Onboard Operational Messaging Interface Document

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REVISION SUMMARY

REV	RELEASE DATE	BRIEF DESCRIPTION/REASON FOR CHANGE	EFFECTIVE PAGES
0.0	30 May 2001	Initial Release	All
0.1	22 June 2001	Modified per review comments from various Swift subsystems	All
1.0	10 July 2001	Modified per review comments from signatories	3, 5-13, 19, 39-44
1.01	07 August 2001	Applied minor changes from D. Burrows to text section, and modified XRT message descriptions in appendices B and C	4, 7-8, 10-11, 13, 48-52, 63
1.02	09 August 2001	Modified "Summary of Events for PPT Observation Scheduling" per D. Spiegel comments.	4, 12
1.03	29 March 2002	Added FOSCSLEWABORT message, and made minor redefinitions to FOPPTREQUEST, FONEXTOBSINFO, FOM2OBSAT, and FOM2OBSPPT (which is renamed FOPPTTARGERR), and corrected typos in GRBPOSITION message. Made various minor edits to clarify descriptions. Also modified the definition of XRTEMERGENCY TDRSS message, XRTPOSITION TDRSS and RT-RT command messages, and added XRTCENTROIDERR TDRSS And RT-RT command messages as per David Burrows request. Modified document per Pat Broos input: merging 4 TDRSS Error/Warning message into a single UVOT TDRSS Emergency message and updating the definition of the UVOT Finding Chart Messages. Also added BAT Transient Image and updated BAT Light Curve messages, and incorporated several minor changes to BAT Science messages input (including Az / El fields replaced with Theta/ Phi in BAT Science messages) as per Scott Barthelmy / David Palmerinput.	14-15, 27-37, 39-42, 44, 51, 53, 61-62, 64

1.03	June 21 2002	Revision 1.03 CCB Review Comments: Added J2000 reference to all position values. Added a ROLL field to XRTIMAGE message and corrected byte offset for Checksum field of XRTCENTROIDERR TDRSS msg as per Dave Burrows request (Appendix B.9, B.11) Added tertiary header to several BAT science messages (ie, BAT Alert, GRB Position, BAT Short / Long Alarm messages) to make consistent with BAT Data Formats Document, version 0.18. (Appendix B.1 - B.3, C.1 &C.2) Specified LIVE TIME field of XRTSPECTRUM message as Floating Pt as per XRT Data Formats document. (App B.8) Updated FOSC2OBSPPT TDRSS message references to reflect new FOPPTTARGERR name (Section 5) Updated references as to where message definitions found to match current locations within document. (Appendix A, B, C) Added 'Telemetry and Telecommand Formats For The Swift Ultraviolet Optical Telecsope' to reference document list. (section 3.0). Released by CCR 410.4-124	
1.03	June 20, 2003	Added Appendix 17 BAT GRB Flux Information (BATGRBFLUXINFO). Released by CCR 410.4-173	

1.03	July 9, 2003	Appendix A, Appendix B and Appendix C – XRT changes Appendix A.15 changed the document number from “XRT-PSU-0028” to “XRT-PSU-028” changed the spare byte in position 57 to “Waveform Number” Appendix A.16 changed the document number from “XRT-PSU-0028” to “XRT-PSU-028” RA and Dec description changed; Waveform Number added Appendix B.7 changed the document number from “XRT-PSU-0028” to “XRT-PSU-028” changed the spare byte in position 61 to “Waveform Number” Appendix B.8 changed the document number from “XRT-PSU-0028” to “XRT-PSU-028” Changed to 3 unsegmented CCSDS packets and deleted segment from description Appendix B.9 changed the document number from “XRT-PSU-0028” to “XRT-PSU-028” changed the spare bytes (38) in packet #1 to Centroid X: 4 bytes F1234 Centroid Y: 4 bytes F1234 Sigma: 4 bytes F1234 Standard Deviation of Centroid Spare: 26 bytes Changed description of RA and Dec; Increased size of packet 3 by by 70 bytes – added fields Appendix B.11 Spare bytes allocated for additional data Appendix C.4 Packet is sent every time XRT boots		

1.03	July 15, 2003	Added two UVOT telecommand interface messages in Appendix A UVOTFWSTART and UVOTFWSTOP Released by CCR 410.4-176		

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1.0 Introduction.

This document describes the onboard science operations concept for observing gamma ray burst targets and the messages that are passed between the spacecraft, instrument, and ground subsystems relating to target observations. This includes messages generated for the detection and observation of Gamma Ray Bursts (GRBs), and for the observation of Pre-planned Targets (PPTs) and Targets of Opportunity (ToOs). In addition to the normal TDRSS "GRB Alert Data Products" associated with a GRB, this document also describes the TDRSS emergency/warning messages that are generated by the spacecraft and the instruments to alert ground operations personnel of onboard anomalies. These emergency/warning messages are described in Appendix C.

2.0 Purpose and Scope

The purpose of this document is to address the operations concept for performing target observations and the messages associated with this process. Even though there may be some overlap between this document and the "Mission Operations Concept Document" being written by Omitron, this document is not intended to supersede information presented in that document. It is meant rather to add a level of detail more conducive to meeting the needs of the instrument personnel.

3.0 Reference Documents

(1) Swift 1553 Bus Protocol Interface Control Document; Spectrum Astro, Inc.
(2) Swift Spacecraft to Payload Telecommand ICD; Spectrum Astro, Inc.
(3) Figure of Merit Flight Software Requirements Document; John Ong, NASA/GSFC Code 582
(4) Swift FoM Software Peer Review (1/25/01), NASA/GSFC Code 582
(5) Swift TDRSS Messages; Scott Barthelmy, NASA/GSFC Code 661
(6) Swift Mission Requirements Document; Dave Bundas, NASA/GSFC Code 730
(7) BAT TDRSS Alarm Messages; Scott Barthelmy, NASA/GSFC Code 661
(8) Swift Telemetry Format Standards Document, Louise Bashar, NASA/GSFC Code 582
(9) XRT Telemetry Data Formats, David Burrows, Penn State University
(10) Swift BAT Telemetry Formats, Scott Bathelmy, NASA/GSFC Code 661
(11) Swift Interface Requirements Document, Dave Bundas, NASA/GSFC Code 410.4
(12) Telemetry and Telecommand Formats For The Swift Ultraviolet Optical Telecsope, Penn State University

4.0 Acronym List

ACK	Acknowledge (positive response message)
ANSI	American National Standards Institute
APID	Application Process Identifier
AT	Automated Target
ATS	Absolute Time Sequence
BAT	Burst Alert Telescope Instrument
BRDC	Broadcast
CCSDS	Consultative Committee for Space Data Systems
DEC	Declination
F1234	ITOS convention for 32-bit floating point, ANSI/IEEE 754-1984
F12345678	ITOS convention for 64-bit floating point, ANSI/IEEE 754-1984
FoM	Figure Of Merit Software
FOT	Flight Operations Team
GRB	Gamma Ray Burst
ICD	Interface Control Document

IEEE	Institute of Electrical and Electronics Engineers
ITOS	Integrated Test and Operations System
LDP	Large Data Product
MRD	Mission Requirements Document
MOC	Mission Operations Center
NACK	Non-Acknowledge (non-positive response message)
NFI	Narrow Field Instrument
PPT	Preplanned Target
RA	Right Ascension
S1	ITOS convention for 8-bit signed big-endian integer
SAA	South Atlantic Anomaly
SCP	Stored Command Processor
SOT	Science Operations Team
SSR	Solid State Recorder
ST-PDU	Swift Telemetry Protocol Data Unit
ToO	Target Of Opportunity
U1	ITOS convention for 8-bit unsigned big-endian integer
U12	ITOS convention for 16-bit unsigned big-endian integer
U1234	ITOS convention for 32-bit unsigned big-endian integer
UTC	Universal Time Code
UTCF	Universal Time Correction Factor
UVOT	Ultraviolet/Optical Telescope Instrument
XRT	X-Ray Telescope Instrument

5.0 Science Operations Target Observation Concept

The primary goal of Swift is to observe and study Gamma Ray Bursts (GRBs). The observing strategy is implemented by uplinking a pre-planned stored command sequence (PPT) from the ground to observe afterglows of older GRBs, or by autonomously slewing to observe a new BAT detected GRB as directed by the onboard Figure of Merit (FoM) software. The FoM concept is the decision process to enable an entirely automated response to unplanned slew requests to observe a GRB. The FoM flight software coordinates all Swift observations, including pre-planned and automated target observations. Upon notification by the BAT of a gamma ray burst the FoM can preempt a current pre-planned observation and direct the spacecraft to autonomously slew to observe the GRB. The FoM will use an observation "merit value" to determine observation priority. The FoM uses a series of operations messages (telecommands and telemetry) to communicate status to the various Swift components.

This section describes the science operations concept for observing pre-planned targets and automated targets resulting from gamma ray bursts and from target of opportunity requests. The "AT Obs Messaging" sheet of the chart in Figure 1.0 describes the operational sequence of events and the transfer of messages that take place for automated target (AT) observations.

Figure 11.0 Swift Observation Messaging Charts

(Double click on Excel icon to view AT and PPT Observation Messaging Charts)

ObsMessagingChart_V1.0.xls

5.1 Automated Target (AT) Observations

Automated targets are targets resulting from BAT's detection of a gamma ray burst or from a Target of Opportunity (ToO) request via ground command.

5.1.1 Gamma Ray Bursts (GRB) Alert and Position Messages

Gamma Ray Bursts (GRBs) are detected by the BAT flight software. The BAT flight software continuously processes event data from the BAT detectors in order to identify Gamma Ray Bursts (GRBs). When an event rate increase which satisfies its burst trigger criteria is detected, the BAT generates a burst alert message to notify the ground that it has detected a potential GRB. The BAT assigns a unique Observation Number (Target ID/Observation Segment combination) to the GRB to identify it. The burst alert message is called BAGRBALERT. The format and content of the burst alert message is described in Appendix B.1.

After a burst alert the BAT flight software will then attempt to determine the location of the burst. The BAT flight software will construct a GRB position message (BAGRBPOSITION) and send it to the FoM and to the ground via TDRSS. The BAGRBPOSITION message will contain a "Solution Status" field to indicate whether or not the burst location was successfully determined. If the burst location was successfully determined, this message will contain position information that the FoM will use when requesting a slew to the GRB. The format and content of the BAGRBPOSITION message are described in Appendix B.2.

It is highly desirable that the Malindi contact not be interrupted by TDRSS to generate burst messages for false triggers. Therefore, a Malindi and TDRSS version of the BAGRBALERT and BAGRBPOSITION NACK (i.e., no burst position determined) messages are generated. During Malindi contacts the TDRSS version of these messages can be filtered out by the BAT so that the TDRSS link will not be raised. The BAGRBPOSITION ACK message (i.e., burst position determined) will always cause the TDRSS link to be raised.

BAGRBPOSITION ACK and NACK messages will use different APIDs. The FoM will only process the BAGRBPOSITION message with the ACK APID. If a BAGRBPOSITION ACK message is generated for the burst the FoM accepts the GRB as a candidate AT for observation.

Summary of Events for GRB Alert and Position

- *BAT detects burst alert and sends GRB Alert message to ground via TDRSS link (or Malindi if during a Malindi contact). BAGRBALERT (Appendix B.1)*
- *BAT successfully determines burst location and populates GRB Position message with burst position and other burst related information, and issues* BAGRBPOSITION ACK message
  OR
- *BAT can't determine burst location and sets "solution status" field in GRB Position message accordingly,* and issues BAGRBPOSITION NACK message
- *BAT sends GRB Position message to FoM and to ground via TDRSS link (or Malindi if during a Malindi contact). BAGRBPOSITION (Appendix B.2)*
- *FoM processes* BAGRBPOSITION ACK message and GRB becomes *a candidate AT.*

5.1.2 Targets Of Opportunity (ToO)

The ground may issue commands to request observation of a certain target of interest to the science community. These ToO command requests are uplinked via TDRSS (or optionally via Malindi if during a Malindi contact) and forwarded to the FoM for processing. When the FoM receives the ToO request command it makes it a candidate AT, and performs the same processes as it would for an AT from a BAT

detected GRB. The ToO observation request command is called FOTOOREQUEST and its format and content are described in Appendix A.2.

Summary of Events for ToO Observation Request

- *MOC uplinks ToO observation request via TDRSS (or optionally via Malindi if during a Malindi contact). FOTOOREQUEST (Appendix A.2)*
- *Spacecraft routes FOTOOREQUEST command to FoM*
- *FoM accepts ToO as candidate AT*

5.1.3 Automated Target Merit Evaluation

When the FoM accepts the new target (GRB or ToO) as the candidate AT, it compares the target's merit value with the merit of the current target. The FoM calculates the merit for GRBs by using the 10 merit value parameters in the GRB position message and a set of merit weights stored onboard. The merit for ToOs is assigned by the ground and is included in the FOTOOREQUEST command message. If the new candidate AT is of higher merit than the FoM AT, the candidate AT becomes the FoM AT. If the new FoM AT is of higher merit than the current target, the FoM will attempt to supersede the current target by issuing a slew request to the new FoM AT.

The FoM will generate the TDRSS FOM2OBSAT ACK/NACK message indicating whether or not the new target has become the FoM AT and whether it will/will not observe the AT based on the merit evaluation. The instruments can request an update to the merit of an AT (GRB type only) and consequently a re-evaluation of the target's merit by the FoM by sending the FOUPDMERITVAL command.

Summary of Events for AT Merit Evaluation

- *FoM receives new candidate AT*
- *FoM calculates merit if AT is a GRB, or gets merit from FOTOOREQUEST if a ToO*
- *FoM compares merit of candidate AT to merit of current FoM AT*
- *If merit of candidate AT is higher than merit of current FoM AT, candidate AT becomes FoM AT*
- *If merit of candidate AT is higher than merit of current target (PPT or AT), preempt observation of current target in favor of new target*
- *FoM generates FOM2OBSAT TDRSS message. (Appendix B.4)*
- *Instruments (optionally) request AT merit value update. FOUPDMERITVAL (Appendix A.14).*

5.1.4 The Automated Target (AT) Slew Request

After the FoM decides that a target is of sufficient merit to warrant a slew, it begins communications with the spacecraft to effect a slew to, and observation of, the new AT. To start the slew process the FoM sends a SACSLEWREQUEST message to the spacecraft requesting it to slew to the AT. The format and content of the SACSLEWREQUEST message are described in Appendix A.3. The spacecraft responds to the FoM slew request with a FSLEWREQREPLY message indicating whether it is OK/Not OK to slew to the requested target. If it is OK to slew to the target, the FSLEWREQREPLY response message includes the amount of time that the target will be viewable. If it is Not OK to slew to the target due to a viewing constraint, the FSLEWREQREPLY response message contains the reason for rejecting the slew request and the amount of time the FoM should wait before making the slew request again. The format and content of the FSLEWREQREPLY message are described in Appendix A.7.

The FoM issues the FOSC2OBSAT TDRSS message in response to the FSLEWREQREPLY from the spacecraft to notify the ground whether the spacecraft will/will not slew to the AT. The FoM generates this message only for first time slews to . The FoM also updates the target attitude with attitude information from the FSLEWREQREPLY message.

The FoM may query the spacecraft as to its ability to slew to a given target before sending the actual SACSLEWREQUEST message. The slew inquiry is performed by sending a SACSLEWINFO message to the spacecraft. The spacecraft will not attempt to perform a slew to the target as a result of receiving this message. It responds with a FSLEWINFOREPLY message which has the same information as the FSLEWREQREPLY message. The FoM can use this information to determine when to request a slew to the target. For example, if a viewing constraint is about to be violated while observing an AT and the spacecraft has to point to another target, the FoM can use the information from the FSLEWINFOREPLY message to determine when to request a slew back to the AT. The format and content of the SACSLEWINFO and FSLEWINFOREPLY messages are described in Appendices A.4 and A.8 respectively.

Summary of Events for AT Slew Request to Spacecraft

- *FoM sets IS_NEW_AT_SLEW flag to indicate whether or not this is a first time slew to this AT.*
- *FoM requests that s/c slew to FoM AT. SACSLEWREQUEST (Appendix A.3)*
- *S/C responds to AT slew request (OK/Not OK to slew). FSLEWREQREPLY (Appendix A.7)*
- *FoM issues TDRSS message indicating whether spacecraft Will/Will Not slew(only for IS_NEW_AT_SLEW=TRUE). FOSC2OBSAT (Appendix B.5)*
- *FoM updates attitude with attitude info from FSLEWREQREPLY*
- *If OK to slew, spacecraft sends out slew warning message to all instruments. SISLEWWARNING (Appendix A.11)*
- *If Not Ok to slew, spacecraft continues to observe current target*
  - *Optionally, FoM sends slew inquiry message to S/C.* SACSLEWINFO (Appendix A.4)
  - *S/C responds to SACSLEWINFO* message *with* FSLEWINFOREPLY message. (Appendix A.8)
  - *FoM will consider issuing another slew request when the constraint violation expires.*

5.1.5 Instrument Safing For Slews

If the spacecraft is able to slew to the requested target it will broadcast a slew warning message notifying all instruments that a slew is about to begin. The format and content of the slew warning message (SISLEWWARNING) are described in Appendix A.11.

Upon receiving the slew warning message the UVOT safes itself by setting its detector cathode voltage to zero. It then responds with the SACSLEWSAFEREPLY message notifying the spacecraft that it has "safed" itself for the slew. The UVOT has VSSLEWWARNTO seconds to safe itself and respond with the SACSLEWSAFEREPLY message. VSSLEWWARNTO is a spacecraft flight parameter that can be changed in flight. The SACSLEWSAFEREPLY message is described in Appendix A.5. The BAT and XRT instruments are not required to respond to the spacecraft slew warning message and no special safing action is required on their part in preparation for a slew.

If the spacecraft does not receive the notification back from the UVOT within VSSLEWWARNTO seconds, the spacecraft aborts the slew and broadcasts a slew aborted (SISLEWABORT) message to all instruments. The SISLEWABORT message is described in Appendix A.12. If the slew is a result of a viewing constraint, the spacecraft will not abort the slew but will power off the UVOT telescope module and continue on with the slew.

The "UVOT Slew Safe Messaging" sheet of the chart in Figure 1.0 describes the sequence of events and the transfer of messages between the spacecraft and UVOT when a slew is performed.

Summary of Events for Instrument Safing for Slews:

- *S/C issues slew warning message to all instruments. SISLEWWARNING (Appendix A.11)*

- *UVOT safes itself by setting the detector cathode voltage to zero.*
- *UVOT responds to S/C with a SACSLEWSAFEREPLY message (Appendix A.5) within* VSSLEWWARNTO seconds
- *If UVOT response received within timeout period, s/c performs slew to target*
- *If UVOT response not received in time (and not viewing constraint)*
  * *S/C issues slew abort message to all instruments. SISLEWABORT (Appendix A.12)*
  * *S/C continues tracking previous target*
- *If UVOT response not received in time (and viewing constraint is imminent)*
  * *S/C powers off UVOT telescope Module*
  * *S/C continues slew to safe target*

5.1.6 The Slew Process

If the spacecraft receives the SACSLEWSAFEREPLY message from UVOT within the required time or if a viewing constraint is about to be violated, it then begins the slew process. As the spacecraft slews, it provides "Slewing", "Within 10 Arcmins of Target", and "Settled on Target" slew status information to all instruments. This information is provided to the instruments via the ACS 5 Hertz message (SISCATTITUDE). The SISCATTITUDE message is described in Appendix A.10.

After receiving the 5 Hz message indicating that the slew to the target has begun, the FoM sends out information about the target to all instruments in the "Next Observation Information" message (FONEXTOBSINFO). The instruments use the information in this message to prepare for target observation. This message is also sent to the ground in BAT/FoM housekeeping telemetry to support FOT timeline reconstruction. The FONEXTOBSINFO message is described in Appendix A.13.

When the FoM receives the 5 Hz "Settled on Target" message, it issues an event message so that the ground can easily determine (in its event timeline) when the spacecraft settled on the target.

Summary of Events for the Slew Process:

- *S/C receives SACSLEWSAFEREPLY message from UVOT. (Appendix A.5)*
- *S/C immediately begins to slew to target, and sets "IS_SETTLED" field in ACS 5 Hz message to false (0). SISCATTITUDE (Appendix A.10)*
- *FoM issues FONEXTOBSINFO message to all instruments and adds packet to BAT/FoM housekeeping telemetry (Appendix A.13)*
- *Instruments use FONEXTOBSINFO information to prepare for target observation.*
- *S/C slews to within 10 arcmins of the target and sets "IS_IN_10_ARCMIN" field in ACS 5 Hz message to true (1). SISCATTITUDE (Appendix A.10)*
- *If first observation of target (i.e., IS_NEW_AT_SLEW=TRUE), UVOT commences transient mode observation*
- *S/C settles on target and sets "IS_SETTLED" field in ACS 5 Hz message to true (1). SISCATTITUDE (Appendix A.10)*
- *FoM issues event message indicating s/c settled on target*
- *Instruments begin observation of target and generation of required GRB products*

5.1.7 Onboard Automated Target (AT) Observation

When the spacecraft is settled on the target it sets the "IS_SETTLED" flag in the ACS 5 Hz message (SISCATTITUDE) to true (1), and waits for the next slew request from the FoM. The current target observation can be pre-empted by the FoM at anytime in favor of a target of higher merit.

The FoM begins accumulating the amount of time spent observing the target (PAST_OBS_TIME in the FONEXTOBSINFO message). FoM also updates the target position with the position information from the XRTPOSITION (Appendix B.7) telecommand message.

All instruments begin target observation and production of their respective "GRB Data Products". The XRT produces the "XRT Position" TDRSS telemetry product described in appendix B.7. The XRT also produces the "XRT Spectrum" and "XRT Image" TDRSS telemetry products described in Appendix B.8 and Appendix B.9 respectively.

The UVOT begins collecting Finding Chart Mode data. Once the XRT position data is received, the "UVOT Finding Chart" data product is produced and sent down via TDRSS. The format and contents of this message are described in Appendix B.10.

The BAT produces the "BAT Light Curve" message described in Appendix B.6.

Summary of Events for AT target observations:

- *IS_SETTLED flag in SISCATTITUDE message set to true (1)*
- *FoM begin accumulating "time spent observing this target".* (This information is provided to the instruments as PAST_OBS_TIME field in the FONEXTOBSINFO message).
- *S/C waits for next slew request from FoM*
- *All Instruments begin observing target*
  - *UVOT begins collecting Finding Chart Mode data*
  - *XRT produces "XRT Position" message and sends to UVOT and BAT/FoM, and sends down via TDRSS*
  - *FoM updates position information with position info from XRTPOSITION telecommand message*
  - *BAT produces the "Light Curve" data product and sends down via TDRSS*
  - *BAT starts looking for new bursts and performing sky surveys*
  - *UVOT receives "XRT Position" message and produces "Finding Chart" data product and sends down via TDRSS*
  - *XRT produces "Spectrum" and "Image" burst data products*
- *If new target of higher merit received, FoM requests slew to new target which pre-empts current target if slew request is accepted by S/C.*
- *Observation of current target completed, FoM directs spacecraft to slew to new target*

5.1.8 Automated Target (AT) Viewing Constraints

When the FoM makes the initial request to slew to the AT the spacecraft may respond that it cannot slew to the requested target due to a viewing constraint. It may also slew to the target and then while observing the target determine that a viewing constraint is about to be violated. Viewing constraints that the spacecraft considers when rejecting a slew request are sun, earth limb, moon, and ram viewing constraints. The spacecraft does not include the SAA in its list of viewing constraint violations. The spacecraft does however indicate when it is in the polygon defined for the SAA by setting the IN_SAA_FLAG in the SISCATTITUDE (ACS 5 Hz) telecommand message to true (1).

If in response to the slew request, the spacecraft responds that the AT is constrained the FoM will use the WAIT_SECONDS parameter to determine when to request the slew again, and the spacecraft will continue to observe the current target. If this is the first time viewing of a GRB target, the FoM will issue a TDRSS message indicating that the spacecraft cannot slew to the AT due to viewing constraints.

If the spacecraft determines that it is entering a viewing constraint while observing an AT it will send a FVIEWCONSTRAINT telecommand message to the FoM. This message is described in Appendix A.9. The FoM will send a SACSLEWINFO telecommand message to the spacecraft to determine when the

viewing constraint will expire. The FoM then requests that the spacecraft slew to a pre-planned target (PPT) until the AT viewing constraint expires.

For the viewing constraints discussed above, the FoM will safely direct the spacecraft as to where it should slew. If no FoM input is provided the spacecraft will slew to a safe target. The instruments should follow normal slew safing procedures under these conditions.

Since the SAA is not included in the spacecraft's list of viewing constraints, the instruments must monitor the IN_SAA_FLAG in the SISCATTITUDE telecommand message (or use their own SAA determination scheme) to determine when they are in the SAA. The instruments will stop observations while in the SAA. The BAT will turn off event generation while in the SAA. The XRT operates in Null mode while in the SAA where it clocks the CCD but does not make any reports. The UVOT will set the detector cathode voltage to zero, move the filter wheel to blocked, and process the target data obtained up to that point and send it to the SSR.

Summary of events for AT viewing constraint violations:

- *FoM sends request to spacecraft to slew to AT. SACSLEWREQUEST (Appendix A.3)*
- *S/C responds to slew request with FSLEWREQREPLY telecommand message (Appendix A.7)*
- *If spacecraft NACK (can't slew due to viewing constraint)*
  - *Spacecraft continues on current target*
  - *FoM issues TDRSS message indicating that AT is not viewable at this time (issued only on first time slew to target). FOSC2OBSAT (Appendix B.5)*
  - *FoM uses WAIT_SECONDS parameter to determine when to request the slew again*
  - *FoM updates attitude with attitude info from FSLEWREQREPLY*
- *If spacecraft ACK (no viewing constraint) follow normal AT observation scenario (See section 5.1.7).*
- *If spacecraft entering viewing constraint while observing an AT*
  - *S/C sends FVIEWCONSTRAINT telecommand message to FoM. (Appendix A.9)*
  - *FoM sends SACSLEWINFO telecommand to determine when viewing constraint will expire*
  - *Spacecraft responds with FSLEWINFOREPLY message*
  - *FoM requests that spacecraft slew to PPT*
  - *When constraint expires, FoM requests spacecraft slew back to AT. Sets IS_NEW_AT_SLEW=False(0).*
- *If entering SAA;*
  - *S/C sets IN_SAA_FLAG=true(1) in SISCATTITUDE*
  - *BAT turns off event generation*
  - *XRT operates in Null Mode*
  - *UVOT sets detector cathode voltage to zero, filter wheel to blocked, and processes data collected up to that point and sends to SSR*

5.2 Pre-Planned Target (PPT) Observations

Pre-Planned target (PPT) operations involve the ground scheduling and onboard processing of requests to observe afterglows from recent GRBs and other targets that are of special interest to the science community. The scheduling of the observations is done via the Pre-Planned Target Observation Schedule. Onboard processing is controlled by the Figure of Merit (FoM) flight software.

This section describes the pre-planned target (PPT) operations process from the ground scheduling of the PPT by the flight operations personnel up through the actual observation of the PPT by the onboard instruments.

The "PPT Obs Messaging" sheet of the chart in Figure 1.0 describes the operational sequence of events and the transfer of messages that take place for PPT observations.

5.2.1 Scheduling Pre-Planned Target (PPT) Observations

Observation of Pre-Planned Targets (PPTs) is scheduled via the PPT Observation Schedule. The PPT Observation Schedule is a sequence of individual observation request commands constructed on the ground by flight operations personnel. PPT observation request commands contain target information such as the observation number (target id and observation segment); the relative merit of the target; the right ascension, declination, and roll angles of the target; and the configuration mode for each instrument. Pre-planned observation request commands are constructed as Absolute Time Sequence (ATS) commands. Refer to Appendix A.1 for a description of the PPT observation request command.

The Mission Operations Center (MOC) is responsible for managing the Pre-Planned Target Observation Schedule. The PPT observation schedule contains commands sufficient to observe up to 7 days of pre-planned targets. This allows the MOC to follow a 5 day/8 hour weekly operations schedule. The PPT observation schedule may be updated as necessary to observe afterglows of newly discovered GRBs, or to observe newly discovered targets that are of interest to the science community.

The PPT observation schedule is incorporated into the flight operations mission timeline and is uplinked during scheduled Malindi ground contacts (or occasionally during TDRSS contacts). The PPT observation request commands are stored by the spacecraft Stored Command Processor (SCP) as Absolute Time Sequence (ATS) commands. The spacecraft forwards the command to the FoM at the appropriate ATS time.

Summary of Events for PPT Observation Scheduling:

- *MOC Mission Planner (in conjunction with science team) determines which targets to observe*
- *MOC SOT builds pre-planned target observation schedule of targets to observe*
- *MOC FOT incorporates pre-planned target observation schedule into observatory timeline and generates ATS commands*
- *MOC FOT uplinks the observatory timeline during Malindi contact*
- *PPT commands get stored as ATS commands by S/C stored command processor (SCP)*
- *If New target of interest (new GRB, new discovery from another satellite, etc.)*
  - *MOC SOT updates pre-planned target observation schedule with new target*
  - *MOC FOT re-generates the observatory timeline and associated ATS command load*
  - *MOC FOT uplinks updated observatory timeline during Malindi contact*
  - *New ATS load is activated (SCP commanded to switch buffers)*
- *S/C sends PPT observation request command to FoM*

5.2.2 Pre-Planned Target (PPT) Observation Processing

This section describes the processing that is performed by the various onboard subsystems when a PPT observation request command is sent from the spacecraft to the Figure of Merit (FoM) flight software. The onboard processing for PPTs is similar to the AT processing described in the previous sections with the following exceptions:

- No GRB detection and product generation
- PPT requests supersede current FoM PPTs regardless of relative merit
- Generally, the PPT observation schedule should provide continuous PPT target coverage
  - This could mean 2-3 PPT targets per orbit as all targets will become constrained at some point each orbit
  - Each PPT should be observable from when it is scheduled until the next scheduled PPT target

PPT slew processing is performed much the same as the AT slew processing described in sections 5.1.4 through 5.1.6. The messages generated for PPT observation processing are described in appendix A.

Summary of Events for PPT Target Observation

- *FoM receives PPT observation request command (FOPPTREQUEST) from S/C. Appendix A.1*
- *PPT request supersedes current FoM PPT and becomes FoM PPT*
- *FoM compares PPT merit to merit of current AT*
- *If PPT is of sufficient merit, FoM requests a slew to the PPT. SACSLEWREQUEST (Appendix A.3)*
- *S/C responds with FSLEWREQREPLY indicating whether PPT Is/Is Not viewable*
- *FoM updates attitude with attitude info from FSLEWREQREPLY*
- *If PPT is not viewable (error condition) ,*
  - *S/C continues to observe current target*
  - *FoM generates TDRSS emergency/warning message to notify ground that PPT is not viewable. FOPPTTARGERR (Appendix C.5)*
  - *FoM waits for view constraint to expire and then will reconsider requesting the slew again*
- *If PPT is viewable,*
  - *S/C slews to PPT. See AT slew processing in sections 5.1.4 through 5.1.6.*
  - *Instruments observe target and perform required PPT target observations. FoM accumulates time on target.*
  - *If constraint entered while observing the PPT (error condition), spacecraft slews to safe target. See section 5.2.3*

5.2.3 Pre-Planned Target (PPT) Viewing Constraints

Two anomalous conditions associated with the viewing of a PPT may occur. First, the spacecraft may respond that it cannot slew to the requested PPT due to viewing constraints. This means that the ground made an error by scheduling the PPT at a time when target viewing is constrained. Even though such an error may raise some doubt as to the overall validity of the PPT request, the FoM will still request a slew at a later time based on the WAIT_SECONDS time in the FSLEWREQREPLY message. The spacecraft will continue to observe the current target (if appropriate), and the FoM will issue a TDRSS emergency/warning message (FOPPTTARGERR) indicating that the requested PPT is not viewable due to constraints.

Secondly, the spacecraft could enter a viewing constraint while observing a PPT. As in the case above, this condition also means that the ground made an error in scheduling the PPT. If the spacecraft is entering a constraint while observing a PPT, it sends a FVIEWCONSTRAINT message to the FoM prior to the constraint violation. This message is described in Appendix A.9. In this case the FoM will check for a backup target to slew to, and if no backup target exists (which will likely be the case) it allows a timeout on its response back to the spacecraft. After the timeout (no response from FoM) the spacecraft sends the slew warning message to all instruments, slews to a safe target, and updates the ACS 5 Hz message to indicate that it is now pointing to a safe target. The FoM then sends a TDRSS message (FOSAFEPOINT, Appendix C.9) indicating that the spacecraft is in "safe point". This condition does not cause a spacecraft safehold condition.

Summary of Events for PPT Viewing Constraint

- *S/C returns "Not Ok to slew" (PPT not viewable) response to PPT slew request. FSLEWREQREPLY (Appendix A.7)*
- *FoM issues TDRSS emergency/warning message indicating that PPT is not viewable. FOPPTTARGERR (Appendix C.5)*
- *S/C continues to observe current target*
- *S/C entering constraint while observing PPT*
- *S/C sends FVIEWCONSTRAINT message to FoM. (Appendix A.9)*
- *FoM checks for backup target to slew to; times out on response to FVIEWCONSTRAINT if no backup target exixts*
- *S/C does not receive new target information from FoM so it slews to a s/c determined safe target*
- *S/C notifies all instruments of safe target pointing condition via ACS 5 Hz message SISCATTITUDE (Appendix A.10).*
- *FoM issues TDRSS FOSAFEPOINT message* (Appendix C.6) *indicating that the spacecraft is pointing to a "safe target".*

Table 11. Application ID (APID) Notation.

In cases where the APID is already assigned, such as spacecraft telecommands from the "S/C to Payload Telecommand ICD", the actual APID is used in this document. Other messages for which the APID is not yet assigned are defined in this document relative to a base starting address. For example, the BAT TDRSS Burst Position telemetry message APID is defined as $BAT_{TD}x01$. If the valid range of addresses for BAT TDRSS (BAT_{TD}) messages starts at 0x180, then the APID of the BAT TDRSS Burst Position message is 0x181 (i.e., 0x180 + 0x01). This notation allows the flexibility of assigning APIDs in this document that can be easily redefined at a later date. The APID for messages described in this document can be changed by simply changing the base starting address.

APID NOTATION	DESCRIPTION	Valid APID RANGE	BASE STARTING ADDRESS
BAT_{RH}	BAT Real-Time housekeeping telemetry	0x120 – 0x17F	0x120
BAT_{TD}	BAT/FoM TDRSS Telemetry	0x180 – 0x1DF	0x180
BAT_{TC}	BAT Telecommand	0x620 – 0x63F	0x630
FoM_{RH}	FoM Real-Time housekeeping telemetry	0x120 – 0x17F	0x130
FoM_{TD}	BAT/FoM TDRSS Telemetry	0x180 – 0x1DF	0x190
FoM_{TC}	FoM Telecommand	0x620 – 0x63F	0x620
UVT_{TD}	UVOT ICU TDRSS Telemetry	0x3C0 – 0x41F	0x3C0

Appendix A. Onboard Observation Interface Messages.

This appendix describes the format and content of various telecommand and telemetry messages that are exchanged between the Swift subsystems for observing pre-planned and automated targets. Most of the messages described in Appendix A are telecommands to the onboard instruments. Appendix A does not contain the TDRSS gamma ray burst related data product messages described in the MRD. Those messages are described in Appendix B. Onboard TDRSS error/warning messages are described in Appendix C.

Note: All telemetry and telecommand messages described in this appendix contain the appropriate CCSDS packet headers. Refer to reference document number 1, "Swift 1553 Bus Protocol Interface Control Document", for details on CCSDS headers for telemetry and telecommand packets.

Table 22. Summary of Onboard Telecommand and Telemetry Interface Messages

Telecommand Interface Messages						
Appendix	Message Mnemonic	SRC	DEST	APID	FC	DESCRIPTION
A.1	FOPPTREQUEST	MOC	FoM	0x620	04	Pre-planned Target (PPT) observation request command
A.2	FOTOOREQUEST	MOC	FoM	0x620	05	Target of Opportunity (ToO) observation request command
A.3	SACSLEWREQUEST	FoM	S/C	0x600	02	Slew request telecommand message from FoM to spacecraft
A.4	SACSLEWINFO	FoM	S/C	0x600	03	Slew information request telecommand message from FoM to spacecraft
A.5	SACSLEWSAFEREPLY	UVOT	S/C	0x600	04	UVOT telecommand message notifying S/C that it has safed itself for the slew
A.6	SACSAFEPOINT	FoM	S/C	0x600	05	FoM telecommand message to S/C requesting a slew to "safe" target
A.7	FSLEWREQREPLY	S/C	FoM	0x620	01	Spacecraft response to FoM slew request message
A.8	FSLEWINFOREPLY	S/C	FoM	0x620	02	Spacecraft response to FoM slew information message
A.9	FVIEWCONSTRAINT	S/C	FoM	0x620	03	Spacecraft view constraint telecommand message
A.10	SISCATTITUDE	S/C	(1)BRDC	0x701	01	Spacecraft 5 Hz attitude information telecommand message to all instruments
A.11	SISLEWWARNING	S/C	(1)BRDC	0x701	03	Slew warning telecommand message from spacecraft to all instruments
A.12	SISLEWABORT	S/C	(1)BRDC	0x701	04	Slew aborted telecommand message from spacecraft to all instruments
A.13	FONEXTOBSINFO	FoM	(1)BRDC	0x702	01	Next observation information telecommand message to all instruments. A realtime housekeeping telemetry version of this message is also generated.
A.14	FOUPDMERITVAL	(2)INST	FoM	0x620	06	Merit value parameters update telecommand message
A.15	XRTPOSITION (CMD)	XRT	(1)BRDC	0x705	00	Command message broadcast to the BAT and UVOT containing XRT position centroid of the new GRB
A.16	XRTCENTROIDERR (CMD)	XRT	(1)BRDC	0x705	01	Command message broadcast to instruments if the XRT is unable to calculate a reliable centroid for a new GRB target
A.17	BATGRBFLUXINFO CMD	BAT	UVOT	0x667	00	Command message from BAT to UVOT to predict optical brightness of the OT
A.18	UVOTFWSTART	UVOT	(1) BAT	0x63E	00	This telecommand message is sent from the UVOT to the BAT ~2 seconds prior to the moving of the UVOT filter wheel
A.19	UVOTFWSTOP	UVOT	(1)BAT	0x63E	01	This telecommand message is sent from the UVOT to the BAT once the UVOT filter wheel movement has stopped

Telemetry Interface Messages							
A.20~~17~~	FONEXTOBSINFO	FoM	Malindi	0x14e	N/A	Next observation information telemetry message for realtime housekeeping downlink. A telecommand version sent to all instruments is also generated.	
A.21~~18~~	FOSCSETTLED	FoM	Malindi	0x14f	N/A	Message from FoM to ground when S/C settles on target	

(1) BRDC – Indicates that message is broadcast to all instruments.
(2) INST – Indicates that message may be issued by all instruments.

Appendix A.1. Preplanned Target Observation Request Message (FOPPTREQUEST)

Message	APID	FC	Length (bytes)	Description
FOPPTREQUEST	0x620	04	44	This telecommand message is a pre-planned target (PPT) observation request from the ground. It is stored by the spacecraft SCP and sent to FoM at the specified ATS time.
Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	8	U1234	Target ID and Observation Segment of the pre-planned target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
MERIT VALUE	4	12	F1234	The relative merit value assigned to this PPT observation by ground operations personnel
RA	8	16	F12345678	Right ascension of the desired target. Range is 0 to 360 degrees (J2000 epoch)
DEC	8	24	F12345678	Declination of the desired target. Range is –90 to +90 degrees (J2000 epoch)
ROLL	4	32	F1234	Roll of the desired target. Range is 0 to 360 degrees (J2000 epoch)
Req Obs Secs	4	36	U1234	(1) Number of seconds until next scheduled PPT target that this target is observable
BAT Mode	2	40	U12	(2) BAT instrument configuration mode for the PPT observation.
XRT MODE	2	42	U12	(2) XRT instrument configuration mode for the PPT observation.
UVOT MODE	2	44	U12	(2) UVOT instrument configuration mode for the PPT observation.
Checksum	2	46	U12	

(1) This ground planner calculated value reflects the number of seconds until the next scheduled PPT target that this PPT target is viewable, less time required to slew and settle on this target, and time that SC is in SAA . This value is distributed by FoM in the Next Observation Info message's Observe_Secs field for PPT targets. See Next Observation Info message for further detail.
(2) Configuration mode value set by ground for PPT observations and is simply a pass through for FoM.

Appendix A.2. Target of Opportunity (ToO) Request Message (FOTOOREQUEST)

Message	APID	FC	Length (bytes)	Description
FOTOOREQUEST	0x620	05	52	This is a command message from the ground to the FoM requesting observation of a Target of Opportunity (ToO).
Message SubField Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	8	U1234	Target ID and Observation Segment of the ToO. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
Trigger Time Secs	4	12	U1234	The seconds field for the time of the data at which original trigger was detected
Trigger Time Subsecs	2	16	U12	The sub-seconds field for the time of the data at which original trigger was detected
FILL	2	18	U12	Fill bytes for data alignment purposes
MERIT VALUE	4	20	F1234	The relative merit value assigned to this ToO observation by ground operations personnel
RA	8	24	F12345678	Right ascension of the desired target. Range is 0 to 360 degrees (J2000 epoch)
DEC	8	32	F12345678	Declination of the desired target. Range is –90 to +90 degrees (J2000 epoch).
ROLL	4	40	F1234	Roll of the desired target. Range is 0 to 360 degrees (J2000 epoch)
BAT Mode	2	44	U12	(1) BAT instrument configuration mode for the observation.
XRT MODE	2	46	U12	(1) XRT instrument configuration mode for the observation.
UVOT MODE	2	48	U12	(1) UVOT instrument configuration mode for the observation.
Checksum	2	50	U12	

(1) Configuration mode value set by ground for ToO observations and is simply a pass through for FoM.

Appendix A.3. FoM To S/C Slew Request Message (SACSLEWREQUEST).

The format and descriptions for this message are taken from the "Swift Spacecraft to Payload Telecommand ICD". In the case of conflicting information, the information in the ICD will take precedence.

Message	APID	FC	Length (bytes)	Description
SACSLEWREQUEST	0x600	2	36	This is the telecommand message from the FoM to the spacecraft requesting the spacecraft to slew to a specific target.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	8	U1234	Target ID and Observation Segment of the requested target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
RA	8	12	F12345678	The right ascension of the target for the requested slew. Range is 0 to 360 degrees (J2000 epoch)
DEC	8	20	F12345678	The declination of the target for the requested slew. Range is –90 to +90 degrees (J2000 epoch)
ROLL	4	28	F1234	The desired roll of the s/c when the slew is settled. Range is 0 to 360 degrees (J2000 epoch)
IS_NEW_AT_ SLEW	1	32	U1	True (1) = first time slew to an automated target. False (0) = pre-planned target or non-first time viewing of an AT
FILL	1	33	U1	Fill byte added to make length an even number of bytes
Checksum	2	34	U12	

Appendix A.4. FoM To S/C Slew Information Message (SACSLEWINFO).

The format and descriptions for this message are taken from the "Swift Spacecraft to Payload Telecommand ICD". In the case of conflicting information, the information in the ICD will take precedence.

Message	APID	FC	Length (bytes)	Description
SACSLEWINFO	0x600	03	36	This is the telecommand message from the FoM to the spacecraft requesting information concerning the ability to slew to a specific target. This command does not result in an actual slew.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	8	U1234	Target ID and Observation Segment of the requested target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
RA	8	12	F12345678	Right ascension of the target. Range is 0 to 360 degrees (J2000 epoch)
DEC	8	20	F12345678	Declination of the target. Range is –90 to +90 degrees (J2000 epoch)
ROLL	4	28	F1234	Roll of the s/c when settled on target. Range is 0 to 360 degrees (J2000 epoch). Parameter ignored if IS_NEW_AT_SLEW=True(1)
IS_NEW_AT_ SLEW	1	32	U1	True (1) = first time slew to an automated target False (0) = pre-planned target or non-first time viewing of an AT
FILL	1	33	U1	Fill byte added to make length an even number of bytes
Checksum	2	34	U12	

Appendix A.5. UVOT to S/C Slew Safe Reply Message (SACSLEWSAFEREPLY).

The format and descriptions for this message are taken from the "Swift Spacecraft to Payload Telecommand ICD". In the case of conflicting information, the information in the ICD will take precedence.

Message	APID	FC	Length (bytes)	Description
SACSLEWSAFEREPLY	0x600	4	10	This is the telecommand message from the UVOT notifying the spacecraft that it has "safed" itself for a s/c slew.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
Checksum	2	8	U12	

Appendix A.6. FoM to S/C Safe Point Request Message (SACSAFEPOINT).

The format and descriptions for this message are taken from the "Swift Spacecraft to Payload Telecommand ICD". In the case of conflicting information, the information in the ICD will take precedence.

Message	APID	FC	Length (bytes)	Description
SACSAFEPOINT	0x600	5	10	This is the telecommand message from the FoM requesting that the spacecraft slew to a "safe pointing" location.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
Checksum	2	8	U12	

Appendix A.7. S/C to FoM Slew Request Reply Message (FSLEWREQREPLY).

The format and descriptions for this message are taken from the "Swift Spacecraft to Payload Telecommand ICD". In the case of conflicting information, the information in the ICD will take precedence.

Message	APID	FC	Length (bytes)	Description
FSLEWREQREPLY	0x620	01	46	This is the telecommand message from the spacecraft to the FoM in response to a slew request. If the s/c can safely slew to the target, this telecommand will contain the number of seconds that the target can be viewed. If the s/c cannot safely slew to the target, the reply will contain the number of seconds until a slew request to the target can be accepted.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
SLEW REPLY	4	8	U1234	Reply to slew request; 0 = s/c accepts the slew request 1 = slew request rejected because of a Sun viewing constraint 2 = slew request rejected because of an Earth limb viewing constraint 3 = slew request rejected because of a Moon viewing constraint 4 = slew request rejected because of a Ram viewing constraint 5 = slew request rejected because of an invalid request parameter
OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment of the requested target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
RA	8	16	F12345678	Right ascension of the target. Range is 0 to 360 degrees. (J2000 epoch)
DEC	8	24	F12345678	Declination of the target. Range is –90 to +90 degrees. (J2000 epoch)
ROLL	4	32	F1234	Calculated roll of the s/c after the slew. Range is 0 to 360 degrees. (J2000 epoch)
WAIT_SECONDS	4	36	U1234	If slew request is rejected, this parameter indicates the number of seconds to wait before making the request again, otherwise this field contains no valid data.
OBSERVE_ SECONDS	4	40	U1234	If slew request is accepted, this parameter indicates the number of seconds that the target can be observed before a constraint is violated (SAA is not included). If the slew request is rejected this field contains no valid data.
Checksum	2	44	U12	

Appendix A.8. S/C to FoM Slew Information Reply Message (FSLEWINFOREPLY).

The format and descriptions for this message are taken from the "Swift Spacecraft to Payload Telecommand ICD". In the case of conflicting information, the information in the ICD will take precedence.

Message	APID	FC	Length (bytes)	Description
FSLEWINFOREPLY	0x620	02	46	This is the telecommand message from the spacecraft to the FoM in response to a request for slew information. If the s/c can safely slew to the target, this telecommand will contain the number of seconds that the target can be viewed. If the s/c cannot safely slew to the target, it will contain the number of seconds until a slew request to the target can be accepted.

Message Sub-Field Descriptions

Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
SLEW INFO REPLY	4	8	U1234	Reply to slew request; 0 = s/c would accept the slew request 1 = slew request would be rejected because of a Sun viewing constraint 2 = slew request would be rejected because of an Earth limb viewing constraint 3 = slew request would be rejected because of a Moon viewing constraint 4 = slew request would be rejected because of a Ram viewing constraint 5 = slew request would be rejected because of an invalid request parameter
OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment of the requested target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
RA	8	16	F12345678	Right ascension of the target. Range is 0 to 360 degrees. (J2000 epoch)
DEC	8	24	F12345678	Declination of the target. Range is –90 to +90 degrees. (J2000 epoch)
ROLL	4	32	F1234	Calculated roll of the s/c after the slew. Range is 0 to 360 degrees. (J2000 epoch)
WAIT_SECONDS	4	36	U1234	If slew request would be rejected, this parameter indicates the number of seconds to wait before making the request again, else this field contains no valid data.
OBSERVE_ SECONDS	4	40	U1234	If slew request would be accepted, this parameter indicates the number of seconds that the target could be observed before a constraint is violated (SAA constraints are not included). If the slew request would be rejected this field contains no valid data.
Checksum	2	44	U12	

Appendix A.9. S/C to FoM View Constraint Message (FVIEWCONSTRAINT).

The format and descriptions for this message are taken from the "Swift Spacecraft to Payload Telecommand ICD". In the case of conflicting information, the information in the ICD will take precedence.

Message	APID	FC	Length (bytes)	Description
FVIEWCONSTRAINT	0x620	03	10	This is the telecommand message from the spacecraft to the FoM notifying it that a view constraint is about to be violated.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
Checksum	2	8	U12	

Appendix A.10 S/C to Instruments 5 Hz Attitude Information Message (SISCATTITUDE).

The format and descriptions for this message are taken from the "Swift Spacecraft to Payload Telecommand ICD". In the case of conflicting information, the information in the ICD will take precedence.

Message	APID	FC	Length (bytes)	Description
SISCATTITUDE	0x701	1	62	This telecommand message from the spacecraft is sent to the instruments at a continuous 5 Hz rate. This message contains spacecraft attitude and slew status information.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
SCLK_Seconds	4	8	U1234	The seconds field of the S/C clock time associated with the spacecraft attitude.
SCLK_Subseconds	2	12	U12	The subseconds field of the S/C clock time associated with the spacecraft attitude.
FILL	2	14	U12	Fill bytes for data alignment purposes
OBSERVATION NUMBER	4	16	U1234	Target ID and Observation Segment of the target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
RA	8	20	F12345678	Right ascension of where the s/c is currently pointing. Range is 0 to 360 degrees. (J2000 epoch)
DEC	8	28	F12345678	Declination of where the s/c is currently pointing. Range is -90 to +90 degrees. (J2000 epoch)
ROLL	4	36	F1234	Current roll angle of the s/c. Range is 0 to 360degrees. (J2000 epoch)
LATITUDE	4	40	F1234	Current latitude, in degrees, of the spacecraft
LONGITUDE	4	44	F1234	Current longitude, in degrees, of the spacecraft
ALTITUDE	4	48	F1234	Current altitude, in meters, of the spacecraft
BUS VOLTAGE	4	52	F1234	Spacecraft bus voltage
IN_SAA_FLAG	1	56	U1	True (1) = s/c in SAA; false (0) = s/c not in SAA
IS_IN_10_ARCMIN	1	57	U1	True (1) = s/c within 10 arcmins target; false (0) = s/c not within 10 arcmins of target
IS_SETTLED	1	58	U1	True (1) = s/c settled on target; false (0) = s/c is slewing to target
IN_SAFE_MODE	1	59	U1	Equal true (1) when s/c in safe mode; otherwise equal false (0).
Checksum	2	60	U12	

Appendix A.11. S/C to Instruments Slew Warning Message (SISLEWWARNING).

The format and descriptions for this message are taken from the
"Swift Spacecraft to Payload Telecommand ICD". In the case of conflicting information, the information in the ICD will take precedence.

Message	APID	FC	Length (bytes)	Description
SISLEWWARNING	0x701	3	10	This is the telecommand message from the spacecraft to the instruments notifying them that the spacecraft is about to slew. The UVOT is expected to safe itself for the slew and then reply to the spacecraft with a SACSLEWSAFEREPLY.
Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
Checksum	2	8	U12	

Appendix A.12. S/C to Instruments Slew Abort Message (SISLEWABORT).

The format and descriptions for this message are taken from the "Swift Spacecraft to Payload Telecommand ICD". In the case of conflicting information, the information in the ICD will take precedence.

Message	APID	FC	Length (bytes)	Description
SISLEWABORT	0x701	4	10	This is the telecommand message from the spacecraft to the instruments notifying them that the spacecraft has aborted the slew. This telecommand is issued when the UVOT does not respond with a SLEWSAFEREPLY message within the allotted time and no viewing constraint is imminent.

Message Sub-Field Descriptions

Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
Checksum	2	8	U12	

Appendix A.13. FoM to Instruments Next Observation Info Message (FONEXTOBSINFO)

Message	[1]APID	FC	Length (bytes)	Description
FONEXTOBSINFO	0x702	01	60	This telecommand message from the FoM to the instruments provides detailed information about the next target to be observed. This message is issued upon confirmation that SC is slewing to a new, FoM requested target. FoM will also add this message to the BAT/FoM housekeeping data stream to be sent to the ground to support FOT timeline reconstruction.
Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	8	U1234	Target ID and Observation Segment of next target to be observed. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
Trigger Time Secs	4	12	U1234	[1] Target's trigger detection time (seconds). Target request value used for GRB / TOO targets. Set to 0 for PPT targets
Trigger Time Ssecs	2	16	U12	[1] Target's burst trigger detection time (subseconds). Target request value used for GRB / TOO targets. Set to 0 for PPT target
BAT MODE	2	18	U12	[2] BAT instrument configuration mode for the target observation
XRT MODE	2	20	U12	[2] XRT instrument configuration mode for the target observation
UVOT MODE	2	22	U12	[2] UVOT instrument configuration mode for the target observation
RA	8	24	F12345678	Right ascension for the next target observation. Range is 0 to 360degrees. (J2000 epoch)
DEC	8	32	F12345678	Declination for the next target observation. Range is -90 to +90 degrees. (J2000 epoch)
ROLL	4	40	F1234	Roll angle for the next target observation. Range is 0 to 360degrees. (J2000 epoch)
MERIT_VALUE	4	44	F1234	The relative merit value assigned to this target
OBSERVE_ SECONDS	4	48	U1234	[3] The number of seconds that the target can be observed between when the slew has settled and a constraint is violated (for AT targets) or the next PPT target is scheduled (for PPT targets). (see footnote for details) .
PAST_OBS_TIME	4	52	U1234	[4] Total number of seconds that this target has previously been observed.
IS_NEW_AT_ SLEW	1	56	U1	Equals true (1) if this is the first observance of the AT, otherwise false (0).
TARGET_TYPE	1	57	U1	Type of target to be observed. 0=GRB; 1=ToO; 2=PPT
Checksum	2	58	U12	

(1) For GRB and TOO requests, Trigger Time values are a pass thru of trigger time values provided in the target request. A trigger time is not provided in PPT target requests, therefore a 0 value is used for PPT type targets.
(2) The configuration mode value is simply a "pass through" for FoM. It is predefined for AT observations and set by the ground for PPTs and ToOs.
(3) For GRB and TOO targets, Observe_Seconds parameter is a "pass through" from FSLEWREQREPLY telecommand provided by the SC. This value reflects the time until a view constraint occurs. For PPT type targets, this value is a pass through of the ground provided Request Observe Seconds field provided in a PPT target request. That value is expected to be the the time between when the SC would settle on this target (if a slew is requested when it is initially received by FoM) and when the next PPT target is scheduled. NOTE: The Request_Observe_Seconds value is not adjusted by FoM should the slew to the PPT target be delayed.
(4) Past_Obs_Time field includes seconds since settled on target, but does not include time spent in SAA.

Appendix A.14. Instrument To FoM Update Merit Values Message (FOUPDMERITVAL)

Message	APID	FC	Length (bytes)	Description
FOUPDMERITVAL	0x620	06	24	(1, 2, 3) This telecommand message is sent by the instruments to the FoM to request an update of the requesting instrument's merit value parameters used by the FoM merit value computation algorithm for the GRB type target with the specified Observation Number. (See footnotes for further description).

Message Sub-Field Descriptions

Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	8	U1234	Target ID and Observation Segment of the target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
INSTRUMENT	2	12	U12	Instrument for which merit value updates apply (0Bat, 1Xrt, 2Uvot)
MERIT_VALUES	10	14	S1*10	The 10 instrument merit value parameters
Checksum	2	24	U12	

(1) FoM will reject command if the requested target is not the Fom AT target or is not a GRB type target.
(2) FoM upon receipt of a valid command will recompute this target's merit, and will request a slew to a new target if the change in merit makes the current observed target no longer the best available target.
(3) Update of this target's merit will effect whether new candidate AT targets will become the Fom AT.

Appendix A.15. XRT Position Command Message (XRTPOSITION).

The format and descriptions for this message are taken from the "XRT Telemetry Data Formats", XRT-PSU-0~~0~~28. For further details, see that document.

Message	APID	FC	Length (bytes)	Description
XRTPOSITION	0x705	0	60	(1, 2, 3) This telecommand message from the XRT is distributed to the UVOT and FoM to provide the XRT position centroid of a new gamma ray burst (GRB). (See footnotes for further description).
Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	8	U1234	Target ID and Observation Segment of the target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
Data Collection Time Seconds	4	12	U1234	The seconds field of the s/c time of the start of CCD frame from which XRT position data was determined
Data Collection Time Subseconds	2	16	U12	The sub-seconds field of the s/c time of the start of CCD frame from which XRT position data was determined
UTCF	6	18		UTC Correction factor
RA	4	24	F1234	Burst location right ascension. Range is 0 to 360 degrees. (J2000 epoch)
DEC	4	28	F1234	Burst location declination . Range is –90 to +90 degrees. (J2000 epoch)
FLUX	4	32	F1234	Estimated X-ray flux in ergs/cm^2/s ~~Integrated signal in target in one CCD frame~~
Significance	4	36	F1234	Floating point detection significance
TAM X1	4	40	F1234	X Position of TAM Image 1
TAM Y1	4	44	F1234	Y Position of TAM Image 1
TAM X2	4	48	F1234	X Position of TAM Image 2
TAM Y2	4	52	F1234	Y Position of TAM Image 2
Amp Number	1	56	U1	Amplifier Number of readout
Waveform ~~SPARE~~	1	57	U1	Waveform number of readout ~~Spare bytes~~
Checksum	2	58	U12	

(1) Upon observation of a new GRB target, XRT will generate either a message indicating that a position centroid was found (ie, XRTPOSITION msg) or was not found (ie, XRTCENTROIDERR msg). XRT will issue 2 versions of the message – one for TDRSS downlink and the other for distribution to other instruments.
(2) FoM will reject command if the requested target is not the Fom AT or is not a GRB type target.

(3) FoM will use the updated positions provided in this message for subsequent slew requests back to this target.

Appendix A.16. XRT Centroiding Error Telecommand Message (XRTCENTROIDERR).

The format and descriptions for this message are taken from the "XRT Telemetry Data Formats", XRT-PSU-0~~0~~28. For further details, see that document.

Message	APID	FC	Length (bytes)	Description
XRTCENTROIDERR	0x705	1	56	(1) This telecommand is generated by the XRT and distributed to other instruments if the XRT is unable to calculate a reliable centroid for a new GRB target, either due to lack of an identifiable source in the FOV or due to source confusion.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	8	U1234	Target ID and Observation Segment of the target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
Data Collection Time Seconds	4	12	U1234	The seconds field of the s/c time of the start of CCD frame from which XRT position data was determined
Data Collection Time Subseconds	2	16	U12	The sub-seconds field of the s/c time of the start of CCD frame from which XRT position data was determined
UTCF	6	18		UTC Correction factor
RA	4	24	F1234	RA (J2000) of pointing direction (degrees)~~Burst location right ascension. Range is 0 to 360 degrees. (J2000 epoch~~)
DEC	4	28	F1234	Dec (J2000) of pointing direction (degrees)~~Burst location declination . Range is -90 to +90 degrees. (J2000 epoch)~~
Error Flag	2	32	U12	1 = no source found in image 2 = algorithm did not converge ~~source confusion – could not identify target~~ 3 = standard deviation too large
Sigma	4	34	F1234	Standard Deviation of Centroid
Sigma Max	4	38	F1234	Maximum standard deviation for valid Centroid
Events in Centroid	4	42	U1234	Calculated events in Centroid Window
Min. events for Centroid	4	46	U1234	Minimum events for valid Centroid
Phase 2 Iterations	2	50	U12	Number of iterations in phase 2 of centroid algorithm
Max Iterations	2	52	U12	Maximum number of iterations in phase 2 for valid Centroid

~~SPARE~~	~~20~~	~~34~~	~~U1~~	~~Spare bytes~~
Checksum	2	54	U12	

(1) Upon observation of a new GRB target, XRT will generate either a message indicating that a position centroid was found (ie, XRTPOSITION msg) or was not found (ie, XRTCENTROIDERR msg). XRT will issue 2 versions of the message – one for TDRSS downlink and the other for distribution to other instruments.

Appendix A.17. BAT GRB Flux Information (BATGRBFLUXINFO).

Message	APID	FC	Length (bytes)	Description
BATGRBFLUXINFO	0x667 FC = 0	0	62	This telecommand message from the BAT is distributed to the UVOT to allow the UVOT to predict the optical brightness of the OT and thus the best observation mode (grism or filter)
Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header APID= 0x667 Function code = 0
OBSERVATION NUMBER	4	8	U1234	Target ID and Observation Segment of the target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
Peak Intensity	4	12	F1234	Height of peak of image. Multiply by image scaling factor (TBD) to get image fluence.
Foreground counts	4	16	I1234	Number of events in foreground interval used in image
Background counts	4	20	I1234	Number of events in background interval used in image (=0 if not background subtracted)
Foreground Duration	4	24	F1234	Duration of foreground interval used in image (seconds)
Background Duration	4	28	F1234	Duration of background interval used in image (=0.0 if not background subtracted)
RateTrigDuration1	4	32	F1234	Duration of the rate trigger that spawned the image (=0 if N/A)
RateTrigScore1	4	36	F1234	Score of the rate trigger that spawned the image (=0 if N/A)
RateTrigDuration2	4	40	F1234	Duration of improved rate trigger acquired while image being processed (=0 if N/A)
RateTrigScore2	4	44	F1234	Score of improved rate trigger acquired while image being processed (=0 if N/A)
Merit Values	10	48	I1*10	The 10 values for FoM merit computation. (range is -127 to +127)
SPARE	2	58	U12	Spare bytes
Checksum	2	60	U12	

Appendix A.18 UVOT Filter Wheel Movcment (UVOTFWSTART)

Message	APID	FC	Length (bytes)	Description
UVOTFWSTART	0x63E	0	10	This telecommand message is sent from the UVOT to the BAT ~2 seconds prior to the moving of the UVOT filter wheel and is planned to be used to offset the microphonics effect of FW movements on the BAT science trigger FSW. This FW movement command will be inhibited for the first 420 seconds of a GRB (default)*

Message Sub-Field Descriptions

Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
Checksum	2	8	U12	

*This default is stored in the ICU's "Standard" table and can be changed temporarily via a single word RAM load or permanently (lasting over a reboot) via an upload to EEPROM of the "Standard" table which is a small EEPROM checksummed table containing important constants. The delay time is also stored in the same way in the same "Standard" table in EEPROM. If this delay is set to 0 the whole of the message sending and delaying is disabled as if the CCR wasn't done.

Appendix A.19 UVOT Filter Wheel Movcment Stopped (UVOTFWSTOP)

Message	APID	FC	Length (bytes)	Description
UVOTFWSTOP	0x63E	1	10	This telecommand message is sent from the UVOT to the BAT once the UVOT filter wheel movement has stopped and is planned to be used to offset the microphonics effect of FW movements on the BAT science trigger FSW.

Message Sub-Field Descriptions

Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	2	6		CCSDS packet secondary header
Checksum	2	8	U12	

Appendix A.20~~17~~. FoM Next Observation Info Telemetry Message (FONEXTOBSINFO)

Message	APID	Length (bytes)	Description
FONEXTOBSINFO	0x14e	64	This telemetry message issued by the FoM from the FoM to the instruments provides detailed information about the next target to be observed. This message is issued upon confirmation that SC is slewing to a new, FoM requested target. FoM will also add this message to the BAT/FoM housekeeping data stream to be sent to the ground to support FOT timeline reconstruction. This telecommand message from the FoM to the instruments provides detailed information about the next target to be observed. FoM will also add this message to the BAT/FoM housekeeping data stream to be sent to the ground to support FOT timeline reconstruction.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	12	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment of next target to be observed. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
Trigger Time Secs	4	16	U1234	(1) Target's trigger detection time (seconds). Target request value used for GRB / TOO targets. Set to 0 for PPT targets
Trigger Time Ssecs	2	20	U12	(1) Target's burst trigger detection time (subseconds). Target request value used for GRB / TOO targets. Set to 0 for PPT target
BAT MODE	2	22	U12	(2) BAT instrument configuration mode for the target observation
XRT MODE	2	24	U12	(2) XRT instrument configuration mode for the target observation
UVOT MODE	2	26	U12	(2) UVOT instrument configuration mode for the target observation
RA	8	28	F12345678	Right ascension for the next target observation. Range is 0 to 360 degrees. (J2000 epoch)
DEC	8	36	F12345678	Declination for the next target observation. Range is -90 to +90 degrees. (J2000 epoch)
ROLL	4	44	F1234	Roll angle for the next target observation. Range is 0 to 360 degrees. (J2000 epoch)
MERIT_VALUE	4	48	F1234	The relative merit value assigned to this target
OBSERVE_ SECONDS	4	52	U1234	(3) The number of seconds that the target can be observed between when the slew has settled and a constraint is violated (for AT targets) or the next PPT target is scheduled (for PPT targets). (see footnote for details) .
PAST_OBS_TIME	4	56	U1234	(4) Total number of seconds that this target has previously been observed.
IS_NEW_AT_ SLEW	1	60	U1	Equals true (1) if this is the first observance of the AT, otherwise false (0).
TARGET_TYPE	1	61	U1	Type of target to be observed. 0=GRB; 1=ToO; 2=PPT

Checksum	2	62	U12	

(1) For GRB and TOO requests, Trigger Time values are a pass thru of trigger time values provided in the target request. A trigger time is not provided in PPT target requests, therefore a 0 value is used for PPT type targets.
(2) The configuration mode value is simply a "pass through" for FoM. It is predefined for AT observations and set by the ground for PPTs and ToOs.
(3) For GRB and TOO targets, Observe_Seconds parameter is a "pass through" from FSLEWREQREPLY telecommand provided by the SC. This value reflects the time until a view constraint occurs. For PPT type targets, this value is a pass through of the ground provided Request Observe Seconds field provided in a PPT target request. That value is expected to be the the time between when the SC would settle on this target (if a slew is requested when it is initially received by FoM) and when the next PPT target is scheduled. NOTE: The Request_Observe_Seconds value is not adjusted by FoM should the slew to the PPT target be delayed.
(4) Past_Obs_Time field includes seconds since settled on target, but does not include time spent in SAA.

Appendix A.21 ~~18~~. S/C Settled On Target Message (FOSCSETTLED)

Message	APID	Length (bytes)	Description
FOSCSETTLED	0x14f	46	Telemetry message generated by the FoM and added to the housekeeping telemetry stream when the s/c settles on the target. The purpose of this message is to support FOT personnel in the re-creation of the as-flown timeline.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	6	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment of the requested target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
Settle Time Secs	4	16	U1234	Seconds portion of S/C time when S/C settled on target (from SISCATTITUDE)
Settle Time Ssecs	2	20	U12	Subseconds portion of S/C time when S/C settled on target (from SISCATTITUDE)
FILL	2	22	U12	Fill bytes for data alignment purposes
RA	8	24	F12345678	(1) Right ascension of the target. Range is 0 to 360 degrees. (J2000 epoch)
DEC	8	32	F12345678	(1) Declination of the target. Range is -90 to +90 degrees. (J2000 epoch)
ROLL	4	40	F1234	(1) Roll angle for the target observation. Range is 0 to 360 degrees. (J2000 epoch)
Checksum	2	44	U12	

(1) These values reflect position values requested by FoM (or updates to ROLL provided in slew replies). If the SC settles on a target FoM has not requested, these position values are set to 0.

Appendix B. TDRSS Burst Data Product Messages.

This appendix describes the format and content of TDRSS "burst data product" messages.

Note: All telemetry messages described in this appendix contain the appropriate CCSDS packet header. Refer to reference document number 1, "Swift 1553 Bus Protocol Interface Control Document", for details on CCSDS headers for telemetry packets. Most messages also contain the Swift-standard tertiary header. The tertiary header consists of the observation number, spacecraft time, and UTCF and immediately follows the CCSDS header. Refer to reference document number 8, "Swift Telemetry Format Standards" for a description of the Swift-standard tertiary header.

Table 33. Summary of TDRSS Burst Data Product Messages

Appendix	Message Mnemonic	Msg Source	(1) APID	DESCRIPTION
B.1	BAGRBALERT	BAT	0x180(TDRS) 0x155 (Mal)	BAT Gamma Ray Burst (GRB) Alert TDRSS telemetry message
B.2	BAGRBPOSITION_Ack	BAT	0x181	GRB Position ACK TDRSS telemetry message from BAT
B.3	BAGRBPOSITION_Nack	BAT	0x182(TDRS) 0x156 (Mal)	GRB Position NACK TDRSS telemetry message from BAT
B.4	FOM2OBSAT	FoM	0x190	TDRSS message from FoM indicating whether FoM will/will not observe AT
B.5	FOSC2OBSAT	FoM	0x191	TDRSS message from FoM indicating whether S/C will/will not observe AT
B.6	BALIGHTCURVE	BAT	0x183	TDRSS message containing BAT Light Curve data from the GRB
B.7	XRTPOSITION	XRT	0x4E0	TDRSS message containing XRT position centroid of the new GRB.
B.8	XRTSPECTRUM	XRT	0x4E1	TDRSS message containing the XRT raw spectrum of the GRB
B.9	XRTIMAGE	XRT	0x4E2	TDRSS message containing the XRT image data for the GRB
B.10	UVOTFINDINGCHART	UVOT	0x2C0	TDRSS message containing the UVOT Finding Chart data for the GRB
B.11	XRTCENTROIDERR	XRT	0x4F0	TDRSS message generated by the XRT if the XRT is unable to calculate a reliable centroid for a new GRB target.
B.12	BATTRANSIENTMAP	BAT	0x184	TDRSS message generate by BAT when a transient image detected.

(1) See Table 1 for explanation of APID notation.

Appendix B.1. BAT GRB Alert TDRSS Message (BAGRBALERT).

The format and descriptions for this message are taken from the "BAT Telemetry Data Formats", version 0.18. For further details, see that document.

Message	[1] APID	Length (bytes)	Description
BAGRBALERT	0x180 (TDRS) 0x155 (Mal)	70	This telemetry message from the BAT alerts the ground personnel that a potential gamma ray burst (GRB) has been detected. It will be downlinked via TDRSS except during Malindi contacts in which case it will be downlinked via the realtime Malindi link.

Message Sub-Field Descriptions					
Sub-Field Name		Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header		6	0		CCSDS packet primary header
CCSDS Secondary Header		6	6		CCSDS packet secondary header
T e r t H d r	OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
	SCLK Seconds	4	16	U1234	The seconds field of the S/C clock time when packet constructed
	SCLK Subseconds	2	20	U12	The sub-seconds field of the S/C clock time when packet constructed
	UTCF	6	22		UTC Correction factor
SCLK Seconds		4	28	U1234	The seconds field of the S/C clock time of the data at which trigger detected
SCLK Subseconds		2	32	U12	The sub-seconds field of the S/C clock time of the data at which trigger detected
UTCF		6	34		UTC Correction factor
TRIGGER SATISFIED		2	40	U12	The table index of the trigger that had the highest significance level of all those satisfied
SIGNIFICANCE LEVEL		2	42	U12	The significance of the highest trigger satisfied
SPARE		24	44	U1*24	Spare bytes
CHECKSUM		2	68	U12	

(1) See Table 1 for explanation of APID notation.

Appendix B.2. BAT GRB Position_Ack TDRSS Message (BAGRBPOSITION_Ack).

The format and descriptions for this message are taken from the "BAT Telemetry Data Formats", version 0.18. For further details, see that document.

Message	[1]APID	Length (bytes)	Description
BAGRBPOSITION_Ack	0x181	112	This is the telemetry message from the BAT indicating that a BAT timing trigger has been confirmed by a valid image. This message will always be downlinked via TDRSS. Malindi contacts will be interrupted for TDRSS downlink of the GRB Position_Ack telemetry.

Message Sub-Field Descriptions					
Sub-Field Name		Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header		6	0		CCSDS packet primary header
CCSDS Secondary Header		6	6		CCSDS packet secondary header
Tert Hdr	OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
	SCLK Seconds	4	16	U1234	The seconds field of the S/C clock time when packet constructed
	SCLK Subseconds	2	20	U12	The sub-seconds field of the S/C clock time when packet constructed
	UTCF	6	22		UTC Correction factor
SCLK Seconds		4	28	U1234	The seconds field of the S/C clock time of the data at which trigger detected
SCLK Subseconds		2	32	U12	The sub-seconds field of the S/C clock time of the data at which trigger detected
UTCF		6	34		UTC Correction factor
FILL		2	40	U12	Fill bytes for data alignment purposes
Trigger Satisfied		2	42	U12	Trigger that had the highest significance level of all those satisfied
Significance Level		2	44	U12	Significance of the highest trigger satisfied
Solution Status		2	46	U12	Provides information regarding the trigger, source type, target type and whether point source solution found for this target bit4: 1 if image trigger, 0 if rate trigger bit3: 1 if cataloged source, 0 if unknown source bit2: 1 if interesting, 0 if boring bit1: 1 if deemed a GRB, 0 if not a GRB bit0: 1 if point source solution found, 0 if not found

RA	8	48	F12345678	Right ascension of the target. Range is 0 to 360 degrees. (J2000 epoch)
DEC	8	56	F12345678	Declination of the target. Range is -90 to +90 degrees. (J2000 epoch)
Theta	4	64	F1234	Distance of target from BAT boresight (ie, ~spacecraft X axis) in degrees Valid range is 0 to 180. Expected range is 0 to 70 for sources in the field of view.
Phi	4	68	F1234	Angle of target about boresight in degrees. Range is 0 to 360 Phi = 0 is in S/C +Y direction. Phi = 90 is in S/C -Z direction,
Peak Intensity	4	72	U1234	Peak count rate observed during integration interval
Burst Fluence	4	76	U1234	Number of burst-only events in the integration interval
Background Fluence	4	80	U1234	Number of background events in the integration interval
Background Start SCLK Seconds	4	84	U1234	Start time of the background interval in s/c clock seconds.
Detector Significance	2	88	U12	Significance of the peak in the FFT coarse image
Integration Time	2	90	U12	Amount of time used in position calculation
Misc Status	4	92		Miscellaneous S/C and BAT status information. (Format to be resolved).
Merit Values	10	96	S1*10	The 10 values for FoM merit computation. (range is -127 to +127)
SPARE	4	106		Spare bytes
Checksum	2	110	U12	

(1) See Table 1 for explanation of APID notation.

Appendix B.3. BAT GRB Position_Nack TDRSS Message (BAGRBPOSITION_Nack).

The format and descriptions for this message are taken from the "BAT Telemetry Data Formats", version 0.18. For further details, see that document.

Message			[1]APID	Length (bytes)	Description
BAGRBPOSITION_Nack			0x182(TDRS) 0x156 (Mal)	112	This is the telemetry message generated by the BAT after a BAT timing trigger that could not be confirmed by a valid image. This message will be downlinked via TDRSS except during Malindi contacts in which case it will be downlinked via the realtime Malindi link.
Message Sub-Field Descriptions					
Sub-Field Name		Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header		6	0		CCSDS packet primary header
CCSDS Secondary Header		6	6		CCSDS packet secondary header
Tert Hdr	OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
	SCLK Seconds	4	16	U1234	The seconds field of the S/C clock time when packet constructed
	SCLK Subseconds	2	20	U12	The sub-seconds field of the S/C clock time when packet constructed
	UTCF	6	22		UTC Correction factor
SCLK Seconds		4	28	U1234	The seconds field of the S/C clock time of the data at which trigger detected
SCLK Subseconds		2	32	U12	The sub-seconds field of the S/C clock time of the data at which trigger detected
UTCF		6	34		UTC Correction factor
FILL		2	40	U12	Fill bytes for data alignment purposes
Trigger Satisfied		2	42	U12	Trigger that had the highest significance level of all those satisfied
Significance Level		2	44	U12	Significance of the highest trigger satisfied
Solution Status		2	46	U12	True (1) = Point source solution was found; False (0) = No point source solution found
RA		8	48	F12345678	[2] Right ascension of the target. Range is 0 to 360 degrees. (J2000 epoch)
DEC		8	56	F12345678	[2] Declination of the target. Range is -90 to +90 degrees. (J2000 epoch)

Theta	4	64	F1234	Distance of target from BAT boresight (ie, ~spacecraft X axis) in degrees Valid range is 0 to 180 Expected range is 0 to 70 for sources in the field of view.
Phi	4	68	F1234	Angle of target about boresight in degrees. Range is 0 to 360 Phi = 0 is in S/C +Y direction. Phi = 90 is in S/C -Z direction,
Peak Intensity	4	72	U1234	Peak count rate observed during integration interval
Burst Fluence	4	76	U1234	Number of burst-only events in the integration interval
Background Fluence	4	80	U1234	Number of background events in the integration interval
Background Start SCLK Seconds	4	84	U1234	Start time of the background interval in s/c clock seconds.
Detector Significance	2	88	U12	Significance of the peak in the FFT coarse image
Integration Time	2	90	U12	Amount of time used in position calculation
Misc Status	4	92		Miscellaneous S/C and BAT status information. (Format to be resolved).
Merit Values	10	96	S1*10	The 10 values for FoM merit computation. (range is –127 to +127)
SPARE	4	106		Spare bytes
Checksum	2	110	U12	

(1) See Table 1 for explanation of APID notation. If more than one APID is given, more than one version of the message will be generated.
(2) Field contains no valid data for BAGRBPOSITION_Nack telemetry message.

Appendix B.4. FoM Will/Will Not Observe AT TDRSS Message (FOM2OBSAT).

Message	[1]APID	Length (bytes)	Description
FOM2OBSAT	0x190	64	This telemetry message from the FoM indicates whether the FoM Will/Will Not observe the new AT. This message is generated upon receipt of a new (first time) AT request.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	6	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
SCLK Seconds	4	16	U1234	The seconds field of the S/C clock time of the data at which trigger detected
SCLK Subseconds	2	20	U12	The sub-seconds field of the S/C clock time of the data at which trigger detected
FILL	2	22	U12	Fill bytes for data alignment purposes
RA	8	24	F12345678	Right ascension of the target. Range is 0 to 360 degrees. (J2000 epoch)
DEC	8	32	F12345678	Declination of the target. Range is -90 to +90 degrees. (J2000 epoch)
ROLL	4	40	F1234	Roll of the target. Range is 0 to 360 degrees. (J2000 epoch)
Merit Value	4	44	F1234	The merit value for the AT. FoM computed for GRB; Ground supplied for ToOs.
Trigger Satisfied	2	48	U12	Trigger that had the highest significance level of all those satisfied
Significance Level	2	50	U12	The significance of the highest trigger satisfied
NEW_FoM_AT	1	52	U1	Was AT of sufficient merit to become FoM_AT? 1=YES 0=NO
FOM2OBS	1	53	U1	Was AT of sufficient merit to warrant requesting a slew? 1=YES 0=NO
SPARE	8	54	U1*8	Spare bytes for future growth
CHECKSUM	2	62	U12	

Appendix B.5. S/C Will/Will Not Slew to AT TDRSS Message (FOSC2OBSAT).

Message	(1) APID	Length (bytes)	Description
FOSC2OBSAT	0x191	70	This telemetry message notifies the ground whether or not the s/c will slew to the requested AT target due to viewing constraints. It is generated by the FoM when a FSLEWREQREPLY message is received for a new (first time) AT target. FoM will not generate this message for subsequent FSLEWREQREPLY messages for this same AT.

Message Sub-Field Descriptions

Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	6	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
S/C REPLY	4	22	U1234	0=Will Slew; Non-Zero=Won't Slew. This field is a pass-through of value from the FSLEWREQREPLY telecommand. See FSLEWREQREPLY msg description for definition of non-zero values.
Trigger Time Secs	4	16	U1234	The seconds field of the S/C clock time of the data at which trigger detected
Trigger Time Ssecs	2	20	U12	The sub-seconds field of the S/C clock time of the data at which trigger detected
Trigger Satisfied	2	26	U12	Trigger that had the highest significance level of all those satisfied
Significance Level	2	28	U12	The significance of the highest trigger satisfied
BAT MODE	2	30	U12	(1) BAT instrument configuration mode for the target observation
XRT MODE	2	32	U12	(1) XRT instrument configuration mode for the target observation
UVOT MODE	2	34	U12	(1) UVOT instrument configuration mode for the target observation
RA	8	36	F12345678	Right ascension of the target. Range is 0 to 360 degrees. (J2000 epoch)
DEC	8	44	F12345678	Declination of the target. Range is -90 to +90 degrees. (J2000 epoch)
ROLL	4	52	F1234	Roll of s/c after the slew. Range is 0 to 360 degrees. (J2000 epoch)
WAIT_SECONDS	4	56	U1234	Number of seconds to wait before target is viewable
OBSERVE_ SECONDS	4	60	U1234	Number of seconds target can be observed before constraint violation (does not include SAA)
MERIT VALUE	4	64	F1234	The merit value for the AT. FoM computed for GRBs and ground supplied for ToOs.
CHECKSUM	2	68	U12	

(1) The configuration mode value is simply a "pass through" for FoM. It is predefined for GRB observations and set by the ground for PPTs and ToOs.

Appendix B.6. BAT GRB Light Curve TDRSS Message (BALIGHTCURVE).

The format and descriptions for this message are taken from the "BAT Telemetry Data Formats", version 0.18. For further details, see that document.

Message	[1]APID	[2]Length (bytes)	Description
BALIGHTCURVE	0x183	Pkt1=958 Pkt2=638 Pkt3=232	This is the TDRSS telemetry message containing the BAT Light Curve data from the GRB. This message is sent using segmented telemetry utilizing three ST-PDUs.

Message Sub-Field Descriptions						
	Sub-Field Name		Size (bytes)	Offset (bytes)	ITOS Type	Description
PACKET #1	CCSDS Primary Header		6	0		CCSDS packet primary header
	CCSDS Secondary Header		6	6		CCSDS packet secondary header
	Tert Hdr	OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
		SCLK Seconds	4	16	U1234	The seconds field of the S/C clock time of the data at which trigger detected
		SCLK Subseconds	2	20	U12	The sub-seconds field of the S/C clock time of the data at which trigger detected
		UTCF	6	22		UTC Correction factor
	SCLK Seconds at Trigger		4	28	U1234	The seconds field of the s/c clock when the Trigger happened.
	SCLK Subseconds at Trigger		2	32	U12	The subseconds field of the s/c clock when the Trigger happened.
	Packet Number		2	34	U12	Packet segment number (=1 for this first of 3 packets).
	Trigger / Light Curve Delta		2	36	S12	Difference between LC T_zero (T_0) and the Trigger Time (T0 – TrigTime). 10msec accuracy.
	Triggers Satisfied		2	38		Trigger that had the highest significance level of all those satisfied
	RA		8	40	F12345678	Burst location RA (J2000). 0.0-360.0.
	Dec		8	48	F12345678	Burst location Dec (J2000). –90.0 to +90.0.
	Theta		4	56	F1234	Burst location in BAT instrument coordinates, Theta. Angle for the boresight (0.0 to ~70.0deg).
	Phi		4	60	F1234	Burst location in BAT instrument coordinates, Phi. Range 0.0 to 360.0deg. Phi=0.0 is s/c Y-axis, and phi=90.0 is the s/c –Z axis.
	T_0-24 to T_0-8 sec in E0 – E3		10 * (4 * 2)	64		1st thru 10th rates samples in energy bands 0, 1, 2, 3 (1.6sec sec samplings).

	T_0-8 to T_0-1.6 sec in E0 – E3	20 * (4 * 2)	144		11th thru 30th rates samples in energy bands 0, 1, 2, 3 (0.32 sec samplings).
	T_0-1.6 to T_0+8 sec in E0 – E3	75 * (4 * 2)	304		31th to 105th rate samples in energy bands 0, 1, 2, 3 (0.128 sec samplings).
	S/C_attitude at T_0-1.6 thru T_0 + 8 sec	7 * (3 * 2)	904		1st 7 ACS Position Triplet. (Sampled each 1.6 sec). Unlike rates, starts at time T_0–1.6 secs. Each RA, Dec, Roll is an integerized triplet (0.01deg units). Ranges are 0 to 360 (RA, Roll) & 0 to 180 (Dec)
	SPARE	10	946		Spare bytes
	Checksum	2	956	U12	
PACKET #2	Repeat Of Packet Headers From Packet #1	28	0		CCSDS primary and secondary header, and Swift-standard tertiary header (bytes 0 thru 27) are repeated from packet #1
	SCLK Seconds at Trigger	4	28	U1234	The seconds field of the s/c clock when the Trigger happened.
	SCLK Subseconds at Trigger	2	32	U12	The subseconds field of the s/c clock when the Trigger happened.
	Packet Number	2	34	U12	Packet segment number (=2 for this first of 3 packets).
	Trigger / Light Curve Delta	2	36	S12	Difference between LC T_zero (T_0) and the Trigger Time (T0 – TrigTime). 10msec accuracy.
	Triggers Satisfied	2	38		Trigger that had the highest significance level of all those satisfied
	RA	8	40	F12345678	Burst location RA (J2000). 0.0-360.0.
	Dec	8	48	F12345678	Burst location Dec (J2000). –90.0 to +90.0.
	Theta	4	56	F1234	Burst location in BAT instrument coordinates, Theta. Angle for the boresight (0.0 to ~70.0deg).
	Phi	4	60	F1234	Burst location in BAT instrument coordinates, Phi. Range 0.0 to 360.0deg. Phi=0.0 is s/c Y-axis, and phi=90.0 is the s/c –Z axis.
	T_0+8 to T_0+22.08 sec in E0 – E3	55 * (4 * 2)	64		Next 55 rates samples in energy bands 0, 1, 2, 3 (0.256 sec sec samplings).
	T_0+22.08 to T_0+38.464 sec in E0 – E3	16 * (4 * 2)	504		Next 16 rates samples in energy bands 0, 1, 2, 3 (1.024 sec samplings).
	T_0+38.464 to T_0+104 sec in E0 – E3	16 * (4 * 2)	632		Next 16 rate samples in energy bands 0, 1, 2, 3 (4.096 sec samplings).
	S/C_attitude at T_0+11.2 thru T_0 + 104 sec	30 * (3 * 2)	760		Next 30 ACS Position Triplet. (Sampled each 1.6 sec). Each RA, Dec, Roll is an integerized triplet (0.01deg units). Ranges are 0 to 360 (RA, Roll) & 0 to 180 (Dec)
	SPARE	16	940		Spare bytes
	Checksum	2	956	U12	
	Repeat Of Packet Headers From Packet #1	28	0		CCSDS primary and secondary header, and Swift-standard tertiary header (bytes 0 thru 27) are repeated from packet #1

PACKET # 3	SCLK Seconds at Trigger	4	28	U1234	The seconds field of the s/c clock when the Trigger happened.
	SCLK Subseconds at Trigger	2	32	U12	The subseconds field of the s/c clock when the Trigger happened.
	Packet Number	2	34	U12	Packet segment number (=2 for this first of 3 packets).
	Trigger / Light Curve Delta	2	36	S12	Difference between LC T_zero (T_0) and the Trigger Time (T0 – TrigTime). 10msec accuracy.
	Triggers Satisfied	2	38		Trigger that had the highest significance level of all those satisfied
	RA	8	40	F12345678	Burst location RA (J2000). 0.0-360.0.
	Dec	8	48	F12345678	Burst location Dec (J2000). –90.0 to +90.0.
	Theta	4	56	F1234	Burst location in BAT instrument coordinates, Theta. Angle for the boresight (0.0 to ~70.0deg).
	Phi	4	60	F1234	Burst location in BAT instrument coordinates, Phi. Range 0.0 to 360.0deg. Phi=0.0 is s/c Y-axis, and phi=90.0 is the s/c –Z axis.
	T_0+104 to T_0+185.92 sec in E0 – E3	20 * (4 * 2)	64		Next 20 rates samples in energy bands 0, 1, 2, 3 (4.096 sec samplings).
	SPARE	6	224		Spare bytes
	Checksum	2	230	U12	

(1) This message will be segmented into smaller packets (as specified in the Swift Telemetry Format Standards Document) to conform to the maximum 958 bytes/packet requirement. Each packet will represent different detector rate samples and s/c attitude.

Appendix B.7. XRT Position TDRSS Message (XRTPOSITION).

The format and descriptions for this message are taken from the "XRT Telemetry Data Formats", XRT-PSU-~~0~~028. For further details, see that document.

Message	(1)APID	Length (bytes)	Description
XRTPOSITION	0x4E0	64	(1) This TDRSS telemetry message provides the XRT position centroid of a new gamma ray burst (GRB). .
Message Sub-Field Descriptions			
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	6	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
Data Collection Time Seconds	4	16	U1234	The seconds field of the s/c time of the start of CCD frame from which XRT position data was determined
Data Collection Time Subseconds	2	20	U12	The sub-seconds field of the s/c time of the start of CCD frame from which XRT position data was determined
UTCF	6	22		UTC Correction factor
RA	4	28	F1234	Burst location right ascension. Range is 0 to 360 degrees. (J2000 epoch)
DEC	4	32	F1234	Burst location declination . Range is –90 to +90 degrees. (J2000 epoch)
FLUX	4	36	F1234	Integrated signal in target in one CCD frame
Significance	4	40	F1234	Floating point detection significance
TAM X1	4	44	F1234	X Position of TAM Image 1
TAM Y1	4	48	F1234	Y Position of TAM Image 1
TAM X2	4	52	F1234	X Position of TAM Image 2
TAM Y2	4	56	F1234	Y Position of TAM Image 2
Amp Number	1	60	U1	Amplifier Number of readout
Waveform ~~SPARE~~	1	61	U1	Waveform number of readout~~Spare bytes~~
Checksum	2	62	U12	

(1) Upon observation of a new GRB target, XRT will generate either a message indicating that a position centroid was found (ie, XRTPOSITION msg) or was not found (ie, XRTCENTROIDERR msg). XRT will issue 2 versions of the message – one for TDRSS downlink and the other for distribution to other instruments.

Appendix B.8. XRT Spectrum TDRSS Message (XRTSPECTRUM).

The format and descriptions for this message are taken from the "XRT Telemetry Data Formats", XRT-PSU-~~0~~028. For further details, see that document.

Message		APID	Length (bytes)	Description
XRTSPECTRUM		0x4E1	Pkt1=958 Pkt2=958 Pkt3=314	This TDRSS telemetry message from XRT contains a 1024 channel raw spectrum of the gamma ray burst (GRB). This message is sent using segmented telemetry utilizing three unsegmented ST-PDUs.
Message Sub-Field Descriptions				
Sub-Field Name		Size (bytes)	Offset (bytes)	ITOS Type	Description
PACKET #1	CCSDS Primary Header	6	0		CCSDS packet primary header
	CCSDS Secondary Header	6	6		CCSDS packet secondary header
	OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
	Spectrum Start Time Seconds	4	16	U1234	The s/c time seconds field of the start time of the first CCD frame in the spectrum
	Spectrum Start Time Subseconds	2	20	U12	The s/c sub-seconds field of the start time of the first CCD frame in the spectrum
	UTCF	6	22		UTC Correction factor
	Packet Number	2	28	U12	(1) 0x0001. Packet ~~segment~~ number
	RA	4	30	F1234	RA of S/C boresight ~~image center~~. Received and calculated as 8 byte float, but reported as 4 byte float. Range is 0 to 360 degrees. (J2000 epoch)
	DEC	4	34	F1234	Declination of S/C boresight ~~image center~~. Received and calculated as 8 byte float, but reported as 4 byte float. Range is –90 to +90 degrees. (J2000 epoch)
	Spectrum Stop Time Seconds	4	38	U1234	The seconds field of the S/C stop time of the last CCD frame in the spectrum
	Spectrum Stop Time Subseconds	2	42	U12	The sub-seconds field of the S/C stop time of the last CCD frame in the spectrum
	SPECTRUM	900	44	U12*450	(1) Spectral Channels 1-450
	LIVE TIME	4	944	F1234	Exposure time for spectrum
	SPARE	8	948	U1*8	Spare bytes
	CHECKSUM	2	956	U12	
PKT	Repeat Of Packet Headers From Packet #1	28	0		CCSDS primary and secondary header, and Swift-standard tertiary header (bytes 0 thru 27) are repeated from packet #1
	Packet Number	2	28	U12	(1) 0x0002. Packet ~~segment~~ number

	SPECTRUM	900	30	U12*900	(1) Spectral channels 451-900
#	SPARE	26	930	U1*26	Spare Bytes
2	Checksum	2	956	U12	
P	Repeat Of Packet Headers From Packet #1	28	0		CCSDS primary and secondary header, and Swift-standard tertiary header (bytes 0 thru 27) are repeated from packet #1
K	Packet Number	2	28	U12	(1) 0x0003 Packet ~~segment~~ number
T	SPECTRUM	248	30	U1*124	(1) Spectral channels 901-1024
#	SPARE	34	278	U1*34	Spare Bytes
3	Checksum	2	312	U12	

(1) The XRTSPECTRUM message uses 3 ST-PDU unsegmented packets. Packet 1 for channels 1-450, packet 2 for channels 451-900, and packet 3 for channels 901-1024

Appendix B.9. XRT Image TDRSS Message (XRTIMAGE).

The format and descriptions for this message are taken from the "XRT Telemetry Data Formats", XRT-PSU-~~0~~028. For further details, see that document.

Message	APID	Length (bytes)	Description
XRTIMAGE	0x4E2	Pkt1=958 Pkt2=958 Pkt3=954 ~~884~~	This TDRSS telemetry message from XRT contains a 51 x 51 pixel 8-bit image centered on the source centroid position. This message is sent using segmented telemetry utilizing three unsegmented ST-PDUs.

Message Sub-Field Descriptions					
Sub-Field Name		Size (bytes)	Offset (bytes)	ITOS Type	Description
PACKET # 1	CCSDS Primary Header	6	0		CCSDS packet primary header
	CCSDS Secondary Header	6	6		CCSDS packet secondary header
	OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
	Data Collection Start Seconds	4	16	U1234	The seconds field of the S/C time of the CCD frame start
	Data Collection Start Subseconds	2	20	U12	The sub-seconds field of the S/C time of the CCD frame start
	UTCF	6	22		UTC correction factor
	Packet Number	2	28	U12	(1) 0x0001. Packet ~~segment~~ number
	CCD Frame Counter	4	30	U1234	Sequential CCD Frame Counter
	RA	4	34	F1234	RA of GRB Centroid (degrees) ~~image center (degrees). Received and calculated as 8 byte float, but reported as 4 byte float. Range is 0 to 360 degrees.~~ (J2000 epoch)
	DEC	4	38	F1234	Dedination of GRB Centroid (degrees) ~~image center (degrees). Received and calculated as 8 byte float, but reported as 4 byte float. Range is -90 to +90 degrees~~. (J2000 epoch)
	Roll	4	42	F1234	Roll angle (degrees) of spacecraft ~~image~~
	RAWY ~~Lower Left X~~	2	46	U12	Row coordinate of image center in pixels ~~Corner X coordinate in pixels~~
	RAWX ~~Lower Left Y~~	2	48	U12	Column coordinate of image center in pixels ~~Corner Y coordinate in pixels~~
	GAIN	1	50	U1	Inverse gain (data were divided by this value)
	IMAGE	867	51	U1*867	(1) Rows 1-17 of image
	Centroid Y	4	918	F1234	Y Centroid position
	Centroid X	4	922	F1234	X Centroid position
	Sigma	4	926	F1234	Standard deviation of centroid
	Sigma Max	4	930	F1234	Maximum std deviation (programmable parameter)

	Events in Centroid	4	934	U1234	Number of events in centroid window
	Min events for Centroid	4	938	U1234	Minimum events for valid Centroid (programmable)
	Phase 2 Iterations	2	942	U12	Number iterations in phase 2 of centroid algorithm
	Maximum Iterations	2	944	U12	Maximum iterations for valid Centroid (programmable)
	Convergence Distance	4	946	F1234	Actual convergence distance
	Max Convergence Distance	4	950	F1234	Maximum convergence distance for valid centroid
	Window half-width	2	954	U12	Centroid window half-width (programmable)
	~~SPARE~~	~~38~~	~~918~~	~~U1*38~~	~~Spare bytes~~
	Checksum	2	956	U12	
PKT # 2	Repeat Of Packet Headers From Packet #1	28	0		CCSDS primary and secondary header, and Swift-standard tertiary header (bytes 0 thru 27) are repeated from packet #1
	Packet Number	2	28	U12	(1) 0x0002 Packet ~~segment~~ number
	CCD Frame Counter	4	30	U1234	Sequential CCD Frame Counter
	IMAGE	918	34	U1*918	(1) Rows 18-35 of image
	Flux Factor~~SPARE~~	4	952	F1234~~U1*32~~	Flux factor (programmable parameter) ~~Spare Bytes~~
	Checksum	2	956	U12	
PKT # 3	Repeat Of Packet Headers From Packet #1	28	0		CCSDS primary and secondary header, and Swift-standard tertiary header (bytes 0 thru 27) are repeated from packet #1
	Packet Number	2	28	U12	(1) 0x0003 Packet ~~segment~~ number
	CCD Frame Counter	4	30	U1234	Sequential CCD Frame Counter
	IMAGE	816	34	U1*816	(1) Rows 36-51 of image
	Boresight Column	4	850	F1234	Boresight row in RAWX (programmable)
	Boresight Row	4	854	F1234	Boresight column in RAWY (programmable)
	Boresight Roll Angle	4	858	F1234	Boresight roll angle in degrees (programmable)
	Plate Scale	4	862	F1234	Plate scale in arcsec/pixel (programmable)
	Spacecraft Y	4	866	F1234	S/C to XRT boresight correction in arcseconds
	Spacecraft Z	4	870	F1234	S/C to XRT boresight correction in arcseconds
	Spacecraft angle	4	874	F1234	S/C to XRT boresight roll correction in degrees
	TAM Ref X1	4	878	F1234	Reference window 1 X position
	TAM Ref Y1	4	882	F1234	Reference window 1 Y position
	TAM Ref X2	4	886	F1234	Reference window 2 X position
	TAM Ref Y2	4	890	F1234	Reference window 2 Y position
	TAM Theta_t	4	894	F1234	TAM angle (see XRT-PSU-037)
	TAM Optical gain	4	898	F1234	Optical gain factor (see XRT-LUX-TN-095)
	TAM Primary Plate Scale	4	902	F1234	Primary window plate scale
	TAM Secondary Plate Scale	4	906	F1234	Secondary window plate scale
	TAM Sequence counter	4	910	U1234	TAM Image sequence counter

	TAM Init	1	914	U1	Boolean: has TAM centroid been calculated
	TAM correction enabled	1	915	U1	Boolean: is TAM correction enabled
	Nominal exposure time	4	916	F1234	Nominal frame time for flux (programmable)
	S/C RA	4	920	F1234	S/C RA from SISCATTITUDE (J2000)
	S/C Dec	4	924	F1234	S/C Dec from SISCATTITUDE (J2000)
	Gy	4	928	F1234	GRB Y position in XRT coordinates
	Gz	4	932	F1234	GRB Z position in XRT coordinates
	GRB RA	8	936	F12345678	GRB Right Ascension – high precision
	GRB Dec	8	944	F12345678	GRB Declination – high precision
	~~SPARE~~	~~32~~	~~850~~	~~U1*30~~	~~Spare Bytes~~
	Checksum	2	952~~88~~ 2	U12	

(1) The XRTIMAGE message uses 3 ST-PDU unsegmented packets. Packet 1 for rows 1-17, packet 2 for rows 18-35, and packet 3 for rows 36-51 of the image.

Appendix B.10. UVOT Finding Chart TDRSS Message (UVOTFINDINGCHART).

The format and descriptions for this message are taken from the " Telemetry and Telecommand Formats For The Swift Ultraviolet Optical Telescope ", SWIFT-UVOT-009. For further details, see that document.

Message		(1) APID	Length (bytes)		Description
UVOTFINDINGCHART		0x2C0	Up to 958 bytes / packet		This TDRSS telemetry message from UVOT contains the UVOT Finding Chart data for the GRB. This message is sent using segmented telemetry utilizing up to 3 ST-PDUs.
Message Sub-Field Descriptions					
Sub-Field Name		Size (bytes)	Offset (bytes)	ITOS Type	Description
PACKET # 1	CCSDS Primary Header	6	0		CCSDS packet primary header
	CCSDS Secondary Header	6	6		CCSDS packet secondary header
	OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
	Finding Chart Start Seconds	4	16	U1234	The S/C time seconds field for the start of the Finding Chart data
	Finding Chart Start Subseconds	2	20	U12	The S/C time sub-seconds field for the start of the Finding Chart data
	UTCF	6	22		UTC Correction Factor
	Exposure ID	4	28	U1234	Exposure ID expressed in Spacecraft Seconds
	RA	8	32	F12345678	Right ascension. Range is 0 to 360 degrees. (J2000 epoch)
	DEC	8	40	F12345678	Declination. Range is –90 to +90 degrees. (J2000 epoch)
	ROLL	4	48	F1234	Roll of the target. Range is 0 to 360 degrees. (J2000 epoch)
	Filter Id	2	52		Filter used for this observation.
	X Offset	2	54		X offset of image window expressed in detector coordinates.
	Y Offset	2	56		Y offset of image window expressed in detector coordinates.
	X Maximum	2	58		Maximum extent of image window in the X direction expressed in detector coordinates.
	Y Maximum	2	60		Maximum extent of image window in the Y direction expressed in detector coordinates.
	N High Star	2	62		Number of high priority stars telemetered.
	X Coord – High Star1	2			X detector coordinate of the brightest pixel in star1
	Y Coord – High Star1	2			Y detector coordinate of the brightest pixel in star1

	(X, Y coord – Stars 2 – N High–1)	. . .	. . .	. . .	…
	X Coord – High StarN High	2			X detector coordinate of the brightest pixel in star NHIGH
	Y Coord – High StarN High	2			Y detector coordinate of the brightest pixel in star NHIGH
	Intensity – High Star 1	2			Value of Brightest pixel of high priority star 1
	Intensity – High Star 2	2			Value of Brightest pixel of high priority star 2
	(Intensity– Stars 2 – N High–1)	. . .	. . .	. . .	…
	Intensity – Star N High	2			Value of Brightest pixel of high priority star NHIGH
	N Medium Star	2			Number of medium priority stars telemetered.
	Data – Medium Star 1	8			Medium Priority data for star 1
	Data – Medium Star 2	8			Medium Priority data for star 2
	(Data– Stars 2 – N Med–1)	. . .	. . .	. . .	…
	Data – Medium Star N Med	8			Medium Priority data for star NMED
	N Low Star	2			Number of low priority stars telemetered.
	Data – Low Star 1	32			Low Priority data for star 1
	Data – Low Star 2	32			Low Priority data for star 2
	(Data– Stars 2 – N Low–1)	. . .	. . .	. . .	…
	Data – Low Star N Low	32			Low Priority data for star NLOW
	Checksum	2		U12	

(2) The UVOTFINDINGCHART message uses up to 3 ST-PDU packets. the logical packet (~2000 bytes) is sent as several CCSCS packets using the CCSCS segment flags (just like all UVOT science telemetry). We cannot predict beforehand where the breaks between packets will occur.
(3) This is a complex packet. After the header there are three logical sections of the packet each with a length field: high, medium, & low priority data on each star in the finding chart. In some packets the low priority section will be missing completely, and it's possible that both medium and low sections will be missing. The length of the packet is variable, but is limited to ~2000 bytes (at launch).

Appendix B.11. XRT Centroiding Error TDRSS Message (XRTCENTROIDERR).

The format and descriptions for this message are taken from the "XRT Telemetry Data Formats", XRT-PSU-~~0~~028. For further details, see that document.

Message	[1] APID	Length (bytes)	Description
XRTCENTROIDERR	0x4F0	64	[1] This high priority TDRSS message is generated by the XRT if the XRT is unable to calculate a reliable centroid for a new GRB target, either due to lack of an identifiable source in the FOV or due to source confusion.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	6	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
Data Collection Time Seconds	4	16	U1234	Spacecraft time of Frame Start - Seconds
Data Collection Time Subseconds	2	20	U12	Spacecraft time of Frame Start - SubSeconds
UTCF	6	22		UTC Correction factor
RA	4	28	F1234	Right Ascension of pointing direction. Range is 0 to 360 degrees. (J2000 epoch)
DEC	4	32	F1234	Declination of pointing direction. Range is –90 to +90 degrees. (J2000 epoch)
Error Flag	2	36	U12	1 = no source found in image 2 = algorithm did not converge ~~source confusion – could not identify target~~ 3 = standard deviation too large
Sigma	4	38	F1234	Standard deviation of centroid
Sigma Max	4	42	F1234	Maximum standard deviation for good centroid
Events in Centroid	4	46	U1234	Calculated events in centroid
Min Events in Centroid	4	50	U1234	Minimum number of events required for centroid (programmable)
Phase 2 Iterations	2	54	U12	Number of iterations in Phase 2 of algorithm
Max Iterations	2	56	U12	Maximum number of iterations for Phase 2
~~SPARE~~	~~20~~	~~38~~	~~U1~~	~~Spare bytes~~
Checksum	2	58	U12	

(1) Upon observation of a new GRB target, XRT will generate either a message indicating that a position centroid was found (ie, XRTPOSITION msg) or was not found (ie, XRTCENTROIDERR msg). XRT will issue 2 versions of the message – one for TDRSS downlink and the other for distribution to other instruments.

Appendix B.12. BAT Transient Image Map TDRSS Message (BATTRANSIENTMAP).

The format and descriptions for this message are taken from the "BAT Telemetry Data Formats". For further details, see that document.

Message			[1]APID	[2]Length (bytes)	Description
BATTRANSIENTMAP			0x184	Pkt1 – Pkt34 = 958 Pkt35 = 82	This is the TDRSS telemetry message formatted as a Large Data Product generated upon BAT detection of a transient image. It contains unsigned byte Mask Weighting Factor values for each of the 32k detector elements that make up the BAT detector assemblies.
Message Sub-Field Descriptions					
	Sub-Field Name		Size (bytes)	Offset (bytes)	ITOS Type	Description
PACKET #1	CCSDS Primary Header		6	0		CCSDS packet primary header
	CCSDS Secondary Header		6	6		CCSDS packet secondary header
	Product Number		2	12	U12	Sequential count of the number of BAT Transient Image files that have been output by BAT. (Should remain the same value throughout the downlink of this LDP)
	Page Number		2	14	U12	Page_Number = 1 (1st page of file) Identifies the segment within this downlink of a BAT Transient Image file. (1 segment per packet).
	LDP Header	OBSERVATION NUMBER (at LDP start)	4	16	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment. (Tertiary header field).
		SCLK Seconds (at LDP start)	4	20	U1234	The seconds field of the S/C clock time of the data at which trigger detected
		SCLK Subseconds Seconds (at LDP start)	2	24	U12	The sub-seconds field of the S/C clock time of the data at which trigger detected
		UTCF Seconds (at LDP start)	6	26		UTC Correction factor
		OBSERVATION NUMBER (at LDP end)	4	32	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment. (Tertiary header field).
		SCLK Seconds (at LDP end)	4	36	U1234	The seconds field of the S/C clock time of the data at which trigger detected
		SCLK Subseconds Seconds (at LDP end)	2	40	U12	The sub-seconds field of the S/C clock time of the data at which trigger detected
		UTCF Seconds (at LDP end)	6	42		UTC Correction factor

		LDP Header Size	2	48	U12	Number of bytes in the LDP header (LDP_Header_Size = 172)
		LDP Type	1	50		The type of this LDP (LDP_Type = 4 = one channel map)
		Datum Type	1	51	U1	Datum Type contained in file. (Datum Type = 21 = scaled 1 byte unsigned int)
		Num E bins in LDP	2	52	U12	Number of E bin in this LDP
		Spare	2	54		Padding added to maintain byte alignment
		Starting ACS pkt	52	56		S/c pointing at start of LDP accum. Contains SISCATTITUDE packet's application data fields (ie, less CCSDS headers and checksum). See SISCATTITUDE message for field details.
		Stopping ACS pkt	52	108		S/c pointing at end of LDP accum. Contains SISCATTITUDE packet's application data fields (ie, less CCSDS headers and checksum). See SISCATTITUDE message for field details.
		Gain Index	4	160		Which set of gains were used
		Offset Index	4	164		Which set of offsets were used
		File name	11	168		An 8.3 filename
		Priority	1	179		Priority of the file
		spare, padding	2	180		
		Block ID map	2	182		Which blocks included in this LDP
		Num Dets	2	184		Number of dets contributing Num_Dets = 255 (ie, all detectors contributing)
		Data_Scale_Factor	2	186	U12*	Reflects scale factor to be applied to each Mask Weighting Factor value. This value is fixed point 8.8 number. (ie, 110000000b = 1.5)
		Data_Offset_Factor	2	188	U12	Reflects Offset to applied to each Mask Weight Factor data values. Offset is applied after scaling.
	Mask Weighting Factors (beginning)		766 * 1	190	766* U1	First of the 32k Detector Mask Weighting Factors.
	Packet 1 Checksum		2	956	U12	Packet checksum
PACKET #2	CCSDS Primary Header		6	0		CCSDS packet primary header
	CCSDS Secondary Header		6	6		CCSDS packet secondary header
	PRODUCT NUMBER		2	12	U12	(Should be same as value in previous packet)
	Page Number		2	14	U12	Page_Number = 2 (2nd page of file)
	Mask Weighting Factors (next)		940* 1	16	940* U1	Next of Detector Mask Weighting Factors.
	Packet 2 Checksum		2	956	U12	Packet checksum

PACKET # n	CCSDS Primary Header	6	0		CCSDS packet primary header
	CCSDS Secondary Header	6	6		CCSDS packet secondary header
	PRODUCT NUMBER	2	12	U12	(Should be same as value in previous packet)
	Page Number	2	14	U12	Page_Number = n (nth page of file)
	Mask Weighting Factors (next)	940* 1	16	940* U1	Next of Detector Mask Weighting Factors.
	Packet n Checksum	2	956	U12	Packet checksum
PACKET # 34	CCSDS Primary Header	6	0		CCSDS packet primary header
	CCSDS Secondary Header	6	6		CCSDS packet secondary header
	PRODUCT NUMBER	2	12	U12	(Should be same as value in previous packet)
	Page Number	2	14	U12	Page_Number = 34 (34th page of file)
	Mask Weighting Factors (last)	42* 1	16	42* U1	Last of Detector Mask Weighting Factors.
	Spares	20	58		Spare field
	File Checksum	2	78	U12	File checksum
	Packet 1 Checksum	2	80	U12	Packet checksum

1. Data_Scale_Factor and Data_Offset_Factor from LDP header should be applied to Mask Weight Factor values as follows:
   counts = (data * scale/256.0) + offset;

Appendix C. TDRSS Error/Warning Messages.

TDRSS messages generated as part of the nominal target observation process are known as standard "GRB Alert Data Products". Those messages are described in Appendix B. Certain anomalous conditions will require the generation of emergency messages for immediate downlink via the TDRSS link so that ground operations personnel can be notified immediately of the anomaly. Upon notification ground operations personnel are expected to began immediate analysis/investigation so that the next Malindi pass could be used to more effectively help resolve the problem. This appendix describes the format and content of onboard emergency/warning messages that are sent down via the TDRSS link.

Use of the TDRSS link precludes the simultaneous operation of the normal Malindi downlink, and preempts any Malindi contact already in progress. This could result in the loss of data for a scheduled ground contact. Therefore, it is important that the use of TDRSS be limited to "real" emergency messages.

Note: All telemetry messages described in this appendix contain the appropriate CCSDS packet header. Refer to reference document number 1, "Swift 1553 Bus Protocol Interface Control Document", for details on CCSDS headers for telemetry packets.

Table 44. Summary of TDRSS Emergency/Warning Messages

APPENDIX	Message Mnemonic	Msg Source	(1) APID	DESCRIPTION
C.1	BATALARMSHORT	BAT	0x185	BAT short format emergency/warning message
C.2	BATALARMLONG	BAT	0x186	BAT long format emergency/warning message
C.3	UVOTEMERGENCY	UVOT	0x3C0	UVOT emergency / warning message
C.4	XRTEMERGENCY	XRT	0X500	XRT emergency/warning message
C.5	FOPPTTARGERR	FoM	0x192	FoM message indicating that PPT slew request was rejected by spacecraft (error condition).
C.6	FOSAFEPOINT	FoM	0x193	FoM message indicating that s/c is in "safe point" mode (i.e., has slewed to a safe target).
C.7	FOSCSLEWABORT	FoM	0x194	FoM message indicating that s/c has aborted a slew request to a target (error condition)

(1) See Table 1 for explanation of APID notation.

Appendix C.1. BAT Short Format Alarm TDRSS Message (BATALARMSHORT).

Message	(1)APID	Length (bytes)	Description
BATALARMSHORT	0x185	68	This TDRSS telemetry message is generated by the BAT in response to any one of several alarm conditions. The message contains an error code field and up to 6 parameters to identify the alarm condition. This message is sent to the ground via TDRSS for immediate action by ground operations personnel.

Message Sub-Field Descriptions					
Sub-Field Name		Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header		6	0		CCSDS packet primary header
CCSDS Secondary Header		6	6		CCSDS packet secondary header
T e r t H d r	OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
	SCLK Seconds	4	16	U1234	The seconds field of the S/C clock time of the data at which trigger detected
	SCLK Subseconds	2	20	U12	The sub-seconds field of the S/C clock time of the data at which trigger detected
	UTCF	6	22		UTC Correction factor
Alarm Code		2	28	U12	Unique number that identifies the error/alarm/warning condition. The interpretation of the following parameter fields will be based on this code.
Parameter1		2	30	U12	Value associated with Alarm condition.
Parameter2		2	32	U12	Value associated with Alarm condition.
Parameter3		2	34	U12	Value associated with Alarm condition.
Parameter4		2	36	U12	Value associated with Alarm condition.
Parameter5		2	38	U12	Value associated with Alarm condition.
Parameter6		2	40	U12	Value associated with Alarm condition.
SPARE		26	42	U1*26	Spare bytes
Checksum		2	66	U12	

(1) See Table 1 for explanation of APID notation.

Appendix C.2. BAT Long Format Alarm TDRSS Message (BATALARMLONG).

Message	(1)APID	Length (bytes)	Description
BATALARMLONG	0x186	Pkt1=958 Pkt2=958 Pkt3=246	This TDRSS telemetry message is generated by the BAT in response to an alarm condition that requires more parameters than allowed in the short message. The message will contain an error code field and up to 1024 parameters to identify the alarm condition. This message is sent to the ground via TDRSS for immediate action by ground operations personnel. This message is sent using segmented telemetry utilizing three ST-PDUs.

Message Sub-Field Descriptions						
	Sub-Field Name		Size (bytes)	Offset (bytes)	ITOS Type	Description
PACKET #1	CCSDS Primary Header		6	0		CCSDS packet primary header
	CCSDS Secondary Header		6	6		CCSDS packet secondary header
	Tert Hdr	OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment assigned to the target by BAT. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
		SCLK Seconds	4	16	U1234	The seconds field of the S/C clock time of the data at which trigger detected
		SCLK Subseconds	2	20	U12	The sub-seconds field of the S/C clock time of the data at which trigger detected
		UTCF	6	22		UTC Correction factor
	Alarm Code		2	28	U12	Unique number that identifies the error/alarm/warning condition. The interpretation of the following parameter fields will be based on this code.
	Parameters 1-460		920	30	U12*460	Parameter values 1-460 associated with alarm condition.
	SPARE		6	950	U1*6	Spare bytes
	Checksum		2	956	U12	
PKT #2	Repeat Of First 14 Bytes From Packet #1		14	0		"CCSDS Header" and "Alarm Code" fields (bytes 0 thru 14) are same as for packet #1
	Parameters 461-920		920	16	U12*460	Parameter values 461-920 associated with alarm condition.
	SPARE		20	936	U1*20	Spare bytes
	Checksum		2	956	U12	

PKT #3	Repeat Of First 14 Bytes From Packet #1	14	0		"CCSDS Header" and "Alarm Code" fields (bytes 0 thru 14) are same as for packet #1
	Packet Number	2	14	U12	(2) 0x0003 Packet segment number
	Parameters 921-1024	208	16	U12*104	Parameter values 921-1024 associated with alarm condition.
	SPARE	20	224	U1*20	Spare bytes
	Checksum	2	244	U12	

(1) See Table 1 for explanation of APID notation.
(2) The BATALARMLONG message uses 3 ST-PDU packets. Packet 1 for alarm parameters 1-460, packet 2 for alarm parameters 461-920, and packet 3 for alarm parameters 921-1024.

Appendix C.3. UVOT Emergency TDRSSAlert Message (UVOTEMERGENCY).

The format of this message is taken from the UVOT telemetry document and is sent by the ICU.

Message	(1)APID	Length (bytes)	Description
UVOTEMERGENCY	0x3C0	22	This TDRSStelemetry message is issued when the UVOT encounters a condition that requires immediate ground intervention.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	6	6		CCSDS packet secondary header
IEMPKGCODE	1	12	UB	Emergency Package Code
IEMERRCODE	1	13	UB	Emergency Error Code
IEMPARAM1	2	14	UI	Emergency Parameter 1
IEMPARAM2	2	16	UI	Emergency Parameter 2
IEMPARAM3	2	18	UI	Emergency Parameter 3
Checksum	2	20	U12	

Appendix C.4. XRT Emergency TDRSS Message (XRTEMERGENCY).

The format and descriptions for this message are taken from the "XRT Telemetry Data Formats", XRT-PSU-0028. For further details, see that document.
This message is generated every time the XRT boots.

Message	APID	Length (bytes)	Description
XRTEMERGENCY	0x500	230	This TDRSS telemetry message is issued when the XRT encounters a condition that requires immediate ground intervention.

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	6	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment of the target being observed when emergency condition occurred. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
Data Collection Time Seconds	4	16	U1234	The seconds field of the time when emergency condition occurred
Data Collection Time Subseconds	2	20	U12	The sub-seconds field of the time when emergency condition occurred
UTCF	6	22		UTC Correction factor
RA	4	28	F1234	Right Ascension of pointing direction. Received and calculated as 8 byte float, but reported as 4 byte float. Range is 0 to 360 degrees (J2000 epoch)
DEC	4	32	F1234	Declination of pointing direction. Received and calculated as 8 byte float, but reported as 4 byte float. Range is –90 to +90 degrees (J2000 epoch)
Roll	4	36	F1234	Roll angle for the target. Range is 0 to 360 degrees (J2000 epoch)
ACS Flags	1	40	U1	ACS status flags: Slewing, Within 10 arcmins, Settled, or SAA
XRT State Flags	1	41	U1	XRT State: 0x11: Auto 0x22: Manual 0x44: Red
XRT Mode	1	42	U1	XRT readout Mode for last CCD frame: 1=Null 2=Short Image 3=Long Image 4=Piled-up Photodiode 5=Low Rate Photodiode 6=Windowed Timing 7=Photon Counting 8=Raw Data 9=Bias Map 10=Stop
XRT Waveform	1	43	U1	CCD Waveform ID
Error Number	4	44	U1234	Error number identifying the XRT emergency: a)CCD bias voltage below threshold, b)TEC Temperature exceeded limit, c)Watchdog reboot, etc.
Analog HK	180	48	U1*180	120 channels of 12 bit housekeeping data
Checksum	2	228	U12	

Appendix C.5. PPT Target Error Message (FOPPTTARGERR).

Message	APID	Length (bytes)	Description
FOPPTTARGERR	0x192	50	TDRSS telemetry message generated by the FoM when the s/c responds that it cannot slew to a requested PPT or a view constraint message is received while viewing a PPT target. Unlike for an AT, the FoM will not generate this message for a successful PPT slew request (only for rejected requests).

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	6	6		CCSDS packet secondary header
PPT RQST INFO	24	12		Observation Number and RA, DEC, and ROLL from original PPT observation request (FOPPTREQUEST).
S/C REPLY	4	36	U1234	0=Will Slew; 1-5=Won't Slew. See FSLEWREQREPLY message for definition of non-zero values. 254 = command rejected due to out of range position values. 255= view constraint message received while viewing PPT target
WAIT_SECONDS	4	40	U1234	(1) Number of seconds to wait before target is viewable (from FSLEWREQREPLY)
OBSERVE_ SECONDS	4	44	U1234	(1) Number of seconds target can be observed before constraint violation (from FSLEWREQREPLY).
Checksum	2	48	U12	

(1) If message generated due to command rejected due to out of range position values or a view constraint message received, these values will be set = 0.

Appendix C.6. S/C In Safe Point Mode Message (FOSAFEPOINT)

Message	APID	Length (bytes)	Description
FOSAFEPOINT	0x193	18	(1) TDRSS telemetry message generated by the FoM and sent to the ground when ACS 5 Hz message indicates that the SC has settled on a safe point target (see footnote for further description)

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	6	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment of the "safe point" target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment.
Checksum	2	16	U12	

(1). SC will initiate a slew to a safe point target if the SC is allowed to enter a viewing constraint and no alternate target request that the SC can slew to has been provided. Safe Point targets are identified as targets with observation numbers of 1-6 (ie, Observation Segment =0, Target ID = 1-6).

Appendix C.7. S/C Slew Abort Message (FOSCSLEWABORT)

Message	APID	Length (bytes)	Description
FOSCSLEWABORT	0x194	18	TDRSS telemetry message generated by the FoM and sent to the ground when the s/c issues a slew abort message. (See footnote for further description).

Message Sub-Field Descriptions				
Sub-Field Name	Size (bytes)	Offset (bytes)	ITOS Type	Description
CCSDS Primary Header	6	0		CCSDS packet primary header
CCSDS Secondary Header	6	6		CCSDS packet secondary header
OBSERVATION NUMBER	4	12	U1234	Target ID and Observation Segment of the "aborted" target. Low Order 24 bits = Target ID, High Order 8 bits = Observation Segment. Observation Number reflects the Observation Number of the current slew request target requested by Fom. If Fom has not requested a target, 0 is inserted.
Checksum	2	16	U12	

(1) Spacecraft will not perform a slew and will broadcast a slew abort telecommand to the instruments in the event that UVOT does not respond to a slew warning message.