TIMED

Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics

TIMED Science Data System (SDS)

Robert DeMajistre

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robert_demajistre@jhuapl.edu
(301)953-6000x8756

The TIMED Science Data System

In order to succeed, TIMED requires

- Collaborations fostered by data exchange within the program
- Delivery of useful data products to the scientific community
- Delivery of useful educational materials to teachers and the general public

The TIMED data services must include much more than the delivery of telemetry

Data System Purpose

The TIMED Science Data System (SDS) is responsible for the generation, acquisition, distribution and archive of science data necessary to support the TIMED mission. In this capacity, the data system will provide useful data products to the program elements, the scientific community, k-12 educators and the general public.

Distributed Data System

- Data services during the mission will be provided by multiple facilities
- Producers of a given data product are best suited to offer support for it.

Mission Data Center (MDC)

- The MDC is located at APL
- The MDC is responsible for telemetry services
- The MDC is responsible for developing and hosting the core common user interface
- Program-wide SDS functions will be hosted at the MDC (e.g., support data acquisition, common software libraries)

Payload Operations Centers (POCs)

- Instrument Operation and Assessment functions of the POCs are not part of the data system
- The POCs are responsible for routine data production for their instrument
- The POCs are responsible for archive and distribution of their routine products and analysis products generated by their instrument science team
- POC Locations

GUVI POC	APL
SABER POC	NASA Langley
SEE POC	LASP
TIDI POC	University of Mich..

Data Analysis Facilities (DAFs)

- Data Analysis Facilities will host data that is not part of the data set from an individual instrument
- There will be a DAF for each IDS, a DAF for project science and education, and possibly a DAF for collaborating investigators
- The main function of the DAF is to archive and serve the data analysis products generated by investigators not associated with a single instrument
- Depending on the infrastructure at their individual facilities, Collaborating Science Teams (e.g. ground based observers) can maintain a DAF, or provide data to the MDC for distribution

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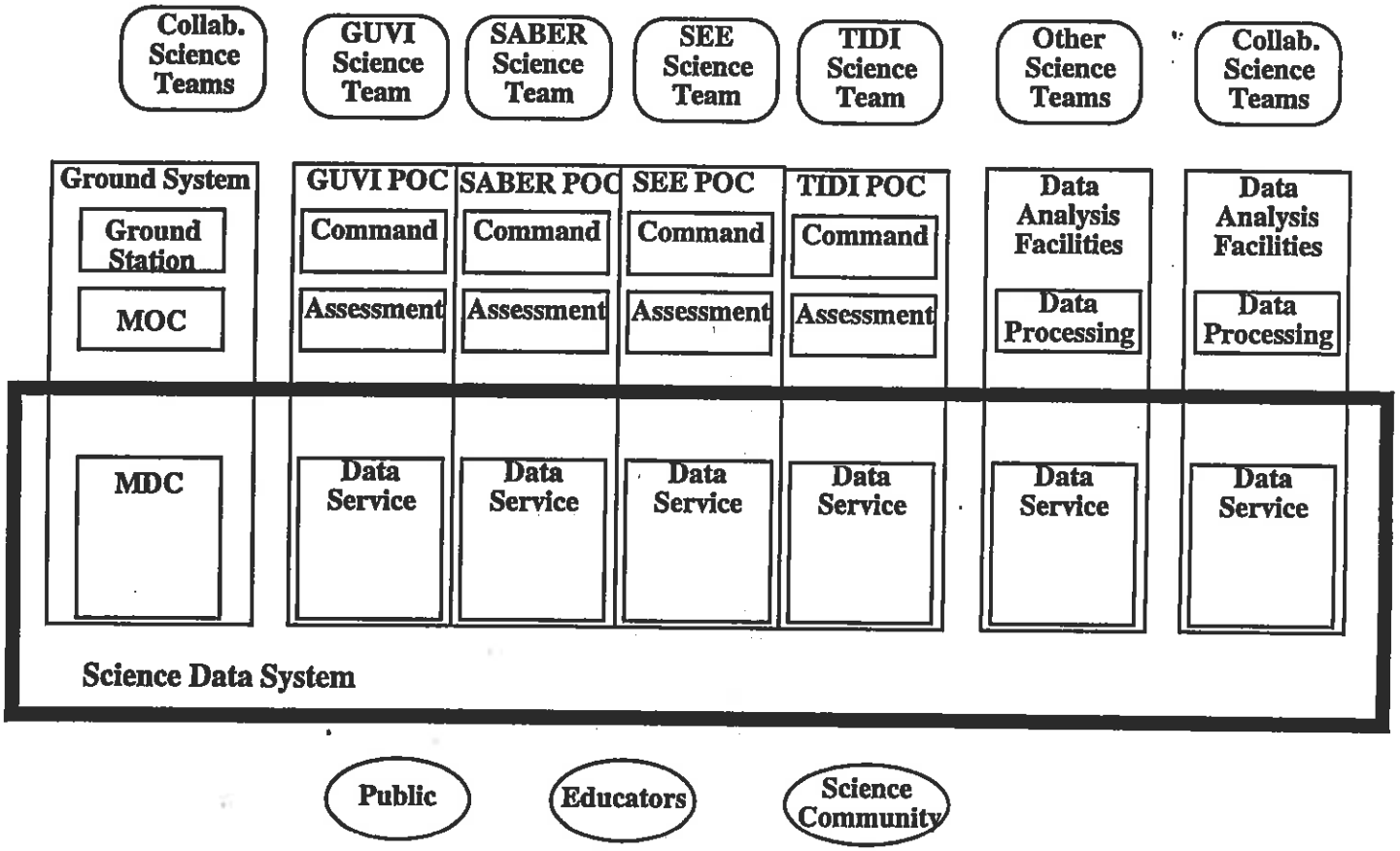
Data System Components



Initial Data Delivery

- **Telemetry is received at the Mission Data Center from the ground station**
- **Some telemetry will be available over a network link to the POCs in near-realtime**
- **All telemetry will be available in 'playback mode'**
- **Working requirement for initial delivery is 12 hours from downlink**

Routine Product Generation

- **Routine products will be generated regularly, and with little human intervention**
- **Routine production will require spacecraft telemetry, spacecraft information and, in some cases, well defined supporting data or other routine products (e.g., meteorological data or geomagnetic indices)**
- **Routine products will be refined and reprocessed as the mission proceeds**
- **These products will be archived for the duration of the mission where they are produced**

Science Team Activities

- **The science teams will access data from their associated facilities (or through the common interface)**
- **Exchange of data products among the science teams will not be monitored by the SDS**
- **Products resulting from data analysis will be fed back into the appropriate archive**

Common Interface

- **A common interface will be provided for browsing and ordering data**
- **The distributed nature of the data should be hidden to the extent possible**
- **The interface will be World Wide Web based**
- **Both mission description and product ordering will be supported**

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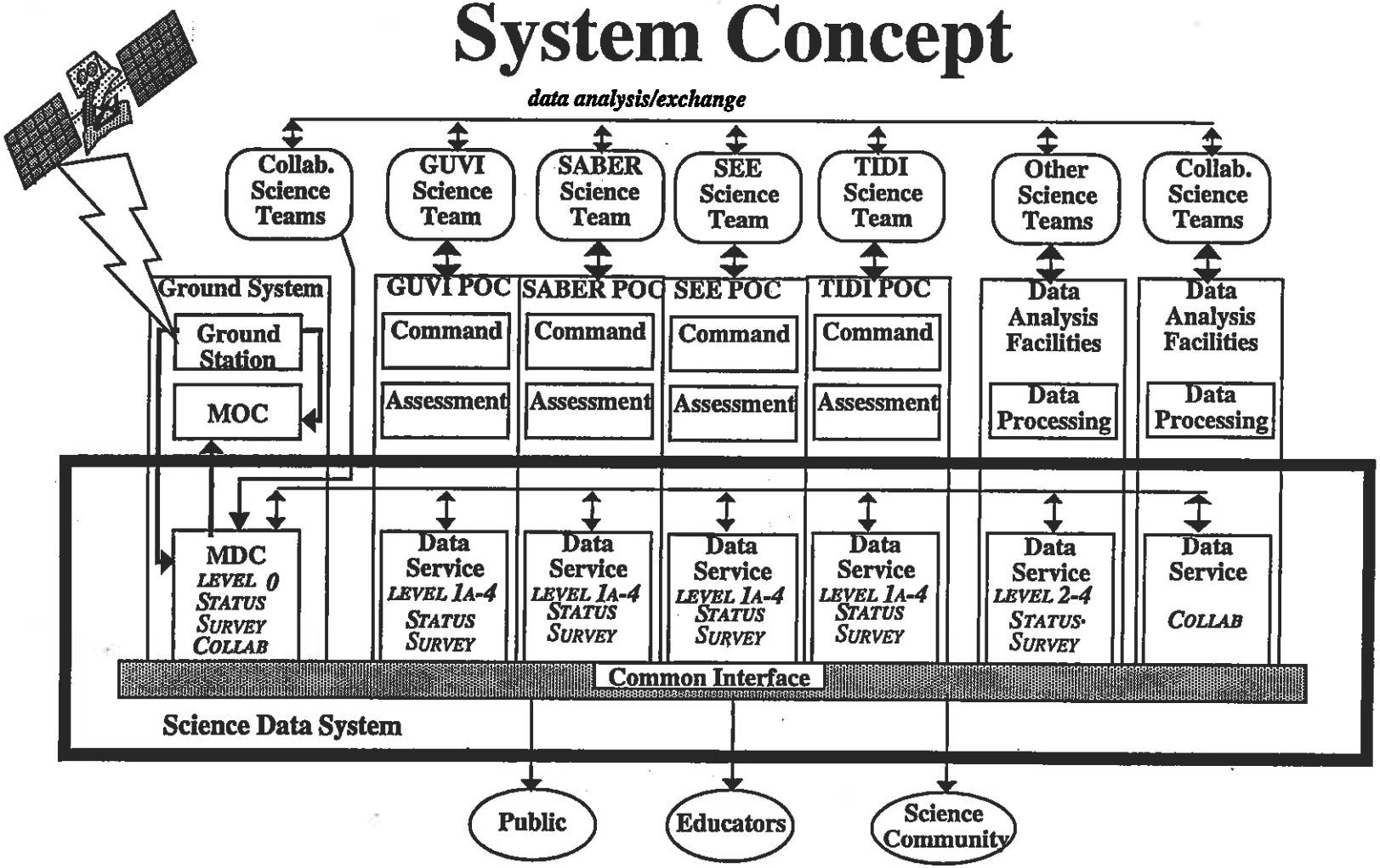
System Concept



TIMED Project Data Management Plan (DMP), 7363-9330

Major Sections

1.0 Introduction
- Purpose

2.0 References

3.0 Data System Purpose
- Relationship of SDS to the mission
- SDS Scope
- SDS Lifecycle

4.0 Data System Organization
- SDS facilities
- Facility responsibilities

5.0 Data System Standards and Policies
- Data access policy
- SDS internal standards and policies
- SDS external standards and policies

6.0 TIMED Data Product Classification

7.0 Data System Concept
- Required data products for each user
- Data sources
- System architecture

8.0 World Wide Web Services

9.0 Data Products

10.0 Ground Based Data

11.0 Educational Outreach

Program Data Management Plan

The TIMED Program Data Management Plan (DMP) documents describes the Science Data System, its structure, policies and products. It includes

- Information to the users of the SDS, including an overview of what products are available and how access is provided.
- Guidelines and specific technical information to the SDS implementation teams to aid in construction of the data system.
- Information useful for evaluation of the SDS by program management and the Space Physics Data System review team

Product Generation Classes

The Product Generation Classification is used to determine delivery schedules and aid in system monitoring

- **Routine Products - Produced regularly and systematically with a minimum of human intervention**
- **Analysis Products - Produced as the result of data analysis or other human intensive process**
- **Automated Products - Produced on demand from a user request (e.g., SEE's planned spectral selections)**

Product Content Classes ('Levels')

Product Content Classes are used to refer to the type of data contained in the product (Levels taken from the EOS handbook).

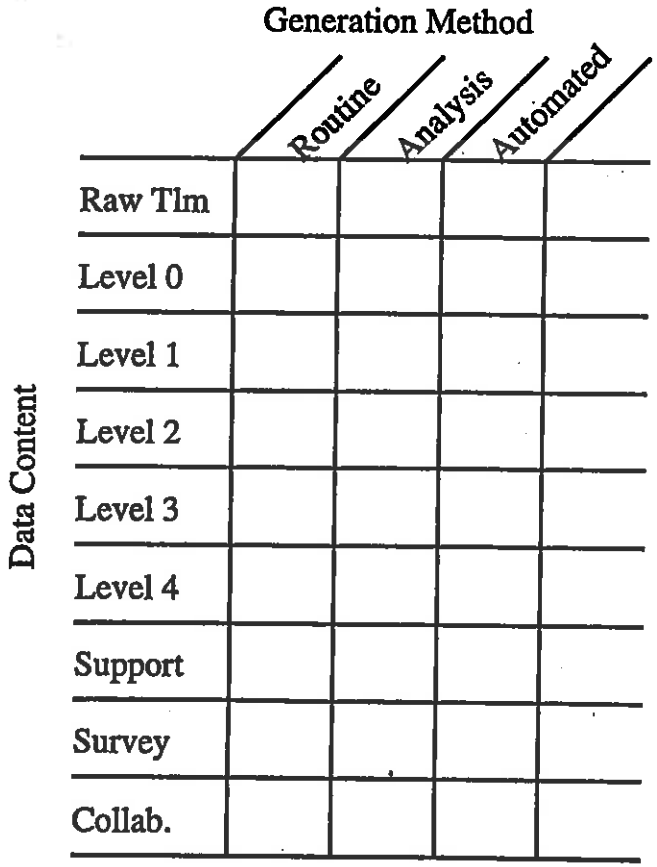
- **–Level 0: reconstructed unprocessed instrument data at full resolution; all communication artifacts removed**
- **–Level 1a: reconstructed unprocessed instrument data at full resolution, time-referenced and annotated with ancillary information including radiometric and geometric parameters**
- **–Level 1b: Level 1A data that have been processed to sensor units**
- **–Level 2: Derived geophysical variables at the same resolution as Level 1**
- **–Level 3: Variables mapped on a uniform space-time grid**
- **–Level 4: Model output or results from analyses of lower level data(i.e., variables derived from multiple measurements)**

Product Content Classes (others)

In addition to standard NASA levels, we introduce the following additional classifications

- **Raw Telemetry: Unprocessed digital telemetry**
- **Survey: Summary or low fidelity data used for quicklook and data location**
- **Support: Data acquired from non-TIMED sources to supplement data analysis**

Data Product Classification



There are 2 important attributes to be captured by the classification scheme:

- **How the data is produced**
- **What information is contained**

Although loosely correlated, these attributes are independent. The matrix to the left will be used to classify the TIMED data products.

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Data System Services

- **Routine Data Production**
- **Data Delivery**
- **Data Product Location**
- **Communication of Mission Information**
- **Acquisition and Processing of Support Data**
- **Short and Long Term Archive**
- **Data System Standards and Quality Control**

SDS Data Products

Tlm Playback Original telemetry packets

Tlm Playback Original telemetry packets

Tlm Files Original telemetry packets

Space-craft position (predict)	Spacecraft Ephemerides and ground track
Space-craft position (actual)	Spacecraft Ephemerides and ground track
Geomag. indices	K_p, A_p, $F_{10.7}$
NMC data	Pressure and Temperature data near the ground track
Instru-ment status (planned)	Planned instrument states and events
Instru-ment status (as-flown)	As-flown instrument states, events and anomalies
Mission history database	Combined instrument status and spacecraft position
Data Product Catalog	Program wide listing of available data products
GUVI Level 1A data	Unprocessed instrument data at full resolution, time-tagged, s/c location specified
GUVI Disk data	Radiance data from disk mode.
GUVI Limb data	Radiance data from limb mode. Gridded in GUVI-based viewing coordinates.
GUVI Proton auroral boundaries	Proton auroral boundaries. Provides poleward and/or equatorward boundaries.
GUVI Mixed auroral boundaries	Mixed proton/electron auroral boundaries.
GUVI Spectro-graph Data	Spectrograph counts
GUVI TEC, nightside disk	Geolocated TEC along line of sight, superpixel, nightside disk
GUVI EDP, nightside limb	Electron density profile, superpixel, nightside limb
GUVI O/N_2 ratio, dayside disk	Geolocated O/N_2 ratio vertical column, superpixel, dayside disk
GUVI O NDP, dayside limb	O neutral density profile, superpixel, dayside limb
GUVI O_2 NDP, dayside limb	O_2 neutral density profile, superpixel, dayside limb
GUVI N_2 NDP, dayside limb	N_2 neutral density profile, superpixel, dayside limb
GUVI Temper-ature profile, dayside limb	Neutral-gas temperature profile, superpixel, dayside limb
GUVI Q_{esr}	Measure of the integrated solar flux
GUVI Q, aurora	Effective** energy flux
GUVI <E>, aurora	Effective** average energy
GUVI E-Region EDP, aurora	E-region electron density profile
GUVI Survey	GUVI survey products
SABER level 1b Data	Calibrated radiance
SABER level 2 para-meters	profiles of kinetic temp., pressure, density, O_3, H_2O
SABER level 2 emission rates	profiles of emission rates of NO, OH, O_2
SABER abun-dances	Profiles of CO_2, O and H
SABER cooling rates	Profiles of cooling rates from CO_2, NO, O_3 and H_2O
SABER solar heating rates	Profiles of heating rates from O_3, O_2 and CO_2
SABER chemical heating rates	Profiles of heating rates various reactions
SABER airglow	Profiles of emission and heating efficiency from OH and O_2
SABER geo-strophic wind	Profiles of geostrophic wind
SEE level 1b Data	SEE data converted to solar irradiance
SEE level 2 Data	SEE daily solar irradiance (no degradation correction applied)
SEE level 3 Data	SEE daily solar irradiance 1nm bins
SEE Edu-cational data	Solar XUV indices
TIDI LOS quantities	Line OF Sight quantities for each spectrum
TIDI Profiles	Retrieved profiles of each geophysical quantity
TIDI Mapped Data	Summary mapped data
GSWM winds	Global Scale Wave Model zonal and meridional tidal winds for each month
GSWM temper-aturea	Global Scale Wave Model tidal temperatures for each month
GSWM vertical velocities	Global Scale Wave Model tidal vertical velocities
GSWM planetary winds	Global Scale Wave Model zonal and meridional planetary wave wind
GSWM planetary temper-atures	Global Scale Wave Model planetary wave temperatures
GSWM	**planetary vertical velocities**

Routine Data Production

Goal: Ensure that the right products are produced on time

Completed

- *Compile list of data products necessary for mission success*
- *Identify dependencies between products*
- *Resolve missing pieces*
- *Finalize critical interfaces (telemetry -> POC)*

Pre-launch

- **Finalize format and content**
- **Implement production**

Post-launch

- **Monitor Changes**

Data Delivery Schedules

- Telemetry delivered to POCs within 30 hours from acquisition on orbit
- Routine products available for distribution 54 hours after acquisition on orbit
- Analysis products will be available upon release by the science team
- Delivery schedules are relaxed during the first six months on orbit

Data Delivery Methods

- Most routine data deliveries (pre-negotiated) will use FTP
- Ad-hoc data delivery will be done through the Data Distribution System DDS

Data Delivery

Goal: Ensure TIMED data users receive the right data

Completed

- *Work out preliminary delivery schedule*
- *Define delivery methods*
- *Define program-wide concept of operations for delivery*
- *Identify implementation methods for data delivery*

Pre-launch

- **Implement and test data delivery system**
- **Refine system with user input**

Post-launch

- **Refine system with operational data**
- **Monitor changes**

Data products will be selected on the basis of

- Time Range
- Data product descriptions
- Instrument coverage
- Spacecraft/Instrument timelines

Data Product Location

Goal: Provide users with a way to find the data they need

Completed

- *Determine the scope of the system*
- *Define data location methods to be used*
- *Define information/products required*
- *Define overall user interface requirements*

Pre-launch

- **Implement user interface**
- **Implement meta-data loading**
- **Refine interface with user input**

Post-launch

- **Refine interface with user input**

Both planned and as flown information will be available

- Spacecraft position and attitude
- Instrument modes, events and anomalies
- Spacecraft modes, events and anomalies
- Special event planning from the science team
- Telemetry archive status information
- Contact plans and reports

Communication of Mission Info.

Goal: Provide users with necessary science planning, results and summary data

Completed

- *Determine the scope of the activity*
- *Determine requirements for information exchange*
- *Define data products required*
- *Define overall user interface requirements*

Pre-launch

- Implement user interface
- Refine interface with user input

Post-launch

- Refine interface with user input

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Support Data

Goal: Provide non-TIMED data necessary for TIMED processing

Complete

- *Identify the data required*
- *Identify sources of information*
- *Define processing methods for support products*

Pre-launch

- Implement acquisition and processing
- Refine as other sources become available

Post-launch

- Monitor changes
- Refine as other sources become available

Long Term Archive

- **The long term archive for TIMED will be the SPDS**
- **Data hosted at remote facilities will be collected by the MDC and mastered on standard media**
- **One final set of data will be delivered to the SPDS, however interim data deliveries will be required**
- **Remote facilities are responsible for the data that they produce during the mission**

Archive Contents

The long term archive will contain

- **Mission documentation and summary data products**
- **The most current version of routine data products**
- **Delivered software for the production of the most current version of routine data products**
- **Most current version of analysis products (determined by SWG)**
- **Supporting products available only through the TIMED program**
- **Utility software for processing**

Archive Delivery Schedule

Three deliveries of products for long term archive will be required

- **Prototype delivery, 1 year after launch. Will contain only a sample of available products**
- **Interim delivery, at close of spacecraft operations**
- **Final delivery, 4 months before mission closeout**

Short and Long Term Archive

Goal: Safeguard, organize and track TIMED data holdings

Complete

- *Identify short and long term archive responsibility*
- *Devise method for product tracking*
- *Plan transition to long term archive*

Pre-launch

- **Implement product tracking system**
- **Define procedures for safeguard and organization**

Post-launch

- **Monitor archiving**
- **Transition to long term archive**

Standards in DMP

- Data formats
  - •netCDF for all binary files (except telemetry)
  - •ASCII files for human readable status data
  - •PDF, GIF, TIF, JPG and MPG for survey products
- Communication Protocols
  - •FTP, HTTP, removable media
- Removable media (CDROM, 8mm tape)
- Time and geometry representations
  - •Binary and text time formats
  - •J2000 for intertial coordinates
  - •geographic coordinates employ WGS84 ellipsoid

Standards and Quality Control

Goal: Ensure efficient and repeatable communications throughout the data system

Complete

- ***Determine scope of standards***
- ***Define internal and external data standards***
- ***Define processes for CM, CA and QA***

Pre-launch

- **Implement CM, CA and QA processes**
- **Monitor success of processes and standards**
- **Develop tools for implementation and testing of standards**

Post-launch

- **Monitor success of processes and standards**

Shared software

The sharing of software among program elements is encouraged, particularly software for reading and processing data products. To this end, the SDS will provide a facility for shared software. While formal delivery of software will not be required, it is suggested that the authors of data products provide basic utilities for reading and processing their data products. These software products will generally be hosted by their author's facility.

The program will provide a set of guidelines for software to be shared, including a minimum documentation standard. The program will provide a structure for the exchange of software, submission guidelines and instructions for users. Authors of the software will identify the software to be shared and submit it for exchange. Guidelines and standards for shared software will be listed in an appendix to this document when they are formulated.

It should be kept in mind that users of this shared software depend upon the good will of the supplier for support.

Sharing Algorithms

Provisions have been made to share algorithms and software to reduce redundant development

- **Library of useful code/pseudo-code and algorithms to be hosted by the MDC**
- **High priority shared code has been identified, e.g.,**
  - **Data product readers**
  - **Conversions for standard time, coordinate system and attitude representation**
  - **Routines for testing algorithms**
- **Framework for sharing has been established**
  - **No 'delivered software'**
  - **Sharing of methods instead of code**

Activities Through Spacecraft I&T

- **Implement routine data production and distribution**
- **Refine and implement data archive and location tools**
- **Include educational outreach and ground based data sources into the data system as they become defined by the science team**
- **Implement CM, CA and QA systems**
- **Refine the system in response to science requirements**
- **Plan and execute data system testing**