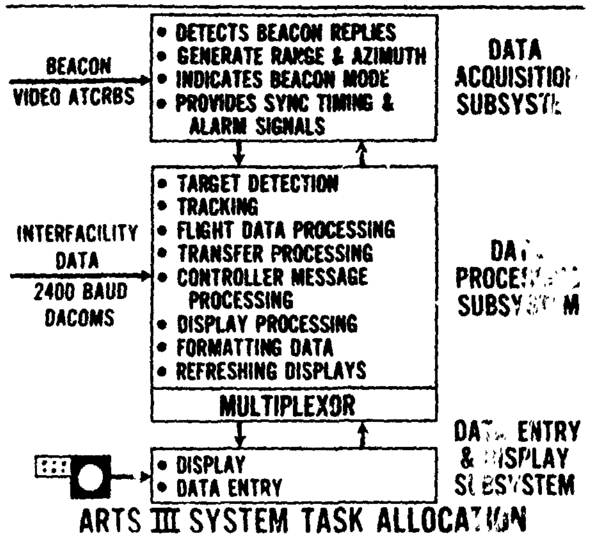

Figure 43. Functional Activities of each Subsystem.

The DPS consists of an Input/Output (I/O) Processor, core memory, integral magnetic tape unit, I/O teletypewriter and the necessary software to perform the data processing function.

The Data Entry and Display Subsystem (DEDS)–Provides the means for the controller to communicate with the data processing subsystem via the data entry equipment. The DEDS also displays the analog target data for both the radar and beacon video as well as alphanumeric data on 22-inch solid state radar controller displays. An artist's conception of terminal display presentations before and after automation is provided by Figure 44.

PROGRESS.

Delivery and installation of the ARTS III is moving at a rapid pace and is progressing on schedule. The current ARTS III schedule is shown in Figure 45.

The first two ARTS III, one for the FAA Academy and one for Chicago O'Hare, were delivered in December 1970. Chicago, the first field ARTS III facility achieved Initial Operating Capability on 22 June 1971. On 4 October 1971, it was the first ARTS III to attain operational status.

The following is a summary of major accomplishments in the ARTS III program

1. The third lot buy was awarded to UNIVAC for the last 29 ARTS III on 24/5/71.

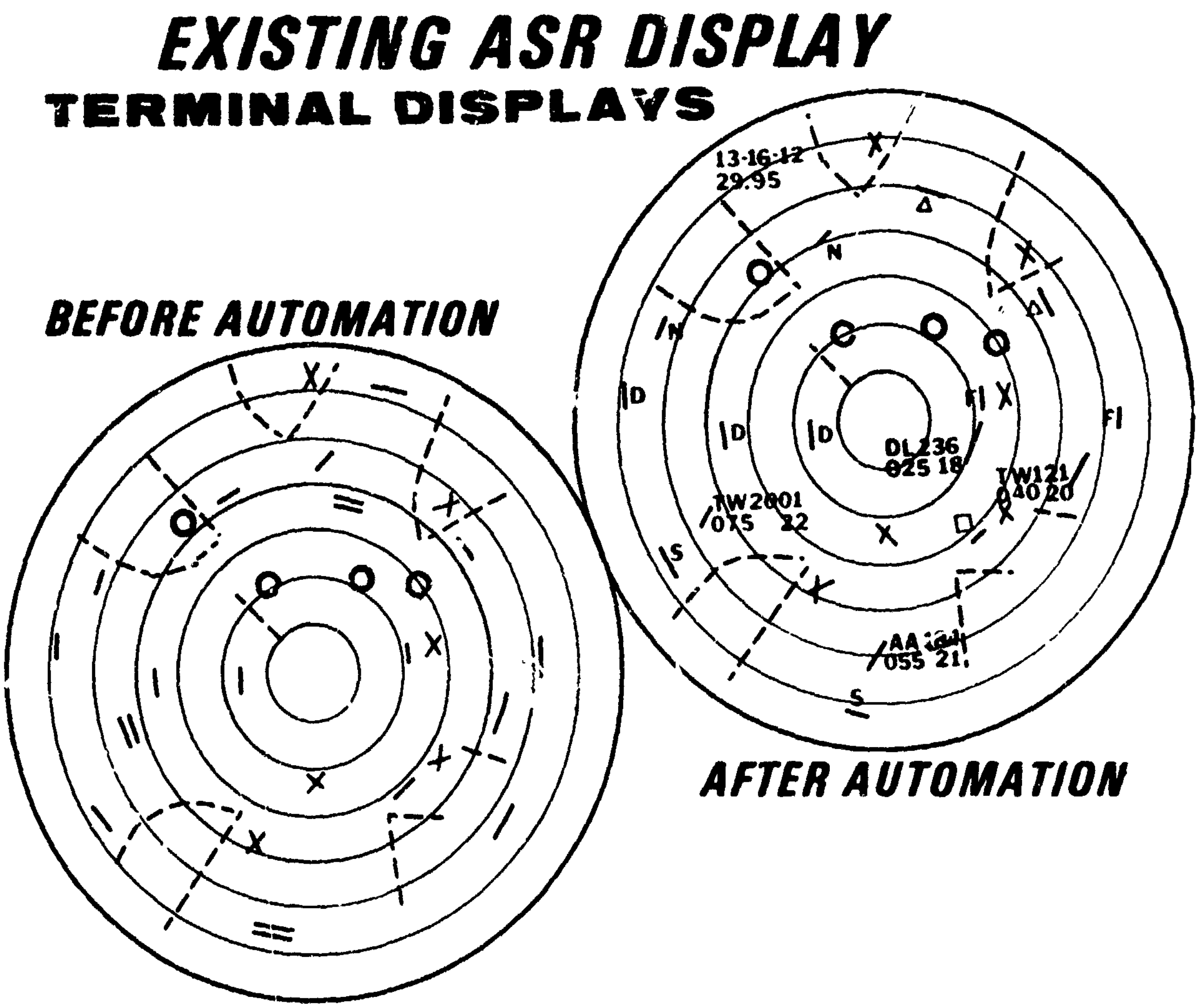

Figure 44. Terminal Displays, Before and After Automation.

2. 37 were delivered by the end of the reporting period.

3. 27 ARTS III achieved Initial Operating Capability by the end of 3/72.

4. 12 ARTS III were in full operational service by the end of 3/72.

TREND.

The following major events are scheduled for this program:

1. All ARTS III delivered by 7/11/72.

2. 37 ARTS III attained Initial Operating Capability by 7/72, the other 27 before 2/73.

3. ARTS III Operational Readiness Demonstration and facility commissioning completed:

   a. 22 systems by 7/72.

   b. 20 additional systems by 1/73.

   c. 19 additional systems by 6/73.

PROGRAM MANAGER.

Spencer S. Hunn–NS-1

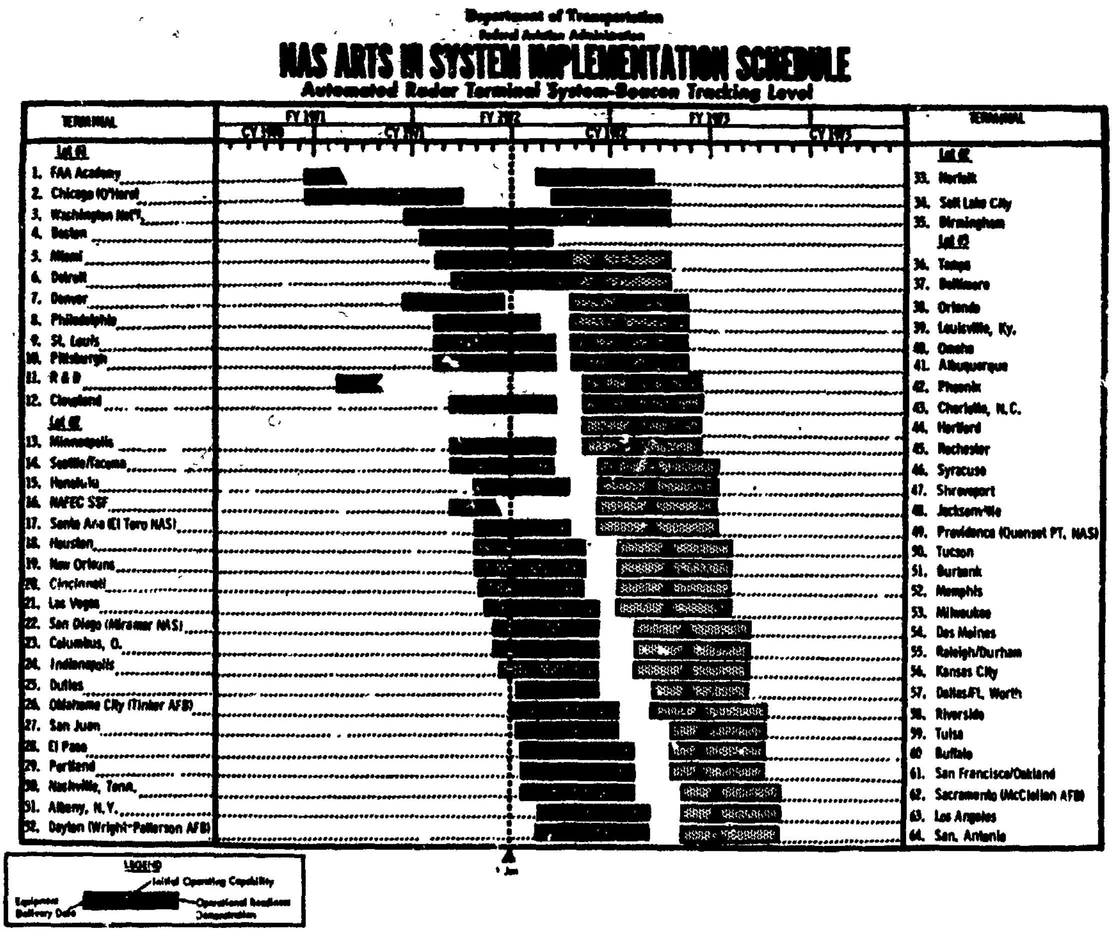

Figure 45. NAS Arts III System Implementation Schedule.

AUTOMATED RADAR TERMINAL SYSTEM EXPANSION

BACKGROUND.

The initial field installation of an Automated Radar Terminal System (ARTS) was at Atlanta, Ga., in 1964. This was the prototype system which provided the means to develop and evaluate the practicality of terminal automation. The success of the ARTS system in Atlanta was reflected by the second ARTS installation at the New York Common IFR Room in 1968.

Development of a modular terminal automation system on a nationwide basis was further advanced when the basic ARTS III (Beacon Tracking Level) contract was let in February 1969.

Sixty-two operational sites are scheduled to receive the basic ARTS III system.

In September 1971 Chicago became the first fully operational site. A number of other sites are presently in some phase of operational implementation. The basic ARTS III system was never intended to be an ultimate terminal automation system. It was designed to be modularly expandable. In July 1969 the Air Traffic Service generated FAAR 6410.3A titled, "Provide Automation Capability for Radar Equipped Terminal Facilities." This FAAR called for the capability to:

1. track primary radar targets.

2. meet expanding functional and capacity demands.

3. provide a fail-safe/fail-soft system.

4. future expansion.

To satisfy a portion of FAAR 6410.3A, the ARTS Enhancement Program was established. In April 1971 the ARTS Enhancement contract (DOT FA70WA-2289) was awarded UNIVAC for the development of functional, capacity, and reliability enhancements to the basic ARTS III system. NAFEC is providing technical support to assist the contractor in the development. This effort is divided into seven major levels of development designed to implement the required enhancements in an orderly manner. All enhancements are to be accomplished through the addition of modules; each more sophisticated system level shall be designed as a modular addition to the previous level. The seven levels of development are briefly described:

Level A – Redundant Basic ARTS III System (Figure 46).

Provide a higher level of reliability to basic ARTS III systems by providing backup hardware, duplicate internal safe storage of critical elements of the data base, software capability for system restart, and manual reconfiguration of system hardware resources.

It will be developed in two phases: (1) a single beacon redundant system and (2) a dual beacon redundant system.

Level B – Radar/Beacon Tracking (Figure 47).

Provide the ARTS with improved tracking reliability and increased capability by introducing radar processing to supplement the beacon only system. The radar processing functions provided are:

1. Radar target report processing.

2. Radar and Beacon target report correlation.

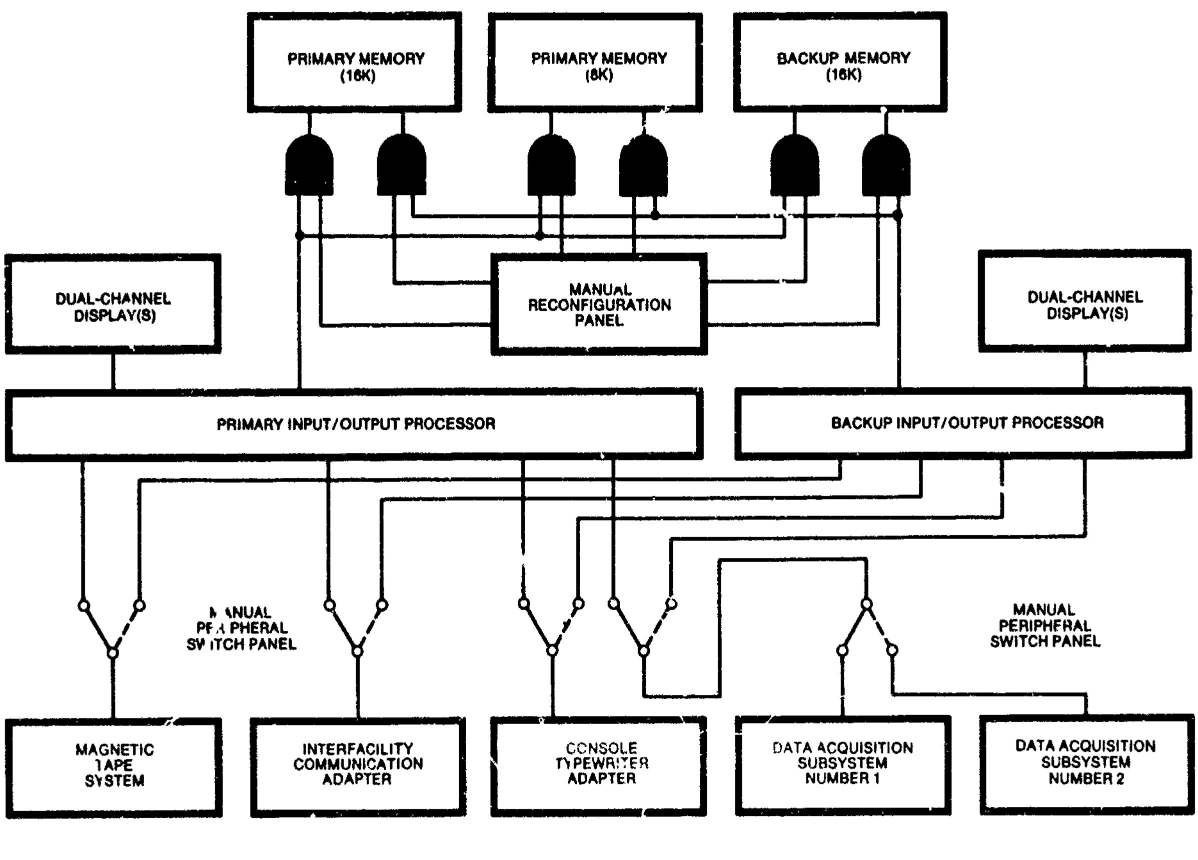

Figure 46. Redundant Basic Arts III System (Level A).

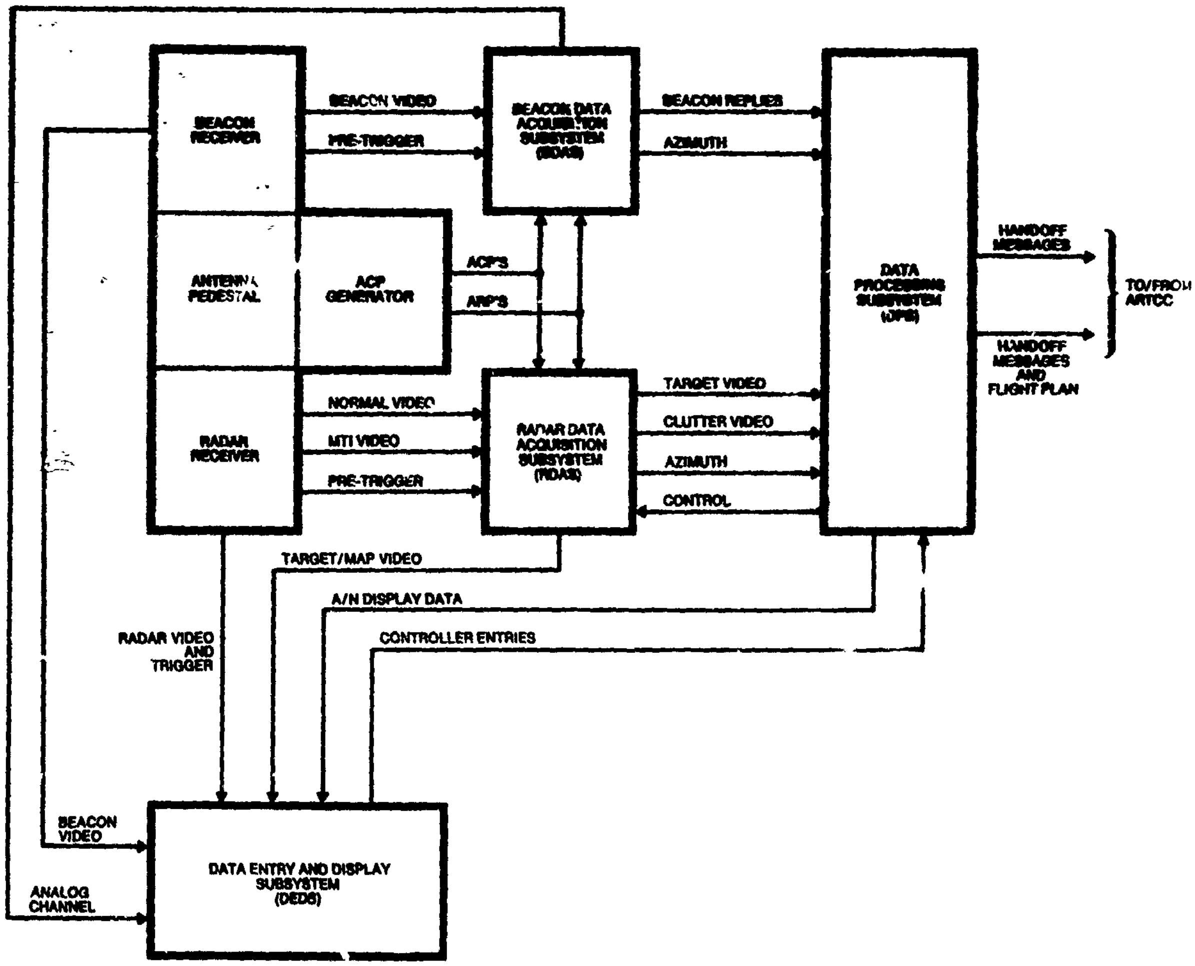

Figure 47. Radar/Beacon Tracking Level (Level B).

3. Radar Target tracking.

Level C – Initial Multiprocessor.

Provide the ARTS system with an increased computing capability and an improved utilization of computing resources by designing an executive capable of controlling several IOPs and efficiently scheduling computing tasks.

Level D – Dual Radar/Beacon Level.

Provide increased reliability and increased sensor coverage. It is the combination of two radar beacon tracking (Level A) system; or one radar beacon tracking (Level A) system and one beacon only ARTS III system.

Level E – Fail-Soft System.

Extend the Level C development by providing an increased computing capability through the addition of computing modules; automatic fail-soft capability; and improved tracking performance. A multiprocessor executive will be designed to provide the fail-safe capability and an augmented tracking algorithm capable of using data from any sensor.

Level F – Common Coordinate Digital Level.

Provide an improved presentation of data on the display console removing the broadband radar/beacon video, and displaying digitized video and associated data.

Level G Fail-Safe System.

Provide the optimum system reliability by providing all system modules with redundancy. The system shall be able to sense failures, isolate the failed module and replace the failed module with a redundant module automatically and with minimum disruption to the operational program.

To demonstrate and test the various levels of development for the ARTS Enhancement Program, the FAA established the ARTS Enhancement Testbed at Minneapolis, Minn.

PROGRESS.

ARTS Enhancement contract (DOT FA70WA-2289) awarded to UNIVAC Defense Systems Division of Sperry Rand Corporation.

Level A–Redundant Basic ARTS III System development and demonstration completed by UNIVAC including:

Final Report issued by UNIVAC: Single Beacon Level A Redundancy.

Design Specification issued by UNIVAC: Single Beacon Level A Redundancy.

Final Test Report issued by UNIVAC: Dual Beacon Level A Redundancy.

Design Specification issued by UNIVAC: Dual Beacon Level A Redundancy.

Level C–Initial Multiprocessor development and demonstration completed by UNIVAC including:

Working Demonstration by UNIVAC of Multi IOP Executive Program.

Design Specification by UNIVAC completed: Multi IOP Executive Program.

TREND.

The following major events are scheduled for completion by UNIVAC under Contract No. DOT FA70WA-2289:

Level B – Radar/Beacon Tracking.

Final Evaluation Report Single RBT Level System–11/72.

Design Specification: Single RBT Level System–11/72.

Level D – Dual Radar/Beacon Level (RBLT).

Final Report: Dual RBTL System–1/73.

Design Specification: Dual RBTL System–1/73.

Level E – Fail-Soft System.

Test Report Document: Fail-Soft Executive Test and Evaluation–9/72.

Design Specification: Fail-Soft Multiprocessor Executive Program–9/72.

Level F – Common Coordinate Digital Level.

Final Report: Multisensor Utilization and all Digital Tracking–2/73.

Design Specification: Multisensor Utilization and all Digital Tracking–2/73.

Design Specification: Functional Characteristics of Vector Generation–6/72.

Level G – Fail-Safe System.

Working Demonstration: Fail Safe Multiprocessor Executive Program–3/73.

Design Specification: Fail-Safe Multiprocessor Executive–6/73.

SUBPROGRAM.

ARTS Expansion, 142-171.

MANAGER.

H. J. Buck, RD-120.

PROJECT MANAGERS.

M. Holtz, NA-532 and Irving Mower, NA-515.

METERING AND SPACING ARTS III

BACKGROUND.

This development effort is responsive to System Requirement: FAAR 6110.1, 12/8/68, Revised 18/6/69, ATS: "Provide Automated TRACONS with Air Traffic Metering, Sequencing and Separation Assistance."

The metering and spacing (M&S) level of terminal automation provides for development and implementation of automated decision assistance to increase the capacity of the system and to maintain standards of safety.

Over the past decade, various techniques for automation of the M&S functions of terminal air traffic control have been developed and evaluated. The studies indicated that significant improvements can be achieved by a computer-aided metering and spacing function, even with the inherent errors and variabilities of today's environment (VOR/DME, ILS, RNAV, voice communications and ASR radars with beacon transponders).

The current M&S program was a logical outgrowth of two prior development/evaluation efforts referred to as the Final Approach Spacing for ARTS I (FASA) and Computer-aided Approach System (CAAS). FASA was introduced at Atlanta, Ga., during 1965 and CAAS at JFK International Airport in 1967. Most of the problems restricting the operational acceptability of the concepts evaluated have been or are being eliminated by the experience acquired in the use of ARTS at Atlanta, the development/implementation of the ARTS III and NAS Stage A enroute automation.

The basic ARTS III program will provide automatic beacon radar tracking and an alphanumeric tag on the radar display which includes identity, ground speed and Mode C altitude presented in association with the aircraft target. Since the program includes tracking and prediction functions, the ARTS III system provides a foundation which is readily expandable to metering, sequencing and spacing information on beacon equipped aircraft and modularly expandable to provide the same service on non-beacon aircraft. Furthermore, flight plan, tracking and handoff data will be exchanged between the ARTS III and NAS Enroute Stage A facilities and this capability can also be expanded to provide for the exchange of flow control information on an intersystem basis.

The expansion of the ARTS III system has been planned to be accomplished through the development of progressive levels of capability and capacity to meet the requirements of many varied facilities. Based on objective criteria the progressive levels were determined to be:

Radar Tracking.
Multi-radar (multi-sensor).
Augmented tracking.
Full digital system.
Fail-safe/fail-soft.

As a consequence of the phased add-on approach for the expansion of ARTS III, the approach for development of automated add-on capability of metering and spacing assistance has been predicated which integrates modular functional expansion levels with the progress of evolutionary system expansion. The development effort provides for the design, program production, experimentation/evaluation and implementation over a 36-month period consisting of four phases (14 tasks) of functional improvement proceeding from a basic M&S of arrivals only through expanded functional levels progressively to command control of arrivals and departures in an Improved Terminal Control System.

In general, development of the computer-aided metering and spacing process will consist of automation of the following functions:

1. A metering (or rate) control function that maintains the proper balance between airport acceptance rates and flow of traffic inbound from the terminal entry points.

2. A scheduling function that establishes landing order and landing times at each active runway consistent with criteria, priorities and other factors. This function also includes schedule slippage and rescheduling that may be caused by early/late deviations from the schedule, missed approaches, or controller decisions.

3. A spacing control process that includes a sequence control and a final spacing control function. The sequence control function affects transition of aircraft from enroute control to the final spacing control. During descent from the enroute or holding altitude, coarse grain spacing is effected, as necessary, commensurate with the limitations of the maneuvering airspace in the final spacing area.

4. A final spacing control function that accepts aircraft from sequence control and effects orderly flow of traffic into the final approach course(s) in accordance with the landing schedule.

5. A VFR control function that affects final spacing control from a VFR assembly and hold area for visual approaches in accordance with the landing schedule.

6. An arrival/departure planning function that establishes proper balance between arrival and departure rates consistent with the respective traffic loads, existing delays and other factors. Departures are scheduled in the natural arrival intervals as available. When, however, the ground departure delays begin to exceed arrival

delays by an appropriate rate, the natural intervals are opened to accommodate departures until sufficient slots are available to maintain the specified arrival/departure delay ratio.

7. A departure scheduling function that provides separation between departing and arriving aircraft when interfering runways are in use (local control).

8. A departure control function that accepts aircraft from local control after departure and delivers these aircraft to the adjacent enroute sectors at desired altitudes and/or times.

Benefits.

A comprehensive analytical study of user cost/benefits is presented in a Staff Study, Report No. RD-67-70, "Alternatives Approaches for Reducing Delays in Terminal Areas," highlights the following:

1. **Conclusion-Reduction in Delay.**

a. Of all the alternatives examined, new parallel runways and new airports provide the greatest reductions in delays.

b. The next most important means of reducing delays are either schedule restrictions during peak hours or computer-aided final approach spacing combined with procedural alternatives.

2. **Conclusions-Benefits vs. Costs.**

a. Of all the alternatives examined, by far the greatest benefits in comparison with costs are achieved by procedural changes and by automation of the final approach spacing function.

The principal recommendation from the alternative courses of action examined was: "Proceed to automate the final approach and sequencing functions in high density terminals as soon as possible. Techniques that show demonstrated gains should be implemented as soon as developed; refinements can be added later. An accelerated program appears to be well worth any additional expense incurred since the benefit/cost ratios are so favorable. For example, increasing expenses by tenfold would still yield a benefit/cost ratio substantially exceeding 1.0."

PROGRESS.

Contract award to Computer Systems Engineering Inc.

Study Report FAA-RD-70-82, December 1970, "Computer-Aided Metering and Spacing with ARTS III–Phase I Design Study," provided initial design data for program activity related to Phase I, Task I of ER-D-150-001, for interim period July-November 1970.

Study Report FAA-RD-72-9, February 1972, "Computer-Aided Metering and Spacing with ARTS III–Phase II Design Study," provides initial design data for program activity related to Phase II of ER-D-150-001, for interim period January-December 1971.

TREND.

During 1971 an administrative and technical decision was made to reorient the approach for accomplishing program development from the use of the NAFEC Digital Simulation Environment to the ARTS III SRDS Test Bed being established at NAFEC to support expansion program activities.

The following major events are scheduled for completion under Computer Systems Engineering Contract No. DOT FA70WA-2433.

Phase I, Task I.

Atlanta Program Testing–6/72.
ARTS III Program Testing (NAFEC/DENVER)–8/72.

Phase I, Task II.

ARTS III Program Development–4/72.
Program Testing (NAFEC)–10/72.

Phase II, Tasks I-VI.

Atlanta Program Development–8/72.
Program Testing–12/72.
ARTS III Program Development–4/73
Program Testing (NAFEC)–7/73

Phase III, Task I, II.

Atlanta Program Development–1/73.
Program Testing–5/73.
ARTS III Program Development–3/73.
Program Testing (NAFEC)–6/73

Phase IV.

Initiate Study–6/71.
Interim Report (RNAV/M&S)–12/72.
Complete Study–7/73.

SUBPROGRAM.

Terminal Automation–Metering and Spacing (M&S), 142-172.

MANAGERS.

R.A. Primeau, RD-151.
R. Hilton, RD-123.

PROJECT MANAGERS.

Don Schlots, NA-513 and Arthur Halverson, NA-516.

FLIGHT DATA DISTRIBUTION SYSTEM

BACKGROUND.

The basic requirements of this program stem from the President's "Project Beacon Report;" the FAA System Design Team document, "Design for the National Airspace Utilization System;" and from FAA Requirement (FAAR) 6410.1, dated 4 November 1966, "Provide a Bright Radar Display in the Tower Cab for the Local Controller." The Air Route Traffic Control Center (ARTCC) and Advanced Radar Traffic Control System (ARTS) automation programs have resulted in the definition of explicit tower automation functions needed to provide compatibility of the tower with other Air Traffic Control (ATC) facilities.

The purpose of this program is to define, develop and procure test model tower automation equipments and issue production specifications. Automation of the tower facilities will be accomplished in three phases to indicate short, medium, and long term development as follows:

Phase I.

1. A Flight Data Distribution System (FDDS) to provide a semiautomatic means of receiving, distributing, and displaying flight data within the tower environment.
2. Acquisition of facilities necessary to provide compatibility of the tower with automated ARTCC and Terminal Radar Control (TRACON) facilities.

Contract for the FDDS was awarded 6/71, and will be installed initially at the NAFEC facility. Figure 48 is a system diagram of the FDDS.

Phase II.

1. SRDS/Contractor establishment of a tower automation test facility to support all efforts under this program.
2. SRDS/Contractor expansion of the FDDS to improve the interface with the TRACON and to incorporate additional data.

Phase III.

1. Ground guidance and display.
2. Advanced data communication.
3. Advanced communication control techniques.
4. Human engineering to provide improved display and control capability.
5. Further studies on such items as V/STOL traffic, data links, and automated ground systems.

Benefits.

The following benefits will be obtained from the system:

1. Easy to use and more accurate data.
2. Inter- and intra-facility data transfer eliminates time-consuming voice communications.
3. Minimization of human errors.
4. Maximum use of Public and Private Investment in Equipment.
5. The FDDS will maximize use of present government and investment in data automation at the ARTCC and TRACON facilities.

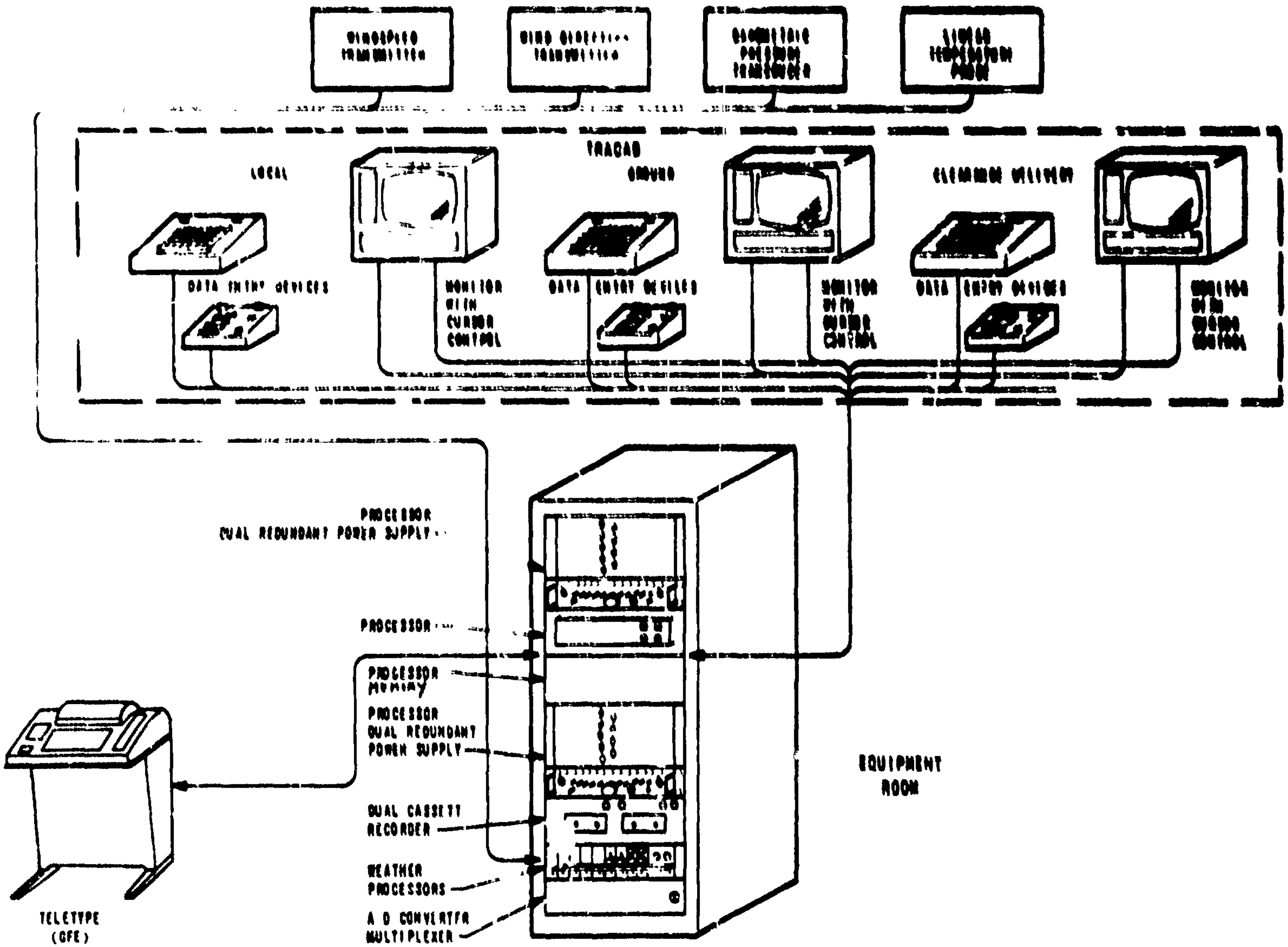

Figure 49. FDDS Model III Configuration.

PROGRESS.

SRDS specification completed for BRITE alphanumerics and Flight Data Distribution System.

Contract placed for Flight Data Distribution System (FDDS).

TREND.

The following major milestones are scheduled for completion:

FAA Contractor software development for FDDS–3/72.

FDDS NAFEC test facility design and fabrication–4/72.

FDDS installed at NAFEC–4/72.

NAFEC systems test of FDDS–5/72.

SRDS production specification for FDDS–6/72.

SUBPROGRAM.

Flight Data Distribution System, 142-173.

MANAGER.

James J. Goeller, RD-123.

PROJECT MANAGERS.

John Maurer, NA-516; Howard Slattery, NA-516; and E. Buckley, NA-550.

CONFLICT CONTROL/IPC

BACKGROUND.

This effort was initiated in response to recommendations of the DOT Air Traffic Control Advisory Committee, December 196 . Because the probability of mid-air collisions increase approximately as a square of the aircraft population, a replacement must be provided for the see-and-avoid system presently used in mixed airspace.

To meet safety requirements and increased demands on existing airspace in the 1980's, a system incorporating the following features was recommended: (1) Detection of intruders into positive control airspace, (2) Intermittent Positive Control (IPC) of aircraft operating in mixed airspace wherein commands for collision avoidance are provided to aircraft as necessary, (3) Automatic vectoring of controlled aircraft in all airspace to reduce the communications workload on the controller, (4) Up and down data-link for delivery and acknowledgement of control instructions; (5) "VFR Highways" to segregate aircraft according to speed and direction of flight to reduce the number of IPC commands in the most severely congested areas, and (6) Planning probes to permit orderly introduction of flights into the system.

The primary function of the air traffic control system is that of providing for the safety of aircraft using the service. Conflict detection, by automation is one of the functions to be incorporated into the NAS/ARTS systems, but it is also this function which requires the maximum in computing power. The estimates of the computational power required of the air traffic control automation systems of the 1980's and 1990's range upwards into tens of millions of instructions executed per second. Achieving this phenomenal rate of data processing in the most efficient, economical manner requires use of advanced computer technology. An advancement in computer architecture which holds great promise to fulfill this requirement is "parallel" or "associative processing."

An associative processor (Figure 49 depicts the processor installed at Knoxville) attains magnitudes of computational speed through the use of arithmetic and logic associated with each word in its memory array. In operations, this computer memory contains the data base, and the "associative array" which permits either mathematical or logical calculations to be performed on that entire data base simultaneously. Thus, while an associative processor is slower than the standard computer, or "serial processor," in executing an instruction on a single word of data, its strength lies in its ability to perform these calculations in parallel.

In considering the implementation of an operational conflict detection function, the reliability of detecting all possible conflictions before they occur, in sufficient time to effect action to avoid the conflict, is extremely important.

It is a simple matter to achieve 100% error-free performance if no concern is paid to the number of warnings issued in which no conflict develops (false alarms). Since it becomes obvious that the false alarm rate will, to a large degree, determine the feasibility of implementing this

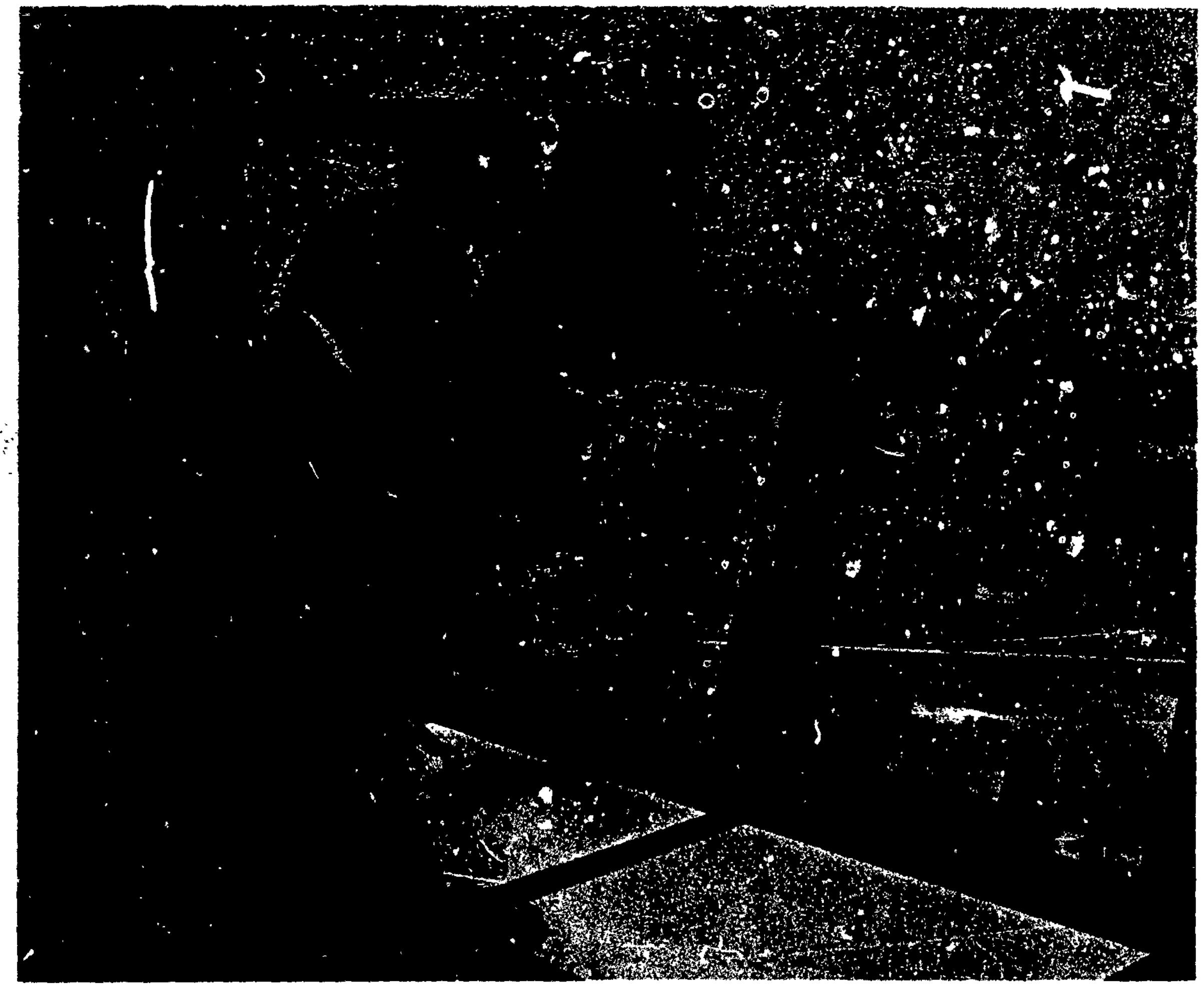

Figure 49. Knoxville Associative Processor.

function in an operational facility, then this rate must be measured against the error rate to determine an acceptable level of performance.

The false alarm/error ratio to be acceptable must be based upon the evolution of the man/machine relationship as the control function is transferred from the present semi-automated system to one which is fully automated. At the present initial stage, conflict detection must assist the system without being a detriment, and since all alerts will be displayed to this end, false alarms are a definite detriment. The emphasis on the false alarm rate would be far less critical, for example if the warnings were issued by direct computer to aircraft communication. In the Knoxville system, conflict prediction is intended to provide "another set of eyes" to back up the controller and assist him in preventing conflictions of aircraft.

For our experiments, prediction of aircraft conflictions are classed into three distinct types according to the probability of collision so that the controller will immediately be aware of the seriousness of the situation. The types are not sequential in the sense that a conflict situation can become progressively worse and the controller will be alerted more than one time for a situation.

Type I is concerned with confliction between aircraft under air traffic control. As such, the warning miss distance is three miles separation after projecting the flight paths 60 seconds into the future. Altitude information is either incomplete, that is, both aircraft do not have Mode C transponder, or is complete and indicates less than 500 feet vertical separation

The display of Type I confliction must be sufficient to alert the controller and get his attention, but not be excessively distracting. To accomplish this, a line will be displayed above the aircraft identification of the targets. This line, or "alert bar," will blink for three scans, then remain on until the conflict is no longer predicted.

Types II and III conflictions are primarily concerned with providing a warning that an aircraft not under air traffic control, an "intruder," will seriously conflict with a controlled aircraft. The warning is issued if the miss distance is one mile or less when the flight paths are projected 60 seconds into the future. The difference between Types II and III is the availability of altitude information; that is, incomplete altitude data will display Type II, and complete data with less than 500 feet vertical separation will display Type III.

Type II then is normally the situation in which a traffic advisory is issued. The alert will be the bar over the flight identification and a vector indicating point of conflict, both of which will blink for three scans.

Type III is the worst case condition which requires immediate attention and action because a collision must be avoided. In this case, all alphanumeric display is erased except for the data showing the confliction. The controller has only to depress two buttons to regain the display of all data, so that the manual action required is minimal. Figure 50 depicts the criteria being evaluated.

The target tracking performed at Knoxville is radar reinforced beacon tracking, with all beacon targets being tracked. In addition to tracking for display purposes, refined methods of detecting target turns and altitude tracking are employed to support the conflict detection function.

PREDICTION AND DISPLAY

TYPE	TARGETS	MISS DIST	MODE C	DISPLAY
I	Both Controlled	3 Mi	Incomplete or Less than 500'	N12K 42 18 E N1515P 15 W
II	One Controlled One Non-Controlled	1 Mi	Incomplete	1000 26 + DL819 21 W
III	One Controlled One Non-Controlled	1 Mi	Less than 500'	1100 25 23 * AA251 22 19 W

Figure 50. Prediction and Display Criteria.

Conflict resolution is concerned with eliminating false alarms, providing a stable display by smoothing the vector lines, and generating suggested control actions to resolve the conflict. The first two parts will become part of the operational usage of the system since the reduction of false alarms and a stable display are needed to perform this function. The generation of suggested actions to resolve a confliction will provide data for future use, because insufficient information is available to implement that function in the Knoxville system.

Another element of the program, Figure 51, is an automatic VFR advisory service, completely independent of the controller. By installing voice synthesis equipment on the ground, an aircraft who wants service can receive the VFR advisory information directly from the computer, thus having this service provided without major equipment installation into the aircraft. This will also relieve the controller of that "additional service" permitting him to concentrate on his IFR traffic. Such a system will be a major step forward in the man/machine relationship because both man and machine will be performing services to aircraft in a compatible environment, side by side.

Development of techniques and software to perform the required functions in a ground based environment will be conducted at an FAA test facility. Software will be tested and evaluated in a simulated operational environment with redesign and retest iterations as required. As design development and validation stages progress, software specifications will be provided and hardware recommendations will be made for implementation of functional packages at prototype operational facilities for test, evaluation, refinement, and demonstration.

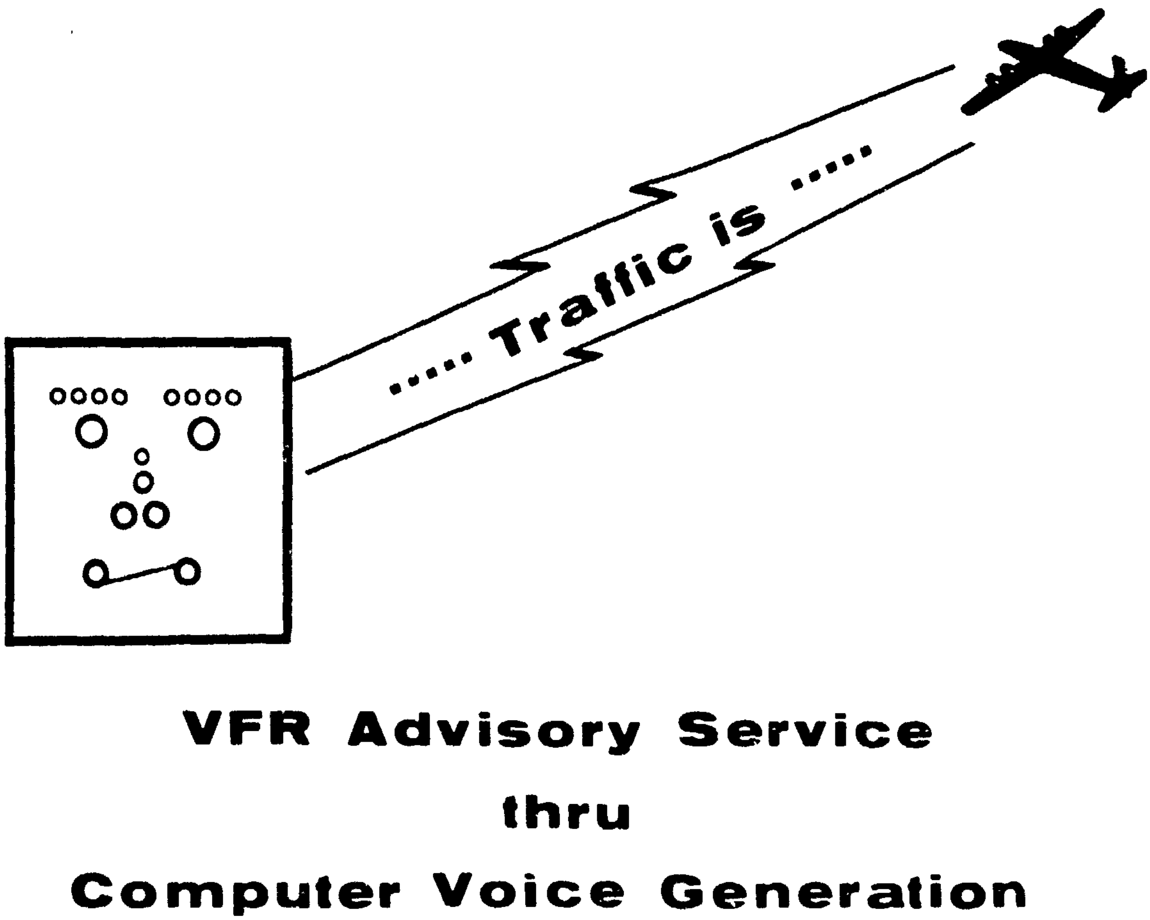

Figure 51. VFR Advisory Service.

PROGRESS.

An SRDS demonstration and technical evaluation of a conflict detection and resolution program was conducted at the Knoxville, Tennessee TRACON in December 1971. Data for the completion of the technical evaluation has been collected by UNIVAC under FAA contract, and a contractor report of the evaluation results is expected in February 1972

A contract has been awarded to demonstrate and test an automated voice traffic advisory and terrain avoidance service for visual flight rules (VFR) traffic. The automated voice feature is provided through the use of a voice synthesis program. The demonstration is scheduled for 19 April 1972 to be followed by a six weeks' test period.

TREND.

The following additional major events are expected to be accomplished within the next year to demonstrate and test further automated features.

1. FAA contract awarded for further ARTS III enhancement–9/72.
2. Report issued by contractor–6/73.

SUBPROGRAM.

Conflict Control/IPC, 142-174.

MANAGER.

Ricardo Cassell, RD-151

APPLICATION OF AUTOMATION TO LOW DENSITY TERMINAL/TOWER

BACKGROUND.

This effort is aimed at providing a low cost programmable ATC automation system for low density terminal facilities.

The need for continuous alphanumeric identity and altitude data on the controllers' radar display was recognized by the "Project Beacon Report," and the "Design for the National Airspace Utilization System," both of which recommended that the Air Traffic Control System should be automated to provide this capability. To implement this system for controlling air traffic in the terminal area, a prototype system was developed, installed and appraised at the Atlanta, Ga. terminal. Based on this appraisal and subsequent E and D studies, a modular programmable system was developed known as the Automated Radar Terminal System (ARTS III). To meet the demands of low activity towers and TRACONs, low cost components to provide automation capabilities are being developed by SRDS/Contractor and will be installed and evaluated by FAA at Wilkes Barre/Scranton Tower. In addition, this system will make it possible to remote alphanumeric data (derived from an ARTS or Common Digitizer location) to a satellite tower where the information will be displayed on a standard BRITE display (Figure 52) "Alphanumeric Modification to BRITE Display." Remoting techniques will be field tested and evaluated as a part of this subprogram.

An important aspect of the programmable system is that it provides an automation base which can be modularly expanded to meet increases in air traffic. The subsystems are expandable to the basic ARTS III level and are interchangeable with ARTS III components if it is necessary to expand to higher levels.

A Beacon Non-Tracking System is, at present, considered to be the initial level of automation and would be used to automate low density radar terminal facilities. This beacon non-tracking level system provides all information now presented on the existing broadband and beacon systems and also provides alphanumeric data on the controller's display. The data is in the form of alphanumeric tags adjacent to beacon targets (Figure 53) "Time Shared PPI Display" and provides actual aircraft identity (for 4096 beacon equipped aircraft) and Mode C altitude. Alphanumeric tags are prepared and displayed only for beacon targets under the jurisdiction of the terminal facility. In addition,

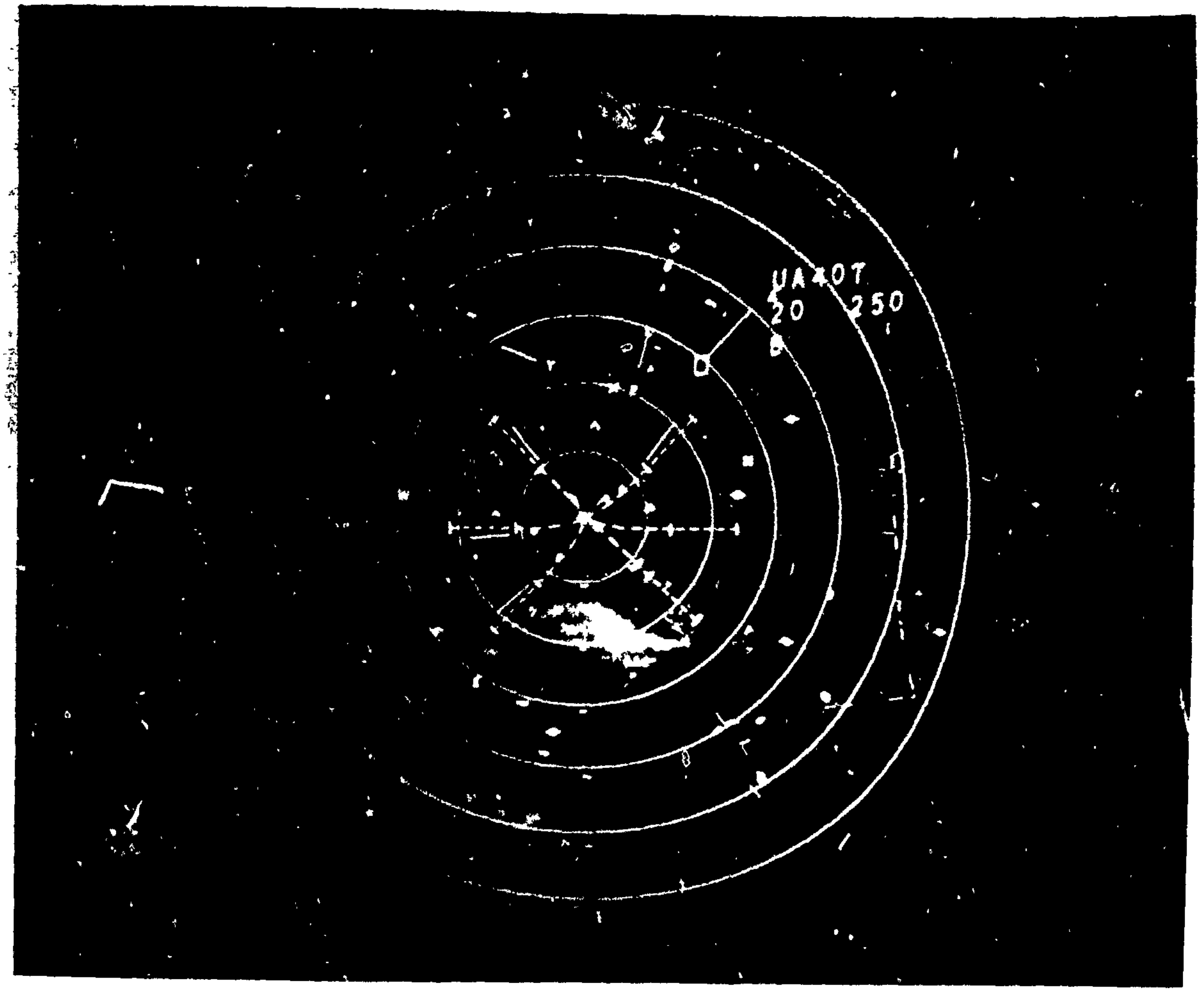

Figure 52. Alphnumeric Modification to Brite Display.

tags are presented only to that particular display(s), within a facility, which is controlling the aircraft. Other alphanumeric data is used to construct tabular displays providing information such as altimeter settings and clock time. A preview area on the display is provided which is used by the controller to verify entries made into the system.

The system provides many functions through manipulation of the data.

The major functions include:

1. Intrafacility handoff capability which transfers tags from one operating position to another within the terminal.

2. Quick-look capability which permits one position to look at alphanumerics displayed at another position.

3. Manual repositioning of tags to avoid display clutter.

In addition, controls enable the controller to eliminate fields in the tags, manually drop data and to otherwise tailor the physical presentation (intensity of targets-alphanumerics, operating range, and offset) to his requirements. There is also the capability to replace the beacon slashes with special symbols. Interfacility handoffs to adjacent automated facilities shall also be possible.

The low cost automation system is designed for use in either the TRACON with time shared PPI displays or the TRACON with BRITE displays modified for alphanumeric capability. The system shall include remoting capabilities

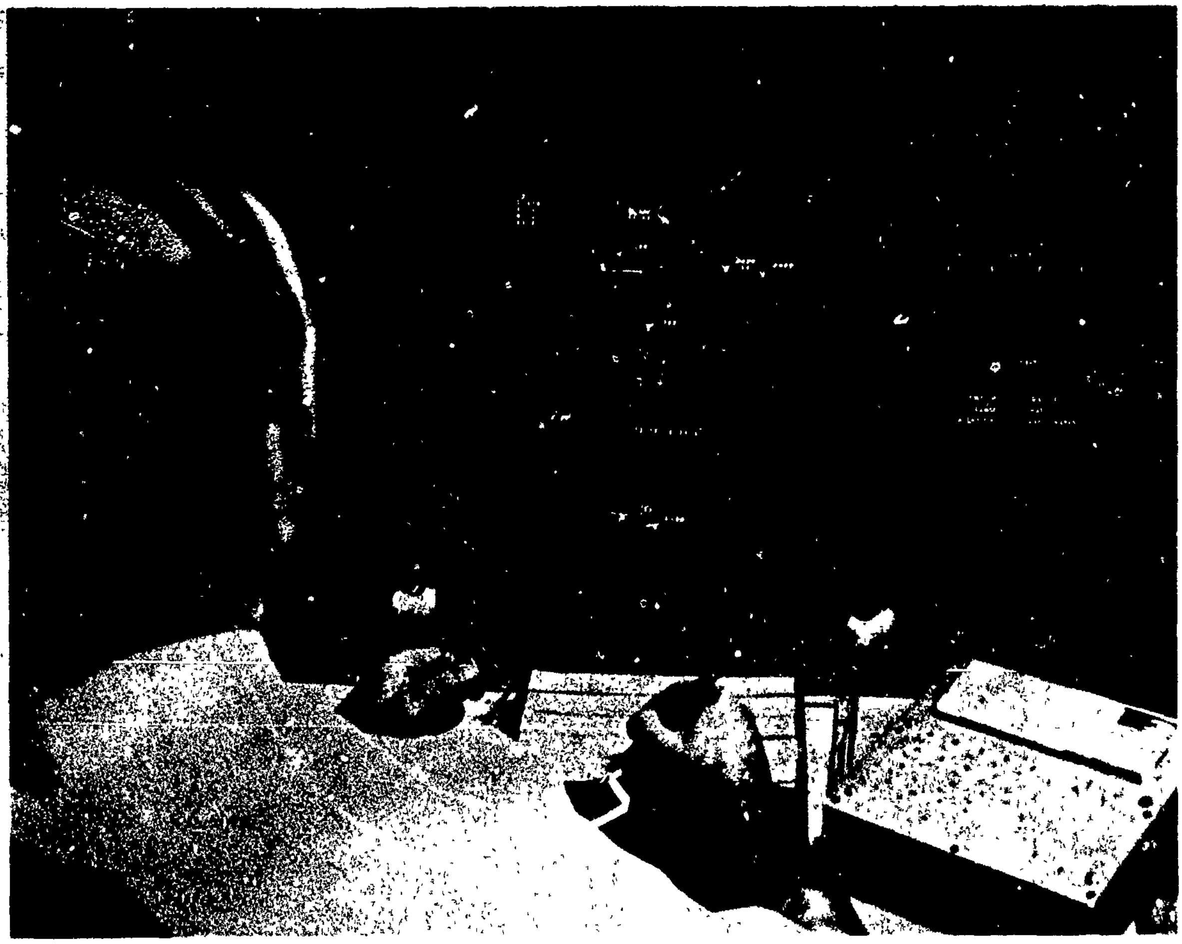

Figure 53. Time-Shared PPI Display.

where digitized radar/beacon information is provided to non-radar satellite airports for presentation of alphanumeric data on the BRITE display. Remoting techniques to be employed are TV Microwave link and narrow band telephone lines.

Benefits.

The following benefits will be obtained from the system:

1. A more efficient, safer air traffic control system.
2. Improved data display for the controller.
3. Intrafacility and interfacility data transfer.

Cost Savings.

1. The modular concept permits each system to be tailored to the immediate and future needs of each facility.
2. The use of standardized subsystem components and interfaces permits full interchangeability and compatibility, with resultant savings in logistics, training and other support items.
3. The use of low cost high performance mini-computers.

PROGRESS.

1. Alphanumeric BRITE display evaluated by FAA/SRDS/Atlanta Region.

2. Time-shared PPI display evaluated by FAA/SRDS/Atlanta Region.

3. ARTS II System using non-standard components operationally evaluated at Knoxville, Tennessee by FAA/SRDS/Region.

4. ARTS II report published by SRDS.

5. RFP for low cost system issued by FAA.

6. Contract award in progress.

TREND.

The following major milestones are scheduled for completion:

1. FAA two-month field evaluation of basic TRACAB Alphanumeric System, assessment of software and hardware–11/72.

2. FAA contractor begin field evaluation of remote BRITE's with alphanumerics–12/72.

SUBPROGRAM.

Application of Automation to Low Density Terminal/Tower, 142-175.

MANAGER.

Nathan Aronson, RD-122.

15 WEATHER PROGRAM

GOAL.

The purpose of this Program is to improve and modernize data acquisition and collection; improve aviation weather information processing and dissemination; and develop devices and improved techniques in coordination with Departments of Defense and Commerce.

SCOPE.

These engineering and development efforts are organized under two Program Elements: 151–Data Acquisition; and 152–Data Processing and Distribution.

In the FY 72 Technical Program, these efforts are covered in the following subprograms.

151-261 Sustaining Engineering for Aviation Weather Devices,* Subprogram Manager, Edward J. Fischer, RD-261.

151-262 Visibility and Ceiling,* Edward J. Fischer, RD-261.

151-263 Clear Air Turbulence (CAT) and Severe Weather, Edward Fischer, RD-261.

151-264 Wind Shear and Representative Wind,* Kenneth A. Kraus, RD-262.

151-265 LAWRS (Limited Aviation Weather Reporting System) and Automation, Alcott J. Larssen, RD-261.

152-261 Improved Aviation Weather Forecasting for NAS,* Arthur Hilsenrod, RD-262.

152-262 Annotation of Hazardous Weather to Controller,* J. G. Gamble, RD-262.

The following selected* major subprograms are highlighted in terms of Background, Progress, and Trend (major events scheduled for completion):

SUSTAINING ENGINEERING FOR AVIATION WEATHER DEVICES

BACKGROUND.

The purpose of this engineering and development effort, in response to Form 9550-1, Request SMS-67-3, 29/11/66, "Design Test Instrument for Use with Transmissometers" and Report of the United States Delegation to the International Civil Aviation Organization (ICAO), Fifth Air Navigation Conference, Montreal, Quebec, Canada, 14/11 through 15/12/67, "Aircraft Operational Requirement No. 2–Surface Wind Information," is to improve, through test and evaluation, weather sensing equipment.

Instrumentation in the air traffic control tower should provide maximum information to the air traffic controller with a minimum amount of distraction. Fluctuating pointers on dials are difficult to read, time consuming to interpret, and may vary in accuracy because of inherent errors of pointer-scale relationship.

Figure 54 shows an altimeter setting indicator as is presently used in many air traffic control towers.

Figure 54. Altimeter Setting Indicator (Circular Dial-Needle Readout).

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This instrument provides the air traffic controller with values which he transmits to the pilot to enable him to correct his altimeter to meet local barometric conditions. Typical needle-scale reading problems exist.

One of the purposes of this effort is to develop the equipment necessary to present weather information in a digital format to provide controllers with more time in the performance of their primary functions to insure safety and efficiency of air traffic control. The panel on which this information is presented has expansion capability to include other weather parameters such as wind direction, wind speed, peak wind, air temperature at the runway, dewpoint or runway visual range values, and digital readout of time. Investigation of other techniques of measuring and displaying these parameters to improve instrumentation and effectiveness of the sensing and display equipment is included.

PROGRESS.

1. Contract and preliminary tests completed on a developmental model of a Transmissometer Calibrator utilizing a laser technique and required design changes were initiated 1/72.

2. A visibility test bed has been established at NAFEC, Atlantic City, which will provide facilities for comparative visibility measurement utilizing equipments employing different techniques or test of those equipments utilized by foreign countries frequented by U.S. air carriers.

3. NAFEC procurement initiated for representative types of commercially available digital barometric pressure indicators to investigate suitability and practicality for adaptation as altimeter setting indication.

4. Development completed by NAFEC on a Remote Runway Light Setting Indicator Panel which will advise the Air Traffic Controller of the light setting intensity setting at which the reported Runway Visual Range is computed.

5. NAFEC conducted evaluation of the adjustment of the Kollsman type Altimeter Setting Indicator (ASI). It included an in-depth review of agency and National Weather Service handbooks related to ASI and actual testing in an altitude chamber.

A procedural summary for installation, monitoring and adjusting ASI devices was recommended by NAFEC to the operating services as a result of this investigation.

TREND.

The following major events are expected to be accomplished:

1. Documentation prepared by NAFEC analyzing existing aviation weather devices utilized in the U.S. from the viewpoint of technical characteristics, siting and installation criteria, reliability data, and cost of procurement, installation, and maintenance–4/73.

2. Two RVR systems installed in the test bed at NAFEC will continue to be used as test and control standards to evaluate proposed modifications for operational suitability and new type visual range measuring equipment.

3. All barometric pressure devices delivered to NAFEC for test and evaluation–6/72.

4. NAFEC analysis of data comparing dual baseline transmissometer with existing system completed–6/72.

5 Transmissometer Calibrator tests completed by NAFEC–7/72.

SUBPROGRAM.

Sustaining Engineering for Aviation Weather Devices, 151-261.

MANAGER.

Cdr. Edward J. Fischer, RD-261.

PROJECT MANAGERS.

Morris Ritter, NA-523; F Schlatter, NA-523; and B. Weinstein, NA-523.

VISIBILITY AND CEILING MEASUREMENT

BACKGROUND.

This effort is in response to FAAR 5335.1, "Visual Range Measurements," dated 27/10/67, relating to Slant Visual Range (SVR), Taxiway Visual Range (TVR), and Runway Visual Range (RVR), particularly for values for Category II and Category III all-weather operation, and a 9550-1 Request for Engineering and Development from Office of General Aviation "Remote Weather Watchers", GA-71-1, dated 25/9/70.

Ceiling and runway visibility data are provided by two different systems. A ceilometer shown in Figures 55 and 56 provides the user with an indication of ceiling conditions.

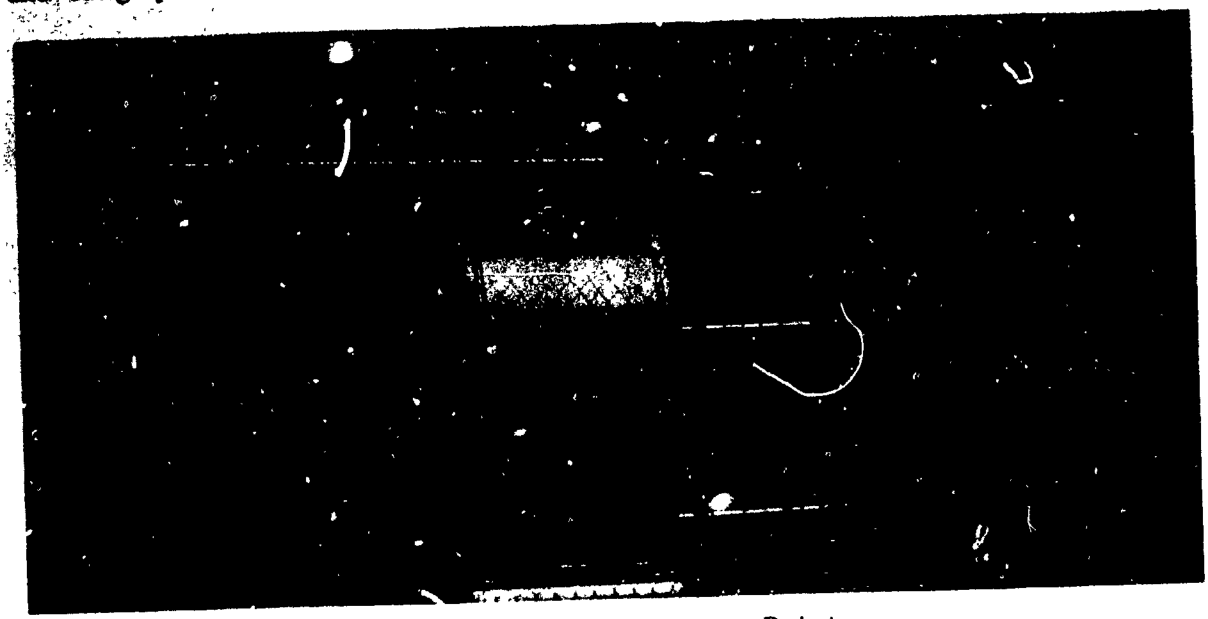

Figure 55. Rotating Beam Ceilometer Projector.

Figure 56. Rotating Beam Ceilometer Detector.

As assessment of the horizontal distance that a pilot may see down the runway is provided by a transmissometer system. This system consists of a projector as shown in Figure 57 with a detector unit located either 250 feet or 500 feet away. This distance is shown as the baseline

When provided with associated signal data conversion equipment (Figure 58), the transmissometer furnishes RVR values for day and night conditions and three values of high intensity runway light intensities.

Two RVR systems are currently in use, one operating on a 250-foot baseline, the other operating on a 500-foot baseline. The older 500-foot baseline system reports RVR values down to 1,000 feet. The newer system installed on a 250-foot baseline reports values down to 600 feet.

All current installations are being established on a 250-foot baseline. Transmittance measurements derived by the transmissometer are fed to

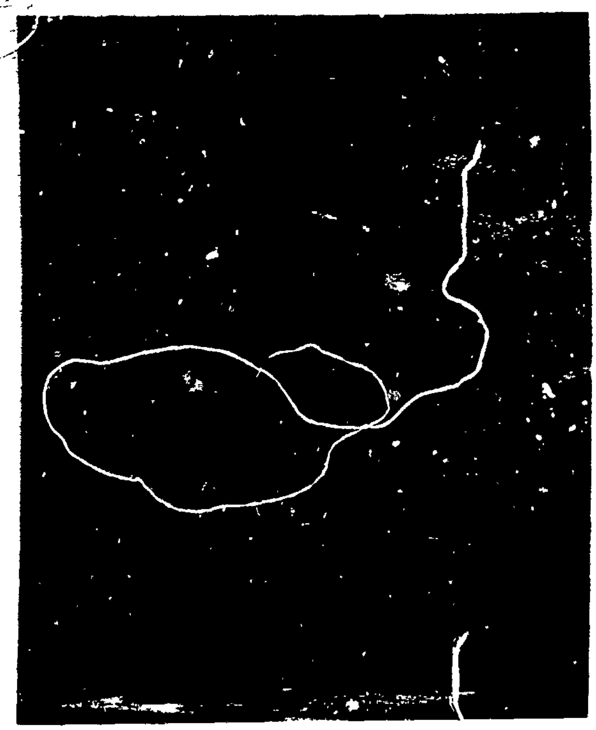

Figure 57. Transmissometer Projector.

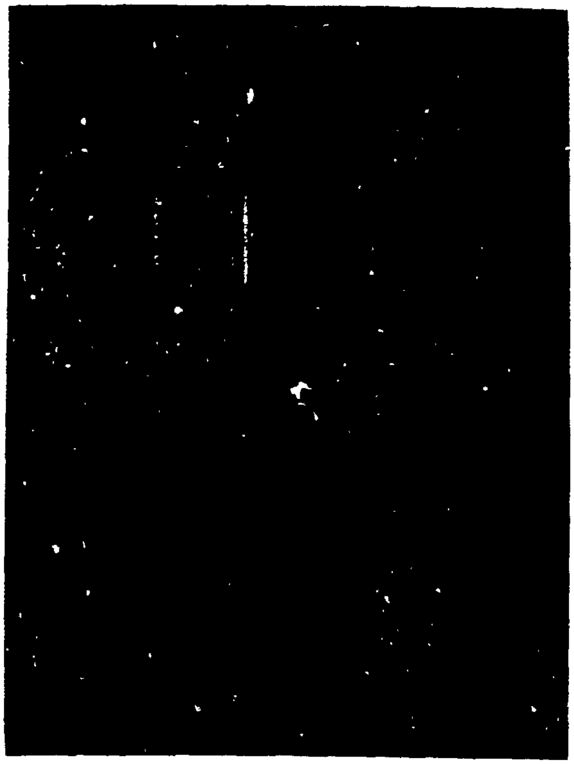

Figure 58. Runway Visual Range Signal Data Converter.

a Signal Data Converter. This Signal Data Converter System develops RVR values from information derived by the transmissometer, day-night switch, and edge light setting. Figure 58 (left to right), shows Rack 1 with two signal data converters, computer selector, and runway light chassis; Rack 2 with two signal data converters, receiver decoder; and Rack 3 with two display panels, recording millimeter, and transmissometer indicator.

The purpose of this subprogram is to select an operational system which provides representative and accurate measurements of ceiling and visibility particularly for Category II and Category III operation. Typical values to be reported are RVR, SVR, and TVR.

The following are some typical problems to be solved:

1. Investigate visibility measuring techniques which will lead to a system for measuring and reporting any one or all of the following visual ranges: RVR, SVR, TVR The system shall report values of 0 to 6,000 feet. Recommendations shall include techniques which will be state-of-the-art in the 1970-1980 period and become economically feasible for production and use in 1980 and beyond. The system shall report RVR, SVR, and TVR values ki...s and intensities of light targets under varying conditions of background brightness. Direct transmission of information to the aircraft and cockpit display characteristics are to be considered in addition to monitoring capability by the air traffic controller.

2 In addition to the above which is considered a long-term program, a shorter term effort will provide a measurement of slant visibility utilizing equipments and techniques which are available as installed equipments or as equipments which are readily available "off-the-shelf." This effort is concentrating on developing a technique which will advise the pilot as to what length of segment of approach lights will be visible to him at a decision height of 100 feet or alternately to report at what height he will see and continue to see a 500-foot segment of approach lights.

3. Conduct an investigation to determine the most practical means of reporting RVR data under condition of Category III operations.

4. Establish a meteorological facility consisting of two towers to be utilized in the measurement of slant visibility and horizontal visibilities at various heights.

5. Investigate a technique for describing the state-of-the-sky through automatic means.

6. Establish a data base for the development of new visibility measuring system.

7. Investigate a technique to remotely monitor the weather in certain mountain passes frequently used by the general aviation pilot.

PROGRESS.

1. Report TSC-FAA-71-1, "Visual Factors in the Detection of Point Sources from Aircraft" released.

2. Report TSC-FAA-71-25, "Visibility Concepts and Measurement Techniques for Aviation Purposes" released.

3. Report TSC-FAA-71-18, "Proposed Control Tower and Cockpit Visibility Readouts Based on an Airport-Aircraft Information Flow System" released.

4. Report FAA-RD-71-25, "Analysis of Techniques for Describing the State of the Sky Through Automation" released.

5. SRDS Memorandum Report, "Ceiling Measurement Devices and the Rotating Beam Ceilometer," released as a reprint.

6. The contractor test program to provide a pilot with Slant Range Visibility is continuing. The modeling phase defining the candidate system completed 2/72.

7. SRDS FAA contract awarded to evaluate closed circuit television equipment which will monitor visibility conditions in selected mountain passes.

8. An engineering model has been developed at the Transportation Systems Center (TSC) for a laser device which will be utilized in visibility measurements using backscatter techniques. The device shown in Figure 59 provides three different modes of laser operation and one receiver. Associated instrumentation utilized in making and observing the backscatter measurements is also shown.

9. Visibility measuring device utilizing forward scatter techniques received at NAFEC, 8/72.

10. Lynx Runway Visual Range Equipment delivered at NAFEC for test evaluation and comparative measure purposes, 2/72.

11. Frungel dual baseline transmissometer equipment final installation at NAFEC initiated January 1972 as a preliminary to test and evaluation purposes and comparative measurement.

12. SRDS initiated procurement action to obtain Marconi Runway Visual Range equipment for test and evaluation by NAFEC and comparative measurements.

13. SRDS initiated specifying test of cloud-based height equipment suitable for automation.

TREND.

The following major milestones are scheduled for completion:

1. SRDS development of specification for a compatible RVR system made up of interchangeable building blocks to permit system expansion without obsolescence prepared, 6/72.

2. An experiment to remotely monitor the weather in a mountain pass frequently used by the general aviation pilot, initiated by SRDS, 9/72. The experiment uses a television camera which scans the weather in the selected pass. The picture is converted to a digital signal and sent via ordinary telephone lines to the nearest flight service station (FSS), converted again and monitored on an ordinary TV screen. The FSS specialists then disseminate this information to the pilot, either by telephone inquiry or radio as required by the user.

3. Testing of a candidate SVR system utilizing off-the-shelf equipment at the NAFEC Stable Meteorological Tower (Figure 60) initiated, 9/72.

4. Test, evaluation, and comparative measurements of various types of Runway Visual Range equipment continued at NAFEC.

5. Development of an automated system for measuring visibility and defining the cloud cover, initiated by SRDS, 6/72.

6. Initial phases of procurement action to result in development of a compatible RVR system, initiated by SRDS, 7/72.

7. Continuation of development by SRDS/TSC of visibility measuring equipment for 1980 and beyond.

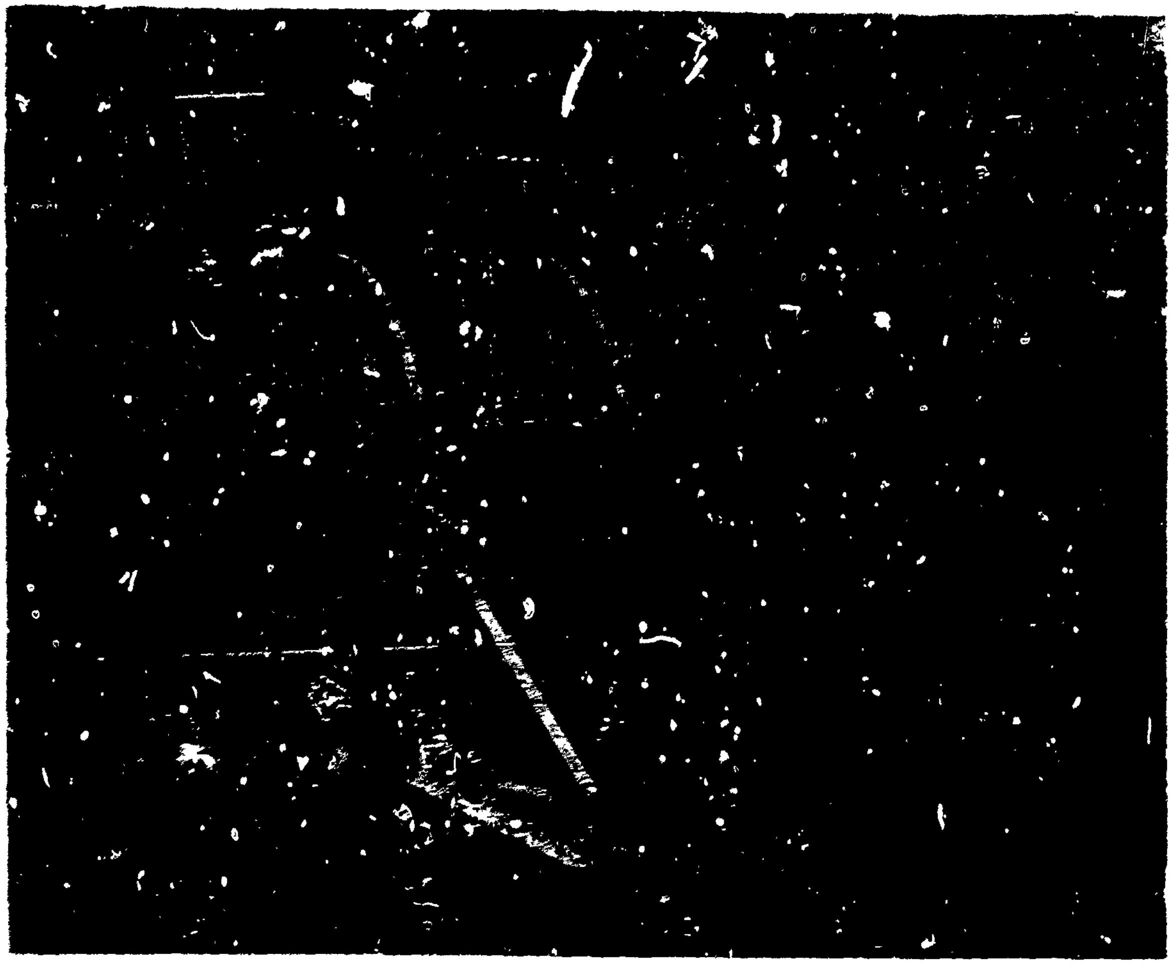

Figure 59. Engineering Model of Laser Backscatter Visibility Measuring Device Utilizing Three Modes of Operation.

SUBPROGRAM.

Ceiling and Visibility System. III. 151-262.

MANAGER.

Cdr. Edward J. Fischer. RD-261.

PROJECT MANAGER.

E. Schlatter. NA-523.

WIND SHEAR AND REPRESENTATIVE WIND

BACKGROUND.

Wind shear and representative surface wind at the airport are recognized as pertinent and essential information necessary for safe and efficient airport operations. The purpose of this effort is to develop a system to provide critical wind and wind shear information. This is in response to a stated requirement by the operating services, and documented in the Annual Letter on Aviation Operational Meteorological Requirements, which is sent by the Secretary of Transportation to the Secretary of Commerce.

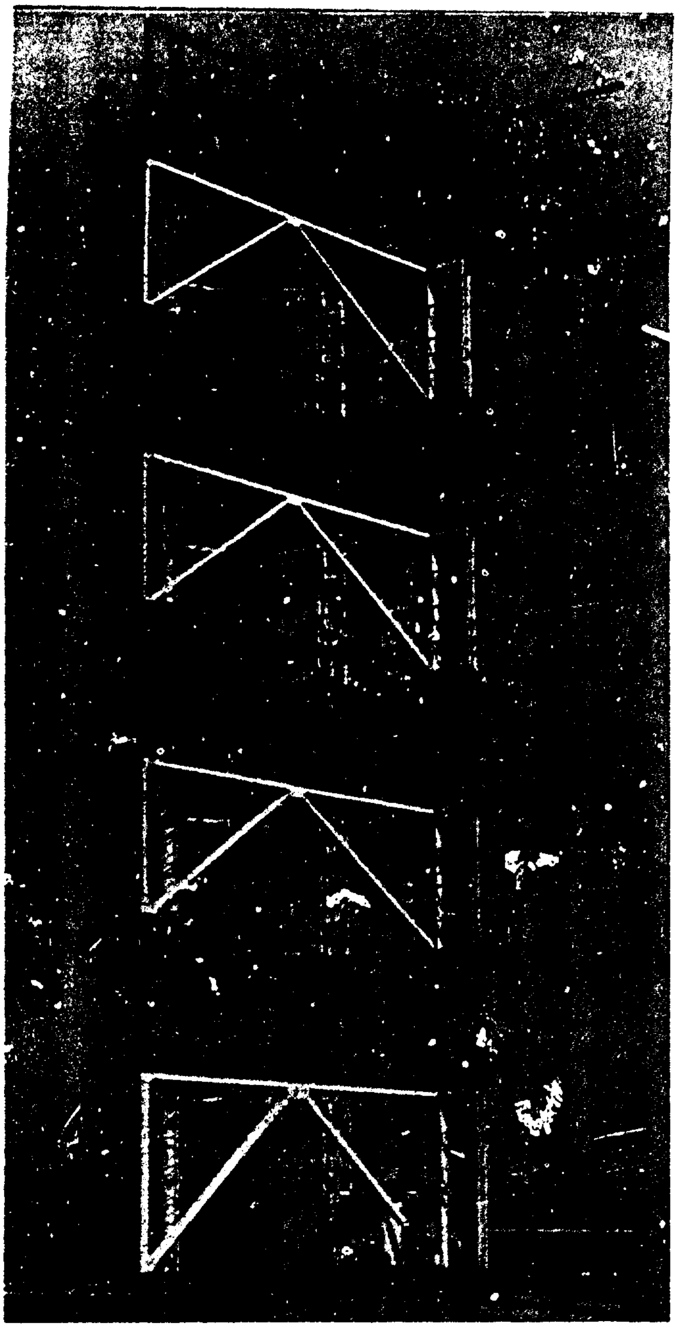

Figure 60. Stable Meteorological Tower.

Under most instances the low level wind environment does not present a problem for the operation of today's aircraft. Even so, there must be a concern for the occasional wind event that does present itself as a problem in the control of the aircraft. This is becoming more true with the increased requirement for design precision and demand for maximum utilization of aircraft and facilities. Knowledge of the limits of the extreme values is not presently available nor the observation capability to determine when the extreme situations are occurring.

Aside from the safety aspect, there is also a significant influence on airport capacity caused by wind shear and turbulence. Aircraft missed approaches as well as aircraft deviations from prescribed courses will cause reduction in the airport acceptance rate. As acceptance rates are increased through improved technical capabilities, the wind shear and turbulence effects must be considered as critical to the system design.

The ability to measure wind shear and to determine the representative wind for relay to pilots will provide important information necessary for the safety of aircraft operations. Air traffic controllers will use the low level wind data to inform pilots of landing conditions and as an important factor in the selection of the best active runway. The results of this program will provide a system that will measure and display the wind environment representative of the wind that will interest with aviation operations.

PROGRESS.

A statement of work has been completed by SRDS and an Interagency Agreement initiated with the National Oceanic and Atmospheric Administration (NOAA) to accomplish the initial phase of the work.

TREND.

1. The following major events are scheduled for completion:

2. Interagency Agreement with NOAA executed–6/72.

3. Experimental System Delivered–4/73.

4. Experimental System Airport Operation Test by NOAA–8/73.

5. Report Issued by NOAA–10/73.

6. Developmental System Delivered–12/74.

7. Operational Test of Total System by Industry–2/75.

8. Report Issued by Industry–4/75.

SUBPROGRAM.

Wind Shear and Representative Wind, 151-264.

MANAGER.

Kenneth A. Kraus, RD-262.

IMPROVED AVIATION WEATHER FORECASTING

BACKGROUND.

Improved weather forecasts, terminal and enroute, will improve the efficiency of the NAS. FAA has stated requirements to the Department of Commerce for provision of aviation terminal forecasts for all terminals with sufficient activity to qualify for a control tower, for improved forecasts of clear air turbulence, wind and temperature for enroute aircraft operations.

Although weather forecasts are provided by the National Weather Service (NWS), it is FAA's responsibility to provide the engineering and development funds to develop improved forecasts unique to aviation, e.g., terminal wind, ceiling and visibility, storm and clear air turbulence, icing.

Statistical terminal forecasts, known as single station REEP forecasts, based on the analysis of historical weather observations at a single terminal are being developed for 150 stations under an agreement with the NWS. These probability forecasts for 3, 6, 9, 12, and 15 hours after the time of observation have been found to assist the forecaster to improve his forecast.

Improved terminal forecasts using physical–mathematical models of the atmosphere, which have become increasingly accurate and detailed, are also being developed under this agreement. This technique development is expected to improve forecasts for terminal winds in addition to improving ceiling and visibility forecasts.

Another major phase of the agreement is directed towards improving the production of the occurrence, intensity and motion of thunderstorms and severe weather for periods of 30 minutes to 24 hours.

PROGRESS.

REEP single station forecasts have been developed by NWS for 32 terminals. For 20 of these stations improved forecasting techniques are also being developed using the physical-mathematical models for comparison with the single station REEP technique. The comparison and integration of techniques are expected to result in significant improvement in terminal forecasts.

The following developments can be expected to improve the forecast of severe storms:

1. Improvement of atmospheric models for forecasting storms.
2. Extrapolation of digitized radar and severe storm pattern recognition of radar data.
3. Transmission of stability factor from the National Meteorological Center to local forecasters for their application of these factors in the forecast of severe storms.

Under a separate agreement with the FAA, the NWS conducted an investigation of techniques for automated forecasting of clear air turbulence (CAT). This technique was the follow-on phase of previous work done by Stanford Research Institute for the FAA.

Tables were developed which could be used in an automated system to specify the probability of CAT. The final report for this project is completed.

The following technical reports have been published:

1. "Development of Base Techniques for Ceiling and Visibility Prediction" 2/70, Report–FAA-RD-70–22.
2. "Single Station Prediction of Ceiling and Visibility," 4/70, Report FAA-RD-70-26.
3. Predicting Ceiling and Visibility with Boolean Predictors," 5/70, Report FAA-RD-70-37.
4. "Regression Estimation of Surface Winds," 6/70, Report FAA-RD-70-42.
5. "Developing Techniques for Automated Forecasting of Clear Air Turbulence" 12/71, Report FAA-RD-70-102.

TREND.

The following major events are scheduled for completion under the agreement with the National Weather Service:

1. Completion by NWS of remainder of prediction equations for 150 terminals based on REEP techniques–2/73.
2. First interim report by NWS following preliminary test on improved prediction techniques–2/73.
3. Development by NWS of interim short-period forecasts of severe storms–2/73.
4. Development by NWS of interim equations for predicting severe weather probability–2/73.

SUBPROGRAM.

Improved Aviation Weather Forecasting for NAS, 152-261.

MANAGER.

Arthur Hilsenrod, RD-262.

ANNOTATION OF HAZARDOUS WEATHER TO CONTROLLER

BACKGROUND.

The requirements for this effort are contained in FAAR 6420.1 dated 10/10/66, for the provision of weather information on the air traffic controllers operational radar display, and in 9550-1 Request from Air Traffic Service, "Evaluation and Development of Meteorological Support System for the ATC Systems Command Center," 19/10/71.

Air traffic controllers in enroute and terminal air traffic control facilities require information on the existence, present location, and future movement of certain weather phenomena which are of sufficient intensity to be potentially hazardous to aircraft operating in or near airspace containing such weather elements, which include tornadoes, thunderstorms, hail, icing conditions, heavy precipitation, and both convective and clear air turbulence. This information is required either on the controller's operational display or on another display in a manner so that it may be used in conjunction with the operational display, to either vector aircraft around such areas, or to track aircraft operating in these areas. The requirement has been accentuated by the provision of circular polarization (CP) capability which eliminates much of the radar return from weather. Additionally, the weather returns from FAA radars presently can not be interpreted to delineate tornadoes, hail, icing conditions, or degree of turbulence, and FAA controllers are not trained in weather interpretation. A system is required to obtain such interpretation and delineation of appropriate areas from the National Weather Service (NWS) and forward to the NAS ATC system in a manner that will allow real-time correlation with ATC operational displays, and allow maximum utilization of airspace with increased safety.

However, in enroute areas with high traffic density, the existence of recognizable severe weather such as thunderstorms hinders air traffic control, because pilots request special vectoring service, or, on occasion, make random unannounced deviations of their own. Thunderstorms in high density areas often require consolidation of ATC sectors and implementation of flow control measures to reduce the volume of air traffic to that which can be safely accommodated. Consolidating ATC sectors and implementing flow control measures require advance warning. It has been determined that a meteorologist provided with adequate real-time meteorological radar information can assist in the provision of such warning for one enroute air traffic control center and satisfy a critical local need. However, the creation of even a part-time meteorological staff together with the necessary communications and weather radar support would be costly, and coordination problems would still exist.

The ATC Systems Command Center at FAA Headquarters has an existing meteorological staff. A requirement has been stated to explore and test the capability of using this meteorological staff to provide a centralized service through an augmented and improved meteorological data system. The scope of effort is limited to the Boston, New York, Cleveland, Indianapolis, Chicago, Washington, Atlanta, Jacksonville and Miami Center areas. It is desired that the first improved configuration be in place and tested by September 1972, with a final configuration completed not later than July 1974.

PROGRESS.

FAA ATS determined that the provision of NWS weather radar data in real time to the meteorological staff of the ATC Systems Command Center is urgently required to undertake the desired test. FAA procurement action has been initiated for the equipment necessary to provide the ATC Systems Command Center with real time weather radar information through facsimile recorders from the majority of the weather radars in the test area, and it is expected that the test will begin in April 1972.

TREND.

The following major events are scheduled for completion:

1. SRDS test of interim ATC Systems Command Center System completed–9/72.
2. FAA contract award for test of digitized weather radar data in a Flight Service Station–10/72.
3. FAA contract award for system design for Enroute Air Traffic Control Center–1/73.
4. FAA contract award for system design for ATC Systems Command Center–1/73.

SUBPROGRAM.

Annotation of Hazardous Weather to Controller, 152-262.

MANAGER.

Joseph G. Gamble, RD-262.

16 TECHNOLOGY PROGRAM

GOAL.

The purpose of this Program is to provide support for the ATC system concept development; advanced subsystems development; engineering and development to solve current system problems; conduct of studies and experiments related to application of new technology; assist in design decisions in tradeoff areas; and support FAA participation in OST fourth generation system design.

SCOPE.

This Program is organized under two Program Elements: 161–System Application and 162–Subsystems Development.

The FY 72 Technical Program includes the following subprograms:

161-601 Time Ordered Technology, Program Manager, P. J. LaRochelle, RD-630.

162-106 Advanced Computer Systems,* Don Scheffler, RD-123.

162-108 ATC System Man/Machine Interface Program, Ricardo Cassell, RD-151.

162-109 Integration Multi-color CRTS and Circuits Application, John Edgbert, RD-130.

The following subprogram is highlighted in terms of Background, Progress, and Trend (milestones scheduled for completion):

ADVANCED COMPUTER SYSTEMS

BACKGROUND.

Air traffic control data processing loads exceeding the capacity of serial type processors have been predicted by the DOT Air Traffic Control Advisory Committee for the 1975 period and beyond. This is true even with predicted technological advances in serial processors. To meet the predicted processing requirements, FAA has been investigating parallel processing techniques. Tests conducted at the Knoxville test facility using a laboratory model associative processor have been sufficiently promising that developmental effort in this area is indicated.

After evaluation of the Knoxville system is completed, an engineering model of a larger parallel processor will be procured and integrated with the expanded ARTS III terminal ATC system. Transportation Systems Center (TSC) will make an analysis of large real-time data processing system architectures and determine which one is best suited to the projected post-1975 ATC environment. A prototype system will be procured and evaluated in a simulated environment after which procurement specifications for an engineering model will be produced. Parallel with the above efforts, software support systems will be developed for the associative processor and the advanced ATC processor. Computer program efficiency analysis packages will also be developed.

PROGRESS.

SRDS/TCS initiated development of a specification for a study to determine the cost effective feasibility of integrating a parallel processor with present terminal and enroute automation systems and to specify and implement an integrated system for experimentation and evaluation.

TREND.

The following major events are expected to be accomplished within the next year:

Contract Awarded for Study of Application of Parallel Processing to Terminal Environment–8/72.

Associative/parallel processor engineering model FAA contract awarded–1/74.

SUBPROGRAM.

Advanced Computer Systems, 162-106.

MANAGER.

Donald L. Scheffler, RD-121.

PROJECT MANAGER.

Gary Wang, TSC.

17 SATELLITE PROGRAM

GOAL.

The purpose of the Satellite Program is to conduct studies of the feasibility of satellite application in the CONUS environment, define requirements and conduct system feasibility tests needed to verify proposed CONUS and Oceanic system and subsystem designs.

SCOPE.

The Satellite Program is organized under two Program Elements: 171–Analyses, and 172–Experimentation. The ATC requirements, some of which are to be met by these designs, will be developed as part of the 01-System, 12-Enroute Control, 14-Terminal/Tower Control and 10-Oceanic Programs. The preoperational portion of the satellite system is now being defined for oceanic areas under 10-Oceanic Program:

In the FY 72 Technical Program, engineering and development efforts include the following subprograms which are highlighted in terms of Background, Progress, and Trend:

171-141–CONUS Satellite System Studies.

172-142–Oceanic Satellite.

CONUS SATELLITE SYSTEMS STUDIES

BACKGROUND.

The purpose of this effort is to conduct studies to determine the feasibility of satellite application for aeronautical service in Continental U.S. (CONUS); to define and analyze concepts for satellite systems for use in the CONUS and oceanic areas; to develop a space channel simulator for use in evaluating the effect of the space links on the various concepts.

This effort is in response to the recommendations in the ATCAC Report, and the report of the ATC Subcommittee of the President's Science Advisory Committee (PSAC). Both reports recommended that FAA investigate the use of satellites in a next generation system because of their improved coverage characteristics, ability to measure aircraft altitude and capability to provide a centralized control system.

PROGRESS.

Concept definition and analysis have been conducted to provide a viable system for CONUS ATC applications. Several concepts were identified which appear to have some promise. These concepts have been documented in contractor (MITRE) reports.

TREND.

The following milestones have been scheduled for completion:

1. Concept definition and analysis continued.
2. Concept reports published as developed.

SUBPROGRAM.

CONUS Satellite System Studies and Feasibility, I, 171-141.

SUBPROGRAM MANAGER.

Francis S. Carr, RD-140.

PROJECT MANAGER.

Francis W. Jefferson, NA-531.

OCEANIC SATELLITE

BACKGROUND.

The purpose of this engineering and development effort is to conduct the experimentation to characterize the space channel to test and evaluate selected signal formats that show promise for application in Oceanic and CONUS ATC systems. The channel measurement program includes definition of multipath and scintillation effects existing in the changed.

The experimental program is being coordinated with NASA ATC related experiments. These include the Position Location and Aircraft Communication Experiment (PLACE) on Application Technology Satellite (ATS-F) and the proposed Continental Air Traffic Control Experiment (CATCE) on ATS-G. This subprogram supports the analytical work conducted under subprogram 171-141.

PROGRESS.

1. Boeing Company conducted experiments to measure L Band Channel characteristics using ATS-5. These measurements provided engieering and scientific data on the characteristics of multipath in oceanic areas. A report on these measurements is being prepared.

2. The Transportation Systems Center (TSC) conducted balloon experiments to measure multipath characteristics in oceanic and land areas. A preliminary presentation of the results was made in March 1972. A formal report, summarizing these experiments will be published this year.

TREND.

The following milestones are scheduled for completion:

1. Boeing Company experiments using ATS-5 to provide further data on channel characteristics, voice intelligibility, digital link error rates and surveillance system accuracies, continued, and report issued, 12/72.

2. Joint DOT/FAA/NASA Planning Group definition of experiments using the ATS F satellite completed 6/72.

3. Supporting activities including development of required avionics and test hardware initiated by Joint DOT/FAA/NASA Planning Group.

SUBPROGRAM.

Oceanic Satellite, I, 172-142.

SUBPROGRAM MANAGER.

Francis S. Carr, RD-140.

PROJECT MANAGER.

Francis W. Jefferson, NA-531.

18 AIRCRAFT SAFETY PROGRAM

GOAL

The purpose of the Aircraft Safety Program is to conduct engineering, development, study, test and evaluation to increase safety in civil aviation. It includes such activities as anti-hijacking, flight safety criteria, and aircraft design criteria as the basis for certification and operation, and accident reduction and prevention.

SCOPE

These engineering and development efforts are organized under four Program Elements: 181–Anti-Hijacking; 182–Flight Safety Criteria; 183–Accident Prevention; and 184–Accident Survival.

In the FY 72 Technical Program, engineering and development efforts are covered in the following subprograms:

181-721 Explosive Detectors and Concealed Weapons Detectors,* Subprogram Managers, Arthur Beier, RD-724.

182-741 Aircraft Flight Characteristics Criteria,* Jerome Teplitz, RD-741.

182-742 Flight Data Survey,* J.C. Staples, RD-742.

182-744 Agricultural Aviation Safety Improvement

182-790 Flight Characteristics Criteria–V/STOL,* Jerome Teplitz, RD-741

182-791 STOL Flight Safety Certification,* J.C. Staples, RD-742.

183-721 Systems Simulation for Pilot Training,* Ward Davis, RD-721.

183-722 Airframe and System Integrity and Reliability, Herb. C. Spicer, RD-722.

183-723 Propulsion Integrity and Reliability, W.T. Westfield, RD-723

183-724 Transport Aircraft Systems and Equipment, A.R. Beier, RD-724.

183-731 Improve Runsay Surface Traction,* R.C. McGquire, RD-733

183-741 Accidents Related to Pilot Cause/Factors, G. Hay, RD-743.

184-731 Aircraft Crash Survivability,* P.F. Castellon, RD-731

184-732 Reduction of Airframe Crashfire Hazards, P. Russell, RD-732.

184-733 Reduction of Propulsion Systems Crash Fire Hazards,* W. McAdoo, RD-732.

The following selected* major subprograms are highlighted in terms of Background, Progress, and Trend (major milestones scheduled for completion):

EXPLOSIVE DETECTORS AND CONCEALED WEAPONS DETECTORS

BACKGROUND

The purpose of this effort is to identify and exploit new applications of existing technologies which would make available improved electronic devices for both weapon and explosive detection. It includes FAA development programs, coordination with other interested government agencies and encouragement of industry to develop systems responsive to civil transportation systems' security needs.

The number and seriousness of hijacking/sabotage incidents dramatically increased to 22 hijacking attempts of U.S. airlines flights in 1968. This situation led to a decision to formally counter the threat with the formation of the FAA Anti-Hijacking Task Force. The Task Force developed and implemented a quick response system for use by the airlines on a voluntary basis. The system which incorporated the use of excess metal detectors, proved to be effective in reducing the percentage of hijacking attempts. However, in 1970 the advent of hijacking as a tool of international warfare and the use of large transports of the Boeing 474 size dictated the system be improved to provide an even more effective deterrent. To assure that the coordinated efforts of all appropriate government agencies would be directed to the problem, President Nixon appointed a Director of Civil Aviation Security in September 1970.

The historical hijacking experience dictated that development efforts be directed to improving detection of firearms, knives, and dynamite. These development efforts recognized the constraints of passenger safety, economics of the transportation system, and the requirement of minimum interference with existing airline operating practices.

PROGRESS.

1. FAA reviewed various technologies, in relationship to currently available security procedures and identified best alternatives for meeting established equipment requirements.

FAA established the following priorities, as result of the review:

Hijacking Weapon Detection

a. Magnetometers active.

b. X-ray.

Explosive Detection.

a. Fast neutron activation analysis.

b. Explosive vapor detection.

2. FAA is currently reviewing new concepts and is considering more detailed investigation on selected technologies that it had initially rejected. The FAA evaluated and rejected the following concepts:

Hijacking Weapon Detection.

a. Physiological.

b. Chemical.

c. Ultrasonics.

d. Electromagnetic radiography.

e. Nuclear activation.

Explosive Detection.

a. Explosive Tagging.

b. Inert and dog effluent detection.

3. Passive and active magnetometers for the detection of both ferrous and non-ferrous metals are now commercially available to interested airlines as excess metal detectors. A Westinghouse, active magnetometer with logic circuits was developed and evaluated by FAA. This system provided an alarm on 95% of passenger carried guns and some knives while triggering an alarm on only 5% of the commonly carried metallic items. Such performance is the best of any known electromagnetic detector and is believed to be adequate for use in the current airport security program.

4. The use of low radiation dosage X-ray equipment for detecting concealed weapons on passengers has been discontinued because there is no foreseeable federal policy for use of X-rays for this purpose. The use of X-ray for detection of concealed weapons or explosive devices in baggage has been demonstrated by FAA as technically feasible. Specific potential application of this capability is now being reviewed by FAA in relationship to the human factors scanning performance that can be achieved in an operational environment.

5. An airport operational prototype of a Fast Neutron Activation Analysis system for detection of explosives in baggage was completed by FAA at Los Angeles, Calif. The inability of this technique to discriminate between explosive nitrogen and copper and the installation requirements necessary to comply with essential operational safety considerations were not resolved. An additional development will be required to resolve these items.

6. The Illinois Institute of Technology Research Institute is currently under contract to establish the sensitivity envelope required of a vapor detection system operating as an explosive vapor detector in the air transportation system. A vapor detection system development program is planned by FAA utilizing the sensitivity requirements obtained from the IITRI effort.

7. The Fairfax County (Va.) Police are now under contract to train and provide four dogs for use in demonstrating their ability to detect explosives concealed in the airport operational environment.

TRENDS.

The following are major milestones scheduled for completion:

1. Completed technology review by Institute of Defense Analysis of promising anti-hijacking and sabotage development programs–FY 72.

2. FAA completed feasibility study of electromagnetic technique for detecting concealed weapons in baggage–FY 72.

3. FAA established position for application of X-ray to the air security problem–FY 72.

4. FAA established vapor sensitivity standards for explosive vapor detection devices–FY 72

5. FAA established vapor detection system development program—FY 72.

6. FAA completed evaluation of Fast Neutron Activation Analysis System—FY 72.

7. FAA completed evaluation of dogs as explosive detectors in the airport environment—FY 73.

SUBPROGRAM

Explosive Detectors and Concealed Weapon Detectors, IV, 181-721.

SUBPROGRAM MANAGER

Arthur R. Beier, RD-724.

AIRCRAFT FLIGHT CHARACTERISTICS CRITERIA

BACKGROUND.

The objective of this subprogram is to establish flight characteristics and handling qualities criteria for the various forms of civil aircraft in use or under consideration, to define optimum flight characteristics, to determine tradeoffs in design factors and to establish minimum standards for airworthiness certification. Individual efforts are undertaken in response to specific request from Flight Standards Service including:

FS-100-68-88, FAR 23 Flight Characteristics Requirements.

FS-100-69-100, Flight Characteristics Criteria for Large Jet Transports.

FS-100-69-101, Derivatives for Calculating Gust Loads.

FS-100-69-102, Flight Characteristics Criteria for STOL Aircraft.

FS-100-71-114, Tentative Airworthiness Standards for Power-Lift-Transports.

FS-100-71-166, Stability Criteria for Large Transport Aircraft.

The scope of the subprogram covers the range of existing and probable future aircraft configurations, including aerodynamic parameters and physical characteristics. The types of aircraft are categorized by function and size, such as VTOL, STOL, rotary wing, small general aviation, executive jet and advanced transport.

Aircraft have been tested specifically as generic types or as in-flight simulators with specialized instrumentation providing the capability of simulating the dynamics and flight control characteristics of a wide variety of vehicles. The results of the research are used to prepare recommendations for revised quantitative and qualitative requirements for revised handling qualities certification requirements.

PROGRESS.

1. **Small general aviation airplanes**—A three-phase flight test program by Princeton University using its variable-stability Navion has been completed. Results reported in four technical reports covering specific combinations of characteristics plus a final summary report presenting recommendations for desirable and minimum acceptable levels of flight characteristics.

2. **Executive jets**—A brief qualitative investigation of a number of currently popular executive jets was made by a joint FAA/NASA team to highlight outstanding problem areas for this aircraft type. An investigation of the jet upset-spiral divergence characteristics of executive jets was made by Cornell Aeronautical Laboratory (CAL), Inc., using the variable-stability T-33 airplane under joint sponsorship of the Air Force Flight Dynamics Laboratory (AFFDL) and FAA. The results were published as Report ADS-69-113. A second phase jointly sponsored by AFFDL and FAA was undertaken to determine lateral control requirements for landing approach in turbulence and crosswinds. The final report was published as FAA-RD-71-26.

3. **Powered-Lift STOL Transports**—A three-phase moving-base simulator investigation has been undertaken of takeoff and landing approach flight characteristics criteria using the NASA-Ames Research Center Transport-Cab, Moving-base Simulator (S-16). Two phases have been completed by Douglas Aircraft Company under FAA contracts, covering lateral-directional and longitudinal flight characteristics criteria. The results have been published as Reports FAA RD-70-61, and FAA-RD-71-81. A third report is in review prior to publication.

A flight test investigation was initiated to validate the ground-based simulator results and other data including present civil certification criteria and military specifications. The work is being conducted by CAL under the joint sponsorship of the Naval Air Systems Command (NAVAIR), AFFDL, NASA and FAA. In addition, CAL is conducting an in-depth review of the FAA "Tentative Airworthiness Standards for Powered-Lift Transport Category Aircraft," so-called Part XX. CAL will determine any flight performance or controllability requirements which may not be adequately covered, and suggest regulatory approaches for amelioration of the noted deficiencies.

4. **Advanced Transports**—The FAA conducted flight tests on F-120A delta-wing airplanes to investigate takeoff performance criteria for supersonic transport aircraft. The results were reported in Report FAA-FS-71-2.

5. Dynamic stability and control characteristics investigation completed by FAA/Princeton University.

TREND.

The following schedule of significant events has been established:

Small General Aviation Airplanes.

1. Advanced flight control systems characteristics completed by FAA—6/75.

2. Improved stall warning and landing characteristics completed by FAA—6/75.

Executive Jets.

1. FAA/Cornell Aero Lab combined effects of degraded longitudinal and lateral—directional flying qualities parameters—completed by FAA/Cornell Aeronautical Laboratories—10/74.

Powered-Lift STOL Transports.

1. FAA moving-base simulator investigation of takeoff and landing-approach flight characteristics criteria completed—8/74.

2. FAA criteria for advanced flight control systems for STOL transports completed—10/74.

3. FAA flight test validation of STOL transport handling qualities criteria completed—6/77.

Advanced Transports.

1. Minimum acceptable handling qualities for advanced high-speed transports for various flight control configuration, completed by FAA/Cornell Aeronautic Laboratories—4/74.

SUBPROGRAM.

Aircraft Flight Characteristics Criteria, IV, 182-741 and 182-790.

MANAGER.

Jerome Teplitz, RD-741.

FLIGHT DATA SURVEY

BACKGROUND.

The purpose of this effort is to investigate accident and incident upsets occurring when atmospheric turbulence was encountered. With the introduction of turbo-jet powered aircraft into airline service, a number of these upsets occurred when atmospheric turbulence was encountered. These upsets resulted in Flight Standards Service Request for R,D&E, FS-100-67-86, to investigate the problem. FAA contractor installed Digital Airborne Recording Systems (DARS) in each of three representative transport category airline aircraft (Boeing 707, 727, and 737). As the recording period for the DARS neared completion without any unusual events having been experienced by the instrumented aircraft, FAA expanded the program objectives to produce several types of statistical data on normal airline operation. FAA initiated a parallel effort, using the Naval Air Developmental Center's Centrifuge at Johnsville, Penna. Navy Air Development Center under FAA direction configured the cockpit and the handling characteristics to simulate Boeing 720 in order to evaluate turbulence penetration techniques. The joint FAA/Navy tests demonstrated that current operational procedures are adequate.

PROGRESS.

An Interim Report, FAA-RD-71-69, "Airline Operational Data from Unusual Events Recording Systems in 707, 727 and 737 Aircraft," 9/71 reflects nearly 2100 hours of usable operational data acquired and alayzed by the Information Systems Division of Technology, Incorporated. The flight data recorders were removed by the contractor from the Boeing 707 and 727, terminating that phase of the program. The FAA contractor modified the recording system on the Boeing 737 and the data acquisition period extended by FAA six months in order to obtain deviations from the glide slope and localizer, and ground data as well as additional in-flight data.

TREND.

The following milestones are scheduled:

1. With regard to detecting turbulence, it is planned to procure a suitable instrument that is capable of quantifying the level of turbulence independent of the aircraft characteristics. This instrument will be installed in four to six representative aircraft operating in scheduled airline service to obtain pilot opinions and the feasibility of transmitting this information to following aircraft.
2. Final Boeing 737 report issued by FAA–6/72.

SUBPROGRAM'

Operational Flight Data Survey and Analysis, IV, 182-742.

SUBPROGRAM MANAGER.

J. Clay Staples, RD-742.

FLIGHT CHARACTERISTICS CRITERIA – V/STOL

BACKGROUND.

The purpose of this effort is to develop flight characteristics for STOL and V/STOL aircraft. It includes analyses and experimental investigations of the flying and handling qualities of various categories of STOL and V/STOL aircraft using in-house and contractor support. Extensive use is made of ground based simulations, variable-stability aircraft and flight test vehicles. Under an FAA/NASA Interagency Agreement, Ames Laboratory is conducting flight experiments to obtain a data base for the development of STOL transport guidance and control systems and STOL approach and landing performance as a function of flight path geometry, speed, flight control systems and displays, automation, operational procedures and environmental factors. AMES is using the STOLAND terminal area navigation guidance and control system installed in a C-8A Buffalo aircraft and a C-8A modified into an augmentor-wing jet STOL research airplane. The flight experiments are supported by ground-based simulation utilizing hardware installed in the AMES Flight simulator facilities.

PROGRESS.

1. Some STOLAND systems delivered for checkout by NASA-AMES.
2. First flight of augmentor-wing C-8A completed by Boeing under NASA AMES contract.

TREND.

The following major milestones are scheduled for completion:

1. STOLAND system installed on C-8A by NASA-AMES and flight tests completed by NASA/AMES/SRDS/NAFEC–1974.
2. STOLAND system installed by NASA-AMES in augmentor-wing C-8A and flight tests by injet STOL research vehicle completed and AMES report issued–1975.

SUBPROGRAM.

Flight Characteristics Criteria-V/STOL–180-790.

MANAGER.

J. Teplitz, RD-741.

STOL FLIGHT SAFETY CERTIFICATION

BACKGROUND.

The purpose of this engineering and development effort is to obtain operational data on STOL aircraft which can be used for the development of certification and operational criteria. The introduction of V/STOL aircraft is dependent in part on being able to interface with the existing air transportation system and to serve the community without adverse environmental influences. The extent or schedule for introduction of such a short haul air transportation system is difficult to assess. However, certain factors must be investigated in order to provide the guidelines which will result in a safe system for the user. Considering that a V/STOL system would generally employ single short runways, often in the area with many flight path obstacles and in some cases at elevated sites, a need for basic data under these conditions is necessary.

PROGRESS.

Using a DeHavilland DHC-6 Twin Otter on load from the Canadian Ministry of Transport and the NAFEC ground level STOLport, a SRDS effort is underway at NAFEC to secure data on radio guidance configuration, obstacle clearance criteria and approach/landing performance, etc. Both FAA and commuter airline pilots are being used for this evaluation.

TRENDS.

The following milestones are scheduled for completion:

1. DHC–NAFEC STOLport testing completed–5/72.
2. DHC–NAFEC STOLport testing report issued–8/72.

SUBPROGRAM.

STOL Flight Safety Criteria, 182-791.

PROGRAM MANAGER.

J. Clay Staples, RD-742.

ASSOCIATE PROGRAM MANAGER.

R.A. Kirsch, RD-742.

PROJECT MANAGER.

Roman Spingler, NA-543.

SYSTEM SIMULATION FOR PILOT TRAINING

BACKGROUND.

The purpose of this effort is to develop improved criteria for use in certification of aircraft, engines and airmen. It includes criteria for pilot ground trainers for use in improvement of Airman Training Regulation. This effort is in response to a Flight Standards Service 9550.1 R,D&E Request, FS-400, 68-28, 1/16/69, for a study to determine capabilities, desired characteristics and effectiveness of pilot ground training required, pilot skills most benefits by simulator training and cockpit configuration and flight characteristics most desirable in a trainer.

PROGRESS.

1. FAA awarded a Phase I contract to Lear Seigler to study simulation for pilot training.
2. NAFEC acquired a specially equipped trainer for Phase II, an In-House evaluation of training maneuvers used in pilot certification flight test.
3. FAA contract awarded De Vore Aviation Associates for a study of the data to develop a method for analyzing features which contribute to accidents.
4. NAFEC completed final design of instrumentation for recording aircraft response to maneuver and initialed procurement of hardware.

TREND.

1. Trainer final report issued by NAFEC –4 qrt./72.

2. Accident cause effort synthesized by NAFEC–FY 73.

3. Aircraft response and visual cue effort completed by NAFEC--FY 72.

SUBPROGRAM.

System Simulation, IV, 183-721.

MANAGER.

Ward D. Davis, RD-721.

PROJECT MANAGERS.

W. Hanley, NA-543; R. Ontiveros, NA-544; and C. Westfall, NA-111.

IMPROVED RUNWAY SURFACE TRACTION

BACKGROUND.

This effort is responsive to 9550.1 FS 100-71-112A, FS-100-72-118, and AS-72-580-1. During 1968-1970, 23 civil transports were involved in slippery runway accidents, about 40% were off the side and the remainder off the end. These are in addition to 49 slippery runway incidents which occurred during this period.

PROGRESS.

An ML Aviation LTD. Mu-meter/Integrator system, and two-vehicle were obtained (Figure 61) to conduct runway friction surveys. A diagonal-braked-vehicle, (Figure 62) was assembled and instrumented for use in the same survey program. A runway friction survey, involving 32 runways on 10 major civil airports,

Figure 61. Tow-Vehicle and Mu-Meter/Integrator System.

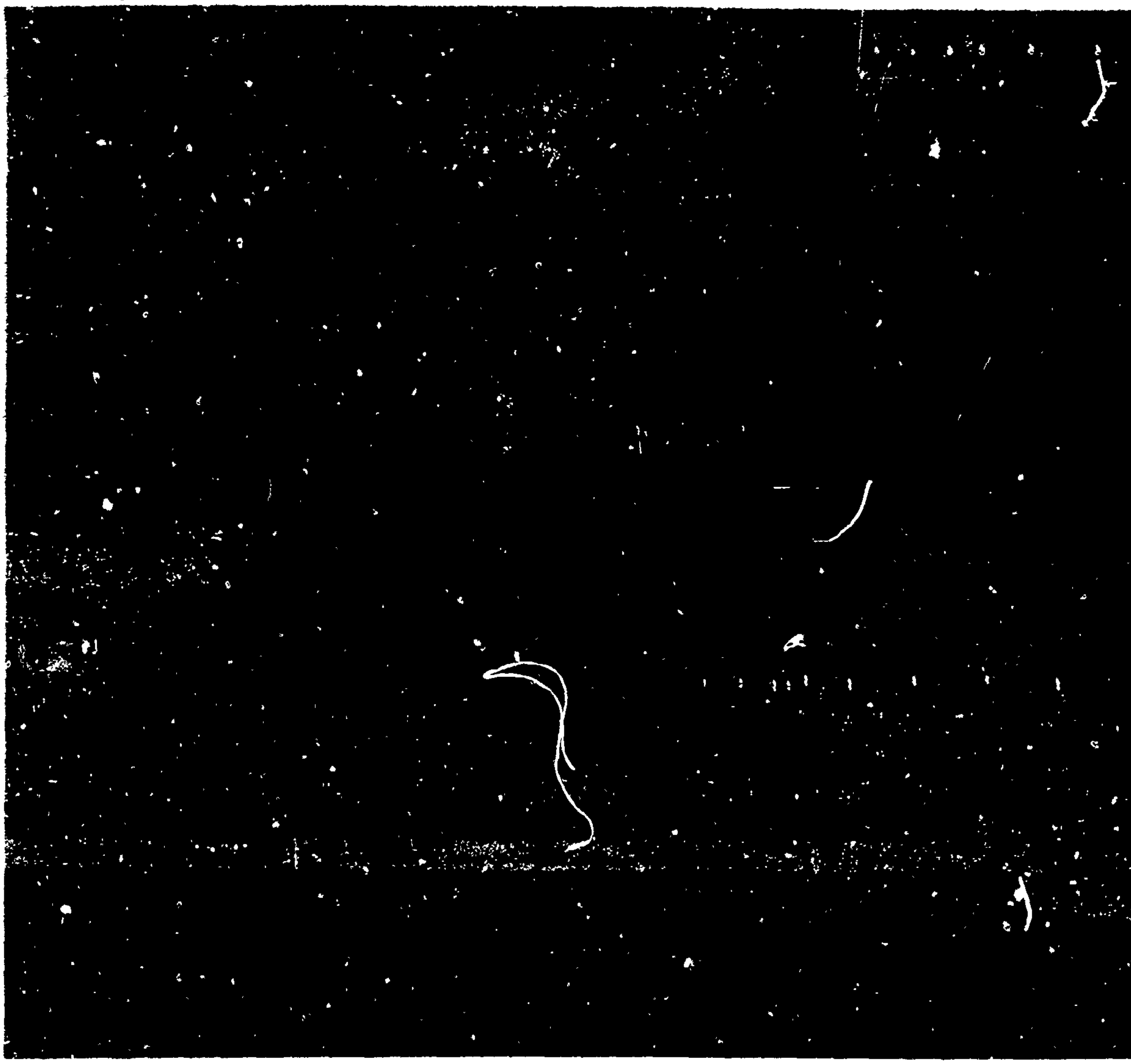

Figure 62. FAA Diagonal-Braked, Friction-Test Vehicle.

was conducted by a Pavement Safety Corporation and NAFEC using the above mentioned test vehicles. This data will be used in the development of new airport and/or aircraft airworthiness standards.

A joint FAA/USAF/NASA Runway Friction Research Program was coordinated by the FAA and involved comparative testing of Mu-meter and Diagonal Brake Vehicle friction test vehicles, and FAA B-727 and DC-9 aircraft at 12 major civil and military airports. Final reports are expected before the end of FY 72 (Figure 63).

A basic method for correlating wet runway friction data with airplane stopping distance was developed under contract with the McDonnell Douglas Corporation and is reported in SRDS Report FAA-RD-70-62, March 1971.

Preliminary studies of the effect of grooved runways on wheel spin-up rate and tire cutting

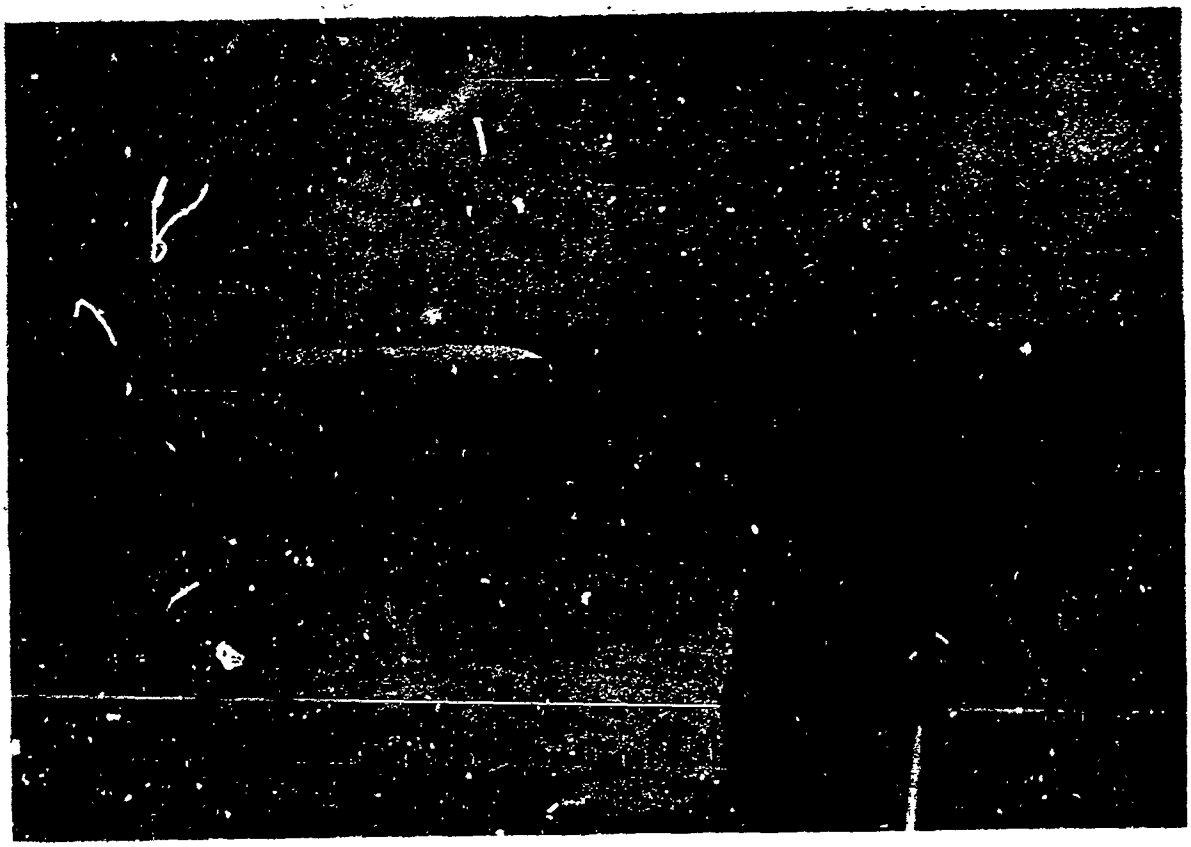

Figure 63. FAA B-727 Test, Joint FAA/USAF/NASA Runway Research Program.

were conducted with a FAA T-29 airplane and are reported in SRDS Report–FAA-RD-71-2 4/71. A joint FAA/USAF program is being planned using modified landing gear drop test facility to develop an optimum runway groove shape and spacing to minimize the incidence of tire cutting during landings on dry grooved runways.

TREND.

Major milestones scheduled for accomplishment are:

1. Final report completed Pavement Safety Corporation on Friction Data–10 airport survey–6/72.
2. Final reports completed on Phase I–Joint FAA/USAF/NASA Runway Friction Research Program–6/72.
3. Interagency agreement signed for Phase II–Joint FAA/USAF/NASA Runway Friction Research Program–6/72.
4. Contract awarded by USAF for joint FAA/USAF Program–Runway Grooves versus Tire Cutting–6/72.
5. Integral Pavement Wetting System developed by FAA for Diagonal Braked Vehicle–10/72.

SUBPROGRAM.

Improve Runway Surface Traction, IV, 183-731.

MANAGER.

R.C. McGuire, RD-733.

PROJECT MANAGERS.

W. Herring, NA-543, and C. Grisee, NA-543.

AIRCRAFT CRASH SURVIVABILITY

BACKGROUND.

Statistics covering small aircraft accidents continued to indicate that a large percentage of fatalities result from occupant head and chest impact on interior portions of the cabin, even though the cabin structure remains relatively intact.

This effort is responsive to 9550-1, Development of Dynamic Crash Loads Criteria, No. FS-100-72-122, develop criteria which can enhance occupant survivability, and of analytical methods to evaluate dynamic crash loads for aircraft.

PROGRESS.

FAA awarded a contract to develop design goals and concepts for an inflatable restraint system for General Aviation Aircraft. The development effort will be followed by a hardware design and evaluation phase. The evaluation will consist of catapult tests utilizing typical small airplane cockpits and anthropomorphic dummies to simulate human response.

NAFEC completed catapult tests of conventional lap belt and shoulder harness restraint installations in small airplane cockpits (Figure 64). NAFEC has analyzed quantitative

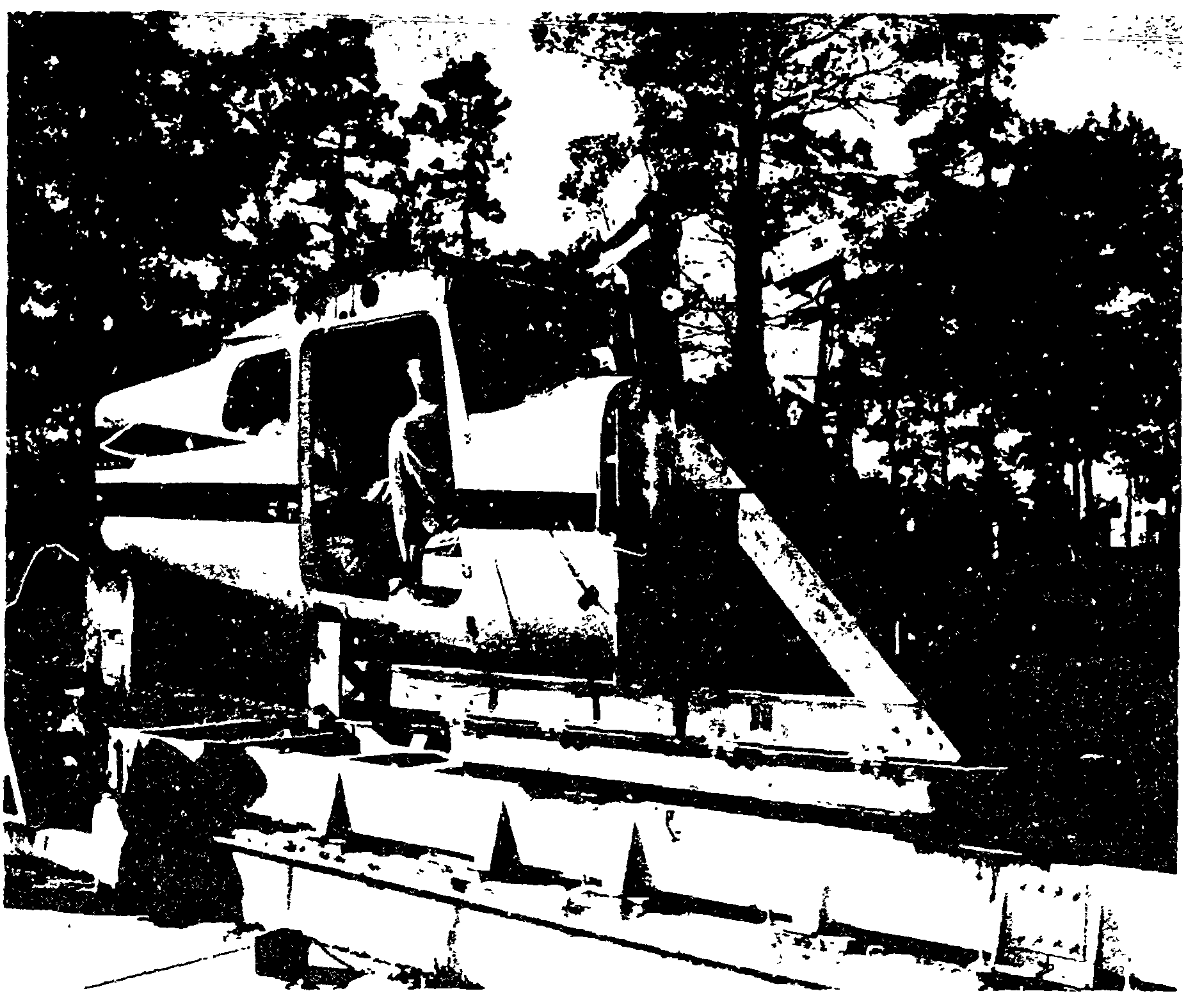

Figure 64. Shoulder Harness and Lap Belt Catapult Test [illegible]

acceleration data and further static and dynamic tests of seat/restraint systems were outlined.

FAA completed planning for the research effort necessary to develop analytical methods to evaluate dynamic crash loads for aircraft. Contracts will be awarded to develop seat system design criteria and aircraft crashworthiness criteria.

TREND.

The following major milestones are scheduled for completion:

1. Evaluation tests of air bag system started–5/72.
2. FAA contract awarded for development of lightweight, low cost, reliable crash resistant fuel system–6/72.
3. FAA contract awarded to develop design concept and specification for seat system based on dynamic criteria–6/72.
4. FAA contract awarded to develop mathematical model to predict aircraft crashworthiness and develop dynamic crash loads criteria–12/72.
5. NAFEC completed catapult tests of conventional seat/restraint system–12/72.

SUBPROGRAM.

Aircraft Crash Survivability, IV, 184-731.

SUBPROGRAM MANAGER.

P. Frank Castellon, RD-731.

PROJECT MANAGERS.

J.J. Jaglowski, NA-541.
H. Daiutolo, NA-541.

PROPULSION SYSTEM CRASH FIRE HAZARDS REDUCTION

BRACKGROUND.

The hazards of post-crash fires have been documented in National Transportation Safety Board aircraft accident reports. Two hundred and five transport accidents during the period 1955-1968 resulted in approximately 350 fatalities due to post crash fires. The goal of this effort is to develop methods, systems, and a crash safe fuel which will reduce the fuel fire and explosive hazard during survivable crash landings and increase the time available for safe evacuation from the aircraft.

PROGRESS.

A nitrogen fuel tank inerting system was developed by Parker Hannifin and certificated by FAA Western Region in the FAA DC-9 jet transport to demonstrate that an inerting system is practicable in eliminating the hazard of fuel tank explosions by maintaining the oxygen concentration in the fuel tank vapor space and vent system at a safe level. Oxygen concentration measurement equipment and techniques were developed and flight tested in the FAA DC-9. In order to determine whether it would be possible to eliminate the logistics requirements and system weight associated with carrying liquid nitrogen in an inerted aircraft, it is planned to award a contract to develop a technique for separating nitrogen from the atmosphere for application to nitrogen fuel tank inerting systems.

A fluid gelled fuel was developed by Dow Chemical Co. under contract which retains the crash fire reduction characteristics of the earlier, thick gels. Figure 65 shows the fire which occurs when one gallon of Jet A kerosene is propelled through a screen over several open flames. The reduction in the fire hazard provided by the use of the new gelled fuel is shown in Figure 66.

Tests were conducted by NAFEC to determine the compatibility of this gelled fuel with a full scale CV-880 transport fuel system and with a J-79-GE-5 turbojet engine. Tests were conducted at the Naval Air Propulsion Test Center in Philadelphia with J-79 fuel system components under simulated flight conditions using gelled fuel.

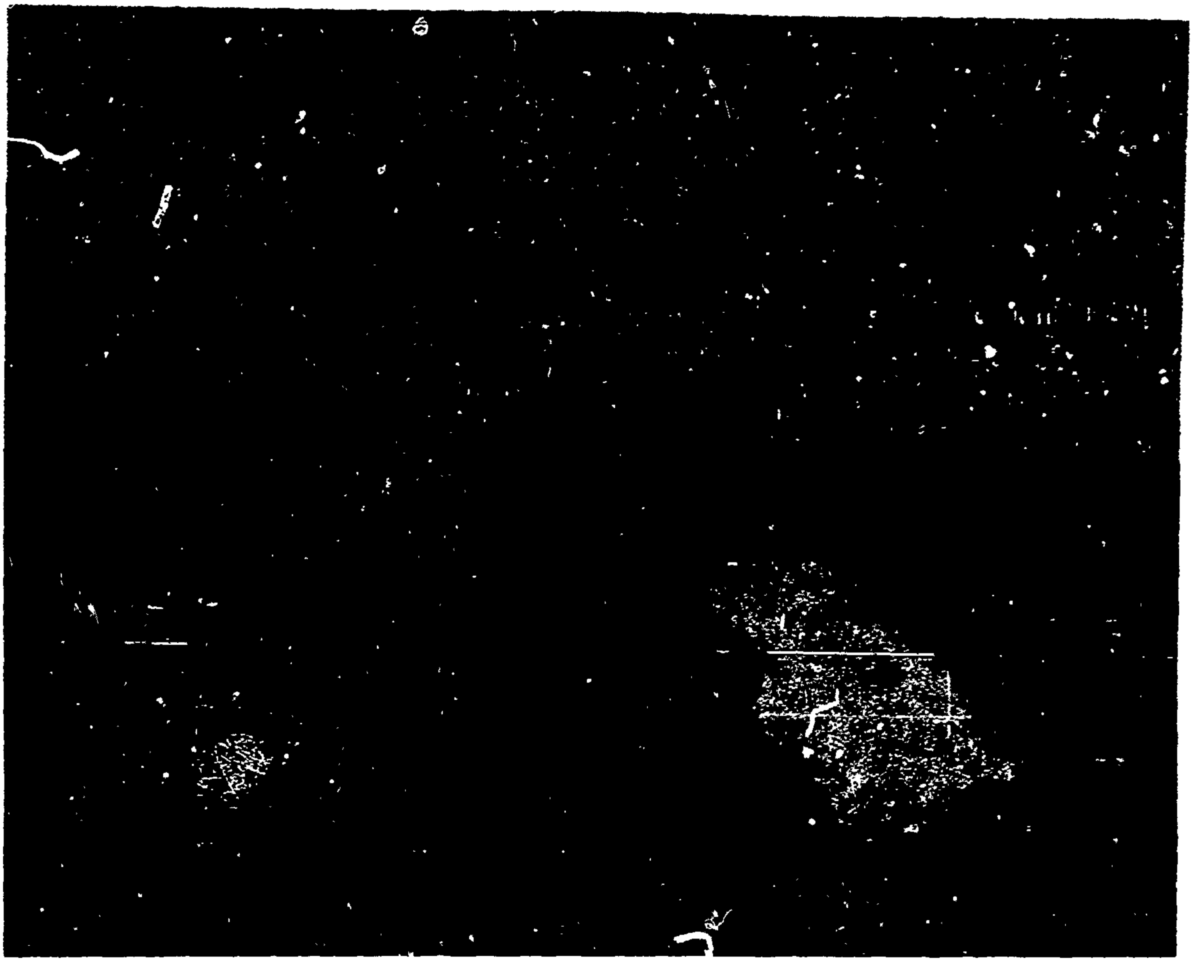

Figure 65. Fire From One Gallon of Jet A Kerosene.

TREND.

The following major events are scheduled for completion:

1. Contract awarded by FAA for a feasibility study of nitrogen separation techniques for fuel tank inerting systems–7/72.
2. J-79 turbojet ground qualification by NAFEC with gelled fuel–4/72.
3. Full scale CV-880 fuel system tests with gelled fuel completed by NAFEC–3/72.
4. Full scale gelled fuel/aircraft crash tests completed at U.S. Naval Air Station, Lakehurst, N.J.–5/72.
5. Gelled fuel flight tests in a CV-880 transport completed by NAFEC–9/72.
6. Crash fire suppression tests with liquid nitrogen completed by NAFEC–2/75.

SUBPROGRAM.

Reduction of Propulsion System Crash Fire Hazards, IV, 184-733.

MANAGER

Cdr. William C. McAdoo, RD-732.

PROJECT MANAGERS.

R. Russell, NA-542 and R. Ahlers, NA-541.

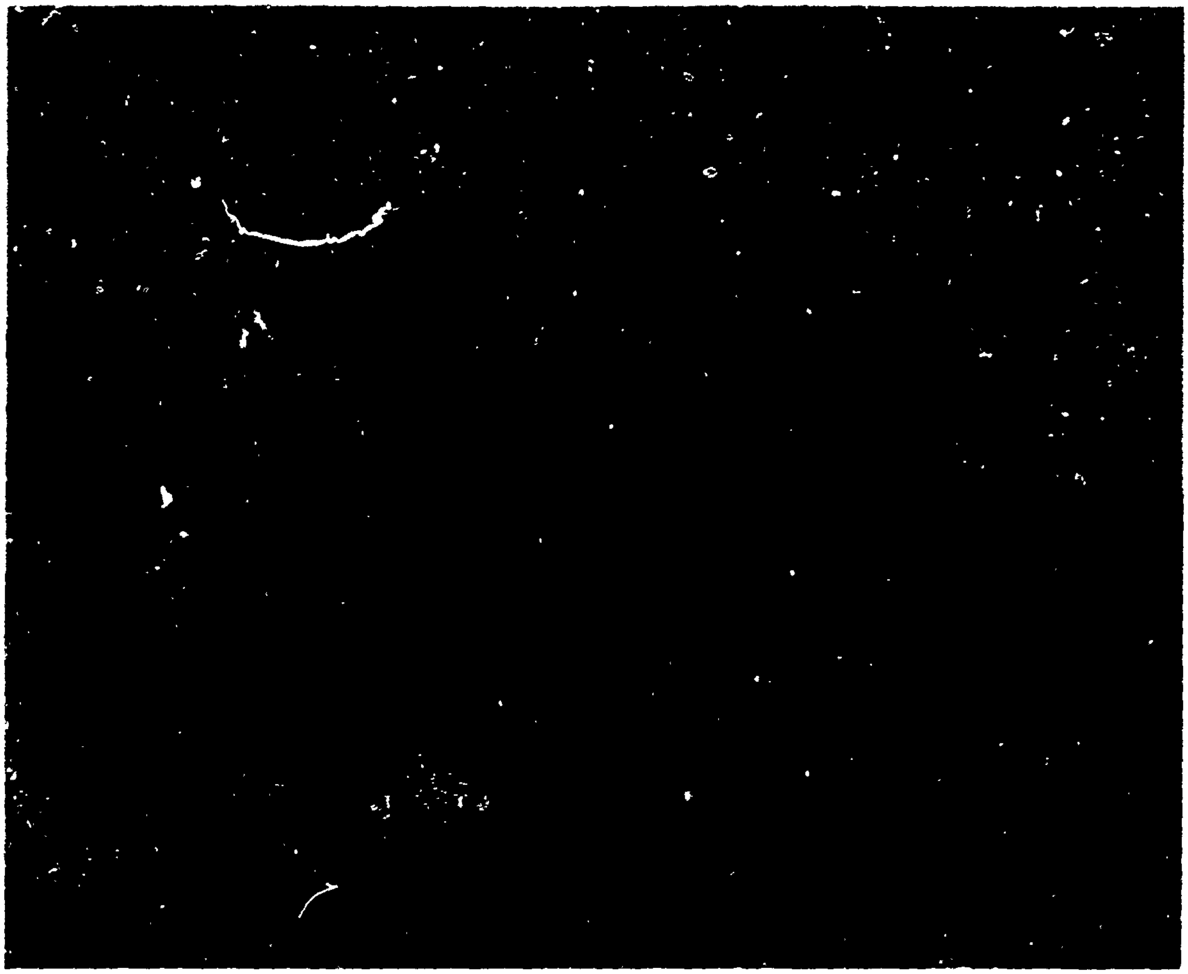

Figure 66. Reduction in Fire Hazard By Use of New Gelled Fuel.

20 ENVIRONMENTAL PROTECTION PROGRAM

GOAL.

The purpose of the Environmental Protection Program is to engineer and develop methods to protect the environment against aircraft noise and pollution. It includes the (1) development of FAA policies, guidelines, criteria, standards and techniques for measuring the source and path of aircraft propulsion system air pollution, noise and the impact on humans, animals and structures; (2) conduct of analytical studies (policy and technical); and (3) evaluation of alternatives for reducing toxic emissions from aircraft engines and retrofitting airline fleets with quiet engines. This Program supports the development of environmental rulemaking, certification standards, guidelines for land use, and improved flight procedures.

SCOPE.

These engineering and development efforts are organized under two Program Elements: 201–Pollution and 202 Noise.

In the FY 72 Technical Program, these efforts include the following subprograms:

201-721 Aircraft Propulsion System*–W. T. Westfield, RD-723.

202-811 Noise Evaluation and Control-Source*–W.C. Sperry, RD-820.

202-812 Noise Evaluation and Control–Transmission Path, W.C. Sperry, RD-820.

202-813 Noise Evaluation and Control–Receiver, W.C. Sperry, RD-820.

202-821 Sonic Boom Eval. and Control–Source, J.K. Power, RD-830.

202-822 Sonic Boom Eval. and Control–Path, J.K. Power, RD-830.

202-823 Sonic Boom Eval. and Control–Receiver, J.K. Power, RD-830.

202-890 V/STOL Noise–W.C. Sperry, RD-820.

The following selected* major subprograms are highlighted in terms of Background, Progress, and Trend (major milestones scheduled for completion):

AIRCRAFT PROPULSION AIR POLLUTION

BACKGROUND.

The Clean Air Amendments of 1970 (Public Law 91-604) directed the Administrator of the Environmental Protection Agency (EPA) to "commence a study and investigation of emissions of air pollutants from aircraft in order to determine,

(A) the extent to which such emissions affect air quality in air quality control regions throughout the United States, and

(B) the technological feasibility of controlling such emissions."

The public law further directs the Administrator of EPA to publish a report of these studies and to issue proposed emission standards applicable to the specific emissions and aircraft within 180 days of beginning the study. After public hearings during the 90 days subsequent to the release of the proposed standards, the Secretary of Transportation is required to prescribe regulations to insure compliance with the standards issued by the EPA.

The FAA, in the summer 1971, made necessary arrangements for the EPA to sample the emissions of various types of engines in use in commercial aviation. In the course of this investigation some 400 engines were sampled to identify the levels of carbon monoxide, carbon dioxide, nitrogen oxides, and total hydrocarbons.

The result of this testing was the submission by EPA of emission standards for turbine and piston powered aircraft. This notice of proposed rule-making has been under review at the Executive Office of Management and Budget since the fall of 1971. Release of these proposed standards and the subsequent inquiry-stage of 90 days is expected in spring of 1972.

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Efforts underway in the FAA bear on the proposed standards. The relationship of the visual appearance of smoke plumes in flight to a standardized ground test procedure was determined through a (FAA/EPA) contract effort with industry. The effort, however, did not establish with sufficient accuracy the threshhold of visibility. Additional work was conducted at NAFEC to establish this level and the method of determination was reached.

Another FAA/EPA contract bearing on the emission standards is an analytical and experimental effort to develop criteria for the control and reduction of nitrogen oxides.

An investigation to determine the effect of the dumping of residual fuel from aircraft drain tanks was initiated by FAA and NAFEC testing was completed.

Although the standards which EPA has proposed apply only to aircraft operations below 3000 feet, the FAA has been examining the pollutant emissions at altitudes above this level. Attempts are being made in this respect to determine if emission values measured at ground conditions can be extrapolated to predict the emissions at the higher altitudes.

Recognizing that emission standards below 3000 feet altitude are directed heavily toward the airport environs itself, an effort has been initiated to combine the known data and modeling techniques for the airport area to the emission patterns developed by constant usage of fixed approach/departure paths. With the experimental data and analytical model resulting from this effort, a three dimensional "footprint" of typical general aviation and commercial airports will be developed under FAA contract with Argonne National Laboratories.

PROGRESS.

1. NAFEC completed definition of the threshhold of visibility to the visual appearance of exhaust plumes in flight.

2. The FAA contract with Northern Research and Engineering Corp., effort to develop design criteria for the reduction of nitrogen oxides from aircraft turbine engines is near completion. The report is under revision and will be printed after review.

3. NAFEC identified the characteristics of fuel dumping from aircraft turbine residual drain tanks, completed testing, drafted a report which is under review.

4. Argonne National Laboratories initiated definition of pollution levels in the vicinity of airports resulting from the approach/departure areas, completed in-flight and ground level emission measurements in the approach/departure paths at Santa Ana Airport and O'Hare International Airport, initiated integration of the data into an analytical model of this airport region.

TREND.

The following major milestones are scheduled for accomplishment:

1. Recommendation completed by SRDS of acceptable emission levels of aircraft gas turbine smoke regardless of whether such emissions are measured in flight, in an installed configuration at ground run-up, or in a developmental test cell–5/72.

2. Design criteria completed by SRDS to produce desired reductions in nitrogen oxide emissions–5/72.

3. Correlation techniques completed by U.S. Naval Propulsion Test Center under FAA/NAVY agreement to any altitude and/or flight speed–5/72.

SUBPROGRAM.

Aircraft Systems Air Pollution, IV, 201-721

SUBPROGRAM MANAGER.

W.T. Westfield, RD-723.

PROJECT MANAGER.

G.R. Slusker NA-542.

AIRCRAFT NOISE

Noise Evaluation and Control–Source. Determination of the primary aircraft/engine performance variables that cause or influence the generation or propagation of noise, development of prediction techniques, and establishment of guidelines for noise reduction.

Noise Evaluation and Control–Transmission Path. Determination of the significant aircraft performance characteristics that influence noise exposure on the ground, development of prediction techniques, evaluation of the effects of the atmosphere on sound propagation, and development of noise monitoring methods.

Noise Evaluation and Control–Receiver. Determination of the significant spectral and temporal variables that influence human response to noise, development of evaluation measures, and establishment of guidelines for control of the residual noise exposure.

NOISE EVALUATION AND CONTROL–SOURCE

BACKGROUND.

In accordance with Public Law 90-411, the Federal Aviation Administration (FAA) became responsible for protecting the public from unnecessary aircraft noise. Federal Aviation Regulation Part 36 has already prescribed noise abatement controls over a large segment of the aviation industry and extensive effort is continuing to complete and continually refine this control. Since every noise abatement regulation must be economically reasonable technologically practicable and appropriate for the particular type of aircraft, detailed development programs are integral to this regulatory process, so that adequate support may be available in meeting these requirements.

The purpose of this effort is to investigate the parameters that cause or influence the actual generation of noise emanating from the aircraft. Guidelines are developed for modifying the propulsion systems to minimize noise. In addition, noise suppression devices of various designs are investigated for installation on aircraft. Studies are also included to improve techniques of noise measurement, data reduction and analysis, plus refinement of criteria for the evaluation and rating of various levels of aircraft noise.

PROGRESS.

1. Two parallel, but independent, projects have been completed on the development of methods for fan and compressor noise prediction and reduction. Methods for predicting these noise sources have been developed by the General Electric Company and Pratt and Whitney Aircraft, and have been validated by a series of engine tests. Each company has utilized different research techniques and unique test facilities to develop a comprehensive, deeper understanding of fan and compressor noise generation mechanisms. In addition, both have demonstrated various complementary methods for reducing this noise source.

2. The investigation of coaxial jet noise by Wyle Laboratories has been completed and a noise prediction method has been derived for parametric variations, corresponding to the operating conditions of present and near-future turbofan and turbojet aircraft engines.

3. An interagency agreement with the U.S. Air Force has been completed on the investigation of propeller noise generating mechanisms and the improvement of propeller noise prediction procedures. Canadair and Hamilton Standard conducted this effort as part of the Air Force Advanced Propeller Development Program.

4. FAA contracts have been awarded to Boeing-Wichita and Boeing-Seattle to investigate the feasibility of retrofitting current aircraft with acoustically treated nacelles to reduce the community noise levels. Test data are being gathered to determine if meaningful noise reduction can be achieved at economically reasonable expense. Flight worthy and flight weight hardware is being tested that is capable of flight certification. The impact on the flight performance and economic return of the B-707

and B-727 is being analyzed for prescribed noise reductions.

5. The core engine (gas generator) noise sources become dominant as the fan and compressor noise levels are reduced. This particular problem becomes apparent with the advancing technology of engines for future aircraft, including STOL and VTOL types. The exhaust jet and the gas generator internal sources will be investigated to determine the noise generating mechanisms. Various methods for reducing the noise intensity and predicting the noise levels at early stages in the design will be developed by FAA contractor.

6. V/STOL aircraft have propulsion-lift systems that are distinctly different from conventional aircraft. The noise parameters of various configurations will be investigated by the FAA contractor to afford realistic estimates of the noise levels of the different V/STOL systems.

7. Contractor final reports issued on fan and compressor noise prediction and reduction.

8. Contractor final reports issued on coaxial jet noise prediction and reduction.

9. Contractor report issued on propeller noise prediction and reduction.

TRENDS.

The following milestones are scheduled for completion:

1. FAA contract awarded on noise and flow performance investigations of model exhaust nozzle configurations–3/72.
2. FAA contract awarded core engine noise evaluation and control–5/72.
3. FAA contract awarded on V/STOL noise prediction and reduction–9/72.

SUBPROGRAM

Noise Evaluation and Control--Source, 202-811.

MANAGER.

William C. Sperry, RD-820.

21 SUPPORT PROGRAM

GOAL.

The purpose of this program is to improve and update FAA ATC environmental conditions in which FAA personnel can operate more efficiently and effectively; to assure that facilities and subsystems keep pace with, and provide for the automation technology; and provide the engineering and development not directly accommodated under the rest of the FAA engineering and development program structure.

SCOPE.

This program is organized under five Program Elements: 211–Power Systems; 212–Performance Assurance; 213–Frequency Utilization; 214–Wake Turbulence; 215–Other (ATC towers, mobile ATC/NAV facilities, flight data recorders, and initial investigations).

In the FY 72 Technical Program, engineering and development efforts are covered in the following subprograms:

211-181 Electrical Power Systems,* Program Manager, Eugene Hall, RD-163.

212-301 Flight Inspection Modernization,* R. Vallone, RD-342

212-302 Flight Inspection Improvement, J.A. Cosner, RD-324.

212-303 New Concepts Performance Assurance,* J.A. Cosner, RD-342.

212-601 Advanced Performance Assurance Concepts, Ray R. Barkalow, RD-650.

213-502 Radar,* Frank Kadi, RD-511.

213-503 ATCRBS, Frank Kadi, RD-511.

213-504 Navigation, R. Johnson, RD-512.1

213-505 CAS, R. Johnson, RD-512.1

213-506 Communications, R. Johnson, RD-512.1.

213-507 Landing System, R. Johnson, RD-512.1.

213-511 RF Propogation, Frank Kadi, RD-511.

213-517 Satellites, R. Johnson, RD-512.1.

213-521 Spectrum Surveillance, Frank Kadi, RD-511.

214-741 Aircraft Wake Turbulence,* Geo. C. Hay, RD-743. Wm. V. Gough, Jr., RD-743

215-182 Development of ATC Facilities,* Carroll Workman, RD-163.

215-183 Mobile ATC Navigation and Communication Facilities,* P. Serini, RD-163.

The following selected* major subprograms are highlighted in terms of Background, Progress, and Trend (major milestones scheduled for completion):

ELECTRICAL POWER SYSTEMS

CRITERIA FOR MAJOR ELECTRICAL DISTRIBUTION SYSTEMS

BACKGROUND.

This effort is responsive to FAA System Requirement FAAR 6950.2, 28/10/70, Terminal Electrical System Improvement.

The need for reliable electrical power has increased rapidly with increases in the volume of traffic, the introduction of larger passenger capacity aircraft and the development of more sophisticated and complex electronic aids.

The purpose of this effort is to establish the electrical distribution system requirements which will provide the quality and reliability commensurate with the importance of the facilities and equipment being energized. It includes the analysis of existing terminal power systems, preparation of standards, recommended operation and maintenance procedures. The interface between airport owned facilities and those owned by the agency are to be considered.

The following benefits are expected:

1. Electrical power system designs which will afford a continuity of service with a system availability approach unity.

2. Electrical power systems which will be maintainable without a complete shutdown of critical or essential systems.

3. An electrical power system which provides the quality and quantity of power to meet input requirements and design tolerances of terminal equipment and facilities.

Representative criteria for a high-reliability standard is shown in Figure 67.

PROGRESS.

1. An architect/engineer contract has been awarded to the Bechtel Corporation for surveys and analysis of 20 major airport systems and to recommend the design standards for continuous power and major airports.

2. Technical Report FAA-RD-71-15 was completed in December 1971. Distribution of this report is approved for U.S. Government pending the preparation and approval of FAA Standards.

3. Completion of the existing system analysis for the continuous power and major airports.

TREND.

The following major events are expected to be accomplished by FAA under this effort:

1. Completion of a system standards handbook–8/72.

2. Establishment of the requirements for and improvement of facility interior electrical systems based on system criticality–12/72.

3. Analysis of essential landside/terminal building facilities power system requirements to provide criteria–4/73.

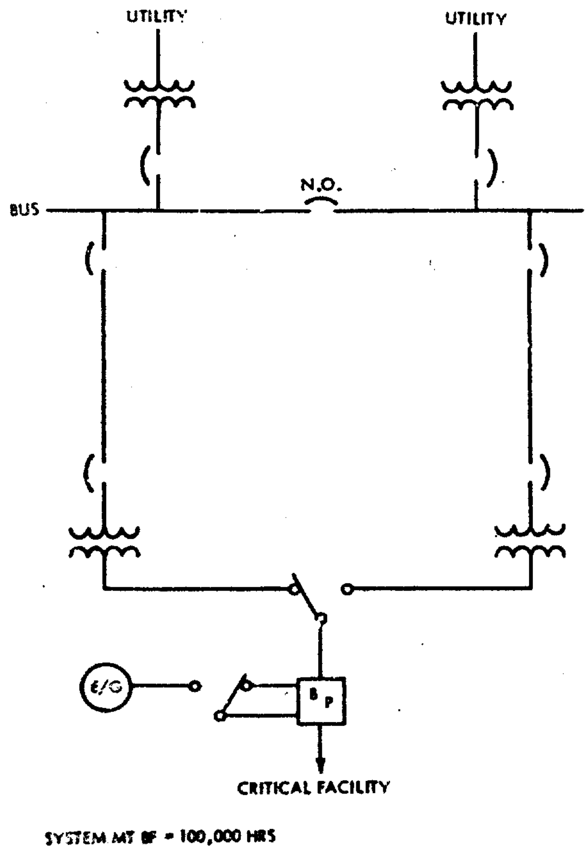

Figure 67. High-Reliability Standard.

PROJECT.

Criteria for Major Hub Electrical Distribution Systems, 211-181-011.

MANAGER.

E. Van Vlaanderen, RD-163.

ELECTRICAL POWER SYSTEMS

POWER SOURCE IMPROVEMENT

BACKGROUND.

Power system problems still account for an appreciably high percentage of critical facility outages. Even though utility supply reliability is reasonably high and extensive, usage is made of engine-generator sets for back up power, the outages which do result have a serious impact on air traffic control and air terminal operational reliability. The system aspects of this problem have been under study since 1970 utilizing an architect/engineer contract to examine the problems and develop standards for air terminal electrical system improvements.

This power sources effort is aimed especially at improvement of system components from the standpoint of performance, reliability, maintainability and cost effectiveness. The optimum level of standardization for power sources is to be determined and suitable designs selected. The effort supplements the Air Terminal Electrical System Improvement Project and is specifically intended to be responsive to requests for R,D&E Effort (Form 9550.1), SMS 68-21, "Standardization and Improvement of Engine Generator Designs;" SMS 69-22, "Remote Monitor and/or Remote Start of Engine Generators;" and SMS 69-23, "Develop a Counter EMF Synchronizer," and in addition a partial response to FAA Register of Requirement FAAR PL-6030.2A, "Mobile Air Traffic Control, Navigational Aid, Communication and Power Systems." Present plans include an initial study and problem definition phase to be immediately followed (under the same contract) with concept development analysis and selection; applicable hardware preliminary design and definition; acquisition, test evaluation and qualification of standardized equipment; and, preparation of equipment and procedural standards and plans for procurement. The end products are to be design and performance standards for power system components and the applicable procurement and maintenance plans, policies and procedures. Also included will be the identification and implementation of "quick fix" problem solutions which do not materially impact long range standardization objectives.

PROGRESS.

The engineering requirements and the purchase request documents have been completed and coordinated for preparation of a Request for Proposals.

TREND.

The following major milestones are scheduled for completion:

1. FAA contract awarded for study, analysis, test evaluation and qualification of standard equipment–4/72.
2. Problem defined and "quick fix" phase identified by FAA–10/72.
3. Initial study completed by FAA–2/73.
4. Evaluation of "quick fix" approaches and standardization level concepts and preparation of prototype specifications completed by FAA.–7/73.
5. Prototype equipment standards acquired and engineering tests begun by FAA–3/74.
6. All qualification tests including service evaluation completed by FAA.
7. Documentation essential to implementation of the standards in final draft status–10/75.

PROJECT.

Power Source Improvement, 211-181-041.

MANAGER.

M. H. Coggins,RD-163.

FLIGHT INSPECTION MODERNIZATION

BACKGROUND.

The Signal Evaluation Airborne Laboratory (SEAL) system is responsive to System Requirement FAAR 6780.1, dated 10/17/66. The basic flight inspection system in use today utilizes airborne VOR/Localizer, Glide Slope, and TACAN equipment which lacks sufficient stability, reliability, and accuracy for adequate in-flight evaluation of ground navigation facilities. Additionally, data is presented in a form which requires hand reduction and considerable time to analyze station performance.

This effort is directed toward the development of a new system including new signal sensors (VOR/Localizer, Glide Slope, TACAN), a human engineered display and recording console (the central control point), an inertial positioning system, an ILS positioning system, and an overall operational concept which would improve the efficiency of flight inspection by employing the following factors:

1. Stable, repeatable measurements.
2. In-flight computation and error readouts.
3. Operational in instrument weather conditions.
4. Real-time go/no-go information.

The SEAL program involved the following major areas:

1. System Design which provide the background for development of hardware items and guidance for integration of these items into an airborne flight inspection system.

2. Inertial Locator Study by MIT Instrumentation Lab explored the feasibility of utilizing practical inertial hardware to accomplish positioning and data handling for the SEAL concept. It provided the necessary background for development of feasibility hardware.

3. Development of Glide Slope Subsystem by Wilcox Corporation of hardware which met the stringent accuracy and stability requirements of SEAL. The Wilcox Model 800 glide slope receiver was used as the basis for the development model equipment.

4. Development of VOR/LOC Subsystem by Airborne Instruments Laboratory included two digital test generator, a control and display test panel. The design employs digital logic throughout the bearing circuitry of both receivers and signal generator, exhibits greatly improved accuracy and stability, and makes extensive use of microcircuitry. This equipment represents a new generation of VOR/LOC equipment.

5. Development of Bearing-Distance TACAN Equipment by ITT Federal Labs for use in the SEAL system which demonstrated accuracy and stability 10 times better than present-day operational equipment. The radical new design is based on digital logic techniques and utilizes microcircuitry throughout.

6. Development of Flight Inspection Console by Airborne Instruments Laboratory for the SEAL system, was guided by a human factors study and the SEAL system design. The console is the focal point of the airborne system in that all control commands are initiated here, and all data are collected and displayed at this console. Displays include illuminated adjustable limit meters, digital in-line numeric displays, and simple light indicators for go/no-go information. An advanced analog strip chart recorder is capable of recording 8 analog signals and 18 coded signals simultaneously. Additionally, all data are recorded on a digital tape recorder for post-flight applications, such as statistical analysis, detailed examination of specific parameters, etc. The console also allows VFR operation using radio-theodolite and manual position inputs in lieu of inertial position (Figure 68).

7. Development of Inertial Locator by MIT Instrumentation Laboratory, following the guidelines of the feasibility study. This inertial locator includes a stable platform digital computer, and interfaces necessary to mate with the SEAL system. The system was designed to provide high accuracy real-time error read-out capability for the SEAL system while operating in either visual or instrument flight conditions (Figure 69).

8. Development of Flight Inspection Positioning System (FIPS) for ILS by the Westinghouse Corporation, to provide back-up for the inertial system in the area of ILS flight checking. The system consists of two ground units, one for vertical angle and one for horizontal. These ground systems are located near the associated ILS glide slope and localizer facilities. The aircraft contains a receiving system which provides guidance to the pilot and also furnishes information to the recording instrumentation. The accuracy of the system is well within Category II ILS tolerances.

9. SEAL System Integration conducted by Airborne Instruments Laboratory, involved the installation, interconnection, and test of all SEAL subsystems on board an FAA test aircraft (Figure 70). In addition to the systems mentioned above, the following additional items were included in the airborne system:

a. In-flight calibration equipment, used to verify the performance of the signal sensors on command from the console operator.

b. Spectrum analyzer, for use in co-channel interference situations, plus other applications that were developed during the flight test program.

c. Polariscope, used to provide usable information concerning polarization effects on VOR and Localizer signals.

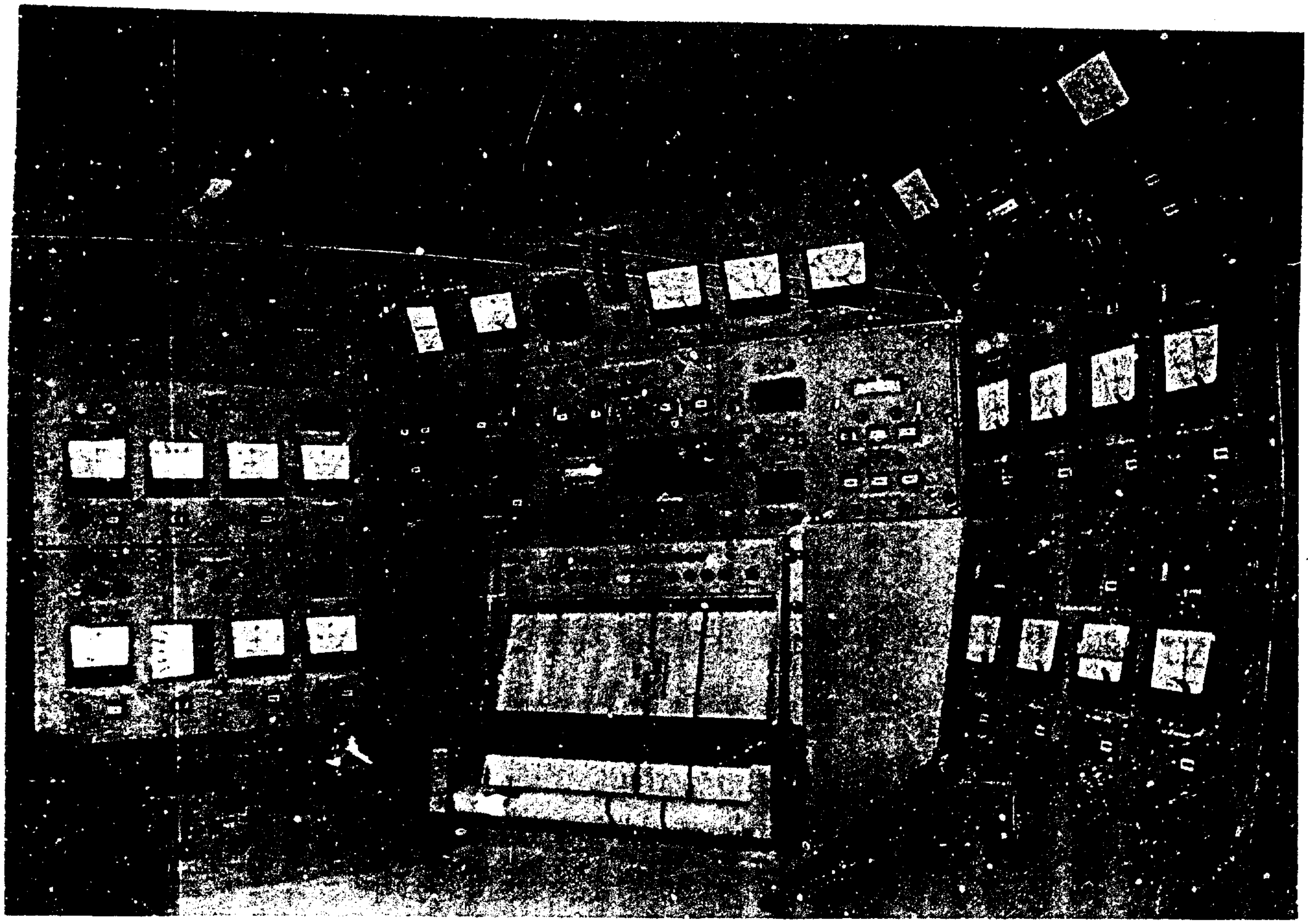

Figure 68. Seal Control and Recording Console.

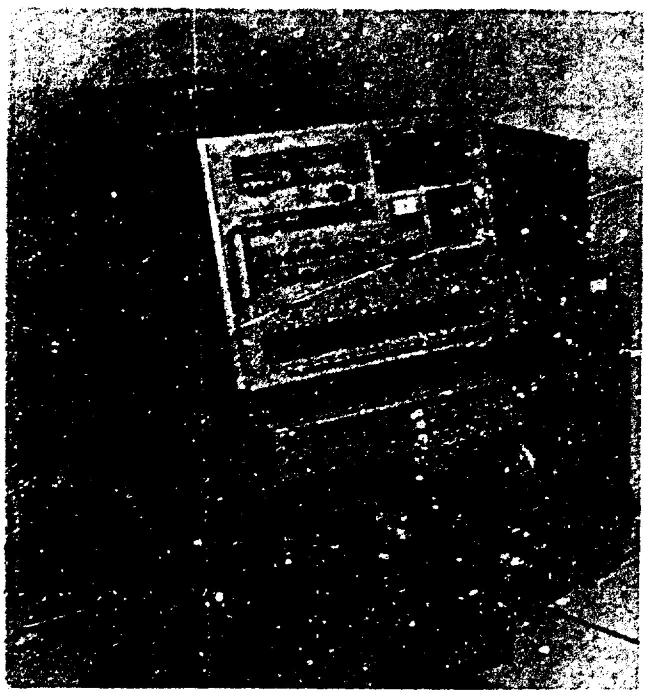

Figure 69. Inertial Locator System.

The following benefits are expected from the SEAL program:

1. Greater efficiency of flight inspection operations, due to: (a) Rapid one-time analysis, (b) IFR operations, (c) Replacement aircraft provide a speed factor improvement, and (d) less maintenance and calibration required.
2. Productivity factors for SEAL are expected to be: (a) IFR operations 65% improvement and (b) VFR operations 30% improvement.
3. Basic fleet size could be reduced significantly.
4. Annual savings in maintenance should exceed $500,000.

PROGRESS.

The SEAL system underwent a field evaluation with an Eastern Region flight inspection crew utilizing its VFR mode. The evaluation report concluded that the system

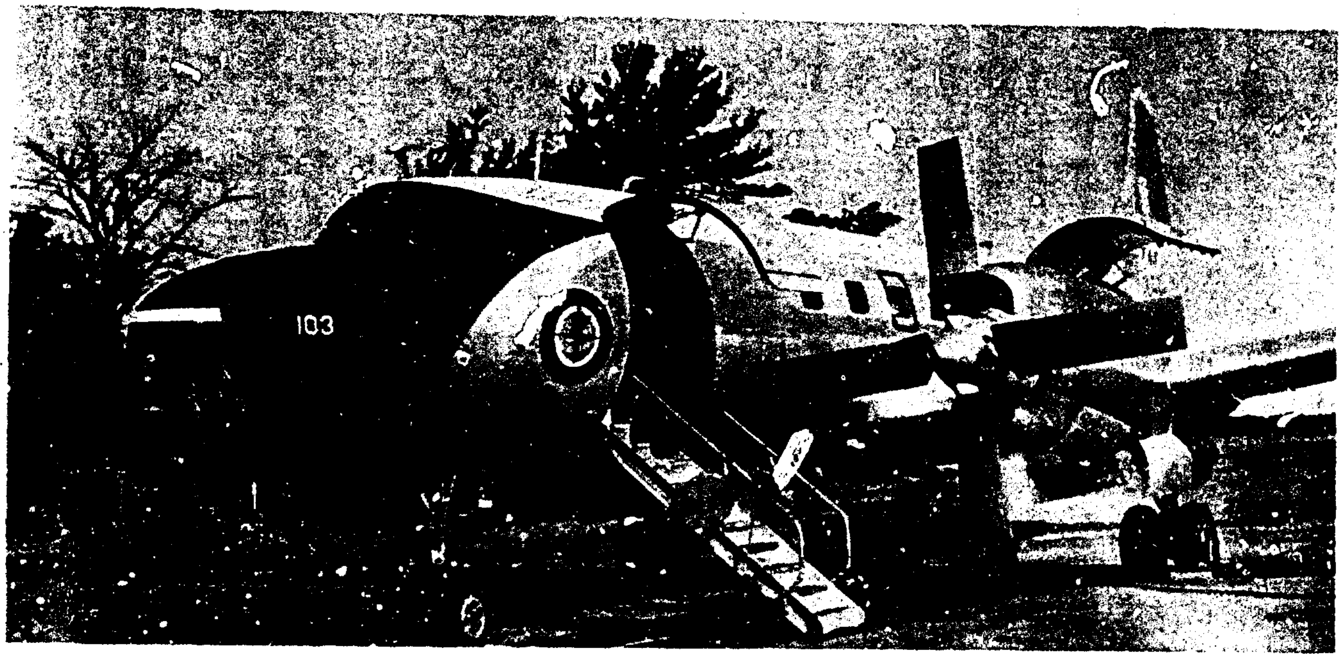

Figure 70. Seal Project Aircraft.

displayed greater stability, accuracy and repeatability than operational systems, as well as accomplishing its tasks in shorter time. Some changes were recommended by the crew. The inertial system was installed and integration with the airborne flight inspection accomplished. Tests of real-time enroute and DME corrected enroute modes as well as real-time ILS mode were accomplished at L. G. Hanscom Field, Mass. and the system was moved to NAFEC for range testing. Testing at NAFEC concentrated on inertial positioning capability in the ILS mode, since the most stringent accuracy requirement is associated with instrument landing. Final data from these tests were analyzed and included in an approved final report currently in printing. Final analysis indicated that inertial positioning is a feasible method of positioning flight inspection aircraft when augmented with suitable updating.

TREND.

The following major event is scheduled for completion:

SEAL Inertial Locator Equipment Final Report--4/72.

PROGRAM.

Flight Inspection Modernization, IIB3, 212-301.

MANAGER.

W. Faux, RD-340 (FAAR 6790.1)

NEW CONCEPTS FOR PERFORMANCE ASSURANCE

BACKGROUND.

The purpose of this subprogram is to develop an advanced concept and system for monitoring more efficiently and economically navaid, radar and user aircraft performance through a combination of air derived measurements and ground monitoring techniques. These ground-based monitoring techniques will also allow for an almost continuous check of the aircraft's flight path and specifically, a subsequent analysis of the navaids performance.

This subprogram is divided into three projects corresponding to phases of flight:

1. Enroute.
2. Terminal.

3. Final approach.

The final approach effort is in response to 9550-1, FS-400-70-1, "Installation and Operation of Aircraft Landing Measurement System (ALMS)."

The following pertains to the enroute project since it is similar in concept to the terminal and final approach projects:

1. The FAA has the statutory responsibility to provide air navigation facilities that will measure up to service demands for safe and efficient use of controlled airspace. This service for enroute navigation is provided by VOR/DME/TACAN ground facilities and the suitability of the signals in the airspace is established and assured by specially instrumented flight inspection aircraft. Inspection aircraft normally are flown in various combinations of orbits, tangents and radials to establish and assure generalized ground facility performance and detailed airway performance at specific sampling rates. Now, however, in keeping with a need to provide more efficient utilization of the airspace and service for increased numbers of aircraft, the FAA is establishing area navigation routes which will add materially to the flight inspection workload.

2. There is no satisfactory substitute for a flight inspection aircraft in initially validating a route, and that portion of the increased workload is accepted. However, the increase in workload for continued validation of the route can be moderated if the lateral deviations of user aircraft from the established routes are monitored by the existing primary and/or secondary radar. The requirement for investigating this application of user track data is stated in the National Aviation System, Policy Summary, dated March 1970.

PROGRESS.

SRDS Report RD-69-9, dated April 1969, entitled "Analysis of User Aircraft for Evaluating VOR Airway Performance," was prepared for the FAA by Airborne Instruments Laboratory.

This effort determined the feasibility of monitoring the performance of navaids, such as the VOR, by recording digitized radar data of user aircraft along an airway. Data on 300 user aircraft were obtained using the JFK ARSR radar, a Beacon Video Digitizer (BVD) at the New York Center and a special recorder. Figure 71, is a block diagram of a typical BVD recorder installation. Special beacon codes were utilized by the user aircraft. The function of the BVD was to process beacon replies and statistically determine the target center in azimuth/range for each aircraft on each antenna rotation and generate a target report. The function of the recorder was to filter out and record only those target reports having desired beacon codes.

With this system, it was possible through discrete transponder codes to identify aircraft and, with digitized radar data (azimuth, range and altitude), automatically process large amounts of such data. It was determined that an average data sample of about 100 aircraft would be desirable to performance monitor any enroute airway within an accuracy of about one-half degree. The effect of sample size on track data is shown in Figure 72. It should be mentioned that the airway chosen for the previous tests can be considered as a worst case where aircraft were climbing from JFK airport to the Manta intersection and under or over-shooting on their route to the Sea Isle VOR (Figure 73). The use of this route was largely dictated by the fact that AIL was required to use radar (EAIR) and recording facilities at NAFEC. Production type systems should monitor a heavily travelled route preferably where most aircraft have reached assigned altitude.

Figure 74 shows the distribution of all user aircraft at 20 nautical mile range from the Sea Isle VOR.

It was concluded that performance assurance monitoring of navaids by statistically sampling user aircraft was technically, operationally, and economically feasible. If a navaid's performance is determined to be substandard, then a special flight-inspection aircraft could be utilized for a more detailed check. The objective of the current program is to develop a hardware/software system for automatically gathering, reducing and presenting radar data in a form that will be operationally effective for the FAA. The system will be applicable to area navigation routes as well as conventional airway structure.

For this specific phase of the overall program, a system will be developed for analyzing existing data in digitized form, at an Air Route Traffic

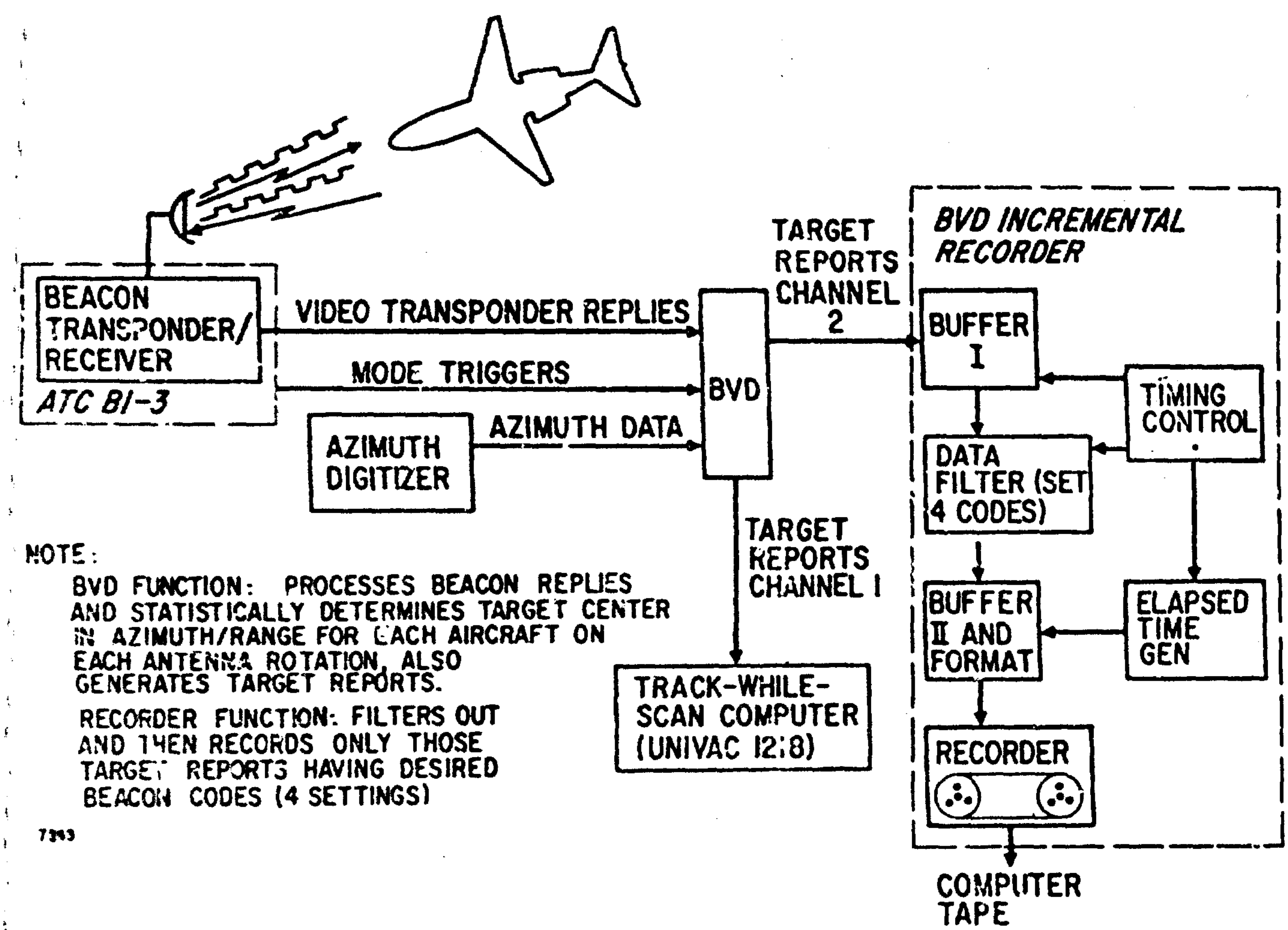

Figure 71. Typical BVD Recording Installation.

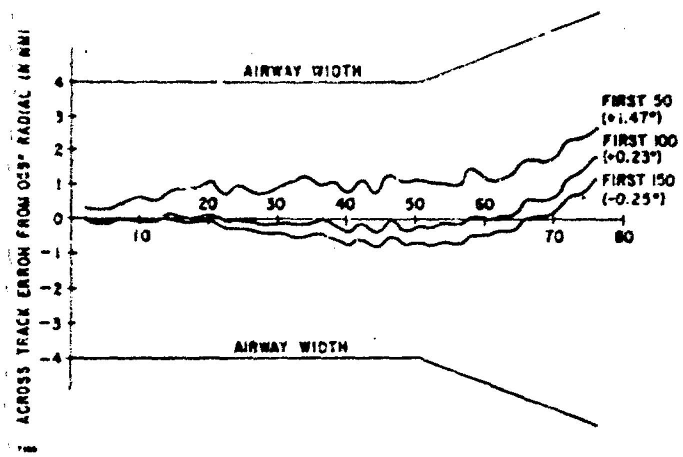

Figure 72. Effect of Sample Size on Track Data.

Control Center (ARTCC), for actual track determination versus the ideal route. This work will utilize and interface with existing NAS Stage A facilities.

Criteria will be developed for eliminating data on aircraft that are not attempting to follow a specific route, either because they are not under positive control or because of radar vectoring. These criteria must be amendable to inclusion in routines for automatically handling of the data. Data from aircraft not using VOR/DME/TACAN derived information as the primary signals for area navigation routes (such as Doppler Radar and Inertial Navigation devices) will be separated and may be utilized in a subprogram as a relative measure of the airborne accuracy of self-contained navigation devices.

The cumulative flight tracks will also be automatically analyzed and presented in a manner that readily reveals or indicates a trend for VORTAC anomalies. Flight inspection aircraft may be dispatched rapidly for final determination of overall facility accuracy.

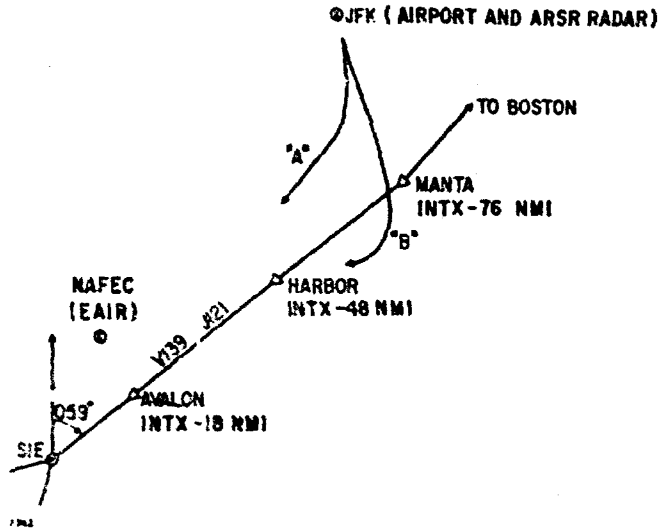

Figure 73. Test Area Showing V139/J121 Airway.

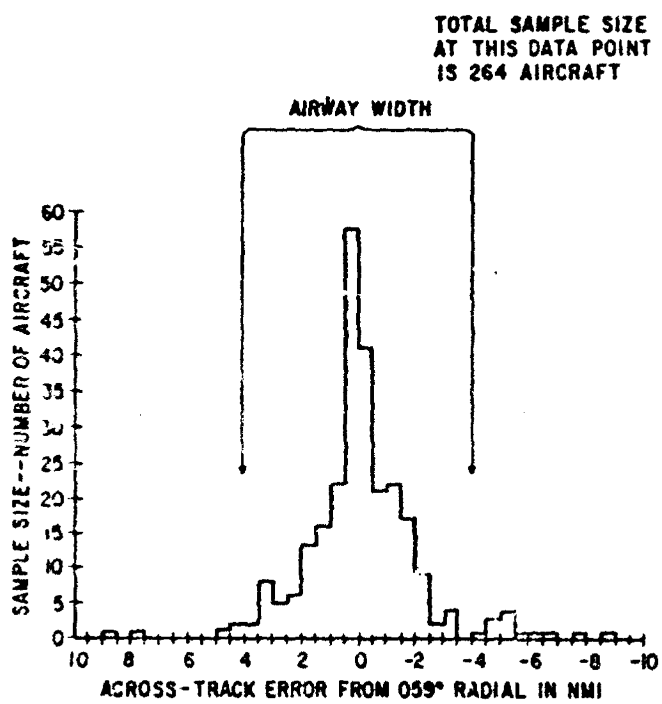

Figure 74. Distribution of All User Aircraft at 20 NMI Range From Sie.

This system allows for a much faster sampling rate of navaids performance (e.g., daily) than existing flight inspections. Additionally, sampling the user aircraft actual path will indicate abnormalities which may be caused by erroneous ground transmitted signals, site effects, avionics equipment in the aircraft and peculiarities of specific types of aircraft.

An FAA contract was awarded to AIL on September 1971 for the development of the automated feasibility model enroute system. The concept of measuring the actual path of aircraft is significant and, is economically, operationally, and technically feasible, especially with the implementation of the NAS Stage A system. Also, this concept of User Track Monitoring will be utilized in the Terminal Area, and for Final Approach, Touchdown and Rollout.

A system is under development for measuring the position of aircraft on selected ILS approaches to major airports, based on signals transmitted from the user aircraft. A statistical analysis of several of these selected approaches will indicate whenever a dangerous trend, towards an out-of-tolerance condition, exists in the ILS signals. A real-time readout of an aircraft's position on final approach may also be available. This system will be utilized during all weather conditions.

TREND.

The following milestones are scheduled for completion:

1. FAA contract awarded for development of feasibility final approach systems–4/72.
2. FAA contract awarded for development of feasibility terminal system–4/73.
3. FAA contract awarded for development of prototype model for enroute system–11/73.
4. FAA contract awarded for development of prototype models for final approach system–4/73.
5. FAA contract awarded for development of prototype of total system–2/75.

PROGRAM.

New Concepts for Performance Assurance, IIB3, 212-303.

MANAGER.

J. Cosner, RD-342.

PROJECT MANAGERS.

J. Walls, NA-521, and E. Zyzys, NA-522.

FREQUENCY SPECTRUM ENGINEERING DEVELOPMENT

BACKGROUND.

This effort supports the National Airspace System, 10 Year Plan and Policy Summary, FAA Requirements FAAR 6360.2 "Provide Improved ATCRBS Interrogators for Joint-Use RAPCON/RATCC Facilities;" FAAR 7310.3 "Future Voice Communications Systems;" FAAR 7310.2 "Provide Air-Ground Communications for Transoceanic and Sparsely Populated Areas," FAAR 9850.1 "Develop Airborne Collision Prevention Systems;" FAAR 6310.2. "Provide Improved Terminal Radar and Beacon Capabilities;" FAAR 6310.3, "Provide Low-Cost Surveillance Radar Remoting Equipment;" FAAR 7310.3, "Future Voice Communications," and 9550-1 Request, SMS-71-20, 5/1/72.

The continuing growth of aviation and the development of new equipment place tremendous demands on the overload radio frequency spectrum. The FAA is a major user of the spectrum, employing more transmitting equipment than any other civilian government agency. Spectrum engineering, planning, and early definitive policy direction are essential to accommodate the expanding operational requirements.

Because of the total dependence of the aviation community on radio communications and almost exclusive reliance on spectrum dependent navigational systems, it is mandatory to seek improved ways to employ the limited allocated frequencies. Soundly engineered frequency criteria and assignment methods will assure greater reliability of the communication and navigation systems and thus enhance safety of flight

The objectives of Frequency Spectrum engineering and development are to assure identification and determination of the future spectrum requirements of the ATC systems, and formulation and implementation of plans for achieving the most efficient utilization of the limited radio frequency spectrum.

This effort accordingly directs its principal thrust to those tasks that would support the objectives. The following is a sampling of spectrum engineering tasks:

1. Examination of terminal and long range radar bands to identify improved assignment methods and determine adequacy of spectrum space for future expanded systems.
2. Study of methods of reducing effects of Radio Frequency (RF) multipath signals on system performance and frequency planning.
3. Reduction or elimination of undesired emissions and interfering signal sources through the use of latest equipments and techniques.
4. Continuous review of spatial and frequency separation standards to insure maximum use of allocated frequency bands.
5. Study FAA electronic equipment reaction to interfering RF signals (i.e., diathermy machines, garage door opener, auto ignition system).
6. Study of modulation techniques to determine those that are least wasteful of the spectrum, but yet provide the desired degree of intelligence transmission.
7. Study and experimentation of pulse generating and amplifying techniques to provide for minimum emission bandwidths.
8. Development of a solid-state radio frequency interference detection and measuring capability, mobile, and portable.
9. Studies and preparation of technical reports in support of additional spectrum needs.
10. Study of the spectrum impact of satellite applications and techniques.
11. Assessment of international space conference spectrum allocation decisions.
12. Introduction of 50 kHz channel spacing in lieu of 100 kHz, for VOR/ILS and Y channels for DME/TACAN.
13. Development of computer modeling techniques for predicting channel requirements for new systems or redeployments of present systems.
14. Identification of types of interference presently degrading the ATCRBS system.
15. Spectrum requirements for satellites in the NAS.
16. Introduction of 25 kHz channels in the VHF communications band.
17. CAS interactions with other systems.
18. Automation of VOR/ILS and communication frequency selection.
19. Investigation of diffraction effects on radar and beacon systems caused by buildings or other obstructions.

20. Completion and exercising of ATCRBS digital model.

PROGRESS.

1. Office of Engineering Planning final report, entitled "Probablistic Interference Prediction Model, Air/Ground Voice Communications," completed. This report discusses an approach to frequency assignment based upon aircraft separation, channel loading and aircraft activity which determine the probability of interference rather than protection in the worst-case condition, our present spacing criteria.

2. U.S. aviation position presented by SRDS to the ITU World Administrative Radio Conference for Space Telecommunications in Geneva, 7 June to 16 July 1971. This represents the culmination of more than two years' work on the part of Frequency Management personnel who actively participated in the Interdepartment Radio Advisory Committee (IRAC) special meetings preparing and coordinating the interests of U.S. aviation in frequency allocation matters. Implementation plans for the conference decisions are presently being jointly prepared by Government agencies, personnel of the Office of Telecommunications Policy and the Federal Communications Commission through the IRAC/SPS mechanism.

3. Contract DOT-FA72WA-2782 awarded to Cornell Aeronautical Laboratory, Inc., of Buffalo, N.Y. This is for a study of the effects of new building construction in the vicinity of ASR, ARSR, or ATCRBS facilities and the development of a computer model to accurately predict the impact of proposed construction upon the coverage of such facilities. This will provide FAA engineers with an effective tool for assessing whether such proposed construction will constitute a hazard to air navigation, in accordance with Federal Aviation Regulations, Part 77.

4. SRDS Frequency Management secured IRAC approval in the U.S. Table of Frequency Allocations of reservations of frequency allocating the bands 5.0-5.25 GHz and 15.4-15.7GHz for a Microwave Landing System.

5. SRDS Frequency Management made a formal presentation to RTCA Special Committee 122 of FAA's programs and plans for implementing the first phase of "split channel" operation in the VOR/ILS/TACAN/DME frequency bands starting in CY 73. The presentation explored in depth all ramifications of the program with industry and other government representatives. Advisory Circular 170-12, "Implementation of 50 kHz/Y Channels For ILS/VOR/DME," was published.

6. FAA Order 6050.25 was issued. It establishes FAA policy for procurement of communications equipment for use in the VHF aeronautical mobile band. This will ensure that future FAA equipment procurements will be compatible with the forthcoming 25 kHz channeling plan.

7. Report FAA-RD-71-91, "Analysis of Factors Affecting Electromagnetic Compatibility of Radars Operating in the 2700 to 2900 MHz Band," was issued. This report describes radar electromagnetic compatibility, discrete channel assignments, and dual diversity systems.

8. Electromagnetic Compatibility Analysis Center (ECAC-DOD) Final Report, "ATC ATCRBS Hot Spots Investigation," was issued. This report analyzes all hot spots within the coverage of Los Angeles and Jacksonville ARTCC's to determine factors causing performance degradation and the amount of performance improvement which could be realized with corrective action.

9. Final Report FAA-RD-71-95, "Collision Avoidance System Analysis," was issued. This report describes the potential electromagnetic interference between the collision avoidance system (CAS) and both existing and future systems in the 1535 to 1660 MHz band.

TREND.

The following major events are scheduled for completion:

1. NAFEC final report and computer program for frequency assignment of VOR/ILS/DME/TACAN facilities completed–6/72.

2. Cornell Aeronautical Labs. Fresnel Diffraction final report and Computer Program completed–8/72.

3. TSC ATCRBS digital simulation model completed and exercised–6/72.

4. Institute of Telecommunications Sciences actual terrain propagation model completed–12/72.

5. Institute of Telecommunications Sciences multipath handbook issued–5/73.

6. Spectrum characteristics analysis and measurement vehicle specified–4/72.

MANAGERS.

Frank S. Kadi, RD-511,
(213-502, 213-503, 213-516, 213-521)
Raymond Johnson, RD-512.1
(213-504, 213-515, 213-507, 213-517)

PROJECT MANAGER.

Charles Santora, NA-531, and Thomas Steger, NA-722.

SENSING AND SUPRESSION OF AIRCRAFT WAKE TURBULENCE

BACKGROUND.

The purpose of this program is to: (1) Evaluate air movement sensing devices, (2) Design equipments/subsystems for dissipation of hazardous wake vortices in airport environs, (3) Reduce vortex strength at the source, (4) Establish a measurement facility at NAFEC in which all of the foregoing will be evaluated, and (5) Determine the feasibility of a wake vortex predictive system for air-air separation.

This subprogram is responsive to Air Traffic Service's Request for R,D&E Effort (9550-1), AT-300-13, 7/1/71, the Air Traffic Control Advisory Committee's report to the Office of the Secretary, Department of Transportation and Flight Standards Service's memorandum requests of 5/11 and 23/5/70.

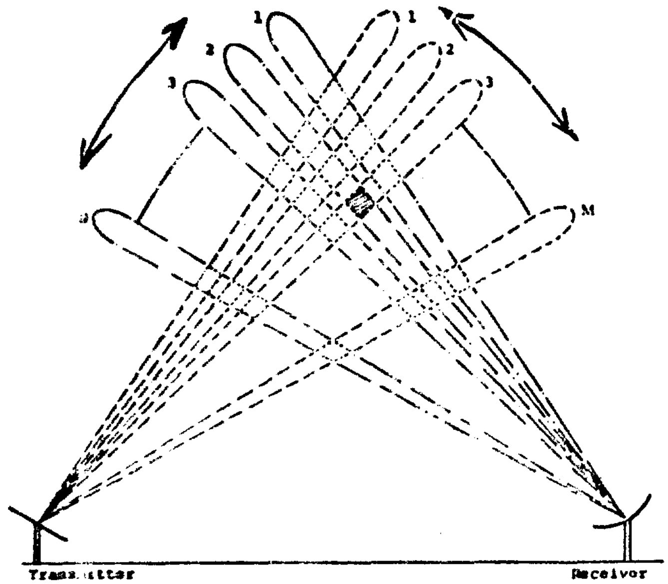

Figure 75. Acoustic Swept-Beam Configuration.

PROGRESS.

The Transportation Systems Center, Cambridge, Mass., initiated a study for sensing techniques within the current state-of-the-art. Laboratory experimentation using laser and acoustic devices is being conducted, prior to field testing and integration of sensing, processing and display into the operational situation, for the purpose of producing an operational system design (Figure 75).

Work statement and procurement request have been prepared for scale model studies that will allow selection, for live evaluation of the most promising devices for removal and decay acceleration of wake vortices in the terminal airport areas.

FAA and NASA roles have been defined so that NASA will conduct further studies on the aerodynamics of the wake vortices phenomenon and aircraft modifications needed to reduce the strength and accelerate the decay of vortices. Modified aircraft will be flown in the NAFEC Measurement facility.

The NAFEC Measurement Facility has been established and additional omni directional hot-film sensors have been procured. Computer programs and test plans are being developed for further testing of sensing systems for identification of wake vortices (Figure 76).

The contractor, for the feasibility study of a vortex predictive system, has been selected.

Work statement and procurement request have been prepared for the development of a study of aircraft wake vortices dissipation techniques using aircraft model and water tank to

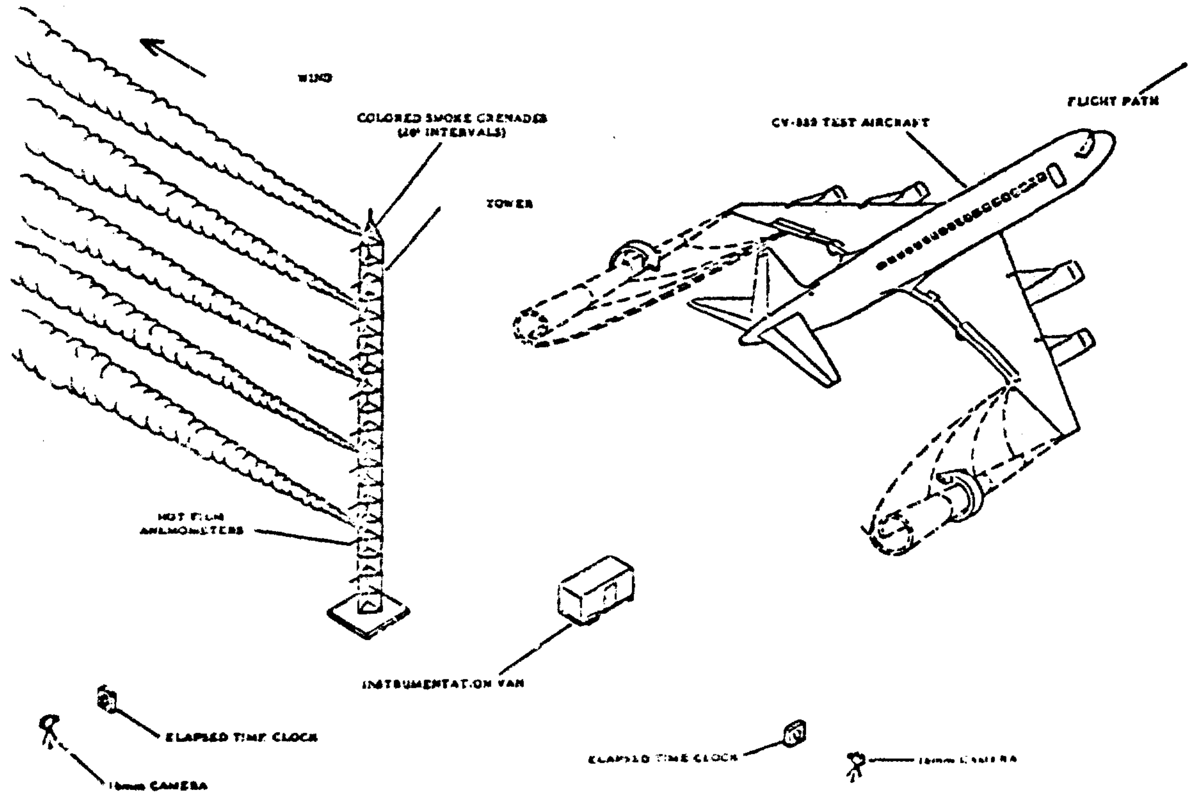

Figure 76. Tower Fly-By Schematic.

obtain high Reynolds numbers which can be related to the airport environment.

Contract awarded for predictive system study and scale study airport environment modification.

TREND.

The following major milestones are scheduled for completion:

1. Completed NAFEC Measurement Facility–6/72.
2. Evaluation of sensor systems completed –5/73.
3. Evaluation of airport environment modifications completed–3/73.
4. Evaluation of aircraft modifications completed–3/73.

SUBPROGRAM.

Sensing and Suppression of Aircraft Wake Turbulence, I, 214-741.

MANAGER.

George C. Hay, RD-742.

ASSOCIATE PROGRAM MANAGER.

William V. Gough, Jr., RD-743.

DEVELOPMENT OF ATC TOWERS

BACKGROUND.

At many FAA facilities, the noise level generated by electronic and mechanical equipment is quite high. Maintenance personnel working under these high noise level conditions experience a lowering of morale, loss in work efficiency, fatigue, nervousness, irritability and other physiological ailments. The problem is not unique to maintenance personnel, but also is present in the air traffic control tower and the flight service station. Here, while noise levels are relatively lower than in equipment areas, voice communications are made difficult due to simultaneous communications.

The purpose of this effort is to develop an acoustical noise level standard to the agency's facilities, and is responsive to 9550.1, Request for R,D&E Effort, SMS 68-13, 19/2/68.

Many methods have been suggested to reduce the noise level at FAA facilities; however, without a standard to define the noise level that should exist within a facility, a broad approach to the problem could not be undertaken.

PROGRESS.

1. A two-phase contract for (a) establishing the acoustical noise level standard and a uniform procedure for conducting acoustical noise surveys, and (b) providing definitive methods of noise reduction in existing types of agency facilities is currently being implemented by the Illinois Institute of Technology Research Institute (IITRI). This contract was awarded in May 1971.

2. Phase one was completed in March 1972.

TREND.

The following major events are scheduled for completion:

1. FAA standards issued--6/72.

2. Noise reduction techniques issued by FAA for agency facilities--12/72.

SUBPROGRAM.

Development of ATC Facilities, 215-182.

MANAGER.

Carroll Workman, RD-163.

MOBILE ATC/NAVIGATION/COMMUNICATIONS FACILITIES

BACKGROUND.

Federal Aviation Administration Register of Requirements, FAAR 6030.2A dated 22/7/70 establishes the requirement for a method which will insure continuity of quality air traffic control and navigational aid service to the aviation community in time of equipment failure, routine maintenance, natural or man-made disaster. This capability in the past has been marginal and with increasing air traffic, increases in numbers and improvements in designs of mobile facilities will be required.

The purpose of this effort is to develop, fabricate, and display a system of mobile air traffic, navigational aid, and communications facilities and is in two phases:

Phase I has been completed. Phase I provided designs for mobile facilities (trailers) with the installation of those electronic equipments which are currently available within the agency inventory.

Phase II is to provide a system approach to the design of mobile facilities to be acquired in the FY 72-81 time period. These facilities will have improved equipment packaging techniques, methods of facility deployment utilizing the latest state-of-the-art equipments, improved reliability, maintainability, and mobility characteristics. These mobile facilities are to be provided in conjunction with the quantity F&E electronic system procurements.

The following major elements of the system will be provided: Very High Frequency Omni-Range (VOR), Air Traffic Control Tower (ATCT), Comlo/Marker, Comm Vans, Instrument Landing System (ILS), Distance Measuring Equipment (DME), Airport Surveillance Radar (ASR), Flight Service Station (FSS), Air Traffic Control Radar Beacon System (ATCRBS), Common Digitizer (CD), Terminal Radar Approach Control (TRACON), and Engine-Generators.

PROGRESS.

The following Phase I mobile facilities have been placed in inventory and are currently being utilized for emergency use, use during the shutdown of primary equipment for routing maintenance, site testing, interim installations and other needs as required:

Mobile Air Traffic Control Towers, AW-2 and AW-X2.

Long Range Radar (MERF) consisting of equipment van and a mobile antenna.

Comlo/Markers.

Communication Van.

Engine Generators (MPU) (37.5 KVA unit).

Very High Frequency Omni-Directional Range, VOR and UHF Omni-Directional Course and Distance Measuring Equipment (TACAN).

TREND.

The following major events are scheduled for completion:

1. System Design Requirements established by FAA for Phase II facilities—FY 73.
2. Phase II facilities procured by FAA in conjunction with the F&E Program—FY 74.

SUBPROGRAM.

Mobile ATC, Navigation, and Communication Facilities, 215-183.

MANAGER.

P. Serini, RD-163.

APPENDIX 1 — COMPLETIONS★

*These summarize R,D&E programs completed during the period 1 April 1970 to 31 March 1971.

INVESTIGATION AND ANALYSIS OF DME TRAFFIC LOADING

The purpose of this effort was to identify a method of measuring DME traffic at a DME saturated and non-saturated TACAN site. Traffic counts were conducted at the following Eastern Region VORTACs: LaGuardia, Robbinsville, Coyle, Kunton, Deer Park, Sea Isle and Yardley.

RESULTS OF PROJECT.

1. Traffic count procedures developed can be utilized by site personnel.
2. Peak traffic counts at the sites tested represent a system operating at the following percentages of full capacity: LaGuardia-66 percent; Deer Park-42 percent; and other sites less than 20 percent.
3. Traffic count procedures should be utilized by site personnel to collect DME traffic data.

PROJECT.

Investigation and Analysis of DME Traffic Loading, Project 043-310-02X (old No. 330-006-07X).

DIRECTOR, NAFEC.

Cecil A. Commander, NA-1.

STAN-38 GLIDE SLOPE TESTS

The purpose of the project was to install and evaluate the performance of the executive monitor system, STAN-38 ILS at NAFEC under conditions of transmitter antenna malfunction and external environmental factors. This phase covers the STAN-38 glide slope installed on Runway 4. It was a three-element, modified Type-M array without clearance, normally used at sites having terrain or building obstructions in the approach zone. Tests were performed to check monitor response during conditions of antenna dephasing, antenna attenuation, and control maladjustment in accordance with a joint U.S./U.K. agreement. Effects of prevailing weather conditions on monitor operations were recorded.

RESULTS OF PROJECT.

1. STAN-38 equipment in M-array without clearance configuration met Category III requirements listed in ICAO Annex 10.

2. STAN-38 system did not perform adequately under degraded performance because satisfactory alarms were not achieved during the dephased upper antenna fault condition when a false path occurred below 1°.

3. STAN-38 system is not suitable for Category III implementation until an operational evaluation determines reliability.

PROJECT.

STAN-38 Glide Slope Tests Project No. 073-318-01X.

DIRECTOR, NAFEC.

Cecil A. Commander, NA-1.

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HUMAN FACTORS/ACCURACY ANALYSIS STUDIES OF FLIGHT PLAN POSITION DISPLAY SYMBOL

The purpose of this project was to evaluate the concept of using computer-generated Flight Plan Position Display (FPPD) information on pictorial and tabular displays to control air traffic in areas with no radar coverage, for example, oceanic sectors. Specific objectives were to:

1. Determine degree of accuracy displayed by Flight Plan Aided (FPA) tracking.
2. Investigate operational use of FPPD information and symbology.
3. Investigate feasibility of using FPPD information to replace printed flight progress strip.

RESULTS OF PROJECT.

1. Analysis of flight progress strip data revealed a 3.2 minute deviation between pilot estimated time at fixes and actual time.
2. Pictorial display symbology was satisfactory for oceanic control functions and tabular display added significantly to the use of the test system.
3. Controller questionnaire response indicated that display and processing techniques provided a more useful presentation than flight progress strip boards.
4. The design and operational documentation for an expanded oceanic air traffic control system using an interactive graphic display concept should be undertaken as soon as possible.
5. ARTCC oceanic areas other than Oakland should be surveyed for potential application of a graphic display system.
6. Refinement of the system should be undertaken by further study of the Oakland ARTCC.

PROJECT.

Human Factors/Accuracy Analysis studies of Flight Plan Position Display Symbol, Project No. 150-540-01X.

SUBPROGRAM MANAGER.

L. N. Douglass, RD-152.

PROJECT MANAGER.

A. J. Spingola, NA-550.

EVALUATION OF HIJACKING CONVERSATION MONITORING SYSTEM

This project was initiated in response to a request of SE-330 to determine the feasibility of monitoring conversations occurring during hijacking. A covert switch and currently installed voice recorder system were used to transmit conversation to the ground station. Voice transmission degradation was measured by a Speech Communication Index Meter (SCIM). Avionic Maintenance Section of the Maintenance Branch provided aircraft and modification installation of covert switch and SCIM equipment. Fairchild Camera and Instrument Company advised FAA on area microphone installations and National Transportation Safety Board provided data on recorder readouts.

RESULTS OF PROJECT.

1. Simple low-cost adaption of existing recording systems can provide intelligible reception to ground stations.
2. Reception quality depends on condition of area microphone-amplifier, microphone location, ambient noise and hijacker location. Stronger signals are received when microphone is located near probable hijacker position.
3. In case of noise spatial distribution a directional microphone could be advantageous but improvement in voice intelligibility is generally negligible.
4. Extended keying period could overheat transceiver.

PROJECT.

Evaluation of Hijacking Conversation Monitoring System, Project 181-721-07X.

SUBPROGRAM MANAGER.

J.S. Szymkowicz, RD-722

PROJECT MANAGER.

C. Santora, NA-531.

TEST AND EVALUATE DUAL DIVERSITY FOR AIRPORT SURVEILLANCE RADARS (ASR)

NAFEC conducted this project to determine the degree of improvement in radar detection by using both radar channels on different frequencies. It was conducted on S-Band NAFEC ASR-5 and was an extension of previous dual-diversity experiment conducted at L-Band.

RESULT OF PROJECT.

1. A 4.0 dB increase in performance for analog video and 3.0 dB increase for digitally processed data.

2. Provided a basis for incorporating a dual diversity capability in radar procurement specifications.

PROJECT.

Test and Evaluate Dual Diversity for Airport Surveillance Radars (ASR) 241-021-04X.

PROJECT ENGINEER.

Dominick L. Offi, NA-533.

INTERROGATOR FREQUENCY MEASURING TEST BED

This project was initiated in response to a request from SM-100, Form 9550-1, No. SMS-69-19 for development of an Interrogator Frequency Measuring Test Set to measure pulsed RF carrier frequency of Air Traffic Control Radar Beacon System (ATCRBS) interrogators with accuracy consistent with U.S. National Standard for ATCRBS. Specification FAA-E-2424 was approved and Procurement Request PRN WA5R-1-0329 (SRDS No. C-10037) submitted to Logistics Service for procurement of one prototype model for test and evaluation. Request for Proposal was released, 2/71 and proposals evaluated, 4/71.

During the proposal evaluation period a non-bidding manufacturer informed the subprogram manager that off-the-shelf commercial test equipment would meet requirements of the specification. A demonstration of the Systron-Donner Corp. electronic counter/transfer oscillator was made at NAFEC, 4/71, and the performance deemed adequate to warrant an in-depth engineering test. A temporary hold was placed on RFP contract negotiations and quick-reaction task No. 198-001-01X assigned to NA-533 to test two available electronic counter/transfer oscillator equipments. The equipments tested are:

1. Syston-Donner, Model 1037 Electronic Counter with Model 1292A Transfer Oscillator plug-in.
2. Hewlitt-Packard, Model 5245L Electronic Counter with Model 5257A Transfer Oscillator plug-in.

RESULTS OF PROJECT.

1. The tests proved that both equipments meet all performance requirements of specification FAA-E-2424.

2. Procurement Request No. PRN WA5R-1-0329 cancelled 5/71.

3. Test results indicate that Aviation Facility Service should procure commercial equipment for ATCRBS facilities.

4. A "black box" transfer oscillator add-on for Systron-Donner Corp. electronic counter model 6133-50 being procured by FAA should be investigated for suitability as a frequency measuring device.

PROJECT.

Interrogator Frequency Measuring Test Set, Project 033-241-11X (old No. 242-001-11X).

SUBPROGRAM MANAGER.

D.D. Asker, RD-242.

MODULAR INSTRUMENT LANDING SYSTEM (MODILS) AND TACTICAL LANDING AND APPROACH RADAR (TALAR)

Projects 320-114-02X MODILS and 320-114-05X TALAR were completed. The purpose of these efforts was to test and evaluate these systems for their ability to provide approach guidance for STOL aircraft.

RESULTS OF PROJECT.

Both systems provide good quality signals which will probably meet requirements of an interim STOL ILS but will need some refinement in the monitoring area. The 500-hour life of the magnetron output of the TALAR may be a negative factor. Both systems will provide approach guidance for the Twin Otter on the STOLport operational evaluation program. A DME may be required for the interim system to provide altitude/distance cross check and approach progress information. MODILS' integral DME may need refining. TALAR has no DME. NAFEC tested two standard off-the-shelf, low-cost, low-power DMEs which might be satisfactory for interim straight-in or offset approaches.

PROJECTS.

Modular Instrument Landing System, Project 074-317-01X (old No. 320-114-02X); Tactical Instrument Landing and Approach Radar, Project 320-114-05X.

DIRECTOR, NAFEC.

C.A. Commander, NA-1.

TACAN/DME INTERFERENCE TO THE AIR TRAFFIC CONTROL RADAR BEACON SYSTEM

The project, 481-310-05F, was undertaken under Inter-Agency Agreement DOT FA70WAI-175, to determine the effects of TCAN/DME on the Radar Beacon System. Both theoretical and experimental approaches were made for the purpose of developing recommendations to minimize or abolish interference if it occurred. The project was initiated by the Frequency Management Division, Spectrum Plans and Programs Branch (RD-510).

RESULTS OF PROJECT

1. ATCRBS Transponder did interfere with the TACON/DME system.

2. TACAN/DME interrogators interfered with ATCRBS beacon.

3. Co-location problems exist between the two systems.

4. Guardbands should be used to prevent interference and no TACAN/DME assignments should be made on channels 1X-19Y, 1Y-19Y, 56X-76X, and 56Y-82Y.

5. To remove interference a distance versus frequency separation criteria should be used as indicated in Report FAA RD 71-5 "TACAN/DME Interference to Air Traffic Control Radar Beacon System."

PROJECT.

TACAN/DME Interference to the Air Traffic Control Radar Beacon System, 481-310-5F.

PROJECT ENGINEER.

Richard F. Bock, RD-512.3.

WING LEADING EDGE FUEL TANK IMPACT TESTS

The purpose of this project was to evaluate the crash and impact resistance of a DC-8-62 leading edge fuel tank and to define a test for integral wing tanks including the test obstacle and test conditions. Twelve tests were conducted, three on each of the following obstacles: (1) a 4-inch diameter white pine log; (2) a seamless schedule 40 2½-inch diameter mild steel pipe; (3) a 2½ by 2½ by ¼-inch steel angle iron; (4) two on 4-pound chickens; and (5) one on a 6-pound, 13 oz. duck. The first three obstacles simulated airport area incidents such as abnormal landing, aborted takeoff, etc. The last three simulated bird strikes.

RESULTS OF PROJECT.

Log tests indicate leading edge wing tank rupture will occur at speeds of approximately 93 mph and above and 74 mph with the pipe. All three angle iron impacts caused rupture; therefore rupture speed can only be defined as less than 74 mph. Impact with birds of four pounds or more will cause rupture at speeds of 314 mph or more.

The criteria of withstanding impact without appreciable leakage or spillage at one-half the stall speed of the aircraft in takeoff condition (82 mph for DC-8-62) was met in these tests.

The testing arrangement developed was considered acceptable to prove compliance with the proposed criteria. However, the design of the end fitting/guide apparatus for the test obstacle should be improved to assure better control of impact speeds.

PROJECT.

Wing Leading Edge Fuel Tank Impact Tests, Project 503-101-05X.

DIRECTOR, NAFEC.

C.A. Commander, NA-1.

GUN FIRE TESTS OF TRANSPORT AIRCRAFT TIRES

In response to request SE-330-1-70 the project was initiated to determine the feasibility of disabling transport aircraft by puncturing tires with gunfire from weapons normally carried by airport security personnel. Various tire sizes and pressures were subjected to gunfire from various type and caliber weapons at different ranges and temperature conditions. Ballistics Research Laboratories, U.S. Army, Aberdeen Proving Ground, Md. provided personnel and facilities at no cost. Pan American Airways contributed the bulk of tires and wheels at no cost and NAFEC obtained new CV-880 tires at invoice cost. Firestone Tire and Rubber Company, Akron, Ohio, provided a new (reject) DC-8 main gear tire and information on tire construction and qualification tests. Air Operations Security Division of FAA Air Transportation Security Office cooperated on the project.

RESULTS OF PROJECT.

1. Following weapon/projectile combinations caused rapid deflation at pressures and entry angles tested:
   a. 12 guage shotgun–rifled slug.
   b. .308 rifle-pointed, soft-point bullet.
   c. .357 Magnum pistol both 2″ and 4″ barrel–metal point bullet.
2. Following weapon/projectile combination failed to puncture tires at any range down to 75 feet.
   a. 12 guage 00 buckshot–20¼″ and 28″ barrels.

3. Variables affecting tire vulnerability are:

a. Higher pressures.

b. Tread wear and age of rubber.

c. Point of impact–sidewall midpoint more vulnerable than head or crown.

4. The .38 lead projectile effective on sidewall and longer range only when fired normal to the tread from 50 feet or less.

5. The .38 caliber–158 grain metal point and 150 grain metal piercing–high velocity bullets punctured the tire and one time each was fired. The .357 Magnum punctured tires four times in four shots. The limited data obtained indicate these projectiles are superior to the .38 special lead projectile for disabling aircraft by deflating tires.

PROJECT.

Gun Fire Tests of Transport Aircraft Tires, 503-301-06H.

PROJECT ENGINEER.

Patrick Russell, RD-732.

APPENDIX 2 — SELECTION ORDERS★

*Method used by the FAA Administrator for selection of new systems, equipment, facilities or devices for incorporation in the National Airspace System (NAS) and the National System of Airports (NSA) in order to assure proper operation and compatibility between elements of the common civil/military of air traffic control and air navigation facilities.

SELECTION ORDER 1010.39A (3/8/71).

"Category II Approach Lighting System (ALS)."

This order is a minor revision to the basic Selection (1010.39) to provide an increased guage in the ALS red barrettes to agree with the wider guage of the runway touchdown zone lighting system.

MANAGER.

P. Darmody RD-323.

SELECTION ORDER 1010.51A (3/8/71).

"U.S. National Aviation Standard for the Mark X (SIF) Air Traffic Control Radar Beacon System (ATCRBS) Characteristics."

[illegible]

…d in the following respects:

1. Relaxation in the level of transponder self test interrogation signal from −70 dBm to −40 dBm.
2. Relaxation in transponder spurious radiation below one watt to a recommendation that cw spurious radiation be limited to −70 db below one watt.

MANAGER.

M. Natchipotsky RD-242.

SELECTION ORDER 1010.19A (10/13/71).

"Digital Defruiter for the Air Traffic Control Radar Beacon System."

This order provides for the selection of certain digital storage and processing techniques for use in the National Airspace System in place of the older storage Tube Type Defruiter.

MANAGER.

M. Natchipolsky RD-242

SELECTION ORDER 1010.58 (11/18/71).

"Runway Perimeter Lighting Systems."

This order provides for the incorporation of improved Runway Perimeter Lighting Systems in the National Aerospace System and establishes implementation criteria.

MANAGER.

T. Evans RD-323.