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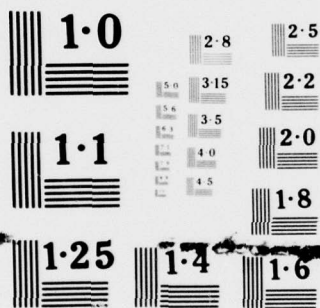
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Quarterly Technical Summary

Development of a  
Discrete Address Beacon System

1 July 1977

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Prepared for the Federal Aviation Administration by

**Lincoln Laboratory**

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LEXINGTON, MASSACHUSETTS



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16. Abstract  <p style="text-align: center;">This is the twenty-second Discrete Address Beacon System Quarterly Technical Summary covering the period 1 April through 30 June 1977. Included are the results to date of analytical studies, laboratory and flight experiments, and software developments supporting the concept feasibility and performance definition phase of the FAA DABS Program.</p>					
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## DEVELOPMENT OF A DISCRETE ADDRESS BEACON SYSTEM

### I. INTRODUCTION AND PROGRAM OVERVIEW

#### A. Introduction

This is the twenty-second Quarterly Technical Summary covering work performed by Lincoln Laboratory between 1 April and 30 June 1977 to develop a Discrete Address Beacon System (DABS). This effort is supported by the Federal Aviation Administration through Interagency Agreement DOT-FA72-WAI-261 between the FAA and the United States Air Force.

DABS is an evolutionary upgrading of the present FAA ATC Radar Beacon System (ATCRBS) employing discretely addressable transponders and incorporating a ground-air-ground data link. DABS will provide the improved surveillance and communication capabilities required to meet the needs of an automated ATC system in the 1980's and 1990's.

Under Phase I, Lincoln Laboratory carried out a detailed system design of DABS based upon design studies, trade-off analyses, and experiments. This system design was described in a set of engineering requirements for engineering development models now being designed and fabricated by the Sensor Development Contractor (SDC), and to be evaluated at NAFEC. The completion of these requirements documents represented the nominal completion of Phase I.

During Phase II, Lincoln Laboratory is continuing to support the FAA as DABS System Engineering Contractor (SEC). Major areas of responsibility during this phase include: validation and refinement of the designs specified, and assisting the FAA in monitoring the SDC.

#### B. Program Overview

Program highlights of the report period were as follows:

- (1) Decision to restructure the DABS National Standard.
- (2) Formulation of a plan to test, in cooperation with NAFEC, potential components of the Elwood DABS prototype sensor back-to-back antenna.
- (3) Near-completion of ARIES diagnostic software and all hardware.
- (4) Completion of TMF site characterization measurements and DABS netting experiments at Warwick, Rhode Island.

#### C. Report Precipis

Sections of this Quarterly Technical Summary contain Phase II task reports as follows:

Section II - FAA Support. As initially written, the DABS National standard was a DABS transponder description and performance specification. At FAA request, Lincoln has now begun to convert the document to a DABS signals-in-space specification. Transponder performance requirements will be transferred to an FAA Technical Standard Order (TSO).

Lincoln is considering several back-to-back antenna configurations for use at Elwood during prototype DABS sensor evaluation. Discussions with NAFEC personnel have led to agreement on relative responsibilities for testing of monopulse feeds for the add-on beacon antenna and for checking radome proximity effects.

Section III – ARIES Simulator. Hardware (excepting external cabling) and diagnostics software for the ARIES Simulator are essentially complete and interfacing of the test simulator to the DABSEF experimental sensor is imminent. A full 400-aircraft LA Basin traffic model meeting ER-26 bunching requirements is being prepared.

Section IV – Experimental Facilities. DABSEF continues to serve as a data reduction center and to support infrequent test/demonstration flights.

The Transportable Measurements Facility is now in temporary storage having completed site characterization tests at T. F. Green Airport, Warwick, Rhode Island. TMF runs while at Warwick have provided data for testing DABS multisensor software (algorithms) and to assist the FAA New England Region Office in evaluating a potential ARTS site at the airport.



## II. FAA SUPPORT

### A. DABS National Standard

The DABS National Standard, originally thought of as a set of specifications for transponders, is being revised. It is now to become a description of the signals in space, while more detailed transponder requirements will ultimately appear in the form of a TSO (Technical Standard Order). The changes are extensive and it will be some time before all references to transponder performance are deleted without removal of essential information.

### B. DABS En Route Sensor Back-to-Back Antenna

Lincoln Laboratory is currently investigating beacon antennas suitable for use in a back-to-back configuration at a DABS en-route installation. The task is two fold. Of immediate concern is a back-to-back antenna that can be installed at the Elwood en-route site to support the DABS prototype sensor. A longer range effort is the recommendation of a permanent back-to-back antenna solution for en-route sites in general.

There are a number of possibilities for the Elwood facility. Listed below are the more mechanically feasible and economical configurations being considered for the initial implementation at Elwood:

- (1) Two top-mounted back-to-back hogtrough antennas modified for monopulse,
- (2) A combination of a hogtrough either top-mounted or rear-mounted on the ARSR-2 reflector and a modified NADIF feed.

Another possibility is the use of the Hazeltine "open-array" although its cost and the complexities of mechanically mounting such an array within the confines of the radome make this choice less attractive.

An unknown introduced by the use of a top-mounted hogtrough antenna is the effect of the proximity of the non-orthogonal radome surface on the monopulse surveillance performance. Lincoln Laboratory is currently planning to make measurements at NAFEC using the TMF to determine the suitability of such an arrangement. The modification of the Elwood hogtrough to monopulse is relatively straightforward and will be performed by Lincoln Laboratory.

The NADIF feed, according to results of preliminary tests by NAFEC, shows promise as a suitable monopulse antenna. NAFEC has generated limited azimuth monopulse patterns at essentially zero degrees elevation using both computer simulation and actual measurements from a ground-based source. The tests were performed using the 6-in. dipole spacing of the original feed as well as larger dipole spacings.

NAFEC is planning more complete tests on at least two versions of a monopulse NADIF feed. One version is the original feed configuration simply modified to monopulse. The other version will include additional dipoles in an arrangement similar to the Texas Instruments Integral beacon feed. NAFEC is planning to generate patterns and measure monopulse performance by using both a fixed ground source and an aircraft.

Current plans are for Lincoln Laboratory to continue antenna measurements at Elwood once NAFEC has completed their NADIF testing program. The task will involve both antenna pattern measurements and generation of surveillance data through use of the TMF and a controlled aircraft. The current hogtrough at Elwood will be modified for monopulse operation by Lincoln Laboratory, and measurements made to determine its monopulse capability and any affects caused by the radome. Similar measurements will be made on the modified NADIF antenna.

### III. ARIES SIMULATOR

#### A. Hardware

All fabrication for ARIES has been completed except for the cabling from the top of the ARIES rack to the DABS sensor. Agreement has been reached with Texas Instruments as to the details of these interfaces, and fabrication is now under way.

Hardware checkout is well along, although behind the schedule anticipated in the April 1977 DABS QTS. As a result, system checkout at DABSEF is now scheduled to begin by mid-July.

#### B. Software

All diagnostic software is very nearly complete, and modifications continue to be made as checkout uncovers programming errors. All diagnostics except the reply generation diagnostic using the self-test unit and the diagnostic for the radar report interface have been successfully run with the hardware.

A program that analyzes the statistical properties of the random replies generated by ARIES (essentially by producing histograms of the various reply parameters) has been written and the results match the desired distributions.

The small traffic model produced as described in the April 1977 QTS has been used to check out the model conversion software for ARIES (which converts the MITRE, 1982 Los Angeles Basin Model format to ARIES input format). This conversion software is now being applied to the 1982 model tape to generate a full 400-aircraft model meeting the bunching specifications of ER-26. The difficulty comes in determining where to locate the sensor within the Los Angeles basin such that (a) it sees no more than 400 targets, (b) ER-26 bunching limitations are not exceeded, and (c) the limits are approached closely enough that the DABS sensor is stressed.

#### IV. EXPERIMENTAL FACILITIES

##### A. DABSEF

Initial processing of TMF data from the Warwick, Rhode Island, site was completed. For clarification and presentation, many TMF experiments have been reprocessed during this reporting period. A modification to the playback system is under way to permit the assignment of a fixed altitude to non-Mode C aircraft on TMF tapes.

Maintenance of the SEL computer and DABSEF hardware has continued. The Bendix transmitter required five days of repair following a series of power failures caused by a May storm. Demonstrations of the IPC playback system were given for NAFEC personnel.

##### B. Avionics

DABS transponders have been flown on a non-regular basis in connection with special projects. No malfunctions have occurred in either the transponders or their ancillary devices.

One transponder was taken first to Hazeltine and then to Lockheed to be used as an analytic device in checking out interrogator hardware. This transponder was then turned over to NAFEC.

A way was found to retrofit a squitter generator to the Bendix transponders so that they may be used in the DCAS test program. Two squitter generators have been constructed.

Several inquiries and visits from NAFEC personnel in need of familiarization with the transponders and their test equipment and procedures occurred this period. Copies of all data and drawings which had been used by the laboratory to construct the transponder test setup have been given to NAFEC together with advice on their design and construction. There was also an inquiry on the design and construction of our RAS (Report, Aircraft State) adaptor for the transponder. This adaptor reports flight data (heading, airspeed, rate of climb, air temperature) and has been used in our test programs. In this case also, all available documentation has been given to NAFEC.

##### C. TMF

On 23 June 1977, the TMF completed its measurement activity at T. F. Green Airport, Warwick, Rhode Island, and was brought back to Lexington for temporary storage.

At T. F. Green Airport, the TMF participated in a number of simultaneous recording exercises with both DABSEF and the ARTS facility at Logan Airport. The data from these missions are being used to support development and testing of software algorithms for a DABS IPC netting task. The missions involved both the use of dedicated aircraft flying prescribed flight patterns and targets-of-opportunity.

While at Warwick, the TMF also provided data requested by the FAA New England Region for evaluating a location on the airport surface for the ARTS radar presently located at Quonset Point. The data included coverage information as seen from TMF at T. F. Green Airport in certain critical areas under the jurisdiction of the Quonset radar, and reflector locations at or near the airport.

DABS DOCUMENTS ISSUED BY LINCOLN LABORATORY  
(Available from National Technical Information Service, Springfield, Virginia 22151)

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FAA-RD-72-44	QTS 1	1 April 1972	Development of a Discrete Address Beacon System
FAA-RD-72-76	QTS 2	1 July 1972	Development of a Discrete Address Beacon System
FAA-RD-72-117	QTS 3	1 October 1972	Development of a Discrete Address Beacon System
FAA-RD-73-12	QTS 4	1 January 1973	Development of a Discrete Address Beacon System
FAA-RD-73-48	QTS 5	1 April 1973	Development of a Discrete Address Beacon System
FAA-RD-73-101	QTS 6	1 July 1973	Development of a Discrete Address Beacon System
FAA-RD-73-165	QTS 7	1 October 1973	Development of a Discrete Address Beacon System
FAA-RD-74-8	QTS 8	1 January 1974	Development of a Discrete Address Beacon System
FAA-RD-74-85	QTS 9	1 April 1974	Development of a Discrete Address Beacon System
FAA-RD-74-136	QTS 10	1 July 1974	Development of a Discrete Address Beacon System
FAA-RD-74-167	QTS 11	1 October 1974	Development of a Discrete Address Beacon System
FAA-RD-75-4	QTS 12	1 January 1975	Development of a Discrete Address Beacon System
FAA-RD-75-67	QTS 13	1 April 1975	Development of a Discrete Address Beacon System
FAA-RD-75-114	QTS 14	1 July 1975	Development of a Discrete Address Beacon System
FAA-RD-75-166	QTS 15	1 October 1975	Development of a Discrete Address Beacon System
FAA-RD-76-10	QTS 16	1 January 1976	Development of a Discrete Address Beacon System
FAA-RD-76-82	QTS 17	1 April 1976	Development of a Discrete Address Beacon System
FAA-RD-76-126	QTS 18	1 July 1976	Development of a Discrete Address Beacon System
FAA-RD-76-174	QTS 19	1 October 1976	Development of a Discrete Address Beacon System



FAA-RD-77-7	QTS 20	1 January 1977	Development of a Discrete Address Beacon System
FAA-RD-77-64	QTS 21	1 April 1977	Development of a Discrete Address Beacon System
FAA-RD-77-107	QTS 22	1 July 1977	Development of a Discrete Address Beacon System

Project Reports

FAA-RD-72-7	ATC-8	24 January 1972	Interrogation Scheduling for the Discrete Address Beacon System	E. J. Kelly
FAA-RD-72-30	ATC-9	12 April 1972	Final Report, Transponder Test Program	G. V. Colby E. A. Crocker
FAA-RD-72-84	ATC-12	14 August 1972	A Comparison of Immunity to Garbling for Three Candidate Modulation Schemes for DABS	D. A. Shnidman
FAA-RD-72-77	ATC-13	14 August 1972	Parallel Approach Surveillance	J. B. Allen E. J. Denlinger
FAA-RD-72-100	ATC-15	29 November 1972	The Influence of Surveillance System Parameters on Automated Conflict Detection and Resolution	J. W. Andrews G. Prado
FAA-RD-73-126	ATC-19	17 October 1973	Interrogation Scheduling Algorithms for a Discrete Address Beacon System	A. Spiridon A. D. Kaminsky
FAA-RD-74-4	ATC-20	28 January 1974	The Effects of ATCRBS P <sub>2</sub> Pulses on DABS Reliability	W. H. Harman D. A. Shnidman
FAA-RD-74-20	ATC-22	19 February 1974	Summary of Results of Antenna Design Cost Studies	J-C. Sureau
FAA-RD-73-160	ATC-25	28 November 1973	DABS/ATCRBS Transponder Bench Testing Program	J. R. Samson J. D. Welch E. R. Becotte E. A. Crocker H. D. Schofield
FAA-RD-74-17	ATC-27	1 March 1974	A Summary of the DABS Transponder Design/Cost Studies	T. J. Goblick P. H. Robeck
FAA-RD-74-142	ATC-29	13 December 1974	DABS Timing: Clocks, Synchronization and Restart	E. J. Kelly
FAA-RD-73-175	ATC-30	9 November 1973	Provisional Signal Formats for the Discrete Address Beacon System	P. R. Drouilhet Editor
FAA-RD-74-62	ATC-30 Rev. 1	25 April 1974	Provisional Signal Formats for the Discrete Address Beacon System (Revision 1)	P. R. Drouilhet Editor
FAA-RD-74-5	ATC-31	13 February 1974	Report on DABS/ATCRBS Field Testing Program	J. R. Samson, Jr. E. A. Crocker

FAA-RD-74-21	ATC-32	4 February 1974	The Effect of Phase Error on the DPSK Receiver Performance	D. A. Shnidman
FAA-RD-74-63	ATC-33	25 April 1974	Provisional Message Formats for the DABS/NAS Interface	D. Reiner H. F. Vandevenne
FAA-RD-74-63A	ATC-33 Rev. 1	10 October 1974	Provisional Message Formats for the DABS/NAS Interface (Revision 1)	D. Reiner H. F. Vandevenne
FAA-RD-74-64	ATC-34	25 April 1974	Provisional Data Link Interface Standard for the DABS Transponder	G. V. Colby P. H. Robeck J. D. Welch
FAA-RD-74-83	ATC-35	24 May 1974	Provisional Message Formats and Protocols for the DABS IPC/PWI Display	P. H. Robeck J. D. Welch
FAA-RD-74-84	ATC-36	20 May 1974	Provisional Message Formats and Protocols for the DABS 32-Character Alpha-numeric Display	J. D. Welch G. V. Colby
FAA-RD-74-144	ATC-37	15 January 1975	An Analysis of Aircraft L-Band Beacon Antenna Patterns	G. J. Schlieckert
FAA-RD-74-145	ATC-38	13 December 1974	Further Studies of ATCRBS Based on ARTS-III Derived Data	A. G. Cameron
FAA-RD-74-162	ATC-40	4 March 1975	DABS Uplink Encoder	J. R. Samson
FAA-RD-74-186	ATC-41	28 April 1975	DABS Link Performance Considerations	G. J. Schlieckert
FAA-RD-74-189	ATC-42	18 November 1974	DABS: A System Description	P. R. Drouilhet
FAA-RD-74-197	ATC-43	8 January 1975	DABS Channel Management	E. J. Kelly
FAA-RD-75-75	ATC-44	16 May 1975	Model Aircraft L-Band Beacon Antenna Pattern Gain Maps	D. W. Mayweather
FAA-RD-75-8	ATC-45	16 May 1975	Network Management	H. F. Vandevenne
FAA-RD-75-210	ATC-46	June 1975	Plan for Flight Testing Intermittent Positive Control	J. W. Andrews J. F. Golden J. C. Koegler A. L. McFarland M. E. Perie K. D. Senne
FAA-RD-75-23	ATC-47	4 April 1975	Scale Model Pattern Measurements of Aircraft L-Band Antennas	K. J. Keeping J-C. Sureau
FAA-RD-75-61	ATC-48	12 September 1975	DABS Downlink Coding	J. T. Barrows
FAA-RD-75-62	ATC-49	25 July 1975	DABS Uplink Coding	J. T. Barrows
FAA-RD-75-91	ATC-50	17 July 1975	Impact of Obstacle Shadows on Monopulse Azimuth Estimate	A. Spiridon

FAA-RD-75-92	ATC-51	20 February 1976	DABS Sensor Interactions with ATC Facilities	D. Reiner H. F. Vandevenne
FAA-RD-75-93	ATC-52	12 March 1976	DABS Modulation and Coding Design - A Summary	T. J. Goblick
FAA-RD-75-112	ATC-53	3 February 1976	Summary of DABS Antenna Studies	J-C. Sureau
FAA-RD-75-113	ATC-54	2 February 1976	Design Validation of the Network Management Function	P. Mann H. F. Vandevenne
FAA-RD-75-145	ATC-56	14 November 1975	Discrete Address Beacon System (DABS) Test Plan for FY 1976	W. H. Harman D. Reiner V. A. Orlando
FAA-RD-76-22	ATC-57	16 March 1976	IPC Design Validation and Flight Testing - Interim Results	J. W. Andrews J. C. Koegler
FAA-RD-75-233	ATC-60	25 March 1976	The Airborne Measurement Facility (AMF) System Description	G. V. Colby
FAA-RD-75-234	ATC-61	9 June 1976	Empirical Characterization of IPC Tracker Performance Using DABS Data	J. Leeper A. Tvirbutas
FAA-RD-76-2	ATC-62	23 March 1976	Beacon CAS (BCAS) - An Integrated Air/Ground Collision Avoidance System	V. A. Orlando J. D. Welch
FAA-RD-76-39	ATC-65	31 January 1977	The ATRBS Mode of DABS	J. L. Gertz
FAA-RD-76-249	ATC-72	4 February 1977	DABS Monopulse Summary	D. Karp M. L. Wood
FAA-RD-77-30	ATC-73	25 April 1977	Air-to-Air Visual Acquisition Performance with Pilot Warning Instruments (PWI)	J. W. Andrews

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1972-38	4 December 1972	The Use of Supplementary Receivers for Enhanced Positional Accuracy in the DAB System	E. J. Kelly
1973-7	9 February 1973	A Maximum-Likelihood Multiple-Hypothesis Testing Algorithm, with an Application to Monopulse Data Editing	E. J. Kelly
1973-44	18 December 1973	Azimuth - Elevation Estimation Performance of a Spatially Dispersive Channel	T. P. McGarty
1973-48	26 September 1973	An Optimum Interference Detector for DABS Monopulse Data Editing	R. J. McAulay T. P. McGarty
1974-7	25 February 1974	Models of Multipath Propagation Effects in a Ground-to-Air Surveillance System	T. P. McGarty
1974-12	12 March 1974	False Target Elimination at Albuquerque Using ARTS-III Software	A. G. Cameron

1975-6	17 July 1975	Effects of Local Terrain and Obstacles Upon Near Horizon Gain of L-Band Beacon Antennas	A. Spiridon
1975-11	25 March 1975	The Statistical Characteristics of Diffuse Multipath Radiation and Its Effect on Antenna Performance	T. P. McGarty