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Report on DABS/ATCRBS Field Testing Program

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16. Abstract

The purpose of this field test program was to verify laboratory measurements of the effect of DABS uplink signal formats on ATCRBS transponders. The DABS interrogations tested were: (i) a combined ATCRBS Mode A/DABS All-Call consisting of a standard Mode A interrogation with an additional pulse following the P_3 pulse; (ii) a DABS uplink message transmission consisting of a P_1-P_2 pulse pair followed by 25 μsec of 4 megabit per second DPSK data modulation. The timing aspects of these waveforms were selected on the basis of a previous series of laboratory bench tests made in a small cross-section of the ATCRBS transponder population. The results of these field measurements performed on a larger cross-section of field operational ATCRBS transponders agree with the results of the bench testing program: The recommended DABS uplink transmissions result in an effective combined ATCRBS/DABS All-Call mode and minimum triggering of ATCRBS transponders by DABS message transmissions.

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A. Introduction

1. Background

In the design of a Discrete Address Beacon System (DABS) to upgrade the existing air traffic control system, one of the more important decisions is the choice of DABS uplink and downlink frequencies and modulation schemes. The use of existing ATCRBS channels and modulation type (PAM) is desirable for then the DABS system could operate within existing frequency band allocations and equipment compatibility between the two systems would be maximized. Compatibility is particularly important since it will be necessary to maintain both ATCRBS and DABS capability during the 5 - 10 year transition period. Transponder compatibility implies, of course, that DABS transponders will be able to provide standard ATCRBS capability during this period. DABS transponder cost will be minimized if common components are used wherever possible. However, as the degree of commonality is increased, the potential for interference between the two systems is also increased. Both uplink and downlink interference can occur from common channel use and in each link the mutual interference may be from DABS to ATCRBS or from ATCRBS to DABS.

2. Bench Testing Program

In April 1972, an experimental program was initiated to provide data for designing the DABS uplink interrogations so as to minimize interference between ATCRBS and DABS. This DABS/ATCRBS Bench Testing Program measured typical

ATCRBS transponders to determine their response to candidate DABS uplink modulation schemes on 1030 MHz (the existing ATCRBS uplink frequency). A detailed report covering the results of the bench testing program has been published [1] and a brief summary is given here.

The bench tests were conducted on 22 different transponder samples including representative air carrier and general aviation transponders and one military transponder. While the bench tests examined only one transponder of each model, they were intended to provide insight into the general response of a broad cross-section of the ATCRBS population.

The first series of bench tests investigated the use of ATCRBS-like PAM formats and PAM waveforms with non-standard ATCRBS pulse characteristics. It was found that ATCRBS transponders responded with significant false reply and suppression rates to both ATCRBS-like PAM modulation and to PAM modulation with non-ATCRBS pulse widths and spacings, and thus eliminated the possibility of using PAM waveforms for DABS uplink data transmissions. The use of non-PAM modulation (PSK and FSK) was also investigated, and although the probability of false reply and suppression triggering was reduced, a significant number of the transponders tested did respond to these waveforms.

Since DABS could not rely on the invisibility of PAM, PSK, or FSK alone to prevent false replies from ATCRBS transponders, it was necessary to investigate an alternative scheme. In this scheme, a DABS message was preceded by a two-pulse preamble designed to intentionally suppress all ATCRBS transponders. Having intentionally suppressed the transponders, continued invisibility relies on either: (1) a short message duration (less than one ATCRBS suppression period), (2) partial invisibility, or (3) the resuppression capabilities of the DABS message waveform to prevent ATCRBS transponders from replying to the DABS interrogations.

It was found that, irrespective of modulation type, ATCRBS transponders generally will not reply to DABS messages of length less than 30 μsec following a suppression preamble, provided the interrogation level (preamble and message) exceeds 3 dB above MTL. (This 30 μsec interval is equal to the 25 μsec minimum specified suppression period plus the 5 μsec required for a valid Mode-2 (military) interrogation.) Further, it was found that in almost every transponder the suppression preamble fails to suppress the transponder reliably at interrogation levels near MTL, i.e., replies are observed even with the suppression pair present. Two schemes were investigated for improving the reliability of suppression at these interrogation levels; (1) increasing the transmitted peak power of P_2 relative to P_1 and the message, and (2) increasing the transmitted peak of both P_1 and P_2 relative to the message. In about 80% of the transponders tested, a 1 dB increase in the peak power of the preamble produced about the same reduction in the maximum reply rates per interrogation for either of the two schemes. It was found that a 2 or 3 dB increase in the level of P_2 alone produced no further improvement over that achieved by a 1 dB increase, while the most notable improvement was obtained when both P_1 and P_2 were increased by 3 dB relative to the message. It is uncertain whether an increase in the transmitted peak power of the preamble will actually be required in the DABS system since the noted improvements are applicable only to a narrow range of interrogation levels near MTL. It was concluded that the DABS uplink interrogation may be safely transmitted with the peak power of the preamble equal to that of the message unless future experience at the system level clearly indicates a need for more reliable suppression.

In investigating the modulation type for the message following the preamble, it was determined that PSK has a slight advantage over PAM in terms of invisibility to ATCRBS transponders. FSK was dropped from consideration because it offered no compelling cost or performance advantages over PAM or PSK. Since PSK has known signal-to-noise and signal-to-jamming performance advantages over PAM, it is a more desirable choice for DABS message modulation.

One of the required interrogation modes in the proposed DABS system is the acquisition All-Call mode in which previously unidentified DABS transponders are requested to respond with their DABS identification. An efficient way to schedule All-Call interrogations is to include them with every ATCRBS Mode-A interrogation by the addition of some special characteristic to the ATCRBS interrogation. This additional characteristic must not alter the response of standard ATCRBS transponders to the interrogation and it must indicate that the interrogation is a DABS All-Call early enough to allow sufficient time for the DABS transponder to inhibit an ATCRBS reply before transmitting the proper DABS acquisition response. Tests were conducted which investigated the response of ATCRBS transponders to two candidate DABS All-Call acquisition mode interrogations. Two schemes were investigated for adding the All-Call capability to the ATCRBS Mode-A interrogation: (1) introduction of 180° phase reversals within P_1 and P_3, and (2) transmission of an extra pulse following the P_3 pulse.

Of the two methods investigated for DABS/ATCRBS discrimination, PSK within the standard ATCRBS pulses was not recommended since it reduced the sensitivity of a large fraction of the transponders, some as much as 9 dB. The scheme using an additional pulse following a standard Mode-A interrogation was recommended since it was found to have no effect on the performance of ATCRBS transponders.

B. Field Testing Program

1. General

Since the conclusions of the bench tests were based on a small sample of ATCRBS transponders, field tests on a larger sample of transponders were required to verify the bench test based conclusions regarding DABS uplink transmissions. The remainder of this report summarizes the results of the field tests.

The data to be presented in this report was obtained from ATCRBS transponders operating _in situ_ in a random sample of aircraft. These tests were intended only to yield more data than was available from the previous series of bench tests and were not intended as tests of installation influences or as a competitive evaluation of units of different manufacture. The tests were performed on private and business aircraft as they became available resulting in a random selection of transponder types.

As a compromise between realistic measurements, which would have involved a highly instrumented flight program, and the desire to minimize cost and time duration, the tests were performed with the aircraft parked on a suitable run-up pad and the mobile test van parked nearby. The aircraft's engine and radio/navigation equipment were operated during the 10 to 15 minutes required to test the transponders. Coupling between the equipment located in the van and the aircraft under test was accomplished through the use of a horn antenna as illustrated in Fig. 1.

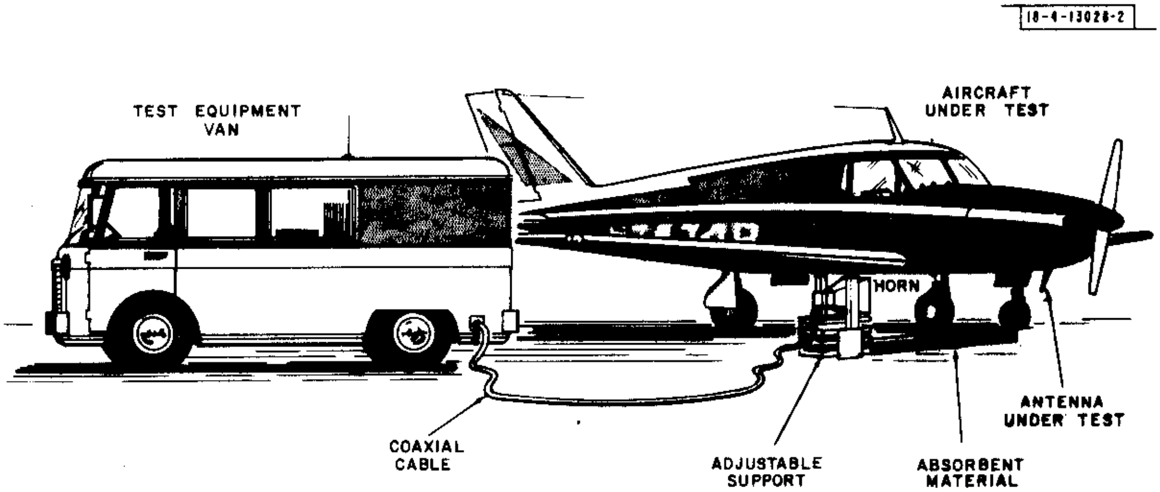

Fig. 1. Typical Test Setup.

2. Sites

The tests on general aviation aircraft were conducted at 6 airports in Massachusetts and 2 in New Hampshire. The airports are listed in Table 1 below, along with the number of transponders tested at each location.

Table 1. Number of Transponders Tested at Each Airport Location.

Airport	No. of Transponders Tested
Norwood	15
Bedford	8
Nashua (N.H.)	3
Manchester (N.H.)	8
Beverly	18
Mansfield	5
Plymouth	10
Tewksbury	3
Total Tested	70

3. Schedule

The project was initiated in late April 1973 following the formal completion of the Bench Testing Program. In an effort to insure at least 50 working transponders in the sample, the field tests were conducted on 70 general aviation aircraft and were completed by late May 1973.

4. Summary of Tests

Three tests were performed: a basic ATCRBS operational check; measurement of ATCRBS transponder response to the proposed DABS All-Call transmission, and measurement of ATCRBS transponder response to the proposed DABS interrogation transmission. The three tests are summarized in the following paragraphs.

The basic ATCRBS operational checkout determined if the transponder was operating properly when subjected to standard ATCRBS interrogating waveforms. This was important since the selection of the proposed DABS uplink transmissions was based on the response of properly operating transponders, and the verification of the uplink selections would also require operational transponders. The preliminary tests also included measurement of the relative MTL* (sensitivity) to Mode-A interrogations and the observation of the response over the 50 dB operational range specified in the ATCRBS National Standard. The relative MTL measurement was necessary for comparison with the measured sensitivity to DABS All-Call interrogations.

The proposed DABS All-Call transmission consists of a P_4 pulse added to a standard Mode-A interrogation. The P_4 pulse is a 0.5 μsec pulse located 1.5 μsec following the leading edge of the P_3 pulse. The DABS All-Call test included a measurement of the relative MTL, and observation of the response over the range of interrogation levels from MTL to 50 dB above MTL. Since the DABS-All-Call will be actually part of the ATCRBS Mode-A interrogation, the possible adverse effects on the ATCRBS transponder performance of this uplink transmission had to be examined over the entire operational range of the ATCRBS signal levels.

*MTL = Minimum Triggering Level, based on a reply probability of 90%.

The proposed DABS interrogation transmission consists of an ATCRBS P_1-P_2 suppressing preamble followed by 25 μsec of 4 Mb/s PSK data. The separation between the trailing edge of P_2 and the beginning of the message was 0.5 μsec. The invisibility of this DABS uplink transmission was checked by observing both the range of interrogation levels over which each ATCRBS transponder replied to this transmission and the maximum observed reply rate within that range. Since replies to this uplink transmission are generally due to unreliable operation of the ATCRBS suppression circuitry at interrogation levels near MTL, this test was conducted with preamble to message peak power ratios of 0, +1, and +3 dB. This test was intended to check the improvement in the reliability of the intentional suppression when the transmitted peak power of the suppressing preamble was increased relative to the peak power of the message. Two preamble schemes were investigated: (1) with transmitted peak power of P_2 increased relative to P_1 and the message, and (2) with the peak power of both P_1 and P_2 increased relative to the message.

C. Implementation

1. General

A mobile test van was outfitted with the necessary instrumentation and equipment. This equipment simulated the transmitter and receiver portions of a DABS/ATCRBS ground interrogator. Coupling to the transponder antenna was accomplished by means of a test horn antenna which was connected to the test equipment in the van by a coaxial cable.

2. Transmitter

A block diagram of this instrumentation is shown in Fig. 2. Two pieces of special test equipment, the DIM (DABS Interrogator Modulator) and the MCU (Modulator Control Unit), which had previously been constructed for general

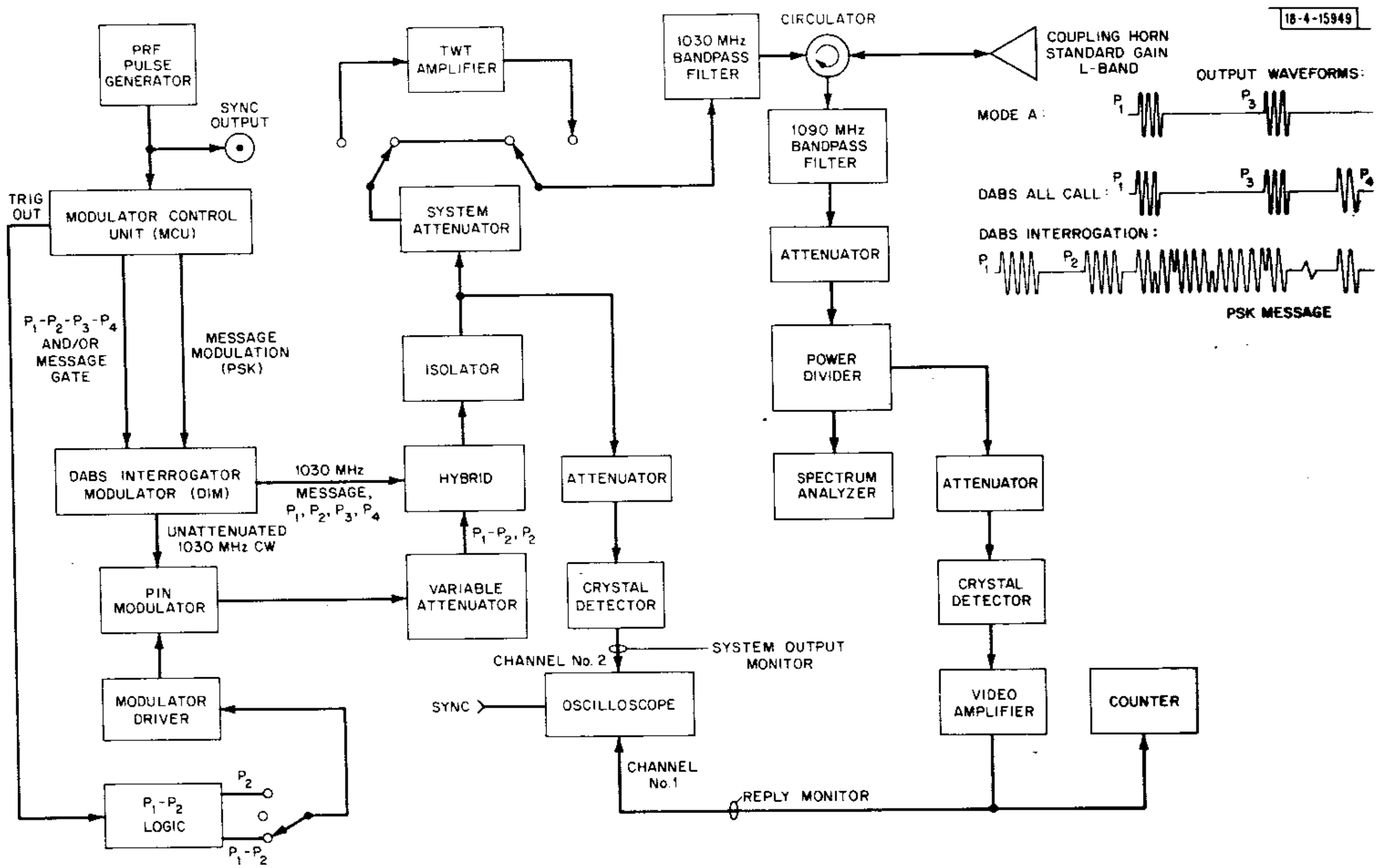

Fig. 2. Instrumentation Block Diagram.

DABS program testing, were installed in the test van. The DIM contains an oscillator which was used as the RF source of the transmitter. The DIM has a nominal power output of +10 dBm and was operated at a stable frequency of 1030 MHz. The DIM accepts the modulating signals directly from the MCU. Most of the modulating signals, P_1-P_3, P_1-P_2-P_3, P_1-P_3-P_4, and P_1-P_2 with 0.25 μsec PSK message bits were generated by the MCU. The adjustable ratio of preamble to message power required that the preamble be generated externally from the MCU. Thus, for the DABS interrogations transmissions, the preamble and message were generated in two separate channels and passed through a power combiner before being amplified in the TWT amplifier. They were then filtered and sent to the horn antenna. The MCU was driven by the output of a pulse generator which established the system PRF of 500 Hz.

3. Receiver

Signals received by the horn antenna were passed through a circulator and a bandpass filter (1090 MHz) and coupled to a spectrum analyzer and a crystal detector. The output of the detector was amplified and displayed on an oscilloscope. The detected output was also fed into a counter where the actual reply counts per interrogation were monitored. The counts were averaged over a period of one second.

4. Antenna

The L-band horn antenna used to couple signals between the test set-up and the transponder antenna (see Fig. 3) was mounted on a fixture with absorbing material on the ground immediately in front of it. Provisions were made for raising the horn so that the top of it was about 9 in. above the lowest

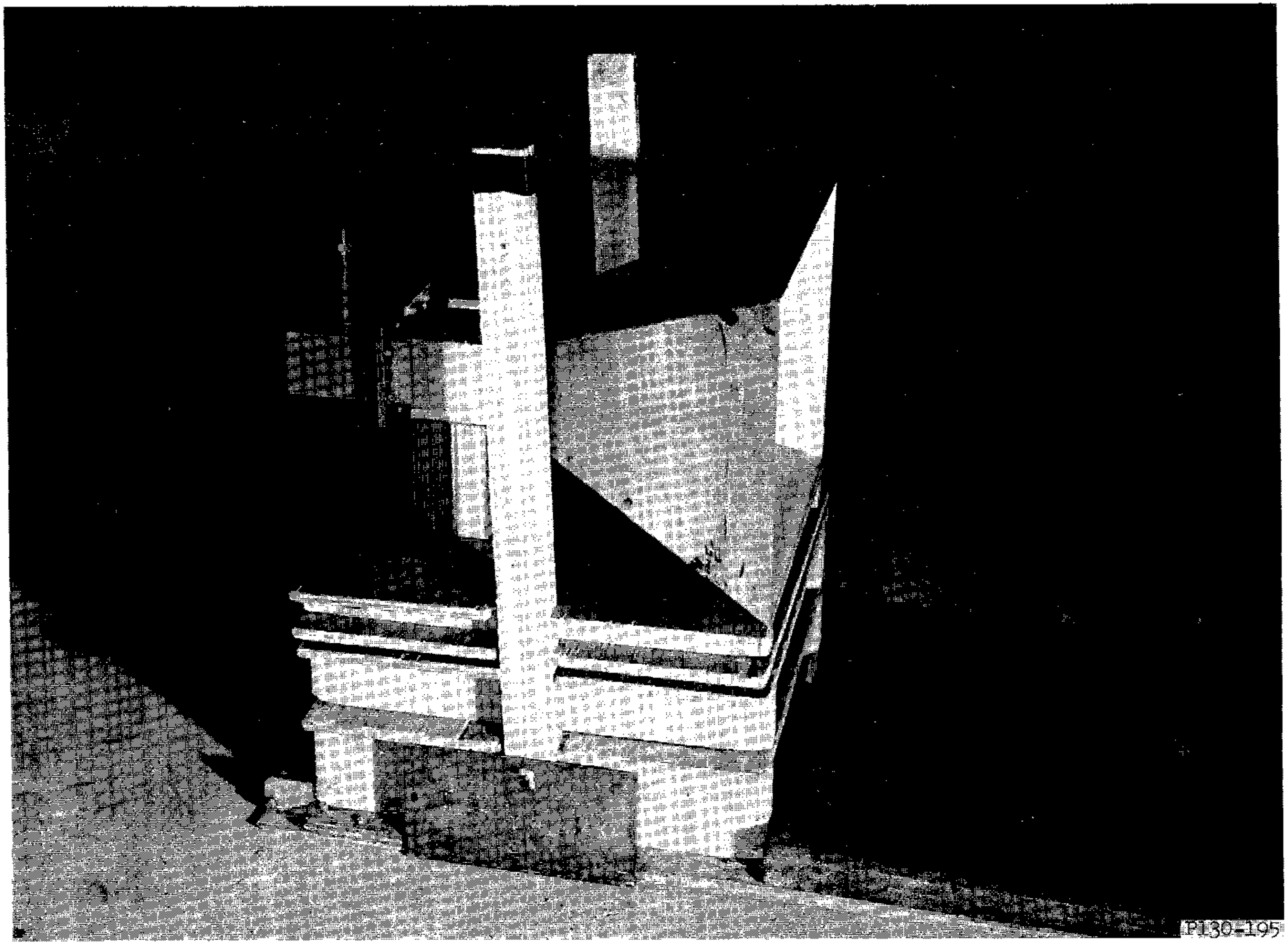

Fig. 3. Test Horn Antenna.

point on the transponder antenna. The distance from the horn to the antenna was normally set at 70 inches. The horn was coupled to the test van by means of a 48 ft coaxial cable.

Because the information sought was to be based on relative MTL only, precise coupling measurements were unnecessary. (Coupling measurements were conducted on a few aircraft, to provide an approximate calibration of the coupling loss.)

The CW leakage from the test van was -85 dBm or lower.

5. Test procedure

A detailed and standardized test procedure was used throughout the tests. Upon arrival of the aircraft to be tested, two members of the crew would position the horn antenna and check the test set-up. The third member of the crew would record aircraft and transponder type data and instruct the pilot in the method of conducting the test.

The pilot was then asked to start the engine, turn on all radio/navigation equipment, and operate the transponder on Mode-A Code <u>0000</u>. As soon as the testers detected reply signals from the transponder, the test routine outlined in Table 2 was started. The test was accomplished in approximately 10 minutes if no unusual circumstances were encountered.

Table 2. Test Procedure.

A. Basic ATCRBS Operational Check

Action	Measurement
1. Turn on transponder, set to Mode-A and 0000 Code	-
2. Switch MCU* to Mode-A (P_1-P_3) adjust system output level for replies if necessary	Replies to standard ATCRBS interrogations
3. Switch MCU to Mode-A with SLS (P_1-P_2-P_3)	Suppresses upon receipt of interrogation with SLS
4. Switch MCU to Mode-A, Adjust system output attenuator for MTL**	Relative MTL (Sensitivity to Mode-A interrogations)
5. Slowly increase system output to 50 dB above measured MTL	Observe response to Mode-A over 50 dB range

B. ATCRBS Response to DABS All-Call Interrogation

Action	Measurement
6. Switch MCU to P_1-P_3-P_4	-
7. Slowly decrease system ouput level	Observe response to DABS All-Call over 50 dB range
8. Adjust system output attenuator for MTL	Relative MTL (Check if DABS All-Call has affected trans. sensitivity to Mode-A)

C. ATCRBS Response to DABS Interrogation

Action	Measurement
9. Set MCU for DABS interrogation with (P_1&P_2)/Message = 0 dB	-
10. Increase system output to 50 dB above MTL	-
11. Slowly decrease system output level, record range(s) of interrogation levels over which replies are obtained and maximum observed reply rate	Check for replies to DABS interrogation
12. Repeat steps 9, 10, and 11 for (P_1&P_2)/Message = 1† and 3 dB	Check for replies to DABS interrogation
††13. Set MCU for DABS interrogation with P_2/(P_1&Message) = 0 dB repeat steps 9 through 12	Check for replies to DABS interrogation

*MCU = Modulator Control Unit.

**MTL = Minimum Triggering Level, based on reply efficiency of 90%.

†1 dB test added for tests 21-70.

††Step 13-added for tests 36-70.

II. TEST RESULTS

A. Basic ATCRBS Check

In the first field test, the basic operation of the transponder was checked. If a transponder was found defective in any way, the remainder of the tests were omitted. Possible reasons for a no test decision were: (1) failure of a transponder to respond properly to Mode-A interrogation, (2) failure of transponder to suppress upon receipt of a P_2 suppression pulse with a Mode-A interrogation, (3) squitter* (transponder replies in the absence of valid interrogations), and (4) insufficient transponder output power. (For some transponders the power was so low that the return signal to the test van was practically undetectable. In these cases, the antenna horn was moved as close as possible to the transponder antenna in an effort to maximize the coupling.)

The transponders in the sample which were not tested and the reason for this are given in Table 3. These transponders do not appear in any subsequent data plots.

Table 3. "No Test" Transponders

Reason	Test Numbers
Failure to respond properly to Mode-A	17 68**
Failure to suppress	7 26
Squitter	16 32 41
Insufficient transponder output power	1 36 37

*National Standard allows some squitter (less than 30 false replies per second), but it was felt that this interfered with the invisibility check.

**Circled numbers, i.e., 1, refer to test number and are cross-referenced to transponder model in Appendix A. This notation is used in all subsequent data plots.

B. Response to DABS All-Call

Since the proposed DABS All-Call interrogation will be part of the standard ATCRBS interrogations, this test was included in the field test measurements to insure that the DABS All-Call interrogation does not degrade the performance of the ATCRBS system by: (1) reducing the sensitivity of ATCRBS transponders to standard ATCRBS interrogations (when included within DABS All-Call), and (2) effect the response over the ATCRBS operational range from MTL to 50 dB above MTL. The DABS All-Call interrogation consists of a standard ATCRBS Mode-A interrogation followed by a 0.5 μsec P_4 pulse whose leading edge starts 1.5 μsec after the leading edge of P_3.

Sensitivities (MTL's) to Mode-A and proposed DABS All-Call interrogations as measured (raw data) are presented in Appendix B. The distribution of transponders as a function of "change in measured MTL" is given in Figure 4. The results show that over 90% of the transponders tested exhibited no significant change in measured MTL and that none of the transponders indicated any response effect as observed over the entire ATCRBS input range. Of the three transponders which did exhibit a change of 1.5 dB or greater, all resulted in an apparent increase in the transponder sensitivity. It is therefore, reasonable to conclude that the proposed DABS All-Call interrogation will not adversly effect the operation of the ATCRBS system.

C. Response to DABS Interrogations

The proposed DABS uplink interrogation was based on the premise that if an ATCRBS transponder is intentionally suppressed at the beginning of the interrogation, it should not reply to any DABS message transmitted within the duration of the suppression period. However, the bench tests showed that almost every transponder tested failed to suppress reliably in a small range

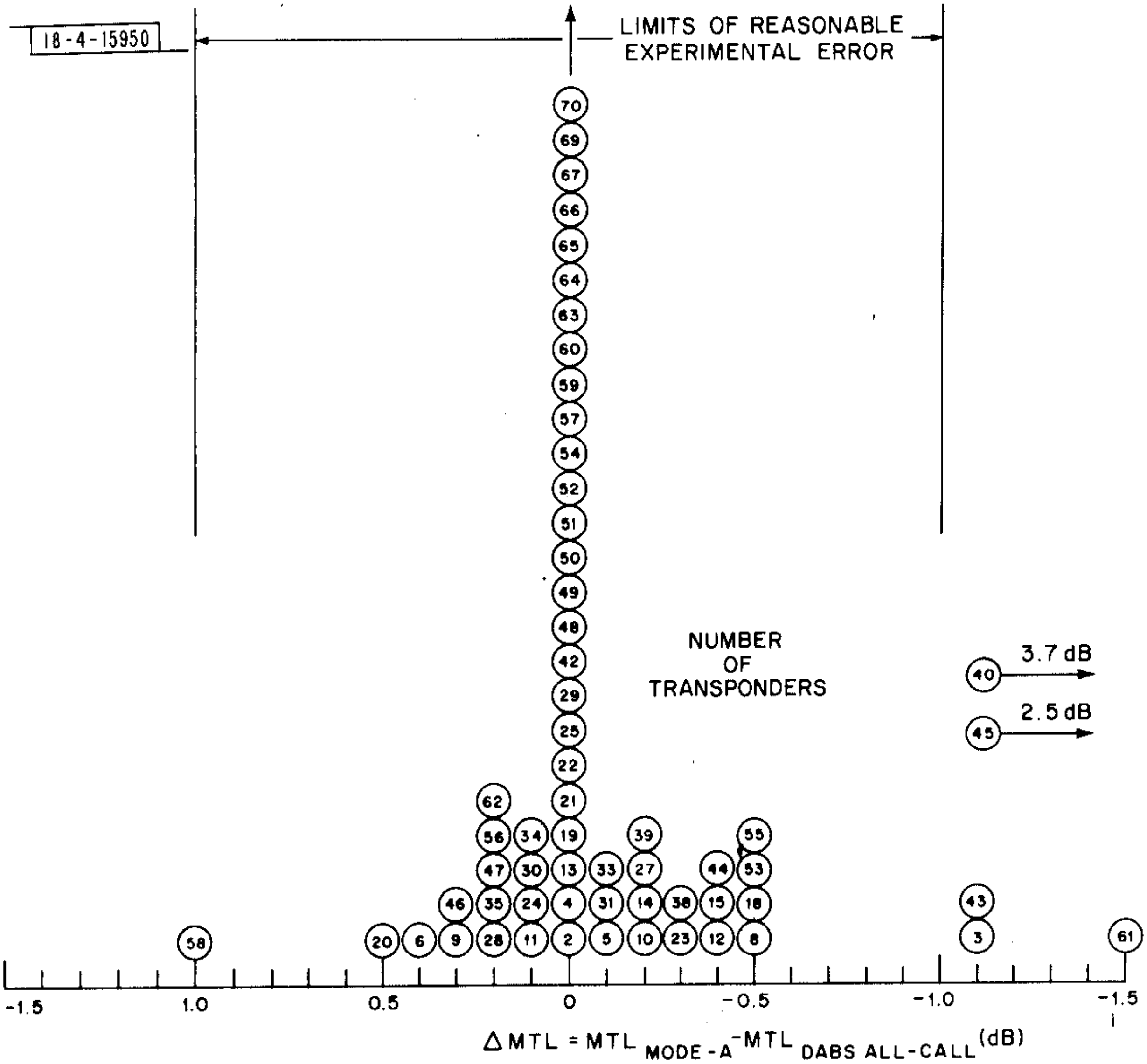

Fig. 4. Distribution of Transponders as a Function of Change in Measured MTL to Mode-A and DABS All-Call Interrogations.

of interrogation levels near MTL. ATCRBS transponders interrogated within this range would reply to DABS interrogations. It was further determined that the reliability of the intentional suppression could be improved by increasing the transmitted peak power of the suppression preamble relative to the message. This set of field measurements was intended to (1) check on the basic invisibility of the DABS uplink interrogation to ATCRBS transponders, and (2) provide more data concerning the improved reliability of suppression with increasing power of the preamble.

The conditions for this test were changed twice during the course of the field measurements. The original plan called for testing with both preamble pulses transmitted with a peak power of either 0 or 3 dB relative to the message. After the first 20 transponders had been tested and the data examined, an additional test was added to check the effect of a 1 dB preamble to message power ratio. This additional test was included in the testing procedure for the remaining transponders. With about half of the transponders yet to be tested, another test was added in which only the transmitted peak power of P_2 was increased relative to P_1 and the message.

The DABS interrogations used in these tests was a P_1-P_2 suppression pair followed by 25 μsec of 4 Mb/s random PSK data. Recorded in these tests were the range of interrogation levels over which replies were obtained and the maximum reply rate within that range. (The reply counts were averaged over a period of 1 sec. The maximum recorded reply rate was a consistent peak or average over several periods.)

These measurements are given in Appendix B. With the DABS message restricted to 25 μsec following the end of the suppression pair preamble, it was not expected that any ATCRBS transponder, exhibiting at least the minimum specified suppression period of 25 μsec, would reply to a DABS interrogation at signal levels much above MTL. Only one of the field tested transponders did reply to strong signals, but it was the only one of the 3 transponders of that type tested which did so. (One transponder of this type which had been previously bench tested also replied to strong signals.)

One quarter of the transponders tested with the peak power of the preamble equal to that of the message did not reply to DABS interrogations at any interrogation level. Seventy per cent of the transponders which did reply to such interrogations, exhibited maximum reply rates which were observed at an interrogation level within $\pm$ 2 dB of measured MTL.

Upon increasing the power of the preamble, two effects on the response of ATCRBS transponders are observed: (1) a downward shift in the sensitivity range and/or (2) a reduction in maximum observed reply rate within that range. It is likely that the downward shift in sensitivity range would be less significant in the system than a reduction in the maximum reply rate, even though the shift is often accompanied by a reduction in the range of signal power over which replies are obtained. If one is interested in making DABS interrogations invisible to ATCRBS transponders, the most significant measure of performance is the maximum reply rate recorded over any range.*

An increase in the peak power of the preamble by 1 dB reduced the maximum reply rates exhibited by almost all of the transponders which did reply to the

*Under all test conditions, the peak in reply rate counts was normally sharp, indicating a fairly narrow range of interrogation levels over which a significant fraction of the replies were observed.

DABS interrogations. In approximately 40% of the cases in which the transponders had been tested with both preamble schemes, the reductions produced by increasing the peak power of both P_1 and P_2 by 1 dB were more significant (larger percentage reduction) than those produced by a 1 dB increase in the level of P_2 alone. It was further determined that increasing the level of P_2 alone by 3 dB did not produce further reductions in the maximum reply rates of most transponders over the reductions produced by the first dB increase. The most significant reductions in the maximum reply rates were obtained when the transmitted peak power of both P_1 and P_2 pulses was increased by 3 dB. Tests with the later preamble scheme showed that only 18% of the transponders replied to more than 1% of the interrogations (only in a small range of interrogation levels near MTL), while 70% of the transponders exhibited no replies at all. This is in contrast to the interrogation with the peak power of the preamble equal to that of the message where 63% of the transponders replied at rates greater than 1%, while only 25% exhibited no replies.

Figure 5 is an overall comparison of the effects of increasing the preamble level on the maximum reply rates of the transponders. The plots are on a percentage basis to facilitate comparison of the results of the 3 different sets of test conditions.

It should be noted that many of the field tested transponders exhibited slightly higher reply rates than those measured in the laboratory with a preamble to message power ratio of 0 dB, but in general, the trends in transponder responses followed those indicated by the bench test results.

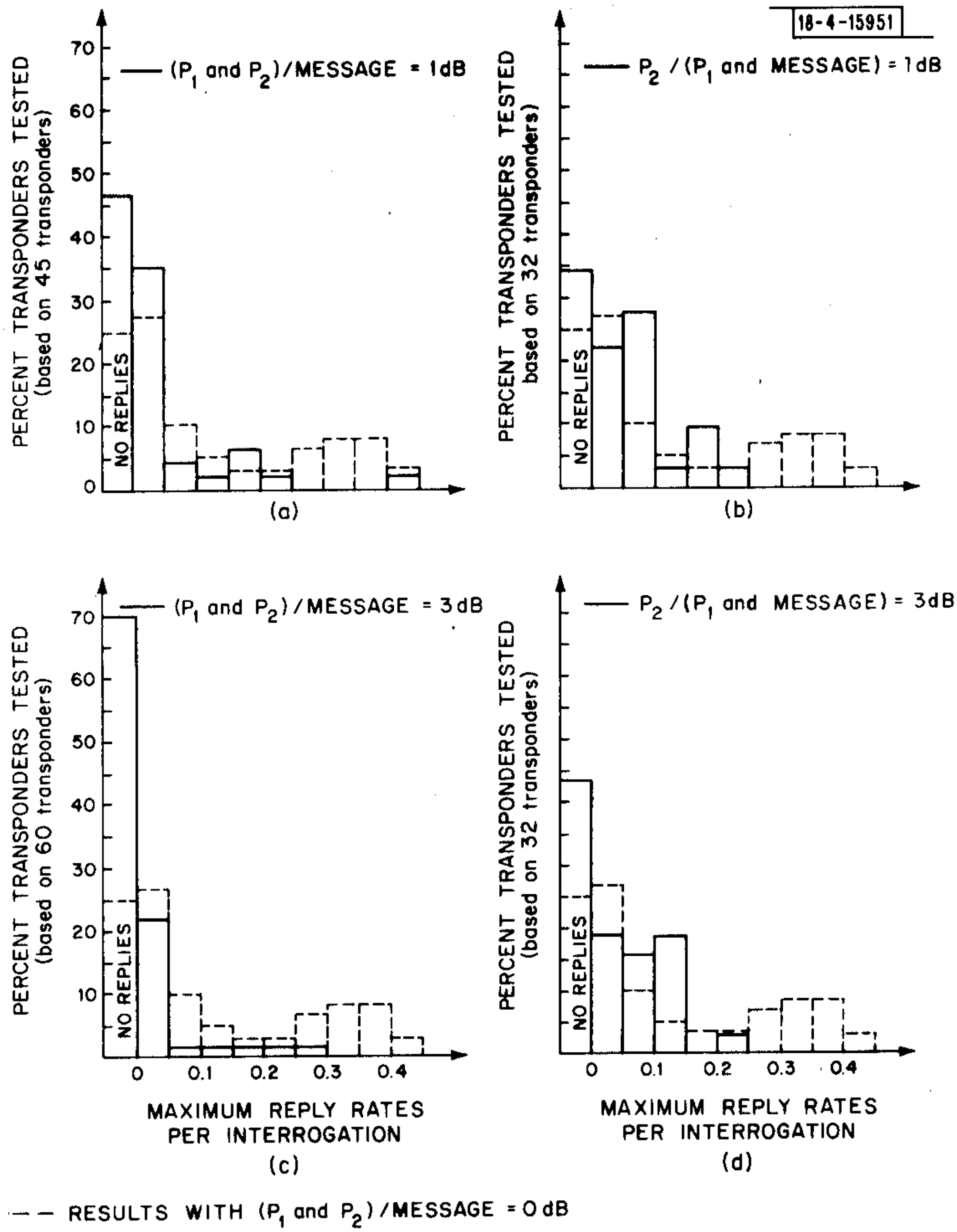

Fig. 5. Percentage of Transponders Replying vs Maximum reply rate Per Interrogation for $(P_1\&P_2)$/Message = 0, 1, and 3 dB and $P_2/(P_1$&Message) 0, 1, and 3 dB.

III. SUMMARY AND CONCLUSIONS

Overall results of these field measurements agree well with the bench test results, verifying the previous conclusion that the proposed DABS uplink interrogations do not interfere appreciably with ATCRBS transponders.

Specifically, the results showed that a DABS All-Call in which a P_4 pulse is added to a standard Mode-A interrogation does not significantly affect the sensitivity of ATCRBS transponders, nor does it affect their response over the specified 50 dB ATCRBS operating range. It was found that the probability of an ATCRBS transponder replying to a DABS interrogation, consisting of a P_1-P_2 suppression pair followed by 25 μsec of 4 Mb/s PSK data, is zero over nearly the entire ATCRBS dynamic range except for a small range of interrogation levels around MTL. Replies to the interrogations over this range are due to inability of the suppression pair to reliably suppress the transponders. It was further found that the maximum reply rates exhibited by the transponders can be reduced by increasing the trasmitted peak power of the P_1-P_2 preamble relative to the message.

It is uncertain whether any increase in the transmitted power of the preamble is required, since the noted improvements are applicable only to a narrow range of interrogation levels near MTL. Only an extensive series of operational-like flight tests can resolve this issue.

APPENDIX A

TRANSPONDER IDENTIFICATION

In the figures and tables in this report, the test results of individual transponders are identified by test numbers to allow further analysis if desired. A cross reference between test number and transponder model is given in Table A-1.

Figure A-1 shows the distribution of transponders tested by manufacturer and model type; the distribution is typical of the general aviation transponder population in the geographic area where the tests were performed.

The distribution of ownership of the aircraft is presented in Table A-2.

Table A-1. Transponder Identification Numbers.

No.	Mfg	Model	Antenna	No.	Mfg	Model	Antenna
1	Bendix	TPR-610	Pole	36	Narco	UAT-1	Blade
2	King	KXP-750	Pole	37	Narco	UAT-1	Blade
3	ARC	300	Pole	38	King	KT-76	Pole
4	Narco	AT-6	Blade	39	Narco	UAT-1	Blade
5	King	KT-75	Pole	40	Narco	AT-50	Pole
6	King	KT-76	Pole	41	Narco	AT-50	Pole
7	King	KXP-750	Pole	42	Genave	Beta 500	Pole
8	Narco	AT-50	Pole	43	Narco	Flt. Grd.	Blade
9	IFD	Starlight	Pole	44	King	KT-76	Pole
10	Narco	Flt. Grd.	Blade	45	Regency	-	Pole
11	King	KT-76	Pole	46	King	KT-76	Blade
12	King	KT-76	Pole	47	King	KT-76	Pole
13	King	KT-76	Pole	48	Narco	AT-50	Blade
14	IFD	Starlight	Stub	49	Regency	-	Pole
15	Narco	AT-50	Pole	50	Narco	Flt. Grd.	Blade
16	Narco	AT-50	Pole	51	Narco	AT-50	Pole
17	ARC	300	Pole	52	IFD	Century	Blade
18	King	KT-78	Pole	53	King	KT-75	Pole
19	ARC	300	Pole	54	Narco	AT-50	Pole
20	Narco	AT-50	Pole	55	King	KT-75	Blade
21	Narco	UAT-1	Blade	56	Regency	505-I	Pole
22	ARC	300	Pole	57	ARC	300	Pole
23	Bendix	-	Blade	58	?	-	Pole
24	Wilcox	-	Blade	59	ARC	300	Pole
25	King	KT-76	Pole	60	King	KT-75	Pole
26	Bendix	-	Blade	61	Narco	UAT-1	Blade
27	Narco	AT-50	Pole	62	Narco	AT-50	Pole
28	Narco	AT-50	Pole	63	King	KT-75	Pole
29	Narco	AT-50	Pole	64	Narco	AT-50	Pole
30	Narco	AT-50	Blade	65	Narco	Flt. Grd.	Blade
31	Narco	AT-50	Pole	66	Regency	505-I	Pole
32	Wilcox	1014-A	Blade	67	King	KXP-750	Pole
33	King	KT-75	Pole	68	Narco	AT-50	Pole
34	King	KT-75	Pole	69	King	KT-76	Pole
35	ARC	300	Blade	70	Narco	AT-50	Pole

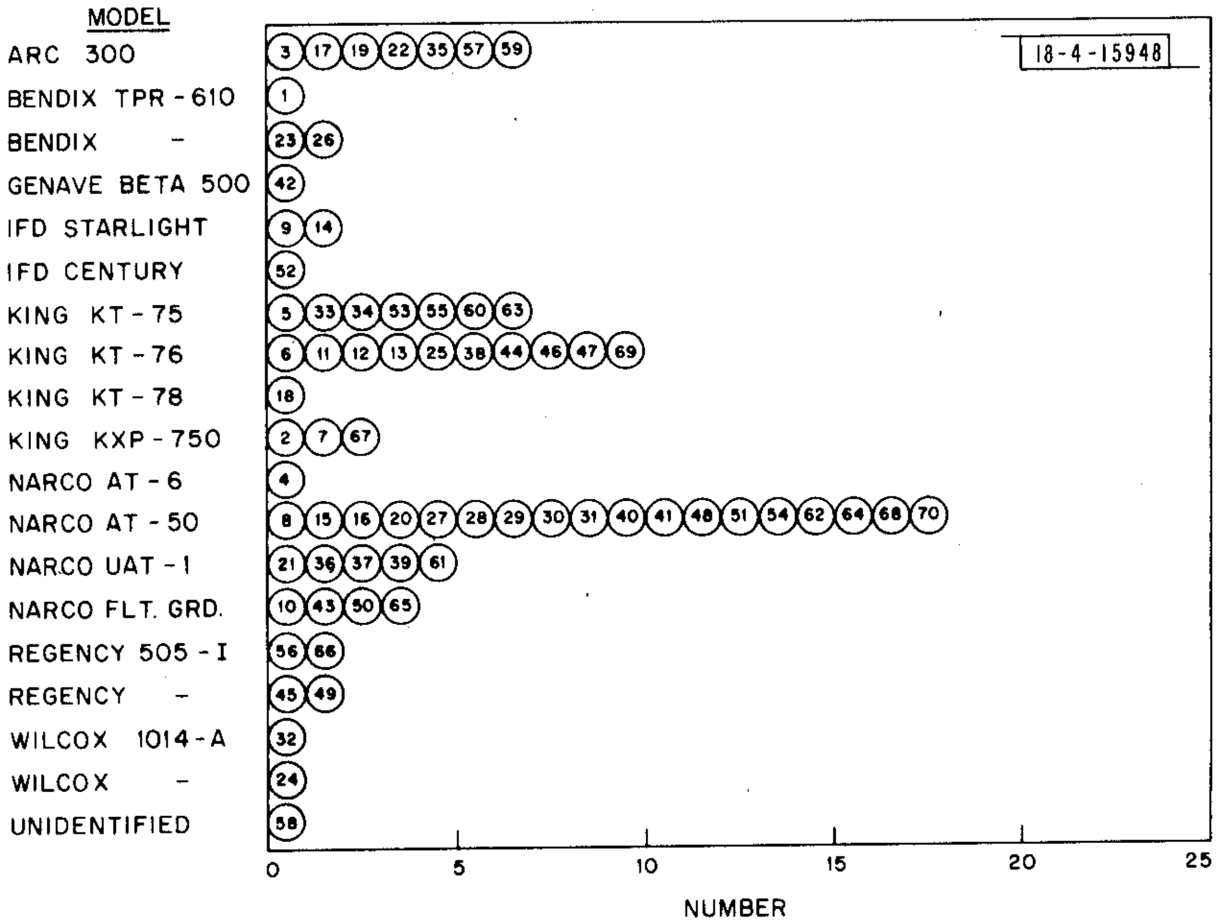

Fig. A-1. Distribution of General Aviation Transponders Tested by Model. (Numbers Inside Circles refer to the Order in Which the Units were Tested; i.e., 13 Was the Thirteenth unit tested.)

Table A-2. Ownership of General Aviation Transponders Tested.

Type Owner	Quantity Owned
Air Charter, Flying Schools	26
Dealers, Avionics Shops	24
Private Individuals	16
Corporations and Businesses	4
Total Tested	70

APPENDIX B

SUPPRESSION RELIABILITY vs PEAK POWER OF PREAMBLE RELATIVE TO MESSAGE, AND RELATIVE MTL FOR MODE-A AND DABS ALL-CALL INTERROGATIONS

This appendix presents data obtained during measurement of the response of ATCRBS transponders to proposed DABS All-Call and DABS uplink interrogations.

In the accompanying figures, the two right hand columns show, respectively, the relative MTL measured with standard Mode-A interrogation, and the relative MTL measured with DABS All-Call. This is the data presented in reduced form in Fig. 4 of the main text (see Section II-B).

The DABS interrogation data is presented as the range of interrogation levels over which replies are obtained and maximum reply rate within that range. Reply counts were averaged over periods of 1 second. The maximum recorded reply rates indicate a consistent peak or average over several periods. In the accompanying figures, the range of interrogation levels over which a transponder replies, has been normalized to the measured MTL of that transponder to Mode-A interrogations. (The MTL measurements are referenced to the peak power of the message.) The numbers in parentheses are the maximum reply rates recorded within that range. The data shown includes all tests which were performed regarding improvement in reliability of suppression as the peak power of the preamble is increased relative to the message.

"No Test," entered for all tests on a particular transponder, was based on the transponder's failure to pass the basic ATCRBS checkout test (see Section II-A). "No test," entered for particular preamble to message power ratios (in test numbers 1 through 35) notes the fact that the test was not performed; test numbers 36 to 70 included the complete set of tests. Table B-1 indicates the particular suppression reliability tests performed during each "segment" of the field testing program (see Section II-C).

Table B-1. Suppression Reliability Tests.

Tests Performed	Test Numbers
$(P_1$ & $P_2)$/Message = 0, +3 dB	1 - 70
$(P_1$ & $P_2)$/Message = 0, +1, +3 dB	21 - 70
$(P_1$ & $P_2)$/Message = 0, +1, +3 dB $P_2/(P_1$ & Message) = +1, +3 dB	36 - 70

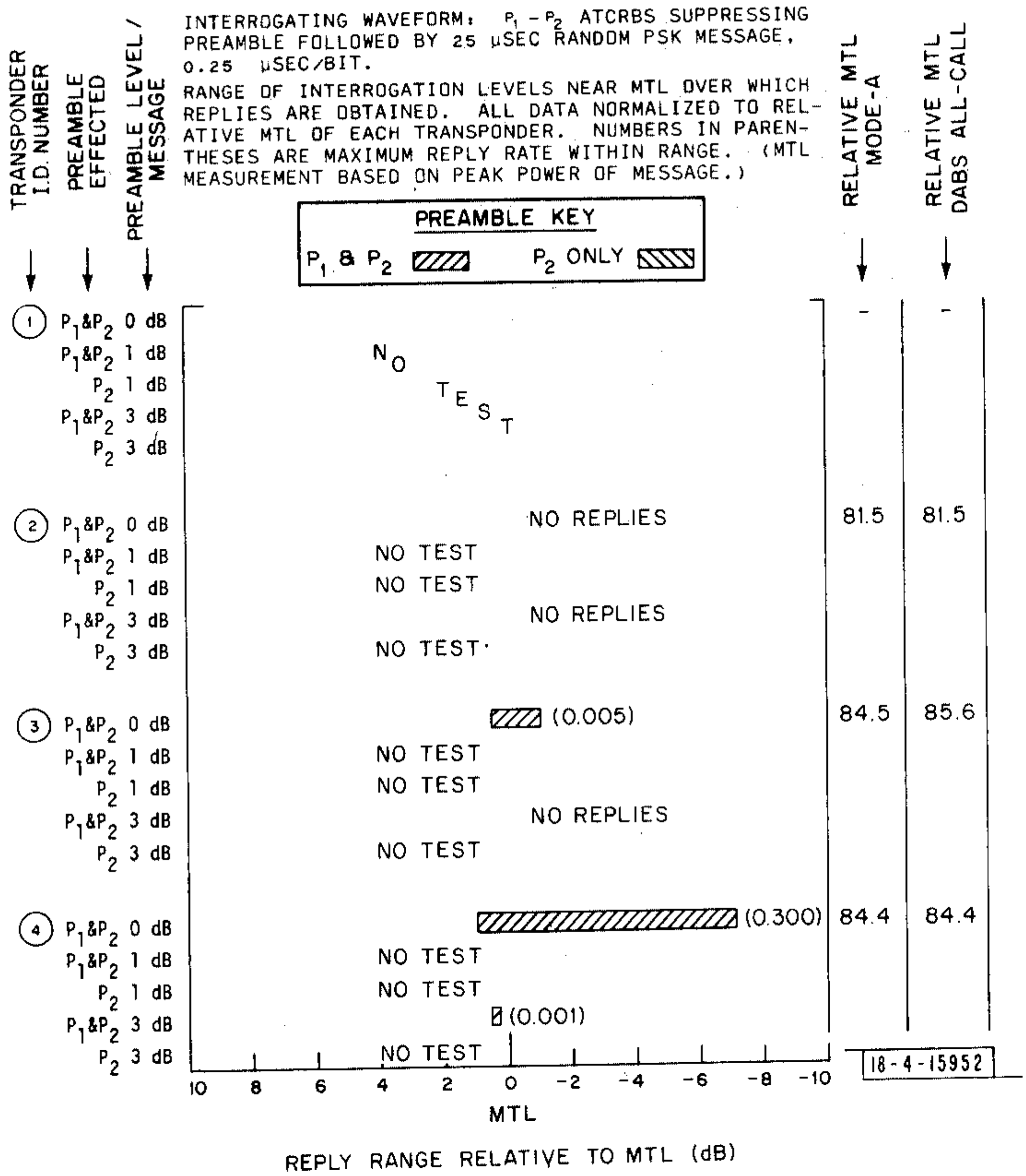

Fig. B-1.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

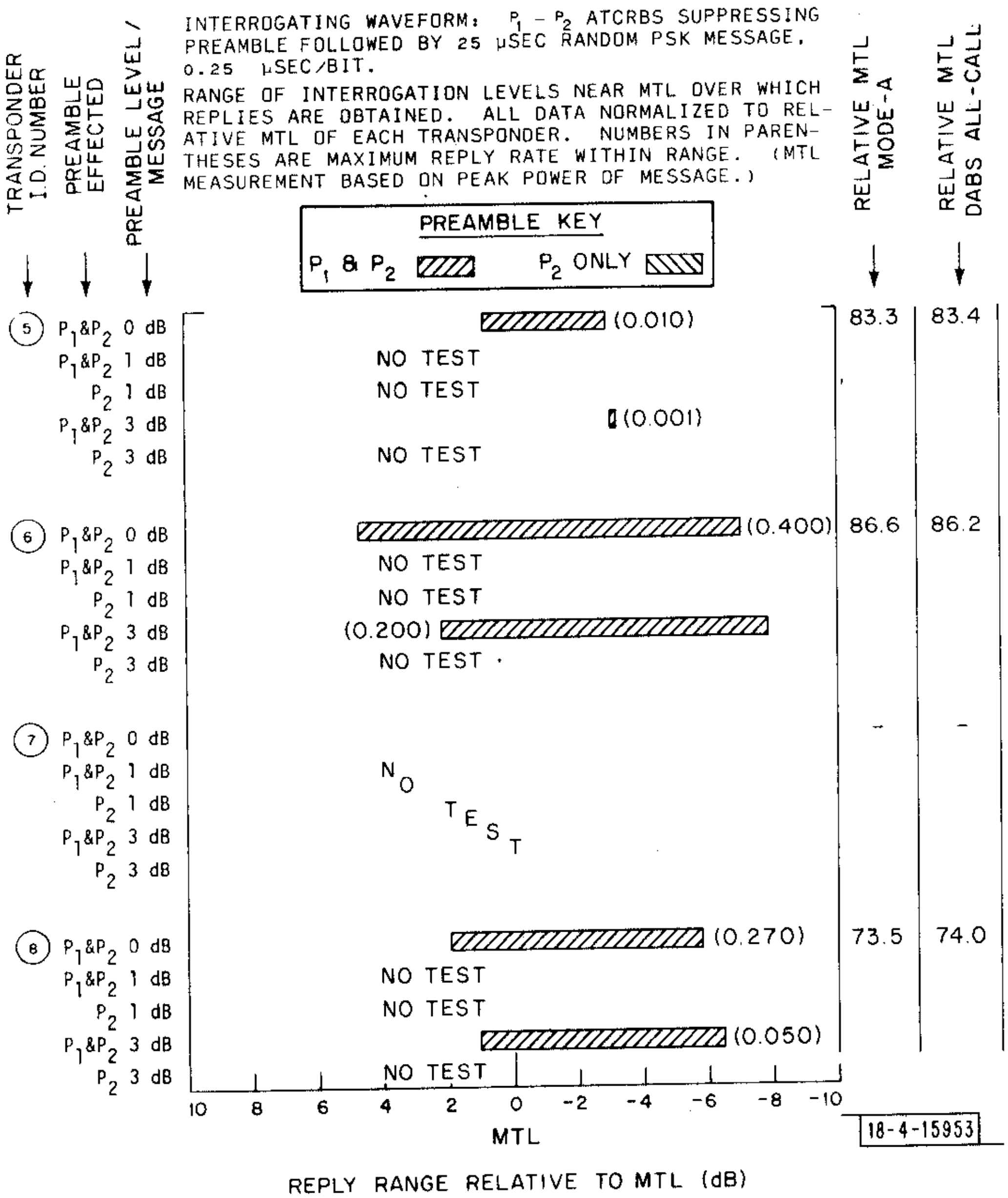

Fig. B-2.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

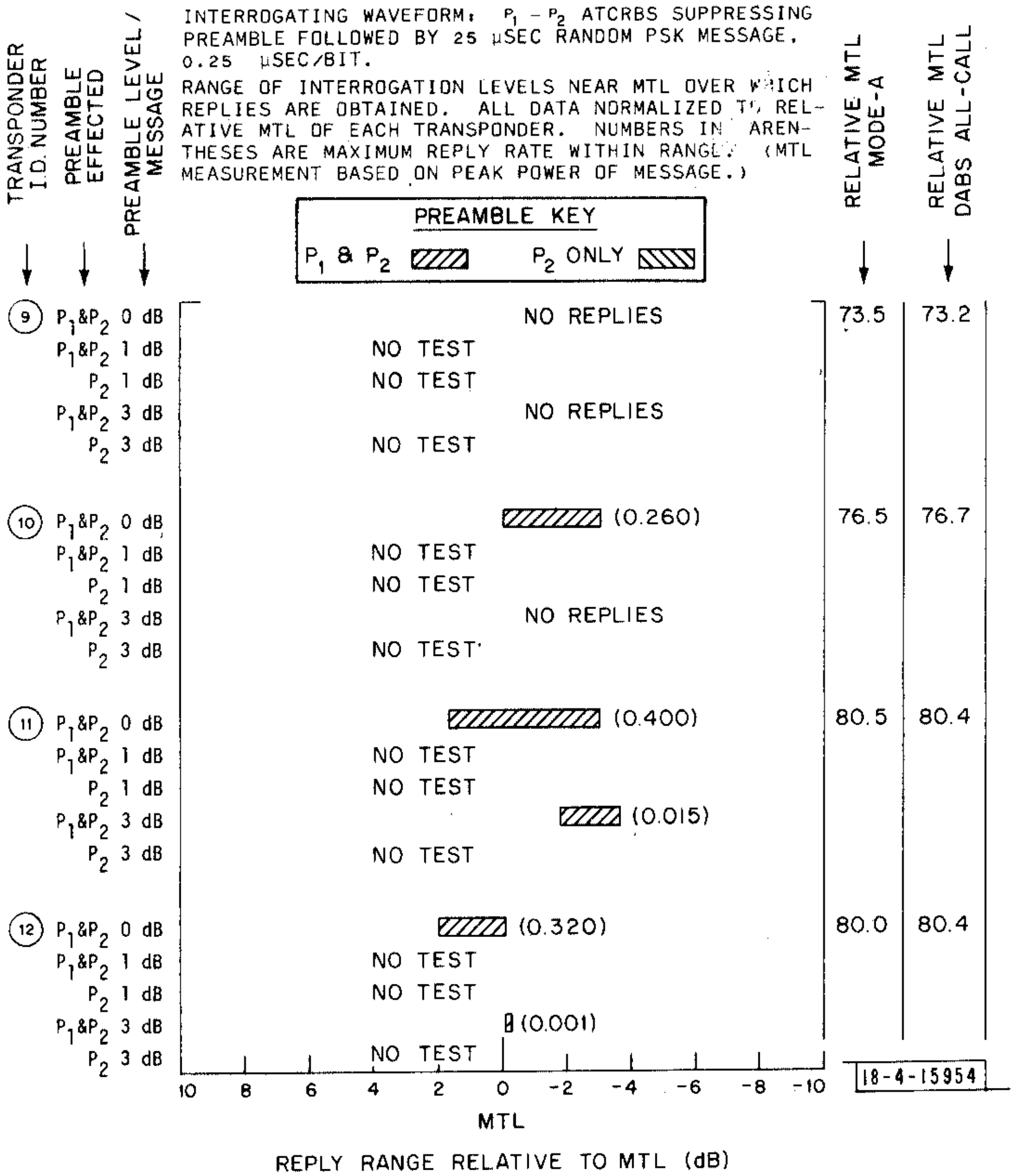

Fig. B-3.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

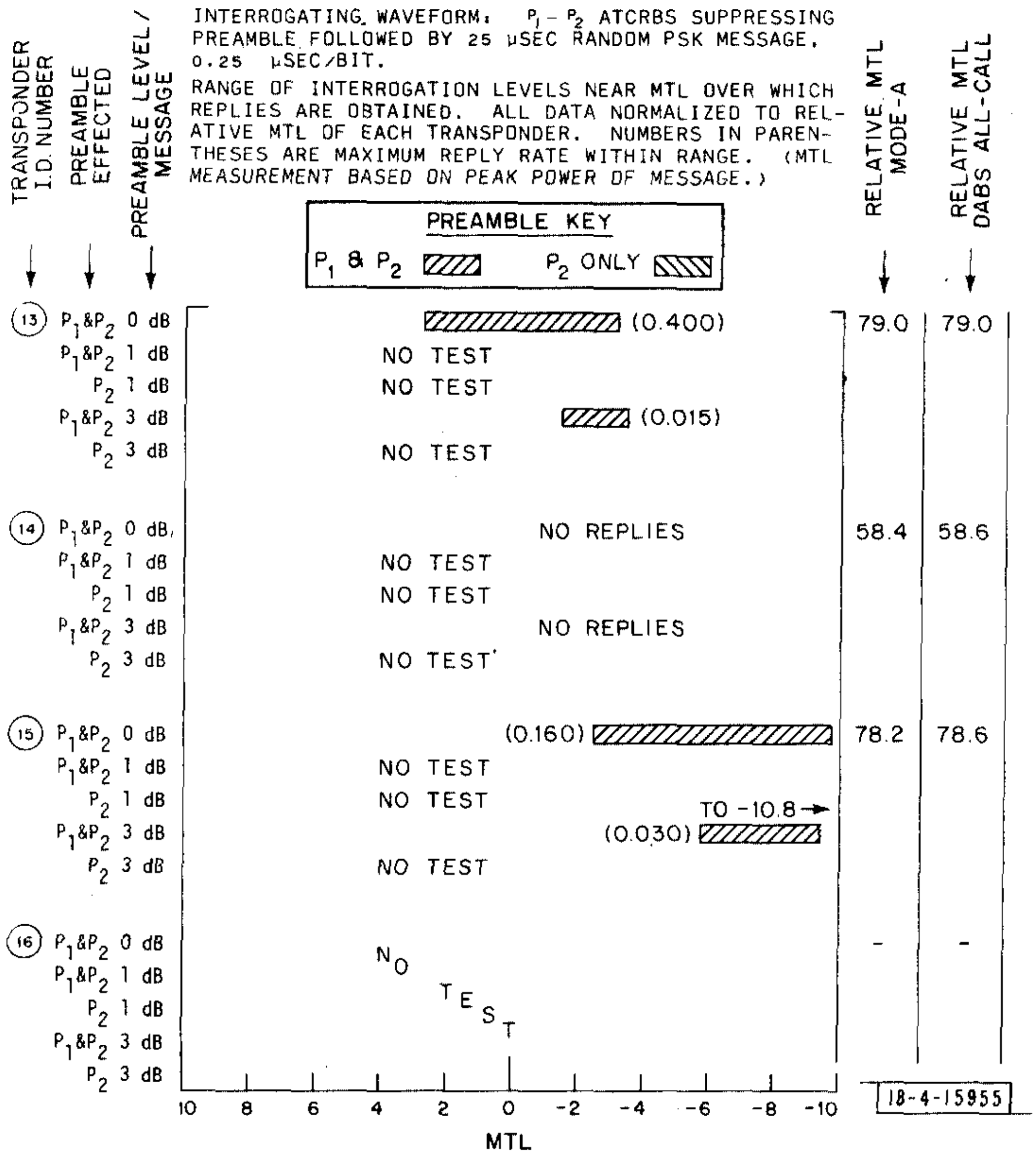

Fig. B-4.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

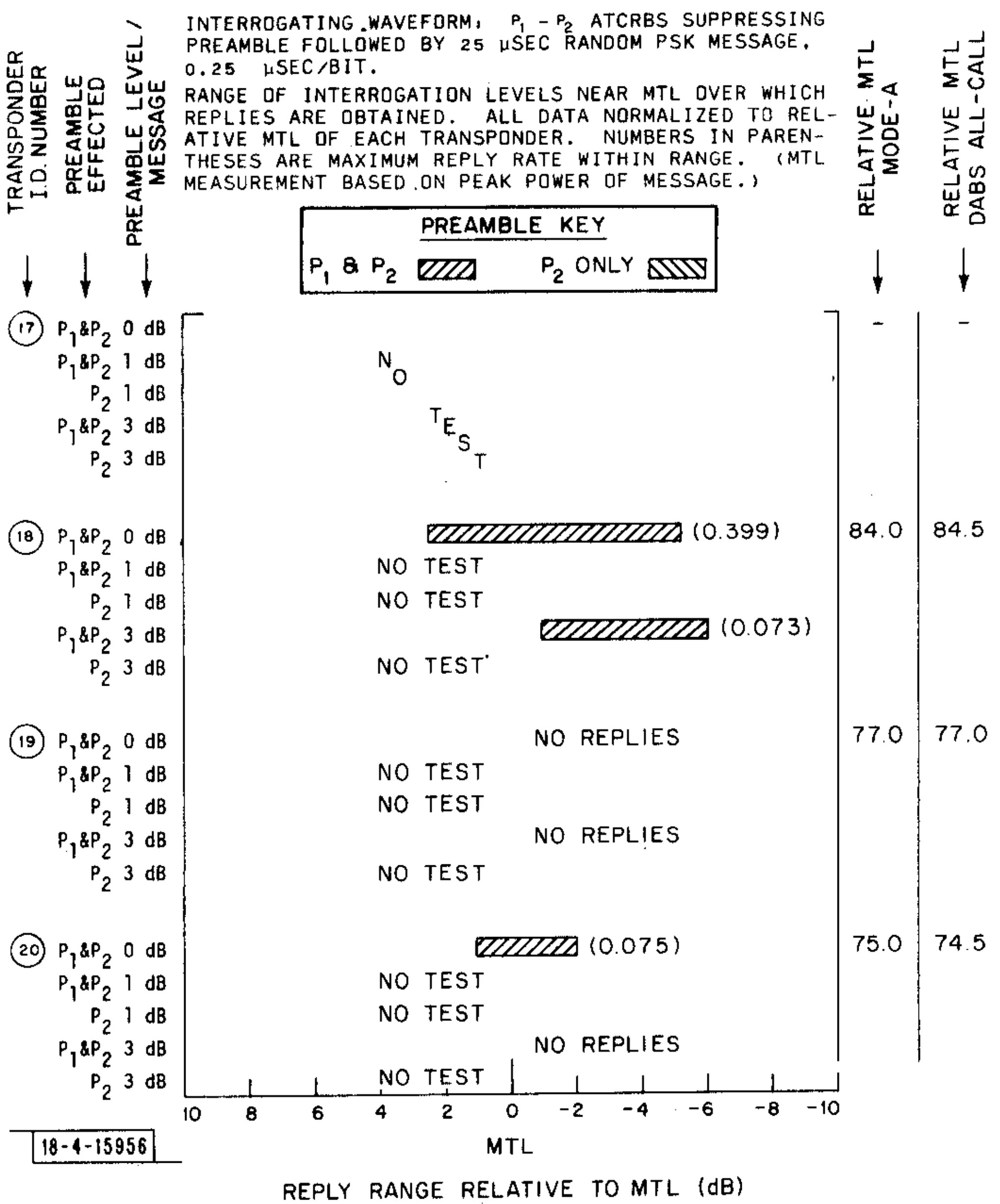

Fig. B-5.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

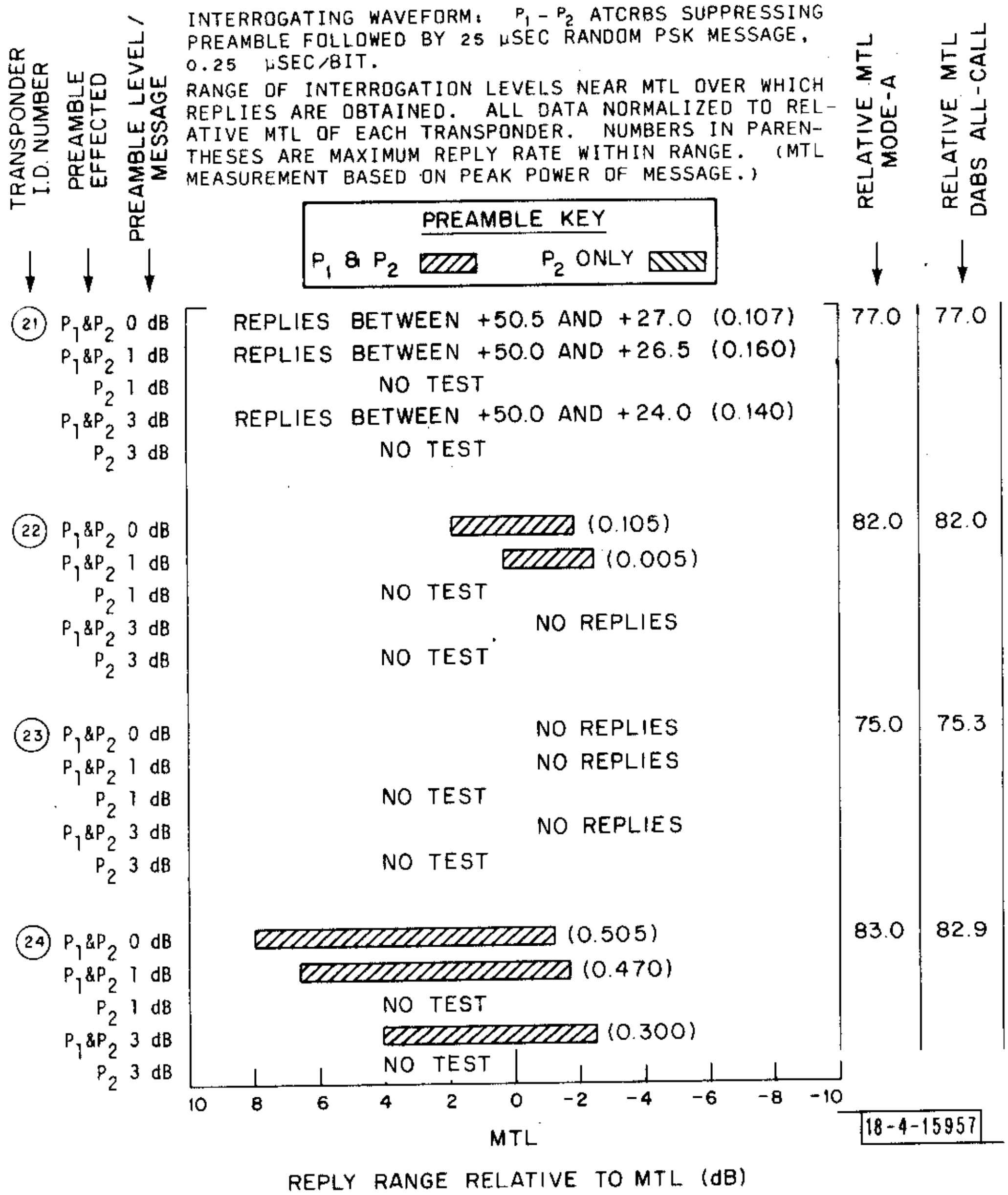

Fig. B-6.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

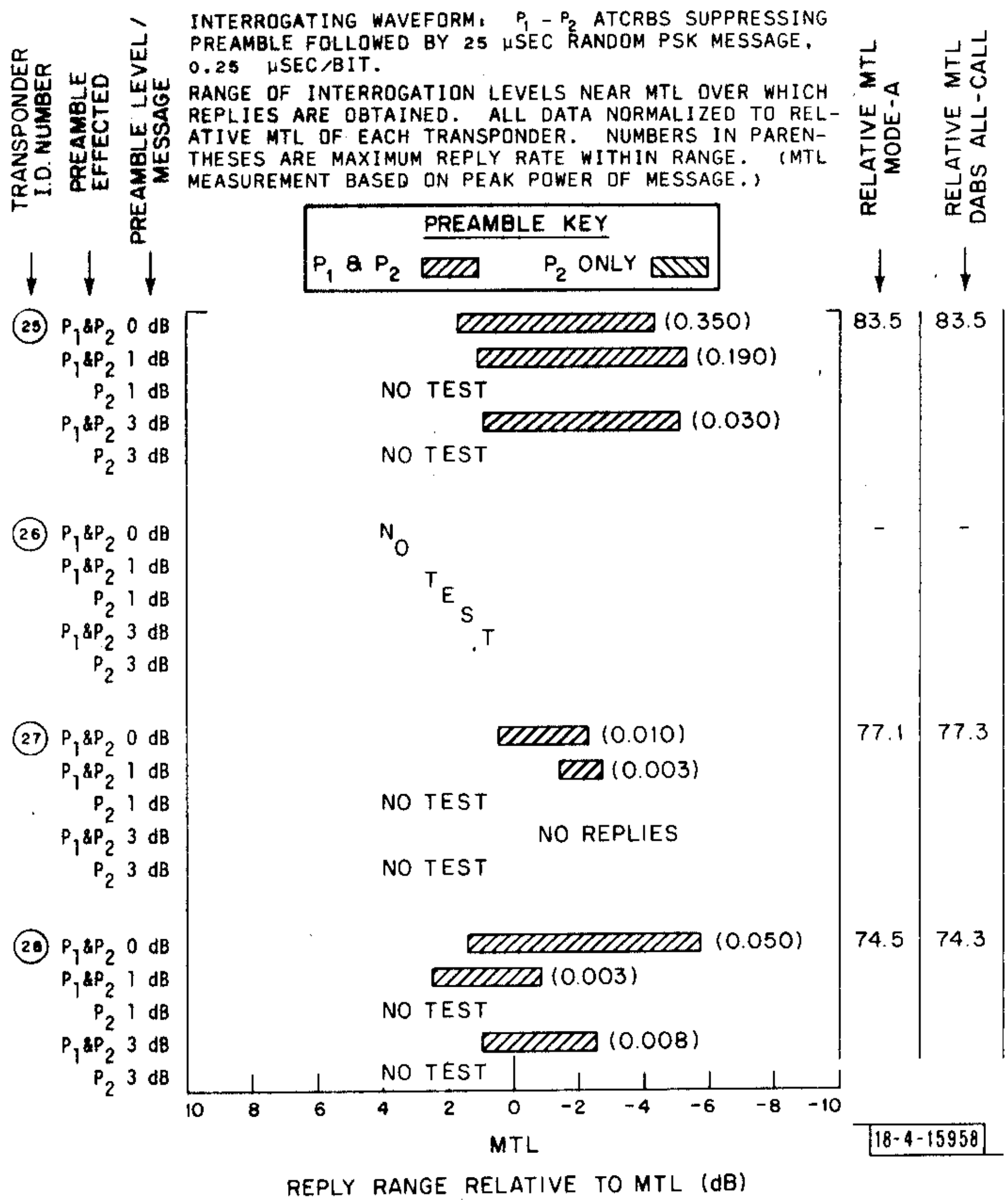

Fig. B-7.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

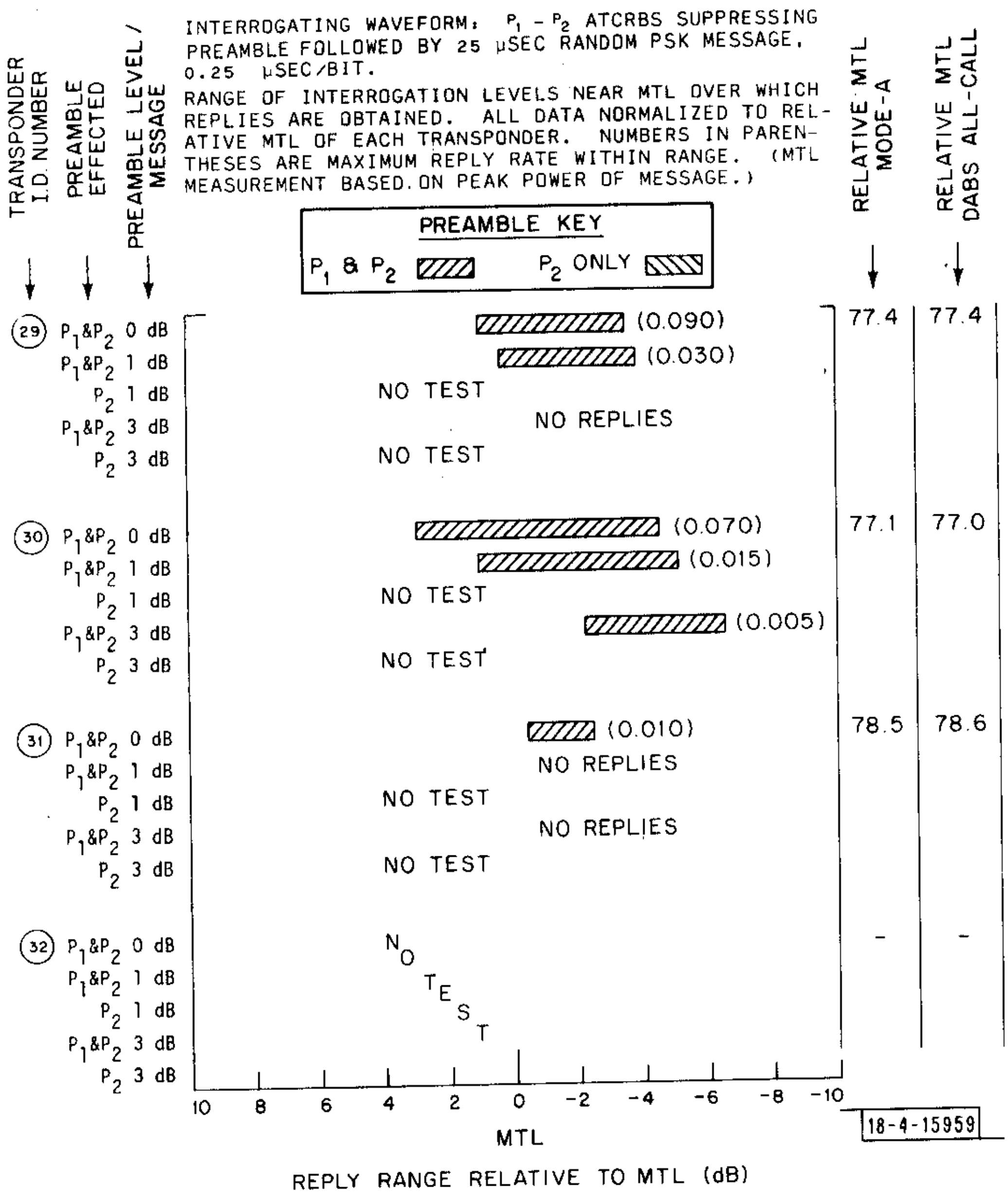

Fig. B-8.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

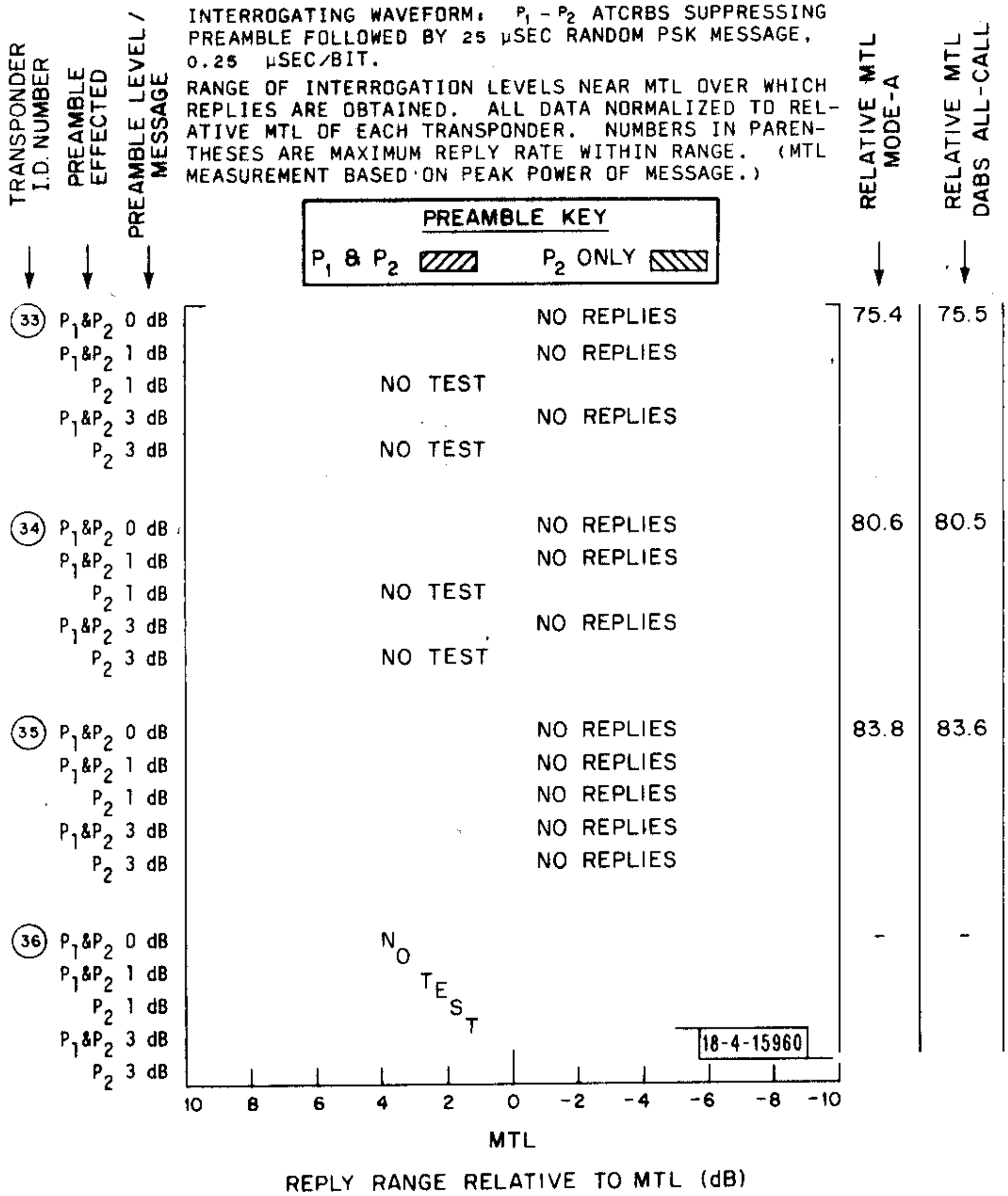

Fig. B-9.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

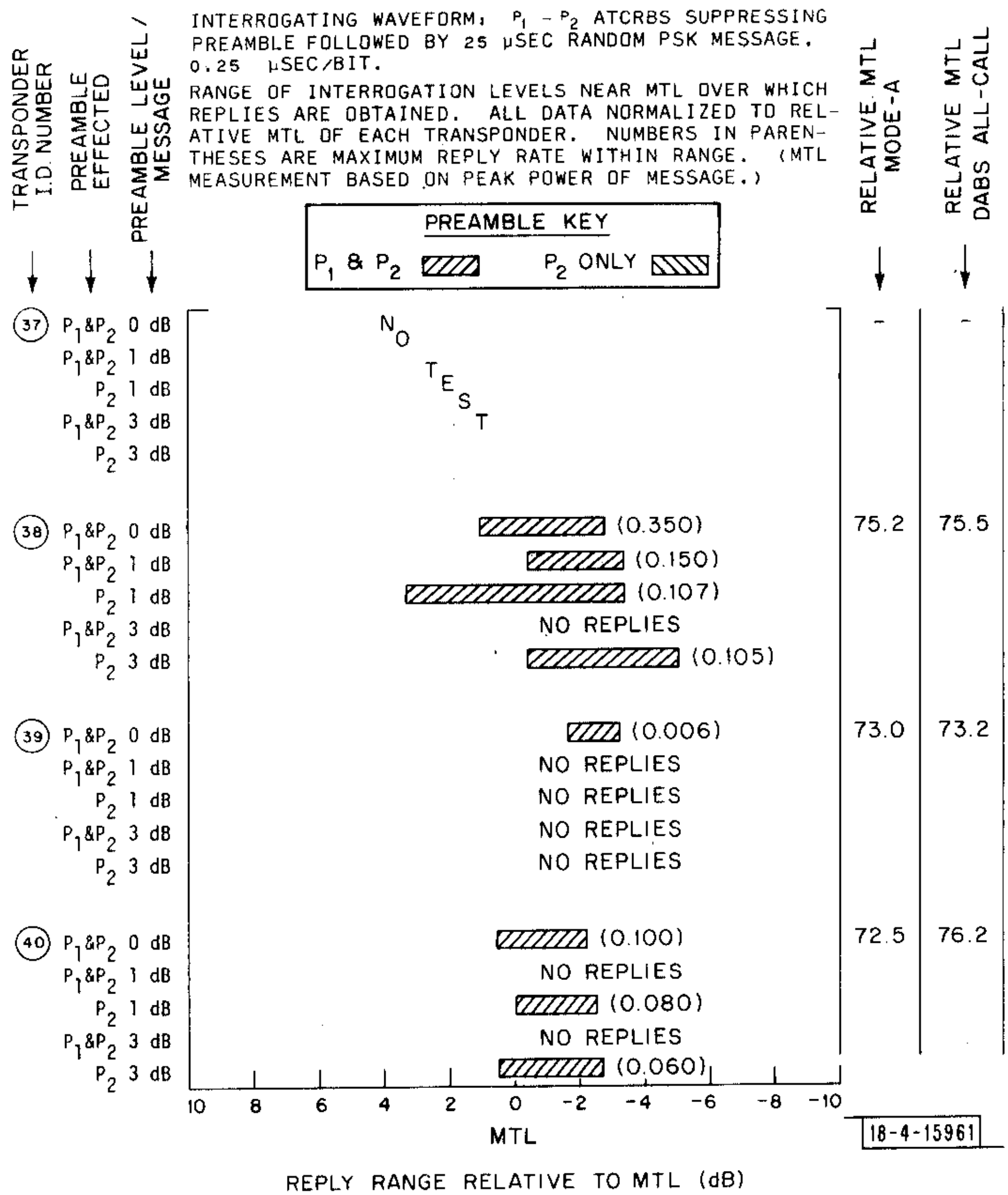

Fig. B-10.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

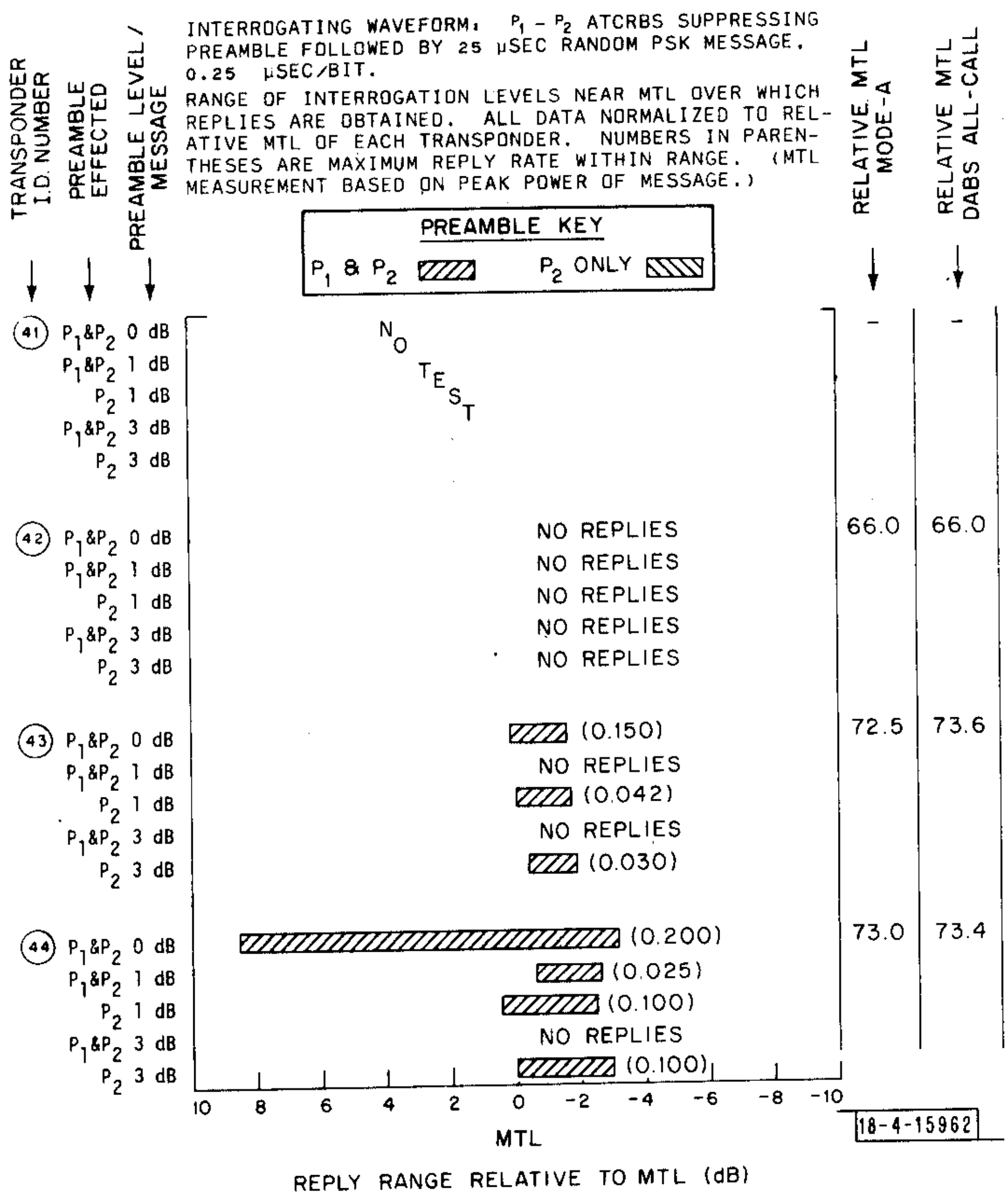

Fig. B-11.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

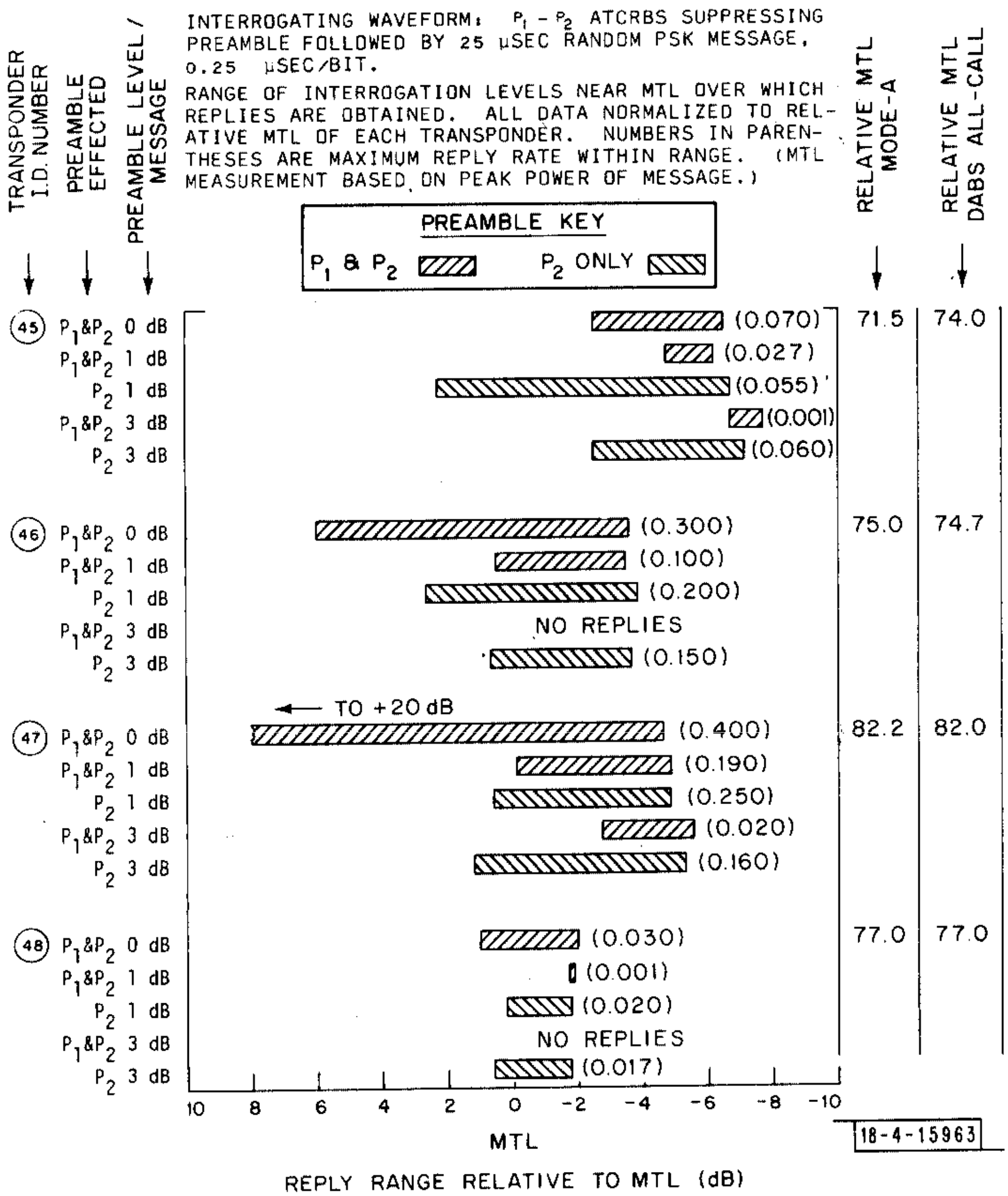

Fig. B-12.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

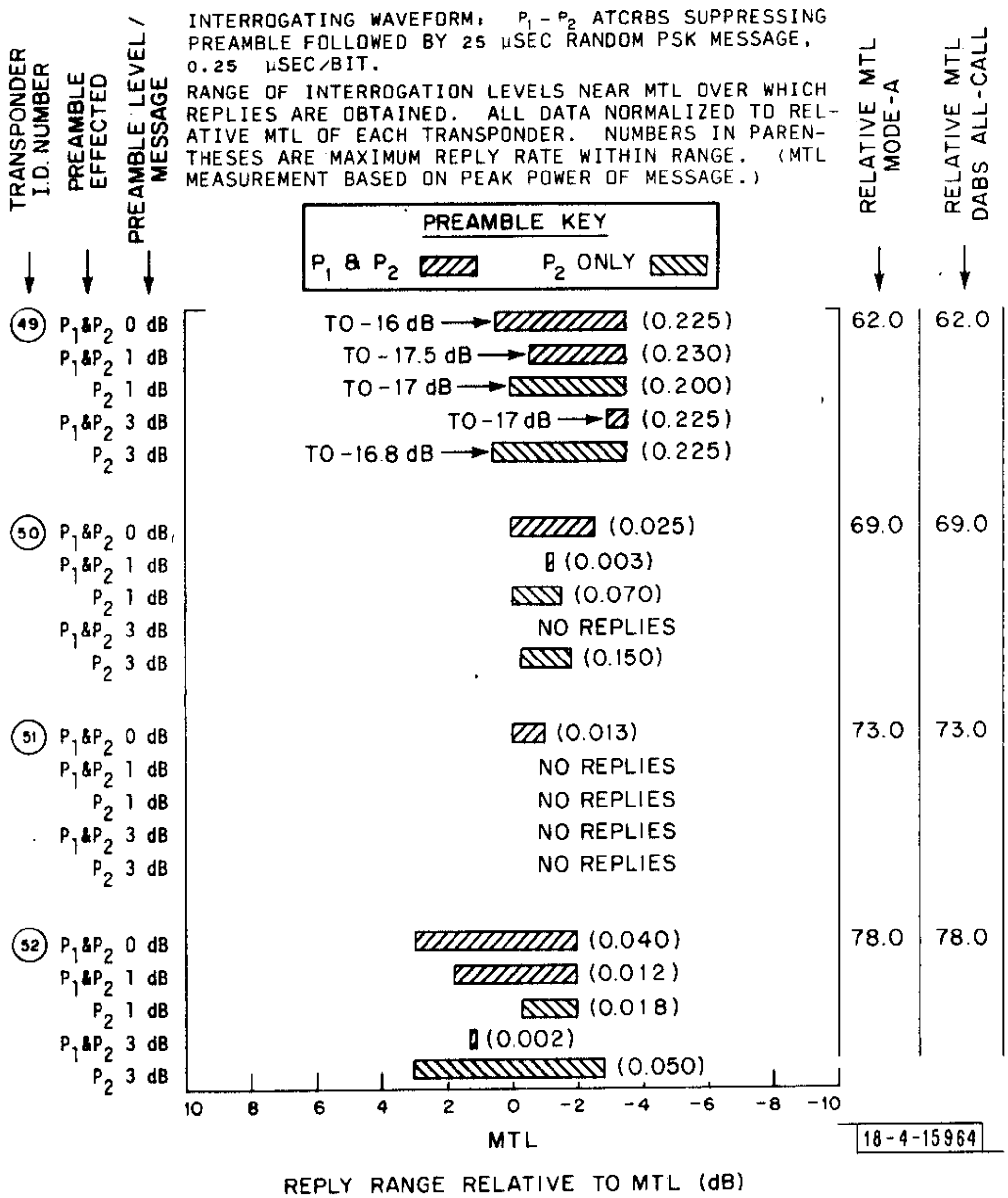

Fig. B-13.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

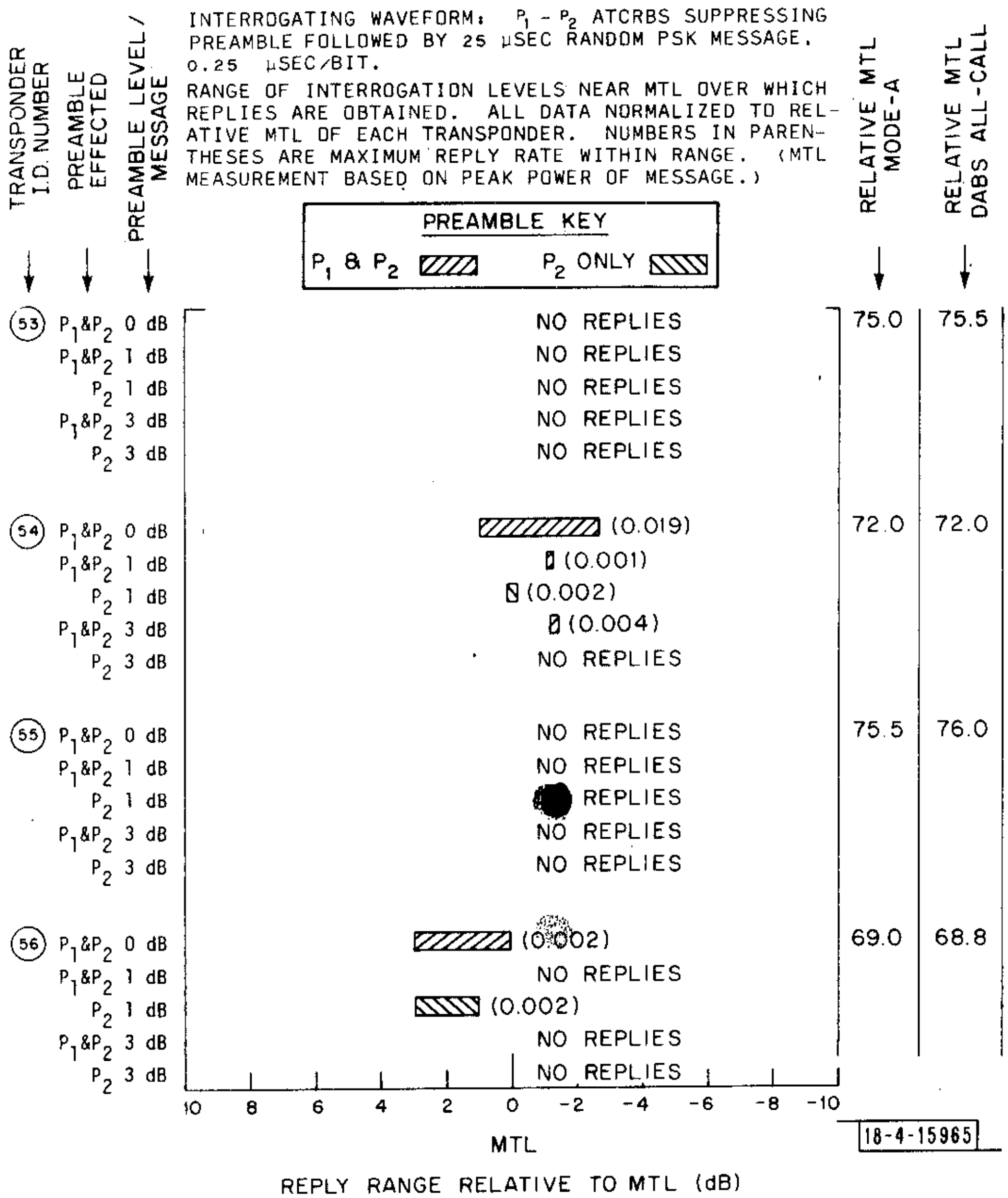

Fig. B-14.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

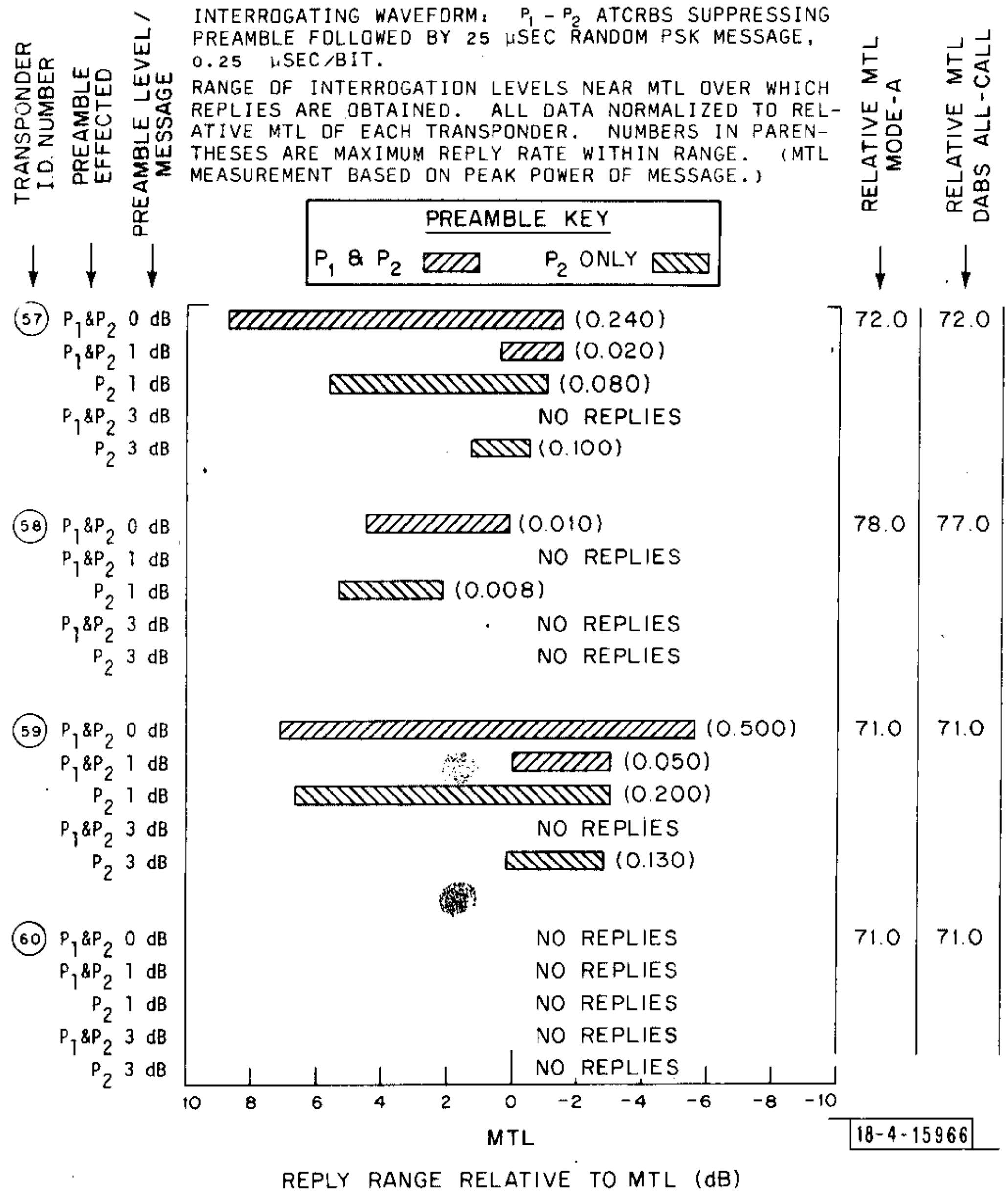

Fig. B-15.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

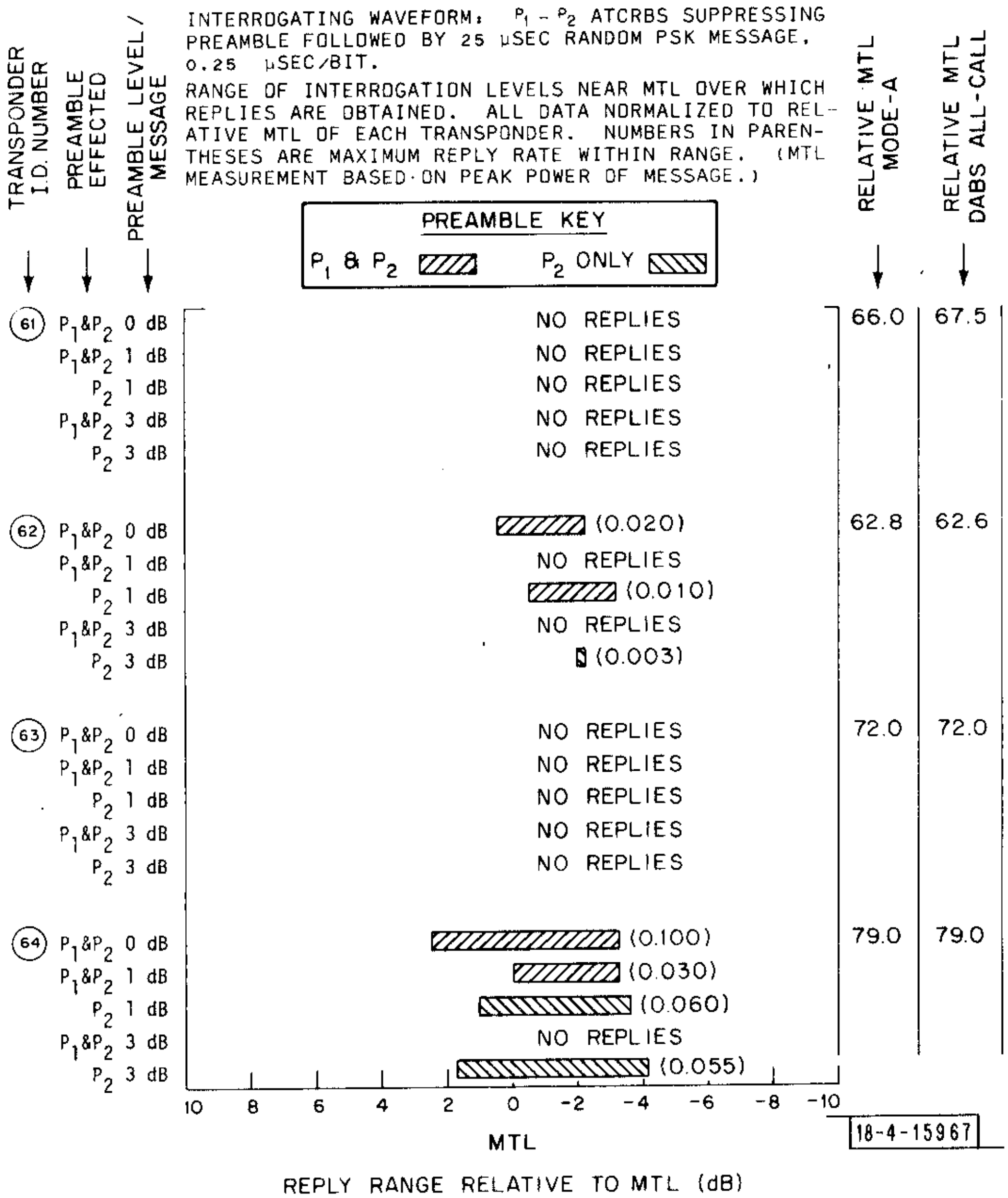

Fig. B-16.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

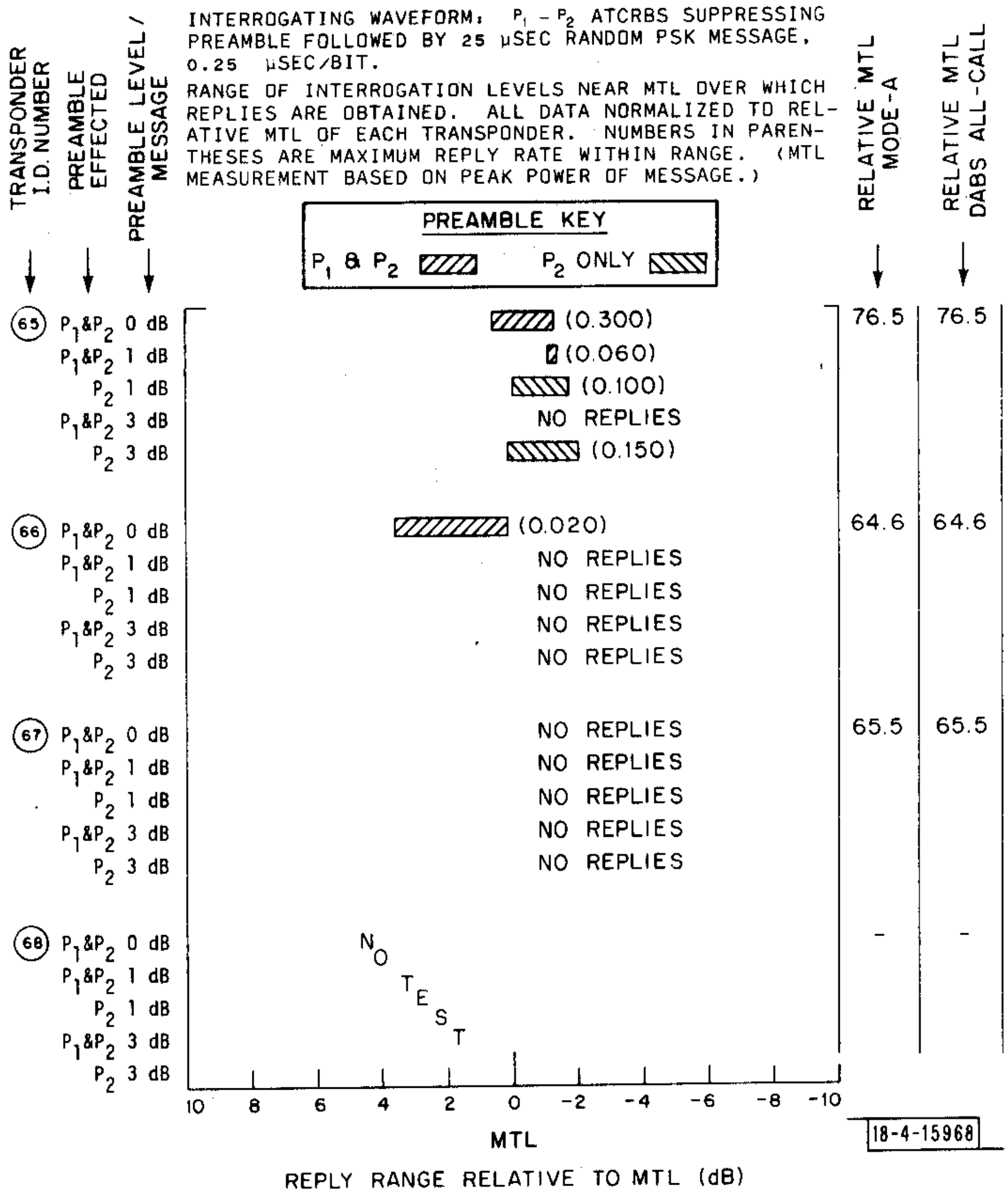

Fig. B-17.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

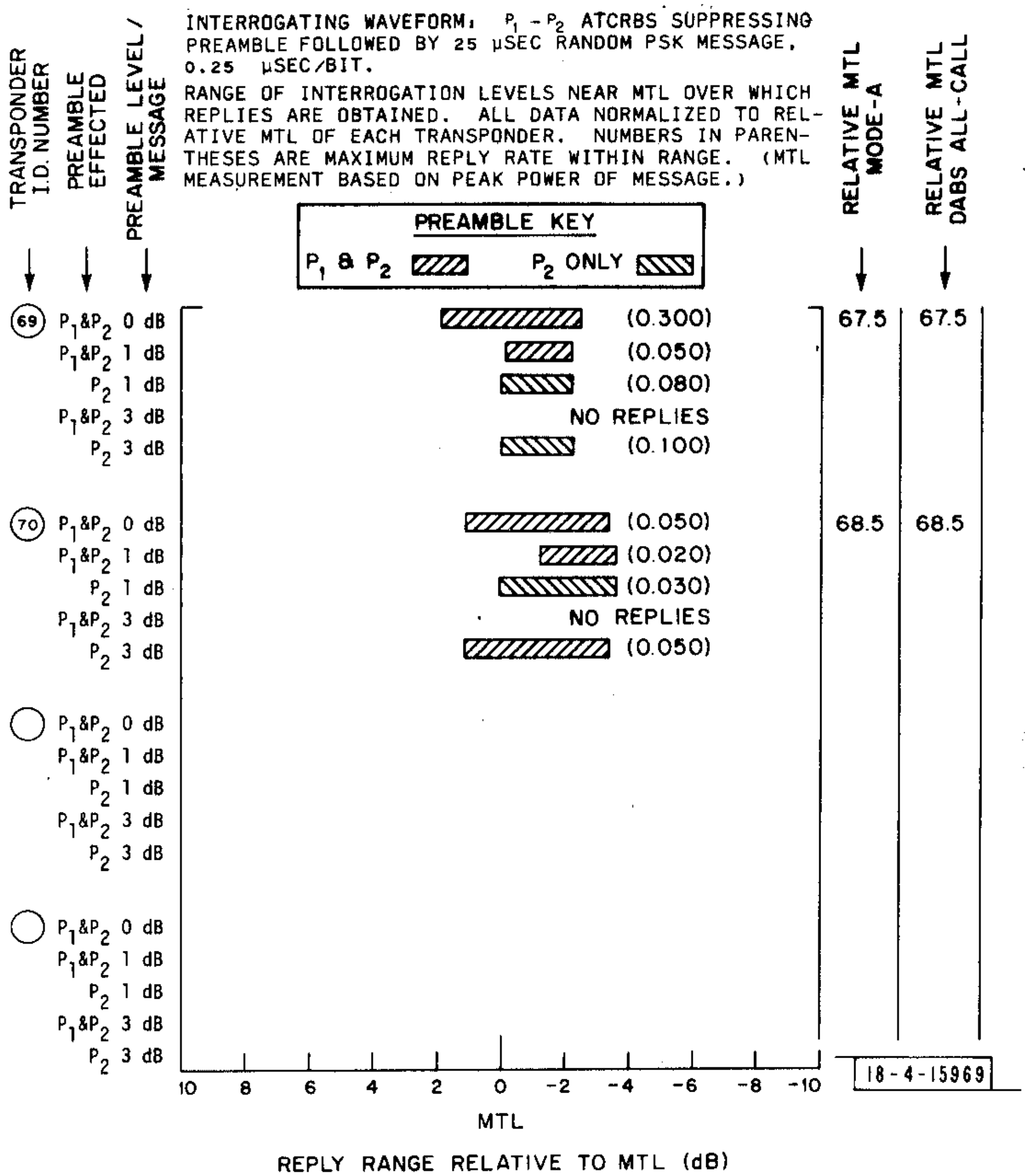

Fig. B-18.

Raw data showing variation in reliability of suppression when transmitted peak power of preamble is increased relative to message and measured relative MTL for Mode-A and DABS All-Call.

REFERENCES

[1]. J.R. Samson, et al., "Final Report - DABS/ATCRBS Transponder Bench Testing Program," Project Report ATC-25, Lincoln Laboratory M.I.T., (28 November 1973), FAA-RD-73-160.

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