TEST INSTRUMENTATION SUBSYSTEM INTEGRATION TEST PROGRAM REQUIREMENTS

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A	The following changes were made in compliance to the X-20 System Program Office's request; Letter ASNRA-3/L. Price/ slc/33190, dated August 30, 1963: Paragraph 3.2.1 The words "reproduced and" were deleted. Paragraph 4.3.2 The words "reproduced by" were deleted and the words "played back through" were inserted. AUTHORITY: BC-2-9500 MC	9/10/63	

REFERENCES

Government Documents

MIL E 6051 C — Electrical-Electronic System Compatibility and Interference Control Requirements for Aeronautical Weapon Systems, Associated Subsystems and Aircraft, dated 17 June 1960

Boeing Documents

D2-80600 — Glider/Transition Detail Specification

D2-80102-5 — Test Instrumentation Subsystem Integration Test Program Plan

D2-80102-2 — Test Instrumentation Subsystem Integration Test Procedures (to be released)

D2-80103-3 — Test Instrumentation Subsystem Integration Test Report (to be released)

ABBREVIATIONS

CTS - Communications and Tracking Subsystem
DSL - Data System Laboratory (Seattle)
FM - Frequency Modulation
IG - Inertial Guidance
PCM - Pulse Code Modulation
TICS - Test Instrumentation Checkout Set
TIC - Test Instrumentation Subsystem

CONTENTS

1.0 INTRODUCTION

1.1 This document presents the requirements for integration tests which are a part of the design qualification testing of the Test Instrumentation Subsystem (TIS). The tests are termed, "integration tests," since they will be performed as the individually qualified subcontractor and Boeing manufactured units are integrated in stages to the subsystem. These requirements will also apply to integration tests performed during acceptance tests of operational subsystems.

1.2 The tests will be performed in the Data Systems Laboratory where a Test Console will simulate the transducers and signal sources.

1.3 The measure of performance in the majority of tests will be data accuracy and acceptable performance will be based on the accuracies specified in the measurement list. Total subsystem accuracies will be determined by modifying the accuracies obtained in test in such a way as to include transducer and signal source accuracies.

1.4 A requirement exists for pre-emphasis schedules to be established for the transmission multiplexes as early as possible in the testing program to allow time for pre-emphasis resistor networks to be manufactured for operational equipment. Tests, to determine these schedules, will be performed with the set of TIS equipment used for design qualification and requirements for these tests are included in this document.

1.5 Testing is divided into four sections and the requirements are defined for each of these sections. The division is such that it will be possible to determine the contribution to inaccuracy of each interface in the subsystem. The testing is divided as follows:

(a) Airborne Conversion and Storage Equipment Integration Test, where the Test Console provides inputs to the Airborne Conversion Equipment.

(b) Instrumentation Subsystem Integration Test, where the Signal Conditioning Equipment is integrated with the Airborne Conversion and Storage Equipment, and the Test Console simulates the glider interface.

(c) Reference Test, where the TIS equipment is integrated with the TICS through the various test functions of the TICS.

(d) Pre-emphasis test, where TIS equipment is combined with the Communications and Tracking Subsystem equipment to determine optimum pre-emphasis schedules.

The sequence of testing will depend on the availability of equipment, and the schedule is given in D2-80102-5.

1.6 Other documentation relative to the TIS Integration effort is as follows: D2-80102-2, Procedure; D2-80102-3, Report; D2-80102-5, Plan.

2.0 TEST OBJECTIVES

2.1 Integration Tests

(a) To verify functional compatibility of the various data units of the TIS.

(b) To verify system procedures and equipment.

(c) To determine the necessary changes, if any, to the production equipment and test procedures to meet subsystem data accuracy requirements.

(d) Provide reference information for later subsystem tests involving the TICS.

2.2 Pre-Emphasis Test

(a) To determine the optimum pre-emphasis networks for the transmission data basebands.

(b) To determine the performance of the TIS equipment when the transmission data multiplexes are pre-emphasized as required for transmission through the Communication and Tracking Subsystem.

3.0 SUBSYSTEM CONFIGURATION

3.1 Equipment Configuration

3.1.1 Design qualification will be performed with one set of equipment in the 02 glider configuration. The units comprising the set will conform to the following drawings.

(a) PCM Conversion Equipment Drawing No. 10-81003-2.

(b) FM Conversion Equipment Drawing No. 10-81003-3. The particular VCO's to be employed, which correspond to the 02 glider configuration, are listed by channel number in Table 1 with the appropriate Electro-Mechanical Research, Inc. VCO drawing numbers included.

(c) Airborne Tape Recorder Drawing No. 10-81003-5.

(d) Mechanical Commutator Drawing No. 10-81003-8.

(e) Signal Conditioning Equipment (the drawing number will be included when this equipment is defined).

(f) TIS Ground Station 600045.

(g) Test Instrumentation Checkout Set. (The drawing number will be included when this equipment is defined).

3.1.2 The airborne TIS units will be mounted in the Test Console which will supply power to these units in addition to simulating the transducers and signal sources of the 02 glider.

3.2 Test Configuration

3.2.1 Airborne Conversion and Storage Equipment Integration Test

The Test Console will provide inputs to the Airborne Conversion Equipment and the recorder output of the Airborne Conversion Equipment will be connected to the Airborne Tape Recorder. Tape recordings produced in the tests will be processed by the TIS Ground Station. The PCM data will be format converted by the ground station for computer evaluation. R

3.2.2 Instrumentation Subsystem Equipment Integration Test

The configuration will be as in 3.2.1 above, except that the Signal Conditioning Equipment will be connected. The Test Console will simulate transducers and signal sources for the Signal Conditioning Equipment.

3.2.3 Reference Test

3.2.3.1 The Test Instrumentation Checkout Set (TICS) will simulate transducer or signal source variations for all channels where simulation capability is provided.

3.2.3.2 The reference test will be divided into three sections corresponding to the three test functions of the TICS. The test configurations will be as described in the following paragraphs.

3.2.3.3 Signal Conditioning Equipment - The Test Console will simulate the ambient condition of each transducer and signal source at the input to the Signal Conditioning Equipment. The TICS will be connected to the simulation connectors of the Signal Conditioning Equipment to simulate transducer and signal source variations and to the patch panel to measure the corresponding variation at the output of the Signal Conditioning Equipment.

3.2.3.4 Airborne Conversion and Storage Equipment - The TICS will be connected to the input of the Airborne Conversion Equipment, and the Airborne Tape Recorder will be set up to record the output for analysis by the TIS Ground Station and Computer.

3.2.3.5 TIS Simulation - The TIS will be set up with the Test Console connected to the input of the Signal Conditioning Equipment to simulate the ambient condition of each transducer and signal source. The TICS will be connected to the simulation connectors of the Signal Conditioning Equipment. The tape recorder will record the test data which will be evaluated by the TIS Ground Station and Computer.

3.2.4 Pre-Emphasis Test

Pre-production Communication and Tracking Subsystem equipment will be used to represent a single communications channel. The Test Console will provide signal inputs to the Airborne Conversion Equipment, and the transmitter output of this unit will be connected to the transmitter. The VHF receiver output will be connected to the Ground Station.

4.0 TEST CONDITIONS

4.1 General

Integration Tests will be performed in a laboratory environment since the individual airborne units will have been fully tested with environmental variations during qualification testing.

4.2 Airborne Conversion and Storage Equipment Integration Test

4.2.1 The PCM data signal format of the Test Console will be fixed throughout the test, and the same format will be employed with each of the FM formats to be described in 4.2.2. The various PCM channel signals will represent the range of specified operating signal conditions, including over-voltage and common-mode conditions. There will be several levels representative of the normal data signal range to define the linearity of the PCM equipment.

4.2.2 The principle FM test will be an overall accuracy test where the accuracy is determined with as many characteristics contributing to the performance as possible. Other tests will check linearity and frequency response in such a manner as to isolate these effects. The conditions for the various tests are as follows.

4.2.2.1 Overall Accuracy - Each channel will be modulated in turn to full band-edge to band-edge deviation by a sinusoidal signal while all other channels are modulated with random noise. The frequency of the modulating signal will be one third the nominal modulation frequency of the particular channel. The random noise will be limited in frequency spectrum to the nominal maximum modulation frequency for each channel.

4.2.2.2 Linearity - For the channels with DC response, five DC signal levels will be applied over the nominal signal range. Sinusoidal signals will be applied to the channels with AC response only; five levels will be applied from small deviation to nominal maximum deviation. The signal frequency will be set to the constant amplitude portion of the modulation band of these channels.

4.2.2.3 Frequency Response - Both DC response and non-DC response channels will have sinusoidal signals applied at the nominal upper modulation frequency and the latter at the nominal lower modulation frequency also. A signal to determine a reference level will also be applied in the constant amplitude portion of the frequency band of each FM channel.

4.2.3 The accuracy of the IG channel will be determined with a simulated IG signal while all other FM channels are modulated with random noise as in 4.2.2.

4.2.4 All data will be recorded by the Airborne Tape Recorder. The TIS ground station will reproduce the data multiplex, format convert the PCM and I.G. data, and provide oscillographic records of the FM data.

4.3 Instrumentation Subsystem Integration Test

4.3.1 All signal sources of the first ground-launch vehicle will be represented by the Test Console. The Test Console will simulate conditions for zero or ambient and 90% for all channels of the subsystem.

4.3.2 The Airborne Conversion Equipment Multiplex output will be recorded by the Airborne Tape Recorder as the signal levels for each channel are varied. This tape recording will be played back through the TIS ground station, which will also format convert the PCM data and provide oscillograph record of the FM data. R

4.4 Reference Test

4.4.1 Signal Conditioning Equipment

The TICS will apply a signal voltage or impedance to each channel to simulate conditions equivalent to 10% and 90% of full scale or 60% and 90% where the channel is at 50% for ambient condition.

4.4.2 Airborne Conversion and Storage Equipment

The TICS will apply voltages to all PCM channels corresponding to zero, 10%, and 90% of full scale. For FM channels with DC response, DC voltages corresponding to zero and ±40% of full scale will be applied and FM channels with AC response only will have zero voltage and an AC voltage corresponding to 80% of full scale applied.

4.4.3 TIS Reference Test

The TICS will apply a signal voltage or impedance at the simulation input of each channel to simulate conditions equivalent to 10% and 90% of full scale or 60% and 90% of full scale where the channel is at 50% for ambient conditions.

4.5 Pre-Emphasis Test

4.5.1 The Communications and Tracking Subsystem equipment will be arranged to operate at SHF received signal levels in the range of carrier FM threshold for the receiver system.

4.5.2 The PCM format will represent a typical data format with signals in the specified operating range of the equipment. FM channel modulation inputs will be random noise inputs to represent vibration and flutter data, except where a measurement of channel noise is made, in which case the input will be grounded. A voice signal will also be applied to the voice channel and simulated I.G. data applied to the I.G. channel.

4.5.3 The test will be performed for both narrow band and wide band transmission data multiplexes.

4.5.4 The multiplex output of the VHF receiver will be monitored by the ground station.

5.0 DATA REQUIREMENTS

5.1 Airborne Conversion and Storage Equipment Integration Test

5.1.1 PCM Data - The PCM data will be recorded for six minutes with each of the conditions specified for the FM channels for a total of three records. Each record will be analyzed to determine the number of points within two tolerance levels for each PCM channel and for all PCM channels combined. For all FM conditions it is required that 95.5% of the points be within 0.6% of full scale of the correct level and 99.9% of the points be within 1% of full scale of the correct level.

5.1.2 I.G. Data - The I.G. data will be analyzed to determine the bit error rate. The I.G. data will be recorded for a total period of 12 minutes comprised of not more than two continuous recordings. It is required that not more than one error bit exist for the 12 minutes of recorded data.

5.1.3 FM Data - The FM data will be recorded for a six-minute period for each of the conditions specified to indicate overall accuracy, linearity, and frequency response. The data recorded to determine overall accuracy will be used to make error records where the modulating signal of each channel is attenuated by a notch filter. The filter bandwidth shall be such that the amplitude frequency product is not reduced more than 25% and the amplitude of each channel output will be increased in proportion to the actual reduction to compensate for filter attenuation. The error records will be analyzed to determine the probability of exceeding tolerance levels which depend on the nominal deviation ratios of the channels as shown below.

Nominal Deviation Ratio	Allowable Error for 1% Probability	Allowable Error for 0.1% Probability
1	± 14.5%	± 18.5%
2	± 5.8%	± 7.4%
5	± 2.0%	± 2.6%

Data will include an analysis of the accuracy at the 1.0% and 0.1% probability levels. It is required that the accuracies be within those shown above when applied to the appropriate channels. Alternatively the requirement for the FM channel accuracy can be expressed in terms of the time that the tolerances are exceeded. In this case the requirement is that the tolerances are not exceeded for a time greater than that indicated by the probability value. For the six-minute data record the 1% probability means that the tolerances associated with this probability must not be exceeded for more than a total of 3.6 seconds and the 0.1% probability that the associated tolerances must not be exceeded for more than a total of 0.36 seconds. The data to indicate linearity and frequency response will be analyzed to determine the linearity and frequency response for each channel.

5.2 Instrumentation Subsystem Integration Test

5.2.1 PCM Data - At least one minute of data will be recorded for each PCM channel at each of two levels, zero or ambient and 90% of full scale. The channels will be switched from zero or ambient to 90% of full scale in turn with at least a one second period between switching channels. The sequence of switching levels will be recorded.

5.2.2 The PCM data will be analyzed to insure that the changes at the output occurred in the correct sequence with reference to the order in which the inputs were switched. An accuracy analysis for each channel will be made to determine the number of points within the measurement list accuracy modified for the transducer or signal source accuracy by the following equation:

$$A_r = \sqrt{A_m^2 - A_t^2}$$

where A_r is the required accuracy, A_m is the measurement list accuracy, and A_t is the transducer accuracy.

The values for transducer accuracies are given in Table 2. It is required that 95.5% of the data points fall within the required accuracy of each level for each of the channels.

5.2.3 FM Data - An analysis of the FM data for each channel will be made to determine the value which is exceeded 4.5% of the time. It is required that this value will be within the required value obtained from the equation in paragraph 5.2.2. The data will be analyzed separately for each signal level for each channel.

5.3 Reference Test

All data obtained in this test will be retained for use as a reference in later tests involving the TICS. Data will be obtained for those channels which will not be stimulated.

5.3.1 Signal Conditioning Equipment

The accuracy of each channel will be determined and compared with TBC requirements for the Signal Conditioning Equipment.

5.3.2 Airborne Conversion and Storage Equipment

Data will be obtained which will include two minutes of data for each of the test conditions, e.g. the PCM data will include two minutes at each of the test levels of 0, 10, and 90% of full scale for all channels. For PCM data, the data will be analyzed to determine the number of points within two tolerance levels of each of the test levels of 0, 10 and 90% of full scale. It is required that 95.5% of the points be within 0.6% of full scale of the required value and that 99.9% of the points be within 1% of full scale of the

5.3.2 (Continued)

required value at each of the three test levels. FM data analysis and requirements are as in 5.1.3. The accuracy must be within the allowable error at each of the test levels.

5.3.3 TIS Simulation Test:

5.3.3.1 At least one minute of data will be recorded for each PCM channel at each of two levels, 10% and 90% of full scale. These levels will be 60% and 90% if the channel is at 50% in ambient conditions. The channels will be set to the lower signal condition initially and will be switched to 90% of full scale in turn allowing at least one second between switching channels. The sequence will be recorded. An accuracy analysis of the PCM data will be made as described in 5.2.2 and for the FM data as in 5.2.3.

5.4 Pre-Emphasis Test

5.4.1 The principal data to be obtained from this test will be the resistor schedules from the variable matrix which will define the optimum pre-emphasis schedules. The PCM bit accuracy and FM channel RMS noise for a range of SHF received signal levels corresponding to the data threshold will be recorded for each transmission data bandwidth. Strip chart recordings will also be made of the FM channel noise to indicate peak noise level.

5.4.2 Data will be obtained concerning the output transmission multiplexes. The Conversion and Storage Equipment transmitter output corresponding to the optimum pre-emphasis schedules will be measured both in terms of RMS voltage and percentage probability of exceeding a given voltage for each of the transmission data bandwidths. Also, the frequency spectrum of each multiplex will be recorded photographically with the FM channels unmodulated.

TABLE 1

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TABLE 2

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