NASA/GSFC	MISSION OPERATIONS & DATA SYSTEMS DIRECTORATE (MO&DSD) CONFIGURATION CHANGE REQUEST (CCR)

1. CCR NO.	2. DATE	3. PRIORITY	4. CHANGE LEVEL
CCR-530-ICD-03	March 27, 1996	☐ EMERGENCY ☐ URGENT ■ ROUTINE	☐ A ☐ B ☐ C ■ D ☐ E ☐ F

5. TITLE OF CHANGE

Guam Remote Ground Terminal (GRGT) Changes

6. DOCUMENT TITLE ICD Between the NCC/FDF and the WSC

DOCUMENT NO. 530-ICD-NCC-FDF/WSC, Rev 4, 4/15/96

LIST ALL AFFECTED DOCUMENTS INCLUDING PROCEDURES

ICD Between the NCC/FDF and the WSC for the TDRS H, I, J Era,

405-TDRS-RP-ICD-001, 8 December 1995

(CONT ON ATTACHMENT)

7. REASON FOR CHANGE

To incorporate changes to the NCC/WSC interface resulting from the addition of the GRGT. Also provided comprehensive cleanup of document (treatment of WSC three ground terminal configuration, FDF clarifications, etc.)

(CONT ON ATTACHMENT)

8. DESCRIPTION OF CHANGE

Pages ii, iii, iv, v, ix, x, xii, xiv, 1-1, 1-2, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7, 2-8, 2-9, 2-10, 2-12, 2-13, 2-14, 2-15, 3-1, 3-2, 4-1, 5-1, 6-3, 7-1, 8-1, 9-4, 9-5, 9-11, 9-35, 9-36, 9-38, 9-39, 9-40, 9-41, 9-42, 9-43, 9-45, 9-46, 9-47, 9-48, 9-49, 9-50, 9-51, 9-53, 9-54, 9-55, 9-56, 9-57, 9-58, 9-59, 9-60, 9-61, 9-62, 9-64, 9-66, 9-67, 9-70, 9-72, 9-73, 12-1, 12-2, 12-3, 12-4, 12-5, 12-6, 12-10, 12-11, 12-12, 12-13, 12-14, 12-15, 12-16, 12-17, AB-1, AB-2, AB-3, AB-4 and AB-5.

(CONT ON ATTACHMENT)

9. IMPACT — SYSTEM

YES	NO		YES	NO		YES	NO	
☐	■	SCHEDULE	☐	■	RELIABILITY/MAINTAINABILITY/SAFETY	■	☐	GROUND SEGMENT
☐	■	BUDGET	☐	■	USER SERVICES/MANUALS	☐	■	SPACE SEGMENT
☐	■	FACILITIES	☐	■	RISK MANAGEMENT	☐	■	LOGISTICS
☐	■	TESTING	☐	■	SECURITY	■	☐	DOCUMENTATION
☐	■	TRAINING	☐	■	USAF FUNDING REQ'D	☐	■	HARDWARE
☐	■	SPECIFICATIONS	☐	■	POWER	☐	■	SOFTWARE
☐	■	CONTRACTOR SUPPORT	☐	■	WEIGHT	☐	■	OTHER
■	☐	INTERFACES						

ORGANIZATIONAL

YES	NO		YES	NO		YES	NO		YES	NO	
☐	■	501	■	☐	530	☐	■	MSFC	☐	■	CODE E
☐	■	502	☐	■	540	☐	■	JSC	☐	■	CODE S
☐	■	503	■	☐	550	☐	■	LERC	☐	■	CODE T
☐	■	510	☐	■	560	☐	■	KSC	☐	■	OTHER
☐	■	520	■	☐	OTHER Code 405	☐	■	JPL			

10. COMMENTS

	SIGNATURE	DATE
STel ANALYST		
HARDWARE ENGINEER		
OPERATIONS REPRESENTATIVE		
SYSTEMS ENGINEER		
I AND T MANAGER		

CONCURRENCE:

CODE 285

DATE

11. BOARD ACTION

☐ APPROVED ☐ WITHDRAWN
☐ DISAPPROVED ☐ DEFERRED UNTIL __________

12. DIRECTION/ACTION REQUIRED

☐ ECP ☐ TECH DIRECTION ☐ CONTRACT MOD
☐ WAIVER ☐ PUBLISH DOCUMENT ☐ PUBLISH DCN
☐ DEVIATION ☐ C.O. LETTER ☐ OTHER __________

13. ORIGINATOR D. Littmann x7643 CODE 530.4

SIGNATURE __________ DATE __________

14. SEGMENT MANAGER'S APPROVAL CODE __________

SIGNATURE __________ DATE __________

15. CCB APPROVAL

SIGNATURE __________ DATE __________

16. CCR IMPLEMENTED

ATR SIGNATURE __________ DATE __________

CCB SIGNATURE __________ DATE __________

Interface Control Document (ICD) between The Network Control Center (NCC)/ Flight Dynamics Facility (FDF) and The White Sands Complex (WSC)

Revision 54

~~15 April~~June 19976

Approved By:

Dave Littmann — Date
WSCPO Systems Engineer

WSC~~STGT~~ Project Approval:

Denver W. Herr — Date
WSCPO Project Manager

Approved By:

Philip E. Liebrecht, Chief — Date
Networks Division,
Code 530

Approved By:

C. E. Woodyard, Chief — Date
Flight Dynamics Division
Code 550

This document supercedes Interface Control Document (ICD) Between the Network Control Center (NCC)/Flight Dynamics Facility (FDF) and the White Sands Complex (WSC), Revision ~~3~~ 4 Issue, dated ~~May~~ 15 April 199~~5~~6. Discard all previously issued copies.

Goddard Space Flight Center
Greenbelt, Maryland

Preface

The information contained in this document applies to the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) Network Control Center (NCC), Flight Dynamics Facility (FDF), and the White Sands Complex (WSC). In this document, detailed definitions of the electronic high-speed message interfaces between the WSC and the NCC, and between the WSC and the FDF are covered.

The detailed definition of the communications interface between the NCC/FDF and the WSC as configured for support of Space Network (SN) operations is provided. The NCC, FDF, and the WSC are three elements of the SN that provide support to user spacecraft using the Tracking and Data Relay Satellite System (TDRSS).

This document and similar documents for other elements of the SN will be used to define and control the configuration of the SN. Once approved by the Chairman of the Networks Division Configuration Control Board (CCB) ~~and the Flight Dynamics Division CCB,~~ the NCC/FDF and WSC interface will not be altered without prior approval of the ~~Mission Operations and Data Systems Directorate (MO&DSD) CCB, the~~ Networks Division CCB~~, and the Flight Dynamics Division CCB~~.

The NCC/FDF WSC Interface Control Document (ICD) was prepared by the Networks Division, Code 530, with the coordination of the Flight Dynamics Division, Code 550. The Networks Division is responsible for processing all changes to this document and presenting the proposed changes to the Network Division CCB ~~and the Flight Dynamics Division CCB~~ for review and approval. Changes will be processed as follows:

a. The sponsor of changes will prepare the proposed changes and submit the changes, along with supportive material (justification and coordination) to the Networks Division via appropriate administrative channels.

b. The Networks Division will review the proposed changes and coordinate with the sponsor to ensure the intent, completeness, and accuracy of the changes. A coordinated document as a proposed ~~Documentation Change Notice (DCN),~~Revision or a Configuration Change Request (CCR)~~,~~ and a letter of transmittal for distribution to all affected ~~divisions~~ organizations and the sponsor will be prepared and distributed by the Networks Division. The transmittal letter will indicate the required date of response.

c. The Networks Division will review and coordinate the comments received from the ~~line divisions~~affected organizations and prepare a final draft of the proposed ~~DCN~~ CCR or Revision and a letter addressing each comment. The letter and the final draft of the proposed ~~DCN~~ CCR or Revision will be submitted to the Networks Division CCB ~~and the Flight Dynamics Division CCB~~ for approval.

d. A CCB-approved ~~DCN~~ CCR or Revision will be returned to the Networks Division for implementation. The Networks Division will arrange for preparation and distribution.

~~of the DCN.~~ This document may be updated by Documentation Change Notice (DCN) or by complete ~~r~~Revision.

Direct all comments, questions, or suggestions regarding this document to:

~~Network Control Center~~ White Sands Complex Project Office
Code 530.~~0~~4
Goddard Space Flight Center
Greenbelt, MD 20771

Change Information Page

List of Effective Pages

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4-1 through 4-3/4-4 (blank)	Revision 54
5-1/5-2 (blank)	Revision 54
6-1 through 6-3/6-4 (blank)	Revision 54
7-1/7-2 (blank)	Revision 54
8-1/8-2 (blank)	Revision 54
9-1 through 9-106	Revision 54
10-1/10-2 (blank)	Revision 54
11-1/11-2 (blank)	Revision 54
12-1 through 12-21/12-22 (blank)	Revision 54
13-1 through 13-3/13-4 (blank)	Revision 54
AB-1 through AB-5/AB-6 (blank)	Revision 54

Document History

Document Number	Status/Issue	Publication Date	CCR Number
530-ICD-NCC-FDF/WSC	Revision 1	March 1994	
530-ICD-NCC-FDF/WSC	Revision 2	February 1995	
530-ICD-NCC-FDF/WSC	Revision 3	May 1995	
530-ICD-NCC-FDF/WSC	Revision 4	15 April 1996	
530-ICD-NCC-FDF/WSC	Revision 5	June 1997	

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Section 1. Introduction

1.1 Purpose

The purpose of this document is to provide detailed definitions of the electronic high-speed message interfaces between the National Aeronautics and Space Administration (NASA) White Sands Complex (WSC) and the Goddard Space Flight Center (GSFC) Network Control Center (NCC), and between the WSC and the GSFC Flight Dynamics Facility (FDF).

1.2 Scope

This Interface Control Document (ICD) defines and controls the applications functions, communications protocol, messages and block formats of the interface between the NCC/FDF and the WSC. WSC is defined as being comprised of three ground terminals: Danzante, Cacique, and the Guam Remote Ground Terminal (GRGT). The definition contained herein, although specified for the Second TDRSS Ground Terminal (STGT), apply to the STGT and the White Sands Ground Terminal Upgrade (WSGTU), i.e., to the WSC.

This document originated as the Appendix D, Operational Systems Interface Requirements (OSIR), to the STGT Phase II Requirements Specification. The STGT Phase II Specification was replaced by the Requirements Specification for the Danzante Ground Terminal (530-RSD-Danzante) and this standalone ICD, the Interface Control Document (ICD) between the Network Control Center (NCC)/Flight Dynamics Facility (FDF) and the White Sands Complex (WSC), 530-ICD-NCC-FDF/WSC. Both documents are traceable to the Phase II Requirements Specifications for the STGT Ground Terminal (P-01) through DCN 17. Additional modifications to Rev 2 of the ICD were (1) to replace Section 10 with reference to STDN 108, PN Codes for use with the TDRSS, (2) to incorporate TDRS H, I, J interface specifications, and (3) to incorporate as built changes to the Ground Terminal that were implemented by the WSC Maintenance and Operations (M&O) contractor after acceptance of the station (i.e. 1000 series STGT CCRs). Revision 5 supercedes and replaces Revision 4. Significant cleanup of the document has been accomplished for a more accurate treatment and representation of the three WSC ground terminals. Changes of a technical and operational orientation have been made to incorporate requirements for the Guam Remote Ground Terminal (GRGT), scheduling of the EDOS interface, end-to-end test tape playback capabilities, as well as to provide additional updates and clarifications consistent with NCC Data System 1998 requirements and the operational interface.

1.3 Time Frame

This ICD shall be in effect from the date of approval by the Mission Operations and Data Systems Directorate (MO&DSD) Configuration Control Board (CCB), the Networks Division (ND) CCB, the Flight Dynamics Division and when applicable signatures are obtained.

1.4 Applicable Documents

This section lists the specifications, standards, and other documents which serve as references for supplemental descriptive information. The most recent version of these documents supercede all previous versions.

1.4.1 Specifications

a. Network Control Center Data System (NCCDS) Detailed Requirements, 530-DRD-NCCDS.

b. Functional Specification, 50 Mbps Statistical Multiplexer, Specification No. 841-79-05.

c. Network Control Center Data System Specification, Volumes 1 and 2, 530-SSD-NCCDS.

d. Mission Operation and Data Systems Directorate Requirements Specification for the WSC~~Danzante~~ Ground Terminal, 530-RSD-WSC~~Danzante~~.

1.4.2 Standards

a. NASCOM Interface Standard for Digital Data Transmission (NISDDT), 542-003.

b. IRIG Standard Parallel Binary Time Code Format, X-814-77-64.

1.4.3 Other Documents

a. Digital Data Source/Destination and Format Codes Handbook for the Nascom Message Switching System, 542-002.

b. Tracking and Acquisition Handbook for the Spaceflight Tracking and Data Network, STDN No. 724.

c. Space Network Users' Guide, 530-SNUG.~~STDN No. 101.2~~

d. Support Identification Code Dictionary, 534-808.

e. PN Codes for use with the Tracking and Data Relay Satellite System (TDRSS), STDN No. 108.

f. Mathematical Theory of the Goddard Trajectory Determination System, Revision 1, GSFC FDD/552-89/001.

Section 2. Interface Definition and Ground Rules

The messages exchanged between the WSCSTGT and the NCC/FDF are generated in the Space to Ground Link Terminal's (SGLT's) at each ground terminal the STGT and in the NCC/FDF at the GSFC. The interface between the Danzante and Cacique SGLT's and the NCC is provided by the Data Interface System (DIS), and the interface between the GRGT SGLT and the NCC is via the Cacique DIS at the STGT. The messages interchanged between the SGLT's and the DIS are shown in Figure 2-1. The protocol and descriptions of the messages between the NCC/FDF and WSCSTGT are contained in this ICD.

2.1 Interfaces

The SGLT's interface with the DIS is via the DIS Secure Voice/Data Switch and the Black Data Switch. The DIS interface to the NCC is via the DIS Security Equipment. All messages described in the following sections are exchanged via these interfaces. The DIS provides the acknowledge/retransmit protocol between the SGLT and the NCC/FDF.

2.1.1 NCC to WSCSTGT Messages

NCC to WSCSTGT messages, consisting of scheduling order messages (SHO's) and operations messages (OPM's), shall be transmitted by the DIS to the SGLT's.

2.1.2 WSCSTGT to NCC/FDF Messages

WSCSTGT to NCC messages, consisting of operations messages (OPM's), TDRSS Service Level Reports (SLR's), and operations data messages (ODM's) shall be transmitted from the SGLT's to the NCC via the DIS. WSCSTGT to FDF messages consist of Tracking Data messages (TDM's) and are also transmitted from the SGLT's and relayed to the FDF via the DIS. Acknowledgment shall be requested of all OPM and SLR messages sent from WSCSTGT to the NCC, except as described below. If there is no message pending transmission to WSCSTGT, then the NCC will send a separate OPM (Acknowledgment of Message Received) to WSCSTGT. A separate OPM (Acknowledgment of Message Received) shall be used if there is no other message pending transmission to the NCC. WSCSTGT will not solicit acknowledgment of the Acknowledgment of Message Received OPM. The DIS Automatic Data Processing Equipment (ADPE) shall provide the acknowledge/retransmit protocol for the WSCSTGT.

The originator shall transmit all blocks of a message before initiating the transmission of another message except for separate acknowledgement messages which shall be transmitted, as required, at the next block transmission opportunity.

No acknowledge/retransmit of tracking data messages (TDM's) and operations data messages (ODM's) is required. Section 12 describes these tracking data, format and content. Section 9.5 describes the ODM's.

2.2 Ground Rules

Ground rules applicable to the various message types defined in Section 9 (i.e., SHO's, OPM's and ODM's) are contained in the sections following.

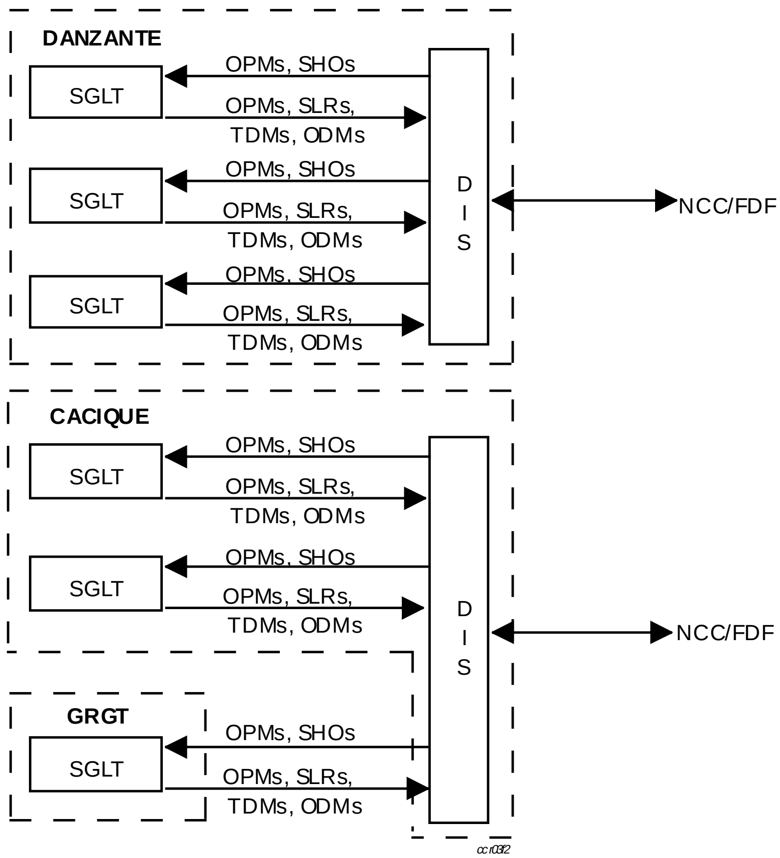


Figure 2-1. SGLT/DIS Interface

2.2.1 Vector Processing Ground Rules

<u>Section 1 - General Application</u>

This section contains the general ground rules and constraints. Before addressing the ground rules, the message class codes (MCC), state vector operations messages (OPM's), and state vector types will be discussed.

Two different message class codes (10 and 15) will be accepted for state vector OPM's (state vector messages). State vectors will be processed identically irrespective of message class code. A state vector OPM will contain one OPM header, followed by up to three sets of state vector data for a single user.

The state vector types that will be processed at WSCSTGT are as follows:

Vector Type	Application	Phase
1	Free-flight (On-Orbit)	Free-flight state vectors
2	Transition to free-flight	A type 2 vector is used only as the transition vector from maneuver sequence vectors to free-flight vectors
3		Not used
4	Ignition	First vector in maneuver sequence
5	Burnout	Last vector in maneuver sequence
6	Reentry	Landing maneuver sequence vectors
7	Launch or on-orbit	Launch or on-orbit maneuver sequence vectors
8	Stationary	Stationary state vectors

The following general ground rules apply:

1. Except for permanent Earth stations, user trajectory data is used according to receipt time. For each user, the most recently received vector, regardless of type, will be used from its epoch time forward. Previously received vectors with later epochs will not be used following receipt of a new vector with an equal or earlier epoch.
2. Free-flight (type 1-2) vectors will be rejected by WSCSTGT if they fail syntax, check sums, or if (1) the magnitude of the position vector is less than 6356 kilometers or (2) the epoch time of the vector is more than 12 hours earlier than the time of receipt at WSCSTGT. If a free-flight vector is rejected for any of the above reasons, a state vector reject message will be sent to the NCC.
3. Except for permanent Earth stations, no stationary state vector will be propagated more than 24 hours from its epoch time. No free-flight state vector will be propagated more than 12 hours from its epoch time.
4. A single state vector OPM may contain up to three state vectors.
5. OPM Classes 61, 64 and 65 will be sent to the NCC without TDRSS Operations and Control Center (TOCC2) operator intervention.
6. The formats for free-flight (types 1-2), maneuver sequence (types 4-7), and stationary (type 8) state vector OPM's are identical. The vector types indicate whether an OPM contains free-flight, maneuver sequence, or stationary state vectors.
7. No more than 15005000 vectors received from the NCC for each user will be stored at STGT. Vectors with no future applicability will be deleted. No more than 15,000 vectors received from the NCC will be stored at STGT for all users. Nand no more than 72 vectors for each TDRS will be stored at on each SGLTSTGT.

The following general ground rules apply only to permanent Earth stations:

8. The NCC will provide the WSC~~STGT~~ with a list of no more than 63 permanent Earth stations. For permanent Earth stations, vector types 1 through 7 will be rejected by WSC~~STGT~~.

9. For permanent Earth stations, the most recently received stationary vector will be used regardless of epoch. Previously received stationary vectors will not be used following receipt of a new vector.

10. There is no limit to the propagation period for permanent Earth station vectors. The permanent Earth station vectors will be retained permanently at each WSC ground terminal ~~the STGT~~. Permanent Earth station vectors may be updated by the NCC at any time by use of an OPM 10 or 15.

Section 2 - Maneuver Sequences

This section addresses the ground rules that are related to the use of maneuver sequences. The formats for maneuver vector sequences are shown in Table 2-1.

Table 2-1. Maneuver Vector Sequence Formats

STATE VECTOR NUMBER	VECTOR TYPE	VECTOR EPOCH
1	4	t_1
2	7 (6)	t_2
.	.	.
.	.	.
.	.	.
n	7 (6)	t_n
n+1	2 (8)	t_{n+1}
n+2	7 (6)	t_{n+1}
.	.	.
.	.	.
.	.	.
n+m	7 (6)	t_{n+m-1}
n+m+1	5	t_{n+1} +6 min.

NOTES:

1. ALL MANEUVER SEQUENCES WILL HAVE THE ABOVE FORMAT.
2. THE MANEUVER SEQUENCE THAT INCLUDES THE TYPE 6 AND TYPE 8 VECTORS WILL BE USED FOR REENTRY ONLY.
3. THE VECTOR EPOCH TIME t_{n+1} IS THE END OF THE MANEUVER (TYPE 2 VECTOR) OR THE REENTRY (TYPE 8 VECTOR). THE SUBSEQUENT VECTORS IN THE MANEUVER SEQUENCE ARE SUPPLIED TO PROVIDE TIME FOR THE IMPLEMENTATION OF THE TYPE 2 AND TYPE 8 VECTORS.
4. ONLY THE 4800-BIT BLOCKS CONTAINING THE TYPE 4 VECTOR AND THE TYPE 5 VECTOR OF A MANEUVER SEQUENCE WILL HAVE THE ACKNOWLEDGEMENT BIT SET IN THE REAL-TIME MODE.

The following ground rules apply to maneuver sequences:

1. The time between epochs of successive maneuver sequence (types 4-7) state vectors can be variable, with a minimum of 0.5 second and a maximum of 6 minutes. The maximum number of vectors in a single maneuver sequence shall be 800.

2. A maneuver sequence must include at least seven state vectors. The required seven state vectors are as follows:

		1	2	3	4	5	6	7
State Vector		1	2	3	4	5	6	7
Vector Type	Launch or on-orbit maneuver sequence	4	7	7	2	7	7	5
	Landing maneuver sequence	4	6	6	8	6	6	5
Epoch		t_1	t_2	t_3	t_4	t_4	t_5	t_6

where $t_6 = t_4 + 6$ minutes

3. Between transmission of the type 4 vector of a maneuver sequence and the type 5 vector of that sequence, only those vectors in that sequence should be transmitted. For a user in the real-time mode (see Section 4), receipt of any other vector for any user Support Identification Code (SIC) will result in WSC~~STGT~~ generation of a type 2 or 8 vector (as appropriate), a type 5 vector to terminate the sequence and notification to the NCC of this action. For a user not in the real-time mode, receipt of any other vector for any user SIC will result in WSC~~STGT~~ rejection of the entire sequence.

4. A type 2, type 6, or type 7 vector will be rejected if it is not received as part of a maneuver sequence. For users in the real-time mode, a maneuver sequence received without a type 2 or type 8 vector will be used as received and WSC~~STGT~~ will generate a type 2 or type 8 vector (as appropriate). The type 2 or type 8 vector will be generated with the identical components and epoch of the last correctly received vector. For users not in the real-time mode, a maneuver sequence received without a type 2 or type 8 vector will be rejected.

5. No reasonableness checks or gross validity checks are made for maneuver sequences. Syntax checks and checksum verification are performed for maneuver sequences.

Section 3 - Delta-T Applications

This section addresses the ground rules and constraints that are related to the use of Delta-T OPM's to shift the epoch times of maneuver sequences and other vectors that are in place at WSC~~STGT~~. The epoch shifts are applied to vectors in an Earth-fixed, rotating coordinate system. The purpose of the Delta-T function is to adjust for any launch slips that occur during the launch phase of a mission (e.g., Shuttle, etc.).

There are several important terms associated with the use of the Delta-T OPM function that need to be defined. These are as follows:

1. The Delta-T adjustment in the Delta-T OPM is the change in the current epoch times of the vectors.
2. The original epoch of a vector atin the WSCSTGT is the epoch of the vector as transmitted to WSCSTGT.
3. The current epoch of a vector atin the WSCSTGT is the original epoch of the vector plus the sum of all Delta-T adjustments received at WSCSTGT.

The following ground rules apply to the use of Delta-T OPM's:

1. Application of a Delta-T OPM does not change any SHO start or stop times.
2. The Delta-T adjustment is always calculated from the current epochs of the vectors because Delta-T adjustments are cumulative.
3. A Delta-T OPM must be received at WSCSTGT at least 30 seconds prior to launch to ensure application. Delta-T OPM's arriving later will be applied as soon as possible.
4. A series of Delta-T OPM's may be sent for a given user. They will be applied successively as they arrive.
5. Delta-T adjustments may be positive (delay) or negative (advance), but the absolute value of the Delta-T adjustments must be less than 12 hours.
6. The Delta-T adjustments will be applied to all vectors that are in place at the receipt time of the Delta-T OPM. It will not be applied to vectors subsequently received at WSCSTGT.
7. A Delta-T OPM must not be transmitted between transmissions of the type 4 and type 5 vectors of a maneuver sequence for the same user.

Section 4 - Real-Time Mode

This section addresses the ground rules that are related to operations in the real-time mode at WSCSTGT.

1. A user will enter the real-time mode upon receipt of any of the following messages less than 6 minutes prior to the start of service or during service:

   a. Delta-T message.

   b. Type 1 or type 8 vector with an epoch prior to the end of service.

   c. Type 2, type 4, type 5, type 6, or type 7 vector as part of a maneuver sequence and with an epoch in the future and prior to the end of service. Real-time maneuver sequence support will not begin until there are at least two maneuver vectors at WSCSTGT with epochs in the future.

2. The user will remain in the real-time mode until completion of the updating of the user ephemeris. This will generally be within 30 seconds of receipt of the OPM or, in the case of a maneuver, 30 seconds after receipt of the last vector in the sequence. (Receipt of multiple Delta-T OPM's may delay implementation.)

3. The WSCSTGT will notify the NCC when a user enters and exits the real-time mode.

4. Acknowledgement of all blocks of a maneuver sequence shall be requested if the epoch of the Type 4 vector is more than 7 minutes later than start of transmission. If the epoch of the Type 4 is less than 7 minutes later than start of transmission, only the blocks containing the type 4 vector and type 5 vector shall request acknowledgement.

5. There can only be one real-time user per SGLT at any given time.

6. Once maneuver sequence support in the real-time mode has begun, if current time passes exceeds the epoch of the last maneuver sequence vector at the WSCSTGT, the remainder of the sequence will be rejected and maneuver sequence support will be terminated.

2.2.2 Schedule Order (SHO) Ground Rules

The following ground rules apply to routine service scheduling:

1. In a SHO structure, the sequence of the data sets for the normal services is: Forward - Return - Tracking. Sections 9.2.3.15 and 9.2.3.17 describe how End-to-End Test data sets are incorporated into a SHO structure.

2. Periodic SHOs (type 8) shall be used to schedule user services whose start times are greater than or equal to 2 hours and less than 48 hours from receipt of the SHO at WSCSTGT.

3. Routine SHOs (type 2, Classes 1 and 3) shall be used to schedule user services whose start times are greater than or equal to five minutes and less than two hours from receipt of the SHO at WSCSTGT. These SHOs will be rejected (OPM-51, Problem Code 1) if a service start time is less than five minutes from receipt at WSCSTGT.

4. Shuttle does not use MA services, and therefore does not use cross-support. All MA service parameters and all cross-support parameters apply only to normal users.

5. Deleted.

6. The service reconfiguration period (the interval between the stop time of a SHO and the start time of the next SHO on the same Single Access (SA) antenna or using the same Multiple Access (MA) return link ID or using the same MAF link) will be at least 30 seconds. The NCC will ensure that the service reconfiguration period is adequate for slewing the SA antenna to the user position. A slew rate of approximately 0.25° /sec. is assumed. If the service reconfiguration period is less than three (3) minutes, pre-service testing is not required.

7. All SHO's have a unique SHO ID. If a SHO is to be replaced, it will be cancelled by a Cancel SHO Request, OPM-Class 12, prior to sending the replacement SHO.

8. The minimum and maximum times which may be contained within the contiguous time interval covered by a SHO are one minute (minimum time) and 24 hours (maximum time).

9. Schedule conflicts will result in the discard of the later received SHO which caused the conflict and the generation of a conflict message (OPM) which will be sent to the NCC. All previously planned and currently ongoing services will continue.

10. Two separate SHO's cannot schedule back-to-back user support periods on the same link without service interruption, i.e., service reconfiguration periods must be provided. Back-to-back (or overlapping) user support periods may be scheduled by separate SHO's on different uniquely steerable links.

11. When requested in the SHO, return link time delay data will be provided on the equipment configuration in use at the start and conclusion of service, when the equipment configuration changes and at reconfigurations during the service period. These return link time delay data will be sent after service termination.

12. All services in the SHO must cover a contiguous time period. During the time interval from the earliest service start time to the latest service stop time in the SHO, there must not be any period for which no service is being provided to the user. Within a SHO, the minimum time between the stop time of a service and the start time of the same service shall be 15 seconds. MA Return (MAR) Channel availability is based on the assumption that a MAR Channel is allocated to a SHO from the earliest MAR service start time to the latest MAR service stop time in the SHO. Overlapping of MAR services in a SHO shall be rejected by the WSC~~STGT~~. This ground rule applies to SMAR also.

13. All services in the SHO must be for the same TDRS. With the exception of S-band Single Access (SSA) combining, all services in the SHO shall be for the same TDRS SA antenna.

14. For tracking services, the related forward and/or return services must be scheduled for the entire duration of the tracking service and must be described in the same SHO. Simultaneous SSA and Ku-band Single Access (KSA) services from the same SA antenna must be described in the same SHO.

15. For optimal performance, all coherent services (i.e., Data Group 1 (DG-1) Modes 1 and 3 and all coherent carrier services) should have the forward and return services starting at the same time. If operational considerations require starting the forward service before the return service, no reconfigurations of the forward service (i.e., OPMs 02, 03, and 11) shall be sent within 30 seconds of the start of return service. OPM 04 shall not be sent within 150 seconds of the start of the return service. These messages will not be rejected, but could cause inaccuracies in subsequently scheduled tracking data.

16. For a User Reconfiguration Request OPM, the reconfigurable parameters shall be contained in the Reconfiguration OPM. The SHO contains the initial configuration (the fixed parameters plus the initial group of reconfigurable parameters for that service).

17. Deleted.

18. Deleted.

19. All SHO's (periodic and routine) shall have the same format.

20. The SHO ID is unique for each new schedule. A SHO retains the same ID for each subsequent schedule change or deletion for reference purposes.

21. The first data block containing scheduling data must be flagged for message acknowledgment in the TDRSS header, i.e., SHOs require acknowledgment of successful receipt by WSC~~STGT~~. The message acknowledgment will occur after the successful receipt of all blocks comprised in the message.

22. Each scheduling data message (single block or multiblock) can contain only one SHO. This constraint makes a SHO and a scheduling data message synonymous.

23. Scheduling order data and operations messages cannot occupy the same 4800-bit block.

24. A scheduling order data message is limited to a maximum group of 15 blocks.

25. The maximum number of services in a SHO is 16. An SSA combining service counts as two, i.e., there will only be one set of SSA Return (SSAR) parameters in the SHO with the SSA combining byte set to 1 = yes, however, this counts as two services. The SSA combining parameters shall be specified as SSA1 parameters.

26. At any point in time, the number of SHOs awaiting execution shall not exceed 600.

27. Deleted.

28. The Support Identifier Code (SUPIDEN) is a spacecraft-unique coded number assigned by NASA. For the TDRS series, the SUPIDENs have been assigned as follows:

    TDRS Serial #1 (F-1) = TDRS A = SUPIDEN 1300
    TDRS Serial #2 (F-2) = TDRS B = SUPIDEN 1301
    . .
    . .
    . .
    TDRS Serial #10 (F-10) = TDRS J = SUPIDEN 1309

    Although the TDRS may not be launched in this ordered sequence, these designations are fixed and shall not change.

29. For KSA/KaSA and SSA DG2, Staggered Quadrature Phase Shift Keying (SQPSK), Single User coded data service (where concurrent encoder symbols are placed on the I and Q phase of the SQPSK carrier), it is necessary that the user's I and Q phase relationship be known in order to properly decode the user data. The definition of the I Channel G2 Inversion parameters, in this case is as follows:

    G2 Inversion - I Channel

    0 = G2 polynomial normal - I leads Q, or
    G2 polynomial inverted and I lags Q

1 = G2 polynomial inverted - I leads Q, or
G2 polynomial normal and I lags Q

30. The four character SIC for a user spacecraft is the same as the four numeric characters of the user SUPIDEN. The second through the fifth characters of the SUPIDEN, along with the Vehicle Identification Code (VIC) are used to identify the User and, in turn, to correlate SHO's with the User spacecraft state vector.

31. Definition of Effective Isotropic Radiated Power (EIRP) - The user spacecraft minimum and maximum EIRP (paragraphs 9.2.3.8, 9.2.3.10, 9.2.3.12) over the scheduled service period are defined as follows:

$$EIRP(t) = EIRP_u(t) - 20 \log \frac{R_u(t)}{R_{spec}} + n \text{ dBW}$$

where:

EIRP(t)	is the User's apparent EIRP, assuming the User spacecraft is located at a range R_{spec} from TDRS.
$EIRP_u(t)$	is the time User's actual EIRP based on the User's transmitter power, antenna gain, efficiency, and pointing losses.
$R_u(t)$	is the time varying range of the user spacecraft from TDRS.
R_{spec}	is the range of the user spacecraft from TDRS corresponding to a propagation space path loss of -192.2 dB for S-band and -209.2 dB for K-band.
n	is a factor which accounts for antenna polarization loss due to imperfect circular polarization of the User spacecraft transmit antenna.

Hence, $EIRP_{max}$ is the maximum value of EIRP(t) and $EIRP_{min}$ is the minimum value of EIRP(t) over the scheduled service period. WSCSTGT shall use the minimum EIRP value, in conjunction with TDRS performance parameters, to compute a C/N_o for configuring the IR. Maximum Data Rate values shall be provided in the SHO. For User End-to-End Test Services, the "EIRP of Simulated User" (paragraph 9.2.3.15) is EIRP(t) at the return End-to-End Test service start time.

32. For a User transmitting DG1 data from a single source by Quadrature Phase Shift Keying (QPSK) modulation, the SHO data rate for the I and Q channels should be set to the same value - that which is the data rate of the user single source. However, if either I or Q modulator of the user is inoperative, then that corresponding I or Q channel data rate should be set to a value of zero in the SHO. For DG2, the I and Q Channel data rates shall be one-half the single source data rate.

33. For a user transmitting data by Binary Phase Shift Keying (BPSK) modulation, the SHO data should be as follows:

DG1 -	I Channel only:	Specify I channel data rate only; set Q Channel data rate to American Standard Code for Information Interchange (ASCII) space.

40. DIS Pre Service Test (PST) shall not be performed when any DIS Shuttle chain is already assigned. A DIS Shuttle chain is assigned from the earliest SHO service start time minus PST period to last service stop time.

41. The minimum value of the Max Data Rate parameter in a SHO shall be 1000 bps.

42. For users transmitting from a single source by QPSK modulation, only the I Channel data of Subheader 6 is applicable. For users transmitting BPSK, the applicable channel of Subheader 6 is as specified in Ground Rule 33.

43. MA services are applicable for TDRS A-G only. SSA and KSA services are applicable for TDRS A-J. SMA and KaSA services are applicable for TDRS H-J only. Incorrectly scheduled services for a TDRS shall be rejected.

44. Simultaneous scheduling of Ku and Ka Band services on the same SA antenna is not permitted.

45. Ka-Band services are DG-2, noncoherent only. There are no tracking services at Ka-Band.

46. The recording (Line Outage Recording (LOR) and Record Only services) of all GRGT supported user services will be performed at Cacique.

47. GRGT will not support Shuttle Analog Data (Shuttle Mode 2, Channel 3 Analog) services.

48. GRGT will have two schedulable MA Return Links, but has the capability to be increased to five.

49. The NCC is responsible for ensuring that the common carrier (Danzante/Cacique-to-GSFC and GRGT-to-Cacique) composite forward and return data rates available for scheduling of user services is not exceeded.

2.2.3 End-To-End Test (EET) Data Ground Rules

The following ground rules apply to End-to-End Test SHO's:

1. Deleted.

2. End-to-End Test services cannot be scheduled alone, i.e., the related traffic services must be included in the SHO.

3. In an End-to-End Test SHO, the start time specified in an End-to-End Test data set must be the same as that of the related traffic service and the stop time in the End-to-End Test data set must be the same as that of the related traffic service.

4. End-to-End Test services cannot be included in a normal SHO. An End-to-End Test SHO must be used for End-to-End Test services.

5. All End-to-End Test SHO reject messages shall be sent to the NCC without operator intervention.

6. Shuttle End-to-End Test and pre-service test shall not overlap on the same SA antenna on any TDRS, e.g., if Shuttle End-to-End Test services are on-going on SGLT1 SA-1, then in order to avoid conflict, schedule overlapping Shuttle pre-service tests on SA-2

of SGLT1, 2 or 3, i.e., not on SA-1 of SGLT2 or 3. Shuttle SHO's shall not be rejected if End-to-End Tests and pre-service tests overlap, i.e., the Shuttle SHO shall be serviced without pre-service test.

7. End-to-End Test services for which End-to-End Test data is sent to a MOC~~POCC~~ shall be reconfigurable by OPM classes 02 (return only), 03, and 11. Shuttle forward End-to-End Tests cannot be reconfigured.
8. Shuttle End-to-End Tests shall be supported only in the local mode.
9. EET EIRP calibration shall be performed during preservice testing.
10. There will only be one S-band (forward and return) and one K-band (forward and return) service per EET SHO. The EIRP of the return EET service shall not be reconfigured.
11. An End-to-End Test SHO which does not have a three minute Preservice Test period shall be rejected with a Problem Code 6 in OPM 51.
12. End-to-End Test for Ka services is not applicable. End-to-End Test SHO's for Ka services shall be rejected with an OPM 51 Problem Code of 18 (End-to-End Test SHO format error).
13. Shuttle End-to-End Test (EET) services (S-Forward, S-Return, K-Forward, K-Return) shall not be required simultaneously. These EET services shall be scheduled with separate EET SHO's.
14. In order to prevent RF interference with S-band Command and Telemetry, the following S-band EET frequency ranges are excluded:

EET Forward	2031 to 2041 Mhz
EET Return	2206 to 2216 Mhz

15. EET Forward and Return frequencies for non-coherent carrier services are constrained as follows:

$$[\text{Return Frequency} - (240/221)\ \text{Forward Frequency}] \leq 1\ \text{Mhz (S-Band)}$$

$$[\text{Return Frequency} - \left(\frac{1600}{1469}\right)\ \text{Forward Frequency}] \leq 1\ \text{Mhz (K-Band)}$$

Non-coherent Forward and Return carrier frequencies cannot be reconfigured by more than 1 MHz.

16. Forward EET services shall always be scheduled with Doppler compensation enabled. For Shuttle SSAF EET services, Doppler compensation of both carrier and PN rate shall be scheduled.
17. GRGT will support local end-to-end testing only.

18. In End-to-End Test SHOs the specified PN code shall be ignored. The following PN codes shall be used for End-to-End Test at WSC:

Service	Danzante PN Codes	Cacique/GRGT PN Codes
Multiple Access (MA)/S-Band MA (SMA)	39	26
S-Band Single Access (SSA)	40	27
K-Band Single Access (KSA)	41	28
K-Band Shuttle (KSH)	42	29
S-Band Shuttle (SSH)	3	2

Each TDRS will provide either MA or SMA services but not both, thus only one PN code is required. (See STDN 108 for more details on PN code).

2.2.4 Operations Message (OPM) Ground Rules

The following ground rules apply to operation messages:

1. A message (single or multiblock) shall not contain more than one OPM.
2. OPM's sent by the NCC to WSC~~STGT~~ which require processing shall be contained in one 4800-bit block message. OPM's which do not require processing (text messages) may contain 1 to 15 4800-bit blocks.
3. The reference to a SHO from a service-related OPM is by SHO ID, TDRS ID, and link ID (service support type and subtype).
4. An OPM received at the WSC~~STGT~~ which references a specific service is valid only for an ongoing service. An OPM which applies to all services in the referenced SHO (i.e., cancel SHO OPM) is valid at any time prior to the termination of the last service in the referenced SHO.
5. NASA has assigned the following numbers:

	SIC	VIC
Danzante~~STGT~~	1540	01
Cacique~~WSGTU~~	1373	01
GRGT	1375	01

6. A reacquisition OPM will be rejected if there is an inoperative status indication for any equipment in the string being used for that service and an OPM reject message will be sent to the NCC.
7. All outbound OPM's will be sent to the NCC without TOCC~~2~~ intervention.
8. MA OPMs apply to TDRS A-G only. KaSA and SMA OPMs apply to TDRS H-J only. Incorrectly received OPMs for TDRS capabilities shall be rejected.
9. Return Channel Time Delay (OPM-52) will not be provided for any scheduled GRGT support irrespective of the setting of the RCTD SHO parameter.

2.2.5 Operations Data Messages (ODM's) Ground Rules

The following ground rules apply to ODM's:

1. An ODM may consist of 1 to 15 4800-bit data blocks.
2. ODM's are sent to the NCC once every five seconds for ongoing (including End-to-End Test) services only.
3. The first ODM to report on a specific service will be sent within five seconds of the service support start time and the last message to report that service will be sent within five seconds of the service stop time.
4. Separate SA/SMAR, MA/SMAF and End-to-End Test ODMs will be used to report the active services for each TDRS. These ODMs shall not be combined within a single message.
5. An ODM does not require an acknowledgment of message received.
6. An End-to-End Test ODM can report data for up to 4 (two forward, and two return) End-to-End Test services.
7. When an End-to-End Test service is active, an End-to-End Test ODM shall be sent to the NCC in addition to any other SA or MA ODMs.
8. In ODM's, Radio Frequency (RF) beam-pointing data associated with a user are not reported when a End-to-End Test service (for the User) is ongoing. Instead, the RF beam-pointing data reported shall be derived from the simulated user being located at the respective WSC ground termial~~STGT~~.
9. In an ODM if a parameter is not applicable, then the value for the parameter will be set to ASCII space.
10. For SQPSK services in which alternate bits/symbols of the I and Q Channels are interleaved to form a single data channel, the Bit Error Rate (BER) status in the ODM's shall be reported under the I Channel.

Section 3. Interface Requirements

The messages exchanged on the WSCSTGT-NCC/FDF interfaces are constructed as 4800-bit data blocks (600 8-bit bytes). The 600 bytes which make up the 4800-bit data blocks are individually numbered in Figure 4-1.

Except as otherwise noted in detail diagrams or text, all characters or digits are ASCII. All numbers are expressed in decimal except as otherwise noted. Also, unless otherwise noted, in a horizontal format presentation, the most significant bit, byte or digit is leftmost and the least significant bit, byte or digit is rightmost in the diagrams. In a tabular format presentation, the most significant bit, byte or digit is at the top and the least significant bit, byte or digit is at the bottom. The message formats contained herein are presented relative to the manner that these data are contained in registers or computer memory sequential byte addresses. In sending messages from the WSCSTGT to the NCC/FDF or from the NCC/FDF to the WSCSTGT, order of transmitting a string of bytes (which make up the message) shall proceed from the most significant byte to the least significant byte, and the order of transmitting the bits of each byte (except TDMs for Johnson Space Center (JSC)) shall proceed from the most significant bit to the least significant bit.

Where messages contain date and/or time, the date is a decimal number, where January 1st = 001 and December 31 = 365 (or 366, during a leap year) and time is Greenwich Mean Time (GMT).Coordinated Universal Time (UTC). In message structures, the codes which are not shown are illegal and shall not be used. Where a code is shown as "not applicable" for a particular message, the characters will be set to an ASCII space (blank) or any other legal value. For example, the parameter for Command Channel Pseudonoise (PN) modulation is not applicable for forward data rates above 300 Kbps and that character must be set to an ASCII space or any other legal value. Also in cases where a parameter will not be used it must be set to ASCII space or any other legal value. For example, in a coherent return service the forward service frequency establishes the receive frequency and this parameter may be set to ASCII space (except for Shuttle).

In any case where a field is defined to have more characters than are being used, data is to be right-justified (unless otherwise specified). Whenever such a field is defined to contain numeric data, the unused characters at the left of the field are to be filled with ASCII zeroes (unless otherwise specified). Whenever such a field is defined to contain anything other than all numeric data, the unused characters at the left of the field are to be filled with ASCII blanks (unless otherwise specified).

3.1 Message Protocol

A message may consist of from 1 to 15 4800-bit blocks. Upon satisfactory receipt of a complete message requiring an acknowledgment, the Receiver will insert an acknowledgment of message received in a block pending transmission or a separate acknowledgment message will be sent at the next block transmission opportunity. Processing of a message shall not proceed until all blocks in a message are received successfully.

3.2 Data Block Integrity

For 4800-bit blocks transmitted between~~from~~ NCC and FDF and~~NASA to~~ the WSC~~STGT~~, the 22-bit remainder (for a 22-bit polynomial code), as described in Section 10, shall be used to detect transmission errors within a data block. The TDRSS header identifies the number and sequence of blocks within a multiblock message. The synchronization pattern of the network control header identifies the start of a 4800-bit block. Any block which fails the polynomial check shall not be used for computational purposes.

3.3 Transmission Control

The flag field in the TDRSS header of each 4800-bit block, as defined in Section 4, contains the transmission control bits. The "acknowledgment of message received" bit may be set in any block. The "last block" bit must be set in the last block of any multiblock message and in a single block message. The retransmission bit must be set in any and all blocks that are retransmitted. Transmission and reception of blocks within a multiblock message must occur in block number sequence. The flag bit to request acknowledgment of receipt of the message is set in the first block of a message. For messages that are retransmitted, the retransmission bit will be set and the receiver will verify that it has successfully received an earlier transmission of the message before dropping the retransmitted message. If the message has not been previously received, then the retransmitted message will be accepted. Messages transmitted without the retransmission bit set shall always be processed as though they were original message transmissions.

3.4 Error Handling

For each message sent, the Sender must indicate whether or not the Receiver is to acknowledge satisfactory receipt of the message. This is done by setting the proper bit in the protocol control flags. (See Section 6.5.)

If the Sender requests a message acknowledgment and does not receive the responding acknowledgment (contained in the acknowledgment subfield of a subsequent in-bound message) within five seconds of the completed message transmission, then the Sender shall set the retransmit flag in each block of the message and resend the entire message. Retransmitted messages shall be sent with at least equal transmission priority as original messages. The retransmitted message blocks shall have the original message ID, message type, block sequence numbers and block count. If the Sender fails to obtain a message acknowledgment for the retransmitted message within five seconds, the Sender shall send the message again. (This would be the third time that the message was sent.)

If at this point the Sender does not obtain a message acknowledgment within five seconds after resending the message, the Operator (TOCC~~2~~ or NCC) shall be notified.

Valid blocks received are retained at least 15 seconds from the time of receipt of the first block of a message. At the end of this time period, the message shall be discarded if all blocks have not been received.

Section 4. TDRSS/NASA 4800-Bit Block Structure

The structure of a 4800-bit data block is illustrated in Figure 4-1 in sequentially numbered 8-bit bytes. The byte numbers indicate the sending order of transmission. The byte numbers are also used to indicate the position and size of the primary and subordinate fields into which the 4800-bit data block is segmented.

The message field contains an acknowledgment subfield (except for Tracking Service Data Service messages; see Section 12) and a data subfield. The message field is variable length; it is made up from a selection of data items according to each message type and its required data content.

The organization of the 4800-bit block is shown in Table 4-1; the formats, coding, and orientation for the contents of the fixed fields (and subfields) are described, follow by the details for the structures and data items used in the variable subfields.

5. Network Control Header

5.1 Synchronization Field

Byte #	1	2	3	Fixed-Sync Pattern
	01100010	01110110	00100111	

First bit sent.

5.2 Interface Type Field

This field is used to distinguish tracking data from other messages (byte 5) and to provide a unique source/destination code (byte 4) for ~~the~~ Danzante and Cacique~~STGT/WSGTU~~. GRGT messages use the Cacique source/destination code. These fields are not used by ~~the~~ Danzante and Cacique~~STGT/WSGTU~~ on incoming messages.

Danzante
~~STGT~~

Byte #	4	5	6	Fixed code for:
Bits	10110110	01001111	00001011	Tracking Data
Bits	10110110	10001111	00001011	SHO, OPM, SLR, and ODM

Cacique/
GRGT~~W~~
~~SGTU~~

Byte #	4	5	6	Fixed code for:
Bits	11111001	01001111	00001011	Tracking Data
Bits	11111001	10001111	00001011	SHO, OPM, SLR, and ODM

This subfield contains a binary count of the number of 4800-bit data blocks in the message, up to a maximum of 15.

6.8 Message Field Size

10 bits

This subfield contains a binary count of the number of bytes in the message field of the 4800-bit data block. Except for Tracking Service Data ~~Service~~ messages, the message field contains an acknowledgment subfield of four bytes and a data subfield of up to 574 bytes. In all messages except tracking data messages, the acknowledgment of message received subfield is to be reserved to enable a response to a "request for acknowledgment" for messages satisfactorily received. Tracking data messages do not contain a message acknowledgment subfield. Therefore, the data subfield may contain up to 578 bytes.

Section 7. Time Field

Byte #	13	14	15	16	17	18

This field is required by NASA for optional insertion of a time tag; it is not required or used by WSCSTGT. For data blocks generated by the WSCSTGT, the entire time field shall be set to a logical one state.

Section 8. Error Control Field

Byte #	597	598	599	600
# of Bits	8	1	1	22

Polynomial remainder (Section 10)

Bit 4778 (~~NASA/~~GSFC-Block Error Detector (BED))
- 0 = Remainder checks OK.
- 1 = Remainder does not check OK.

Bit 4777 (WSC~~STGT~~)
- 0 = Remainder checks OK.
- 1 = Remainder does not check OK.

Spare - shall contain logical 1s.

9.2.1 SHO Header

The structure of the SHO header is:

Byte #	# of Bytes	Data Item
23-24	2	Message Type 1 = Tracking Data => 2 = SHO - Routine 3 = OPM (Operations) 4 = SLR (TDRSS Service Level Status) 5 = ODM (SA/SMAR Operations Data) 6 = ODM (MA/SMAF Operations Data) 7 = ODM (End-to-End Test Data) => 8 = SHO - Periodic
25-31	7	SHO ID SHO's shall be sequentially numbered: 1 to 9,999,999 to 1
32-33	2	SHO Class 1 = Normal 2 = Spare 3 = End-to-End Test 4 = Spare 5 = Spare 6 = High Data Rate Multiplexer (HDRM) from IFL (see subheader No. 6)
34-40	7	SUPIDEN - Code assigned by NASA - normal user
41-42	2	Vehicle Identification Code (VIC) - Code assigned by NASA - normal user
43-49	7	SUPIDEN - Code assigned by NASA - Shuttle
50-51	2	Vehicle Identification Code (VIC) - Code assigned by NASA - Shuttle
52-53	2	User Code Assignment - S-Band This subfield contains the code assigned for a user (STDN 108)*
54-55	2	User Code Assignment - K-Band This subfield contains the K-Band code assigned for a user (STDN 108)
56	1	Copy of Byte 53 This subfield contains the code assigned for a user (STDN 108)
57	1	SHO Source 0 = ~~NASA –~~NCC 1 = WSC~~TDRSS - TOCC2~~

* For Shuttle the least significant byte of the S-Band User Code Assignment applies.

Byte #	# of Bytes	Data Item
58-59	2	Number of Services Requested in this SHO This subfield indicates the number of services requested in this SHO. (1-16)
60-62	3	NASCOM/User Channel ID This subfield is for NASA use to identify a channel assignment at the NCC end of the NASA Communications Network (NASCOM) link. WSC~~STGT~~ does not use these data.
	40	

SHO Header Notes
Use the S-Band PN code for all S-Band services. Use the K/Ka-Band PN code for all K/Ka-Band services. Use SHO Subheader No. 3 to distinguish a Shuttle service from a normal user service.

S-Band and K/Ka-Band codes may be the same for a given user. Dual users (i.e., two users in the same SHO with S-Band services to one user and K/Ka-Band services to the other) shall be designated by a single unique SUPIDEN/VIC identified in SHO Header bytes 34-42. User vectors shall be provided for the SIC/VIC corresponding to this unique SUPIDEN/VIC. S and K/Ka-Band dual user services may be reconfigured in the same way as a single user. Dual user services apply to SSA and KSA/KaSA only.

9.2.2 SHO Subheaders

9.2.2.1 SHO Subheader No. 1: Service Type, Subtype, and TDRS ID

# of Bytes	Data Item
1	Service Support Type 0 = Forward 1 = Return 2 = Tracking 3 = Forward End-to-End Test 4 = Return End-to-End Test

# of Bytes	Data Item
2	Hours
2	Minutes
2	Seconds
1	Data Destination 1 = LI 2 = HDRM 3 = MDM 4 = Record Only 5 = Television (TV) - Shuttle Only 6 = Analog Data - Shuttle Only
1	LI 0 = Local MTRS Recorder Interface 1-4 Channel I.D. 100 BPS ≤ Data Rate ≤ 10 MBPS 5-8 Channel I.D. 10 MBPS < Data Rate ≤ 300 MBPS If Data rate is ≥ 150 MBPS, 5-8 specifies the service, i.e., no Q-Channel specified. A zero (0) shall be specified if the data destination is not LI.
1	HDRM 0 = Not used 1-4 Input Port Number If non-zero and SHO Class = 6, this is the HDRM input port for data which is received on the same High Data Rate Demultiplexer (HDRD) port. When SHO Class = 6 the SHO will contain only the SHO Header and Subheader 6. The same HDRM input ports at Danzante~~STGT~~ and Cacique~~WSGTU~~ shall not be simultaneously scheduled. A SHO Class 6 shall be sent to Cacique~~WSGTU~~ whenever the HDRM at Danzante~~STGT~~ is scheduled.
2	Port Address* 4 Hexadecimal Characters

* Applicable to MDM only.

9.2.3.15 End-to-End Test Data Set (See 9.2.3.17 for End-to-End Test SHO Structure)

9.2.3.15.1 Forward Data

# of Bytes	Data Item
3	SHO Subheader No. 1
22	SHO Subheader No. 2
70	SHO Subheader No. 6*
4	Spare
4	G/T of Simulated User (LSD = ± 0.1 dB/°K)
1	Local or DIS Data 0 = Local Signal Source 1 = MOC~~POCC~~ Signal Source
10	Spare
114	

* SHO Subheader 6 shall specify the return path for the user forward data in the MOC~~POCC~~ mode (1 = MOC~~POCC~~ Signal Source) and in the Local Signal Source mode (0 = Local Signal Source) if the local forward signal is to be sent to a MOC~~POCC~~. If the local forward signal is not sent to the MOC~~POCC~~, the SHO Subheader 6 Designation shall be set to ASCII "N".

9.2.3.15.2 Return Data

# of Bytes	Data Item
3	SHO Subheader No. 1
22	SHO Subheader No. 2
146	SHO Subheader No. 5*
4	EIRP of Simulated User (LSD = ± 0.1 dBw)
4	Spare
1	Local or DIS Data 0 = Local Signal Source 1 = MOC~~POCC~~ Signal Source 2 = Local Playback-I Channel 3 = Local Playback-Q Channel 4 = Local Playback-Shuttle Channel 3 5 = Local Playback-Shuttle Channel 2 6 = Local Playback-I and Q Channels 7 = Local Playback-Shuttle Channels 2 and 3
10	Spare
190	

* SHO Subheader 5 shall specify the forward path for the user return data in the MOC~~POCC~~ mode (1 = MOC~~POCC~~ Signal Source). For the modes in which the return data is locally generated (0 = Local Signal Source and 2 thru 7 = Local Playback) the SHO Subheader 5 Designation shall be set to ASCII "N". If the locally generated return data is to be sent to the MOC~~POCC~~, the return path shall be specified in Subheader 6 of the Return Parameters corresponding to the EET Data Set (see Section 9.2.3.17). If the locally generated return data is not sent to the MOC~~POCC~~, that Subheader 6 Designation shall be set to ASCII "N". If other channels are required with the Local Playback Channel, those channels shall be locally generated.

9.2.3.17 Example of an End-to-End Test SHO Structure

Note the placement of the End-to-End Test data sets. There must be a corresponding traffic service for each End-to-End Test service. This example shows three Forward and Return services with their End-to-End Test data sets. For Shuttle and all users requiring data to be sent to the MOC~~POCC~~, there shall be legitimate parameters in all fields of SHO Subheaders 5 and 6. End-to-End test data sets are not included when calculating the maximum number of services in a SHO.

Network Control Header	
TDRSS Header	
Time Field	
Acknowledgment Subfield	
SHO Header	
Forward No. 1	Fixed Parameters
	Reconfigurable Parameters
End-to-End Test Data Set for Forward No. 1	
Forward No. 2	Fixed Parameters
	Reconfigurable Parameters
End-to-End Test Data Set for Forward No. 2	
Forward No. 3	Fixed Parameters
	Reconfigurable Parameters
End-to-End Test Data Set for Forward No. 3	
Return No. 1	Fixed Parameters
	Reconfigurable Parameters
End-to-End Test Data Set for Return No. 1	
Return No. 2	Fixed Parameters
	Reconfigurable Parameters
End-to-End Test Data Set for Return No. 2	
Return No. 3	Fixed Parameters
	Reconfigurable Parameters
End-to-End Test Data Set for Return No. 3	
Tracking Data Set No. 1	
Tracking Data Set No. 2	
Tracking Data Set No. 3	
Filler (as required)	
Error Control Field	

~~Note: In End-to-End Test SHOs the specified PN code shall be ignored. The following PN codes shall be used for End-to-End Test at STGT:~~

~~Service~~	~~PN Code~~
~~Multiple Access (MA)/S-Band MA (SMA)*~~	~~39~~
~~S-Band Single Access (SSA)~~	~~40~~
~~K-Band Single Access (KSA)~~	~~41~~
~~K-Band Shuttle (KSH)~~	~~42~~
~~S-Band Shuttle (SSH)~~	~~3~~

~~* Each TDRS will provide either MA or SMA services but not both, thus only one PN code is required. (See STDN 108 for more details on PN code).~~

9.3 Message Subfield for OPM's

Within a 4800-bit data block, the data subfield starts at byte 23. For OPM's, bytes 23 through 34 contain the OPM Data Header, made up of the message type (OPM = 03) and the OPM identity (ID), source, and class. The remainder of the OPM is made up of a combination of data items, depending upon the class of the OPM. OPM's may be of variable message length (1 to 15 4800-bit data blocks) to accommodate special instruction textual messages.

9.3.1 OPM Header

The structure of the OPM header is:

Byte #	# of Bytes	Data Item
23-24	2	Message Type 1 = Tracking Data 2 = SHO - Routine => 3 = OPM (Operations Messages) 4 = SLR (TDRSS Service Level Status) 5 = ODM (SA/SMAR Operations Data) 6 = ODM (MA/SMAF Operations Data) 7 = ODM (End-to-End Test Data) 8 = SHO - Periodic
25-31	7	OPM ID The ID is a seven-digit number. OPM's shall be sequentially numbered: 1 to 9,999,999 to 1

Byte #	# of Bytes	Data Item
32	1	OPM Source 0 = ~~NASA -~~ NCC 1 = WSC~~TDRSS - TOCC2~~
33-34	2	OPM Class Paragraph 9.3.1.1 provides a list of OPM's by class code, referenced to sections following which provide specific information.
	12	

9.3.1.1 OPM's by Class

Reference Paragraph	Class Code:	Description
9.3.3		NCC OPM's
9.3.3.1	01	Special Instruction or Request
9.3.3.2	02	Reacquisition Request
9.3.3.3	03	Reconfiguration Request
9.3.3.4	04	Forward Link Sweep Request
9.3.3.5	05	Deleted
9.3.3.6	06	Forward Link EIRP Reconfiguration Request
9.3.3.7	07	Expanded User Frequency Uncertainty Request
9.3.3.8	08	Deleted
9.3.3.9	09	Test Message
9.3.3.10	10	Spacecraft State Vector
9.3.3.11	11	Doppler Compensation Inhibit Request
9.3.3.12	12	Cancel SHO Request
9.3.3.13	13	TDRS Maneuver Approval
9.3.3.14	14	Acknowledgment of Message Received
9.3.3.15	15	~~Emergency~~ Spacecraft State Vector

Reference Paragraph	Class Code:	Description
9.3.3.16	16	Deleted
9.3.3.17	17	Deleted
9.3.3.18	18	Delta-T Adjustment

Note: For a given user, consecutive OPMs requiring reconfiguration of support equipment shall not be sent to the WSC~~STGT~~ until (1) receipt of an OPM-62 for the previous OPM or (2) expiration of the maximum time to complete the action of the previous OPM. Note that OPM's for different users may arrive at the maximum line rate. If, for instance, multiple OPM's for different MA users on the same SGLT arrive consecutively, they shall be processed in order of arrival, with each OPM allowed its specified implementation period.

Note: OPM class codes 19 through 50 not used.

Reference Paragraph	Class Code:	Description
9.3.4		WSC~~STGT~~ OPM's:
9.3.4.1	51	SHO Status
9.3.4.2	52	Return Channel Time Delay (N/A to GRGT)
9.3.4.3	53	Preventive Maintenance (PM) Request
9.3.4.4	54	Special Request or Information
9.3.4.5	57	Service Terminated
9.3.4.6	59	TDRS Maneuver Request
9.3.4.7	60	Acknowledgment of Message Received
9.3.4.8	61	Spacecraft State Vector Rejection
9.3.4.9	62	OPM Status
9.3.4.10	63	Acquisition Failure Notification
9.3.4.11	64	Real-Time Mode
9.3.4.12	65	Delta-T Adjustment Rejection
9.3.4.13	66	Time Transfer
9.3.4.14	67	Stationkeeping/Momentum Dump Data

Note: OPM class codes 68 through 99 not used.

9.3.2 OPM Subheader

An OPM subheader is used when it is necessary to refer to a specific SHO (and service within that SHO) to complete the function of the OPM. This subheader, when used, follows immediately after the OPM header in byte positions 35 through 45 of a 4800-bit data block. This subheader structure and code is:

# of Bytes	Data Item
7	SHO ID
1	TDRS ID: A = TDRS 1300 B = TDRS 1301 C = TDRS 1302 D = TDRS 1303 E = TDRS 1304 F = TDRS 1305 G = TDRS 1306 H = TDRS 1307 I = TDRS 1308 J = TDRS 1309
1	Service Support Subtype 0 = MA 1 = SSA1 2 = SSA2 3 = KSA1 4 = KSA2 5 = SMA 6 = KaSA1 7 = KaSA2
2	MA/SMA Return Link ID (01-05) (Used to identify the specific MA/SMA Return service in the SHO. This field will be set to ASCII space if the service is not an MA/SMA Return.)
11	

9.3.3 NCC OPM's

9.3.3.1 Special Instruction or Requests, OPM - Class 01

This message shall be used to send free-form alphanumeric text from the NCC to WSC~~STGT~~. The WSC~~STGT~~ shall print this message and display it on a TOCC~~2~~ console. Only a TOCC~~2~~ operator uses this message; it is not used in automatic processing/control.

This OPM consists of one or more 4800-bit data blocks, the first of which contains an OPM header immediately followed by two bytes (35 and 36) which indicate the number of 4800-bit data blocks in the entire message. In any 4800-bit data block following this first one, the complete data subfield (bytes 23 through 596) may be used for alphanumeric text.

# of Bytes	Data Item
12	OPM Header
2	Number of 4800-bit data blocks
Variable	Free-form text field. The character set for free-form text messages is provided in Section 13.

9.3.3.2 Reacquisition Request, OPM - Class 02

The NCC shall send this message to WSC~~STGT~~ to initiate a reacquisition. Within 10 seconds of receipt of the return acquisition message and within 20 seconds of receipt of the forward reacquisition message, WSC~~STGT~~ shall complete the specified reacquisition procedure. This message structure is:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
1	Service Support Type: 0 = Forward 1 = Return
24	

9.3.3.3 User Reconfiguration, OPM - Class 03

In the event of a need to reconfigure equipment supporting a User spacecraft, the NCC will transmit a User reconfiguration message. WSC~~STGT~~ reconfiguration shall be completed within 35 seconds of receipt of the User reconfiguration message. User reconfiguration OPM's shall be used to accomplish the following functions:

a. Change mode of operation for DG1,

b. Change in data rate, data format, data bit jitter,

c. Initiation or termination of DG1 operation,

d. Initiation or termination of DG2 operation,

e. Initiation or termination of the command channel PN code,

f. Reinitiation of Forward link carrier Doppler compensation,

g. Reinitiation of Shuttle PN rate Doppler compensation,

h. Change in Forward and/or Return link carrier frequency,

i. Change of polarization,

9.3.3.4 Forward Link Sweep Request, OPM - Class 04

In the event of the inability to accurately define f_o for a user spacecraft resulting in a need to sweep the Forward link carrier frequency, the NCC will send this message. A Forward link sweep shall not impact simultaneous Doppler compensation of f_o as scheduled by the NCC. The Forward Link Sweep Request shall not be required for Shuttle S-band. Initiation of a Forward Link Sweep shall be completed within 10 seconds of receipt of this message. The message structure is:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
23	

9.3.3.5 Deleted

9.3.3.6 Forward Link EIRP Reconfiguration Request, OPM - Class 06

This OPM is used to set the SSA and KaSA/KSA EIRP to normal or high power. The TDRS shall complete this configuration within 10 seconds of receipt of this message. The message structure is:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
1	Power Mode: 0 = Normal 1 = High
24	

9.3.3.7 Expanded User Frequency Uncertainty Request, OPM - Class 07

If it is not possible to accurately predict the user transmit frequency for DG1, Mode 2, and DG2 (noncoherent turnaround), the NCC will transmit to the WSC~~STGT~~ an expanded user frequency uncertainty request. The TDRS shall complete the reconfiguration to accommodate the user transmit frequency uncertainty within 5 seconds of receipt of the request. An OPM-07 for a coherent service will be rejected with a Problem Code 8 in OPM-62. This OPM, when received and accepted, shall remain in effect for the remainder of the applicable service during reacquisition.

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
23	

9.3.3.8 Deleted

9.3.3.9 Test Message, OPM - Class 09

The NCC shall use this message to determine the availability of the NCC/Danzante or NCC/CaciqueSTGT communication channel. The acknowledge bit will be set. No processing other than acknowledgment is required. The Danzante or CaciqueSTGT Source/Destination code shall be used.

# of Bytes	Data Item
12	OPM Header

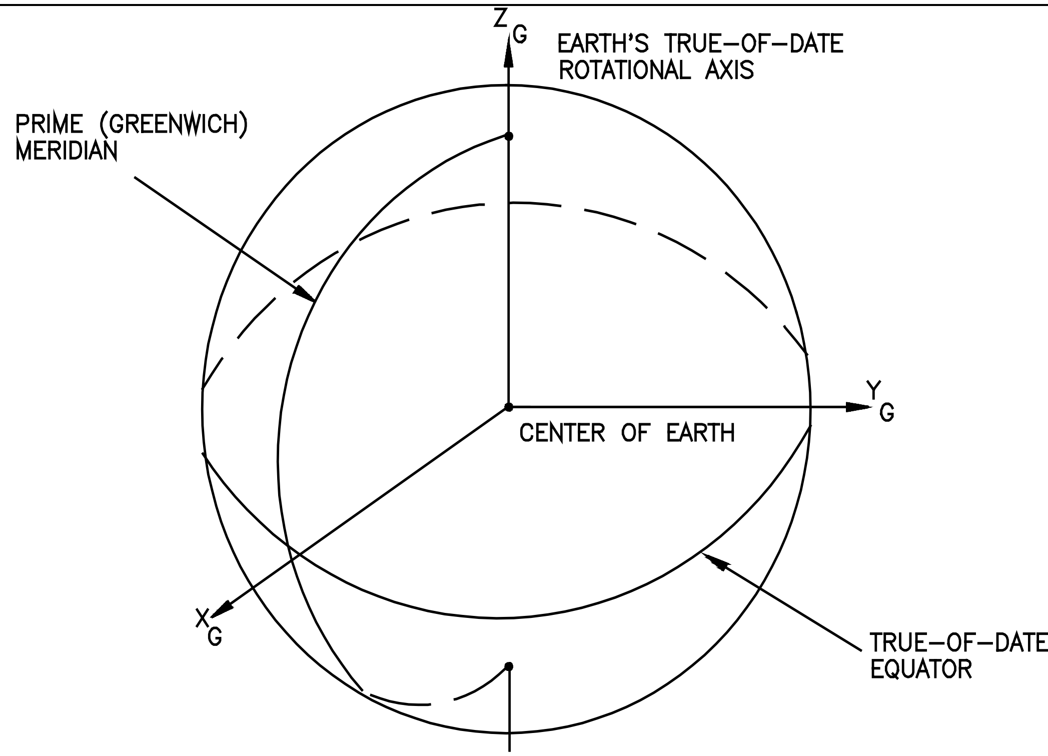
9.3.3.10 Spacecraft State Vector, OPM - Class 10

The NCC shall use this message to send TDRS and user spacecraft state vectors to the WSCSTGT. The message format used is a subset of the improved interrange vector (IIRV).

The Greenwich true-of-date rotating coordinate system, as shown in Figure 9-1, shall be used as the coordinate system for all the NCC-provided state vectors. The WSCSTGT shall perform the necessary transformation from the Greenwich true-of-date rotating NASA specified coordinate system to the coordinate systems used at the WSCSTGT.

The vehicle force model data consists of the user mass, and user average cross-sectional area. This data is received as part of the user state vector but is not applicable at WSCSTGT.

This space is intentionally left blank.



Name:	Greenwich True-of-Date ~~(Geographic)~~Rotating Coordinate System
Origin:	The Center of the Earth
Orientation:	The X_G-Y_G plane is the ~~e~~Earth's ~~T~~true-of-~~D~~date ~~E~~equator The Z_G axis is directed along the ~~e~~Earth's ~~T~~true-of-~~D~~date rotational axis and is positive north The $+X_G$ axis is directed toward the prime meridian The Y_G axis completes a right-handed system
Characteristics:	Rotating, right-handed, Cartesian. Velocity vectors expressed in this system are relative to a rotating reference frame fixed to the earth, whose rotation rates are expressed relative to the mean equator and equinox of ~~1950~~ J2000.0 system. True-of-date Greenwich implies reference to the instantaneous position of the equator and the prime meridian, not reference to an equator of a nearby epoch date. ~~NASA~~The FDF equations for rotation rate of the ~~e~~Earth* shall be used in relating spacecraft positions in True-of-Date coordinates to an inertial system for integration.

* A. C. Long, J. O. Cappellari, C. E. Velez, and A. J. Fuchs, "Mathematical Theory of the Goddard Trajectory Determination System," Revision 1,~~April 1976,~~ GSFC~~ x-582-76-77~~FDD/552-89/001.

Figure 9-1. Greenwich True-Of-Date ~~(Geographic)~~Rotating Coordinate System

The User spacecraft ephemerides are defined to be a series of state vectors. Ephemerides are differentiated from state vectors by vector type.

The data items marked with an asterisk(*) are included in this message structure in order to conform to the IIRV message format. WSC~~STGT~~ ~~is~~ does not require~~d~~ and does not use these data items.

# of Bytes	Data Item
12	OPM Header
	Start of State Vector Data
1	G (Fixed Code)
1	I (Fixed Code)
1	I (Fixed Code)
1	R (Fixed Code)
1	V (Fixed Code)
1	Delete character*
4	Destination ID (Assigned by NASA)*
2	Carriage return*
2	Line feed*
1	Vector Type: 1 = Free Flight 2 = Transition to Free Flight 3 = Not Used 4 = Ignition 5 = Burnout** 6 = Reentry 7 = Launch or on-orbit 8 = Stationary (for a ground-based User ~~--, including Null location~~also used in selected Shuttle and expendable launch vehicle support modes)
1	Source of data:* 1 = Type 1 2 = Type 2 3 = Type 3

* See last textual paragraph of 9.3.3.10.

** The type 5 vector is the last vector in a~~n unstable~~ maneuver sequence.

# of Bytes	Data Item
1	Transfer type (Fixed - set to "one")*
1	Coordinate system (Fixed - set to "one")*
4	User ID, Support Identification Code (SIC), assigned by NASA
2	User ID, Vehicle Identification Code (VIC), assigned by NASA Note: The combination of SIC and VIC will be unique for each user.
3	Vector Count*
	Time in UTC:
3	Day
2	Hour
2	Minute
5	Second (to 1 millisecond)
3	Checksum The contents of this field will be the arithmetic sum of bytes 49-73. In the arithmetic sum, the sign character (byte 52) is interpreted as a 1 for a minus character and a 0 for a space character.
2	Carriage Return*
2	Line Feed*
	Position Components ~~of Position~~:
13	X
13	Y
13	Z

* See last textual paragraph of 9.3.3.10.

# of Bytes	Data Item
	The contents of these fields will be the X,Y, and Z components, respectively, of position in meters resolved to one meter. The most significant byte will be the polarity indicator for each component. The minus character in these bytes will indicate a negative quantity, whereas the space character will indicate a positive quantity.
3	Checksum The contents of this field will be the arithmetic sum of bytes for X, Y, and Z. In the arithmetic sum, the sign byte is interpreted as a 1 for a minus character and a 0 for a space character.
2	Carriage Return*
2	Line Feed*
	Velocity Components ~~of Velocity~~:
13	$\dot{X}$
13	$\dot{Y}$
13	$\dot{Z}$ The contents of these fields will be the $\dot{X}$,$\dot{Y}$, and $\dot{Z}$ components, respectively, of velocity in meters/second resolved to one thousandth meter/second. The most significant byte will be the polarity indicator for each component, and ~~are~~ is defined the same as for the position components above.

* See last textual paragraph of 9.3.3.10.

# of Bytes	Data Item
3	Checksum The contents of this field will be the arithmetic sum of $\dot{X}$, $\dot{Y}$, and $\dot{Z}$. and is defined the same as the previous checksum. In the arithmetic sum, the sign byte is interpreted as a 1 for a minus character and a 0 for space character.
2	Carriage Return*
2	Line Feed*
8	User Mass*(not applicable at WSC) The contents of this field will be the mass of the user spacecraft in kilograms resolved to one tenth of a kilogram. The contents of this field will be zero when NASA requires that the solar radiation forces not be used for user orbit prediction.
5	User Average Cross-sSectional Area* (not applicable at WSC) The contents of this field will be the average cross-sectional area of the User spacecraft in meters squared resolved to one hundredth meter squared. The contents of this field will be zero when NASA requires that the solar radiation forces not be used for user orbit prediction.
4	User Drag Coefficient * (Nnot applicable at WSC) - Reserve for drag factor.* The User Mass and Average Cross-sectional Area apply to the user's force model.
8	User Solar Reflectivity Coefficient* (Nnot applicable at WSC) (Fixed - set to zeros)*
3	Checksum* The contents of this field will be the arithmetic sum of the bytes for the User Mass, and the User Cross-sSectional Area, the User Drag Coefficient, and the four bytes reserved for drag factor.User Solar Reflectivity Coefficient. In the arithmetic sum, the most significant sign byte is interpreted as a 1 for a minus character and a 0 for a space character.

* See last textual paragraph of 9.3.3.10.

NOTE

Forward link Doppler compensation may also be terminated by using a User Reconfiguration, OPM - Class 03, in which "Doppler Compensation Required" is set to "0 = No."

For Shuttle S-Band forward link service, Doppler compensation of the PN rate shall be terminated only upon receipt of a Doppler compensation inhibit request from the NCC.

The message format and fields in this Doppler compensation inhibit request OPM are defined as follows:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
1	Doppler Compensation Inhibit 0 = Other than SSA Shuttle 1 = Carrier only (SSA Shuttle) 2 = PN rate only (SSA Shuttle) 3 = Both carrier and PN rate (SSA Shuttle)
24	

9.3.3.12 Cancel SHO Request, OPM - Class 12

This message is used to request cancellation of either an ongoing or pending SHO. The message structure is:

# of Bytes	Data Item
12	OPM Header
7	SHO ID
19	

9.3.3.13 TDRS Maneuver Approval, OPM - Class 13

As a result of a TDRS maneuver request message from the WSC~~STGT~~, the NCC will transmit to WSC~~STGT~~ a message approving or denying the maneuver request. This message will be routed to the TOCC~~2~~ operator for action. The message structure is:

# of Bytes	Data Item
12	OPM Header
7	TDRS Maneuver Request, OPM ID
1	Approval Code: 0 = Approved 1 = Rejected
	New Start Time: The contents of this field provide a suggested TDRS maneuver start time that would be acceptable to the NCC~~NASA~~
2	Year
3	Day
2	Hour
2	Minute
2	Second
Variable	This is a free-form text field for comments

The character set for free-form text messages is provided in Section 13.

9.3.3.14 Acknowledgment of Message Received, OPM - Class 14

This message shall be sent to acknowledge receipt of a message. This message structure consists of only the OPM Message Header, since the "acknowledgment" subfield in the data subfield provides the ID of the message satisfactorily received.

# of Bytes	Data Item
12	OPM Header

9.3.3.15 Spacecraft ~~Emergency~~ State Vector, OPM - Class 15

The NCC shall use this message (or OPM-Class 10) to send ~~emergency~~ TDRS and user spacecraft state vectors to WSC~~STGT~~. This message structure is the same as that for the Spacecraft State Vector OPM - Class 10, except that the OPM class code in the OPM Header is 15.

9.3.3.16 Deleted

9.3.3.17 Deleted

9.3.3.18 Delta-T Adjustment, OPM - Class 18

This message shall be used by the NCC to adjust the epoch times ~~within State Vectors~~ of user state vectors resident at WSC. The structure of this message is:

# of Bytes	Data Item
12	OPM Header
4	User ID, Support Identification Code (SIC)
2	User ID, Vehicle Identification Code (VIC)
1	Sign 0 = Plus 1 = Minus (Delta-T)
5	Epoch Time ~~Period~~Adjustment, LSD = 1 Second (Delta-T)
24	

9.3.4 WSC~~STGT~~ OPM's

9.3.4.1 SHO Status OPM - Class 51

This message shall be used to inform the NCC of the status of a SHO. The structure of this message is:

# of Bytes	Data Item
12	OPM Header
7	SHO ID
1	SHO Status Code: 0 = Accepted 1 = Rejected 2 = Problem at SHO start 3 = (Spare) 4 = Problem with processing User or TDRS trajectory at SHO start
7	Conflicting SHO ID

# of Bytes	Data Item
2	Problem Code: 0 = No error 1 = Constraint on Service Start Time/SHO Receipt Time violation 2 = Unrecognizable parameter 3 = Parameter out of range 4 = No user ephemeris* 5 = Visibility check failure* 6 = Schedule conflict** 7 = Ground Antenna for TDRS not specified or designated TDRS not active 8 = Equipment not available* 9 = Acceleration exceeded (0.05 km/sec^2)* 10 = No TDRS ephemeris* 11 = SHO directory table overflow 12 = Duplicate SHO ID* 13 = Invalid User Configuration 14 = WSC ~~STGT~~ Software/Data Base Error 15 = Spare 16 = Altitude exceeded (40,000 km)* 17 = SHO duration too short or too long 18 = End-to-End Test SHO format error 19 = Spare
2	Service number within the SHO (1-16) (Note: A zero value denotes the problem is not related to a specific service.)
31	

* Will not cause SHO to be rejected. At SHO receipt, Status Code 0 will be used with Problem Codes 4, 10 and 12. Six minutes prior to SHO start, Status Code 2 will be used with Problem Code 8 and Status Code 4 will be used with Problem Codes 4,5,9,10, and 16. In the case of Problem Codes 5,9, and 16, SHO support will be provided. Problem Code 8 is used only when there is no equipment available at start of service. Problem Code 12 indicates SHO received with duplicate I.D. was not processed. SHO support of existing SHO will be provided.

** If Problem Code 6 indicates a conflict with an ongoing Pseudo SHO, the conflicting SHO ID will be ASCII blanks. If the Problem Code is not equal to 6, the Conficting SHO ID field will contain either ASCII blanks or the ID of the SHO for which the OPM-51 is being sent. This field should be ignored if Problem Code is not equal to 6.

9.3.4.2 Return Channel Time Delay, OPM - Class 52

When a SHO includes a request for return channel time delay data, this message shall be used to send the NCC that data. The return channel time delay data will be obtained at the start and stop of the return service, when equipment configuration changes, and at service reconfiguration. These data will be sent to the NCC after termination of the return service. This OPM will not be provided for any GRGT scheduled support. The message structure is:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
	Time delay at service start (LSB = 1 microsecond)
7	I Channel
7	Q Channel
7	Spare
	Time delay at service stop (LSB = 1 microsecond)
7	I Channel
7	Q Channel
7	Spare
	Interim Time Delays
2	Number of Time Delays to follow
9	Day, Hour, Minute, Second of Delay Time
	Time Delay (LSB = 1 microsecond)
7	I Channel
7	Q Channel
7	Spare
67+30n	Repeat last 30 bytes as required

9.3.4.3 Preventive Maintenance (PM) Request, OPM - Class 53

The WSC~~STGT~~ shall request preventive maintenance (PM) periods from the NCC one week in advance of the requested date by using a preventive maintenance request message. The format for this message is free-form text; the message structure is:

# of Bytes	Data Item
12	OPM Header
2	Number of 4800-bit data blocks
Variable	Data field for alphanumeric text. Unused characters shall be set to space. This data field length is limited to 560 bytes in the first 4800-bit data block and 574 bytes in each succeeding 4800-bit data block.

The character set for free-form text messages is provided in Section 13.

9.3.4.4 Special Request or Information, OPM - Class 54

This message shall be used to send free-form alphanumeric text from the WSC~~STGT~~ to the NCC. The message structure is:

# of Bytes	Data Item
12	OPM Header
2	Number of 4800-bit data blocks
Variable	Data field for alphanumeric text. Unused characters shall be set to space. This data field length is limited to 560 bytes in the first 4800-bit data block and 574 bytes in each succeeding 4800-bit data block.

The character set for free-form text messages is provided in Section 13.

9.3.4.5 Service Terminated, OPM - Class 57

This message is sent from the WSC~~STGT~~ to the NCC to notify the NCC of the termination of a service. The message structure is:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
1	Termination Reason: 0 = Normal completion of service 1 = Termination requested by OPM
1	Service Support Type: 0 = Forward 1 = Return 2 = Tracking 3 = Forward End-to-End Test 4 = Return End-to-End Test
7	Message ID of OPM or SHO which requested termination (set to blank if termination reason = 0)
	Termination Time
2	Year
3	Day
2	Hour
2	Minute
2	Second
43	

9.3.4.6 TDRS Maneuver Request, OPM - Class 59

When the WSC~~STGT~~ desires to perform a TDRS maneuver which might have an impact on providing service, approval must be requested from the NCC. The structure for this OPM message is:

# of Bytes	Data Item
12	OPM Header
1	TDRS ID A = TDRS 1300 B = TDRS 1301 C = TDRS 1302 D = TDRS 1303 E = TDRS 1304 F = TDRS 1305 G = TDRS 1306 H = TDRS 1307 I = TDRS 1308 J = TDRS 1309
1	Type of Maneuver: 0 = E/W Stationkeeping 1 = N/S Stationkeeping 2 = Satellite Repositioning
	Start -
2	Year
3	Day
2	Hour
2	Minute
2	Second
	Stop -
2	Year
3	Day
2	Hour

# of Bytes	Data Item
2	Minute
2	Second
Variable	Narrative field for comments (This alpha-numeric text field is limited to 538 bytes.)

9.3.4.7 Acknowledgment of Message Received, OPM - Class 60

In the event that there is no other pending message to be sent, this message shall be sent to acknowledge receipt of a message. This message structure consists of only the OPM header, since the "Acknowledgment" subfield in the data subfield provides the ID of the message satisfactorily received.

# of Bytes	Data Item
12	OPM Header

9.3.4.8 Spacecraft State Vector Rejection, OPM - Class 61

Upon receipt of a state vector, WSC~~STGT~~ performs checks. If any of these checks should result in the detection of an unusable state vector, this rejection OPM will be sent to the NCC. The message structure is:

# of Bytes	Data Item
12	OPM Header
4	User ID, Support Identification Code (SIC)
2	User ID, Vehicle Identification Code (VIC)
7	OPM ID (ID of the OPM - Class 10 or 15) of the rejected state vector message
	Epoch Time of the Rejected State Vector:
3	Day
2	Hour
2	Minute
5	Second (LSD = 1 millisecond)

# of Bytes	Data Item
1	Problem Code: 0 = Checksum Error 1 = Maneuver Vector out of sequence 2 = User state vector epoch time check failed 3 = Syntax error 4 = Maximum number of vectors for a single User exceeded 5 = ~~Maximum number of vectors for STGT exceeded~~ Spare 6 = Vector Magnitude < 6356 kilometers 7 = No Type 2 or 8 8 = Invalid Earth Station Vector Type 9 = Spare

9.3.4.9 OPM Status, OPM - Class 62

OPM's received from the NCC will be checked for validity. If any of these validity checks should result in the detection of an erroneous OPM, an OPM status message will be sent to the NCC with a Problem Code from the list below.

For certain OPM classes, an acceptance message with the Problem Code set to zero will be sent, acknowledging receipt of an OPM without detected errors. These OPM classes are:

2	Reacquisition*
3	Reconfiguration*
4	Forward Link Sweep*
6	Forward Link EIRP Reconfiguration
7	Expanded User Frequency Uncertainty*
11	Doppler Compensation Inhibit*
12	Cancel SHO

The message structure is:

# of Bytes	Data Item
12	OPM Header
7	OPM ID of bad OPM message
2	OPM class code of bad message

* OPM-62 will be transmitted to the NCC upon completion of these actions at the WSC~~STGT~~.

9.3.4.11 Real-Time Mode, OPM - Class 64

WSC~~STGT~~ shall use this OPM to notify the NCC when a user enters and exits the Real-Time Mode. This OPM shall also be used to inform the NCC that a Real-Time maneuver sequence was interrupted and WSC~~STGT~~ generated a type 2 or 8 vector.

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
1	1 = Real-Time Mode (enter) 2 = Normal Mode (exit) 3 = Real-Time Sequence interrupted
24	

9.3.4.12 Delta-T Adjustment Rejection, OPM - Class 65

This message shall be used by WSC~~STGT~~ to advise the NCC that a requested Delta-T adjustment has not been implemented. The structure of this message is:

# of Bytes	Data Item
12	OPM Header
4	User ID, Support Identification Code (SIC)
2	User ID, Vehicle Identification Code (VIC)
7	OPM ID (ID of the rejected Delta-T adjustment, OPM-Class 18)
1	Problem Code: 1 = Spare 2 = Delta-T adjustment greater than the maximum (11 hours 59 minutes 59 seconds) allowed 3 = Syntax Error
26	

# of Bytes	Data Item
1	Message Source 0 = Danzante~~STGT~~ 1 = Cacique/GRGT~~WSGTU~~
2	Message Class 67
4	TDRS SIC (1300-1399)
1	Activity 0 = Stationkeeping 1 = Momentum Dump
	Planned Start Time
3	Day
2	Hour
2	Minute
2	Second
	Planned Stop Time
3	Day
2	Hour
2	Minute
2	Second

Stationkeeping Information (Zeros if momentum dump)

# of Bytes	Data Item		
	Predicted Thruster Configuration		
4	1)	ID #1	(+/-,A-Z,0-9,A-Z)
4	2)	ID #2	(+/-,A-Z,0-9,A-Z)
4	3)	Spare	(Zeros)
4	4)	Spare	(Zeros)
	Predicted Delta Velocity (ft./sec.)		
8	1)	Body R	(+/-00.0000 to +/-99.9999)
8	2)	Body I	(+/-00.0000 to +/-99.9999)
8	3)	Body C	(+/-00.0000 to +/-99.9999)

Momentum Dump Information (Zeros if stationkeeping)

1	Dump Type 0 = roll/yaw 1 = pitch

# of Bytes	Data Item		
	Predicted Thruster Configuration		
4	1)	ID #1	(+/-,A-Z,0-9,A-Z)
4	2)	ID #2	(+/-,A-Z,0-9,A-Z)
4	3)	Spare (Zeros)	
4	4)	Spare (Zeros)	
	Predicted Pulse		
2	Count (00-99)		
	Predicted Start Momentum (Newtons/sec^2)		
5	1)	Hx	(± 0.00 to ± 1.00)
5	2)	Hy	(± 0.00 to ± 1.00)
5	3)	Hz	(± 0.00 to ± 1.00)
	Predicted Stop Momentum (Newtons/sec^2)		
5	1)	Hx	(± 0.00 to ± 1.00)
5	2)	Hy	(± 0.00 to ± 1.00)
5	3)	Hz	(± 0.00 to ± 1.00)
	Predicted Momentum Wheel		
7	1)	Delta RPM Sum	(± 000.00 to ± 999.00)
7	2)	Delta RPM Difference	(± 000.00 to ± 999.00)
140			

9.4 Message Subfield for SLR's (Service Level Status Report)

The WSC~~STGT~~ service level status information shall be sent from the WSC~~STGT~~ to the NCC in the form of service level status report (SLR's) as changes in equipment status occur or as requested verbally by the NCC. The service level status information for GRGT will be provided within Cacique SLRs in the SGLT 3 Service Chains and the End-to-End 3 Ground Antenna data items. The GRGT 11-m ground antenna service level status information will be provided using an OPM-54.

9.4.1 SLR Header

The SLR provides the service availability of each WSC ground terminal~~the STGT~~ to the NCC for user service scheduling. SLR's shall be sent to the NCC (1) upon verbal request from the NCC, (2) upon change in any reported parameter within 15 minutes of the change.

SLR (Cont.)

(Byte #s)	(# of Bytes)	Data Item		
		SGLT 1 Service Chains		
		TT&C Chains		
87-88	2	Command (CMD)	N,C/0,1,2	
89-90	2	Telemetry (TLM)	N,C/0,1,2	
91-92	2	Range	N,C/0,1,2	
		SGLT 2 Service Chains		
93-141		(Repeat of 49 bytes of SGLT 1)		
		SGLT 3 Service Chains		
142-190		(Repeat of 49 bytes of SGLT 1)		Represents GRGT SGLT status within a Cacique SLR
		Ground Terminal~~STGT~~ Antennas		
191-192	2	North	N,C/0,1	1 = Available
193-194	2	Central	N,C/0,1	0 = Unavailable
195-196	2	South	N,C/0,1	North, Central and South
197-198	2	End-to-End 1	N,C/0,1	refer to K-Band availability only.
199-200	2	End-to-End 2	N,C/0,1	
201-202	2	End-to-End 3	N,C/0,1	Represents GRGT EET antenna status within a Cacique SLR
		DIS and CTFS		
203-206	4	Multiplexer (MUX) (P)	N,C/000-075	000-0XX = number available
207-210	4	MUX (R)	N,C/000-075	
211-214	4	GSFC DEMUX (P)	N,C/000-030	
215-218	4	GSFC DEMUX (R)	N,C/000-030	
219-222	4	JSC DEMUX (P)	N,C/000-030	
223-226	4	JSC DEMUX (R)	N,C/000-030	
227-228	2	HDR MUX	N,C/0,1,2	
229-230	2	HDR DEMUX	N,C/0,1,2	
231-232	2	X MUX (Cross Strap Mux)	N,C/0,1,2	
233-235	3	LOR DEMUX	N,C/00-10	
236-237	2	A/B Switch (GSFC)	N,C/0,1	
238-239	2	A/B Switch (JSC)	N,C/0,1	

SLR (Cont.)

(Byte #s)	(# of Bytes)	Data Item	
		ETRO	
322-332+7n	11	ETRO/Byte 1	N,C/d,d,d,h,h,m,m/xxx
.	.	.	.
.	.	.	.
322-332+7n+11(m-1)	11	ETRO/Byte m	N,C/d,d,d,h,h,m,m/yyy

Notes:

(1) Affected SHO's are those which were in the ~~STGT~~ integrated schedule but can no longer be supported because of an equipment failure. Only those SHO's whose earliest start time is earlier than the ETRO are affected SHO's. Receipt of new SHO's which are affected will also generate SLR's.

(2) Estimated Time of Return to Operation (ETRO)/Byte is the estimated time of day to restore to operation the service or equipment whose first byte number is specified. If both P&R are unavailable, ETRO is the time to restore one (1) service or equipment. ETRO's will be listed in order of ascending byte numbers.

(3) P = Prime R = Redundant

(4) The SLR sent upon request from the NCC shall be the last previously sent SLR.

(5) Secure/GSFC and other GT include MUX/DEMUX, BED and Security Equipment.

(6) DIS ADPE, BACKBONE Local Area Network (LAN), Secure/GSFC or Common Time and Frequency System (CTFS) unavailable implies no NCC schedulable services from ~~STGT~~the respective ground terminal.

(7) Low Rate Black Switch (LRBS) unavailable implies no data via the MDM.

(8) High Rate Black Switch (HRBS) unavailable implies no LI data >10 Mbps and no non LI data >7 Mbps.

(9) ETRO's will be updated (new SLR) 10 minutes prior to their expiration.

(10) When redundant ADPE are in the Maintenance and Software Delivery Mode (MSM), they are considered to be available for user service.

(11) Affected SHO's will be deleted from the SLR's (new SLR sent) at the SHO stop time.

(12) All parameters are reported in each SLR.

(13) A/B Switch (GSFC) = 0 implies no output from X MUXs and no input from GSFC DEMUXs.

9.5 Message Subfield for ODM's

The message subfield of the 4800-bit data block (bytes 23 through 596) shall be used to send operation data messages (ODM's). These messages shall be sent from WSCSTGT to the NCC once every five seconds. The staleness of the data provided at the DIS interface shall not exceed five seconds relative to the time that the data were acquired. The time tag in the ODM's shall be the time at which the data in the ODM were acquired. ODM's shall be sent from WSCSTGT to the NCC only for ongoing services.

An ODM consists of a header followed by a combination of subheaders and structured data items, to indicate each specific service and provide the related data.

For TDRS H, I, and J S-Band MA return service (SMAR) ODM's shall be provided within SA ODM formats while S-Band MA forward service (SMAF) ODMs shall be provided within MA ODM formats.

Separate SA/SMAR, MA/SMAF, and End-to-End Test ODM's are used to report on the active services for each TDRS. Therefore, if three TDRS's are providing both SA/SMAR and MA/SMAF services, six ODM's are required to report these operations data.

Angles 1, 2, and 3 in the following ODM headers provide the orientation of the corrected local TDRS body coordinate system relative to the NASA-definedTDRS reference coordinate system. The corrected local TDRS body coordinate system is the spacecraft body coordinate system with the has its origin at the spacecraft center-of-mass, the Z-axis along the spacecraft longitudinal centerline and pointing toward the Earth, the Y-axis parallel to the solar array rotational axis and pointeding toward the SGL antenna side of the spacecraft, and the X-axis completing the right-handed set. The NASA-definedTDRS reference coordinate system is the spacecraft attitude reference coordinate system with the its origin at the spacecraft center of mass, the Z-axis in the orbit plane pointed toward nadirthe center of the Earth, the X-axis in the orbit plane pointed in the direction of spacecraft orbital motion, and the Y-axis completing the right-handed set. These angles transform the attitude TDRS reference coordinates to local TDRS body coordinates, given by the following order of rotations: Angle 1 (yaw), a rotation about the Z-reference-axis; angle 2 (roll), a rotation about the resultant X-axis; and angle 3 (pitch), a rotation about the resultant Y-axis. The orientation of the corrected local TDRS body coordinate system (body coordinates) relative to the NASA-definedTDRS reference coordinate system (attitude reference coordinates) will be provided to an accuracy of 0.1° in pitch and roll and 0.25° in Yyaw.

RF beam pointing data in the ODM's provide the orientation of the RF beam relative to the TDRS orientation. The angles to be reported shall be derived from the TDRS to user vector from which MA beamforming data was derived. The RF beam pointing parameters will be given as rotation angles from the spacecraft local TDRS body coordinate system in the following order: Azimuth, a rotation about the Y-body-axis; and Elevation, a rotation about the resultant X-axis. The RF beam pointing shall be provided to an accuracy of 0.5° for SA and 2.0° for MA.

The DIS provides only Shuttle forward DQM ODM data. For TDRS F1-F7, TDRS orientation and RF beam pointing are provided by TTC for all applicable ODMs except for MA return service (provided by USS). All other data is provided by USS.

Section 12. Tracking Service Data

12.1 Tracking Service Data Format

12.1.1 General

The user spacecraft tracking service data parameters identified in Table 12-1 of this section shall be transmitted from each WSC ground terminal~~the STGT~~ to the FDF, JSC and LI. The TDRS tracking service data parameters identified in paragraph 12.1.5 shall be transmitted from each WSC ground terminal~~the STGT~~ to the FDF. The staleness of data provided by the SGLT at the DIS shall not exceed five seconds relative to the time of measurement.

Each tracking data sample shall be formatted in accordance with the NASA Universal Tracking Format. All tracking data messages shall consist of one or more standard TDRSS~~NASA/STGT~~ 4800-bit blocks, with each block containing at least one tracking data sample in the data field of the block.

Formatting the tracking data for transmission requires generating a 4800-bit block which consists of a network control header, a TDRSS header for FDF and LI TDMs, a unique TDRSS header for JSC TDMs, a time field, a data field, and an error control field. The bytes of the tracking data samples for JSC TDMs shall be formatted LSB first. The time field and the error control field shall be set to a logical one state by the SGLT. The format of the unique TDRSS header for TDMs destined for JSC is shown below:

Bit						Bit
49	01_{16}				01_{16}	64
65	Message Type - MSB 213				01_{16}	80
81	0	0	0	Number of Bits in Data Field		96

Table 12-1 defines the message format and fields for the TDRSS user~~STGT~~ tracking service data message.

12.1.2 Tracking Data Destination

All user tracking data shall be sent to the LI. All user tracking data, designated by predefined Support Identification Codes (bytes 7-8 of Table 12-1), shall be sent to the FDF and JSC and shall be logged. TDRS tracking data (defined in paragraph 12.1.5) shall be sent to the FDF and LI. Tracking data sent to the LI shall not be recorded.

12.1.3 Ground Rules

The following ground rule applies to tracking service data messages:

a. Acknowledgment of message receipt from the FDF is not required.

12.1.4 Data Field Description

A description of each data field in the tracking sample is given below:

a. Message Leader. Bytes 1-5 are constants used to conform to the NASA Universal Tracking format.

b. Current Year. The contents of this field (byte 6) shall be the two least significant digits of the current year. The Least Significant Bit (LSB) equals 1 year.

Table 12-1. TDRSS User Tracking ~~Data~~ Service Data Format

BYTE	BYTE FORMAT	# OF BITS	BYTE CONTENTS
1	HEXADECIMAL	8	OD$_{16}$
2	HEXADECIMAL	8	OA$_{16}$
3	HEXADECIMAL	8	O1$_{16}$
4	HEXADECIMAL	8	41$_{16}$
5	HEXADECIMAL	8	41$_{16}$
6	BINARY	8	CURRENT YEAR
7-8	BINARY	16	SUPPORT IDENTIFICATION CODE (SIC)
9-10	BINARY	16	VEHICLE IDENTIFICATION CODE (VIC)
11-14	BINARY	32	TIME TAG (SECONDS OF YEAR)
15-18	BINARY	32	TIME TAG (MICROSECONDS OF SECOND)
19-22	BINARY	32	RETURN LINK GROUND ANTENNA ANGLE AXIS NO. 1 (AZIMUTH)
23-26	BINARY	32	RETURN LINK GROUND ANTENNA ANGLE AXIS NO. 2 (ELEVATION)
27-32	BINARY	48	RANGE (ROUND TRIP LIGHT TIME)
33-38	BINARY	48	DOPPLER COUNT
39-40	HEXADECIMAL	16	00$_{16}$ (EACH BYTE)
41-44	BINARY	32	REFERENCE FREQUENCY
45	HEXADECIMAL	8	60$_{16}$
46	BINARY	8	FORWARD LINK GROUND ANTENNA I.D.
47	HEXADECIMAL	8	60$_{16}$
48	BINARY	8	RETURN LINK GROUND ANTENNA I.D.
49	BINARY	8	TDRS I.D.'s (FORWARD AND RETURN LINK)
50	BINARY/DISCRETE	8	MA RETURN LINK I.D., TDRS TRACKING DATA ONLY INDICATOR, TRACKING SERVICE CONFIGURATION
51	DISCRETE	8	DATA VALIDITY
52	HEXADECIMAL	8	FREQUENCY BAND AND SERVICE TYPE

Table 12-1. TDRSS User Tracking ~~Data~~ Service Data Format (Cont'd)

BYTE	BYTE FORMAT	# OF BITS	BYTE CONTENTS
53-54	HEXADECIMAL/ DISCRETE/BINARY	16	TRACKER TYPE, END OF TRACK, AND SAMPLE RATE
55	DISCRETE/BINARY	8	SERVICE LINK I.D., SINGLE ACCESS TDRS/GROUND TERMINAL CARRIER FREQUENCY I.D., TDRS AND RF BEAM ORIENTATION DATA VALIDITY
56	DISCRETE/BINARY	8	NASA GROUND-BASED TDRS TRACKING DATA TRANSPONDER I.D., USER BIT RATE INDICATOR
57-62	BINARY	48	TDRS ORIENTATION
63-68	BINARY	48	TDRS RF BEAM ORIENTATION
69	BINARY	6	STATUS BITS FOR PN LOCK, CARRIER LOCK, DOPPLER COMPENSATION, SGLT, SA EQUIPMENT STRING
69	BINARY	2	00_{16}, SPARE BITS
70-72	HEXADECIMAL	24	00_{16} (EACH BYTE), SPARES
73	HEXADECIMAL	8	04_{16}
74	HEXADECIMAL	8	OF_{16}
75	HEXADECIMAL	8	OF_{16}

c. Support Identification Code. The contents of this field (bytes 7-8) shall be the SIC, or the Support Identification Code of the TDRS providing the return link service when the user is a NASA ground-based transponder. The SIC will be assigned by NASA.

d. Vehicle Identification Code. The contents of this field (bytes 9-10) shall be the vehicle identification code assigned by NASA. The combination of SIC and vehicle identification code will be unique for each user or TDRS as described in c. above.

e. Time Tag. The contents of these fields shall be a multiple of the sample rate and shall be the seconds of year (bytes 11-14) and the microseconds of the second (bytes 15-18). Time for seconds of the year is referenced to 00:00:00.0 January 1 of the current year. The LSB of byte 14 equals one second. The LSB of byte 18 equals one microsecond.

f. Return Link Ground Antenna Angle. The contents of these fields (bytes 19-22 and bytes 23-26) shall be the ground antenna angles associated with the return link providing the tracking service. Azimuth shall be measured in the local horizontal plane positive clockwise from north. The local horizontal plane is defined to be perpendicular to the local gravitational vertical. Elevation shall be measured positive above local horizontal. The resolution of each angle shall be 0.0055°. These angles shall be reported to the FDF with an uncertainty $\leq$ 0.03°. The angles in both fields shall be represented by fractions of a circle. For both fields, the LSB equals $360.\overline{0}^\circ \text{x} 2^{-32}$ and the Most Significant Bit (MSB) equals $180.\overline{0}^\circ$. Bytes 19-22 shall contain azimuth. Bytes 23-26 shall contain elevation.

g. Range. The contents of this field (bytes 27-32) shall be the range measurement (round trip light time) to a resolution of one nanosecond. The LSB of this field equals 2-8 nanosecond.

h. Doppler Count. The contents of this field (bytes 33-38) shall be the count of the Doppler counter. The LSB of this field equals one cycle of the biased Doppler signal (240.$\bar{0}$ MHz + 1000 fd for S-Band and 240.$\bar{0}$ MHz + 100 fd for Ku-Band). The count shall be cumulative for the duration of the tracking service.

i. Byte 39. Constant (00_{16}).

j. Byte 40. Constant (00_{16}).

k. Reference Frequency. The contents of this field (bytes 41-44) shall be the frequency used for Doppler extraction. The LSB of this field equals 10 Hz, which is the required resolution of the reference frequency.

The tracking reference frequency shall be included in all tracking data frames, regardless of the range and Doppler validity status. During periods of Doppler compensation, the frequency provided shall be the current actual frequency, applicable within 0.1 seconds of the tracking frame time tag. If Doppler compensation is not required, the tracking reference frequency shall be available at least 2 seconds before the scheduled service start.

l. Byte 45. Constant (60_{16}).

m. Forward Link Ground Antenna ID. The contents of this field (byte 46) shall be the WSC~~STGT/WSGTU~~ ground antenna ID associated with the TDRS which is providing the forward link for the tracking service. The ground antenna IDs as defined by NASA are:

Danzante~~STGT~~ ID	Cacique~~WSGTU~~ ID	GRGT ID	Ground Antenna
0	0	0	None (for one-way tracking service)
47	9	94	North antenna
48	10	N/A	Central antenna
49	11	N/A	South antenna
25	33	N/A	S-Band antenna

n. Byte 47. Constant (60_{16}).

o. Return Link Ground Antenna ID. The contents of this field (byte 48) shall be the WSC ~~STGT/WSGTU~~ ground antenna ID associated with the TDRS which is providing the return link for the tracking service. The ground antenna IDs are:

Danzante~~ST GT~~ ID	Cacique~~WS GTU~~ ID	GRGT ID	Ground Antenna
47	9	94	North antenna
48	10	N/A	Central antenna
49	11	N/A	South antenna
25	33	N/A	S-Band antenna

p. TDRS IDs. The contents of this field (byte 49) shall be the 4-bit identification of the TDRS providing the forward link and 4-bit identification of the TDRS providing the return link for the tracking service.

NASA has defined a unique Support Identification Code (SIC) for each TDRS as follows:

TDRS-A : 1300
TDRS-B : 1301
TDRS-C : 1302
. .
. .
. .
TDRS-J : 1309

The WSC~~STGT~~ shall perform a transformation from the SIC to a unique 4-bit code for each TDRS. The transformation shall be:

SIC minus 1299 equals unique 4-bit TDRS ID:

TDRS-A : 1
TDRS-B : 2
TDRS-C : 3
. .
. .
. .
TDRS-J : 10

The contents of this field shall be as defined below:

Field Location	Contents
Bits 5-8	Forward link TDRS ID, 0_{16} shall indicate forward link not supporting. The LSB is Bit 5.
Bits 1-4	Return link TDRS ID, 0_{16} will not be used. The LSB is Bit 1.

q. MA Return Link ID, TDRS Tracking Data Only Indication, and Tracking Service Configuration. The contents of this field (byte 50) shall be an identification of the MA return link supporting the tracking service, an indication if <u>the WSC ground terminal</u>~~STGT~~ is providing tracking service to the NASA ground-based TDRS tracking data transponders that are identified in byte 56, and the configuration of the tracking service.

The contents of this field shall be as defined below:

Field Location	Contents		
Bits 4-8	MA return link ID; binary ID of the MAR equipment string (including receiver), providing the tracking service. Binary zero shall indicate MA return link not supporting. The LSB is Bit 4.		
Bit 3	TDRS tracking data only indication. Bit 3 is zero when: 1309 < User SIC < 1373; otherwise: Bit 3 is one.		
Bits 1-2	Tracking service configuration		
	<u>Bit 2</u>	<u>Bit 1</u>	
	0	1	Return link only (no forward link established to user)
	1	0	Forward and return link established by this TDRS
	1	1	Spare
	0	0	Spare

r. Data Validity. The contents of this field (byte 51) shall indicate the validity of the contents of the range field (bytes 27-32), the Doppler count field (bytes 33-38), and the return link antenna angle fields (bytes 19-26).

Two-way Doppler data is valid if:

1. Associated receiver has indicated carrier track at each sample point (once/second) throughout last tracking sample period.
2. Forward Doppler is per the following three cases: Case 1: Forward Doppler compensation has been inhibited i.e., the slow and hold function has been completed and the forward frequency is fixed. Case 2: Same as Case 1, except for DG-1. Doppler compensation is not a factor for validity in the DG-1 mode. Case 3: Doppler compensation is not a factor for validity in any mode. Cases are set by TOCC~~2~~ operator for individual users.
3. The associated IR is not exhibiting a fault indication.

Field Location	Contents
Bit 3 Bit 2 Bit 1	Return Link ID and TDRS/GT Carrier Frequency ID
0 0 0	Spare
0 0 1	SA Link 1, TDRS/GT Carrier Frequency 1
0 1 0	SA Link 2, TDRS/GT Carrier Frequency 1
0 1 1	MA
1 0 0	Spare
1 0 1	SA Link 1, TDRS/GT Carrier Frequency 2
1 1 0	SA Link 2, TDRS/GT Carrier Frequency 2
1 1 1	Spare

v. NASA Ground-Based TDRS Tracking Data Transponder ID and User Bit Rate (BR) Indicator. The contents of this field (byte 56) shall be the identification of the NASA ground-based tracking data transponder which ~~NASA~~ will be utilized to obtain TDRS tracking data, and an indicator to designate the telemetry bit rate group of the user for which the return link service is being provided. When support is to a ground-based transponder, the SGLT shall perform a transformation from SIC to unique code for this field. The transformation shall be: If 1309 < SIC < 1373 this field is set to SIC minus 1309. Otherwise this field is set to 00.

The contents of this field shall be as defined below:

Field Location	Contents
Bit 8 Bit 7	User BR
0 0	5000 bps < BR
0 1	1000 bps < BR $\leq$ 5000 bps
1 0	500 bps < BR $\leq$ 1000 bps
1 1	BR $\leq$ 500 bps
Bit 1-6	Bits 1-6 shall be zero when: 1309 $\geq$ User SIC, or User SIC $\geq$ 1373 Otherwise: Bits 1-6 shall contain the results of subtracting 1309 from the User SIC

w. TDRS Orientation. The contents of this field (bytes 57-62) shall be the orientation of the ~~corrected~~ local TDRS body coordinate system relative to the ~~NASA defined~~TDRS reference coordinate system for the TDRS providing the return link for the tracking service.

The ~~corrected~~ local TDRS body coordinate system has its origin at the spacecraft center-of-mass, the Z-axis along the spacecraft longitudinal centerline~~,~~ and pointing toward the Earth, the Y-axis parallel to the solar array rotational axis and pointe~~d~~ing toward the SGL antenna side of the spacecraft, and the X-axis completing the right-handed set. The ~~NASA defined~~ TDRS reference coordinate system has its origin at the spacecraft center-of-mass, the Z-axis in the orbit plane pointed toward ~~nadir~~the center of the Earth, the X-axis in the orbit plane pointed in the direction of spacecraft orbital motion, and the Y-axis completing the right-handed set.

The TDRS orientation parameters will be given as Euler angles transforming the ~~NASA defined~~ TDRS reference coordinate system to the ~~corrected~~ local TDRS body coordinate system, given by the following order of rotations: Yaw, a right-handed rotation about the Z ~~NASA system~~ axis of the TDRS reference system; followed by roll, a right-handed rotation about the resultant X-axis; followed by pitch, a right-handed rotation about the resultant Y-axis.

Field Location	Contents
Bytes 57-58	Yaw
59-60	Roll
61-62	Pitch

For each angle, the MSB shall be 180.$\overline{0}$°, the LSB shall be 360.$\overline{0}$° x 2^{-16}, and the resolution shall be .0055°. The accuracy shall be 0.1° in pitch and roll and 0.25° in yaw.

x. TDRS RF Beam Orientation. The contents of this field (bytes 63-68) shall be the orientation of the RF beam for the return link providing the tracking service. The orientation shall be relative to the ~~corrected~~ local TDRS body coordinate system.

The RF Beam Orientation parameters will be given as azimuth and elevation relative to the ~~corrected~~ local TDRS body coordinate system defined in w. above, by the following order of rotations: azimuth, a right-handed rotation about the Y TDRS-body axis, followed by elevation, a right-handed rotation about the resultant X-axis.

Bytes 63-65 shall contain the azimuth and bytes 66-68 shall contain the elevation. The LSB of each shall be 90.$\overline{0}$° x 2^{-23}, the resolution shall be 90.$\overline{0}$° x 2^{-23}, the range shall be ±90°, and negative values shall be expressed in ones complement form. The accuracy of the data shall be 0.5° for an SA service and 2° for an MA service.

y. Status Bits and Equipment Configuration. The contents of this field (byte 69, bits 3 through 8) shall be the status of Doppler compensation, PN lock, and carrier lock and shall indicate the SGLT and SA equipment string in use. All of the status bits are to be implemented on all associated frames immediately following any system status change, reconfiguration, or equipment failover.

Byte 69, bits 3 through 8 are defined as follows:

Bit	Value	Description
8		Doppler Compensation
	0	On
	1	Off
7		PN lock at receiver
	0	Out of lock
	1	In lock
6		Carrier lock at receiver
	0	Out of lock
	1	In lock
5-4		SGLT
	00	N/A
	01	SGLT-1
	10	SGLT-2
	11	SGLT-3/GRGT
3		SA Equipment String
	0	A
	1	B

The Doppler compensation status bit shall reflect the currently requested (via SHO or OPM) Doppler compensation state. When a Doppler compensation inhibit OPM is received, the Doppler compensation status bit shall remain on (0) during the slow-and-hold interval and be changed to off (1) on the frame following frequency stabilization. When a Doppler compensation enable OPM is received, the Doppler compensation status bit shall be changed to on (0) on the frame preceding initiation of the slow-and-hold interval.

12.1.5 TDR Spacecraft Tracking

The NCC will provide Tracking and Data Relay (TDR) Spacecraft specific schedules to WSC~~STGT~~ for initiating tracking and gathering and transmitting TDR Spacecraft tracking data.

12.1.5.1 Tracking Schedules

The tracking schedules shall be of two types, generic and specific, and shall be forwarded to WSC~~STGT~~ through administrative means (i.e., the schedule is not processed by WSC~~STGT~~ ADPE).

a. Generic Schedules. The generic schedule will incorporate the following classes:

- routine operations (e.g., 5 minutes every hour on the hour at a 1 per 10 seconds sample rate).
- supplemental support (e.g., 1 minute every eighth hour on the hour at a 1 per second sample rate).
- maneuver support (e.g., 10 minutes each half hour on the half hour and hour for 6 hours at a 1 per 10 seconds sample rate).

b. Specific Schedule. A specific schedule shall be requested for support under special conditions, such as testing. It shall contain a specific list of event times.

12.1.5.2 Schedule Parameters

The following schedule parameters shall be included in any schedule request and apply to each class on an individual TDR Spacecraft basis:

a. Duration of tracking event (e.g., 5 minutes, 10 minutes).

b. Frequency of tracking event (e.g., every half hour, every hour, every other hour).

c. Sample Rate during tracking event (e.g., 1 sample per second, 1 sample per 10 seconds).

d. Start time of first tracking event covered by schedule class.

e. Period of time, relative to the start time of the first event, for which schedule is applicable.

f. Vehicle Identification Code (VIC).

Procedures for schedule implementation, transition from one schedule class to another, transition to an updated schedule, preemption of scheduled events, schedule prioritization, schedule conflict resolution, and schedule deactivation shall be provided by the NCC. Schedule activation shall be supported by WSC~~STGT~~ ADPE.

12.1.5.3 Data Field Description for TDR Spacecraft Tracking Frames Data

A description of each data field in the TDR spacecraft tracking data sample is given in what follows (see Table 12-1a). Those fields that contain measurement data state the reporting resolution. This number tells the value represented by the Least Significant Bit of the field. The description also contains references to the resolution and accuracy of the measurement itself.

a. Frame Leader. Bytes 1-5 are constants used to conform to the NASA Universal Tracking format. Byte 1 is OD_{16}, Byte 2 is OA_{16}, Byte 3 is 01_{16}, and Bytes 4-5 are each 41_{16}.

b. Current Year. The contents of this field (byte 6) shall be the two least significant digits of the current year. The Least Significant Bit (LSB) equals 1 year.

c. Support Identification Code. The contents of this field (bytes 7-8) shall be the Support Identification Code (SIC) of the TDRS being tracked. The SIC will be assigned by NASA.

d. Vehicle Identification Code. The contents of this field (bytes 9-10) is the Vehicle Identification Code (VIC). It shall be given a default value of 1. The VIC may be specified according to the type of TDRS-specific schedule from which the tracking event (routine, supplemental, maneuver, or specific) is derived.

e. Time Tag. The contents of this field shall be the seconds of year (bytes 11-14). Time for seconds of the year is referenced to 00:00:00.0 January 1 of the current year and is computed according to the rule

Time in Seconds = 86400 K + M,

where K is the number of full days which have elapsed since the beginning of the year and M is the number of seconds since the beginning of the day of track. The time tag shall be a multiple of the sample rate. The LSB of byte 14 equals one second.

Table 12-1a. TDR Spacecraft Tracking Service Data Format

BYTE	BYTE FORMAT	NO. OF BITS	BYTE CONTENTS
1	HEXADECIMAL	8	OD_{16}
2	HEXADECIMAL	8	OA_{16}
3	HEXADECIMAL	8	$O1_{16}$
4-5	HEXADECIMAL	16	41_{16} (EACH BYTE)
6	BINARY	8	CURRENT YEAR
7-8	BINARY	16	SUPPORT IDENTIFICATION CODE(SIC)
9-10	BINARY	16	VEHICLE IDENTIFICATION CODE(VIC)
11-14	BINARY	32	TIME TAG (SECONDS OF YEAR)
15-18	BINARY	32	TIME TAG (MICROSECONDS OF SECOND, SET TO ZERO)
19-22	BINARY	32	RETURN LINK GROUND ANTENNA ANGLE AXIS NO. 1 (AZIMUTH)
23-26	BINARY	32	RETURN LINK GROUND ANTENNA ANGLE AXIS NO. 2 (ELEVATION)
27-32	BINARY	48	RANGE (ROUND TRIP LIGHT TIME)
33-38	HEXADECIMAL	48	00_{16} (EACH BYTE)
39-40	HEXADECIMAL	16	SPARES (EACH UNUSED BIT SET TO 0)
41-44	BINARY	32	FORWARD LINK FREQUENCY
45	HEXADECIMAL	8	FORWARD LINK GROUND ANTENNA SIZE & TYPE

Table 12-1a. TDR Spacecraft Tracking Service Data Format (Cont'd)

BYTE	BYTE FORMAT	NO. OF BITS	BYTE CONTENTS
46	BINARY	8	FORWARD LINK GROUND ANTENNA I.D.
47	HEXADECIMAL	8	RETURN LINK GROUND ANTENNA SIZE & TYPE
48	BINARY	8	RETURN LINK GROUND ANTENNA I.D.
49-50	DISCRETE	16	STATUS AND CONFIGURATION INDICATION
51	DISCRETE	8	SUBSYSTEM/DATA VALIDITY
52	HEXADECIMAL	8	FREQUENCY BAND AND SERVICE TYPE
53-54	HEXADECIMAL/ DISCRETE/BINARY	16	TRACKER TYPE, END OF TRACK, AND SAMPLE RATE
55-72	HEXADECIMAL	144	SPARES (EACH UNUSED BIT SET TO 0)
73	HEXADECIMAL	8	04_{16}
74	HEXADECIMAL	8	OF_{16}
75	HEXADECIMAL	8	OF_{16}

f. Bytes 15-18. Constant (00_{16} in each byte). This field usually contains the microseconds of seconds. For reporting TDR Spacecraft data, this field shall be zero.

g. Return Link Ground Antenna Angle. The contents of these fields (bytes 19-22 and bytes 23-26) shall be the ground antenna angles associated with the return link providing the tracking service. Azimuth shall be measured in the local horizontal plane positive clockwise from north. The local horizontal plane is defined to be perpendicular to the local gravitational vertical. Elevation shall be measured positive above local horizontal. The resolution of each angle shall be 0.0055°. These angles shall be reported to the FDF with an uncertainty $\leq 0.03°$. The angles in both fields shall be represented by fractions of a circle. For both fields, the LSB equals $360.\overline{0}° \times 2^{-32}$ and the Most Significant Bit (MSB) equals $180.\overline{0}°$. Bytes 19-22 shall contain azimuth. Bytes 23-26 shall contain elevation.

h. Range. The contents of this field (bytes 27-32) shall be the unambiguous range measurement (total round trip light time for the entire signal propagation path). The Least Significant Bit of this field equals 2^{-8} nanosecond. The measurement resolution and accuracy shall be as follows:

Range resolution (one-way) < 3m

Range accuracy (one way):

1. Range component (thermal noise, quantization error) < 15m (1σ).
2. RMS short-term drift (1 sec. to 24 hrs.) and tracking error < 10m (1σ).
3. Long-Term Systematic error (bias) < 10m.
4. False ambiguity resolution probability < 10^{-3}.

i. Bytes 33-38. Constant (00_{16} in each byte).

j. Bytes 39-40. Spares (all unused bits set to 0).

k. Forward Link Frequency. This field (bytes 41-44) shall contain the forward link center frequency used to track the TDRS. The LSB of this field represents 10 Hz.

l. Forward Link Ground Antenna Size and Type. The contents of this field (byte 45) shall be the forward link ground antenna size and type. Set this field to 60_{16} for the Danzante 19-m, Cacique 18.3-m, and GRGT 11-mTDRSS 18 m (az-el) Ku-band (az-el) antenna (TBR) and 30_{16} for the 10 m 30 ft. (az-el) S-band antenna.

m. Forward Link Ground Antenna ID. The contents of this field (byte 46) shall be the WSCSTGT/WSGTU ground antenna ID of the antenna providing the forward link for tracking the TDRS. The ground antenna ID's are:

DanzanteST GT ID	CaciqueWS GTU ID	GRGT ID	Ground Antenna
47	9	94	North antenna
48	10	N/A	Central antenna
49	11	N/A	South antenna
25	33	N/A	S-Band antenna

n. Return Link Ground Antenna Size and Type. The contents of this field (byte 47) shall be the return link ground antenna size and type. Set this field to 60_{16} for the Danzante 19-m, Cacique 18.3-m, and GRGT 11-m TDRSS 18 m (az-el) Ku-band (az-el) antenna (TBR) and 30_{16} for the 10 m 30 ft. (az-el) S-band antenna.

o. Return Link Ground Antenna ID. The contents of this field (byte 48) shall be the WSCSTGT/WSGTU ground antenna ID of the antenna providing the return link for tracking TDRS. The ground antenna ID's are:

DanzanteST GT ID	CaciqueWS GTU ID	GRGT ID	Ground Antenna
47	9	94	North antenna
48	10	N/A	Central antenna
49	11	N/A	South antenna
25	33	N/A	S-Band antenna

p. Status and Configuration Indication. The contents of these fields (bytes 49-50) are shown.

Bits	Name	Values
16-13	Spares	All unused bits set to zero

Bits	Name	Values
12	Uplink Equipment Chain	1 = Primary Chain 0 = Secondary Chain

Bits	Name	Values
11	Downlink Equipment Chain	1 = Primary Chain 0 = Secondary Chain
10-5	Spares	All unused bits set to zero
4-3	Track Type	11 = Spare 10 = Manual Track 01 = Program Track 00 = Autotrack
2-1	Spares	All unused bits set to zero

q. Subsystem/Data Validity. The contents of this field (byte 51) shall indicate the validity of the return link antenna angle field (bytes 19-26) and the range field (bytes 27-32).

Antenna angles are valid under conditions that include but are not limited to:

1. Antenna is in autotrack mode.
2. Antenna is not exhibiting a major fault or a control fault.
3. Antenna measurements are on time (i.e., there was a measurement update received corresponding to the time tag).

Range data will be valid under conditions that include but are not limited to:

1. The receiver used for the associated downlink has carrier lock.
2. The range tone demodulator has lock.
3. The range equipment used for the tracking service is not exhibiting a fault.

The contents of this field shall be as listed below:

Field Location	Contents
Bit 8	Tracking Subsystem 0 - not used 1 - WSC~~STGT/WSGTU~~
Bits 5-7	Spares (unused bits set to zero)
Bit 4	Angle data error model correction applied 0 - not applied 1 - applied
Bit 3	Validity of the antenna angle data in bytes 19-26 0 - not valid 1 - valid
Bit 2	Constant at 0

Abbreviations and Acronyms

ACS	Attitude Control System
ADPE	Automatic Data Processing Equipment
ASCII	American Standard Code for Information Interchange
BED	Block Error Detector
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BR	Bit Rate
CAB	Circuit Assurance Block
CCB	Configuration Control Board
CCR	Configuration Change Request
CDCN	Control and Display Computer Network
CMD	Command
CTFS	Common Time and Frequency System
DCN	Document Change Notice
DEMUX	Demultiplexer
DG	Data Group
DIS	Data Interface System
DQM	Data Quality Monitor
EET	End-to-End Test
EIRP	Effective Isotropic Radiated Power
EOT	End of Track
EXEC	Executive
ETRO	Estimated Time of Return to Operation
FDF	Flight Dynamics Facility
~~GMT~~	~~Greenwich Mean Time~~
GRGT	Guam Remote Ground Terminal
GSFC	Goddard Space Flight Center

G/T	Gain to Noise Temperature Ratio
GT	Ground Terminal
HDR	High Data Rate
HDRD	High Data Rate Demultiplexer
HDRM	High Data Rate Multiplexer
HDRR	High Data Rate Receiver
HRBS	High Rate Black Switch
~~HSM~~	~~Hot Standby Mode~~
I	In-Phase (channel)
ICD	Interface Control Document
IF	Intermediate Frequency
IFL	Interfacility Link
IIRV	Improved Interrange Vector
IR	Integrated Receiver
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
Kbps	Kilobits Per Second
KaSA	Ka-Band Single Access
KSA	Ku-Band Single Access
KaSAF	Ka-Band Single Access Forward
KSAF	Ku-Band Single Access Forward
KaSAR	Ka-Band Single Access Return
KSAR	Ku-Band Single Access Return
KSH	Ku-Band Shuttle
LAN	Local Area Network
LCP	Left-Hand Circular Polarization
LI	Local Interface
LO	Local Oscillator
LOR	Line Outage Recorder
LRBS	Low Rate Black Switch

~~LRD~~	~~Low Rate Demodulator~~
LSB	Least Significant Bit or Byte
~~LSD~~	~~Logistics Support Depot~~
LSD	Least Significant Digit
MA	Multiple Access
MAF	Multiple Access Forward
MAR	Multiple Access Return
Mbps	Megabits Per Second
MCC	Message Class Codes
MDM	Multiplexer/Demultiplexer
MHz	Mega Hertz
MOC	Mission Operations Center
~~MO&DSD~~	~~Mission Operations and Data Systems Directorate~~
MS	Mission Support
MSB	Most Significant Bit
MSD	Most Significant Digit
MSM	Maintenance and Software Delivery Mode
MTRS	McMurdo TDRSS Relay System
MUX	Multiplexer
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications Network
NCC	Network Control Center
NCCDS	Network Control Center Data System
ND	Networks Division
~~NGT~~	~~NASA Ground Terminal~~
NRZ	Non-Return to Zero
NRZ-L	Non-Return to Zero-Level
NRZ-M	Non-Return to Zero-Mark
NRZ-S	Non-Return to Zero-Space
ODM	Operations Data Messages

OPM	Operations Messages
PDA	Pin Diode Attenuator
PM	Preventative Maintenance
PMMS	Performance Measuring and Monitoring Subsystem
PTE	PMMS Test Equipment
Q	Quadrature (channel)
QPSK	Quadrature Phase Shift Keying
RCP	Right-Hand Circular Polarization
RF	Radio Frequency
SA	Single Access
SDU	Signal Distribution Unit
SGLT	Space Ground Link Terminal
SHO	Schedule Order
SIC	Support Identification Code
SLR	Service Level Report
SMA	S-Band Multiple Access
SMAF	S-Band Multiple Access Forward
SMAR	S-Band Multiple Access Return

S-Band Multiple Access refers to the MA services provided by TDRSs with ID's 1307, 1308 or 1309.

SQPSK	Staggered Quadrature Phase Shift Keying
SRDP	Shuttle Return Data Processor
SSA	S-Band Single Access
SSAF	S-Band Single Access Forward
SSAR	S-Band Single Access Return
SSH	S-Band Shuttle
~~STGT~~	~~Second (TDRSS) Ground Terminal/Danzante Ground Terminal~~
SUE	Shuttle-Unique Equipment
SUPIDEN	Support Identifier
~~T&C~~	~~Telemetry and Command~~
TDM	Tracking Data Messages
TDR	Tracking and Data Relay
TDRS	Tracking and Data Relay Satellite

TDRSS	Tracking and Data Relay Satellite System
TLM	Telemetry
TOCC2	TDRSS Operations and Control Center at STGT
TT&C	Tracking, Telemetry and Command
TV	Television
USS	User Services Subsystem
UTC	Coordinated Universal Time
VIC	Vehicle Identification Code
WSC	White Sands Complex
WSGTU	White Sands Ground Terminal Upgrade/Cacique Ground Terminal
X MUX	Cross-Strapping Multiplexer