



- Home
- More About AMMOS
- AMMOS Catalog
- Contribute to AMMOS
- Future AMMOS Plans
- Contacts & Help

For More Information Contact:
 Mission Interface Office
 ammos_info@jpl.nasa.gov
 818-393-0686

Welcome to the AMMOS Website!

The **Advanced Multi-Mission Operations System (AMMOS)** provides most of the ground data system functions needed to design, implement, and operate a **Mission Operations System (MOS)**. AMMOS consists of a core set of products that can be readily customized to accommodate the specific needs of individual missions. It is based on a simple idea: build the elements of an MOS that are common to multiple missions **once** rather than individual missions duplicate development and maintenance effort. Using AMMOS lowers mission cost and risk by providing a mature base for mission operations systems at significantly reduced development time. AMMOS enables Principal Investigators by providing direct, immediate, flexible, and seamless interaction with their instruments and data from almost any location without requiring expertise in mission operations or the AMMOS. High quality and cost effectiveness of our products is why NASA has chosen the AMMOS to support NASA Deep Space and Astrophysics missions.

Who uses AMMOS



Mars Science Laboratory (MSL) is a rover that will assess whether Mars ever was, or is still today, an environment able to support microbial life. [More ...](#)



The Advanced Multi-Mission Operations System (AMMOS) – An Introduction to the Multi-Mission Products and Services Used by 50+ NASA Missions

Eleanor Basilio, California Institute of Technology / JPL / NASA
 Peter Di Pasquale, California Institute of Technology / JPL / NASA



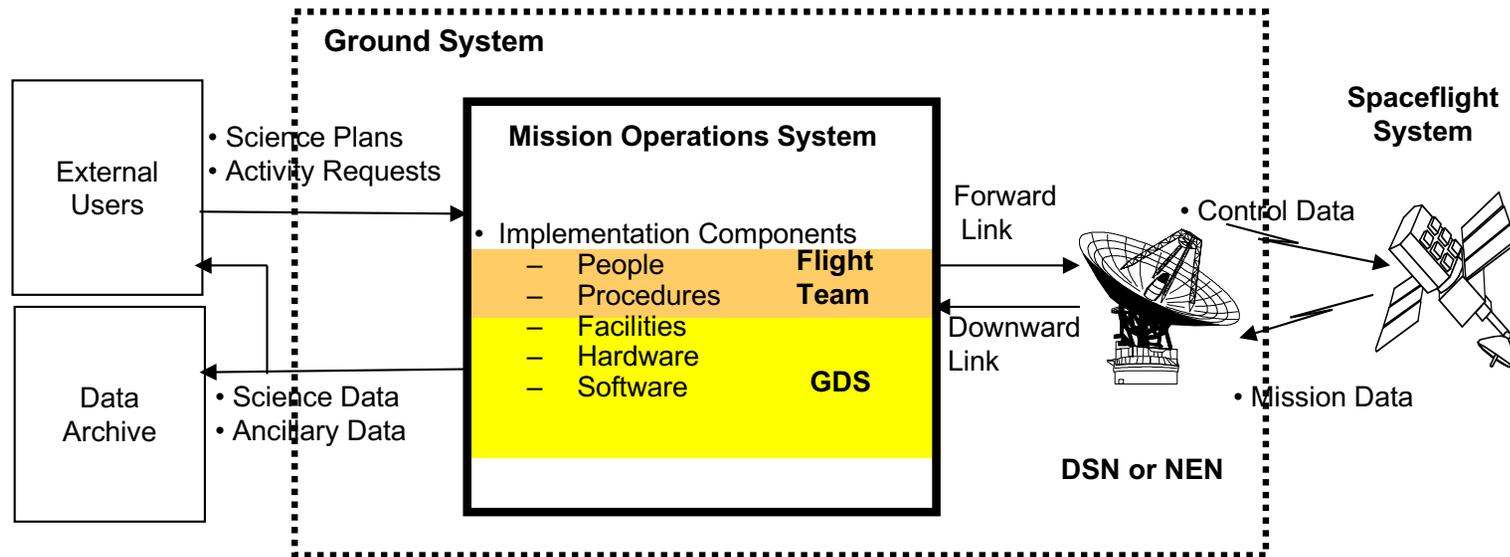
Jet Propulsion Laboratory
 California Institute of Technology

Acknowledgment/Contributors

- David Berry California Institute of Technology / JPL / NASA
- Boris Borelly California Institute of Technology / JPL / NASA
- Brian Giovannoni California Institute of Technology / JPL / NASA
- Costin Radulescu California Institute of Technology / JPL / NASA
- Brian Roth California Institute of Technology / JPL / NASA
- Barbara Streiffert California Institute of Technology / JPL / NASA
- Karen Yetter California Institute of Technology / JPL / NASA



Definition: What is a Mission Operations System

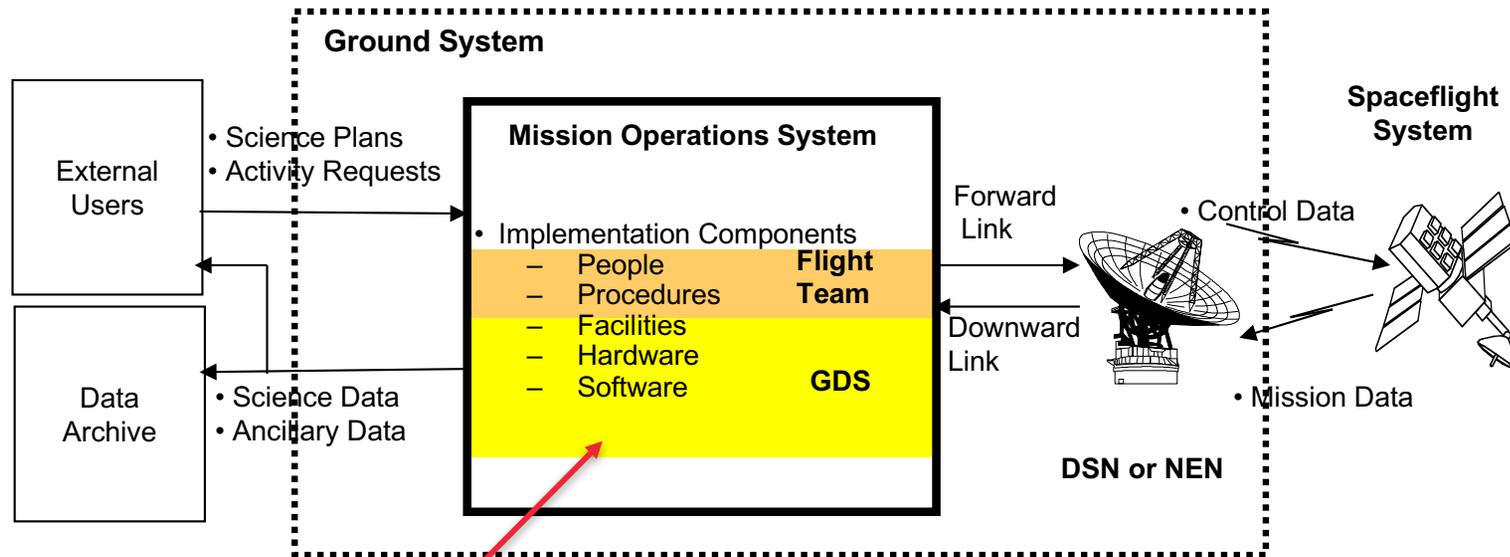


- **It is an integrated system of people, hardware, software, and activities that have to work together to ensure the successful execution of a mission.**

-- James R. Wertz, David F. Everett, Jeffery J. Puschell, *Space Mission Engineering: The New SMAD*. Hawthorne, CA, Microcosm Press, Second Printing 2015



Definitions: What is AMMOS? What is MGSS?

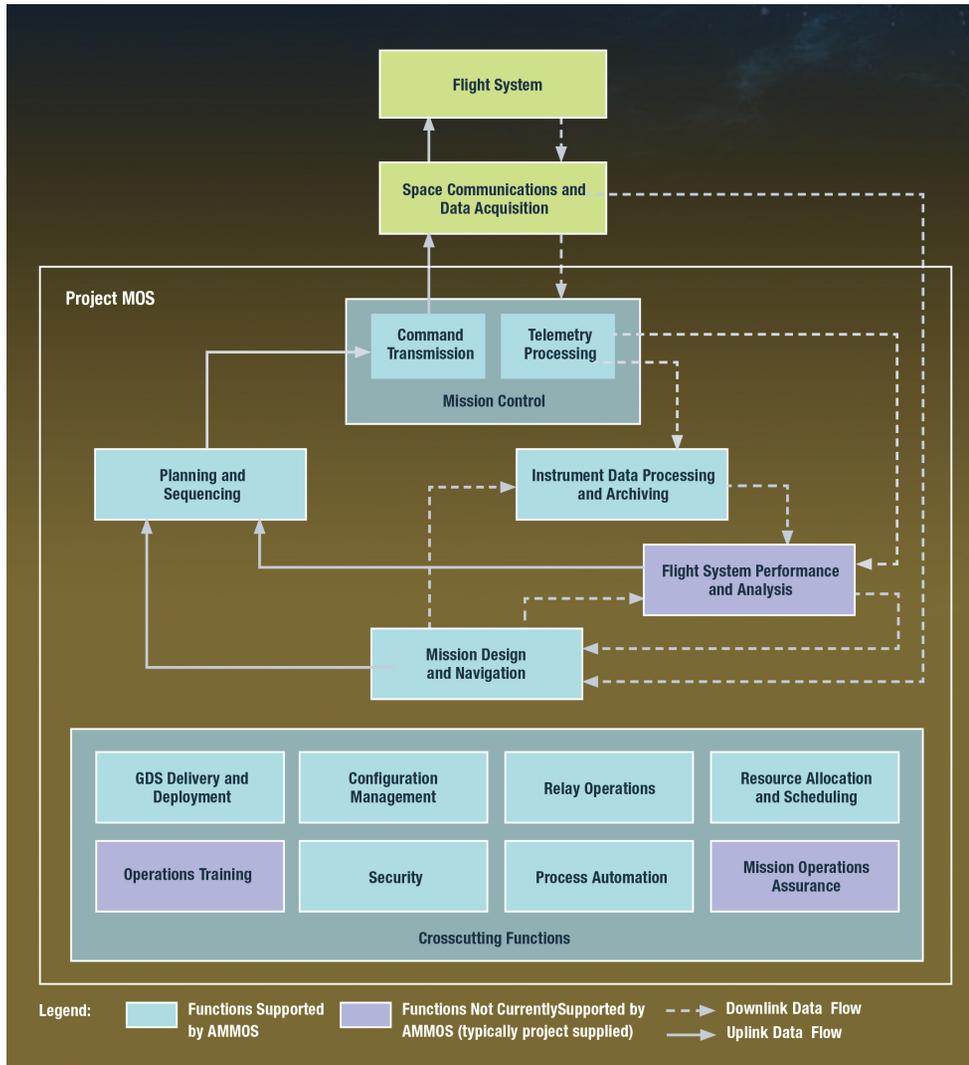


AMMOS is here

- **Product: Advanced Multi-Mission Operations System (AMMOS)**
 - This is the part of the Mission System that is the core multi-mission set of hardware and software (aka multi-mission Ground Data System (GDS))
- **Organization: Multi-mission Ground Systems and Services Program Office (MGSS)**
 - This is the organization that manages the multi-mission Ground Data System (GDS)

Mission Operations System (MOS) Functional Elements

Advanced Multi-Mission Operations System (AMMOS)



- A Project must acquire/develop, integrate, and operate each of these functional elements of its MOS
- Each element can contain hardware, a number of software elements, people, procedures, and facilities (i.e. products and services)
- For those elements of mission operations systems that are common to multiple projects, build them once rather than duplicating that development and maintenance effort for each project
 - AMMOS has over 50 products and services



AMMOS Users: Example Utilization Levels

Project	Size of GDS (Equivalent LOC)	% from AMMOS*
Mars Exploration Rover	11.3M	68%
Mars Reconnaissance Orbiter	9.7M	97%
Spitzer Space Telescope	12.0M	71%
Dawn	9.2M	95%

*This represents the software that the project did **not** have to develop



Benefits of Using AMMOS

Standardized tools that support multiple missions

- Enables lower cost missions - Project does not have to pay for the development of the capability
- Lowers Project risk by providing a mature base for the Project Ground System
- Reduces Project Ground System development time - adaptation takes less time than development (weeks or months, rather than years)
- Provides greater reliability – Most AMMOS elements have been maintained and improved over a number of years and have been used by a variety of NASA projects in a variety of situations. Many bugs have been discovered and resolved



AMMOS for Cubesats

- AMMOS is a NASA resource that can reduce the cost and risk of building or acquiring a project's mission operations system for missions of various size and complexity *from flagships to cubesats*.
- AMMOS products/services available for cubesat missions:
 - Navigation service – Design of efficient routes for a spacecraft to a desired Solar System destination
 - DSN Scheduling service - Coordinates mission subsystem level requirements into one integrated mission tracking strategy
 - Cmd/Tlm software – Used for spacecraft telemetry processing. It also includes a spacecraft commanding capability.
 - Sequencing software - Allows a small mission to create syntactically correct commands and sequences.
 - Instrument Ops toolkit – Contains tools for instrument telemetry processing (including early-phase development & test), instrument operations, science data system interfaces, mission operations process workflow, data distribution and science product archiving.



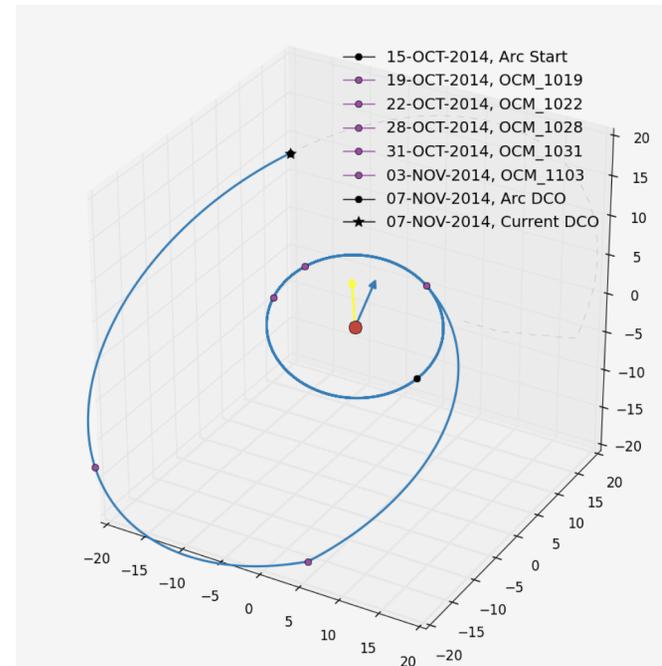
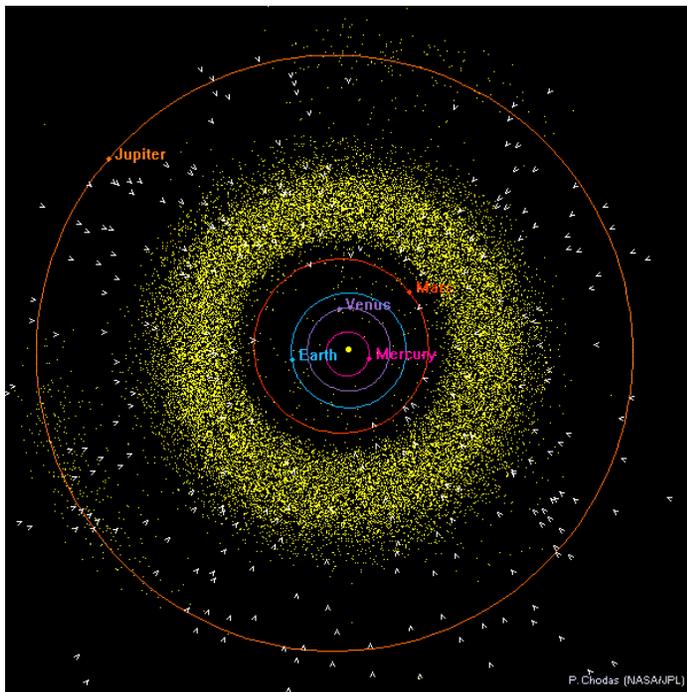
Jet Propulsion Laboratory
California Institute of Technology

AMMOS for Cubesats

Mission Design and Navigation

Mission Navigation

1. You need a map of potential destinations...

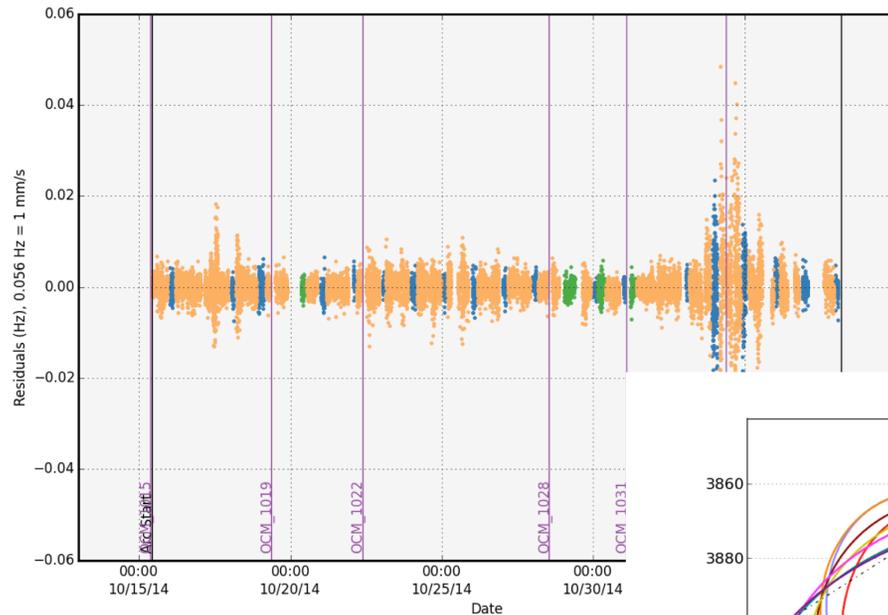


2. With map in hand, you need to have a plan for getting to where you want to go.

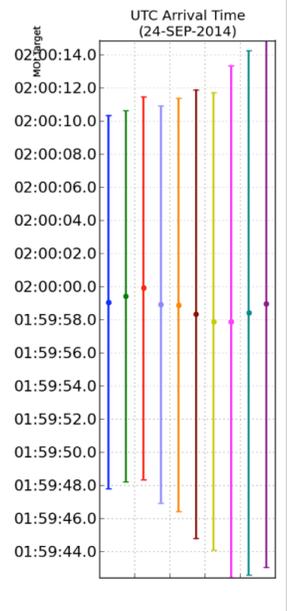
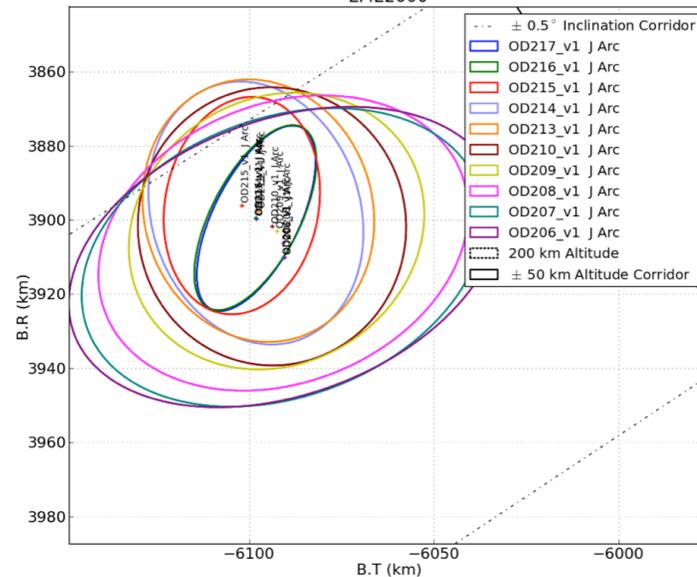
Mission Navigation

- Once underway, you need to keep track of where you are (comparing measured progress against your plan). This is done by examining observed minus computed residuals and B-plane

Doppler Residuals

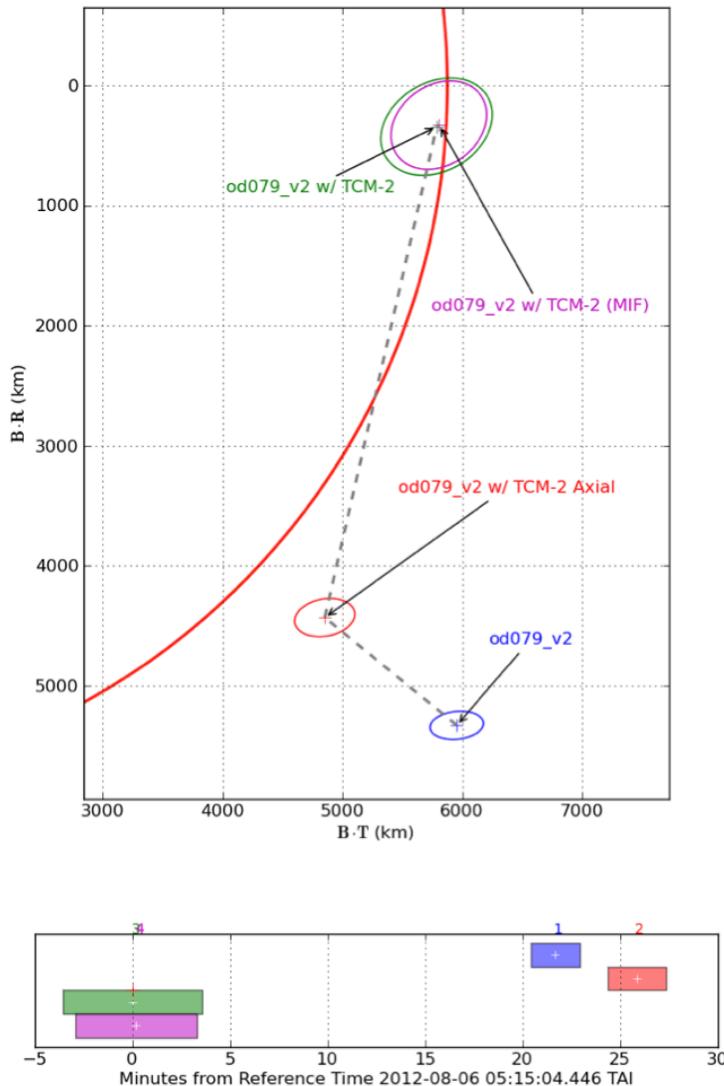


MOM B-Plane Plot, 3-Sigma Ellipses
EME2000

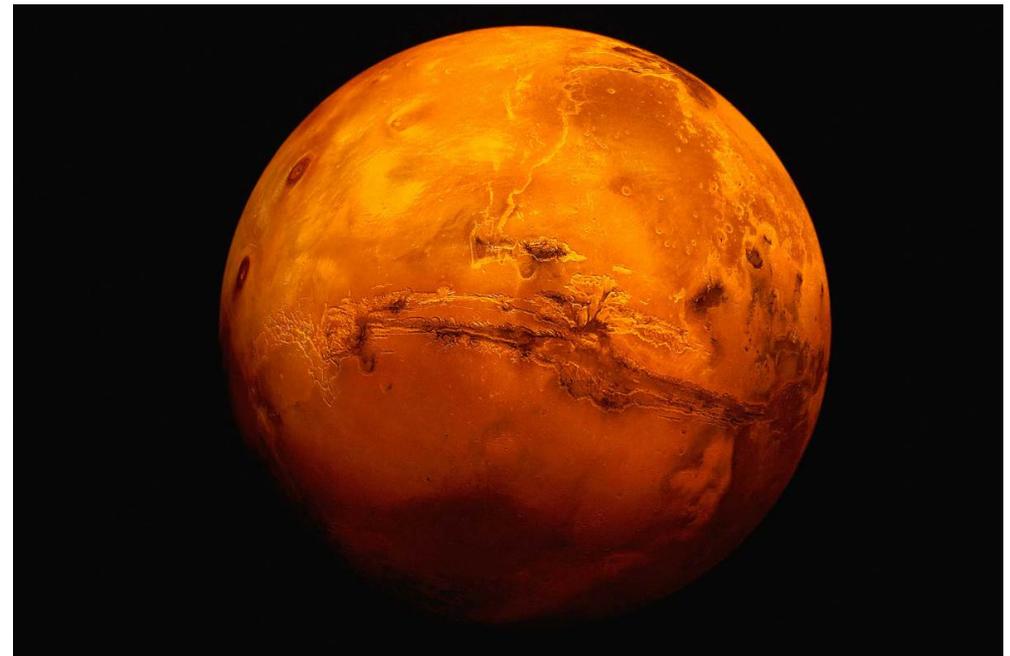


Mission Navigation

4. If you are not where you want to be, you need to design a maneuver to change the trajectory.



5. Iterate until you get there...



AMMOS Mission Design and Navigation software tools do all this and more...

NOTE: Images from multiple missions.



Jet Propulsion Laboratory
California Institute of Technology

AMMOS for Cubesats

Deep Space Network (DSN) Scheduling
via Multi-mission Resource Scheduling
Services (MRSS) Team



MRSS



- Coordinate mission subsystem level requirements into one integrated mission tracking strategy, including collaboration with project elements to provide solutions to technical and engineering problems related to DSN scheduling
- Represent the project in the DSN negotiation process: Maintain tracking requirements, provide solutions for conflict resolution, and keep project aware of any potential or real constraints for DSN tracking resources
- Distribute tracking information to project in support of operational planning
- Continuous monitoring of DSN resources scheduled. 24/7 support if needed



Jet Propulsion Laboratory
California Institute of Technology

AMMOS for Cubesats

**AMMOS Mission Data Processing and Control
System (AMPCS)**

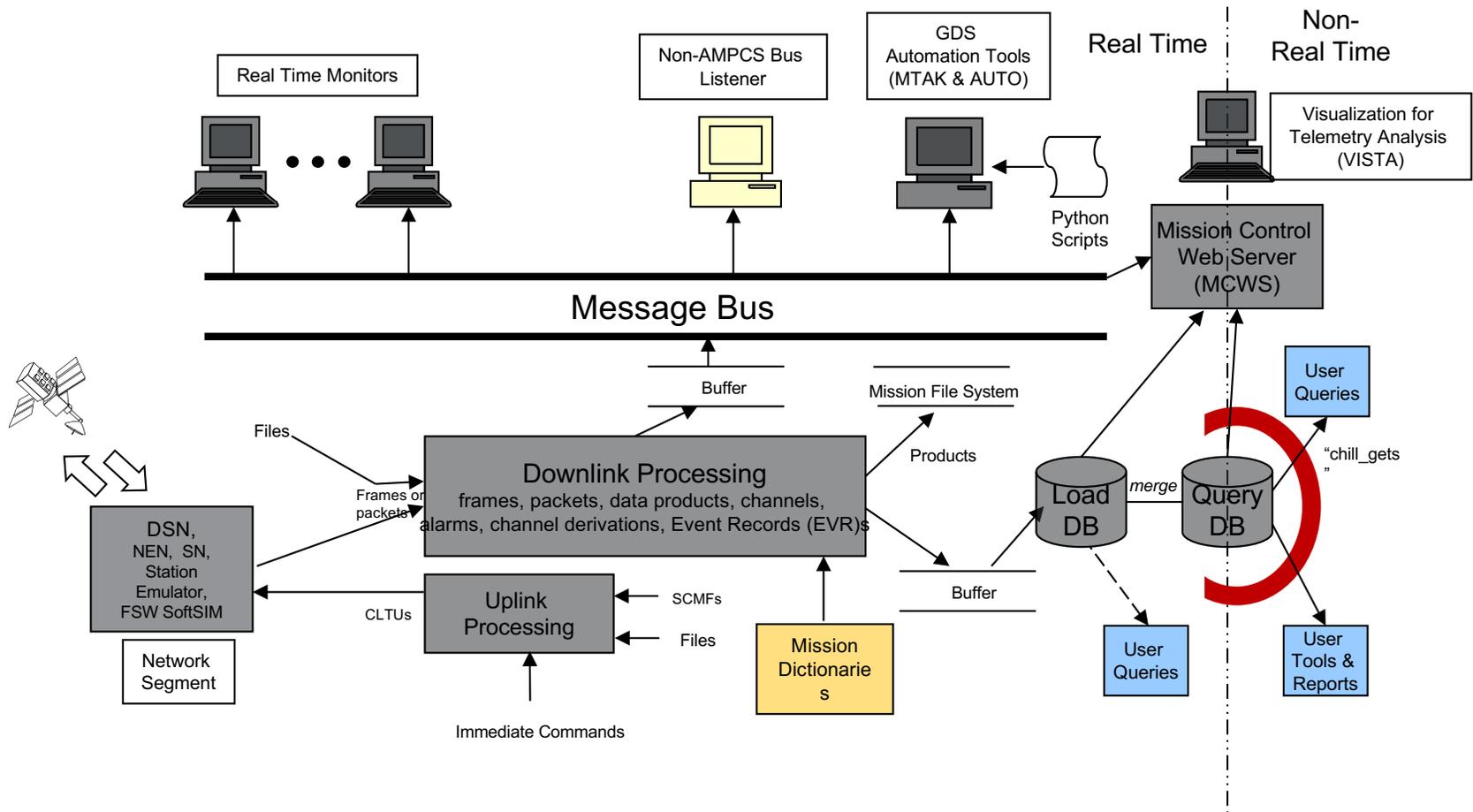


What is AMPCS?



- **Flexible, full function, real-time Mission Control application**
 - Flexible deployment model: from a single linux laptop, to multi-node hardware
 - Supports both telemetry processing and commanding; provides realtime displays; performs ground-derived channel derivation; supports custom (Java) mission-provided derivation algorithms
 - All input, processed data, logs, messages, etc is stored, and can be queried
 - During FSW Development, Testbed and ATLO operations: test tool for flight software development, spacecraft integration and test
 - During Operations: operational system for spacecraft telemetry processing and monitoring
- **Accepts CCSDS formatted in-sync frames and/or packets**
 - Sources: DSN, NEN/SN, a station emulator, simple ground support equipment, files
 - Processes frames and/or packets into telemetry products (channelized data, EVRs, Products, etc.) for delivery to real time and non-real-time users
- **Testbed and ATLO Telemetry Environments**
 - “Test session” concept organizes access to each test’ s pertinent data
 - Captures all incoming and processed data, logs, FSW version used, and dictionary version used, etc.
 - Allows cross-test session analysis
 - Specialized test environment features to assist spacecraft integration and test (e.g. command fault injection, test session management, frame/packet watch displays, frame quality displays)
 - (A)MPCS Test Automation Toolkit (MTAK) for spacecraft test scripting (session dependent)
 - AMPCS is in JAVA. We supply a Python API “mpcstools” to interface with it.
- **Extensive command line queries and tools, python scripting environment**
 - AMPCS Utility Toolkit for Operations (AUTO) for lights-out operations automation (session independent)

AMPCS System Architecture





Jet Propulsion Laboratory
California Institute of Technology

AMMOS for Cubesats

Mission Planning and Sequencing (MPS)



AMMOS Basic Sequencing Solution

A Software Suite for Commanding Small Spacecraft

Command and sequence editor:

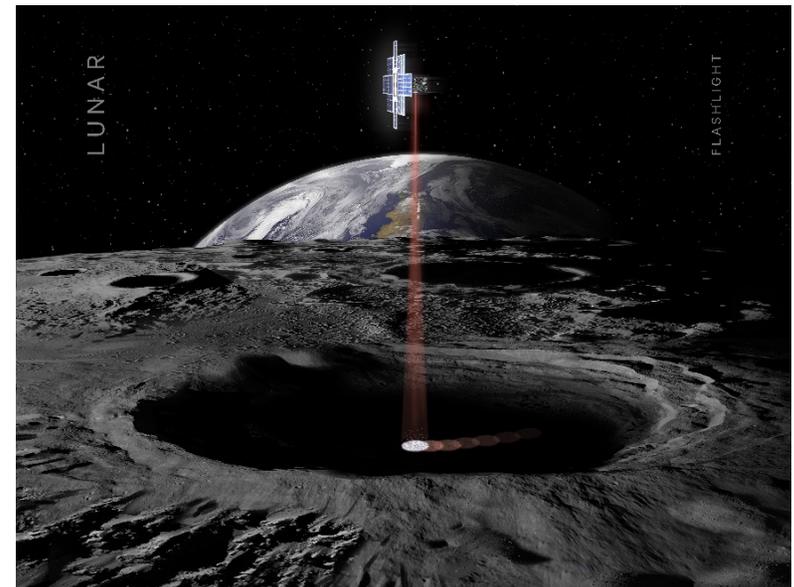
- Context-sensitive editing support
- Verification of command and sequence syntax
- Verification of command parameter values

Command translation application (if needed):

- Translation of commands and sequences to binary format ready for the Cmd/Tlm tool and DSN

Users' Guide written specifically for cubesats/smallsats:

- Installation and configuration instructions
- Tutorials





Jet Propulsion Laboratory
California Institute of Technology

AMMOS for Cubesats

**Instrument Data Systems/Instrument
Operations**



Instrument Data Systems (IDS) Element for CubeSats

IDS provides tools and services in the area of Instrument Data Processing including:

- Observation planning (including tactical)
- Instrument health and performance analysis
- Data archive activities

Science Data System functionality in the the following areas:

- Experiment product tools and services:
 - Instrument telemetry processing (Bespoke Link to Instrument for Surface and Space <BLISS>)
 - Experiment (EDR) product generation (telemproc)
 - Data access and distribution (Webification <w10n>, FEI)
 - Product archive pipeline (into the PDS <APPS>)
 - Product visualization (including localization)
 - Instrument product data management (catalog interface for instrument metadata)
- Tactical capability:
 - Low-latency (time critical) products of higher order instrument products (RDR)
- Process automation for lights-out and autonomous instrument operations:
 - Workflow design, development and deployment (CWS)
- SDS Infrastructure:
 - Support requirements for data engineering, software tools development system hardware, staffing, and product-based processing and distribution of science instrument data.



Jet Propulsion Laboratory
California Institute of Technology

From systems engineering perspective...

MGSS small-satellite software

MPS Editor

- Context Sensitive Editor for Command Sequence Generation
- Automatic command database import
- Simple sequence generation with parameter validation
- Easily adaptation for mission

AMPCS

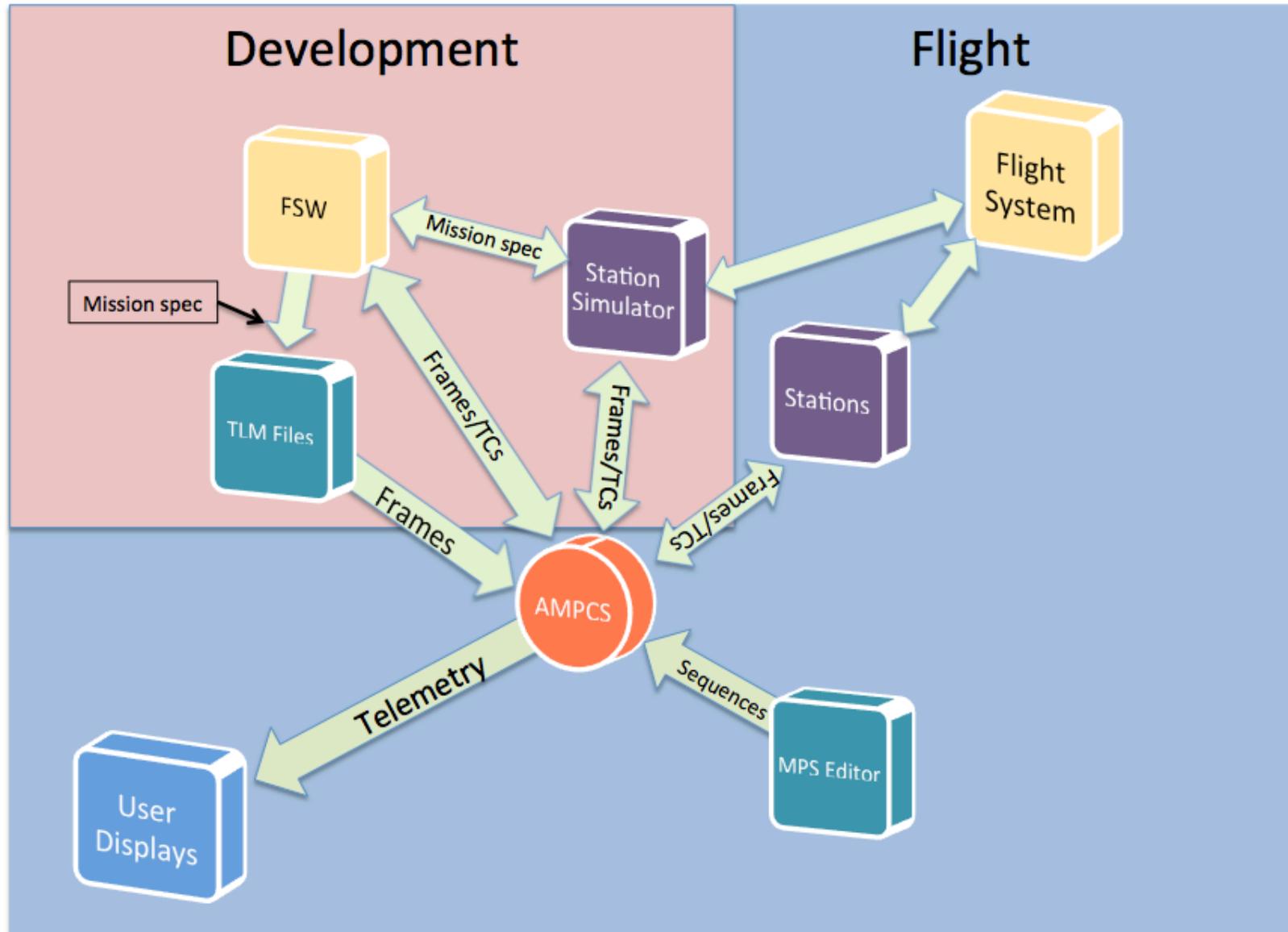
- Flexible multi-mission mission control application
- Deployable single machine installation for simple setup and use
- Supports CCSDS synced frames and/or packets
- Extensive query tools enable complex mission-specific capabilities

System Capabilities

- MGSS maintained (focus development on your satellite, not your GDS)
- DSN compatible (spend less time making and testing your interfaces)
- Enables flagship command generation tools and telemetry displays with minimal time investment
- Enables early flight software development to work with flight ground tools



A Typical Set-Up





How to infuse AMMOS into your missions

- Browse through AMMOS Website at <http://ammos.jpl.nasa.gov>
- Go to the AMMOS Catalog link
- Select AMMOS products/services that can be used in your mission.
- Contact MGSS Mission Interface Office at ammos_info@jpl.nasa.gov or call 818-393-0686 to:
 - Obtain more information on selected AMMOS products
 - Request a demo if needed
 - Request a cost estimate
 - Request a Service Level Agreement
 - Coordinate a combined MGSS/DSN Letter of Commitment



Jet Propulsion Laboratory
California Institute of Technology

jpl.nasa.gov