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**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.

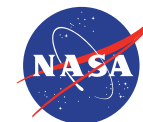
## Who uses AMMOS



**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 Tools and Services Used by 35+ NASA Missions

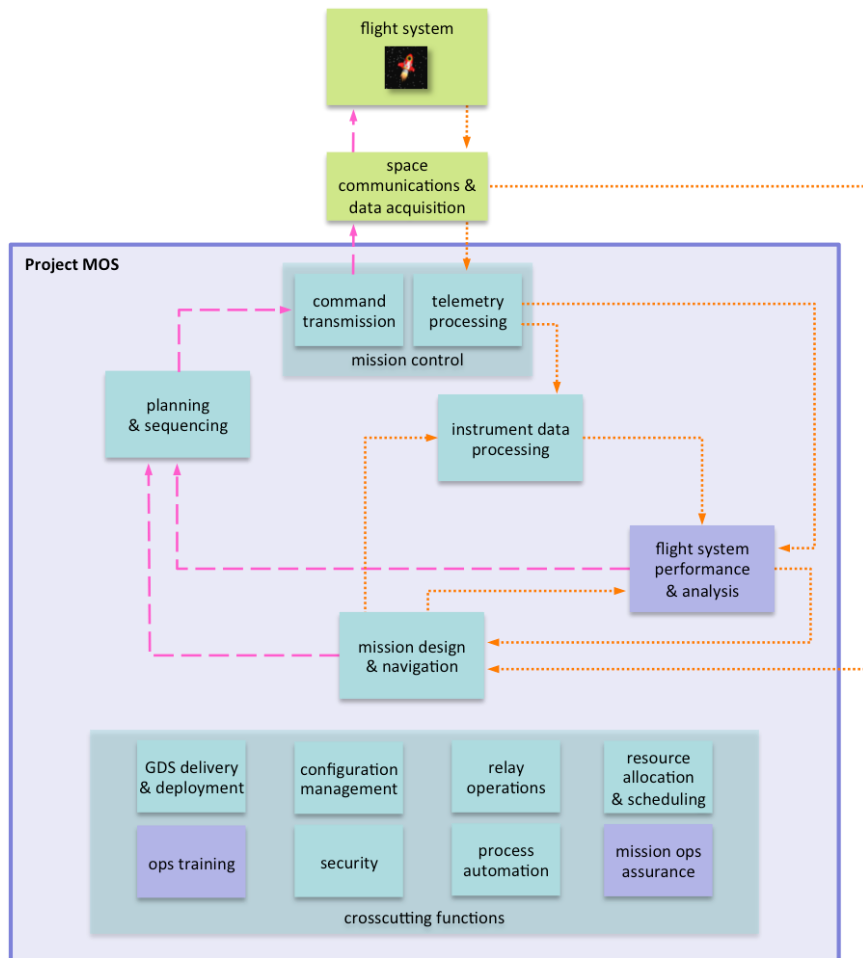
Brian Giovannoni, California Institute of Technology/ JPL / NASA  
 Multi-Mission Ground System and Services Program Chief Engineer  
 Approved: William Knopf, AMMOS Program Executive, NASA HQ



**Jet Propulsion Laboratory**  
 California Institute of Technology

# 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 (“Project MOS”)
- Each element can contain hardware, a number of software elements, people, procedures, and facilities
- 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

### LEGEND

- functions supported by AMMOS
- functions not currently supported by AMMOS (typically Project supplied)
- downlink data flow
- uplink data flow

# What is AMMOS?



## Advanced Multi-Mission Operations System

- The Advanced Multi-Mission Operations System (AMMOS) is NASA Planetary Science Division's recommended provider of multimission products and services for NASA space science missions, particularly missions exploring our solar system and beyond
  - This recommendation is based on the high quality, low risk, and cost effectiveness of AMMOS products and services
  - The AMMOS is an agency-wide products and services offering comprising implementers and customers from multiple NASA centers, FFRDCs, UARCs, academia, and industry
- The AMMOS is based on a simple idea: For those elements of a mission operations system that are common to multiple projects, build them once rather than duplicate that development and maintenance effort for each project
- The Multimission Ground System and Service (MGSS) Program Office at NASA's Jet Propulsion Laboratory (JPL) manages the AMMOS

# Quick Definition

AMMOS Capabilities = AMMOS Products & Services

- Products
  - Cost free, multimission capabilities that include AMMOS core software, data, and models that are licensed for use by mission customers.\* Adaptation of these products to meet mission specific requirements is not considered multimission core and thus paid for and maintained by the project.
- Services
  - Services are mission operations functionality performed by human capital (expertise) according to agreements negotiated between the project customer and MGSS. MGSS works with an implementing organization to staff and cost the expertise. This is in contrast to obtaining and using products directly.

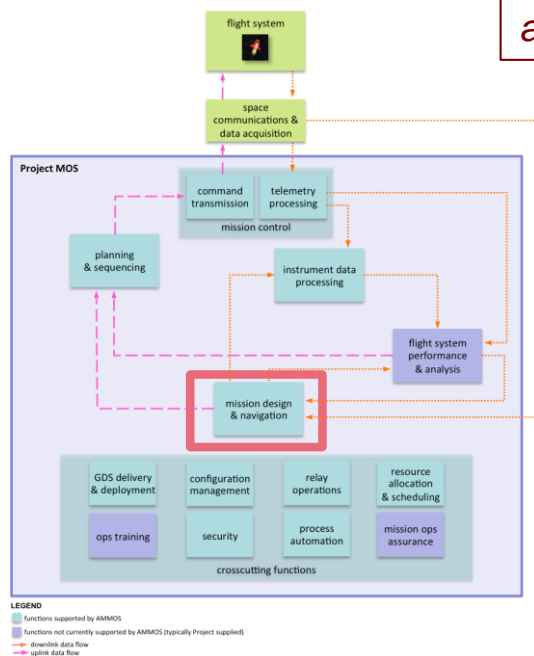
**\*Disclaimer:** A project/mission customer can request copies of AMMOS software products and depending on the requesting entity such as a U.S. Government Agency (including NASA) and 3<sup>rd</sup> Party for Research Use, a royalty free license granted for use. In some cases, a partner U.S. Government Contractor may also be granted a royalty free license for use. The Software Release Authority (SRA) at JPL's Office of Technology Transfer is the software licensee for all JPL-developed software described herein in accordance with Caltech copyright policy for such software (see <http://ott.jpl.nasa.gov/index.php?page=software>).



# Mission Design & Navigation (MDN)

## High-Level Overview

*Planning/optimizing the flight system trajectory for future mission activities and maintaining knowledge of its position/velocity during flight*



- **Mission Design Products and Services**

- Design, analysis and optimization of spacecraft trajectory based on mission goals, requirements, and constraints

- **Navigation Products and Services**

- Orbit determination
- Trajectory propagation
- Maneuver analysis and design
- Optical Navigation Tools and Services
  - Analysis of optical navigation requirements and design
  - Planning and acquisition of spacecraft imaging
  - Conversion of images into navigation observables

- **Navigation Ancillary Data (NAIF/SPICE)**

- Tools to perform trajectory and geometry-based calculations in other AMMOS subsystems, including science planning and data processing
- Interfaces between Navigation, the DSN, and other mission subsystems

- **Solar System Ephemerides and Gravity Services**

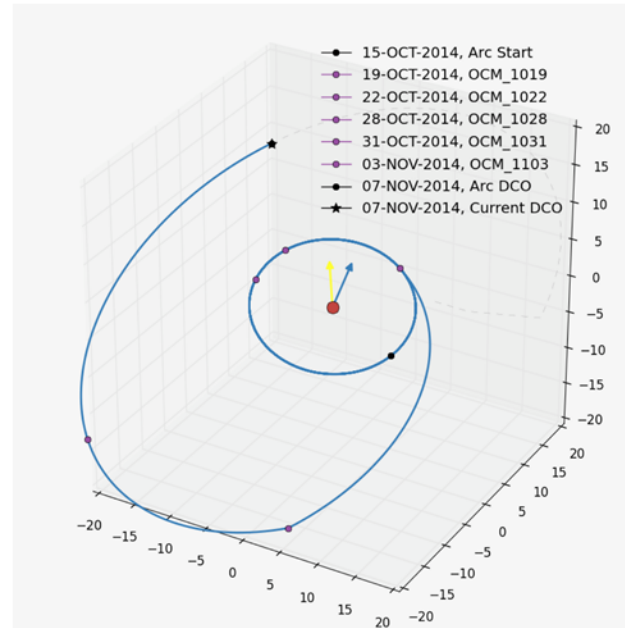
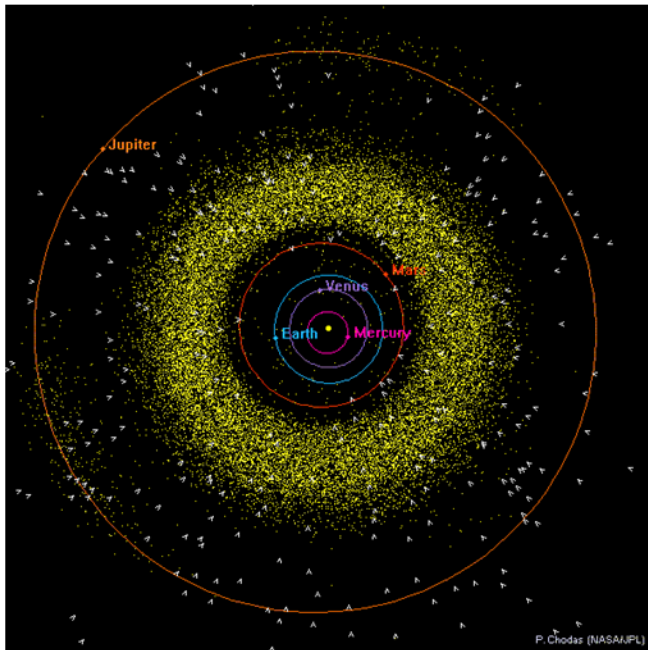
- Up-to-date Ephemerides for Solar System bodies and generation of Gravity Products



# Mission Design & Navigation (MDN)

## High-Level Example of Mission Navigation Service (1)

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

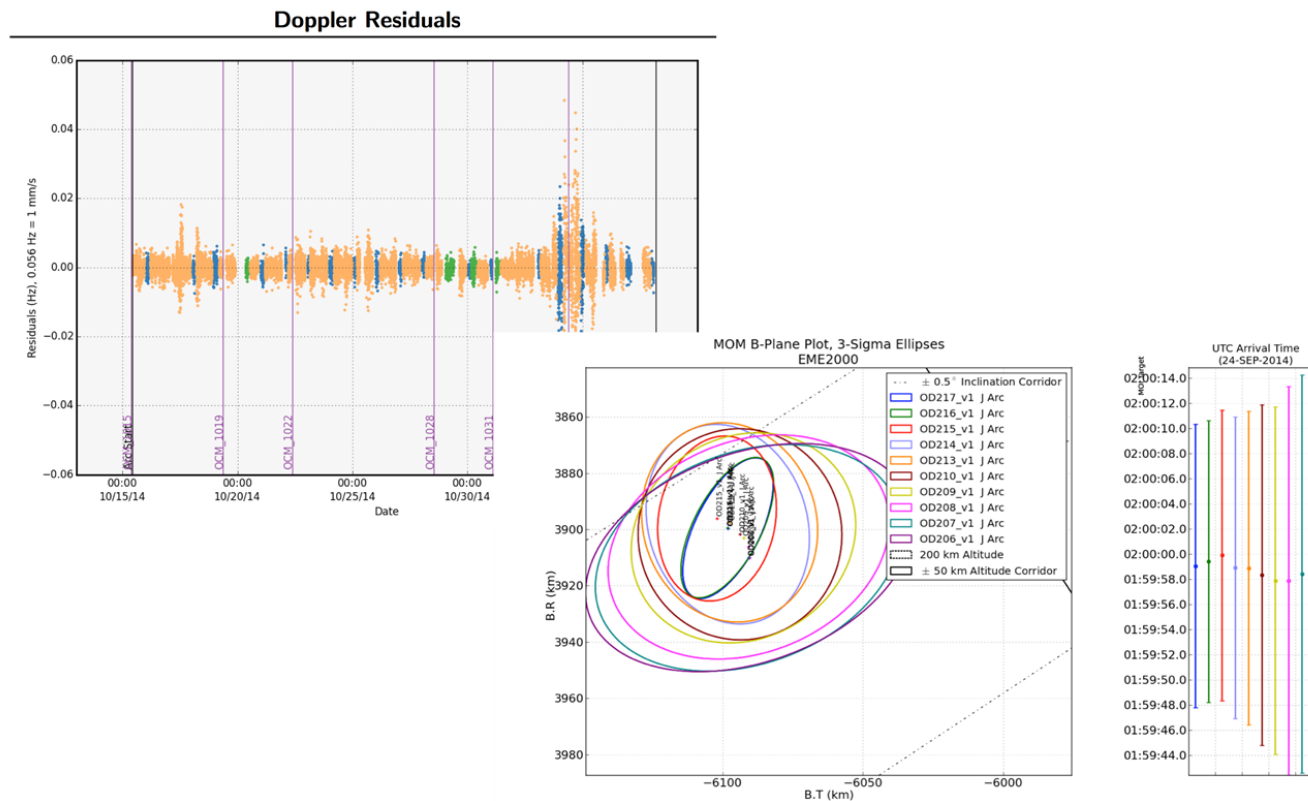


2. With map in hand, you need to have a plan for getting to where you want to go.

# Mission Design & Navigation (MDN)

## High-Level Example of Mission Navigation Service (2)

- 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 mappings.

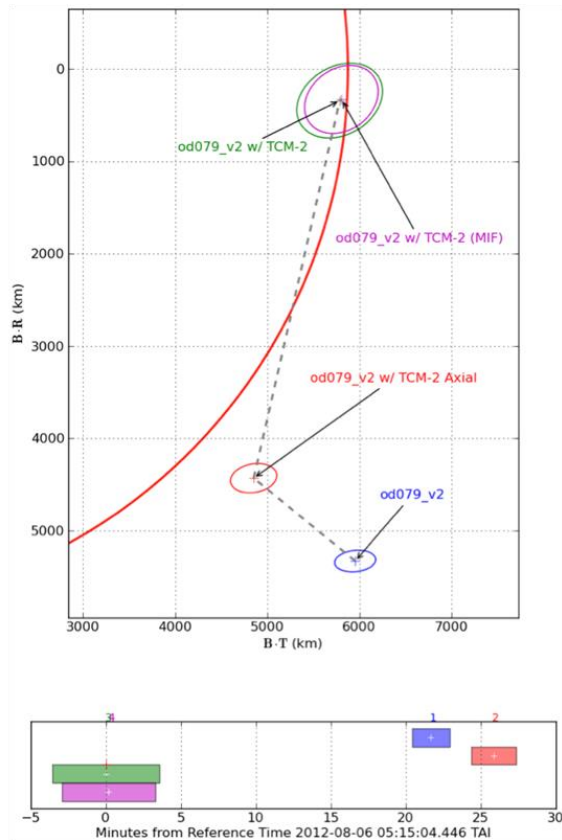




# Mission Design & Navigation (MDN)

## High-Level Example of Mission Navigation Service (3)

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...



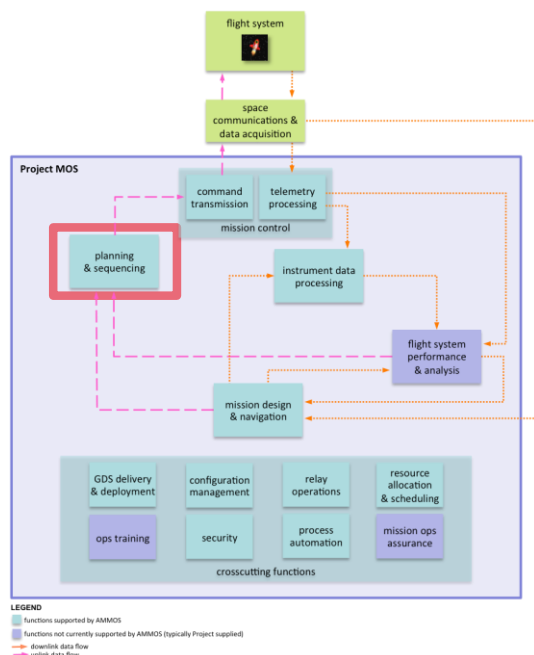
AMMOS Mission Design and Navigation software tools do all this and more...

NOTE: Images from multiple missions.

# Planning & Sequencing (P&S)

## High-Level Overview

*Generation of activity plans, science observation plans, and sequence and command generation. Spacecraft operability constraints, mission rules, and flight rules are enforced, and spacecraft activities, science activities, and instrument activities are merged during the planning and sequencing process to produce integrated, conflict-free command products to control the spacecraft.*



### • Science Observation and Mission Planning

- Plan science observation opportunities
- Generate mission plan with science and engineering activities (e.g. Deep Space Network (DSN) and relay network communication windows)
- Validate mission plan based on resource usage and spacecraft (S/C) constraints

### • Mission Sequencing

- Design and generate sequences of S/C activities, real time commands, and DSN keywords
- Model changes in spacecraft states due to sequence commands in order to generate event predictions
- Validate command sequences based on spacecraft flight rules and constraints

### • Command Translation and Sequence Execution

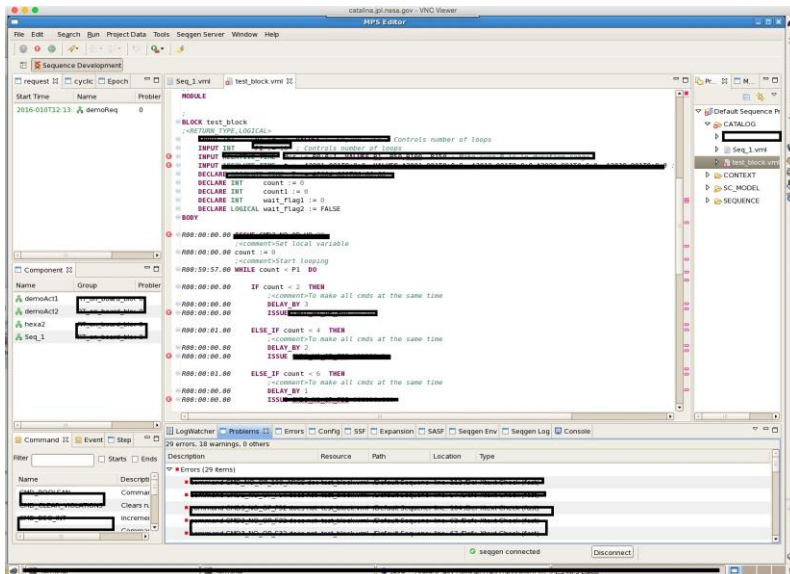
- Translate sequence commands from command mnemonics to binary to be radiated to spacecraft
- Support flight project testing with ground simulation software

### • Telecom Analysis

- Currently used by the DSN and most current Deep Space Projects for Telecom analysis
- Telecom. forecaster predictor (TFP)

# Planning & Sequencing (P&S)

## High-Level Example of a few P&S Software Products (1)



### Mission Planning & Sequencing Editor

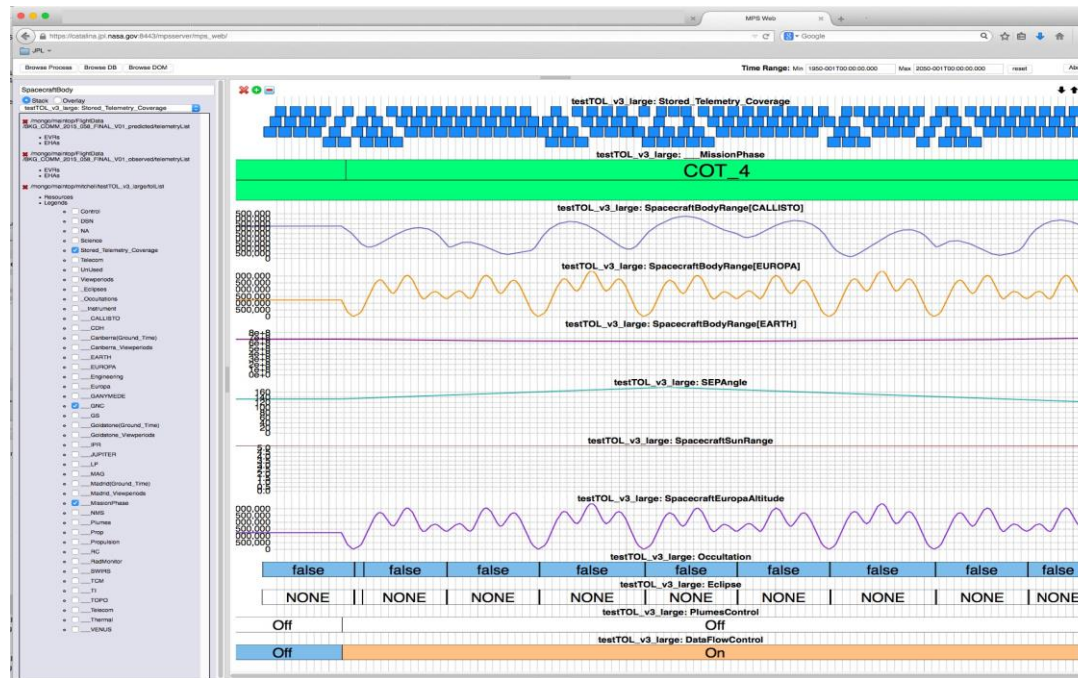
MPS Editor is a context sensitive editor for building and checking spacecraft activities and commands. The MPS Editor's graphical user interface (GUI) is comprised of multiple perspectives, each of which is tailored to assist the user to:

1. Building and editing mission-specific activity dictionaries
2. Creating command sequences and command files
3. Modeling/simulating activities and sequences
4. Conflict reporting and resolution
5. Creating project specific SEQUENCE GENERATOR (SEQGEN) adaptation

MPS Editor is an Eclipse Rich Client application. MPS Editor runs on the following operating systems: Windows, Mac OSX, Linux, and Solaris

# Planning & Sequencing (P&S)

## High-Level Example of a few P&S Software Products (2)

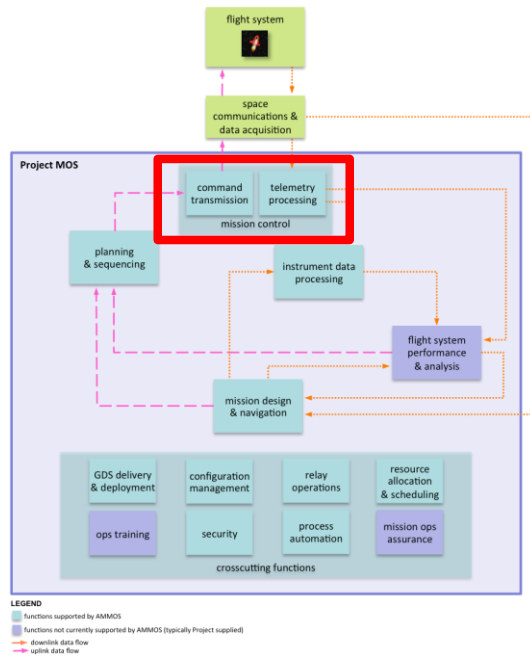


## RAVEN

The RAVEN allows users to view spacecraft activity timelines, resource usage and predicted data displays via a web browser. Data can be imported from various project repositories and viewed simultaneously by distributed teams in order to collaborate while creating, updating and validating activity plans and command sequences

# Mission Control (MC)

## High-Level Overview



*Real-time monitoring and control of a spacecraft (both pre-launch and post-launch) including downlink telemetry processing and display as well as preparation and initiation of the transmission of spacecraft commands through the ground-space telecommunications network (e.g., DSN and NEN)*

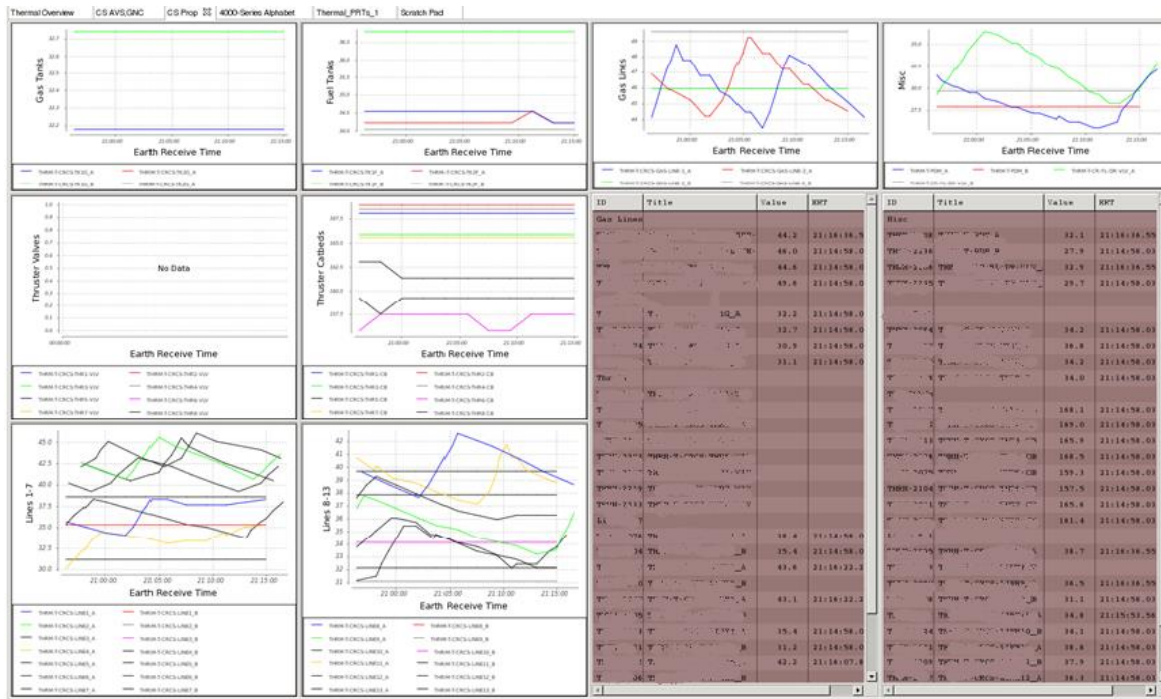
## AMPCS (Advance Mission Data Processing and Control System)

- Telemetry processing and display for development, test and operations
  - Includes: channelization, DN to EU conversion, alarm notification, product building etc.
- Accepts CCDS formatted frames and packets
- Test and analytic support capabilities including:
  - Capture of all processed data in databases for quick access and post session analysis
  - Configurable display tools for session management and data display
  - Test automation toolkit



# Mission Control (MC)

## High-Level Example of Display and Telemetry Analysis Tools (1)



- AMPCS is a scalable, full function, real-time telemetry processing and display system
  - During Phase E Operations: Provides real Time S/C telemetry display, telemetry product distribution with user query support (primarily for downlink operations)
  - During FSW Development, TestBed (TB) and ATLO operations: Provides the test tool for spacecraft integration and test (for both uplink and downlink operations)
- Supports test-bed and ATLO telemetry processing and commanding
- Provides real-time telemetry display – Customizable to allow mission to see TLM overlaid on system
- Stores all telemetry artifacts allowing post pass (and test session) analysis



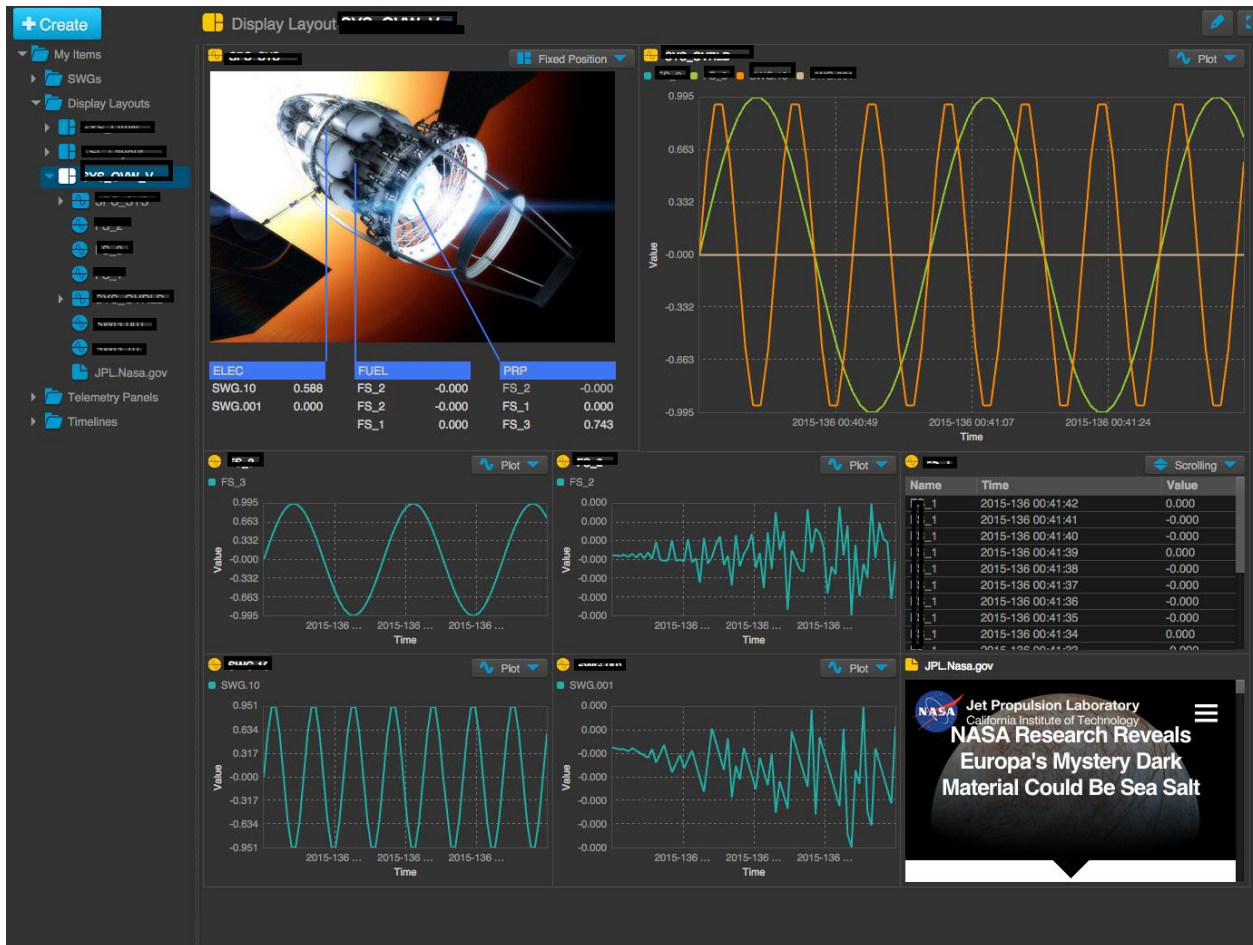
# Mission Control (MC)

## High-Level Example of Display and Telemetry Analysis Tools (2)

VISTA

Provides a framework for spacecraft teams to build analysis displays from life of mission store

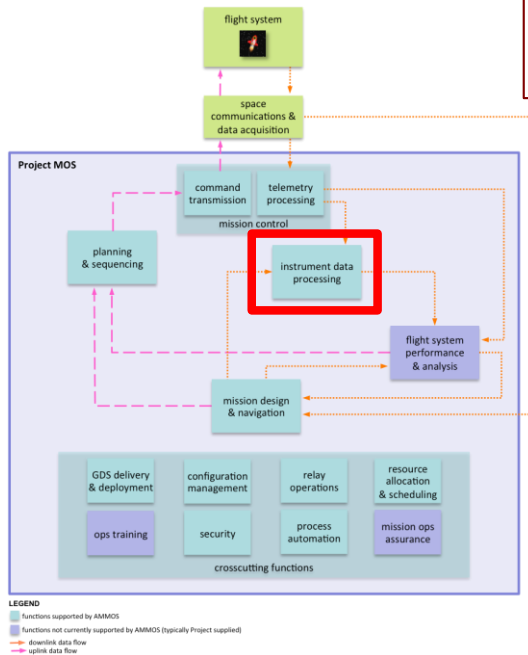
Allows distributed teams to securely view telemetry



# Instrument Data Systems (IDS)

## High-Level Overview

*Science instrument data product generation, includes processing: display and delivery of science and related engineering data for use by instrument engineers, activity and science planners, in-situ drivers and operators; and public information releases*



### • Experiment Product Tools & Services – EPTS

- Provides timely, reliable, accountable, secure EDR generation and delivery
- Ingest instrument telemetry
- Package, validate, catalog, track, deliver and provide accessibility to Level-0 products (Experiment Data Records - EDRs)
- Assess instrument performance (health & status)

### • Tactical Product Tools & Services – TPTS

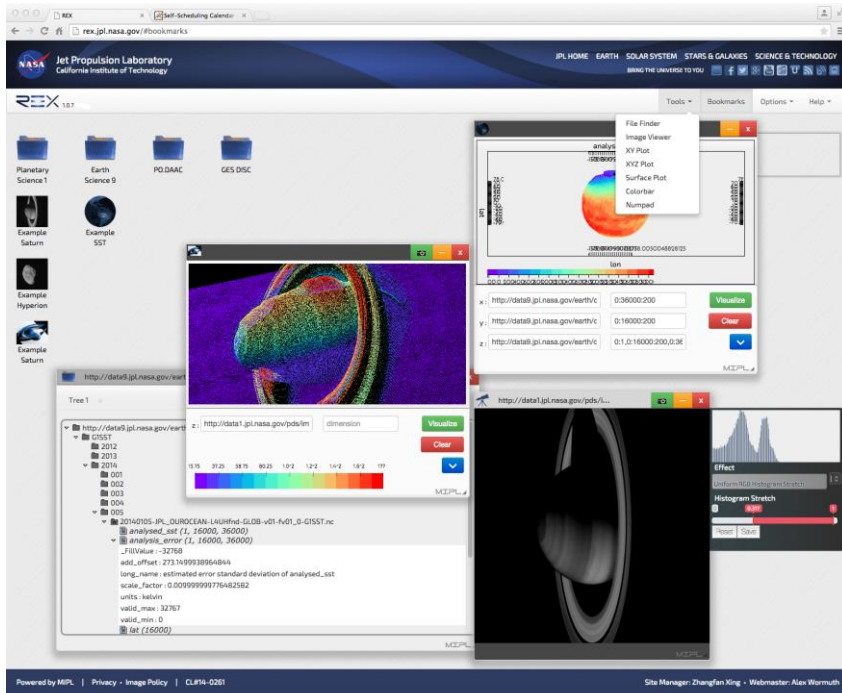
- Provides time-critical high-order precision product generation for operations decision-making
- Generate specialized, high-order engineering products (Level-1 or above; Reduced Data Records - RDRs) -- algorithms and image processing
- Deliver to mission teams in support of time-critical engineering decisions and asset commanding events (place instrument on a rock, drive into crater, verify optical navigation, etc.)

### • Strategic 3D Mission/Instrument Observational Planning Support

- Provides modeling/animations supporting end-to-end instrument observation & process planning and analysis

# Instrument Data Systems (IDS)

## High-Level Example – Web-based access to Instruments Data Products



### Webification (Numeronym: W10n):

W10n is an enabling technology, which provides ubiquitous access to data and resources using well-defined and meaningful URLs. It provides remote access to data and applications via HTTP/HTTPS in a ReSTful way.

# Instrument Data Systems (IDS)

## High-Level Example – Science Product Long-Term Archival

AMMOS-PDS Pipeline Service

PDS – Planetary Data System

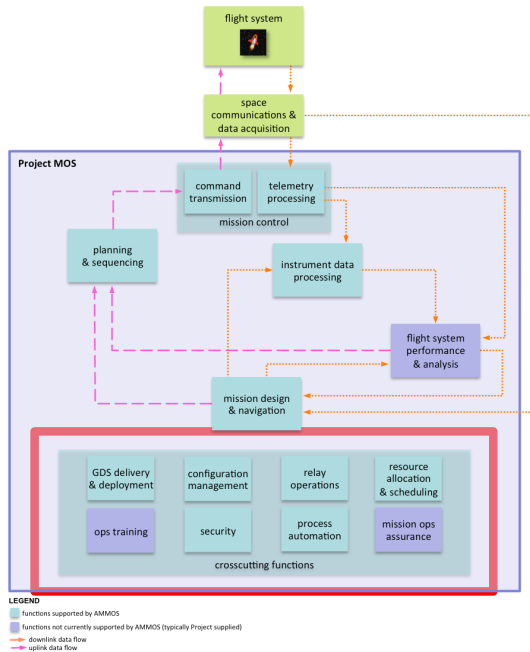
The Planetary Data System (PDS) is an archive of data products from NASA planetary missions, which is sponsored by NASA's Science Mission Directorate. We actively manage the archive to maximize its usefulness, and it has become a basic resource for scientists around the world

### APPS:

The AMMOS-PDS Pipeline Service (APPS) is an end-to-end pipeline for PDS archiving, which streamlines the delivery of science data to the PDS. It provides a multi-mission science data (instrument data + metadata/label) transformation service, which connects product generation pipelines and the PDS Archive, while ensuring compliance to the PDS4 standard. Its goal is to improve the efficiency (e.g. reduce cost to projects) and reliability of providing mission data to the PDS.

# AMMOS-Supported Crosscutting Capabilities

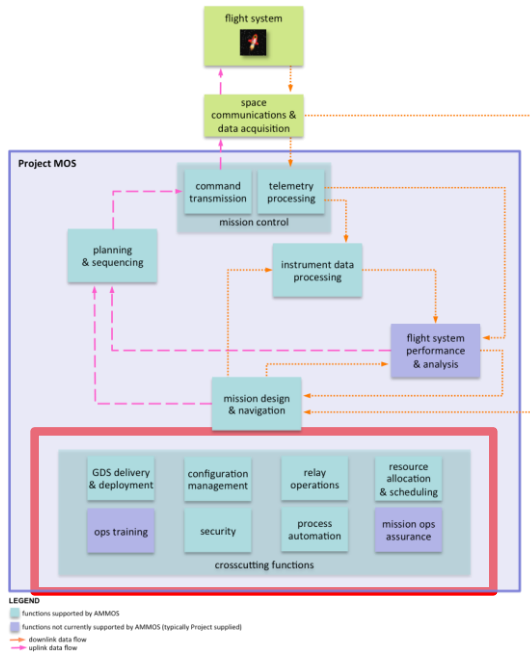
## High-Level Overview (1/2)



- **GDS Delivery and Deployment** – Provision of a standard, cost effective, GDS configuration based on a multimission solution that facilitates deployment and operations procedures with minimal tailoring to project specific needs.
- **Configuration Management** – A process-oriented function that establishes and maintains consistency of a product’s attributes with the requirements and product configuration information throughout the product’s lifecycle. From a mission operations perspective, its scope includes configuration management of GDS software products from development through sustaining and maintenance. Its scope also includes configuration control of mission operations products and systems comprised of flight project/mission adaptations, mission development, test, and operations environments.
- **Relay Operations** – Operational infrastructure and support given to an in-situ telecommunications network established for purposes of providing space communications and data acquisition between landed assets (e.g., landers, rovers) and orbiting assets around specific target bodies of exploration. Such a network is often referred to as a ‘relay network.’
- **Resource Allocation and Scheduling** – A key function needed by all project mission operations for generating opportunities and conflict-free schedules for usage of space communications and data acquisition resources. It is important to note that flight system tracking hours are limited by practical limits of total user demand and internal engineering and maintenance.

# AMMOS-Supported Crosscutting Capabilities

## High-Level Overview (2/2)

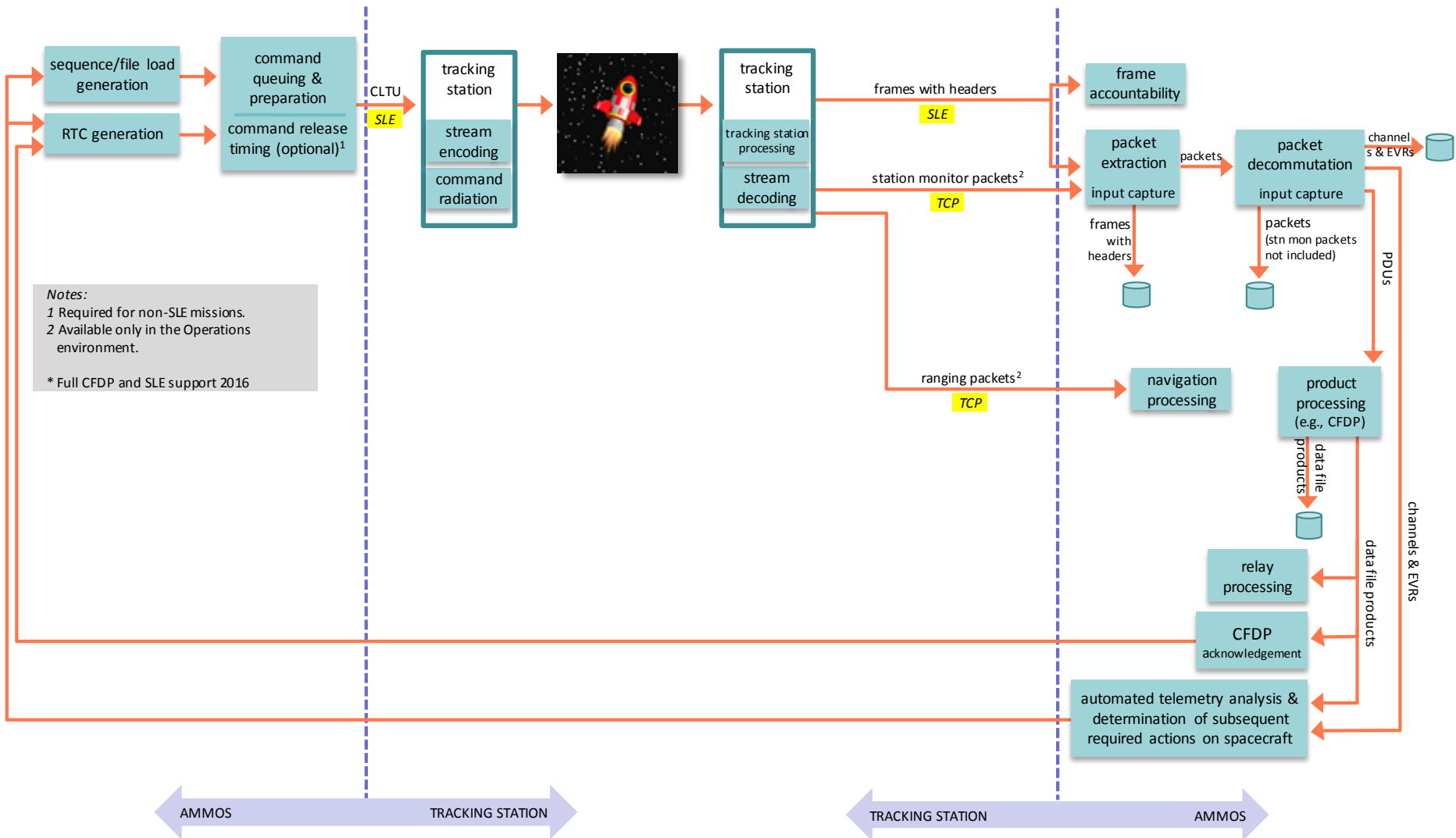


- **Security** – Ensures the confidentiality, integrity, and availability of mission operations resources. This includes restricting access to critical GDS software products as well as operations data/information products to authorized users while also protecting critical mission data/information both at rest and in transit.
- **Process Automation** – Mission operations processes are comprised of a set of operations-related activities each forming a logical step within a process to carry out a unit of work. Historically, operations-related activities have largely been performed manually by human intervention (i.e., *manual activities*); however, efficiency gains can be achieved by identifying potential *automated activities* in which machine resources could support automated execution.



# High-Level Uplink / Downlink Functions & Interfaces

How AMMOS Supports Mission Operations Environment (Partial view at 10,000 ft.)



# AMMOS Contact

- Contact MGSS Mission Interface Office at [ammos\\_info@jpl.nasa.gov](mailto: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

Questions?