The Space Department of
The Johns Hopkins University
Applied Physics Laboratory

TIMED Mission Data Center

Software Requirements Specification

(Build 3 – Flight Operations)

Document: 7363-9327

Rev 0-01

Document Prepared by: Kevin Lyons

Signature Page

TIMED Missions Software Engineer _____

Martha Chu

TIMED Ground System Lead Engineer _____

Elliot Rodberg

TIMED SDS/MDC Lead Engineer _____

Stuart Nylund

TIMED MDC Software Lead Engineer _____

Paul Lafferty

Change History

Date of Change	Description of Change
May 1998	Initial Release
19 June 2001	Revision 0-01 updated following sections: Signature Page: Changed names for the positions of Ground System Lead Engineer, SDS/MDC Lead Engineer and MDC Software Lead Engineer to reflect changes in personnel. Section 3.2.3 Mission Data Cataloging and Distribution (MDCD): Added TIMED Science Data System Requirements 1-6 and 8 (established by the Requirements Review on 7 Jan 1999) . Removed Requirement 5.2 (The SDS/MDCD distribute data product availability sets identified by a subscription) per TIMED Science Data System Preliminary Design Review, 10 Feb 1999, Action Item TSDSPDR-2-99-005. Removed Requirement 6.2 (The SDS/MDCD shall track monthly the number of data product orders) per TIMED Science Data System Preliminary Design Review, 10 Feb 1999, Action Item TSDSPDR-2-99-006. Section 3.2.4 Mission Publication (MP): Added TIMED Science Data System Requirements 7 (established by the Requirements Review on 7 Jan 1999) . Removed Requirement 7.2.13.1 (The Mission Publication interface shall provide access to the service to Subscribe to Data Product) per TIMED Science Data System Preliminary Design Review, 10 Feb 1999, Action Item TSDSPDR-2-99-005.

Table of Contents

1 Scope

1.1 Identification

This document defines the software requirements for the TIMED Mission Data Center (MDC). This document is formally delivered during build 2[1] of the software development. At that time the document will be under configuration management described in the TIMED Mission Data Center Software Development Plan (Reference [3]). The TIMED MDC is part of the TIMED Ground System that will be resident at The Johns Hopkins University Applied Physics Laboratory (JHU/APL).

1.2 System Overview

The MDC serves as the archiver and deliverer of all telemetry and mission data and archiver of all telecommands during the TIMED Mission. The MDC delivers cleaned and merged Level 0 telemetry data and ground based data to the MOC and POCs. The POCs produce the Level 1-4 products. The MDC is responsible for converting the Level 0-4 data products for ingestion into the Space Physics Data System (SPDS). The MDC provides mission summary information to experimenters.

The concept for the MDC was defined in the TIMED Systems Requirements Document (Reference [1]) and further refined for presentation at the TIMED Conceptual Design Review (CoDR) (Reference [2]).

The MDC is being developed at JHU/APL to support the spacecraft emulator (Reference [11]), bench-level testing of spacecraft subsystems at JHU/APL, spacecraft Integration and Test (I&T) at JHU/APL, spacecraft I&T at Goddard Space Flight Center (GSFC), launch at Vandenberg Air Force Base, and operations at JHU/APL.

As discussed in Reference [3] the MDC is composed of 4 Computer Software Configuration Items (CSCIs) that will fulfill the requirements of the MDC:

- Telemetry Service (TS)
- Data Product Production (DPP)
- Mission Data Cataloging and Distribution (MDCD) and
- Mission Publication (MP).

1.3 Document Overview

This document gives the software level requirements for the MDC. The MDC is being developed in accordance with the Space Department Software Quality Assurance Guidelines (Reference [4]), the TIMED Software Quality Assurance Plan (Reference [5]), and the TIMED Project Data Management Plan (Reference [9]). The content and format of this document are in compliance with the MIL-STD-498 (Reference [6]) and this is required documentation as described in Reference [3]. The information is for the use of official members of the TIMED mission, JHU/APL staff, and NASA officials; other users of the material in this document must contact TIMED Project Manager, David Grant, at JHU/APL prior to use.

[1] See Reference [3] for a definition and schedule for the software builds.

2 References

2.1 Referenced Documentation

[1] 7363-9001, TIMED System Requirements Document, 1 December 1997
[2] TIMED Conceptual Design Review, 14 December 1994
[3] 7363-9102, TIMED Mission Data Center Software Development Plan, April 1998
[4] SDO-9989, Space Department Software Quality Assurance Guidelines, September 1992
[5] 7363-9101, TIMED Software Quality Assurance Plan, September 1996
[6] MIL-STD-498, Military Standard Software Development and Documentation, AMSC No. N7069, December 1994
[7] Consultative Committee for Space Data Systems, Blue Book, CCSDS 201.0-B-2, November 1995
[8] 7363-9050, TIMED General Instrument Interface Specification, 28 August 1997
[9] 7363-9330, TIMED Project Data Management Plan, 1 December 1997
[10] 7363-9328, TIMED MDC & MOC Interface Control Document, Draft
[11] Spacecraft Emulators for TIMED Spacecraft Instruments Requirement Document, April 1997
[12] 7363-9359, TIMED Ground Software CM Plan, 10 October 1997
[13] 7363-9318, TIMED Ground Station Requirements Document, 17 September 1997

3 Requirements

3.1 Required States and Modes

The MDC is required to operate in two distinct modes:

- Pre-Launch mode: MDC will be supporting the testing of the spacecraft and subsystems and the emphasis will be on rapid turn-around of the information. The MDC will have personnel available during the time of the tests. This mode pertains to the operation prior to launch. **Build 1 and Build 2** are defined in the TIMED Mission Data Center Software Development Plan (Reference[3]).

- Post-Launch mode: Data will be delivered from the MOC, the Ground Station, and the POCs and will run autonomously. This mode will apply to post-launch operations of the spacecraft. **Build 3 and Build 4** are defined in Reference[3]).

Most requirements will be satisfied in both modes of operation. It should be noted that the software development process detailed in Reference [3] designates 4 distinct software builds and these builds are associated with the modes as designated above. Particular capabilities and requirements may be associated with a particular build, in these cases they are designated as such.

3.2 System Capability Requirements

The following high level MDC requirements were identified in Reference [1] and presented at the TIMED Conceptual Design Review (Reference[2]):

- Generate Level 0 data products to support the TIMED Mission. (Level 0 is Standard Telemetry Messages or Command Packets).
- Provide access to ground-based measurements in support of TIMED.
- Provide timely data distribution among TIMED program elements.
- Provide scientifically useful products derived from the TIMED measurements to the scientific community in a timely manner.
- Provide relevant and useful educational products derived from TIMED data to K-12 educators and the public in a timely manner.
- During the mission, archive products generated by the spacecraft and the MDC.
- Provide for the long term utility and archiving of data products generated by the TIMED program in cooperation with the Space Physics Data System (SPDS).

From these high level requirements, derived capabilities have been established. These capabilities evolved into a conceptual design of the MDC with 4 components. Each of the components' capabilities and requirements is detailed in the next sections.

3.2.1 Telemetry Service (TS)

Telemetry Service includes receiving, archiving, ordering and distributing the spacecraft telemetry to both mission operations and the TIMED investigators that require telemetry data.

Derived requirements from MDC CoDR

- Maintain an on-line archive of packetized telemetry data for the life of the mission
- Maintain an off-line copy of all data sent to and received from the spacecraft
- Provide access to packetized telemetry data: Real-time, Play-back, File download

The format of the input telemetry data is a Supplemented Telemetry Frame (STF) and the output is a Supplemented Telemetry Packet (STP), a Telemetry Packet (TP), a Telemetry Frame (TF), a Supplemented Telemetry Frame (STF) or a POC Telemetry Packet (PTP). The STF is a CCSDS Transfer Frame (Reference [7]) with an attached Sync Marker and supplemented with a Ground Receipt Header. This is illustrated in Figure 1. For TIMED, the CCSDS Transfer Frame will contain 4 fixed length packets. The STP consists of a CCSDS packet supplemented with a Ground Receipt Header and all of the headers from the transfer frame that contained the packet. This is illustrated in Figure 2. The PTP consists of the Ground Receipt Header and the telemetry packet. This is illustrated in Figure 2.

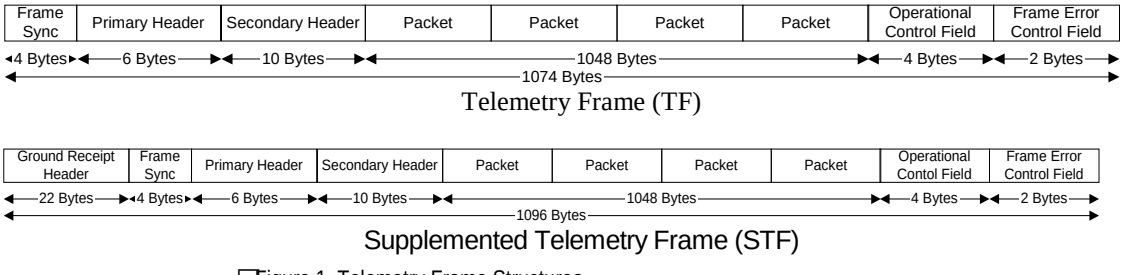

Figure 1. Telemetry Frame Structures.

.

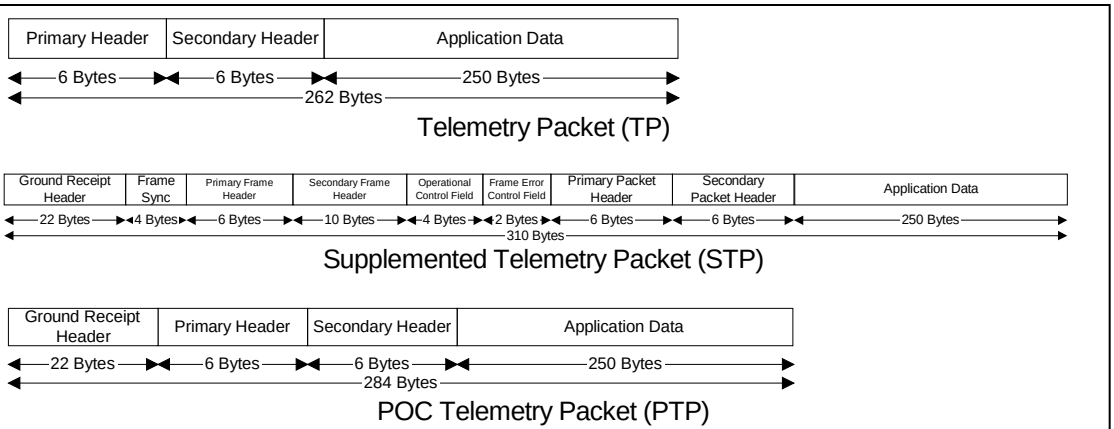

Figure 2. Telemetry Packet Structures.

All Telemetry service rate requirements are expressed for TP service. Required rates for PTP and STP service shall be increased to result in the same net TP rate. All telemetry service rate requirements shall be verified over a period of at least 10 minutes, and shall be met over every 10-second interval within that period.

3.2.1.1 Real-Time Telemetry Service (RTS)

The purpose of the real-time telemetry service is to provide telemetry to the various ground system elements as the data is received from the ground station or the MOC. The function of taking data from the ground station and routing it is needed in the MDC, in the MOC, and in the spacecraft emulator software. The basic unit of information that is delivered to the MDC is a CCSDS Transfer Frame augmented with various information. The telemetry service running in the MOC transforms that data into STFs for storage.

MDC-TS-1 The RTS shall be capable of receiving telemetry from multiple sources. The format of the data shall be a form of augmented transfer frame described above. The protocol used shall be TCP/IP sockets with the RTS acting as a server to a source client.

MDC-TS-2 The RTS shall be responsible for transforming the input data into a Supplemented Telemetry Frame.

MDC-TS-3 The RTS shall be able to handle at least 4 simultaneous input streams.

MDC-TS-4 The RTS shall be capable of receiving data via a TCP/IP stream at a rate of 70 kbps, not including delays due to network traffic.

MDC-TS-5 The RTS shall be capable of receiving telemetry on all virtual channels prior to Launch.

MDC-TS-6 The RTS shall provide Supplemented Telemetry Packets (STPs), CCSDS Telemetry Packets (TPs), POC Telemetry Packets (PTPs), Supplemented Telemetry Frames (STFs) and Telemetry Frames (TFs).

MDC-TS-7 The RTS shall be capable of providing telemetry to multiple clients. The protocol used shall be TCP/IP sockets with the RTS acting as a server to a destination client.

MDC-TS-8 The RTS shall allow selection of data based on source, front-end, virtual channel, application ID, and quality.

MDC-TS-9 The RTS shall provide a stream service for at least 30 clients for a total aggregate rate of 1320 kbps, not including delays due to network traffic.

MDC-TS-10 The RTS shall be capable of supporting service at least 68.8 kbps for each stream up to 30, not including delays due to network traffic.

MDC-TS-31 The RTS shall restrict access to input client services based on a maintained list of valid input client IP addresses.

MDC-TS-32 The RTS shall provide the capability to maintain a list of valid input client IP addresses that allow RTS input client access.

MDC-TS-33 The RTS shall restrict access to output client services based on a maintained list of valid output client IP addresses.

MDC-TS-34 The RTS shall provide the capability to maintain groups of output clients. The output client groups shall contain at a minimum a group name, list of valid IP addresses that allow RTS output client access, and a maximum number of concurrent connections for the group.

MDC-TS-35 The RTS shall restrict access to the MDC operator console services based on a maintained list of valid MDC operator console IP addresses.

MDC-TS-36 The RTS shall provide the capability to maintain a list of valid MDC operator console IP addresses that allow administrative access.

MDC-TS-52 The RTS shall disconnect any input telemetry stream where the Ground Receipt Time differs from the RTS system time by more than one hour. Notification of this event will be included in the Telemetry Server Monitor status telemetry.

MDC-TS-57 The RTS shall allow the exclusion of APIDs from output by user specification.

3.2.1.2 Playback Telemetry Service (PTS)

The purpose of the playback telemetry service is to replay telemetry data to the MOC and POCs.

MDC-TS-11 The PTS shall provide Supplemented Telemetry Packets (STPs), CCSDS Telemetry Packets (TPs), POC Telemetry Packets (PTPs), Supplemented Telemetry Frames (STFs) and Telemetry Frames (TFs).

MDC-TS-12 The PTS shall allow selection of data based on source, front-end, virtual channel, application identification (AP ID), quality, and Spacecraft or Ground Receipt time, allowing a client to give a start and stop time for data.

MDC-TS-13 The PTS shall allow the time ordering to be selected by Ground Receipt Time.

MDC-TS-37 The PTS shall allow the time ordering to be selected by Spacecraft Time.

MDC-TS-14 The PTS shall provide a playback service for 50 clients for a total aggregate rate of 1542 kbps, not including delays due to network traffic.

MDC-TS-15 The PTS shall be capable of supporting a 123 kbps service for each of the clients, if the number of clients is 10 or less.

MDC-TS-16 The PTS shall be capable of supporting a (1296 kbps)/N aggregate service for each of the clients where N is the number of clients, if the number of clients is greater than 10 and less than 49.

MDC-TS-17 The PTS shall maintain the rate of 123 kbps for each of at least two MOC clients.

MDC-TS-38 The PTS shall restrict access to input client services based on a maintained list of valid input client IP addresses.

MDC-TS-39 The PTS shall provide the capability to maintain a list of valid input client IP addresses that allow PTS input client access.

MDC-TS-40 The PTS shall restrict access to output client services based on a maintained list of valid output client IP addresses.

MDC-TS-41 The PTS shall provide the capability to maintain groups of output clients. The output client groups shall contain at a minimum a group name, list of valid IP addresses that allow PTS output client access, and a maximum number of concurrent connections for the group.

MDC-TS-42 The PTS shall restrict access to the MDC operator console services based on a maintained list of valid MDC operator console IP addresses.

MDC-TS-43 The PTS shall provide the capability to maintain a list of valid MDC operator console IP addresses that allow administrative access.

MDC-TS-53 The PTS shall provide playback service based on data quality (indicated in the Ground Receipt Header). Good data only, bad data only and both good and bad services shall be provided.

MDC-TS-58 The PTS shall allow the exclusion of APIDs from output by user specification.

3.2.1.3 Telemetry Archive

The purpose of the telemetry archive is to store all telemetry data (raw telemetry and/or Level 0) during the mission. The archive process will produce an original back-up tape and a duplicate tape to be stored at the MOC.

MDC-TS-18 The MDC shall archive all telemetry data online.

MDC-TS-19 The MDC shall archive all original telemetry formats for the life of the mission for re-ingestion in case of ingest failure.

MDC-TS-44 The MDC shall provide backup and recovery services for the online telemetry archive.

MDC-TS-20 The MDC shall make the archived data available within 20 seconds of receipt at the MDC over a network connection.

MDC-TS-45 The MDC shall make the archived data available within 10 minutes of receipt of a telemetry data file via a File Transfer Protocol (FTP) from a Ground Station Front-end.

MDC-TS-46 The MDC shall provide the capability to receive telemetry frames without archiving. The MDC will determine on a message by message basis, whether or not the data should be archived.

MDC-TS-54 The MDC shall provide the capability to switch by operator command the archiving of duplicate telemetry.

3.2.1.4 Telemetry File Service (TFS)

The purpose of the telemetry file service is to provide requestors telemetry data files from the telemetry archive.

MDC-TS-21 The TFS shall provide telemetry files upon requests.

MDC-TS-22 The TFS shall allow selection of data based on source, front-end, virtual channel, application ID, quality, and Spacecraft or Ground Receipt time, allowing a client to give a start and stop time for data.

MDC-TS-23 The TFS shall allow the time ordering to be selected by Ground Receipt Time.

MDC-TS-47 The TFS shall allow the time ordering to be selected by Spacecraft Time.

3.2.1.5 FTP Telemetry File Requirements

The sources of the telemetry data will store data that they collect on local file systems and will send the data to the MDC using FTP.

MDC-TS-24 The MDC shall be capable of receiving and archiving telemetry data from the ground station via FTP.

MDC-TS-25 The MDC shall be capable of using FTP to get telemetry data from the ground station and store the data.

MDC-TS-55 The MDC shall monitor the real-time telemetry stream and detect a message indicating the availability of a telemetry file from Universal Space Net.

3.2.1.6 Command Archive

The purpose of the command archive is to store all data sent to the spacecraft during the mission. The archive process will produce an original back-up tape and a duplicate tape to be stored at the MOC.

MDC-TS-26 The MDC shall provide the capability to maintain an offline copy of all data that is sent to the spacecraft.

3.2.1.7 Other Telemetry Requirements

MDC-TS-27 The MDC shall provide the capability to configure and control all TCP/IP socket connection services without affecting operations. This includes at a minimum adding and removing valid IP addresses to and from client lists, closing active connections, and modifying the maximum output client group number of concurrent connections.

MDC-TS-28 The MDC shall provide a Telemetry Server monitor service to the MOC. The protocol used shall be TCP/IP socket with the MDC acting as a client to the MOC server.

MDC-TS-29 **THIS REQUIREMENT DELETED** - The MDC shall provide the capability to determine and set the quality of the telemetry frame, by the state of the quality flags within the message.

MDC-TS-30 The MDC shall provide a daily report containing the processing status of the Telemetry Server processes.

MDC-TS-48 The MDC shall provide the capability to generate on demand the Archive Map sorted by Ground Receipt Time. This report shall contain at a minimum for each AP ID all contiguous ranges of CCSDS packets stored in the Telemetry Server.

MDC-TS-49 The MDC shall provide the capability to generate on demand the Archive Map sorted by Spacecraft Time. This report shall contain at a minimum for each AP ID all contiguous ranges of CCSDS packets stored in the Telemetry Archive.

MDC-TS-50 The MDC shall provide the capability to generate the Archive Change Report. This report shall be ordered by the time of ingestion by the archive, and shall contain at a minimum for each AP ID all contiguous ranges by Ground Receipt Time of CCSDS packets processed by the Telemetry Archive.

MDC-TS-51 The MDC shall provide the capability to generate the Archive Change Report. This report shall be ordered by the time of ingestion by the archive, and shall contain at a minimum for each AP ID all contiguous

ranges by Spacecraft Time of CCSDS packets processed by the Telemetry Server.

MDC-TS-56 The MDC shall provide the MOC with two text reports for each telemetry dump received from a ground station. a) The MDC shall provide a report showing the APIDs and spacecraft time of the blocks of telemetry updated in the archive as a result of the processing of the dump data. b) The MDC shall generate an Archive Map report covering the preceding 36 hours. These reports shall be FTPed to the MOC with 20 minutes of the receipt of the dump file.

3.2.2 Data Product Production (DPP)

The Data Product Production includes the generation of MDC data products (with the exception of the data handled by TS). This component is required to produce important planning, support and summary products. The outputs of this component are deliverables of the TIMED mission.

Derived requirements from MDC CoDR

- Maintain planned and as-flown timelines for spacecraft and instruments (DPP)
- Provide planning, support and summary data for the TIMED data users

3.2.2.1 Planned and As Flown Timeline Files

MDC-DPP-1 The MDC shall provide the individual Planned and As Flown Timeline Files as received from the MOC, POCs and Project Scientist. The MDC shall make these files available to the MOC, POCs, and Project Scientist.

MDC-DPP-2 *The MDC shall produce four weekly merged Timeline Reports for the MOC, POCs and Project Scientist (Delivered in the next build).*

- *The Long Range Planning Report shall contain all timeline data for eight weeks after the date of generation. This report shall only be available until the next one is generated.*
- *The Short Range Planning Report shall contain all timeline data for one week after the date of generation. This report shall only be available until the next one is generated.*
- *The MOC Planning Report shall contain timeline data for the following events: high priority, yaw maneuvers, software uploads, contacts and real-time commanding. The report shall include data for eighth weeks after the date of generation. This report shall only be available until the next one is generated.*
- *The As Flown Report shall contain all timeline data for [(generation time – 246 hours) to (generation time – 78 hours)]. The MDC shall update these reports as needed.*

MDC-DPP-3 *The MDC shall provide the TIMED data users the capability to run an additional report for which the users will be able to specify a time range and the source(s) of the timeline data for either Planned or As Flown timelines (Delivered in next build).*

3.2.2.2 File Change Notification Message

MDC-DPP-4 The MDC shall provide a File Change Notification Message for the MOC, POCs, and Project Scientists to indicate the availability of a new data product or an update of an existing data product. The File Change Notification Message will be provided for the following files: Timeline and Spacecraft Telemetry Definition.

3.2.2.3 Spacecraft Telemetry Definition File

MDC-DPP-5 The MDC shall be capable of receiving and storing the Spacecraft Telemetry Definition Files as sent from the MOC. The MDC shall make these Spacecraft Telemetry Definition Files available to the POCs.

3.2.2.4 Other Data Product Requirements

MDC-DPP-6 The MDC shall be responsible for protecting all of the data products that the MDC receives or produces from loss or corruption. The MDC shall maintain a copy of all data products on a stable off-line medium for the life of the mission. This data shall be made available as needed.

3.2.3 Mission Data Cataloging and Distribution (MDCD)

The Mission Data Center is required to provide a summary and index of data products, spacecraft and instrument configuration and performance information, and other data that is necessary to locate, understand and use TIMED data. The outputs of this component are deliverables of the TIMED mission.

Derived requirements from MDC CoDR

- Ingest, maintain, provide access to, and document correlative measurements, ground based and other data products (MDCD)
- Maintain and provide access to an index of science products (MDCD)
- Pull the TIMED science products from the POCs and master media for delivery to the SPDS for long term archive (MDCD)
- Convert the level 0 mission data and the correlative ground-based measurements to a format compatible with the SPDS and deliver media to SPDS for long term archive (MDCD)

Note: The TIMED MDC component, Mission Data Cataloging and Distribution (MDCD) will not be part of this TIMED MDC Build delivery. The requirements will be further defined in a future version of this document.

1. The SDS/MDCD shall create a catalog of TIMED mission data
   - 1.1 The SDS/MDCD shall acquire information describing available science data products
     - 1.1.1 The SDS/MDCD shall acquire text descriptions of each science data product type
     - 1.1.2 The SDS/MDCD shall acquire a science data product status file for each product
       - 1.1.2.1 The data product status file shall be in ASCII format
       - 1.1.2.2 The data product status file shall contain product filename, product revision, version number, new/update/delete flag, time range, data collection start and stop time, product file location, data product type, Earth locati for GBIs (latitude and longitude), and comments
   - 1.2 The SDS/MDCD shall acquire timeline files
     - 1.2.1 The SDS/MDCD shall acquire planned timeline files from the project scientist
     - 1.2.2 The SDS/MDCD shall acquire planned timeline files for each instrument
     - 1.2.3 The SDS/MDCD shall acquire as flown timeline files for each instrument
     - 1.2.4 The SDS/MDCD shall acquire planned timeline files for the TIMED spacecraft
     - 1.2.5 The SDS/MDCD shall acquire as flown timeline files for the TIMED spacecraft
   - 1.3 The SDS/MDCD shall acquire orbit information

1.3.1 The SDS/MDCD shall acquire predicted orbit files
1.3.2 The SDS/MDCD shall acquire actual orbital elements
1.3.3 The SDS/MDCD shall acquire predicted and actual orbit number files
1.4 The SDS/MDCD shall acquire spacecraft telemetry definition files
1.5 The SDS/MDCD shall acquire geomagnetic and solar index values
1.5.1 The SDS/MDCD shall acquire validated index values
1.5.1.1 The SDS/MDCD shall acquire validated Kp values
1.5.1.2 The SDS/MDCD shall acquire validated ap values
1.5.1.3 The SDS/MDCD shall acquire F1O.7 81 day averages
1.5.1.4 The SDS/MDCD shall acquire validated Equatorial Distance values
1.5.1.5 The SDS/MDCD shall acquire validated Zurich Sunspot Number values
1.5.2 The SDS/MDCD shall acquire estimated index values
1.5.2.1 The SDS/MDCD shall acquire estimated daily Kp values for the period after the last validated value.
1.5.2.2 The SDS/MDCD shall acquire estimated daily ap values for the period after the last validated value.
1.5.2.3 The SDS/MDCD shall acquire daily FIO.7 values for the period covered by the estimated values of Kp and ap
1.6 The SDS/MDCD shall acquire meteorological data
1.6.1 The SDS/MDCD shall acquire temperature as a function of pressure for the area near the ground track
1.6.2 The SDS/MDCD shall acquire geopotential height as a function of pressure for the area near the ground track
1.7 The SDS/MDCD shall maintain a reference bibliography for the TIMED mission
1.8 The SDS/MDCD shall log errors in data acquisition
1.8.1 The SDS/MDCD shall log the time at which an error occurred
1.8.2 The SDS/MDCD shall log the type of data associated with the error
1.8.3 The SDS/MDCD shall log the type of error
1.8.4 The SDS/MDCD shall log the recovery effort
1.8.5 The SDS/MDCD shall log the results of recovery efforts

2. The SDS/MDCD shall maintain the catalog of TIMED mission data
2.1 The SDS/MDCD shall validate the science product URLs stored in the catalog
2.1.1 The SDS/MDCD shall validate science product URLs upon receipt of each new product notification
2.1.2 The SDS/MDCD shall validate science product URLs upon receipt of each product change notification
2.1.3 The SDS/MDCD shall validate at least weekly all URLs contained in the catalog
2.2 The SDS/MDCD shall store electronically the information contained in the catalog
2.2.1 The catalog information shall be readable by computer
2.2.2 The catalog information shall be available in human readable form
2.3 The SDS/MDCD shall provide notification of changes to previously cataloged information
2.3.1 The SDS/MDCD shall maintain a repository of change notices

2.3.2 The SDS/MDCD shall send notification of changes to registered users

2.4 The SDS/MDCD shall update the catalog at least once a day

2.5 The SDS/MDCD shall log errors associated with maintaining the catalog

2.5.1 The SDS/MDCD shall log invalid science product URLs

2.5.2 The SDS/MDCD shall log errors that occur when storing data in the catalog

2.5.3 The SDS/MDCD shall log errors that occur when updating the catalog

3. The SDS/MDCD shall support data queries of the content of the catalog
   - 3.1 The SDS/MDCD shall respond to queries about data source
   - 3.2 The SDS/MDCD shall respond to queries about data product type
   - 3.3 The SDS/MDCD shall respond to queries about time range of data acquisition
   - 3.4 The SDS/MDCD shall respond to queries about all product version and sub-version numbers
   - 3.5 The SDS/MDCD shall respond to queries about Earth location
   - 3.6 The SDS/MDCD shall respond to queries about solar conditions
   - 3.7 The SDS/MDCD shall respond to queries about as flown instrument modes
   - 3.8 The SDS/MDCD shall respond to queries about as flown instrument events
   - 3.9 The SDS/MDCD shall respond to queries about as flown instrument anomalies
   - 3.10 The SDS/MDCD shall respond to queries about as flown spacecraft modes
   - 3.11 The SDS/MDCD shall respond to queries about as flown spacecraft events
   - 3.12 The SDS/MDCD shall respond to queries about as flown spacecraft anomalies
   - 3.13 The SDS/MDCD shall respond to queries about orbit number
   - 3.14 The SDS/MDCD shall respond to queries about validated Kp values
   - 3.15 The SDS/MDCD shall respond to queries about validated ap values
   - 3.16 The SDS/MDCD shall respond to queries about daily FIO.7 values
   - 3.17 The SDS/MDCD shall respond to queries about equatorial distance
   - 3.18 The SDS/MDCD shall respond to queries about Zurich sunspot number
   - 3.19 The SDS/MDCD shall respond to queries about data parameters
   - 3.20 The SDS/MDCD shall respond to queries about nominal tangent point locations for all instruments, in geographic, magnetic and local solar coordinates

4. The SDS/MDCD shall archive data and software related to the TIMED mission
   - 4.1 The SDS/MDCD shall use ftp or http based file transfer to ingest data for archive
   - 4.2 The SDS/MDCD shall verify data ingest
   - 4.3 The SDS/MDCD shall archive all TIMIED mission data and software one year after launch
   - 4.4 The SDS/MDCD shall archive all TIMED mission data and software at close of spacecraft operations
   - 4.5 The SDS/MDCD shall archive all TIMED mission data and software four months after mission closeout

5. The SDS/MDCD shall distribute data product availability information and data products

5.1 The SDS/MDCD shall distribute data product availability sets identified by an on-line query of the catalog

5.3 The SDS/MDCD shall deliver data to a user's local system

5.3.1 Delivery of data products shall use a web browser interface at the customer site

5.3.2 Delivery of data products shall use a web server interface at the archive site.

6. The SDS/MDCD shall provide administrative services

6.1 The SDS/MDCD shall provide user registration

6.1.1 The SDS/MDCD shall share user registration information among remote sites

6.3 The SDS/MDCD shall track daily the number of files ingested for archive

6.4 The SDS/MDCD shall track daily the number of data product ingest failures

6.5 The SDS/MDCD shall track monthly the number of new entries to the catalog

6.6 The SDS/MDCD shall track monthly the number of changes to existing entries in the catalog

6.7 The SDS/MDCD shall report monthly on all administrative services provided

8. The SDS/MDCD shall be Year 2000 compliant

8.1 The SDS/MDCD shall correctly interpret the century of any date containing a year

8.2 The SDS/MDCD shall recognize the year 2000 as a leap year

8.3 The SDS/MDCD shall correctly convert dates before the Year 2000 boundary

8.3.1 The SDS/MDCD shall correctly convert dates to day of week

8.3.2 The SDS/MDCD shall correctly convert GPS time to UTC

8.3.3 The SDS/MDCD shall correctly convert UTC to GPS time

8.4 The SDS/MDCD shall correctly convert dates after the Year 2000 boundary

8.4.1 The SDS/MDCD shall correctly convert dates to day of week

8.4.2 The SDS/MDCD shall correctly convert GPS time to UTC

8.4.3 The SDS/MDCD shall correctly convert UTC to GPS time

8.5 The SDS/MDCD shall correctly compute time intervals spanning the Year 2000 boundary

8.6 The SDS/MDCD shall correctly exchange date information with other TIMED components

3.2.4 Mission Publication (MP)

The MP component includes all user interfaces used to access data held at the MDC by the general public. This will be implemented as a WWW site for the distribution and coordination of TIMED data as well as satisfying the mission objectives in the area of public and educational outreach. The outputs of this component are deliverables of the TIMED mission.

Derived requirements from MDC CoDR

- Produce and distribute TIMED products that shall be available to the K-12 educational community (MP).
- Develop and serve TIMED Project WWW Page (MP).

Note: The TIMED MDC component, Mission Publication (MP) will not be part of this TIMED MDC Build delivery. The requirements will be further defined in a future version of this document.

7. The SDS/MP shall use the Mission Publication web interface for interaction with users
   - 7.1 The Mission Publication interface shall use a link from the TIMED Home Page to SDS/MDCD services
   - 7.2 The Mission Publication interface shall provide web-based access to all the SDS and the MDCD services
     - 7.2.1 The Mission Publication interface shall provide a view of the Daily Contact Schedule
     - 7.2.2 The Mission Publication interface shall provide a view of the current Experiment Plan
     - 7.2.3 The Mission Publication interface shall provide access to Data System News
     - 7.2.4 The Mission Publication interface shall provide access to Survey Product Gallery
     - 7.2.5 The Mission Publication interface shall provide access to Planning and Operations
       - 7.2.5.1 The Mission Publication interface shall provide access to Planned and As Flown Timelines
       - 7.2.5.2 The Mission Publication interface shall provide access to Coverage Plots
       - 7.2.5.3 The Mission Publication interface shall provide access to the Coincidence Calculator
       - 7.2.5.4 The Mission Publication interface shall provide access to Ground Based Instrument Coverage
     - 7.2.6 The Mission Publication interface shall provide access to Data Ordering service
       - 7.2.6.1 The Mission Publication interface shall provide access to the List of Data Product Types

7.2.6.2 The Mission Publication interface shall provide access to the service to Locate Products of Interest

7.2.6.3 The Mission Publication interface shall provide access to the service to directly download data

7.2.7 The Mission Publication interface shall provide access to Instrument/IDS web sites

7.2.7.1 The Mission Publication interface shall provide access to the GUVI web site

7.2.7.2 The Mission Publication interface shall provide access to the SABER web site

7.2.7.3 The Mission Publication interface shall provide access to the SEE web site

7.2.7.4 The Mission Publication interface shall provide access to the TIDI web site

7.2.7.5 The Mission Publication interface shall provide access to other TIMED data related web sites as they are identified.

7.2.8 The Mission Publication interface shall provide access to the Mission Data Center

7.2.8.1 The Mission Publication interface shall provide access to the MDC Home Page

7.2.8.2 The Mission Publication interface shall provide access to Detailed Descriptions of MDC Products

7.2.8.3 The Mission Publication interface shall provide access to a Description of MDC Processing

7.2.8.4 The Mission Publication interface shall provide access to information about MDC Data Availability

7.2.9 The Mission Publication interface shall provide access to TIMED Shared Software

7.2.9.1 The Mission Publication interface shall provide access to a List of Available Software

7.2.9.2 The Mission Publication interface shall provide capability to Download Available Software

7.2.10 The Mission Publication interface shall provide access to the Education web site

7.2.11 The Mission Publication interface shall provide access to the TIMED Publications List

7.2.12 The Mission Publication interface shall provide access to the User Registration service

7.2.12.1 The Mission Publication interface shall provide access to the Data Access Policy and Rules of the Road

7.2.12.2 The Mission Publication interface shall provide access to service to Register

7.2.13 The Mission Publication interface shall provide access to User Account Management service

7.2.13.2 The Mission Publication interface shall provide access to the

service to Subscribe to Mailing Lists for Product Information

7.3 The SDS/MDCD shall provide updates to the information available via the Mission Publication interface

7.3.1 The SDS/MDCD shall provide updates upon receipt for the Survey Product Gallery

7.3.2 The SDS/MDCD shall provide updates daily for Planning and Operations

7.3.3 The SDS/MDCD shall provide updates daily for the Data Ordering service

7.3.4 The SDS/MDCD shall provide updates upon receipt for the Instrument/IDS web sites

7.3.5 The SDS/MDCD shall provide updates upon receipt for the Mission Data Center

7.3.6 The SDS/MDCD shall provide updates upon receipt for the TIMED Shared Software

7.3.6 The SDS/MDCD shall provide updates upon receipt for the Education web site

7.3.8 The SDS/MDCD shall provide updates upon receipt for the TIMED Publications List

7.3.9 The SDS/MDCD shall provide updates daily for the User Registration service

7.3.10 The SDS/MDCD shall provide updates daily for the User Account Management service

3.3 System External Interface Requirements

There are many external interface requirements required for the MDC to deliver and to receive data. The MDC interfaces with the following external systems:

- APL Ground Station
- Off-Site Ground Station
- MOC
- POC
- DAF
- Ground Based Facilities
- SPDS
- Public

The requirements for the system external interfaces shall be addressed in the TIMED MDC-to-MOC Interface Control Document (Reference [10]), the TIMED General Instrument Interface Specification (Reference [8]), the Data Management Plan (Reference [9]), and the Ground Station Requirements Document (Reference [13]).

4 Qualification Provisions

During the software development process the design of the system and subsystem will be checked against the requirements from section 3. In the following table the requirements are given general qualification methodology to act as a guide during the software development process.

The Qualification Methods used in the following table are taken from Reference [6].

Demonstration: Qualification that relies on observed functional operation.

Test: Specific test plans to match performance criteria and characteristics.

Analysis: The processing of accumulated data obtained from other qualification methods. Usually requiring results from multiple tests from other requirements.

Inspection: Visual examination of system components, documentation etc.

MDC Requirement	Qualification Method	Notes
MDC-TS-1	Test	Build 1.0
MDC-TS-2	Test	Build 1.0
MDC-TS-3	Test	Build 1.0
MDC-TS-4	Test/ Analysis	Build 1.0
MDC-TS-5	Test	Build 1.0
MDC-TS-6	Test	Build 1.0, Build 1.5
MDC-TS-7	Test	Build 1.0
MDC-TS-8	Test	Build 1.0
MDC-TS-9	Test	Build 1.5, Build 2.0
MDC-TS-10	Test	Build 2.0
MDC-TS-11	Test	Build 1.0, Build 1.5
MDC-TS-12	Test	Build 1.5
MDC-TS-14	Test	Build 1.5, Build 2.0

MDC Requirement	Qualification Method	Notes
MDC-TS-15	Test	Build 1.5
MDC-TS-16	Test	Build 1.5, Build 2.0
MDC-TS-17	Test	Build 2.0
MDC-TS-18	Demonstration	Build 1.5
MDC-TS-19	Analysis	Build 2.0
MDC-TS-20	Test	Build 1.5, Build 2.0
MDC-TS-21	Test	Build 3.0
MDC-TS-22	Test	Build 3.0
MDC-TS-23	Test	Build 3.0
MDC-TS-24	Test	Build 2.0
MDC-TS-25	Test/Demonstration	Build 2.0
MDC-TS-26	Analysis	Build 2.0
MDC-TS-27	Test	Build 2.0
MDC-TS-28	Test	Build 2.0
MDC-TS-29	Test	Build 2.0
MDC-TS-30	Test/Analysis	Build 2.0
MDC-TS-31	Test	Build 2.0
MDC-TS-32	Test	Build 2.0
MDC-TS-33	Test	Build 2.0
MDC-TS-34	Test	Build 2.0
MDC-TS-35	Test	Build 2.0
MDC-TS-36	Test	Build 2.0
MDC-TS-37	Test	Build 3.0
MDC-TS-38	Test	Build 2.0

MDC Requirement	Qualification Method	Notes
MDC-TS-39	Test	Build 2.0
MDC-TS-40	Test	Build 2.0
MDC-TS-41	Test	Build 2.0
MDC-TS-42	Test	Build 2.0
MDC-TS-43	Test	Build 2.0
MDC-TS-44	Test/ Demonstration	Build 2.0
MDC-TS-45	Test	Build 2.0
MDC-TS-46	Test/ Analysis	Build 2.0
MDC-TS-47	Test	Build 3.0
MDC-TS-48	Test/ Analysis	Build 2.0
MDC-TS-49	Test/ Analysis	Build 3.0
MDC-TS-50	Test/ Analysis	Build 2.0
MDC-TS-51	Test/ Analysis	Build 3.0
MDC-DPP-1	Test	Build 2.0
MDC-DPP-2	*Test*	*Build 3.0*
MDC-DPP-3	*Test*	*Build 3.0*
MDC-DPP-4	Test	Build 2.0
MDC-DPP-5	Test	Build 2.0
MDC-DPP-6	Test/Demonstration	Build 2.0
MDC-TS-52	Test	Build 3.0
MDC-TS-53	Test	Build 3.0
MDC-TS-54	Test	Build 3.0
MDC-TS-55	Test	Build 3.0
MDC-TS-56	Test	Build 3.0

MDC Requirement	Qualification Method	Notes
MDC-TS-57	Test	Build 3.0
MDC-TS-58	Test	Build 3.0

5 Requirements Traceability

TIMED System Requirements	MDC Requirements
Generate Level 0 data products to support the TIMED Mission. (Level 0 is Standard Telemetry Messages or Command Packets)	**MDC-TS-1, MDC-TS-2, MDC-TS-6, MDC-TS-11, MDC-TS-24, MDC-TS-25, MDC-TS-29**
Provide access to ground-based measurements in support of TIMED.	*Next Build*
Provide timely data distribution among TIMED program elements.	**MDC-TS-4, MDC-TS-7, MDC-TS-8, MDC-TS-9, MDC-TS-10, MDC-TS-12 MDC-TS-14, MDC-TS-15, MDC-TS-16, MDC-TS-17, MDC-TS-20, MDC-TS-37, MDC-TS-45, MDC-TS-47**
Provide scientifically useful products derived from the TIMED measurements to the scientific community in a timely manner	**MDC-DPP-1, MDC-DPP-2, MDC-DPP-3, MDC-DPP-4, MDC-DPP-5**
Provide relevant and useful educational products derived from TIMED data to K-12 educators and the public in a timely manner	*Next Build*
During the mission, archive products generated by the spacecraft and the MDC.	**MDC-TS-18, MDC-TS-19, MDC-TS-26, MDC-DPP-6**
Provide for the long term utility and archiving of data products generated by the TIMED program in cooperation with the Space Physics Data System (SPDS)	*Build 4*

6 Abbreviations

APID	Application Identification
CoDR	Conceptual Design Review
CM	Configuration Management
DAF	Data Analysis Facility
DPP	Data Product Production
CCSDS	Consultative Committee for Space Data Systems
CSCI	Computer Software Configuration Item
FE	Front-End
FTP	File Transfer Protocol
GSFC	Goddard Space Flight Center
GUVI	Global Ultraviolet Imager
I&T	Integration and Test
ICD	Interface Control Document
GPS	Global Positioning System
JHU/APL	The Johns Hopkins University Applied Physics Laboratory
kbps	Kilobits per Sec
Mbyte	Megabyte
MDCD	Mission Data Cataloging and Distribution
MDC	Mission Data Center
MOC	Mission Operations Center
MP	Mission Publication
NASA	National Aeronautics and Space Administration
NetCDF	Network Common Data Format
NMC	National Meteorological Center
PDR	Preliminary Design Review
POC	Payload Operations Center
PTP	POC Telemetry Packet
PTS	Playback Telemetry Service
PVAT	Position, Velocity, Attitude and Time
R/T	Real-Time
RTS	Real-Time Telemetry Service
SABER	Sounding of the Atmosphere using Broadband Emission Radiometry
S/C	Spacecraft
SDS	Science Data System
SDP	Software Development Plan
SEE	Solar EUV Experiment
STP	Supplemented Telemetry Packet
SPDS	Space Physics Data System
STF	Supplemented Telemetry Frame
TCP/IP	Transition Control Protocol/Internet Protocol
TF	Telemetry Frame
TFS	Telemetry File Service
TIDI	TIMED Doppler Imager
TIMED	Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics
TP	Telemetry Packet
TS	Telemetry Service
URL	Uniform Resource Locator
WWW	World Wide Web