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REPORT NO.
TOR-930(2110)-8
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**Satellite Control Facility
Equipment Augmentation**

Design Criteria: *Inter-Station Communications Subsystem*

3 AUGUST 1962

Prepared by
SATELLITE CONTROL OFFICE

Prepared for COMMANDER SPACE SYSTEMS DIVISION

UNITED STATES AIR FORCE

Inglewood, California

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CONTRACT NO. AF 04(647)-930

Report No.
TOR-930(2110)-6
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**SATELLITE CONTROL FACILITY
EQUIPMENT AUGMENTATION**

DESIGN CRITERIA, Inter-Station Communication Subsystem

Prepared by
SATELLITE CONTROL OFFICE

AEROSPACE CORPORATION
El Segundo, California

Contract Nos. AF 04(647)-930
AF 04(695)-169

3 August 1962
(Replaces TOR-930(2110)-6 dated April 1962)

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Prepared by
SATELLITE CONTROL OFFICE

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FOREWORD

This reissue, Reissue A, of Report No. TOR-930(2110)-6, dated 3 August 1962, supersedes and replaces Report No. TOR-930(2110)-6, dated April 1962.

Changes to this document will be accomplished either by reissue of the entire document or by transmitting one or more revision pages. Reissues (complete republication) will be identified by the word Reissue and a sequential letter of the alphabet, beginning with capital A, placed below the report number on each page. If changes are made by revision pages, each page will be identified by the abbreviation Rev and a sequential Arabic number, beginning with one, placed immediately below the report number. The revision number reflects the total number of revisions to the particular report issue, not necessarily the number of revisions to any particular page.

A new title page and Revision Summary Sheet will accompany each revision. Revision title pages will carry the revision date below the revision designation. Title pages for reissues will carry a new publication date and supersession statement.

Revision summary sheets should be retained as a permanent part of the particular document issue to serve as a record of all change action. Revision summary sheets replace previously issued sheets if they include all prior change information; otherwise they are handled as additional pages and numbered accordingly.

SECTION 1

SCOPE

²/~~2~~ This document establishes the design criteria for reconfiguration of the inter-station communications equipment of the Satellite Control Facility (SCF) under the Augmentation Program. The communication equipment to be furnished as a result of this design criteria shall be combined with existing inter-station communication equipment to provide the total capability delineated in Section 2.1. ²/~~2~~ END

The requirements for intra-station communications will be prepared by the integrating contractor for each station included in the Augmentation Program.

SECTION 2
GENERAL CONCEPT

In order to support a number of vehicles in orbit simultaneously, it is necessary to reconfigure and augment the present satellite control capability at the SCF ground stations and the Satellite Test Annex (STA). The basic tracking, commanding, and telemetry capability of five stations is to be augmented under this program, namely, Hawaii Tracking Station (HTS), New Hampshire Station (NHS), Fort Greely Station (FGS), Vandenberg Tracking Station (VTS), and Thule Tracking Station (TTS). The additional equipment furnished as part of the Augmentation Program will permit all but the FGS to support two low-altitude vehicles simultaneously and to support additional vehicles by switching. A new station is being implemented in Canada (CTS). In addition, all station configurations are being revised to provide standardization of operations and data flow throughout the network.

The inter-station communication links defined by this criteria shall terminate in a central location for connection to the intra-station communication facilities and terminal equipment.

2.1 SUBSYSTEM CAPABILITY

The Augmented Inter-Station Communication Subsystem shall be capable of providing the following:

- a. Simultaneous voice communications from two controllers at each of the augmented SCF ground stations to two controllers at the STA, and single voice channels to the other stations via STA.
- b. Efficient machine handling of data between each tracking station and the STA to support as many as two simultaneous passes at any one station.
- c. Supervisory and control message traffic for satellite support.

- d. Normal administrative traffic not specifically associated with satellite support (see Section 3.1.5).
- e. Auto synchronization check unit to permit rapid resynchronization of the KG-13 (see Figures 1 and 2).

2.2 SUBSYSTEM INTEGRATION

One of the objectives of the SCF Augmentation Program is to provide equipment which will become part of a well-integrated satellite control network. To achieve this objective, it is necessary that the communication equipment added to each station be integrated with the existing communication equipment to provide a highly flexible communication subsystem. All inter-station communication links shall terminate at each SCF station and at the STA in a central communication technical control facility as defined in Section 4.0. Maximum utilization of the communication facilities shall be provided by appropriate patching and switching equipment.

2.3 DATA HANDLING CAPABILITY

This section of the design criteria defines the mode for transmitting and handling tracking, telemetry, and command data. Additional information on the data handling subsystem is provided in the "Design Criteria for the Data Subsystem." All data transmission will be accomplished by duplex, secure, 1200 bit/second digital data links. The normal mode of operation with the STA will be direct transmission between computers and their associated magnetic tape units. The 100-WPM TTY lines will be limited to non-data, tracking and command traffic only. Flexibility of cross-connection between communication lines and terminal equipment of all types will be provided on a manual basis at the tracking stations. Automatic and/or manual switching will be provided at the STA.

SECTION 3
SUBSYSTEM LINK REQUIREMENTS

This section of the design criteria defines all links required between each SCF station and the STA.

3.1 LINK DESCRIPTIONS

3.1.1 1200 bit/sec Secure Full-Duplex Digital Data Link

This link is the primary communication link for tracking, telemetry, command schedule and status data.

3.1.2 Voice Link

This link will be used for voice communication between a controller at an SCF station and a controller at the STA.

3.1.3 1200 bit/sec Line, Full Duplex/Alternate Voice Link Capability

This link will normally be used for voice communication between one controller at a station and one controller at the STA. It can also be used for full encrypted data transmissions as a back-up.

3.1.4 100 WPM TTY, Full Duplex, Secured Link Capability

This link is for administrative traffic.

3.2 NUMBER OF LINKS REQUIRED

3.2.1 NHS To/From STA

The following links shall be provided between NHS and the STA:

- a. 2/1200 bit/sec full duplex, secured digital data links
- b. 1/1200 bit/sec full duplex, alternate voice link
- c. 1/1200 bit/sec full duplex, secured payload digital link
- d. 1 voice link
- e. 1/100 WPM TTY secure full duplex administrative link

3.2.2 VTS To/From STA

The following links shall be provided between VTS and the STA:

- a. 2/1200 bit/sec full duplex secured digital data links
- b. 1/1200 bit/sec full duplex secured payload digital link
- c. 1/1200 bit/sec full duplex alternate voice link
- d. 2 voice links
- e. 1/100 WPM TTY secured full duplex administrative link

3.2.3 FGS To/From STA

The following links shall be provided between the FGS and the STA:

- a. 2/1200 bit/sec full duplex secured digital data link
- b. 1/1200 bit/sec full duplex alternate voice link
- c. 1 voice link
- d. 1/100 WPM TTY secured full duplex administrative link

3.2.4 HTS To/From STA

The following links shall be provided between the HTS and the STA:

- a. 2/1200 bit/sec full duplex, secured digital data link
- b. 1/1200 bit/sec full duplex alternate voice link
- c. 1 voice link
- d. 1/100 WPM TTY full duplex secured administrative link

3.2.5 TTS To/From STA

The following links shall be provided between the TTS and the STA:

- a. 2/1200 bit/sec full duplex secured digital data link
- b. 1/1200 bit/sec full duplex alternate voice link
- c. 1 voice link
- d. 1/100 WPM TTY full duplex secured administrative link

3.2.6 KTS To/From STA

The following links shall be provided between the KTS and the STA:

- a. 1/100 WPM TTY full duplex alternate voice link
- b. 1/100 WPM TTY full duplex secured teletype link
- c. 1 voice link

3.2.7 ATS To/From STA

The following links shall be provided between the ATS and the STA:

- a. 1/1200 bit/sec full duplex secured digital data link
- b. 1/1200 bit/sec full duplex alternate voice link
- c. 1/100 WPM TTY full duplex secure administrative link

3.2.8 CTS To/From STA

The following links shall be provided between the CTS and the STA:

- a. 1/1200 bit/sec full duplex secured digital data link
- b. 1/1200 bit/sec full duplex alternate voice link
- c. 1/100 WPM TTY full duplex secure administrative link

SECTION 4

COMMUNICATION TECHNICAL CONTROL FACILITY

A Communication Technical Control Facility shall be provided at the STA and a communication terminal shall be provided at each of the tracking stations considered.

4.1 FUNCTIONS

This facility shall perform, but not be limited to, the following functions:

- a. Provide termination for all inter-station communication links including all necessary line balancing terminations.
- b. Provide patching facilities for connections to appropriate terminal equipment and for connections to the intra-station communication links.
- c. Provide switching capability for selection of the inter-station communication configuration necessary for a given orbital support plan.

4.2 TERMINAL EQUIPMENT

The terminal equipment for the inter-station communication subsystem at each of the SCF stations and at the STA is defined in the following subsections:

4.2.1 DATA LINKS

All data links to the STA shall be 1200 bit secure, duplex and shall terminate at the Technical Control Facility.

The following terminal equipment shall be provided for each link:

- a. Line Balance Equipment to insure proper termination.
- b. MODEM (Modulator-Demodulator) equipment to process data from the 1200 bit lines. The modem is a full duplex digital line transmitter and receiver that supplies its own internal timing.

It provides the proper interface logic between the 1200 digital bit line and the KG-13 equipments. The modem selected should be designed that it will continue to work well into noise and will hold the data in such a form that it is acceptable to the KG-13 without drop out for 5 hours, and an error rate of no more than 1 part in 10^6 .

- c. An Auto Check Device to resynchronize the KG-13 within 1-1/2 seconds.
- d. A Computer Communications Converter which will allow two CDC-160A computers to communicate over a full duplex channel. Parity bit generation is included in the CCC but it is not to be construed as a data error detection and correction device (error bit and detection is to be programmed into the computers which are sending and receiving data).
- e. A Communications Data Select and Cross-Connect Unit will upon manual or computer direction distribute data to the proper equipment (CDC-160A or other special devices).

Note: All equipments within the Technical Control Facility are designated as Red or Black. In Figure 1 everything up to the input of the KG-13 is considered Black (encrypted). All information from the output of the KG-13 through the CCC and through the CDSCCU including the 160A computers is considered Red (Unsecure).

4.2.2 Voice Links

All voice links to the STA and each tracking station shall terminate at the Communication Technical Control Facility. Appropriate patch panels and switching to any of the intra-station voice lines and the station switchboard shall be provided as specified in the intra-station communication plan for each station.

4.2.3 1200 bit/sec, Alternate Voice Links

The 1200 bit/sec data links shall terminate at the Communications Technical Control Facility. These high-speed data lines are to be utilized for the transfer of payload and telemetry data.

4.2.4 Teletype Links

All teletype links to the STA and each tracking station shall be 100 WPM duplex and terminate at the Communication Technical Control Facility. The following terminal equipment shall be provided for each teletype link:

- a. A full duplex teletype terminal including a typing reperforator.
- b. KW-26 terminal equipment for the links carrying encrypted information.
- c. Teletype network patching where more than one teletype circuit is required.

4.3 TRACKING STATION CONFIGURATION

All 1200 bit/sec lines are switched by the Select and Cross-Connect Unit which is part of the Data Subsystem. A typical configuration is shown in Figure 1.

4.4 STA CONFIGURATION

The capability for automatic switching of the incoming data lines at the STA will be provided. This will be done on a basis under computer control. The method for accomplishing this is described in more detail in the Data Subsystem Criteria. This method of switching incoming and outgoing lines will permit the utilization of the CDC-160A bird-buffer concept wherein the proper data lines are selected and connected to the proper CDC-160A computer complex. Figure 2 shows the communications terminal and automatically controlled cross-select unit to be implemented at the STA.

No diodes or transistors are to be used. Modular construction will be used throughout, with particular significance given to reliability and fail-safe construction. The individual switch elements will be of the plug-in type, and failure of a switch element will affect the operation of only the one piece of equipment attached through the switch.

The logic of the switch matrix will be under the control of a CDC-160A cross-select unit control computer, which generates the control words for the matrix logic circuitry. The CDC-160A computer will generate a new control word whenever a change in the configuration of the cross-select unit is required. A manual over-ride and a manual backup method of establishing the switch control words is also provided.

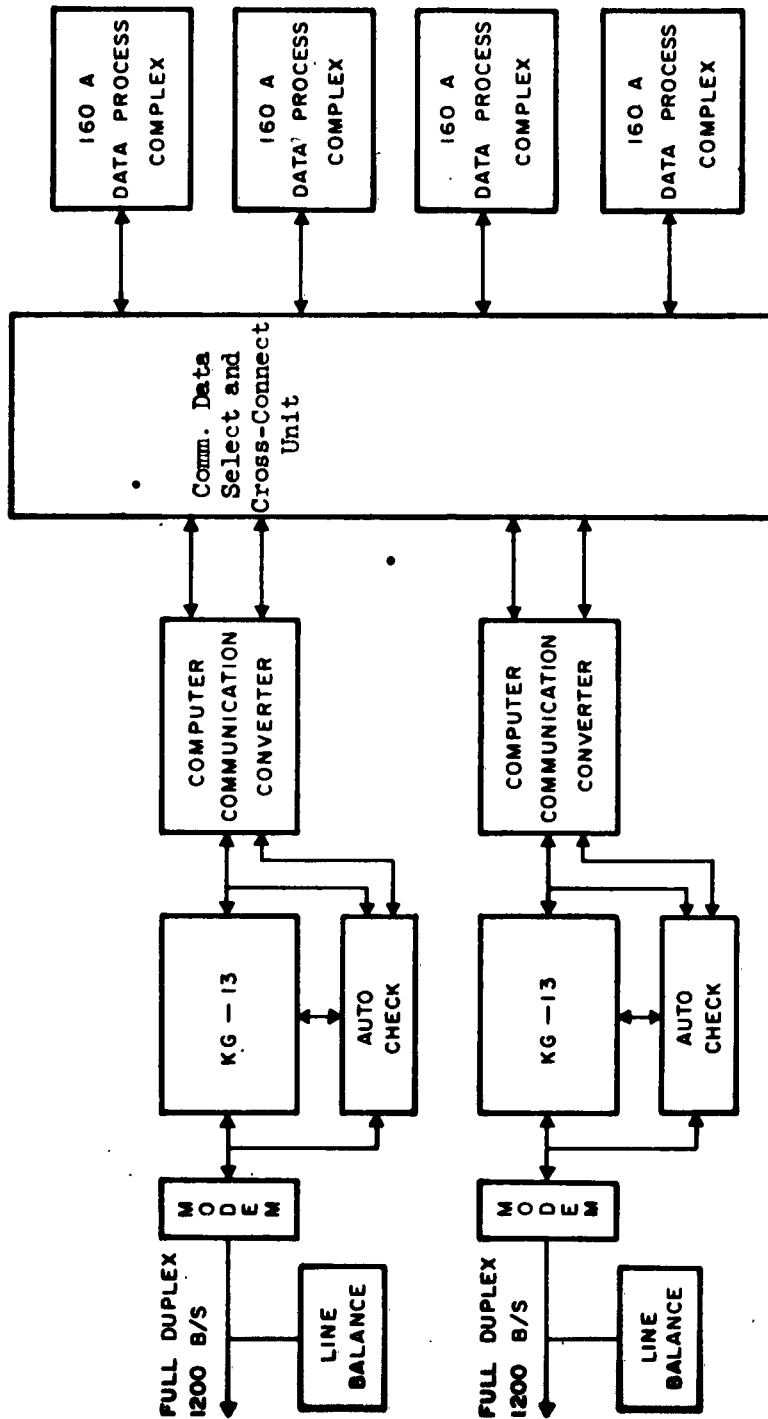


Figure 1. Typical Tracking Station Line Termination Complex

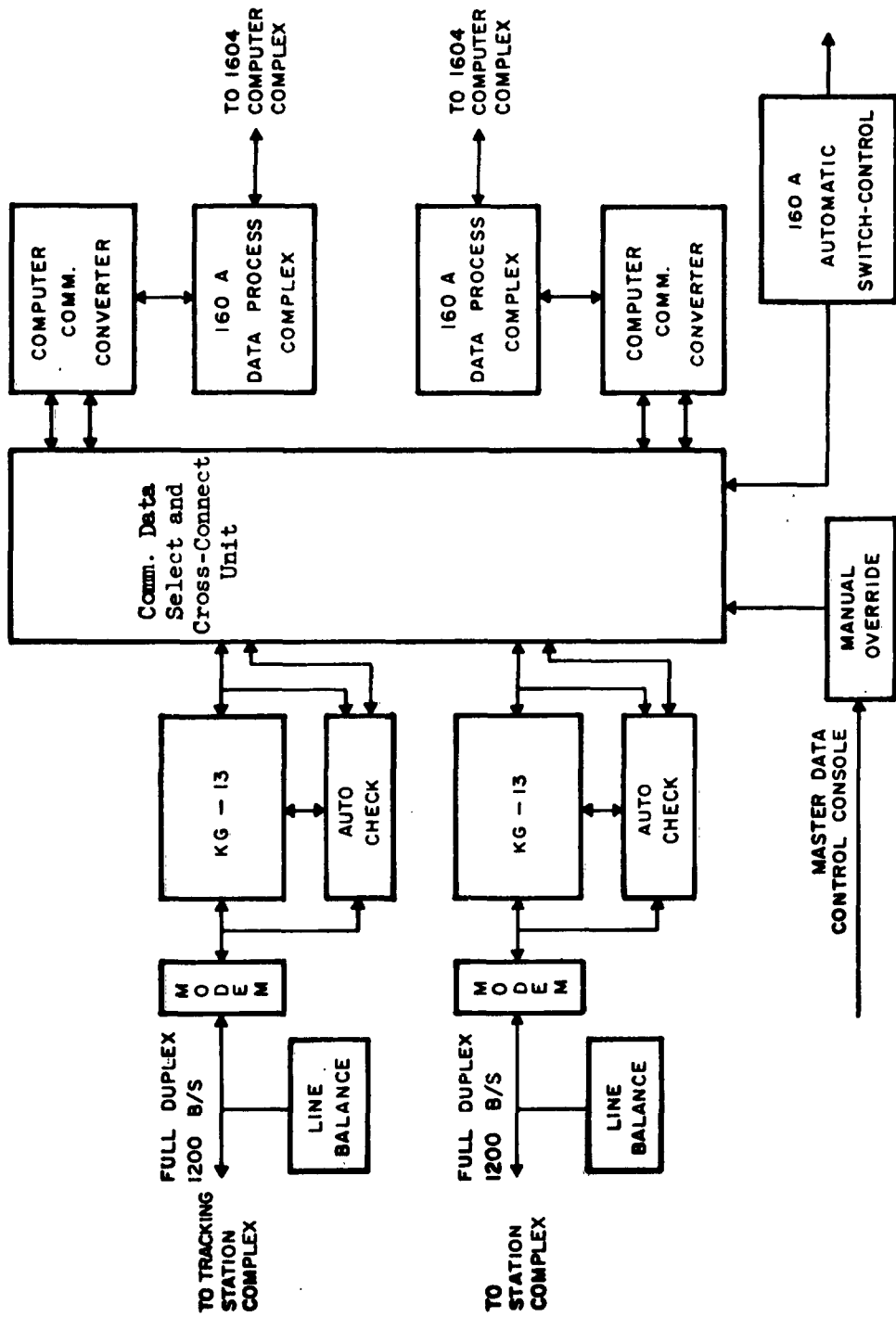


Figure 2.. Communications Terminal and Select and Cross-Connect Switch -- STA

SECTION 5

GENERAL DESIGN REQUIREMENTS

5.1 BASIC APPROACH

Although every detail of equipment performance is not necessarily described in this design criteria, the responsible contractor shall consider the intent of this document and shall produce an adequate subsystem. Maximum use shall be made wherever possible of general purpose commercial test equipment (signal generators, receivers, etc.) for subsystem checkout. Special purpose test equipment already commercially available shall be given preference for testing the S-band and telemetry tracking subsystems before a new checkout equipment design is initiated.

Insofar as feasible, equipment shall be designed to use materials which are not nutrients for fungus. If materials which are nutrients for fungus must be used, they shall be suitably protected. The contractor shall provide shelter and environmental control facilities compatible with the specified operation of the system elements.

5.2 DEFINITIONS

Because of the location of certain sites, extreme tropical conditions of heat and humidity will be encountered. Therefore, for purposes of such sites, the following definitions are given:

5.2.1 Ground Sheltered Equipment

"Ground Sheltered" indicates the various equipments, racks, and cables contained within a building proper and which are either supplied conditioned air or surrounded by conditioned air furnished by the air conditioning system.

5. 2. 2 Ground Unsheltered Equipment

"Unsheltered" applies to equipment that may be protected by a radome or other protective cover but not supplied complete conditioned air nor surrounded by such conditioned air.

5. 3 ENVIRONMENTAL

5. 3. 1 Ground Sheltered Equipment

Shelter shall be provided for equipment in inhabited portions of buildings so as to give protection from precipitation, wind, salt spray, direct solar radiation, or sediment. Equipment shall operate within specifications in temperatures from 10 to 30°C, at pressures from 610 to 775 mm Hg, and with relative humidity of from 10 to 98 percent but without condensation conditions.

Non-housed equipment, such as cables, shall be capable of operation within specification under temperature, moisture, salt spray, direct sunshine, wind, and other environmental conditions encountered in arctic or tropical regions.

5. 3. 2 Ground Unsheltered Equipment

The equipment shall operate satisfactorily when subjected to relative humidities ranging from 10 to 98 percent over a temperature range from -40 to +54°C, including the effects of condensation due to temperature change.

The equipment shall operate satisfactorily at any atmospheric pressure from 610 to 775 mm Hg.

5. 3. 3 Explosive Atmospheres

The electrical equipment, switches, lights, motors, and contacts--located in an explosive atmosphere shall be designed to minimize arcing or unsafe conditions.

5.4 RELIABILITY

Reliability of operation shall be considered of prime importance in the design and installation of this system. All possible means shall be employed to ensure quality and maximum reliability consistent with the state of the art. The contractor shall specify, in his Reliability Program Plan, the documents to be used as design goals.

5.4.1 Point Availability (A)

The point availability design goal is at least 0.998 as defined by the formula:

$$A = \frac{MTBF}{MTBE + MTR}$$

5.4.2 Mean-Time-Between-Failure (MTBF)

The reliability design goal is a MTBF of at least 500 hours. Failure is defined as the inability of the system to perform as required by this specification when the system is operated and adjusted in the manner specified herein.

5.4.3 Mean-Time-to-Repair (MTR)

MTR is defined as the arithmetic mean of the time intervals during which the system is not capable of performing its operational function because of failures.

SECTION 6

GENERAL CONTRACTUAL REQUIREMENTS

6.1 AGENCIES RESPONSIBLE

The contractor has primary responsibility for procurement and subsystem specifications and procedures. The Space Systems Division (SSD) of the Air Force Systems Command (AFSC), assisted by the Aerospace Corporation, shall exercise subsystem test monitoring and final approval authority over the subsystem and acceptance specifications except for that communications equipment to be provided GFE.

6.2 CONDUCT OF TESTS

Complete acceptance test of all subsystem components shall be conducted at the contractor's plant. This test shall be designed to verify all of the requirements of these criteria and include a complete system evaluation test. Exceptions to this statement must be individually justified by the contractor and must be approved by SSD/Aerospace representatives. The contractor shall design similar tests for the complete system to confirm that its overall performance, when integrated, is as required. Successful completion of subsystem and system acceptance tests shall be based on the acceptance team's evaluation of any failures that occur.

6.3 SUBMISSION OF DATA

In lieu of monitor tests during the acceptance test, test data may be submitted to the acceptance team upon prior approval of each submission. This approval will be implicit in approval of the acceptance test plan.

6.4 REJECTION AND RETEST

In the event of failure of a subsystem, or the complete system, to pass the acceptance test, acceptance of the subsystem shall be withheld until the extent, cost, and significance of the failure have been determined and acceptable remedial action taken. Appropriate portions of the acceptance test shall then

be rerun to show compliance with the test specification. Contractual implications of the failure of the contractor to meet specified performance requirements shall be the subject of separate negotiations.

6.5 TEST RECORDS

Complete records of acceptance test data and events shall be kept by the contractor and submitted to SSD/Aerospace after completion of the test. These records shall include a tabulation of repairs and adjustments made during the test.