

NASA/GSFC		MISSION OPERATIONS & DATA SYSTEMS DIRECTORATE (MO&DSD) CONFIGURATION CHANGE REQUEST (CCR)			
1. CCR NO.	CCR-405-ICD-05	2. DATE December 15, 1997	3. PRIORITY <input type="checkbox"/> EMERGENCY <input type="checkbox"/> URGENT <input checked="" type="checkbox"/> ROUTINE	4. CHANGE LEVEL <input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input checked="" type="checkbox"/> D <input type="checkbox"/> E <input type="checkbox"/> F	
5. TITLE OF CHANGE Baseline Merge Assessment 3 - GRGT Changes (WSC 98001)					
6. DOCUMENT TITLE <u>ICD Between the NCC/FDF and the WSC for the TDRS H, I, J Era</u>  DOCUMENT NO. <u>405-TDRS-RP-ICD-001, 8 December 1995</u> LIST ALL AFFECTED DOCUMENTS INCLUDING PROCEDURES <u>530-NCC-FDF/WSC ICD, ICD Between the NCC/FDF and the WSC, Revision 5</u>  <span style="float: right;">(CONT ON ATTACHMENT)</span>					
7. REASON FOR CHANGE  To incorporate changes to the NCC/WSC interface resulting from the addition of the GRGT.  <span style="float: right;">(CONT ON ATTACHMENT)</span>					
8. DESCRIPTION OF CHANGE  Pages iv, viii, ix, xi, 1-1, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7, 2-8, 2-9, 2-10, 2-11, 2-13, 2-14, 2-15, 2-16, 3-1, 3-2, 4-1, 5-1, 7-1, 8-1, 9-5, 9-11, 9-39, 9-40, 9-41, 9-42, 9-43, 9-45, 9-46, 9-48, 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, 12-4, 12-5, 12-6, 12-12, 12-13, 12-16, 12-17, AB-1, AB-4, AB-5  <span style="float: right;">(CONT ON ATTACHMENT)</span>					
9. IMPACT					
<b>SYSTEM</b> YES NO <input type="checkbox"/> <input checked="" type="checkbox"/> SCHEDULE <input type="checkbox"/> <input checked="" type="checkbox"/> BUDGET <input type="checkbox"/> <input checked="" type="checkbox"/> FACILITIES <input type="checkbox"/> <input checked="" type="checkbox"/> TESTING <input type="checkbox"/> <input checked="" type="checkbox"/> TRAINING <input type="checkbox"/> <input checked="" type="checkbox"/> SPECIFICATIONS <input type="checkbox"/> <input checked="" type="checkbox"/> CONTRACTOR SUPPORT <input checked="" type="checkbox"/> <input type="checkbox"/> INTERFACES		<b>SYSTEM</b> YES NO <input type="checkbox"/> <input checked="" type="checkbox"/> RELIABILITY/MAINTAIN- ABILITY/SAFETY <input type="checkbox"/> <input checked="" type="checkbox"/> USER SERVICES/MANUALS <input type="checkbox"/> <input checked="" type="checkbox"/> RISK MANAGEMENT <input type="checkbox"/> <input checked="" type="checkbox"/> SECURITY <input type="checkbox"/> <input checked="" type="checkbox"/> USAF FUNDING REQ'D <input type="checkbox"/> <input checked="" type="checkbox"/> POWER <input type="checkbox"/> <input checked="" type="checkbox"/> WEIGHT		<b>ORGANIZATIONAL</b> YES NO    YES NO    YES NO    YES NO <input type="checkbox"/> <input checked="" type="checkbox"/> 501 <input checked="" type="checkbox"/> 530 <input type="checkbox"/> <input checked="" type="checkbox"/> MSFC <input type="checkbox"/> <input checked="" type="checkbox"/> CODE E <input type="checkbox"/> <input checked="" type="checkbox"/> 502 <input type="checkbox"/> <input checked="" type="checkbox"/> 540 <input type="checkbox"/> <input checked="" type="checkbox"/> JSC <input type="checkbox"/> <input checked="" type="checkbox"/> CODE S <input type="checkbox"/> <input checked="" type="checkbox"/> 503 <input type="checkbox"/> <input checked="" type="checkbox"/> 550 <input type="checkbox"/> <input checked="" type="checkbox"/> LERC <input type="checkbox"/> <input checked="" type="checkbox"/> CODE T <input type="checkbox"/> <input checked="" type="checkbox"/> 510 <input type="checkbox"/> <input checked="" type="checkbox"/> 560 <input type="checkbox"/> <input checked="" type="checkbox"/> KSC <input type="checkbox"/> <input checked="" type="checkbox"/> OTHER <input type="checkbox"/> <input checked="" type="checkbox"/> 520 <input checked="" type="checkbox"/> <input type="checkbox"/> OTHER <div style="text-align: center;">Code 405</div>	
10. COMMENTS					
STel ANALYST _____ HARDWARE ENGINEER _____ OPERATIONS REPRESENTATIVE _____ SYSTEMS ENGINEER _____ I AND T MANAGER _____		SIGNATURE	DATE	CONCURRENCE:  _____ CODE 285  _____ DATE	
11. BOARD ACTION		12. DIRECTION/ACTION REQUIRED			
<input type="checkbox"/> APPROVED <input type="checkbox"/> WITHDRAWN <input type="checkbox"/> DISAPPROVED <input type="checkbox"/> DEFERRED UNTIL _____		<input type="checkbox"/> ECP <input type="checkbox"/> TECH DIRECTION <input type="checkbox"/> CONTRACT MOD <input type="checkbox"/> WAIVER <input type="checkbox"/> PUBLISH DOCUMENT <input type="checkbox"/> PUBLISH DCN <input type="checkbox"/> DEVIATION <input type="checkbox"/> C.O. LETTER <input type="checkbox"/> OTHER _____			
13. ORIGINATOR    D. Littmann x7643		CODE <u>530.4</u>	14. SEGMENT MANAGER'S APPROVAL		CODE _____
SIGNATURE _____		DATE _____	SIGNATURE _____		DATE _____
15. CCB APPROVAL			16. CCR IMPLEMENTED		
SIGNATURE _____			ATR SIGNATURE _____		
DATE _____			DATE _____		
			CCB SIGNATURE _____		
			DATE _____		

## Change Information Page

List of Effective Pages			
Page Number	Issue		
Title	<del>Original</del> <u>Revision 1</u>		
ii through xiii	<del>Original</del> <u>Revision 1</u>		
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2-1 through 2-14	<del>Original</del> <u>Revision 1</u>		
3-1 through 3-3/3-4 (blank)	<del>Original</del> <u>Revision 1</u>		
4-1 through 4-3/4-4 (blank)	<del>Original</del> <u>Revision 1</u>		
5-1/5-2 (blank)	<del>Original</del> <u>Revision 1</u>		
6-1 through 6-3/6-4 (blank)	<del>Original</del> <u>Revision 1</u>		
7-1/7-2 (blank)	<del>Original</del> <u>Revision 1</u>		
8-1/8-2 (blank)	<del>Original</del> <u>Revision 1</u>		
9-1 through 9-106	<del>Original</del> <u>Revision 1</u>		
10-1/10-2 (blank)	<del>Original</del> <u>Revision 1</u>		
11-1/11-2 (blank)	<del>Original</del> <u>Revision 1</u>		
12-1 through 12-21/12-22 (blank)	<del>Original</del> <u>Revision 1</u>		
13-1 through 13-3/13-4 (blank)	<del>Original</del> <u>Revision 1</u>		
AB-1 through AB-5/AB-6 (blank)	<del>Original</del> <u>Revision 1</u>		
Document History			
Document Number	Status/Issue	Publication Date	CCR Number
405-TDRS-RP-ICD-001	Original	8 December 1995	
<u>405-TDRS-RP-ICD-001</u>	<u>Revision 1</u>	<u>January 1998</u>	

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# Section 1. Introduction

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## 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), during TDRS H, I, J Era.

## 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. ~~The definition contained herein, although specified for the Second TDRSS Ground Terminal (STGT), (Danzante), apply to the STGT and the White Sands Ground Terminal Upgrade (WSGTU), (Cacique), i.e., to the WSC.~~ WSC is defined as being comprised of three ground terminals: Danzante, Cacique, and the Guam Remote Ground Terminal (GRGT).

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 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 the 530-ICD-NCC-FDF/WSC 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). For the TDRS H, I, J modifications to the WSC, 530-RSD-Danzante and the 530-ICD-NCC-FDF/WSC have been superseded by 405-TDRS-RP-SY-011 and 405-TDRS-RP-ICD-001 respectively. ~~This~~ The original interface control specification (405-TDRS-RP-ICD-001) was created from the 530-ICD-NCC-FDF/WSC, Revision 3 by removing approved but not yet implemented CCRs, and incorporating 530-ICD-NCC-FDF/WSC, Revision 3 approved but not yet published CCRs which have been were implemented at the WSC commensurate with WSC software delivery baseline 95005. Revision 1, when published, supercedes and replaces the original issue, incorporating approved contract changes (ECP-027), including WSC baseline updates through 98001.

Changes of a technical and operational orientation have been made to incorporate requirements for the Guam Remote Ground Terminal (GRGT). Cleanup of the document has been accomplished for a more accurate treatment and representation of the three WSC ground terminals.

## Section 2. Interface Definition and Ground Rules

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The messages exchanged between the STGT-WSC and the NCC/FDF are generated in the Space to Ground Link Terminal's (SGLT's) at ~~the STGT~~ each ground terminal 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 STGT-WSC 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 STGT-WSC Messages

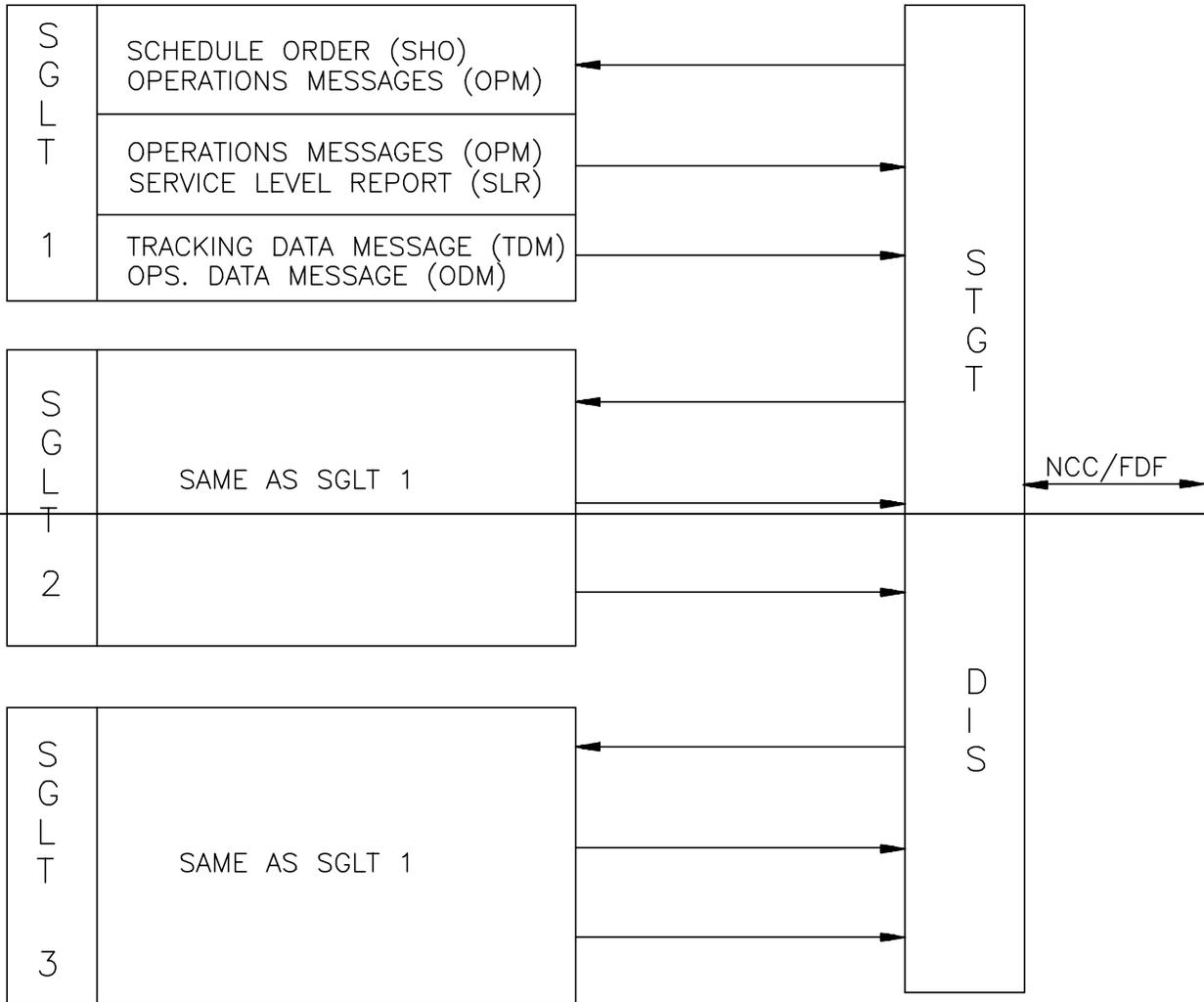
NCC to STGT-WSC messages, consisting of scheduling order messages (SHO's) and operations messages (OPM's), shall be transmitted by the DIS to the SGLT's.

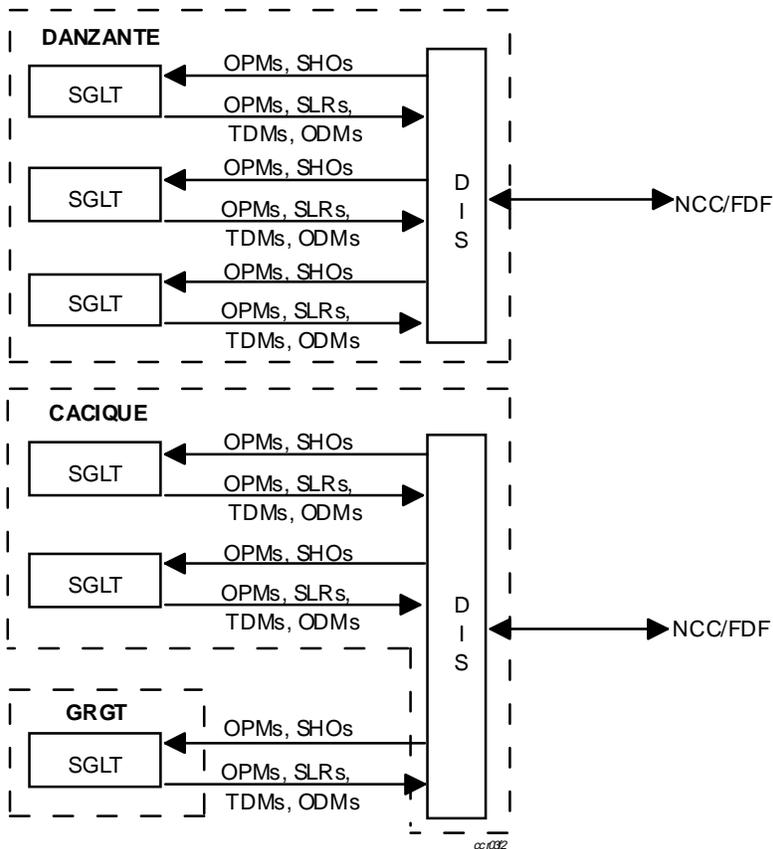
#### 2.1.2 STGT-WSC to NCC/FDF Messages

STGT-WSC 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. STGT-WSC 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 STGT-WSC to the NCC, except as described below. If there is no message pending transmission to STGTWSC, then the NCC will send a separate OPM (Acknowledgment of Message Received) to STGTWSC. A separate OPM (Acknowledgment of Message Received) shall be used if there is no other message pending transmission to the NCC. STGT-WSC 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 STGTWSC.

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.





**Figure 2-1. SGLT/DIS Interface**

## 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.

### 2.2.1 Vector Processing Ground Rules

#### Section 1 - General Application

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 STGT-WSC are as follows:

<u>Vector Type</u>	<u>Application</u>	<u>Phase</u>
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
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 STGT-WSC 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 STGTWSC. 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 ~~5000-1500~~ 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. No~~ and no more than 72 vectors for each TDRS will be stored at STGT on each SGLT.

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

8. The NCC will provide the ~~STGT-WSC~~ with a list of no more than 63 permanent Earth stations. For permanent Earth stations, vector types 1 through 7 will be rejected by ~~STGTWSC~~.
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 ~~the STGTeach WSC ground terminal~~. 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	$t_{n+1} + 6 \text{ min.}$

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:

State Vector		1	2	3	4	5	6	7
Vector Type	{ Launch or on-orbit maneuver sequence  { Landing maneuver sequence	4	7	7	2	7	7	5
		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 STGT-WSC 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 STGT-WSC rejection of the entire sequence.
4. A type 2, 6, or 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 8 vector will be used as received and STGT-WSC will generate a type 2 or 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 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 STGTWSC. 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 Shuttle missions.

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 in the STGT-WSC is the epoch of the vector as transmitted to STGFWSC.
3. The current epoch of a vector ~~in~~at the STGT-WSC is the original epoch of the vector plus the sum of all Delta-T adjustments received at STGFWSC.

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 STGT-WSC 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 STGFWSC.
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 STGFWSC.

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 8 vector with an epoch prior to the end of service.
  - c. Type 2, 4, 5, 6, or 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 STGT-WSC 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 STGT-WSC 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 the 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 STGTWSC, 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 STGTWSC.
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 STGTWSC. These SHOs will be rejected (OPM-51, Problem Code 1) if a service start time is less than five minutes from receipt at STGTWSC.
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 STGFWSC. 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 STGTFWSC. 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

I = 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:

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

where:

$\text{EIRP}(t)$  is the User's apparent EIRP, assuming the User spacecraft is located at a range  $R_{\text{spec}}$  from TDRS.

$\text{EIRP}_u(t)$  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.

$R_{\text{spec}}$  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,  $\text{EIRP}_{\text{max}}$  is the maximum value of  $\text{EIRP}(t)$  and  $\text{EIRP}_{\text{min}}$  is the minimum value of  $\text{EIRP}(t)$  over the scheduled service period. ~~STGT-WSC~~ 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  $\text{EIRP}(t)$  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 which use forward and return data from NASA shall be reconfigurable by OPM classes 02 (return only), 03, and 11. Local mode End-to-End Tests shall not be reconfigurable.
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:

[Return Frequency - (240/221) Forward Frequency] $\leq$ 1 Mhz (S-Band)
[Return Frequency - $\left(\frac{1600}{1469}\right)$ Forward Frequency] $\leq$ 1 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:

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

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 STGT-WSC 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 STGT-WSC 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:

	<u>SIC</u>	<u>VIC</u>
<u>STGTDanzante</u>	1540	01
<u>WSGTUCacique</u>	1373	01
<u>GRGT</u>	<u>1375</u>	<u>01</u>

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 TOCC2 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 ~~STGT~~the respective WSC ground terminal.
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

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The messages exchanged on the STGFWSC-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 STGT-WSC to the NCC/FDF or from the NCC/FDF to the STGFWSC, 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). 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 ~~from NASA~~ between NCC and FDF and to the STGFWSC, 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 (TOCC2 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**

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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 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, followed by the details for the structures and data items used in the variable subfields.

## 5. Network Control Header

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### 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 STGT/WSGTUDanzante and Cacique. GRGT messages use the Cacique source/destination code. These fields are not used by the STGT/WSGTUDanzante and Cacique on incoming messages.

#### STGTDa

#### nzante

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

#### WSGTU

#### Cacique/

#### GRGT

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

## Section 7. Time Field

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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 STGTWSC. For data blocks generated by the STGTWSC, the entire time field shall be set to a logical one state.

## Section 8. Error Control Field

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Byte #  
# of Bits

597	598	599	600
8	1	1	22

Polynomial remainder (Section 10)

Bit 4778 (NASA-Block Error Detector (BED))

0 = Remainder checks OK.

1 = Remainder does not check OK.

Bit 4777 (STGFWSC)

0 = Remainder checks OK.

1 = Remainder does not check OK.

Spare - shall contain logical 1s.

<u>Byte #</u>	<u># of Bytes</u>	<u>Data Item</u>
57	1	SHO Source 0 = <del>NASA</del> -NCC 1 = <del>TDRSS</del> - <del>TOCC2</del> WSC
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. <del>STGT</del> -WSC does not use these data.
40		

## 9.2.2 SHO Subheaders

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

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

<u># of Bytes</u>	<u>Data Item</u>
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
	1-4 Channel I.D.
	100 BPS ≤ Data Rate ≤ 10 MBPS
	5-8 Channel I.D.
	10 MBPS < Data Rate ≤ 300 MBPS
	0 = not LI
	If Data rate is ≥ 150 MBPS, 5-8 specifies the service, i.e., no Q-Channel specified.
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 <del>STGT-Danzante</del> and <del>WSGTU Cacique</del> shall not be simultaneously scheduled. A SHO Class 6 shall be sent to <del>WSGTU-Cacique</del> whenever the HDRM at <del>STGT-Danzante</del> is scheduled.
2	Port Address*
	4 Hexadecimal Characters

\* Applicable to MDM only.

~~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:~~

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

~~\* 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:

<u>Byte #</u>	<u># of Bytes</u>	<u>Data Item</u>
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

<u>Byte #</u>	<u># of Bytes</u>	<u>Data Item</u>
32	1	OPM Source 0 = <del>NASA</del> —NCC 1 = <del>TDRSS</del> — <u>TOCC2WSC</u>
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

<u>Reference Paragraph</u>	<u>Class Code:</u>	<u>Description</u>
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

<u>Reference Paragraph</u>	<u>Class Code:</u>	<u>Description</u>
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 ~~STGT-WSC~~ 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.

<u>Reference Paragraph</u>	<u>Class Code:</u>	<u>Description</u>
9.3.4		<del>STGT-WSC</del> OPM's:
9.3.4.1	51	SHO Status
9.3.4.2	52	Return Channel Time Delay ( <u>N/A to GRGT</u> )
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:

<u># of Bytes</u>	<u>Data Item</u>
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 STGTWSC. The STGTWSC shall print this message and display it on a TOCC2 console. Only a TOCC2 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.

<u># of Bytes</u>	<u>Data Item</u>
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 STGT-WSC 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, STGT-WSC shall complete the specified reacquisition procedure. This message structure is:

<u># of Bytes</u>	<u>Data Item</u>
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. STGT-WSC 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  $f_0$  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  $f_0$  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:

<u># of Bytes</u>	<u>Data Item</u>
12	OPM Header
11	OPM Subheader
<hr/>	
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:

<u># of Bytes</u>	<u>Data Item</u>
12	OPM Header
11	OPM Subheader
1	Power Mode: 0 = Normal 1 = High
<hr/>	
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 ~~STGT-WSC~~ 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.

<u># of Bytes</u>	<u>Data Item</u>
12	OPM Header
11	OPM Subheader
<hr/>	
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/~~STGT-Danzante~~ or NCC/Cacique communication channel. The acknowledge bit will be set. No processing other than acknowledgment is required. The ~~STGT-Danzante~~ or Cacique Source/Destination code shall be used.

<u># of Bytes</u>	<u>Data Item</u>
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 STGFWSC. The message format used is a subset of the improved interrange vector (IIRV).

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

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 STGFWSC.

This space is intentionally left blank.

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. ~~STGT-WSC doesis~~ not required and does not use these data items.

<u># of Bytes</u>	<u>Data Item</u>
12	OPM Header
	Start of State Vector Data
1	G
1	I
1	I
1	R
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 (a ground-based User, including Null location)
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 an unstable sequence.

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:

<u># of Bytes</u>	<u>Data Item</u>	
12	OPM Header	
11	OPM Subheader	
1	Doppler Compensation Inhibit	
	0 = Other than SSA Shuttle	} SSA Shuttle
	1 = Carrier only	
	2 = PN rate only	
	3 = Both carrier and PN rate	
<hr style="width: 10%; margin-left: 0;"/>		
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:

<u># of Bytes</u>	<u>Data Item</u>
12	OPM Header
<hr style="width: 10%; margin-left: 0;"/>	SHO ID
7	
19	

**9.3.3.13 TDRS Maneuver Approval, OPM - Class 13**

As a result of a TDRS maneuver request message from the ~~STGTWSC~~, the NCC will transmit to ~~STGTWSC~~ a message approving or denying the maneuver request. This message will be routed to the TOCC2 operator for action. The message structure is:

<u># of Bytes</u>	<u>Data Item</u>
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 <del>NASA</del> <u>the WSC</u>
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.

<u># of Bytes</u>	<u>Data Item</u>
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 state vectors to STGFWSC. 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 time within State Vectors. The structure of this message is:

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

### 9.3.4 STGT WSC 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:

<u># of Bytes</u>	<u>Data Item</u>
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

<u># of Bytes</u>	<u>Data Item</u>
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 <sup>2</sup> )* 10 = No TDRS ephemeris* 11 = SHO directory table overflow 12 = Duplicate SHO ID* 13 = Invalid User Configuration 14 = <del>STGT</del> <u>WSC</u> 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 Conflicting 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:

<u># of Bytes</u>	<u>Data Item</u>
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
<hr/>	
67+30n	Repeat last 30 bytes as required

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

The ~~STGT-WSC~~ 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:

<u># of Bytes</u>	<u>Data Item</u>
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 ~~STGT-WSC~~ to the NCC. The message structure is:

<u># of Bytes</u>	<u>Data Item</u>
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 STGT-WSC to the NCC to notify the NCC of the termination of a service. The message structure is:

<u># of Bytes</u>	<u>Data Item</u>
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
<u>2</u>	Second
43	

### 9.3.4.6 TDRS Maneuver Request, OPM - Class 59

When the STGT-WSC 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:

<u># of Bytes</u>	<u>Data Item</u>
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

<u># of Bytes</u>	<u>Data Item</u>
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.

<u># of Bytes</u>	<u>Data Item</u>
12	OPM Header

#### **9.3.4.8 Spacecraft State Vector Rejection, OPM - Class 61**

Upon receipt of a state vector, ~~STGT~~ WSC 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:

<u># of Bytes</u>	<u>Data Item</u>
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)

<u># of Bytes</u>	<u>Data Item</u>
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 <del>STGT</del> <u>WSC</u> exceeded 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:

<u># of Bytes</u>	<u>Data Item</u>
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 ~~STGT~~WSC.

#### 9.3.4.11 Real-Time Mode, OPM - Class 64

~~STGT-WSC~~ 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 ~~STGT-WSC~~ generated a type 2 or 8 vector.

<u># of Bytes</u>	<u>Data Item</u>
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 ~~STGT-WSC~~ to advise the NCC that a requested Delta-T adjustment has not been implemented. The structure of this message is:

<u># of Bytes</u>	<u>Data Item</u>
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	

<u># of Bytes</u>	<u>Data Item</u>
1	Message Source 0 = <u>STGTDanzante</u> 1 = <u>WSGTUCacique</u>
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)

<u># of Bytes</u>	<u>Data Item</u>
	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
---	--

<u># of Bytes</u>	<u>Data Item</u>
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 <sup>2</sup> )	
5	1) Hx ( $\pm 0.00$ to $\pm 1.00$ )
5	2) Hy ( $\pm 0.00$ to $\pm 1.00$ )
5	3) Hz ( $\pm 0.00$ to $\pm 1.00$ )
Predicted Stop Momentum (Newtons/sec <sup>2</sup> )	
5	1) Hx ( $\pm 0.00$ to $\pm 1.00$ )
5	2) Hy ( $\pm 0.00$ to $\pm 1.00$ )
5	3) Hz ( $\pm 0.00$ to $\pm 1.00$ )
Predicted Momentum Wheel	
7	1) Delta RPM Sum ( $\pm 000.00$ to $\pm 999.00$ )
	2) Delta RPM Difference ( $\pm 000.00$ to $\pm 999.00$ )
7	
140	

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

The ~~STGT-WSC~~ service level status information shall be sent from the ~~STGT-WSC~~ 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 ~~the STGT each WSC ground terminal~~ 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.)

<u>(Byte #s)</u>	<u>(# of Bytes)</u>	<u>Data Item</u>		
<u>SGLT 1 Service Chains</u>				
<u>TT&amp;C Chains</u>				
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	
<u>SGLT 2 Service Chains</u>				
93-141		(Repeat of 49 bytes of SGLT 1)		
<u>SGLT 3 Service Chains</u>				
142-190		(Repeat of 49 bytes of SGLT 1)		
<u>STGT-Ground Terminal Antennas</u>				
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
199-200	2	End-to-End 2	N,C/0,1	only.
201-202	2	End-to-End 3	N,C/0,1	<u>Represents GRGT EET antenna status within a Cacique SLR</u>
<u>DIS and CTFS</u>				
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	
240-241	2	HDRR/P ( $\leq 150$ Mbps)	N,C/n	n = number available

## SLR (Cont.)

<u>(Byte #s)</u>	<u>(# of Bytes)</u>	<u>Data Item</u>	
		<u>ETRO</u>	
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 representative 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 ~~STGT-WSC~~ 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 ~~STGT-WSC~~ 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 coordinate system relative to the NASA-defined coordinate system. The corrected local TDRS coordinate system is the spacecraft body coordinate system with the origin at the spacecraft center-of-mass, the Z-axis along the spacecraft longitudinal centerline, the Y-axis parallel to the solar array rotational axis and pointed toward the SGL antenna side of the spacecraft, and the X-axis completing the right-handed set. The NASA-defined coordinate system is the spacecraft attitude reference coordinate system with the origin at the spacecraft center of mass, the Z-axis in the orbit plane pointed toward nadir, 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 reference coordinates to 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 coordinate system (body coordinates) relative to the NASA-defined coordinate system (attitude reference coordinates) will be provided to an accuracy of  $0.1^\circ$  in pitch and roll and  $0.25^\circ$  in Yaw.

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 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  $0.5^\circ$  for SA and  $2.0^\circ$  for MA.

## 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 ~~the STGTeach WSC ground terminal~~ to the FDF, JSC and LI. The TDRS tracking service data parameters identified in paragraph 12.1.5 shall be transmitted from ~~the STGTeach WSC ground terminal~~ 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 NASA/~~STGT-TDRSS~~ 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 <sub>16</sub>	64
65	Message Type - MSB 213	80
81	0   0   0   Number of Bits in Data Field	96

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

- 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 (240.0 MHz + 1000 fd for S-Band and 240.0 MHz + 100 fd for Ku-Band). The count shall be cumulative for the duration of the tracking service.
- i. Byte 39. Constant (00<sub>16</sub>).
- j. Byte 40. Constant (00<sub>16</sub>).
- 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<sub>16</sub>).
- m. Forward Link Ground Antenna ID. The contents of this field (byte 46) shall be the STGT/WSGTUWSC 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:

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

- n. Byte 47. Constant (60<sub>16</sub>).

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

<u>WSGTU</u> Cacique ID	<u>STGT</u> Danzante ID	<u>GRGT ID</u>	<u>Ground Antenna</u>
9	47	<u>94</u>	North antenna
10	48	<u>N/A</u>	Central antenna
11	49	<u>N/A</u>	South antenna
33	25	<u>N/A</u>	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 STGT-WSC 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:

<u>Field Location</u>	<u>Contents</u>
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 ~~STGT~~the WSC ground terminal 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:

<u>Field Location</u>	<u>Contents</u>		
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: $1309 < \text{User SIC} < 1373$ ; 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 compensation has been inhibited; i.e., the slow and hold function has been completed and the forward frequency is fixed.
3. The associated IR is not exhibiting a fault indication.

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

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

The Doppler compensation status bit shall remain 0 (on) during the slow-and-hold interval and be changed to 1 (off) on the frame following frequency stabilization. The Doppler compensation status bit shall also be set to 0 (on) during an expanded frequency search and reset to 1 (off) on the frames immediately following frequency stabilization.

### 12.1.5 TDR Spacecraft Tracking

The NCC will provide Tracking and Data Relay (TDR) Spacecraft specific schedules to STGT WSC 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 ~~STGT-WSC~~ through administrative means (i.e., the schedule is not processed by ~~STGT-WSC~~ 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 ~~STGT-WSC~~ 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<sub>16</sub>, Byte 2 is OA<sub>16</sub>, Byte 3 is OI<sub>16</sub>, and Bytes 4-5 are each 4I<sub>16</sub>.

- i. Bytes 33-38. Constant (00<sub>16</sub> 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<sub>16</sub> for the ~~TDRSS 18 m (az-el)~~ Danzante 19-m, Cacique 18.3-m, and GRGT 11-m Ku-band (az-el) antenna and 30<sub>16</sub> for the ~~10 m 30 ft-~~ 10 m (az-el) S-band antenna.
- m. Forward Link Ground Antenna ID. The contents of this field (byte 46) shall be the ~~STGT/WSGTUWSC~~ ground antenna ID of the antenna providing the forward link for tracking the TDRS. The ground antenna ID's are:

<u>WSGTU</u> <u>Cacique ID</u>	<u>STGT</u> <u>Danzante ID</u>	<u>GRGT ID</u>	<u>Ground Antenna</u>
9	47	<u>94</u>	North antenna
10	48	<u>N/A</u>	Central antenna
11	49	<u>N/A</u>	South antenna
33	25	<u>N/A</u>	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<sub>16</sub> for the ~~TDRSS 18 m (az-el)~~ Danzante 19-m, Cacique 18.3-m, and GRGT 11-m Ku-band (az-el) antenna and 30<sub>16</sub> for the ~~30 ft-~~ 10 m (az-el) S-band antenna.
- o. Return Link Ground Antenna ID. The contents of this field (byte 48) shall be the ~~STGT/WSGTUWSC~~ ground antenna ID of the antenna providing the return link for tracking TDRS. The ground antenna ID's are:

<u>WSGTU</u> <u>Cacique ID</u>	<u>STGT</u> <u>Danzante ID</u>	<u>GRGT ID</u>	<u>Ground Antenna</u>
9	47	<u>94</u>	North antenna
10	48	<u>N/A</u>	Central antenna
11	49	<u>N/A</u>	South antenna
33	25	<u>N/A</u>	S-Band antenna

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

<u>Bits</u>	<u>Name</u>	<u>Values</u>
16-13	Spares	All unused bits set to zero

12	Uplink Equipment Chain	1 = Primary Chain 0 = Secondary Chain
----	------------------------	--

<u>Bits</u>	<u>Name</u>	<u>Values</u>
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:

<u>Field Location</u>	<u>Contents</u>
Bit 8	Tracking Subsystem 0 - not used 1 - <u>STGT/WSGTUWSC</u>
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

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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
<u>GRGT</u>	<u>Guam Remote Ground Terminal</u>
GSFC	Goddard Space Flight Center

PMMS	Performance Measuring and Monitoring Subsystem	
PTE	PMMS Test Equipment	
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	} S-Band Multiple Access refers to the MA services provided by TDRSs with ID's 1307, 1308 or 1309.
SMAF	S-Band Multiple Access Forward	
SMAR	S-Band Multiple Access Return	
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	
<del>STGT</del>	<del>Second (TDRSS) Ground Terminal/Danzante Ground Terminal</del>	
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 <del>STGT</del>	
TT&C	Tracking, Telemetry and Command	

TV	Television
USS	User Services Subsystem
UTC	Coordinated Universal Time
VIC	Vehicle Identification Code
WSC	White Sands Complex
<del>WSGTU</del>	<del>White Sands Ground Terminal Upgrade/Cacique Ground Terminal</del>
X MUX	Cross-Strapping Multiplexer