National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
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GSAW 2009: Focusing on the User

Session 11A: Why does it take so long to deploy new technologies into Ground Data Systems

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Agenda

Institutional View

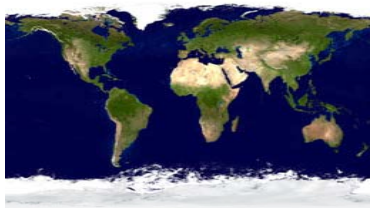
- Overview of JPL's Operational **G**round **D**ata **S**ystem
- Impediments to Deployment of New Technologies into the GDS
- Technology Strategies In Place
- Successful Technology Infusion in Software Products
- Long Term Strategy
- Summary of Lessons Learned

The GDS Must be Adaptable and Scalable to a Spectrum of Mission Classes

- Orbiter
  - Saturn - Cassini
  - Mars - Odyssey, MRO
  - Asteroids - Dawn
  - Moon - GRAIL (GRACE on the Moon)
  - Jupiter – Juno
- Surface Mission
  - Soft Lander: Mars - Phoenix
  - Soft Lander/Rover –MER and MSL
- Flyby: Comet - Deep Impact
- Sample and Earth Return: Stardust and Genesis
- Interplanetary and interstellar cruiser: Voyagers I & II
- Earth "Trailing" Observatory – Spitzer
- Earth Orbiters
  - Earth Observing – SMAP
  - Astrophysics – Wide-field Infrared Survey Explorer (WISE)

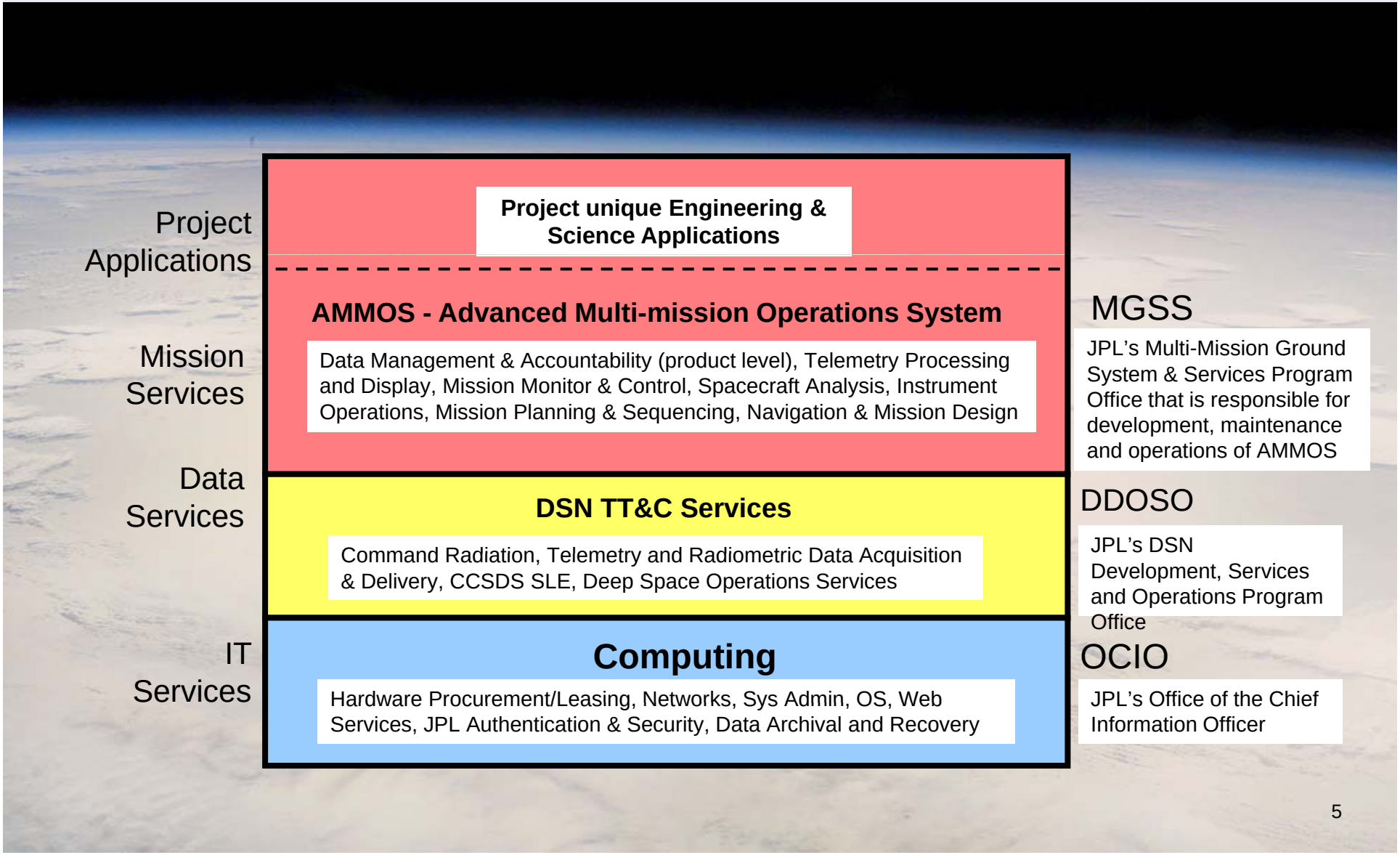
The GDS Must be Flexible to Enable Different Project Implementation Approaches

- Typical “In-House” Approach
  - Spacecraft developed at JPL with contracts for specific subsystems/hardware
  - Instruments developed at JPL and other institutions
  - Spacecraft and instruments integrated and tested at JPL
  - Mission operations center at JPL
  - Some science-related operations at other institutions



- Typical “System-contract” Approach
  - Geographically distributed ATLO & Flight Operations
  - Spacecraft developed by system contractor such as LMA, Ball, Orbital
  - Instruments developed at JPL and other institutions
  - Spacecraft and instruments integrated and tested at system contractor
  - Mission operations options
    - Mission operations center at JPL
    - Spacecraft engineering operations done by system contractor; other mission operations functions done at JPL
  - Science Center or science-related operations at other institutions

Integration and Deployment of the Project GDS Crosses Institutional Boundaries



Impediments to Deployment of New Technologies into the GDS

Legacy Related Impediments

- Incremental upgrades to existing multi-mission software rather than replacement with new software technologies
- Legacy software deficiencies
  - Tightly integrated software components
  - Third party software tightly coupled with computing platform
- Cost-capped, schedule-constrained competed missions claim leverage from multi-mission heritage
- Workforce in place with legacy software skill mix
- Industry partner investment in current AMMOS paradigm
  - Trained operations teams (processes, procedures and tools in place)

Programmatic and Organizational Structure

- AMMOS and DSN TT&C functional and organizational boundaries
- AMMOS and DSN TT&C budget cuts

Other factors:

- Conservative approach to updating or replacing Class B, Mission-Critical SW
- Lack of funding for technology demonstration missions

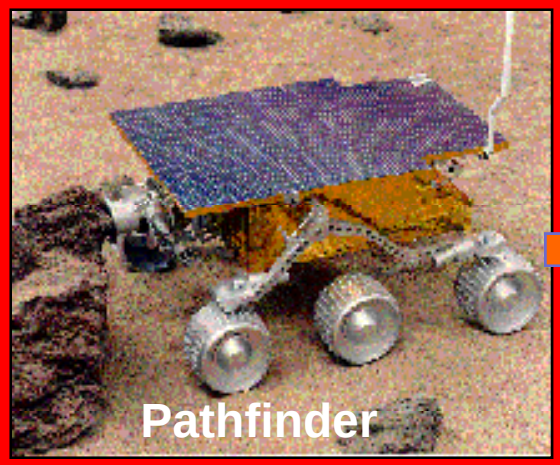
Technology Strategies In Place

- Creation of the Office of the Chief Information Officer
  - Responsible for institutional IT services, now extending into the flight project world
- AMMOS Technology Program
  - The Multi-mission Ground System & Services office issues an annual technology proposal call. The technology program is aligned with the AMMOS implementation plan. Infusion is expected within 6 years of approved technology proposal
- Project Engineering Management Council Robust Operations Initiative
  - Sponsors ground system technology tasks and promotes collaboration with both flying and developing projects
- Direct collaboration between line organization and flight projects
  - Bypasses multi-mission organization to meet mission-unique needs and increased mission complexity
- Ground Software technology collaboration with other NASA centers

Successful Technology Infusion in Ground Software Products (1of 2)

- Increased mission complexity has resulted in increased software capabilities
- Series of unique missions have provided an incremental maturity path for new ground software technology
- Direct collaboration between line organization and project

1996 to present



MAPGEN: Activity planning and resource modeling with automated scheduling component from Ames Research Center
RoSE: Rover Sequence Editor
RSVP: Rover Sequencing & Visualization Program
MER Data Product Builder
MER EVR Tool

MSLICE: MSL Operations Interface
Cutting edge visualization and planning tools for Mars surface missions.
Automated validation of plans against flight rules and science constraints.
MPCS – Mission Data Processing & Control System

Successful Technology Infusion in Ground Software Products (2 of 2)

- CCSDS Standards can be another vehicle for successful technology deployment into the ground data system
  - CFDP and the 6Mbps science data rate let to the infusion of third party data accountability software in the Mars Reconnaissance Orbiter Project

CFDP Uplink/Downlink

Deep Impact 2005

CFDP Downlink

MRO 2005 - present

CFDP Downlink

JUNO 2011

Long Term Strategy for JPL Ground Software

- **D**eep Space **I**nformation **S**ervices **A**rchitecture
  - Goal is to modernize AMMOS and the DSN through the application of industry best practices in both software and enterprise architecture
  - Provides infrastructure services framework common to AMMOS and the DSN, which has a unifying effect both programmatically and technically
  - Component level integration, which facilitates reuse and interoperability
  - Facilitates reference architecture adoption by both AMMOS and DSN
  - Governance and technology specifications
- Emphasis on inherited Architecture rather than inherited code
- Continued collaboration between line organization and projects
  - In response to mission unique requirements
  - Explore alternative software acquisition approaches
- AMMOS Technology Program
  - In addition, MGSS (AMMOS program office) has opened up proposals to its **P**rogram **O**perating **P**lan to other NASA centers

Summary of Lessons Learned

Mission Uniqueness = Technology Opportunity

- Increased mission complexity and first of a kind missions provide opportunity for technology infusion

Business Model

- Return On Investment model is needed to encourage partners and projects to engage in technology upgrades

Technology Risk Mitigation

- Technology programs sponsoring agile software development and parallel demonstration provide technology risk mitigation

Reference Architecture

- Ground software architecture to include specifications for technology infusion

Human Factor - Retooling of Workforce

  - Partnership between sustaining workforce and new hires with updated technology skills has resulted in technology cross-pollination