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Report No. FAA-CT-81-159

EXPERIMENTAL RADAR BEACON TRANSPONDER TEST PLAN

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AUGUST 1981

Prepared for

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1. INTRODUCTION.

The Federal Aviation Administration (FAA) is currently engaged in the development of an Active Beacon Collision Avoidance System (BCAS) as a part of its Aircraft Separation Assurance (ASA) Program. Designed to operate in both controlled and noncontrolled airspace, BCAS performs its separation function through the active interrogation of the Air Traffic Control Radar Beacon System (ATCRBS) and/or the Discrete Address Beacon System (DABS) transponders of other aircraft. Operating in this fashion, BCAS is primarily an airborne system. Under certain situations, however, BCAS uses a ground-based 1030-megahertz (MHz) transmitter/receiver known as the Radar Beacon Transponder (RBX). The purpose of the RBX is twofold. First, it provides a means for desensitizing (adapting) the BCAS threat logic to the reduced aircraft separations that arise in terminal areas. This has the effect of reducing the probability of unwarranted threat declarations by BCAS. Secondly, the RBX provides a data channel whereby BCAS evasive maneuvers displayed to the pilot can be relayed to the appropriate air traffic control (ATC) facility. The ATC facility would be that terminal facility in whose airspace the BCAS is flying.

In order to demonstrate the RBX/BCAS concept and to provide a testbed for further RBX developments, the FAA Technical Center has fabricated two experimental RBX's (ERBX's). The purpose of these units is to support the BCAS test flights at the Technical Center during calendar year (CY) 1981 and to provide a functional demonstration of the RBX approach to controlling BCAS sensitivity levels.

This document addresses the tests that will be conducted prior to and during the functional demonstration of the RBX approach.

2. TEST OBJECTIVES.

The objectives of the tests described herein will be to demonstrate that the ERBX's can operate with and control the sensitivity levels of the BCAS Experimental Units (BEU's) built by Lincoln Laboratory.

3. SCOPE OF TESTING.

The tests that will be conducted with and upon the ERBX's will be limited to verifying that the units can establish a data link with and correctly set the sensitivity levels of the BEU's. These tests will be performed under laboratory conditions and later during a demonstration flight series. The data collected will pertain to the number and content of successful transactions that transpire between the ERBX's and the BEU's per unit time. The data derived will come primarily from the BEU data tapes, the ERBX data collection software, as well as the track plots of test aircraft obtained from the Technical Center's tracking facilities.

4. TECHNICAL APPROACH.

The testing will be conducted in two phases: phase 1 — the engineering tests, and phase 2 — the ERBX demonstration tests. In the first phase, the ERBX will be functionally tested without the BEU, while in the second, the ERBX and BEU will be mated and demonstration flights made. Data collected during the flights will be used to demonstrate the RBX/BCAS concept.

4.1 ENGINEERING TESTS (PHASE 1).

Prior to operating the ERBX's with the BEU's, certain baseline information will be gathered on the ERBX's and, to a limited extent, their radiofrequency (RF) environment.

Initially, overall verification of the ERBX functions will be performed by exercising the major software functions under controlled conditions; i.e., performance level logic, data collection, and transmitter/receiver control logic. This will be done by using laboratory test equipment configured to simulate BEU interrogations and various counters and analyzers to count and ascertain the contents of the ERBX transmissions. A result of this testing will be a partial characterization of the ERBX under varying operating parameters; e.g., interrogation rate and ATCRBS beacon pretrigger rate.

The second part of the engineering tests will be to verify that the ERBX can establish an RF link with a BCAS aircraft. This will be done by exercising the uplink portion of the ERBX/BEU transaction cycle during several abbreviated flights at the Technical Center. Only the uplink will be checked in these flights for two reasons:

a. The first reason is the greater likelihood of the aircraft being exposed to the effects of 1030-MHz interference, most notably due to ATCRBS interrogators, than would the ERBX.

b. The second reason is that a BEU implementing the necessary ERBX communications functions will not be available at the time of this phase of testing. (A suitably modified BEU will not be available until completion of the test flights required under the Active BCAS test program.)

During the engineering tests an aircraft will be equipped to receive, decode, and count the number of ERBX transmissions received per unit time. These data will be used to indicate the probability of a successful uplink transaction. The aircraft will also be equipped to gather data on the received signal strength of the ERBX transmissions as well as the total number of interfering transmissions from other ATCRBS sites. These data will provide insight into any mechanism that might interrupt the ERBX transmissions; e.g., lobing or reflections.

4.2 ERBX DEMONSTRATION (PHASE 2).

The ERBX demonstration tests will commence with the arrival of a BEU implementing the necessary ERBX communications functions. The tests will first seek to confirm the compatibility of the ERBX and the BEU under laboratory conditions. This will entail varying the sensitivity level settings of the BEU via the ERBX and confirming the results with the ERBX printouts and the BEU data dumps.

Subsequent to determining the ERBX/BEU compatibility, several flights will be performed which will, with the exception of the presence of the BEU, replicate those performed under the engineering tests. The data obtained from the BEU data dumps and the ERBX data collection software will be correlated with the plots from the Technical Center's Extended Area Instrumented Radar (EAIR) tracking facility to demonstrate ERBX control of the BEU sensitivity level as a function of range and altitude.

5. ERBX DESCRIPTION.

The ERBX essentially operates as a beacon, transmitting squitter messages at approximately 4-second intervals. These messages are formatted such that any BEU that receives them will recognize them as transmissions by an ERBX. (All transmissions by the ERBX, as well as all BEU interrogations of the ERBX, comply in terms of signals in space with the 112-bit transmissions identified in reference 1, hereafter referred to as ATC-71.) Based upon the 24-bit unique ERBX address contained in the squitter, the BEU discretely interrogates the ERBX to obtain the appropriate sensitivity level setting that the threat logic should be using. Determining the sensitivity level setting follows a fixed protocol of transmissions and receptions between the BEU and the ERBX. The sequence that is followed is for the BEU to interrogate the ERBX, following reception of the squitter, with a message that will provide the BEU with a measure of its range from the ERBX. This is done by padding the range field of the BEU's initial interrogation with all 0's. The ERBX interprets this as the BEU "ranging" interrogation. The ERBX then responds with a fixed turnaround time, which is the same for all ERBX replies, from which the BEU determines its range. During each subsequent interrogation of the ERBX, the BEU inserts the previously determined range into the appropriate field of the message. The ERBX then extracts the altitude and range of the BEU from the interrogation, the altitude being supplied by the BEU, and compares the values with a prestored sensitivity level map. The resulting sensitivity level is then transmitted to the aircraft in the ERBX reply.

Throughout each of the preceding transactions, with the exception of the ERBX squitters, the messages are all discretely addressed using the address/parity cyclic redundancy coding (CRC) identified in ATC-71. In the case of the ERBX squitters, the address portion of the address/parity field is all 0's.

The major hardware elements of the ERBX are shown in the block diagram in figure 1. These can be broken down into three functional groups. In the first, the transmitter/receiver group, are the elements related to the actual transmission and reception of the 1030-MHz signals. This group is composed of several off-the-shelf items. Among these are a Hazeltine APX-76A(V) interrogator (transmitter) and a Bendix Series 200 DABS transponder (receiver). Other elements of this group include a 5-foot omnidirectional antenna (Texas Instruments) and a modulator (Hazeltine) that provides the pulse amplitude and differential phase shift keying modulation (PAM/DPSK) identified in ATC-71.

The second functional grouping of the ERBX is composed of the signal processing and interface unit (SPIU). It is the purpose of the SPIU and this grouping to provide the requisite interface signals between the computer and the transmitter/receiver group. The SPIU performs the CRC encoding of all ERBX transmissions as well as the error decoding of any interrogations received by the ERBX; i.e., address decoding.

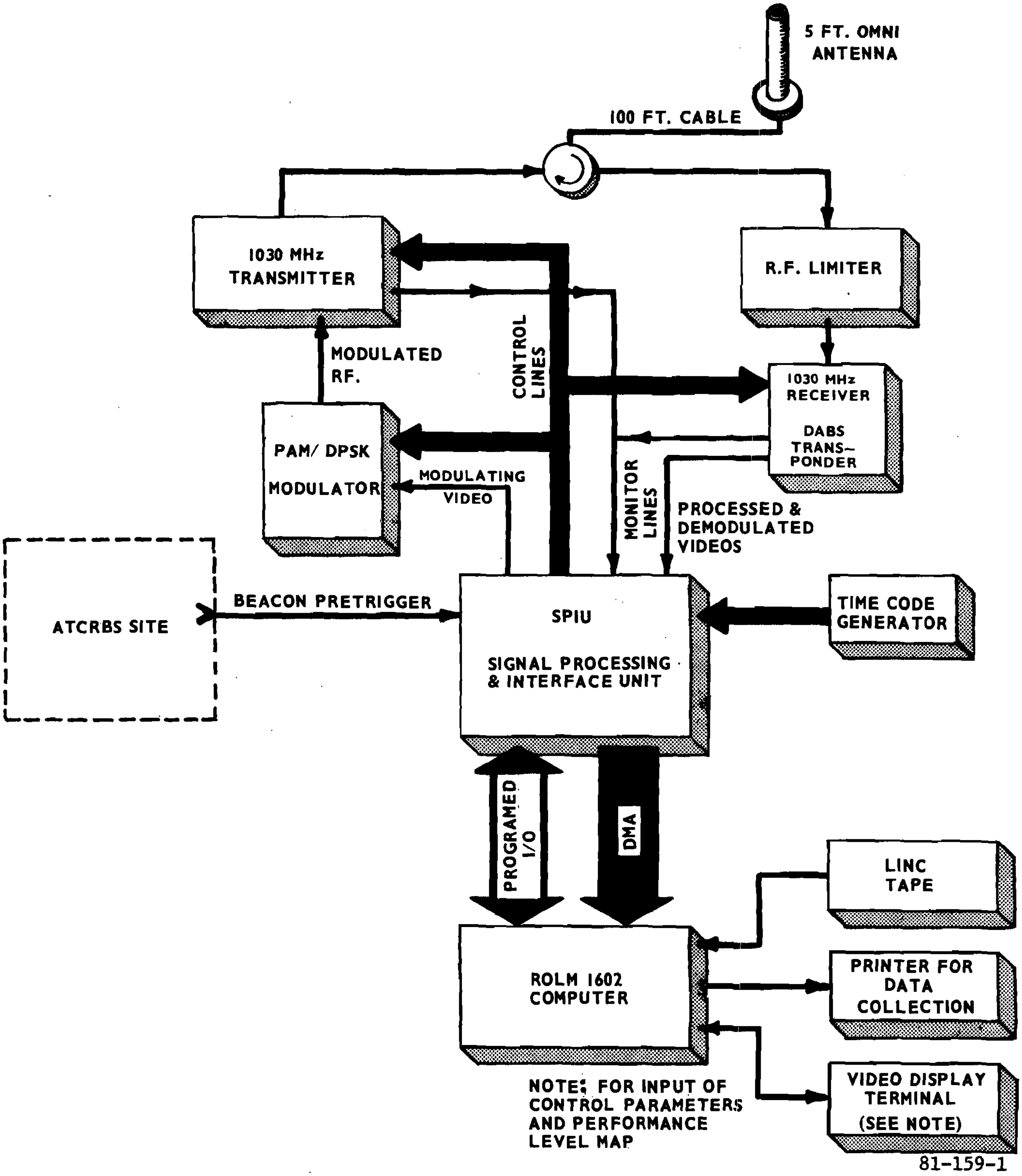

FIGURE 1. ERBX BLOCK DIAGRAM

The SPIU also provides the interface between the ERBX and the ATCRBS facility with which the ERBX may be associated. Any external devices that are not directly interfaced with the central processing unit (CPU) are also interfaced via the SPIU. Currently, the only external device not directly interfaced with the CPU is the time code generator (TCG) which is used for correlating the ERBX and BEU data collection outputs. The interface between the ERBX and the ATCRBS facility is limited to the use of the beacon pretrigger. Derived from the facility's interrogator, the pretrigger is used as a synchronization source for squitters. This interface is required to assure that the ERBX does not receive or transmit while the ATCRBS facility is interrogating; i.e., ATCRBS aircraft will not be suppressed due to ERBX transmissions during an ATCRBS interrogation.

The third grouping of the ERBX is the computer and all devices that interface directly with it. The computer, a ROLM 1602 CPU with 32,000 words of memory, is the controlling agent of the ERBX. It provides control over all transmissions of the ERBX through programmed commands to the SPIU and, consequently, the transmitter/receiver group. The CPU receives the content of any interrogations addressed to the ERBX from the SPIU via direct memory access (DMA). The computer also interfaces with a Linc tape from which the operating software is loaded, a video display terminal by which operating parameters for the ERBX as well as the sensitivity level map are input by the operator, and a printer by which all transactions between the operator and the ERBX and between the BEU and the ERBX are recorded. Limited statistics on the ERBX/BEU transactions are also output via the printer.

Functionally, the ERBX software is composed of an operational and a data collection component. The salient features of these components are as follows:

a. Operational Software.

1. Provides all control commands to the SPIU for controlling the transmitter/receiver group.

2. Provides a transaction file into which all interrogations received and the subsequent replies by the ERBX are entered in time ordered sequence. Time is derived from the TCG. Also included with each transaction is an indicator of whether the reply was aborted by the coincidence of the ERBX/BEU transaction cycle and the ERBX suppression period. The transaction cycle covers the time from the reception of an interrogation to the completion of a reply.

3. Provides for scheduling of squitters and records whether they are preempted by an interrogation/reply transaction cycle. If a squitter is preempted by a transaction cycle, the squitter is normally rescheduled for the next occurrence of a beacon pretrigger.

4. Determines the sensitivity level for an interrogating BEU based upon the range and altitude values contained in the interrogation.

5. Provides for operator input of or modifications to the sensitivity level map.

b. Data Collection Software.

1. Provides a record of all operator inputs; e.g., modifications to the sensitivity level map, as well as a summary of the ERBX's operational parameters.

2. Provides a time ordered listing of all ERBX/BEU transactions. These listings include:

(a) Time of transaction.

(b) BEU 24-bit address.

(c) BEU to ERBX range.

(d) BEU altitude.

(e) BEU maneuver advisory.

(f) Sensitivity level setting contained in the ERBX reply.

(g) Reply transmission complete indicator.

3. Provides a summary of the transactions between the ERBX and each BEU-equipped aircraft contained in the transaction file. The summaries are performed on a 1- or 5-minute interval (established by the operator) and include the following:

(a) Time of summary.

(b) BEU 24-bit address.

(c) Number of interrogations received from the BEU.

(d) Number of replies transmitted successfully; i.e., not aborted.

(e) Number of replies with a sensitivity level setting of 0, 1, 2, 3, 4, and 5.

(f) Number of interrogations with an "up" maneuver advisory and the number with a "down" maneuver advisory.

(g) Number of squitters transmitted during the summary period.

6. DATA COLLECTION.

The tests and the data to be collected are described in the following paragraphs in the order in which they will be performed. The engineering and demonstration phases of the testing have both been divided into two subcategories based upon whether or not test flights are involved. The subcategories for the engineering tests are the software verification and the uplink check (flights involved). The division of the demonstration phase is in terms of the bench check with the BEU and the demonstration flight.

6.1 ENGINEERING TESTS.

These tests will be performed with the ERBX, and will occur prior to the arrival of a BEU implementing the ERBX communications functions.

6.1.1 Software Verification.

These tests will exercise the major ERBX software functions; i.e., performance level control, data collection, and transmitter/receiver control, and verify their correct performance. In conducting this verification, simulated BEU interrogations will be generated using various configurations of pulse generators to modulate a controlled 1030-MHz RF source. The appropriate bits in the interrogations will be set using a digital word generator while the content of the ERBX replies will be verified using a logic analyzer (both pieces of equipment are standard test items). When needed, counters will be used to determine the number of ERBX replies per second.

The sensitivity level selection logic will be exercised by interrogating the ERBX with simulated messages containing various range and altitude values. The resulting replies of the ERBX will be examined to confirm the correct sensitivity level settings. The sensitivity level map of the ERBX will also be varied in range and altitude to confirm changes in sensitivity levels.

The data collection function will be verified by varying the rate of interrogations addressed to the ERBX. The ERBX transmissions will be decoded and counted to segregate replies from squitters. The resulting values will be compared with the data collection printouts of the ERBX to verify correct recording of all transactions and their summaries. The interrogation rate will be varied up to 100 times per second. This represents a higher rate than the 15-millisecond (ms) reinterrogation intervals of the BEU's.

The transmitter/receiver function will be checked and characterized by determining the probability of a reply; i.e., the number of replies per second under varying interrogation rates and ERBX suppression periods. (The suppression period is the time immediately following the receipt of an ATCRBS beacon interrogator pretrigger during which the ERBX can neither receive nor transmit.) The interrogation rate will be varied up to 100 times per second, while the suppression period will be varied over a range of 40 to 256 microseconds (μs).

The sensitivity of the ERBX will be determined by controlling the power level of the interrogations and noting the point at which 90 percent of the transmissions are accepted by the ERBX. The power level will be varied from -80 decibels with respect to one milliwatt (dBm) to -20 dBm.

A result of the foregoing tests will be a set of curves relating the probability of a successful transaction for a given combination of ATCRBS pretrigger rate, received power level, and ERBX suppression time.

6.1.2 Uplink Check.

This test will use an aircraft to receive ERBX transmissions for the purposes of demonstrating and gathering data upon the ERBX uplink channel. The testing will be performed by determining the number of discretely addressed ERBX transmissions received by a project aircraft equipped to decode the address fields of those transmissions. In essence, the aircraft will be equipped with a DABS transponder that has had its reply circuitry disabled. This will preclude the chance of one of the DABS sensors at the Technical Center acquiring the aircraft's discrete code. The transponder will be monitored using a printing counter to count the number of correctly addressed interrogations received per second. This will, in turn, be compared with the transmission rate (10 per second) of the ERBX to derive a success ratio for the uplink portion of the ERBX/BCAS data channel. The aircraft will be tracked using the EAIR tracker.

The flights that will be conducted will be limited to duplicating several common scenarios that are likely to arise in an operational situation. Specifically, the aircraft will perform a takeoff, a landing, and a flyover (5,000 feet) at the Technical Center's airfield; i.e., Atlantic City Airport. This flight pattern, essentially a 30-nautical-mile-long figure eight, will be replicated with the ERBX located at two positions relative to the main runways. These locations are also likely to arise under operational conditions at a typical airport. The first position will have the ERBX antenna atop a 55-foot tower approximately 6,400 feet from the runways. The second geometry will have the antenna located atop a 17-foot tower directly adjacent to the runways.

Although the intent of the flights will be to demonstrate that the ERBX/BCAS link can be accomplished, the aircraft will also be equipped to record other data that may have a bearing upon identifying the characteristics of any disruption of the link. Excluding range, factors that might impair the RF link are lobing, reflection phenomena, and interference from other interrogators.

To account for these elements, it is necessary to record the signal levels of the received ERBX transmissions as well as the total number and types of ATCRBS interrogations "seen" during the flight. To collect these data, the aircraft will carry a flight inspection monitor (FIM) (appendix A) and a specially configured 1030-MHz receiver/oscilloscope/high speed camera system (appendix A), hereafter referred to as the high speed camera system.

During the foregoing flights, the FIM will be used to record on magnetic tape the total number of ATCRBS transmissions to which the aircraft is subject. These will include modes 1, 2, A, and C, and all side-lobe suppressions (SLS).

The high speed camera system will provide the means for determining the received signal levels of the ERBX transmissions. The high speed camera system operates by filming the oscilloscope presentation of the intermediate frequency (IF) video of a -80 dBm receiver. The camera's 35-millimeter (mm) film will be calibrated prior to and subsequent to the flights using controlled RF levels. These calibration marks, or levels, will be used to determine the received signal level of the photographed RF transmissions of the ERBX. The signal level will be the measured value of the P_1 and P_2 preamble pulses (ATC-71) of the received transmissions.

6.2 ERBX DEMONSTRATION.

Subsequent to the engineering tests, the ERBX will be tested with the Lincoln Laboratory BEU's. These tests will include certain bench tests as well as several flight tests.

6.2.1 Bench Tests.

Initially, a bench test will be performed to assure compatibility between the ERBX and the BEU's. This test will be done by exercising the sensitivity level selection logic of the ERBX and correlating the resulting selections with the reported range and altitude of the BEU. Range and altitude will be controlled by varying the turnaround time of the ERBX for an interrogation and by simulating differing altitude inputs to the BEU. The data will be obtained from the BEU data tapes as well as from the data collection printouts of the ERBX.

During the testing, the RF sensitivities of the ERBX and the BEU will be determined by attenuating the transmitted signals of the units separately and noting when the receptions fall below 90 percent of the number of transmitted messages. These data will also be obtained from the BEU data tapes and the ERBX printouts.

6.2.2 Flight Tests.

The demonstration flight tests will replicate those flights conducted during the engineering tests with the exception that the aircraft will be equipped with a BEU in addition to the other onboard instrumentation; i.e., FIM, and the high speed camera system. The purpose of these flights will be the actual demonstration of the ERBX/BEU functions. The additional instrumentation that will be retained on the aircraft will be used to isolate anomalies that might arise during the actual flights; e.g., loss of the ERBX/BEU data link. The flights will also be performed at the Technical Center.

The data for the flights will come from the BEU data tape, the ERBX data collection printouts, and the data tape from the FIM and the 35mm film of the high speed camera system. Additionally, the aircraft will be tracked using the EAIR at the Technical Center. The tracker will provide the relative range and altitude of the aircraft with respect to the ERBX. These data will then be used as a reference against which the sensitivity level settings received from the ERBX will be compared. This comparison will be done to demonstrate that the BEU's sensitivity level can be controlled by the ERBX as a function of range and altitude. The range and altitude boundaries for the sensitivity level map are listed in table 1. The comparison will take the form of a plot in which the aircraft's track will have superimposed upon it the sensitivity levels received by the BEU.

TABLE 1. SENSITIVITY LEVEL BOUNDARIES FOR OPERATIONAL FLIGHT

Sensitivity Level	Range Greater Than (in nmi)	Altitude Greater Than (in ft)
1	0.0	0
2	2.0	1,000
3	8.0	2,000
4	12.0	3,000
5	*	10,000

*Not a factor.

7. DATA ANALYSIS.

Analysis of the data collected during each phase of the testing will, in general, be limited to verifying the functioning of the ERBX and for the flights, providing plots of the number of successful ERBX/BEU transactions per unit time versus range. Where the ERBX/BEU link shows marked degradation, as evidenced by a low number of received transmissions, a comparison will be made between received power levels and the number of completed transactions. Based on the RF sensitivity curves for the DABS transponder during the uplink check or the RF sensitivity of the BEU during the demonstration flight, companion plots will be generated to indicate the anticipated number of successful transactions that should have taken place. The plots will be adjusted to account for the probable number of receptions that would be lost because of interfering ATCRBS transmissions.

7.1 UPLINK CHECK.

The data for this flight will come from a printing counter which will provide a hardcopy output of the number of interrogations received by the DABS transponder. The printer will also output the time of day (recorded to the nearest second), which will be synchronized with the EAIR tracking facility prior to the flight. Based on the correlated times, the number of successful receptions will be manually plotted against the range of the aircraft from the ERBX.

Signal level versus time and, therefore, range will be plotted by manually measuring the signal level of the P_1 and P_2 pulses recorded on the 35mm film of the high speed camera system. The correlation with the range determined by the EAIR will be by way of the encoded time of day, which will also be recorded on the 35mm film.

The total number of ATCRBS transmissions; i.e., modes A, C, 1, and 2 and SLS, per second of flight time will be extracted from the FIM's seven-track data tape and will be correlated with the aircraft's position. This will be done by using the FIM data reduction and plotting software previously developed at the Technical Center under another effort (reference 2 and appendix A).

7.2 ERBX DEMONSTRATION FLIGHT.

The data that will be output during this phase will include the ERBX data collection printouts and the BEU data cartridge tapes. These data will be used to indicate the round reliability of the ERBX/BEU link and to provide the demonstration of the ERBX concept.

Although some modifications may arise in the way in which a BEU records data related to the ERBX transactions, it is expected that the resulting form will be consistent with the data recorded for other DABS transmissions. Because of this, the Beginning of Scan, the DABS Interrogation, and the Reply Control blocks from the BEU data tapes (messages 1, 5, and 6, respectively) are currently planned to be used. The contents of these blocks are as follows (reference 3):

a. Message 1.

1. Current BEU system time.
2. BEU altitude and altitude rate.
3. Current sensitivity level as established by ATC; i.e., the ERBX.
4. RBX track flag.
5. Range to RBX.
6. BEU address; i.e., the DABS address.

b. Message 5.

1. System time of the interrogation; i.e., the BEU interrogation.
2. Modulation Control Block, which contains the entire 112-bit message sent to the DABS target; i.e., the ERBX.

c. Message 6.

1. Most current range to the DABS target (ERBX).
2. DABS transmitted data (88 bits) as received by the BEU; i.e., from the ERBX.

The BEU data tapes will initially be processed by the BCAS Dump and Deblock Program (CASPGM, reference 3) to obtain the pertinent data blocks. The sort/merge portion of CASPGM will then be used to correlate the BEU data with the output tape of the EAIR tracking facility and, indirectly, the FIM and the high speed camera system. The resulting data base will be stored on disc in the Honeywell 66/60 computer at the Technical Center for subsequent plotting. The resulting plots will consist of the following:

a. Round reliability versus range to the ERBX. Round reliability will be the average over 1-minute intervals of the number of BEU interrogations of the ERBX divided by the number of ERBX replies received. Range will be that determined by the BEU.

b. Sensitivity level setting received by the BEU versus the range to the ERBX. The sensitivity level setting will be obtained from the BEU's DABS Reply Control Block while range will be that determined by the BEU.

c. Sensitivity level setting received by the BEU versus the aircraft's position as determined from the EAIR track data.

The plots will also contain any maneuver advisory indications that arise during the flight. For demonstration purposes, the BEU will be forced to issue maneuver advisories by flying the aircraft over a remotely located ATCRBS transponder. Commonly referred to as a "parrot," the transponder will have an altitude setting equal to that of the aircraft.

8. ORGANIZATIONAL RESPONSIBILITIES.

a. ERBX Design and Fabrication.

1.	System Design and Fabrication.	ACT-100J
(a)	SPIU Design Requirements	ACT-100J
(b)	SPIU Design	Lockheed Electronics Corporation
(c)	SPIU Modification	ACT-100J
(d)	ERBX Software Specifications	ACT-100J
(e)	ERBX Software Design and Coding	Input/Output Computer Service

b. ERBX Testing.

1.	ERBX Test Plan	ACT-100J
2.	Engineering Tests	ACT-100J
3.	BEU Modification for Operation with the ERBX	Lincoln Laboratory
4.	ERBX Demonstration	ACT-100J
5.	Project Report	ACT-100J
6.	RBX Technical Data Package	ARD-240

9. REFERENCES.

1. Welch, J. D. and Robeck, P. H., Proposed Technical Characteristics for the Discrete Address Beacon System (DABS), FAA-RD-77-143, Lincoln Laboratory, ATC-71, September 1977.

2. Mahnken, G. and Wapelhorst, L., Interim Results of DABS/ATCRBS Electromagnetic Compatibility Testing, FAA-RD-79-71, June 1979.

3. Munafo, C., Handal, J. G., and Cipione, A., Beacon Collision Avoidance System Software Documentation, Internal Document at FAA Technical Center, Systems Test and Evaluation Division, May 1980.

10. ERBX TEST SCHEDULE.

ERBX hardware checkout	8/80 to 10/80
ERBX software coding	8/80 to 11/80
Data reduction software for BEU tapes	10/80 to 11/80
Engineering tests	11/80 to 12/80
BEU modified for operation with ERBX (arrival date)	11/80 to 12/80
Operational tests	12/80 to 1/81
Data reduction	1/81 to 2/81
Report draft	2/81 to 3/81
Report final	3/81 to 5/81

APPENDIX A

TEST FACILITIES

1. FLIGHT INSPECTION MONITOR-TYPE 1.

The flight inspection monitor (FIM)-1 is an airborne environment performance monitor specifically designed for use on Federal Aviation Administration (FAA) semiautomated flight inspection (SAFI) aircraft. It consists of a receiver/processor, a digital magnetic tape recorder, and a dual-antenna installation. The system provides a measure of the ATCRBS interrogator environment by continuously recording the number of received interrogations. Provisions are included for recording elapsed time or the SAFI operations (OP) number so that data can be correlated with aircraft position. Front panel controls allow selection of interrogation modes to be recorded, and a front panel four-digit display allows inflight monitoring of the interrogator environment. Detailed data analysis is obtained by postflight computer processing of the magnetic tape. The following brief descriptions of the major FIM components are abstracted from reference 1.

1.1 RECEIVER/PROCESSOR.

The receiver/processor consists of two receivers and a digital processor. Each receiver has two video outputs identified as reply rate limiting (RRL) and minimum trigger level (MTL). After individual thresholding and pulsewidth discrimination of the receiver videos, the two RRL signals and the two MTL signals are combined, respectively, for further processing as a single RRL video and single MTL video. Both videos are routed down independent digital delay lines designed to decode SLS and mode 1, 2, A, and C interrogations. Front panel switches on the receiver/processor allow operator selection of the modes to be decoded.

Within the MTL channel, the decode count of selected modes is accumulated in a single counter. The contents of the counter are transferred to a shift register at 125-millisecond (ms) intervals for formatting and recording on tape. Operation of the RRL channel is identical to MTL except that three counters are employed: one for modes 1 and 2, one for modes A and C, and one for SLS.

The RRL output of both receivers is subject to desensitization at high interrogation rates. This is accomplished by integrating the RRL decode pulses and producing a desensitizing voltage that increases as the interrogation rate increases. In addition to desensitizing the RRL output of both receivers, the voltage is converted to a digital count.

The contents of all the counters plus status bits, time, and control signals are formatted in the processor and routed to the tape recorder. Front panel switches allow the selection of any or all interrogation modes for processing.

1.2 FIM-1 DATA REDUCTION SOFTWARE.

The output tapes of the FIM-1 consist of consecutive 1/8-second samples of:

a. Mode A and C interrogation counts.
b. Mode 1 and 2 interrogation counts.
c. MTL interrogation counts.
d. SLS interrogation counts.
e. RRL voltage sample.

The data reduction software available for use with the FIM-1 data tapes can provide reduction based on the 1/8-second sample interval of the FIM-1 or can form 1-, 5-, or 10-second averages of the data. The reduction programs also have the following features:

a. Listing of the refined data.
b. Plots of the modes A and C counters.
c. Plots of the modes 1 and 2 counters.
d. Plots of the MTL counters.
e. Plots of the SLS counters.
f. Averages of several consecutive data elements.
g. Plots of the RRL voltage.
h. Listings of the peak values for any function.
i. A summation of the SLS, A and C, and 1 and 2 counters.
j. Auto scaling or fixed scaling of the graphic plot.

2. HIGH SPEED CAMERA SYSTEM.

The high speed camera system is a data collection system assembled by the FAA Technical Center for investigating ATCRBS antenna phenomena (reference 1). The system operates by generating a continuous photographic record of the transmissions of the ATCRBS facility under investigation. This is effected by way of a synchronizing ATCRBS mode D transmission generated by a separate 1030-MHz transmitter. The system, excluding the transmitter of the ATCRBS facility, is composed of two subsystems. The airborne subsystem consists of a 1030-MHz receiver, an oscilloscope, a time-of-day clock, and a 35mm motion picture camera. The directional transmitter is ground based and is composed of a 1030-MHz transmitter and a directional antenna.

2.1 AIRBORNE SUBSYSTEM.

The receiver of the airborne subsystem is a -80 dBm, 1030-MHz transponder (RCA model 2.3NA1B) with its reply function disabled. The transponder provides two outputs to the oscilloscope. The first is an ATCRBS mode D (23 microseconds (μs) pulse spacing) decode pulse. This pulse is used to trigger the horizontal sweep circuitry of the oscilloscope (Tektronix model 545). The second output of the receiver is the intermediate frequency (IF) video, which is fed to the oscilloscope's vertical amplifier.

The camera, operating with its shutter locked open and at a film speed of 4 inches per second, is focused on the face of the oscilloscope's cathode ray tube (CRT) via a periscope arrangement. As each mode D interrogation is recieved from the ground subsystem, the oscilloscope is triggered and the camera's high speed film is exposed. Additionally, the film is exposed to the serial binary coded decimal (BCD) output of the time-of-day clock to provide a time reference. The film is calibrated by injecting a 1030-MHz signal of a known strength into the receiver and externally triggering the oscilloscope. A typical example of the film recording for a single scan of an ATCRBS antenna is shown in figure A-1 (reference 2).

2.2 DIRECTIONAL TRANSMITTER SUBSYSTEM.

The ground portion of the high speed camera system is composed of a 200-watt, 1030-MHz transmitter (AIL model TPX-42A(V)) and a 13 decibels-above-isotropic (dBi) directional antenna (Scientific Atlanta model 12-0.9). The transmitter receives a synchronizing trigger (normally the beacon pretrigger of an ATCRBS facility), and generates a mode D ATCRBS interrogation. This transmission is directed to the test aircraft by manually aiming the directional antenna along the aircraft's flight radial. Subsequent to this transmission, the interrogator of the ATCRBS facility generates its transmission which, in turn, is recorded by the airborne subsystem.

2.3 DATA REDUCTION PROCESS.

Data reduction is performed manually after the flight by using a 35mm projector to project the film onto a screen where, based on the reference calibration signals, a reference scale is drawn. Using this scale, the received signal level of each transmission is determined and recorded. The measured amplitudes are then plotted versus time, which is also extracted from the film record. The resulting plots are then translatable into signal level versus range plots by correlating the recorded times with the aircraft's position. The aircraft's position can be determined from various sources which provide a time reference; e.g., Automated Radar Terminal System (ARTS III) tracker outputs, etc.

3. REFERENCE.

1. Mahnken, G. and Wapelhorst, L., Interim Results of DABS/ATCRBS Electromagnetic Compatibility Testing, FAA-RD-79-71, June 1979.

2. Beaty, J. S., Results of Test Evaluation of ATS Surveillance Antenna, NA-79-33-LR, April 1980.

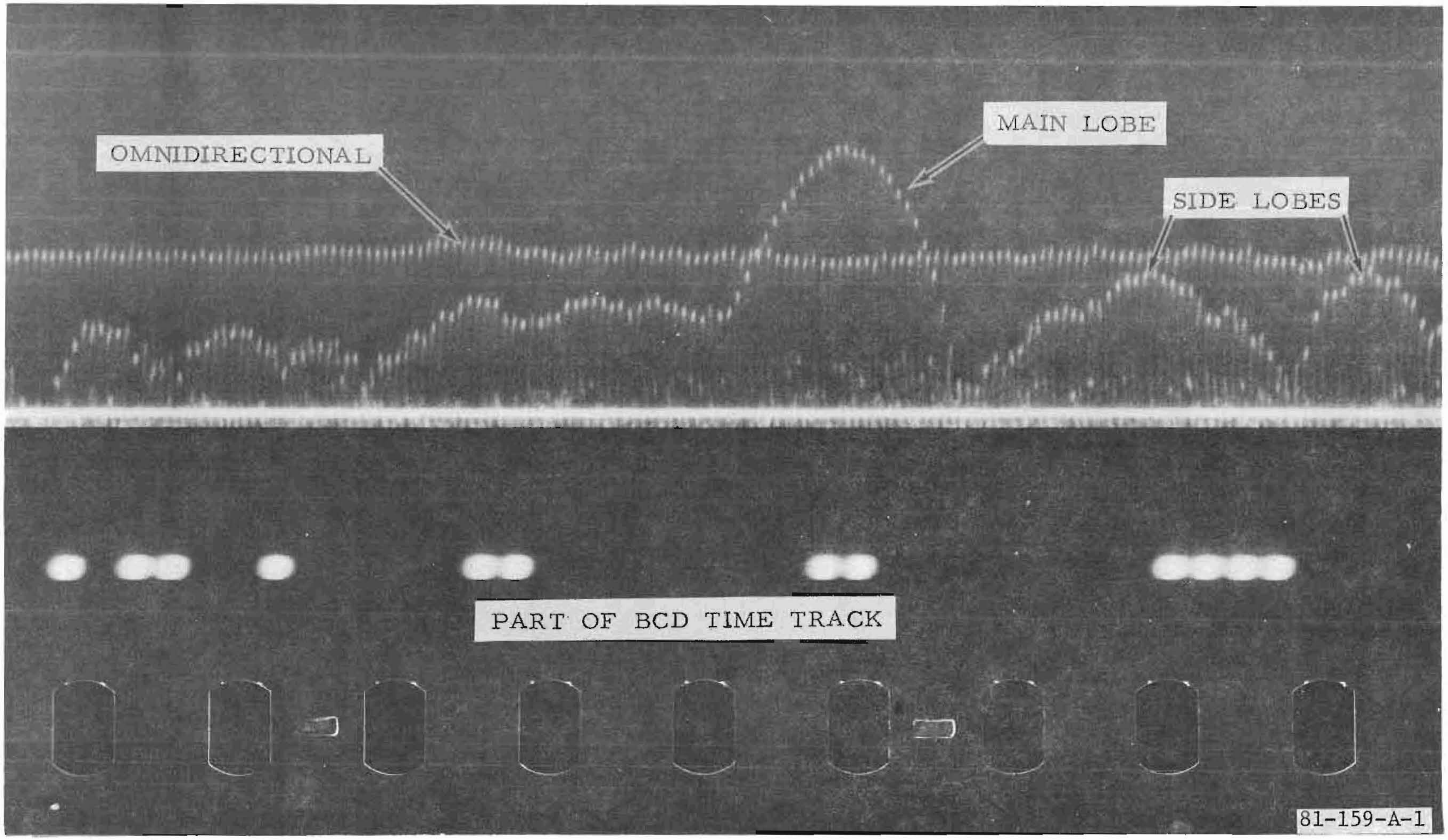

FIGURE A-1. EXAMPLE OF HIGH SPEED CAMERA SYSTEM FILM RECORDING