501-215/STARLink

MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE

Detailed Mission Requirement (DMR) Document for the Satellite Telemetry and Return Link (STARLink)

July 1995

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

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9. AUTHORITY (REFERENCES)

10. REMARKS

PROJECT CENTER(S)		LEAD CENTER	
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		11. PREPARED BY: Gia Tran - ATAC Mission Operations Engineer High Altitude Mission Code OPH NASA, Ames Research Center	14. REVIEWED BY: Mark E. Ambrose Mission Support Manager Code 501 Goddard Space Flight Center	
		12. APPROVED BY: Andrew Roberts Mission Project Manager High Altitude Mission Code OPH NASA, Ames Research Center	15. APPROVED BY: Carroll G. Dudley Acting Director of Mission Operation and Data Systems Code 500 Goddard Space Flight Center	
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Page	Revision	Page	Revision	Page	Revision	Page	Revision

1. PAGE TITLE: Change Approval				2. REPLACES	3. PAGE NO: 1032
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			13. APPROVED BY: Andrew Roberts Mission Project Manager High Altitude Mission Code OPH NASA, Ames Research Center	16. APPROVED BY: Carroll G. Dudley Acting Director of Mission Operation and Data Systems Code 500 Goddard Space Flight Center	
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Revision	Page No.	Ch. No.	Revision	Page No.	Ch. No.	Revision	Page No.	Ch. No.

1. PAGE TITLE: Contents and Document Outline		2. REPLACES	3. PAGE NO: 1040
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9. Page No.	10. Used	11. Title
1010	X	Approval Authority
1030	X	Revision Approval
1031	X	Revision Control
1032	X	Change Approval
1033	X	Change Control
1040	X	Contents and Document Outline
1061	X	Special Abbreviations and Nomenclature
1064	X	Responsibilities for Management, Project and Operations
1065	X	Technical References
1066		Aerospace Data System Standards
1100	X	Project Description
1110	X	Experiment(s) Description
1120	X	Mission Operations Concept
1140	X	Planned Mission Milestones
1310	X	Launch Vehicle Description - General
1311		Launch Vehicle Characteristics
1312	X	Launch Vehicle Drawing
1320	X	Spacecraft/Payload Description
1322	X	Spacecraft/Payload Drawing
1405	X	Frequency Utilization Summary
1410		Launch Vehicle Metric Tracking Systems - Operating Description
1411		Launch Vehicle Metric Tracking Systems - Transponder/Beacon Telecommunications System Parameters
1420	X	Spacecraft/Payload Telemetry Systems Description
1421		Spacecraft/Payload Telecommunications System Parameters - Telemetry
1430		Spacecraft/Payload Command Systems Description
1431		Spacecraft/Payload Telecommunications System Parameters - Command
1710		Launch Vehicle Major Mission Events
1711		Launch Vehicle Flight Sequence - Mark Events
1715		Spacecraft/Payload Major Mission Events
1720		Launch Vehicle Trajectory Data
1725	X	Spacecraft/Payload Orbital Parameters

1. PAGE TITLE: Contents and Document Outline		2. REPLACES	3. PAGE NO: 1040.1
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Page No.	10. Used	11. Title
2000	X	Radio Frequency (RF) Telecommunications Requirements
2005		RF Telecommunications - Summary Tables
2020		RF Telecommunications - Telemetry Frame Structure
2030		RF Telecommunications - Command Word Structure
2100	X	Space Network (SN) Requirements - Summary
2110		SN - Tracking Requirements
2120	X	SN - Return Link Requirements
2130	X	SN - Forward Link Requirements
2200		Deep Space Network (DSN) Requirements - Summary
2210		DSN - Radiometric Requirements
2215		DSN - Radio Science Requirements
2220		DSN - Downlink Requirements
2230		DSN - Uplink Requirements
2240		DSN - Multimission Navigation Requirements
2250		DSN - Monitor and Control Requirements
2300		Ground Network (GN) Requirements - Summary
2310		GN - Metric Tracking Requirements
2320		GN - Downlink Requirements
2330		GN - Uplink Requirements
2400		Wallops Flight Facility (WFF) Requirements - Summary
2410		WFF - Metric Tracking Requirements
2420		WFF - Downlink Requirements
2430		WFF - Uplink Requirements
2500		Interagency Requirements - Summary
2510		Interagency Metric Tracking Requirements
2520		Interagency Downlink Requirements
2530		Interagency Uplink Requirements
2600		International Networks Requirements - Summary
2610		International Networks - Metric Tracking Requirements
2615		International Networks - Radio Science Requirements
2620		International Networks - Downlink Requirements
2630		International Networks - Uplink Requirements
2700		Additional RF Telecommunications Requirements

1. PAGE TITLE: Contents and Document Outline		2. REPLACES	3. PAGE NO: 1040.2
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Page No.	10. Used	11. Title
3000	X	Testing and Training Requirements - Summary
3100	X	Compatibility Testing
3200	X	Networks Readiness Testing
3300	X	Mission Readiness Testing
3400	X	Simulators and Test Tools
3500	X	Training
4000	X	Mission Operations Center Requirements - Summary
4100	X	Mission Operations Systems Requirements
4200		Flight Software Maintenance Requirements
4300		Facilities Requirements
4400		Mission Operations Support Requirements
5000	X	Ground Communications and Data Transport Requirements - Summary
5100	X	Ground-to-Ground Data Transport Requirements
5200		Additional Ground Communications
6000		Data Processing Requirements - Summary
6100		Real-time Data Processing Requirements
6200		Non-Real-time Data Processing Requirements
6300		Data Archive/Storage Requirements
6400		Additional OSC-provided Data Processing
7000	X	Trajectory and Attitude Support Requirements - Summary
7100		Attitude Determination and Control Requirements
7200		Trajectory Requirements
7300		Attached Payload Requirements
Appendix A	X	Mission Requirements Request (MRR)
Appendix B		Lead Center Exceptions

9. Description

Term	Definition
AMA	Airborne Modem Assembly
ARC	Ames Research Center
bps	bits per second
CLS	Cloud Lidar System
DCF	Data Capture Facility
DDF	Data Distribution Facility
DG	Data Group
DSN	Deep Space Network
ENG	Engineering
ETE	End-to-End
FDF	Flight Dynamics Facility
ER-2	Earth Resources Aircraft
FEC	Forward Error Correction
FEMA	Federal Emergency Management Agency
GCMR	Ground Control Message Request
GSFC	Goddard Space Flight Center
HGA	high gain antenna
HQ	headquarters

9. Description (con't)

Term	Definition
HRBS	High Rate Bit Sync
HVPS	High Voltage Power supply
IIRV	Improved Inter-Range Vector
JPL	Jet Propulsion Laboratory
kbps	kilobits per second
km	kilometer
LGA	low gain antenna
MA	multiple access
MAS	Modis Airborne Simulator
Mbps	Megabits per second
MO&DSD	Mission Operations and Data Systems Directorate
MOM	Mission Operations Manager
MOSP	Mission Operations Support Plan
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications Network
NCC	Network Control Center
PA	Power Amplifier
POCC	Payload/Project Operations Control Center

9. Description (con't)

Term	Definition
PSK	Phase Shift Keying
PUE	Project Unique Equipment
RAMS	Radiation Measurement System
RF	radio frequency
RFA	radio frequency Assembly
RHCP	Right Hand Circularity Polarized
R/T	real-time
SASS	STARLink Airborne Sub-System
SN	Space Network
SSA	S-band single access
STARLink	Satellite Telemetry and Return Link
STATmux	Statistical Multiplexer
STGT	Second TDRSS Ground Terminal
S/W	software
TBD	to be determined
TBS	to be supplied
TCXO	Temperature Compensated Crystal Oscillator
TDM	tracking data message

9. Description (con't)

Term	Definition
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TLM	telemetry
TRK	Tracking
UUE	User Unique Equipment
WFF	Wallops Flight Facility
WSC	White Sands Complex
WSGT	White Sands Ground Terminal

1. PAGE TITLE: Responsibilities for Management, Project and Operations		2. REPLACES	3. PAGE NO: 1064
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Organization/Title	10. Responsibilities
Program Office	The Associate Administrator for Space Science and Applications, NASA Headquarters, is responsible for the overall direction, management and evaluation of the STARLink Program.
Project Center	NASA Ames Research Center High Attitude Mission Branch (Code JOH) is responsible for overall project management.
Project Manager	Andrew Roberts - ARC Code JOH is the Project Manager and is responsible for ensuring the performance of all functions necessary for the management of the project.
Mission Project Engineer	Gia Tran - ARC/ATAC is the Mission Project Engineer and is responsible for ARC ER-2 Telemetry, ARC ground station and POCC/NCC communication.
Mission Support Manager	Mark Ambrose - GSFC Code 501.0 is responsible for coordinating and committing all necessary resources to support the mission(s).

1. PAGE TITLE: Aerospace Data System Standards		2. REPLACES	3. PAGE NO: 1066
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Applicable Aerospace Data System Standards

Standard	System/Compliance	Deviations	Waivers/Remarks
1. X-560-63-2 (GSFC)	Yes		

1. PAGE TITLE: Project Description		2. REPLACES	3. PAGE NO: 1100
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5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

Satellite Telemetry and Return Link (STARLink) is a real-time airborne science and disaster assessment system on board the Lockheed ER-2. One of its main mission objectives is to provide real-time/near real-time digitized image, voice and video data for scientists and engineers via the TDRSS. This system will lower the number of scientists and technicians in the field by allowing the engineering and science teams at home the ability to support, control, adjust or repair their instruments in flight. The audio link will allow the chief scientist, through the mobile pilot, to redirect the mission once airborne or support the flying pilot in an emergency. Its other mission objective is to provide near real-time data processing of image data for primary disaster coordinators. For example, STARLink would give the fire chief near real-time Infrared image data to determine the hot spots. The same is true when supporting earthquake, hurricane and flood assessment information for FEMA.

9. Description

9.1 Payload

9.1.1 The ER-2 can carry numerous instruments on a single flight to altitudes above 65,000 feet and outside 95% of the Earth's atmosphere. A maximum of 2600 lbs. can be distributed between the equipment bay, the nose area , and the wing pods. The following are typical instruments aboard the ER-2.

9.1.2 Cloud Lidar System (CLS)

The Cloud Lidar System is flown on the ER-2 to conduct cloud radiation and severe storm field experiments. Designed to operate at high altitudes in order to obtain measurements above the highest clouds, the instrument provides the true height of cloud boundaries and the density structure of less dense clouds. The height structure of cirrus, cloud top density and multiple cloud layers may also be profiled. System specifications are as follows:

Transmitter

Laser Type:	Nd:YAG I,II
Wavelength:	1064, 532 nm
Pulse Energy:	90, 30 mJ
PRF:	10 Hz
Beamwidth:	1 mrad
Data Acquisition:	Measurements at 20m intervals at 200 m/sec aircraft speed

Receiver:

Diameter:	0.15 m
Beamwidth:	1.4 mrad
Polarization:	v & h

Data System:

Range Resolution:	7.5 m
Number of Channels:	4
Samples per Channel:	3310

9.1.3 Radiation Measurement System (RAMS)

The Radiation Measurement System (RAMS) is an integrated system of several radiometers. The system provides airborne measurements to support analysis and theoretical calculations of cloud properties and radiation fields and to provide validation of satellite radiance measurements. The airborne instruments consist of the following:

1). An electrically calibrated pyroelectric radiometer for hemispherical, broad spectral bandpass, radiative flux measurements in the solar spectral region (0.26 to 2.6 µm). This radiometer has two detectors. One is located on the upper Q-bay hatch and the down looking instrument is located on the lower E-bay hatch.

2). An IR net flux radiometer (rotating) radiometer covering the spectral range from 5 to 40 µm. This radiometer is mounted on the S20 location on the right wing.

3). A narrow field-of-view, narrow spectral bandpass IR radiometer (2 channels in the 5 to 40 µm region). This radiometer uses a liquid nitrogen cooled black body reference. This instrument provides upwelling infrared intensities above cloud. It is mounted on the lower Q-bay hatch.

4). A total-direct-diffuse multichannel narrow spectral bandpass (about 5 to 10 nm) flux radiometer. This radiometer is used for optical depth determinations and direct/diffuse ratios. The up-looking detector is mounted on the upper Q-bay hatch and the down-looking detector is located on the lower E-bay hatch.

The data system and radiometer electronics are located on the upper Q-bay rack.

9.14 Modis Airborne Simulator (MAS)

The Modis Airborne Simulator is a modified Daedalus multispectral scanner. It records up to twelve 8-bit channels, which can be selected from an array of 50 available spectral bands. The band selection is made prior to flight and the instrument is hard-wired to that configuration. Channel one is used to store additional bits which provide 10-bit resolution for channels 9 through 12. The following MAS band combination (configuration SCARP1) was used on this flight for Smoke, Cloud and Radiation (SCAR) experiments:

Data System Channel	MAS Channel	Band edges µm
1	---	--------
2	1	0.529 - 0.572
3	2	0.635 - 0.688
4	7	0.852 - 0.893
5	9	0.926 - 0.969
6	15	1.855 - 1.905
7	20	2.126- 2.173
8	31	3.659 - 3.810
9*	42	8.342 - 8.738
10*	45	10.791 - 11.239
11*	48	13.023 - 13.375
12*	46	11.799 - 12.246

* 10-bit resolution

Sensor/Aircraft Parameters:

Spectral Channels:	50
Output Channels:	7 8-bit and 4 10-bit
IFOV:	2.5 mrad
Ground Resolution:	163 feet (50 meters at 65,000 feet)
Total Scan Angle:	85.92^{o}
Pixels/Scan Line:	716
Scan Rate:	6.25 scans/second
Ground Speed:	400 kts (206 m/second)
Roll Correction:	Plus or minus 3.5 degrees (approx.)

9. Description:

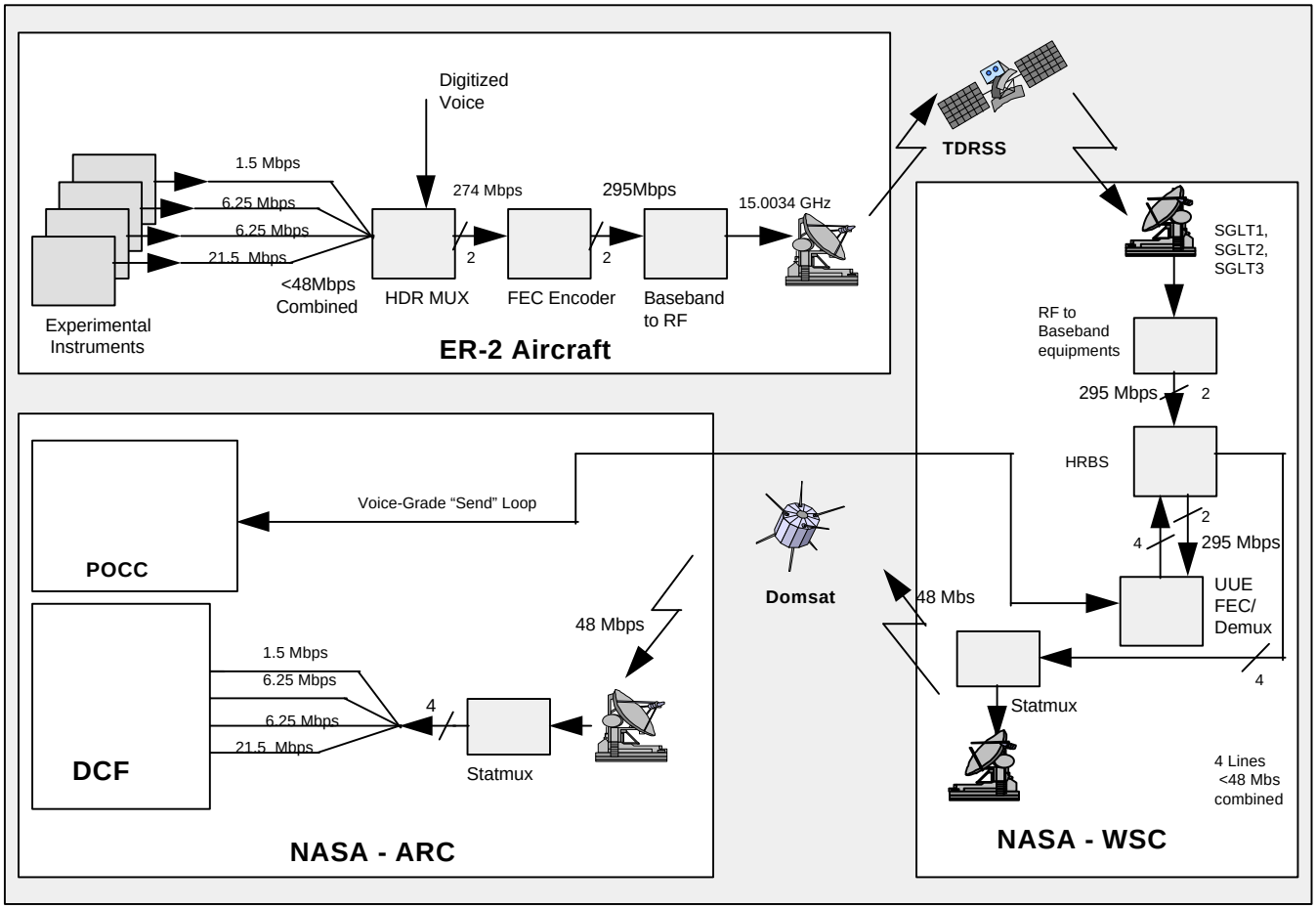
9.1 STARLink operates from various locations around the globe. A typical non-emergency mission with a duration of one (1) to two (2) weeks will be scheduled according to standard NCC scheduling and operation guidelines. During this period, the aircraft will operate an average of 8-10 hours a day. The TDRSS KSA forward and return link will be required during these time intervals. However, there will be emergency missions such as nature disaster assessment that will need TDRSS links with minimum advance scheduling. Such missions may require as little as four (4) hours advance notice and scheduling. STARLink will have an average of ten (10) to twenty (20) missions per year including emergency missions.

9.2 The STARLink telemetry system consists of 295 Mbps return and 400 kbps forward link using KSA services. The return data link is limited by the ground to ground (STATmux) communication between WSC and ARC. Thus, effective return data link will have an upper limit of 48 Mbps data throughput.

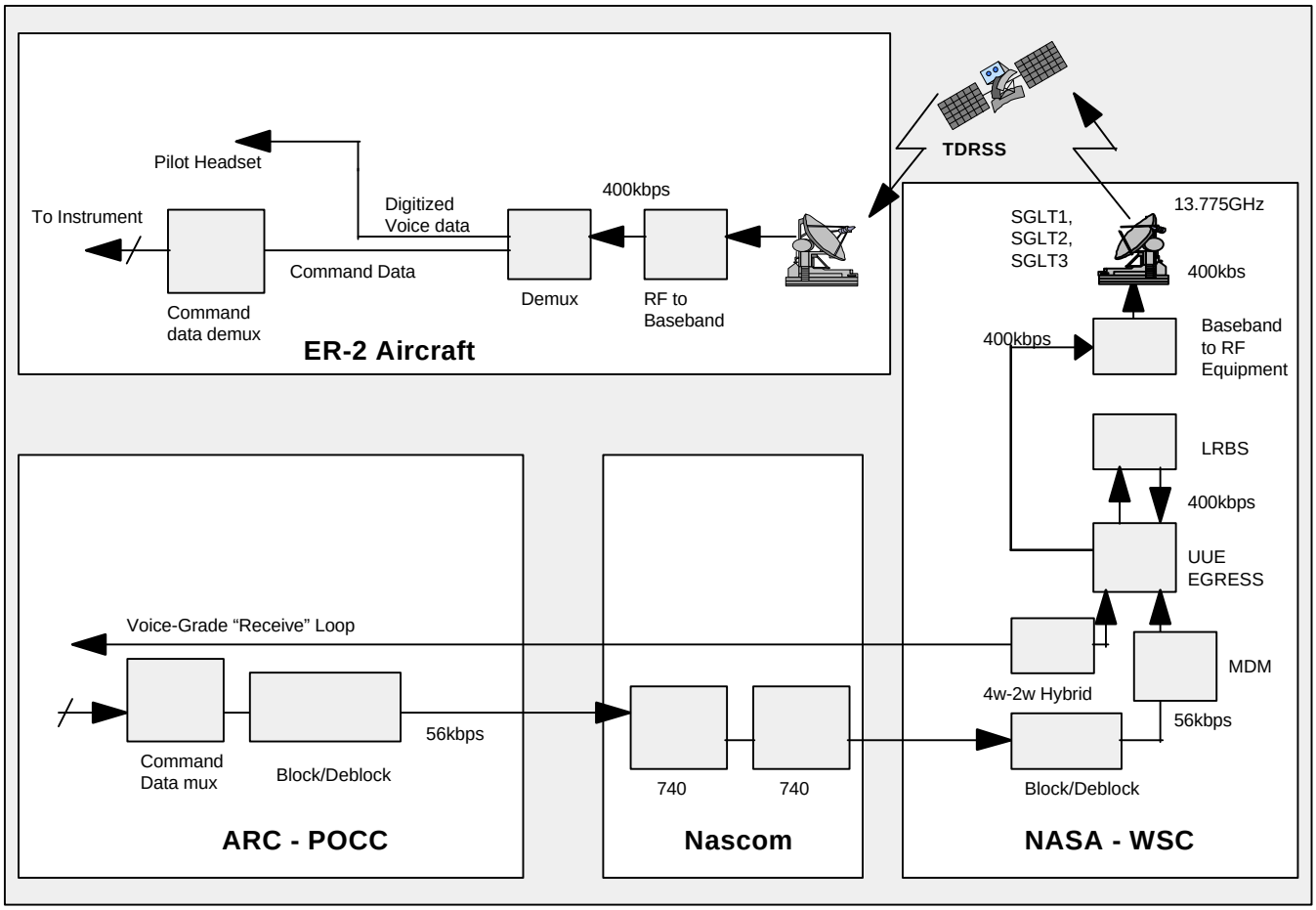
9.3 The STARLink return data consists of two (2) to four (4) bit streams with a composite data rate less than 48 Mbps. See figure on page 1120.1 for return link detail.

9.4 The STARLink forward data consists of one (1) 56 kps bit stream and one (1) two-pair voice-grade line. See figure 1120.2 for forward link detail.

9.5 Return link diagram



9.6 Forward link diagram



1. PAGE TITLE: Planned Mission Milestones		2. REPLACES	3. PAGE NO: 1140
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

	MILESTONES	CY 1994				CY 1995				CY 1996				CY 1997				CY 1998		
		1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q
1	Submit DMR			X																
2	Procure POCC to NCC Command Equipment and Data Link.					X														
3	Unisys to WSC Link Test					X														
4	WSC to POCC STATmux Test					X														
5	End-to-End Test						X													
6	First Flight Mission							X												
7																				
8																				
9																				
10																				

9. Description.

The ER-2 was developed for the National Aeronautics and Space Administration (NASA), to serve as a high altitude scientific research platform. Powered by a single jet engine, the single seat ER-2 carries a single pilot and up to 2600 pounds of payload to altitudes approaching 70,000 feet. The ER-2 has been utilized to conduct scientific studies of stratospheric and tropospheric chemistry, geographic mapping, disaster assessment, and preliminary testing of space payload concepts. Typical ER-2 missions last six and one half hours and cover a range of 2200 nautical miles. It is possible to accomplish missions of up to ten hours duration covering approximately 3000 nautical miles.

Payload area:

A maximum of 2600 pounds can be distributed between the equipment bay, the nose area, and the wing superpods. Page 1312 shows the primary payload areas available on the ER-2.

The primary payload compartment on the ER-2 is the equipment bay. Also known as the Q-bay, this compartment provides 64.6 cubic feet of volume and features removable upper and lower hatches. The upper and lower Q-bay hatches can be interchanged and configured to accommodate a wide variety of specialized sensors. The payloads are installed on a rack assembly which is hoisted into the Q-bay through the lower hatch opening and attached at structural mounting points.

Attached to the ER-2 fuselage via four quick release latches, the nose area provides a payload volume of 47.8 cubit feet. The 101 inch long nose compartment accepts payloads of up to 650 pounds on custom built racks. The wing superpods provide approximately 86 cubic feet of payload capacity. Each superpod may accommodate payloads up to a maximum weight of 650 pounds. The superpods consist of five individual segments. These are: nose cone, forward pod, mid-body, aft pod, and tail cone. Normal separation points via latches are at the forward and aft ends of the superpod midbody.

1. PAGE TITLE: Launch Vehicle Characteristics		2. REPLACES	3. PAGE NO: 1312
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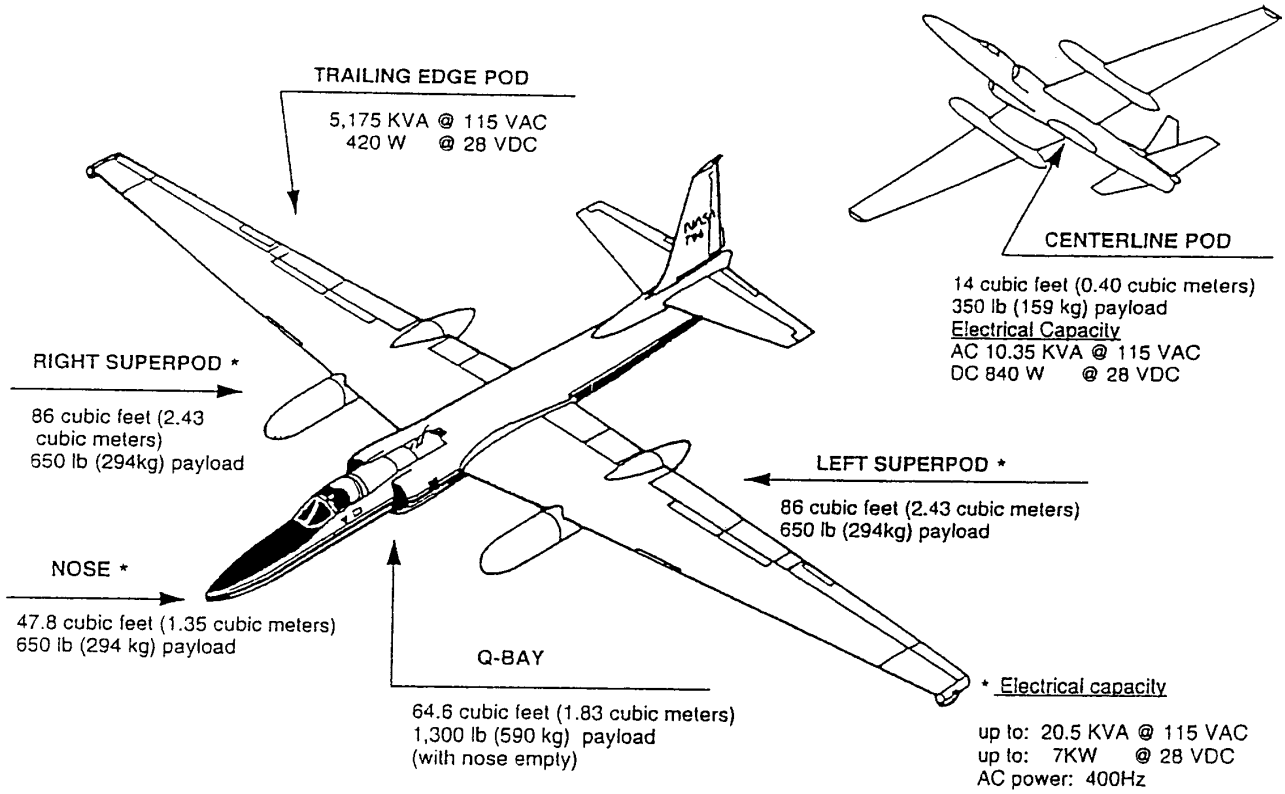
9. Drawing.



1. PAGE TITLE: Spacecraft/Payload Description		2. REPLACES	3. PAGE NO: 1320
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

The STARLink Communications System includes a STARLink Airborne Sub-System (SASS) data link which will communicate to a TDRSS. The SASS data link equipment includes an airborne modem assembly (AMA), RF assembly (RFA), a high voltage power amplifier assembly (HPA), a high voltage power supply (HVPS), and a high gain antenna assembly (HGA). The SASS data link equipment components will be inside a pylon mount on the ER-2 as shown on page 1322.

1. PAGE TITLE: Spacecraft/Payload Drawing		2. REPLACES	3. PAGE NO: 1322
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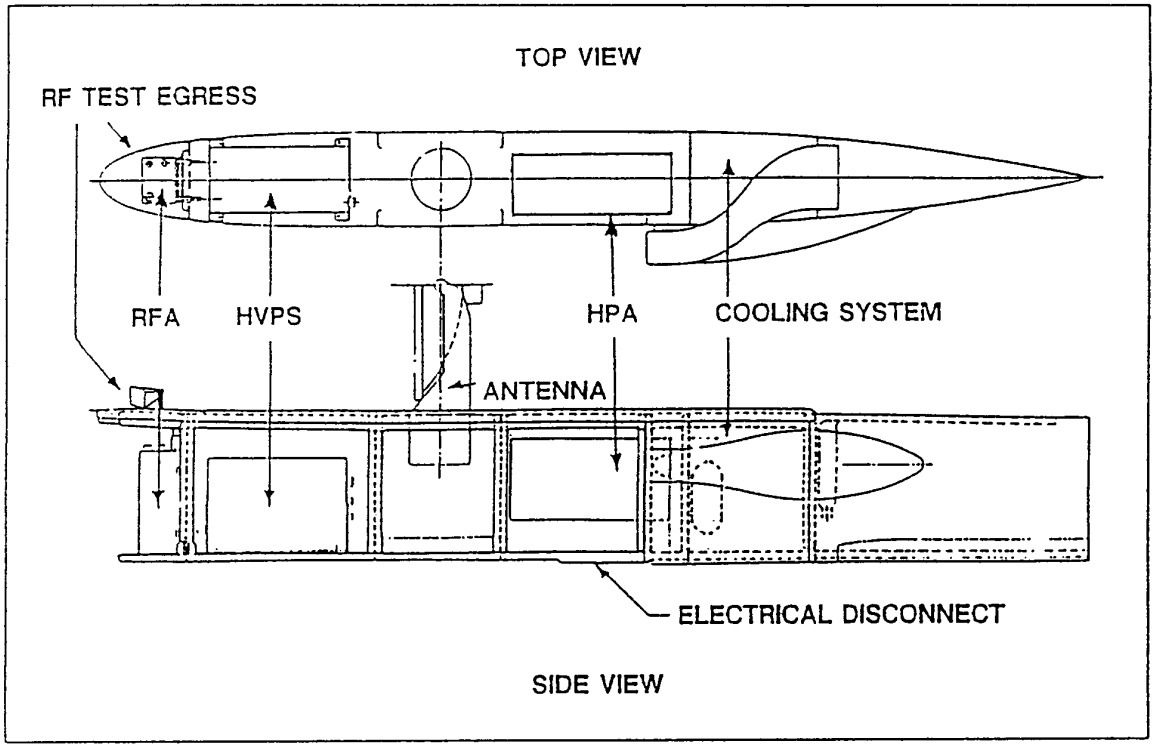
9. Drawing



PYLON EQUIPMENT CONFIGURATION

1. PAGE TITLE: Frequency Utilization Summary		2. REPLACES	3. PAGE NO: 1405
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

The STARLink will use the TDRS KSA service for both Forward Link and Return Link. The Return Link will be in TDRS Data Group-2 (DG-2). The Return Link consists of I and Q channel with FEC bandwidth 147.456 Mbps each. The combined available bandwidth is 294.912 Mbps with FEC. The Forward Link will transmit 400 Kbps on the I-channel. The Forward Link consists of I channel with FEC bandwidth 400 Kbps.

The TDRSS S-band Single Access (SSA) and Multiple Access (MA) service will not be used.

9. Description

STARLink will use a K-band transmitter and Receiver.

a. Receiver:

(1) Carrier acquisition threshold into diplexer: 32.4 db-Hz.

(2) Carrier acquisition rang e: +/- 71 KHz (from actual transponder center frequency).

(3) Carrier tracking ranger: +/- 120 KHz (about the assigned center frequency).

b. Transmitter:

(1) Frequency determining source: Internal Temperature Compensated Crystal Oscillator (TCXO) with stability of +/- 5.1 KHz in noncoherent (DG2) mode.

(2) RF Power: 400 watts (from internal Power Amplifier (PA) less 2.88 dB passive loss in HGA path)

(3) Science channels: I-channel, Q-channel.

(4) I/Q power ratio: 1: 1 +/-0.4 dB

c. Antenna:

(1) Number, type: 1 (HGA).

(2) Beam, Beam width: 2 degrees.

(3) Polarization: LHCP or RHCP (selectable)

(4) Transmit Gain: 37.8 dB.

(5) Receive Gain: 36.6 dB.

9. Description

A Typical ER-2 mission begins with a short ground roll followed by a very high rate of climb at a high climb angle. Depending upon takeoff gross weight and planned mission endurance, the aircraft will reach the intermediate cruise altitude of 60,000 feet within thirty to forty-five minutes of launch. At this point the cruise climb is initiated. While holding Mach number and engine exhaust temperature constant, the aircraft will steadily climb as fuel is burned off. The cruise climb is terminated at approximately 70,000 feet. The descent is generally initiated 1/2 hour prior to landing. Page 1725.1 shows a typical mission profile for a six and one half hour mission.

Stability Augmentation

The automatic flight control system on the ER-2 provides stability augmentation in the yaw, pitch and roll axes. The automatic flight control system also incorporates autopilot functions that include Mach hold and automatic navigation via the inertial navigation system.

Attitude Control

Axis	Rate (millirad/sec)		Period (s)	
	W/ Autopilot	W/O Autopilot	Range	Average
Pitch	2.5	3 - 7	4 - 6	5
Roll	2.5	3 - 7	2 - 5	4 - 5
Yaw	1.7	1.5 -7	2 - 5	3 - 5

Speed/Altitude Stability

The cruise Mach number of 0.75 is maintained to within a very close tolerance. The ER-2 flight control system is unique in that it operates on a constant Mach number while at high altitude. The altitude deviation can be as much as 150 to 200 feet. In general, the true air speed of the ER-2 is 410 +15kts.

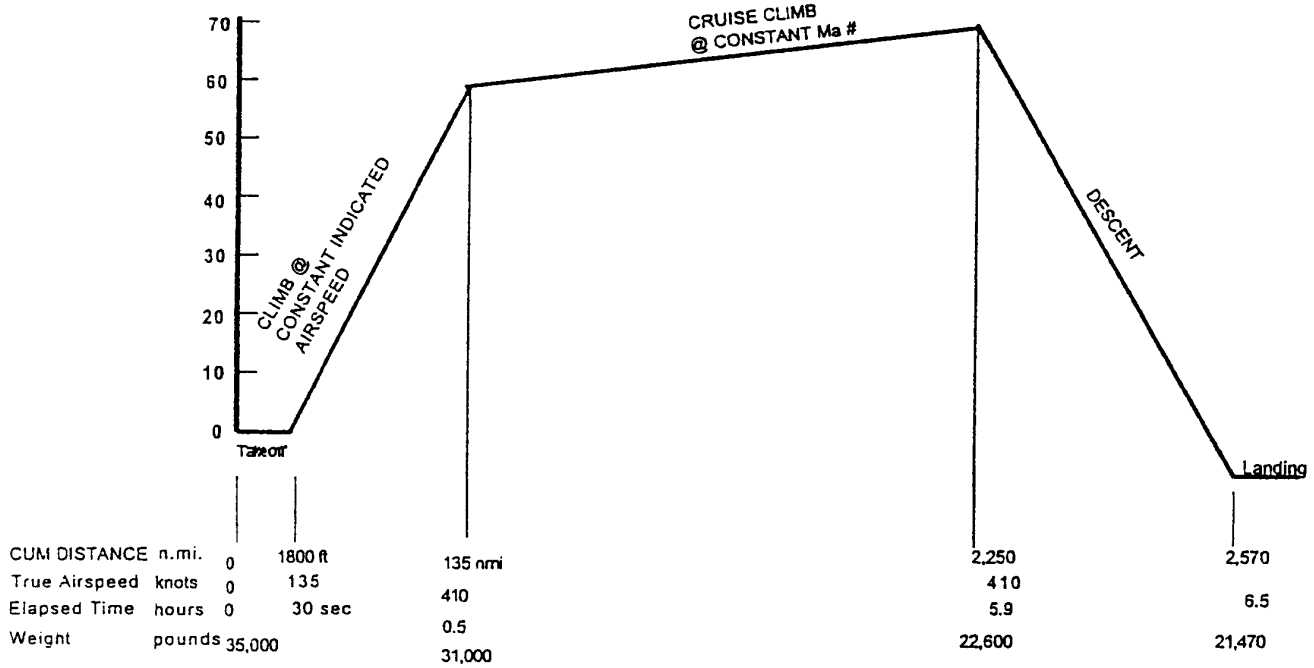
Turning Capability at Altitude

Bank Angle (degrees)	Turn Diameter (Nautical Miles)
5	56.2
10	27.9
15	18.3
20	13.5
22(Standard)	12.2

1. PAGE TITLE: Spacecraft/Payload Orbital Parameters		2. REPLACES	3. PAGE NO: 1725.1
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Drawing

TYPICAL MISSION PROFILE



1. PAGE TITLE: Spacecraft/Payload Orbital Parameters		2. REPLACES	3. PAGE NO: 1725.2
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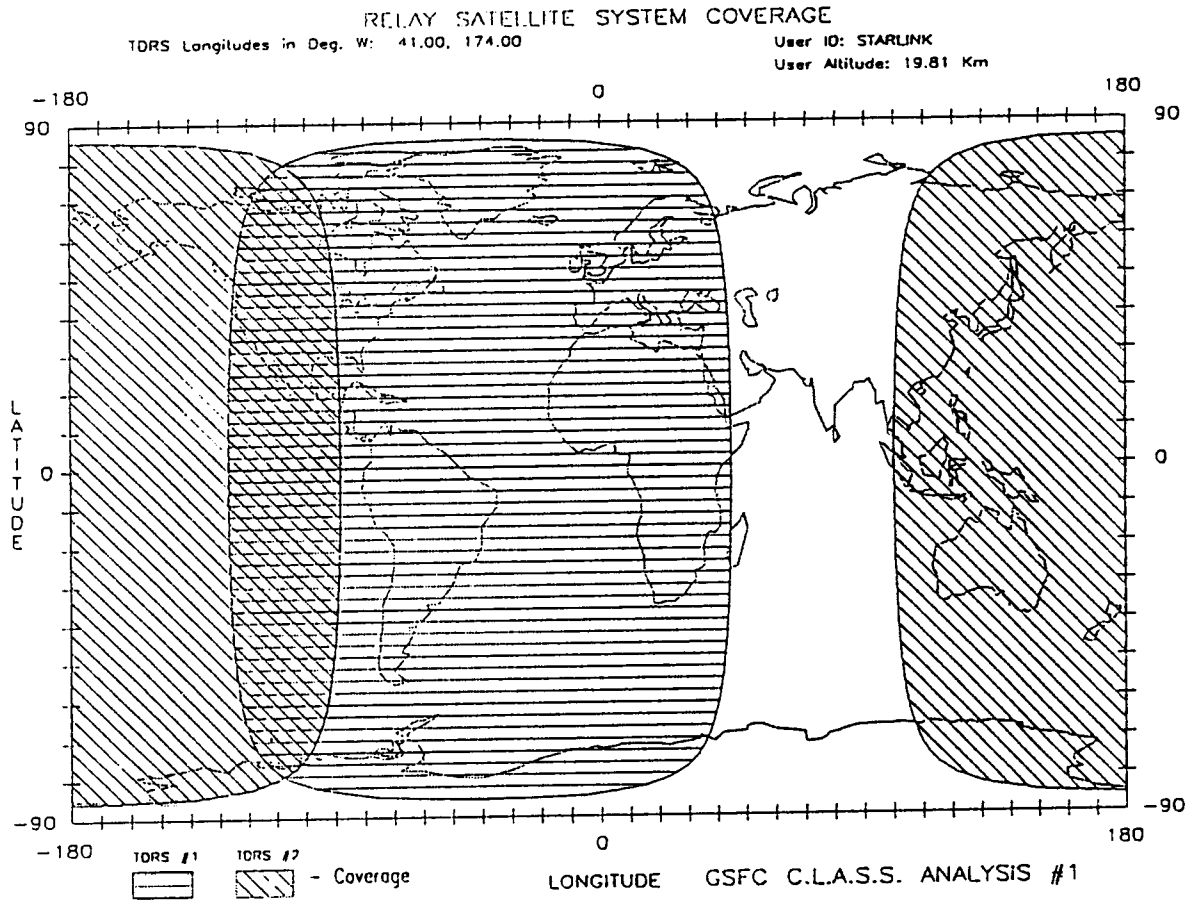
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Drawing (Con't)



1. PAGE TITLE: Radio Frequency (RF) Telecommunications Requirements - Summary		2. REPLACES	3. PAGE NO: 2000
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

The STARLink telecommunication functions are accomplished via the TDRSS, using the KSA service. The communication subsystem was designed and built by Unisys. Its functions are to receive command/science data on the forward carrier, demodulate, and distribute these command/science data to the experimental instruments on board the ER-2. In addition, the communication subsystem receives science data from the experimental instruments, multiplexes, RS encodes, modulates and radiates to the TDRS for Return Link to the ground.

1. PAGE TITLE: Radio Frequency (RF) Telecommunications Requirements		2. REPLACES	3. PAGE NO: 2005
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

Return link Frequency Utilization Summary - SN

TDRS Service	Link Frequency (GHz)	Data Group	Modulation Error-Correcting Code	I/Q Ratio	TDRS Channel	Antenna	Total Data Rate (Mbps)
KSAR	15.0034	DG-2	RS Code S-QPSK	1:1	I Q	HGA	147.456 147.456

Forward link Frequency Utilization Summary - SN

Service Name	Link Frequency (GHz)	Modulation Error-Correcting Code	TDRS Channel	Antenna	Total Data Rate (Kbps)
KSAF	13.775	BPSK RS Code	I	HGA	400 kbps

Forward and Return Polarization, either RHCP or LHCP (selectable) will be supported according to the schedule.

10. Response.

Support will be provided as stated.

1. PAGE TITLE: Space Network (SN) Requirements Summary		2. REPLACES	3. PAGE NO: 2100
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

The STARLink will use the TDRS KSA service for both Forward and Return Link on all missions. Space Network (SN) Support will be required for several two-week mission periods per year. During these missions, SN support will be needed every day. The maximum SN support interval would be ten (10) hours and the minimum SN support interval would be one (1) hour without interruption. STARLink requires the Forward and Return Link to operate at the same time during all missions.

Currently only one set of Project Unique Equipment (PUE) exists at the STGT. It is understood that if the PUE fails, the SN will be unable to provide support until the PUE is repaired.

1. PAGE TITLE: Trajectory and Attitude Support Requirements - Summary		2. REPLACES	3. PAGE NO: 2110
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9 Description:

9.1. The NCC will receive Type-8 vectors in accordance with established formats from the ARC POCC for transfer to the WSC.

9.2. The NCC will transmit TDRS IIRVs to the ARC POCC in accordance with established formats. In the event the TDRS IIRVs routinely transmitted by FDF to the NCC are not sufficient to meet the needs of the POCC, NCC will request transmission of the necessary TDRS IIRV from FDF via GSFCMAIL and CCMAIL. The NCC will nominally allow FDF 3 working days to meet such a request. Specific procedures and FDF personnel will be identified in the Mission Operations Support Plan (MOSP).

1. PAGE TITLE: SN - Return Link Requirements		2. REPLACES	3. PAGE NO: 2120
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description:

Transmitter Frequency 15.0034 GHz (KSA)

Item	Service	Modulation	Data	SN Support	Antenna	Purpose and Remarks
1	KSAR DG-2	RS Code S-QPSK	I-Channel Real-time telemetry at 147.456 Mbps	1 - 10 hours	HGA	Normal mission configuration.
2	KSAR DG-2	RS Code S-QPSK	Q-Channel Real-time telemetry at 147.456 Mbps	1 - 10 hours	HGA	Normal mission configuration.

10. Response

Support will be provided as stated.

1. PAGE TITLE: SN - Forward Link Requirements		2. REPLACES	3. PAGE NO: 2130
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

Receiver Frequency 13.775 GHz (KSA)

Item	Service	Modulation	Data	SN Support	Antenna	Purpose and Remarks
1	KSAF	RS Code BPSK	I-Channel Real-time telemetry at 400 Kbps	1 - 10 hours	HGA	Normal mission configuration.

10. Response

Support will be provided as stated

1. PAGE TITLE: Testing and Training Requirements Summary		2. REPLACES	3. PAGE NO: 3000
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description:

9.1 MO&DSD will provide support as required to assure that the RF, ground and operations interfaces between NASA and STARLink are validated. In addition to the major mission test and simulations described on pages 3100 through 3400, periodic troubleshooting will be performed as required.

1. PAGE TITLE: Compatibility Testing		2. REPLACES	3. PAGE NO: 3100
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

9.1 TDRSS RF compatibility with STARLink will be demonstrated using direct TDRS support of rooftop tests. The STARLink, located at the integration facility, will communicate to TDRS through the STARLink antenna located on the integration facility's rooftop. The NCC will provide the operational scheduling and coordination of the testing in response to the POCC's requests. The established WSC/ARC interface will be used in support of these tests.

9.2 TDRSS RF compatibility with STARLink will be demonstrated using direct TDRS support of the fully integrated platform at the integration facility (tarmac tests). The tests will be conducted in a manner similar to the STARLink rooftop tests described above.

10. Response

Support will be provided as stated

1. PAGE TITLE: Network Readiness Testing		2. REPLACES	3. PAGE NO: 3200
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

9.1 WSC/ARC interface testing will be performed, on an as needed basis, to verify the communications and data link between the ARC and the WSC through to the TDRS. These tests will validate the baseband signal parameters and electric signal levels defined in the STARLink/STGT ICDs. WSC simulation capabilities will be used to support end-to-end data flow simulations between ARC and TDRS. Test equipment at the ARC and the WSC will be used to test and troubleshoot the individual circuits between the WSC and ARC.

9.2 NCC/POCC interface testing will be conducted, as required, to validate the communications links and message format compatibility defined in the NCC/POCC ICDs. This type of testing will typically be conducted to verify new NCC and POCC software releases and/or hardware installations.

10. Response

Support will be provided as stated

1. PAGE TITLE: Mission Readiness Testing		2. REPLACES	3. PAGE NO: 3300
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

A total STARLink/SN/POCC compatibility verification (end-to-end test) will be scheduled as required for performance evaluation of the STARLink platform. The end-to-end test will validate the interface compatibility and operational readiness of the fully integrated STARLink platform, and all of the systems required to provide operations support including TDRS, ARC, NCC, and the POCC. This type of testing is similar to the rooftop and tarmac testing described on page 3100 with the exception that is also exercises the POCC/NCC scheduling and operations interface.

10. Response

Support will be provided as stated

1. PAGE TITLE: Simulator and Test Tools		2. REPLACES	3. PAGE NO: 3400
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

The WSC and ARC will maintain test equipment to facilitate communications troubleshooting between the facilities. Data simulation equipment will be available to simulate the STARLink forward and return links. Spectrum analyzers will be available to support RF troubleshooting.

10. Response

Support will be provided as stated

1. PAGE TITLE: Training		2. REPLACES	3. PAGE NO: 3500
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

9.1 MO&DSD will provide Network Readiness training to the STARLink POCC during Network Readiness Testing described on page 3200.

9.2 MO&DSD will provide Mission Readiness training to the STARLink POCC during Mission Readiness Testing described on page 3300.

9.3 MO&DSD will provide POCC Operations training to the STARLink POCC.

10. Response

Support will be provided as stated

1. PAGE TITLE: Mission Operations Center Requirements - Summary		2. REPLACES	3. PAGE NO: 4000
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

The ARC POCC is located in Building 240 at the Ames Research Center. The ARC POCC will have control of the ER-2 STARLink subsystems. Data storage and real-time voice and data communication will be performed at ARC POCC. The ARC POCC will support all STARLink mission during both planned and unplanned missions. The ARC POCC will maintain external communication via voice or computer link with GSFC NCC, Nascom and Primary Investigators during normal , emergency, and test missions.

1. PAGE TITLE: Mission Operations Systems Requirements		2. REPLACES	3. PAGE NO: 4100
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

9.1 Code 510 will assemble a STARLink POCC using TDRS Scheduling and Control Software (TSCS) to include the following functions:

9.1.1 Preparation of TDRS scheduling requests.

9.1.2 Real-time status and control.

9.1.3 GCMR capabilities.

9.2 Code 510 will train the POCC software and related technologies to the STARLink POCC personnel to ensure knowledgeable and efficient operations.

9.3 ARC will bear the cost associated with the hardware/software procurement.

10. Response

Support will be provided as stated.

1. PAGE TITLE: Ground Communications and Data Transport Requirements - Summary		2. REPLACES	3. PAGE NO: 5000
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

Nascom will provide all voice and data circuit interfaces to support the STARLink testing and mission operations. This will include voice grade lines, land based data lines and STATmux interfaces between ARC and WSC/GSFC.

1. PAGE TITLE: Ground to Ground Data Transport Requirements		2. REPLACES	3. PAGE NO: 5100
		DATED:	4. DATE July 1995
5. PROJECT TITLE: STARLink	6. MISSION(S)	7. PROGRAM NO.	8. REV. NO.

9. Description

9.1 Nascom will provide the TDRSS scheduling, status, and control data link between the ARC POCC and GSFC NCC. The link will have 56 kbps (full duplex) using Nascom 4800-bit message format for transport of GCMR's and UPD's from/to the POCC's TSCS.

9.2 Nascom will provide the forward command data link from the ARC POCC to GSFC to WSC. The link will have 56 kbps (full duplex) using Nascom 4800-bit message format.

9.3 Nascom will provide the return science data link from the WSC to ARC POCC. This link will have the maximum bandwidth (up to 48 Mbps) via the STATmux. The four (4) STATmux inputs :

One (1) 21.42 Mbps.
Two (2) 6.12 Mbps.
One (1) 1.53 Mbps.

9.4 Nascom will provide the voice grade lines between the ARC POCC, GSFC and WSC. A total of two (2) full duplex voice-grade loops that support voice are required.

9.5 Nascom will provide one user unique equipment full duplex data line between ARC POCC to GSFC to WSC. This line will have 9600 bps with RS232 capability.

9.6 Nascom will provide the voice grade lines between ARC and GSFC NCC. One (1) voice line is for the voice communication between ARC POCC and GSFC NCC. One (1) voice line is for the communication between Ames room N254-216 and Nascom.

10. Response.

Support will be provided as stated.

Appendix A

Mission Requirements Request

NASA
National Aeronautics and Space Administration

MISSION REQUIREMENTS REQUEST
For Office of Space Communications Capabilities
(NASA NMI 8430.1C)

NOTE: *Please read and detach instructions before completing this request.*

NASA Form No.	
MAR Submission Date:	
Change No.	
OSC Control No.	

TO	National Aeronautics and Space Administration Office of Space Communications Code O Washington, D.C. 20546	FROM	Requesting Office/Agency Name and Address: NASA - Ames Research Center Principal Contact/ Name, Phone, Position/Title Andrew Roberts, 415-604-5621, ER-2 NASA Chief Engineer

1. Mission Title: STARLink

2. Category/Sponsor:
☒ NASA ☐ Non-NASA Government ☐ NASA Cooperative ☐ Foreign Commercial
☐ DoD ☐ Foreign Government ☐ U.S. Commercial ☐ Other
If Other, Describe:

3. Mission Objectives:

To transmit real-time airborne data collected during Disaster, Earth Resource, Tropospheric and Stratospheric assessment/research programs. These programs are of both multiagency and international significance.

4. Launch Information:
☐ Space Shuttle LV ☐ Expendable LV ☒ Aircraft ☐ Other
Specify: Vehicle ER-2 Upper Stage
Launch/Operations Site: Global
Trajectory Regime Description:
Launch Date(s): Starting Summer 95

5. Orbit/Path Data:
☒ Aeroflight ☐ Suborbital ☐ Low-Earth Orbit ☐ High-Earth Orbit ☐ Deep Space ☐ Other
Specify Orbital Parameters as Applicable:
Apogee Perigee Inclination
Other Trajectory Information (See DSN):
If Other, Please Describe:

6. Key Mission Events and Dates: First Operational Deployment September 95 from Brazil
Mission Duration (mo/yr.);Prime: 15 years Extended:

7. Other Information:
Approved Mission Start Date: November 93 C/D Phase Start Date:
Present Phase of Development (pre A, A, B, C, D,): B
Requirements Maturity Assessment: ☒ > 80% ☐ > 50% ☐ < 50%
Funding Approval Status: 100% Funding Approved
Spacecraft Autonomy/Self-protection Potential: N/A

8. Point of Contact:
Mission Lead Center: Ames Research Center
Project Manager: Andrew Roberts Phone: 415-604-5621

MISSION REQUIREMENTS REQUEST	Mission Title: STARLink

A. GENERAL FACILITIES REQUIREMENTS

1. OSC Data Acquisition Services Anticipated, by Mission Phase/Type:

OSC Data Acquisition Networks	Aero	Suborb	Launch/Inject	Orbital	Cruise	Encounter	Re-Entry
WFF							
DFC							
SN	X						
DSN							
GN							
RTS							
ETR/WTR							
Additional: Specify							

2. Mission Operations Concept Related to OSC Capabilities:

Mission Control Center Location ARC Building 240

Remote Science (PI) Centers

Data Archives ARC

OSC Facility Interface GSFC

3. OSC Data Transport Facility Requirements:

Brief Data Transport Network Description ER-2 / WSC / ARC

Terminal Locations

Nascom Requirements: ☒ VOICE ☒ DATA ☒ TTY ☐ VIDEO ☐ PSCN Highest Data Rate: 274 mb/sec

4. OSC POCC Facility Requirements:

OSC-Provided POCC YES ☐ ☒ NO (IF NO, SKIP TO #5) Location

Command Management Services ☐ Mission Planning Services ☐

Spacecraft Autonomy Design:

Average Command Activity by Mission Phase Pass Interval Minutes per Pass

5. OSC Flight Dynamics Facility Requirements:

FDF ☐ NAV ☐ Other NONE No. of S/C Vehicles

Aquisition Data ☐ Attitude Determination ☐ Orbit Determination ☐ Maneuver Planning ☐ End of Life Analysis ☐

Special/Non-Standard Services:

6. OSC Data Processing Facility Requirements: NONE

Telemetry Data Rate No. of Channels

Data Input Data Delivery Process Level

Radio Metrics Accuracies Types

No. of Channels Data Input

Data Delivery Process Level

Command Data Rate RT/Store-Forward

Data Input Data Delivery Process Level

Location

7. Other Non-Data Acquisition Network OSC Requirements

Network-Spacecraft Compatibility Testing Required ☐ L-24 Months ☐ L-12 Months ☒ L-6 Months ☐ L-3 Months

Interfacility Tests and Simulations: ☐ L-24 Months ☒ L-12 Months ☐ L-6 Months ☐ L-3 Months

MISSION REQUIREMENTS REQUEST	Mission Title: STARLink

C. SPACE NETWORK REQUIREMENTS

1. Telecommunications and Tracking :

Forward Service	Contacts per Day	Minutes per Contact	Data Rate
MA			
KSA			200 kb/sec
SSA			

SSA FWD Frequency: _____

Data System Format: ☐ CCSDS ☐ TDM ☐ Other

Return Service	Contacts per Day	Minutes per Contact	Data Rate RT / PB	Tracking Service Range	Tracking Service Range Rate
MA			/	☐	☐
KSA			274 mb /	☐	☐
SSA			/	☐	☐

SSA RTN Frequency: _____

Data System Format: ☐ CCSDS ☒ Non-CCSDS ☐ TDM ☐ Other

Special Requirements: (Note: Use additional pages to explain "Non-Standard" Requirements)

Project to provide unique equipment @ WSC to DEMUX Telemetry Return

D. GROUND NETWORK REQUIREMENTS

1. Standard Telemetry Requirements ☐ ; No. of Links:_____ ; If Non-standard, Explain Below:

Frequency	Bandwidth	Modulation	Coding	Subcarrier	Data Type	Format

2. Standard Command Requirements ☐ ; No. of Links:_____ ; If Non-standard, Explain Below:

Frequency	Bandwidth	Modulation	Subcarrier	EIRP	Format

3. Standard Metrics Data Requirements ☐ ; Radar ☐ ; If Non-standard, Explain Below:

Ranging	Doppler	Angle	Optical	Special Data Handling

4. Special Data Links, Radio Metrics, or Optical Metrics, Destruct, Voice Communication; Explain Below:

5. Special Communications Links to Other Facilities ☐ ; Special Data Handling ☐

Explain:

6. Other Special Requirements: (Note: Use additional pages to explain "Non-Standard" Requirements)

7. Stations Required: ☐ MIL ☐ BDA ☐ DAK ☐ PDL

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501-215/STARLink

Detailed Mission Requirements (DMR) Document for the Satellite Telemetry and Return Link (STARLink)