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RELAY NETWORK FUNCTIONAL SPECIFICATION

PRELIMINARY DATA FOR PLANNING PURPOSES

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FUNCTIONAL SPECIFICATION

1.0 SCOPE

This functional specification of the Relay Network is to define the design requirements and to establish the minimum performance requirements that must be provided to achieve the overall mission objectives.

2.0 APPLICABLE DOCUMENTATION

2.1 System Interface Specification (To be supplied)

2.2 Titan IIIC System Specification (Launch Environment)

3.0 RELAY NETWORK REQUIREMENTS

3.1 Functional Description - Relay Network

The Relay Network shall consist of at least two Relay Satellites dedicated to provide nearly world-wide coverage and real-time relay of mission, telemetry, and command data between satellites and ground stations. The functional interfaces are shown in Figure 3.1.1 between the Relay Network and its associated system elements. The frequency plan described in Section 3.8 is based on

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3.1.1 Relay Satellite

Each Relay Satellite shall provide the necessary capability to transfer by frequency translation techniques all signals between the Mission Satellite and the Ground Station. The relay transfer function of each signal at carrier or subcarrier level shall be fully compatible with all system elements and shall introduce minimum performance degradation (1 db) relative to the specified signal-to-noise ratio at either the Ground Station or Mission Satellite terminals as stated in Reference 2.1.

3.1.1.1 Imaging Data Channel

The imaging data channel shall be directly frequency translated at carrier level.

3.1.1.2 Telemetry Data Channel

The operational telemetry data channel from the Mission Satellite shall be demodulated at carrier level for translation at subcarrier level. Frequency multiplexing techniques shall be utilized to combine the Relay Satellite's telemetry at baseband level for modulation at

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carrier level and transmission to the Ground Station.

3.1.1.3 Command Data Channel

The operational command data channel shall be time multiplexed utilizing appropriate addressing techniques to provide command data to both the Relay Satellite and the Mission Satellite. This channel shall be demodulated at carrier level and continuously translated at subcarrier baseband level for re-modulation and transmission to the Mission Satellite.

3.1.2 Mission Satellite

The Mission Satellite shall be in a near-polar orbit at 100 - 300 miles altitude. The configuration description and requirements are as specified in Reference 2.1.

3.1.3 Ground Terminals

Ground support will be provided as required by mission phases to achieve operational deployment of the Relay Network.

3.1.3.1 Launch

During the launch phase, each Relay Satellite's performance will be monitored via

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telemetry signals relayed through the launch vehicle to the Eastern Test Range (ETR) facilities. The launch vehicle will provide all necessary tracking, telemetry, and command signals compatible to ETR required to assure successful launch of the Relay Satellites.

3.1.3.2 Orbital

After orbit insertion and separation from the booster, the Relay Satellite will be supported as required by the Satellite Control Facility (SCF) to provide range and range rate tracking, telemetry, and command via [redacted] compatible equipment (Reference 2.3). This support by the SCF is world-wide and only for the initial deployment of the Relay Satellite to provide orbit determination, performance monitoring and redundancy switching prior to operational use.

3.1.3.3 Mission

During the mission operations by the Mission Satellite, the Relay Network shall relay all mission data, telemetry, and command

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data between [redacted] Mission Satellite [redacted] and the Ground Station. All normal SCF support of the Relay Network will be suspended during mission operations.

In support of the mission operations, the Ground Station shall perform range and range rate tracking of the Relay Satellite utilizing [redacted] equipment as required to up-date orbit emphemeris data. If necessary, the [redacted] links will serve as a backup to provide operational command and telemetry signals to the Relay Satellites from the Ground Station.

3.2 Physical Characteristics

3.2.1 Payload

The total payload capability of Titan IIIC launch vehicle is assumed to provide for the tandem launch of two Relay Satellites and dispenser from ETR into [redacted] orbits.

3.2.2 Dispenser

The dispenser shall consist of that equipment attached to the last booster stage and required to support the satellites during powered flight and to

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inject the[illegible]ence.

3.2.3 Shroud

The Relay Satellite shall be compatible with a standard Titan IIIC shroud subject to normal launch and separation environments (Reference 2.2).

3.3 Reliability

3.3.1 Relay Network

The probability of successful operation of all RF channels of the Relay Network shall be at least 0.97 after six months and greater than 0.70 after [redacted] in orbit, including eclipse operation.

3.3.2 Relay Satellite

The Relay Satellite may incorporate assembly and subsystem redundancy where necessary to attain the performance life requirements and to meet the above estimated reliability requirements. Any assembly or subsystem which, upon failure, can cause loss of a data channel shall be designed to have an estimated reliability of 97 percent or greater after [redacted] in orbit. If this estimated probability is less than 97 percent, some form of redundancy or alternate operational mode shall be incorporated into the Relay Satellite's design.

3.4 Coverage

The Relay Network shall be capable of relaying image,

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telemetry, and command data between the Mission Satellite and the Ground Station whenever the Mission Satellite is in view of a Relay Satellite. It is assumed that the Mission Satellite is in view whenever the line-of-sight vector is at least 60 n. miles above any point on the Earth's surface. The Relay Network shall consist of at least two identical Relay Satellites dedicated to provide continual real-time relay of mission, telemetry, and command data. For reference purposes only, it is assumed that the Network will provide real-time relay at least 98 percent of any 24-hour period throughout its operational lifetime.

3.4.) Orbital Parameters

All Relay Satellites shall be in circular orbit with a nominal inclination of [redacted] The ascending nodal longitudes of the Relay Satellites relative to the Earth's equatorial plane are 6.5 degrees West longitude (RS - East) and 147.5 degrees West longitude (RS - West) as shown in Figure 3.4.1. Each Relay Satellite shall provide for East-West station keeping over a ± one degrees of

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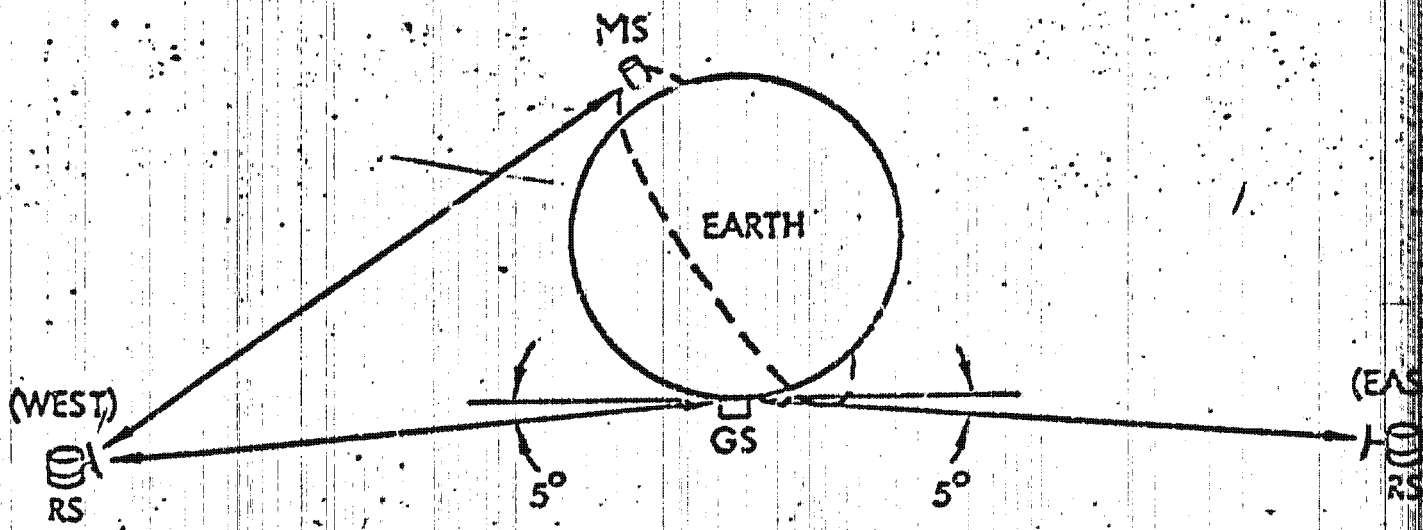

FIGURE 3.4-1: RELAY COVERAGE

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longitude to assure a minimum elevation angle of five degrees at the Ground Station's horizon.

3.4.2 Occultation

3.4.2.1 Solar

The Relay Network shall be capable of continuous performance throughout all solar occultation periods.

3.4.2.2 Mission Satellite

Prior to an occultation of an Mission Satellite with respect to anyone of the Relay Satellites, the Relay Network shall be capable of providing with a probability of success of at least 95 percent handover of relayed data in a period not in excess of three minutes. It is assumed that this handover period is based on the requirements that (a) the data meets minimum performance specifications and (b) each Relay Satellite must only search, acquire, and track a doppler shifted carrier within an angular volume due to the position uncertainty (1) of the Mission Satellite.

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In the event that relaying of data between a Relay Satellite and an Mission Satellite is terminated (e.g. occultation), the Relay Satellite shall be capable upon Ground Control of re-orienting the required antenna beams at an angular rate of at least one degree per second.

3.5 Operating Modes

3.5.1 Relay Network

The Relay Network shall be capable of providing direct relay via either Relay Satellite of mission telemetry, and command data between the Mission Satellite and the Ground Station as shown in Figure 3.5.1 by the active or alternate relay modes.

3.5.1 Relay Satellite

The Relay Satellite shall be capable of relaying any combination of the designated links received from either the Mission Satellite or the Ground Station. The Relay Satellite shall provide operating modes consistent with acquisition and tracking of all links during handover of the Mission Satellite as dictated by Ground Control.

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The Relay Satellite shall be capable by Ground Station command of continuous transmission of mission type data regardless of mission operations or status. The Relay Satellite shall be capable by Ground Station Command of operating in receive only mode and shall provide at least [redacted] of on-board storage of command sequences.

3.6 Signal Characteristics

3.6.1 Security

Encryption - All command and telemetry data transmitted between the Relay Satellite and Ground Station via RF links shall be encrypted.

Privacy - The system RF links shall be designed to minimize the probability that associated RF transmissions may be detected by unauthorized receivers. In addition, the RF links shall be designed such that unauthorized interception of the RF signals will yield a minimum of information relating to system operational and performance characteristics.

ECM Vulnerability - The system RF links shall be designed to minimize the probability of disruption of operations or corruption of mission data by externally generated RF transmissions.

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3.6.2 Signal Levels

With the exception of the immediate area surrounding the location of the Ground Station, the total RF flux density due to inter-satellite signals shall not exceed -130 dBW/meter^2 at any point on the Earth's surface regardless of angle of arrival or transmission bandwidths.

3.7 Environment

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WATER

AIRCRAFT

SPACE

3.8 Interface Definition

The Relay Satellite has two major interfaces with the Ground Station and Mission Satellite. These interfaces are described in the following sections.

3.8.1 Mission Satellite - Relay Satellite

3.8.1.1 Frequency Plan

To Be Supplied

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3.8.1.2 Information

The information exchange between the Relay Satellite and Mission Satellite shall be provided as follows:

a) Mission data at a rate to be determined between

b) Telemetry data from the Mission Satellite to the Relay Satellite at a bit rate of

c) Command information from the Relay Satellite to the Mission Satellite at a bit rate of

3.8.1.3 Modulation

To Be Defined

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3.8.1.4 Performance Modes

The Relay Satellite shall have two performance modes:

a) Acquisition Mode - This mode shall be initiated by command from the Ground Station. On command, the Relay Satellite shall continuously transmit to the Mission Satellite a signal until commanded to terminate transmission. Concurrently, the Relay Satellite shall continuously receive a transmission from the Mission Satellite until this transmission is terminated.

b) Data Mode - The Mission Satellite shall transmit to the Relay Satellite a data signal in accordance with the mission activity schedule.

3.8.1.5 Performance

The Relay Satellite to Mission Satellite interface shall be characterized by the overall input/output signal performance required to provide a given quality of information at either the Mission Satellite or Ground Station. The following performance specification shall apply:

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Equivalent Isotropic Radiated Power (EIRP)

The total EIRP of the Relay Satellite for the command data channel shall be at least [redacted] as measured within a half-power beam width of not less than 0.5 degrees.

Receive Antenna Gain to Noise Temperature ($G/_T$)

The receive G/T of the Relay Satellite in the direction of the Mission Satellite, evaluated at any frequency within the designated bandwidth and anywhere within the receiver antenna beam width, shall be at least [redacted] This value of G/T is that referred to the interface between the receive antenna and the pre-amplifier. The noise temperature involved in this ratio is the total system noise temperature referred to the pre-amplifier's input which includes the noise received by the antenna when properly oriented in orbit, the noise of the receiver's pre-amplifier and the noise of all subsequent elements in the receiver channel.

Performance Margin

The performance margin of the command data link from the Relay Satellite to the Mission Satellite

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shall be at least 3 dB as an allowance for worst-case tolerances of the link parameters. The performance margin of the mission and telemetry data channels from the Mission Satellite to the Relay Satellite shall be at least [redacted] This value is based on an allowance of [redacted] for minimum performance degradation at carrier level and 3 dB for worst case tolerances of the link parameters.

3.8.2 Relay Satellite - Ground Station

3.8.2.1 Frequency Plan

To Be Supplied

3.8.2.2 Information Characteristics

To Be Supplied

3.8.2.3 Modulation Characteristics

To Be Supplied

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3.8.2.4 Performance Modes

To Be Supplied

3.8.2.5 Performance

The performance requirements for the Relay Satellite to Ground Station interface shall be characterized by the overall input/output signal performance necessary to assure a specified quality of information at either terminal. The following performance specifications shall apply:

Equivalent Isotropic Radiated Power (EIRP)

The total EIRO of the Relay Satellite for both the mission and telemetry data channels, shall be at least [redacted] as measured within half-power beam width of not less than 0.5 degrees.

Receive Antenna Gain to Noise Temperature (G/T)

The receive G/T of the Relay Satellite in the direction of the Ground Station, evaluated at any frequency within the designated bandwidth and

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