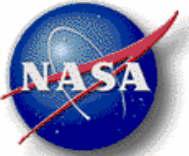


**Space Communication and Navigation (SCaN)  
Integrated Network  
Architecture Definition Document (ADD)  
Overview and Status**

**Briefing to the  
NASA Advisory Committee (NAC)  
Planetary Science Subcommittee**

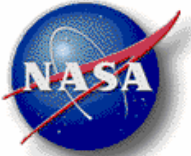
**John Rush,  
Director, Systems Planning  
NASA Space Communications Office**

**July 10, 2009**



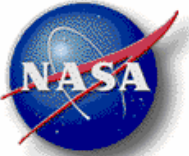
# Background

- **With the consolidation of NASA’s space communication networks in the Space Communication and Navigation (SCaN) Office, it was determined that there was a need for a “Go To” architecture to help guide our technology investments, standards development, and system acquisitions**
- **The architecture should be targeted for the 2025 time frame**
- **A multi-Center NASA team was established that that developed requirements, determined what technologies should be considered, and identified system trades**
- **The Architecture Team went on to develop the architecture which was recently baselined at the SCaN Configuration Control Board**



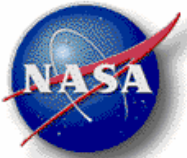
## NASA Level 0 Requirements (Presented to and accepted by SMC – 8/27/08)

1. SCaN shall develop a **unified** space communications and navigation network infrastructure capable of meeting **both robotic and human** exploration mission needs
2. SCaN shall implement a **networked** communication and navigation infrastructure across space.
3. SCaN infrastructure shall provide the **highest data rates technically and financially feasible** for both robotic and human exploration missions.
4. SCaN shall assure data communication protocols for Space Exploration missions are **internationally interoperable**.
5. SCaN shall **provide** the end space communication and navigation infrastructure on **Lunar and Mars surfaces**.
6. SCaN shall provide **anytime/anywhere** communication and navigation services **as needed** for Lunar and Mars human missions
7. SCaN shall continue to **meet its commitments** to provide space communications and navigation services to existing and planned missions.



## Architectural Goal and Challenges

- **Goal:** To detail the high level SCaN integrated network architecture, its elements, architectural options, views, and evolution until 2025 in response to NASA's key driving requirements and missions. The architecture is a **framework** for SCaN system evolution and will guide the development of Level 2 requirements and designs.
- **Challenges:**
  - Forming an **integrated** network from three pre-existing individual networks
  - Addressing **requirement**-driven, **capability**-driven, **technology-driven** and **affordable** approaches **simultaneously**
  - **Interoperability** with U.S. and foreign spacecraft and networks
  - **Uncertainty** in timing and nature of future communications mission **requirements**
  - Requirements for **support** of missions already in **operation**, as well as those to which support commitments have already been made



## SCaN Current Networks

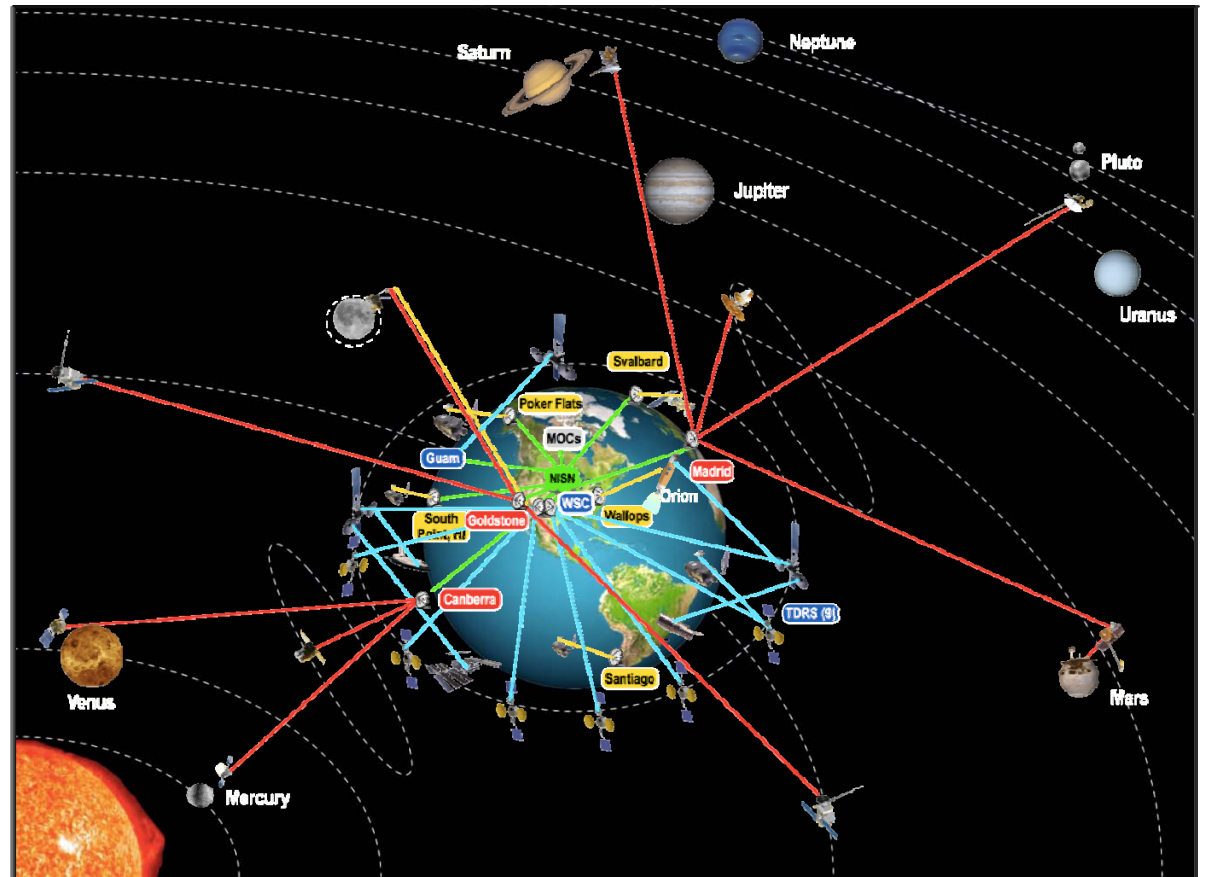
The current NASA space communications architecture embraces three operational networks that collectively provide communications services to supported missions using space-based and ground-based assets

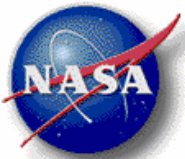
**Near Earth Network** - NASA, commercial, and partner ground stations and integration systems providing space communications and tracking services to orbital and suborbital missions

**Space Network** - constellation of geosynchronous relays (TDRSS) and associated ground systems

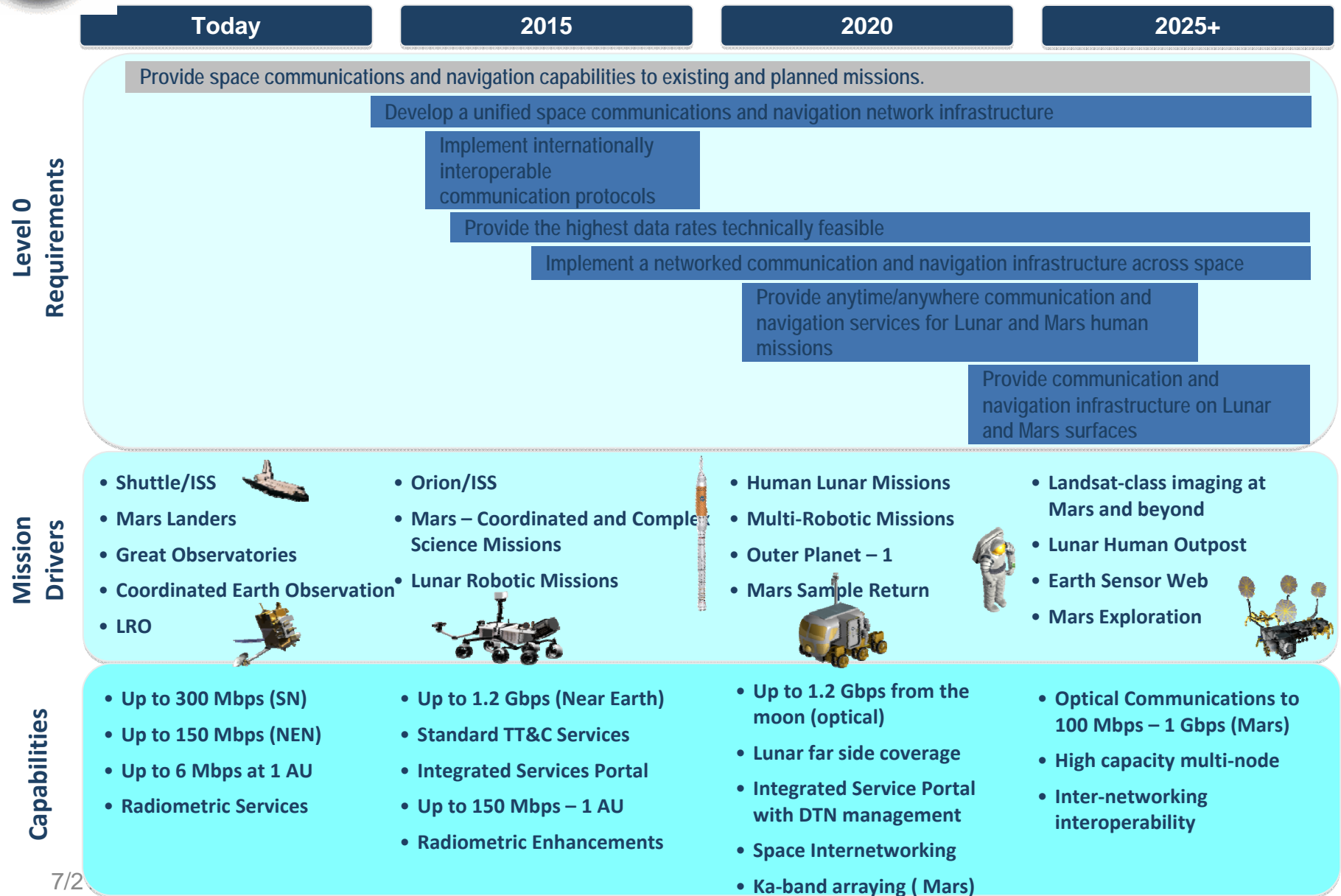
**Deep Space Network** - ground stations spaced around the world providing continuous coverage of satellites from Earth Orbit (GEO) to the edge of our solar system

**NASA Integrated Services Network (NISN)** - not part of SCaN; provides terrestrial connectivity

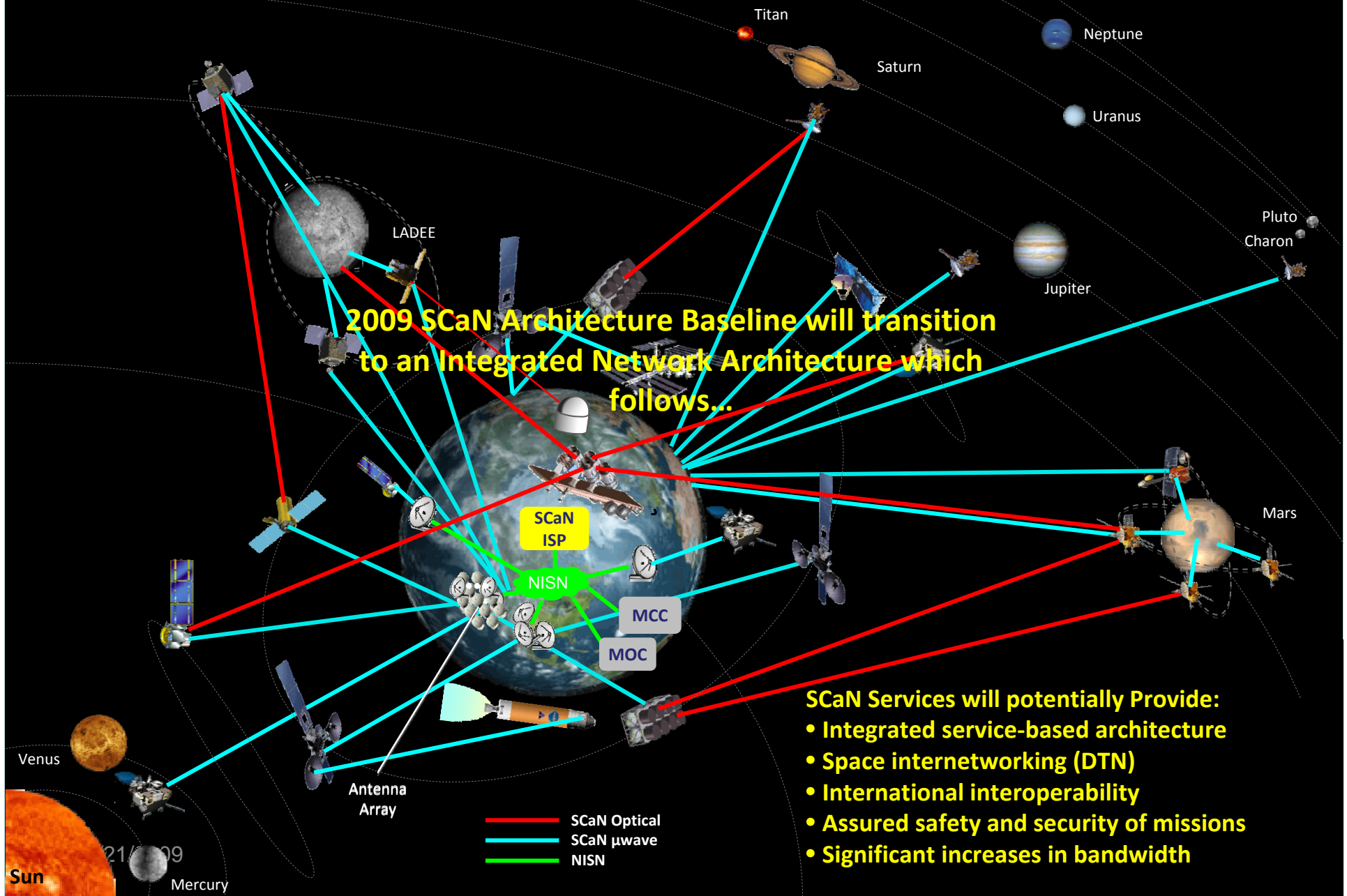


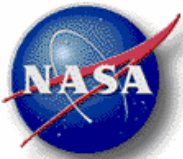


# Key Requirements, Mission Drivers, and Capabilities Flowdown



# SCaN Notional Integrated Communication Architecture

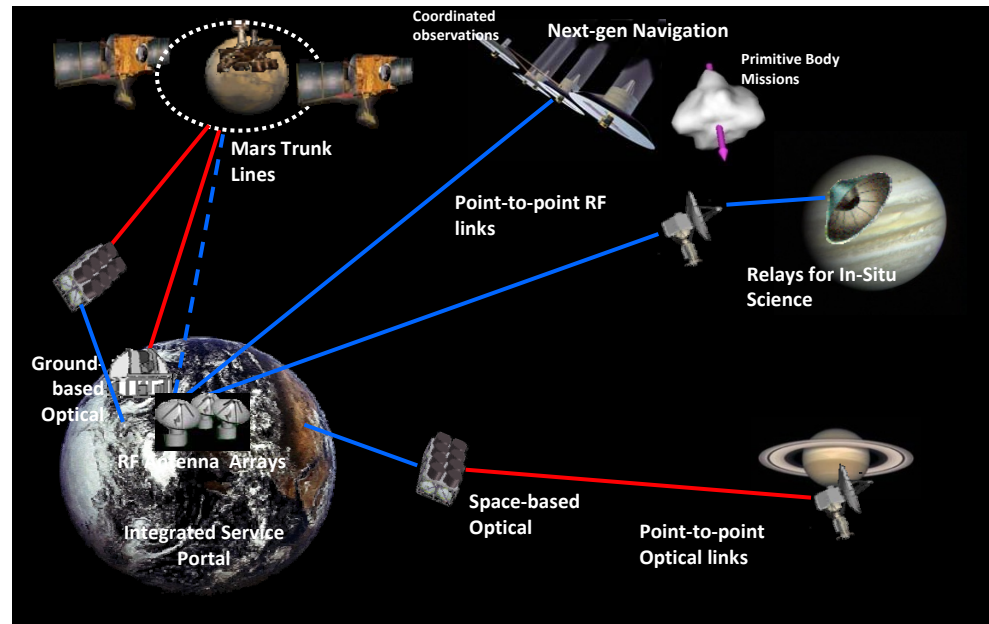




# Enhanced Deep Space Domain Capability

## Mission/Program Drivers

- **MAVEN:** Extends reliable communications for Mars relay
- **Mars Orbiter:** Mars relay and high-rate trunk line
- **Large Scale Lander:** High data rate
  - return for high resolution camera
- **Outer Planetary:** long distance link to Jovian or Saturnian spacecraft; survival-time limited missions
- **New Frontiers:** extreme distance return link and emergency TT&C
- **Mars Sample Return:** higher radiometric accuracy for precision rendezvous and docking
- **Integrated network:** common services, service interfaces, and service management for interoperability (international and U.S.)
- **Higher data rates:** to enable new missions and increase operations efficiency

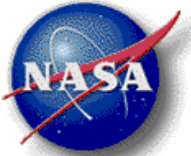


## Infrastructure Enhancements

- **Optical Initiatives:** flight and ground terminals
- **Potential Deep Space Optical Relay** for higher availability
- **RF Ground Stations**
  - 70m replacement with antenna array
  - Capacity and performance upgrade
- **Space / Ground Internetworking Nodes**

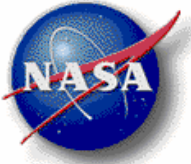
## Performance

- **Possible Deep Space Optical IOC**
  - 100 Mbps extensible to 1Gbps return link at 1AU;  $\geq 2$  Mbps forward
- **RF enhancement for return link**
  - Predominant use of deep space Ka for data return
- **New tracking data types for navigation support**
  - Ka uplink/downlink
  - Optimetric uplink/downlink (IOC)
- **Robust, Scalable RF** (Array of antennas)
- **Anytime, anywhere connectivity** within Earth line of sight
- **Robust emergency X-band TT&C**
  - Robust high-power uplink capability
- **Standard services** across all component networks



## Summary and Next Steps

- **SCaN has defined an Integrated Network Architecture that will:**
  1. Meet SOMD, ESMD, SMD, and also external agencies mission requirements
  2. Enable future NASA missions requiring advanced communications and tracking capabilities
  3. Increase SCAN operational efficiency through standardization, commonality and technology infusion
- **Next steps are:**
  1. Participate and support by the SCaN stakeholders in the base-lining and implementation of the integrated network architecture as documented in the Architecture Definition Document (ADD)
  2. Participation from the Mission Directorates in the Architecture Decision Point (ADP) process before their respective implementation
  3. Build an advocacy for SCaN architecture development and for the evolution of its enabling technology
  4. Jointly develop a plan for flight opportunities to validate new technologies that enable these architectural enhancements

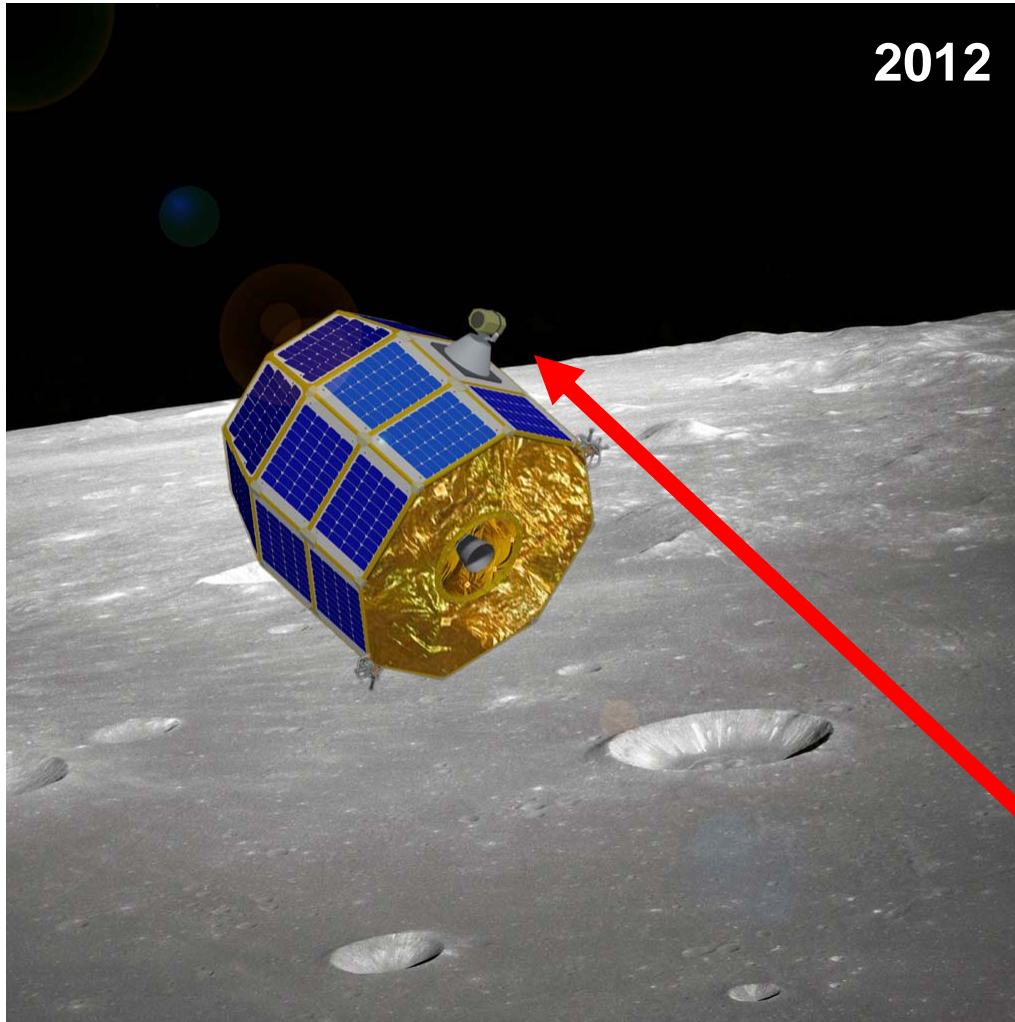


# Backup Charts

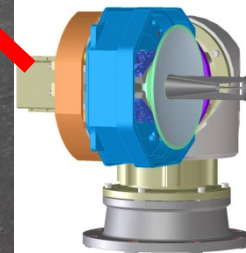


# SCaN Is Taking the 1<sup>st</sup> Step Now

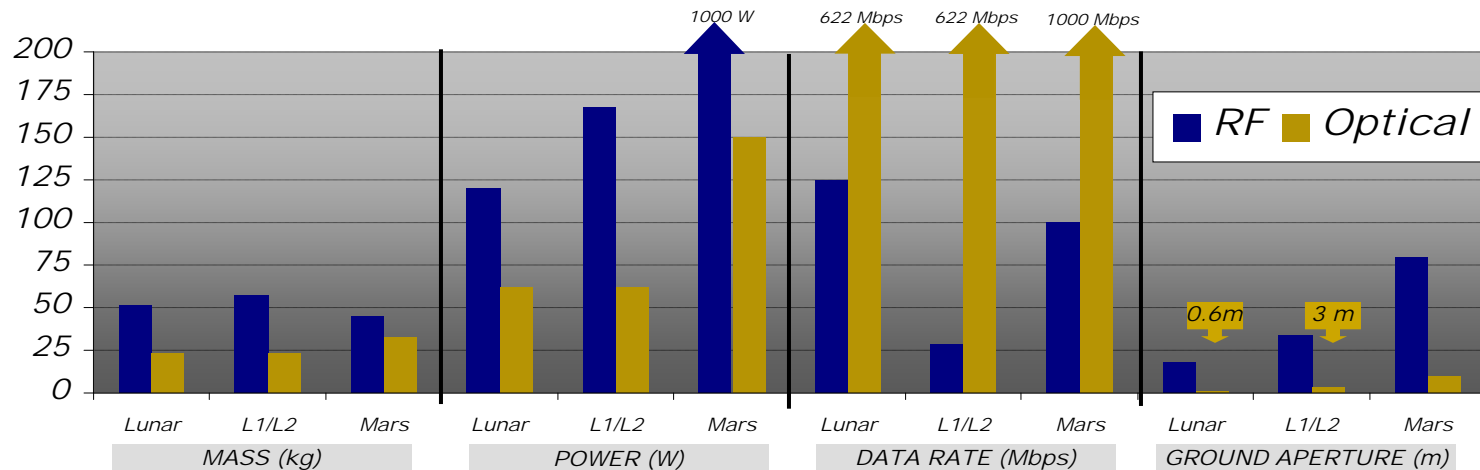
In Partnership with SMD on LADEE Spacecraft



- **Optical Terminal for LADEE on track**
  - **PDR Scheduled for 2 – 4 June**
  - **Fits within LADEE resource margins**
  - **Earth-based photon-counting technology**
- **Will provide 600 Mbps from moon**
  - **10 cm terminal**
  - **Earth-based Beacon-aided acquisition & tracking**



# Benefits of Optical Communications



A comparison of Lunar (LRO), L1/L2 (JWST), and Mars (SCAWG) RF solutions against optical comm. solutions shows vast improvements in mass, power, data rate, and ground complexity

Depending on the mission application, an optical communications solution could achieve...

- ~50% savings in mass
  - Reduced mass enables decreased spacecraft cost and/or increased science through more mass for the instruments
- ~65% savings in power
  - Reduced power enables increased mission life and/or increased science measurements
- Up to 20-fold increase in data rate
  - Increased data rates enable increased data collection and reduced mission operations complexity

...over existing RF solutions

## Mars Reconnaissance Orbiter (MRO) Example

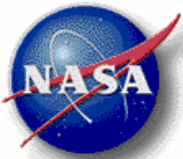


This recent image taken by the Mars Reconnaissance Orbiter represents what one could see from a helicopter ride at 1000 feet above the planet. While this mission is collecting some of the highest resolution images of Mars to date and it will collect 10 to 20 times more data than previous Mars missions, bandwidth is still a bottleneck.

Data collection for climate observations must be turned off while not over the poles because we cannot get the data back.

At MRO's maximum data rate of 6 Mbps (the highest of any Mars mission), it takes nearly 7.5 hours to empty its on-board recorder and 1.5 hours to transfer a single HIRISE image to earth.

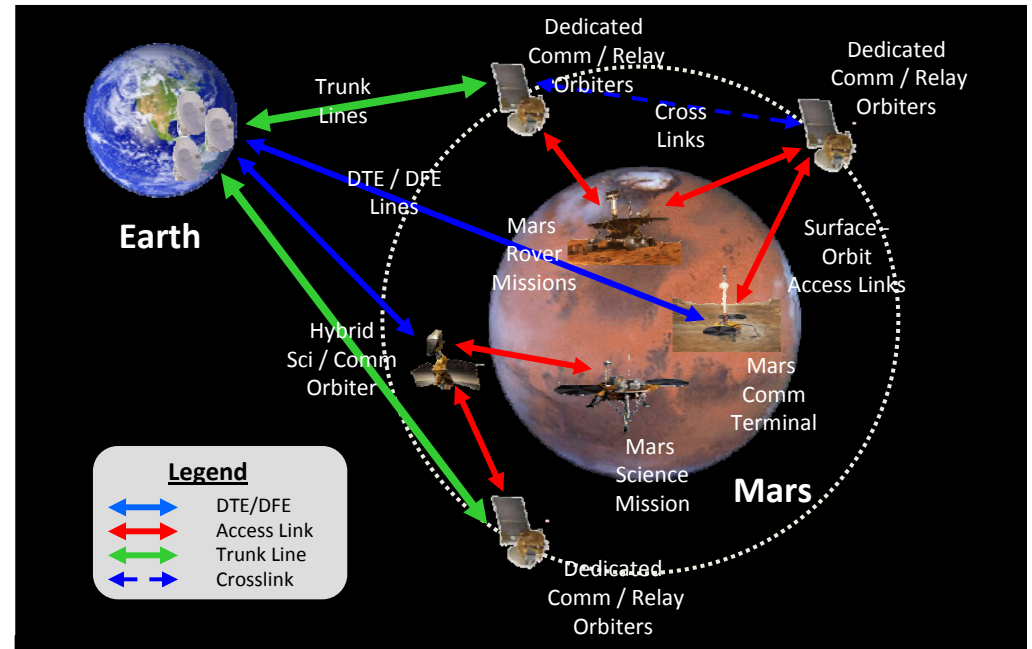
In contrast, with an optical communications solution at 100 Mbps, the recorder could be emptied in 26 minutes, and an image could be transferred to earth in less than 5 minutes.



# Notional Mars Relay Capability

## Mission/Program Drivers

- **Mars Exploration**
  - Science orbiters
  - Science landers and rovers
  - Mars sample return
- **Human Exploration Pre-cursor**
  - Dedicated Mars comm / relay orbiters
  - Mars communication terminal

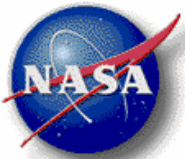


## Infrastructure Enhancement

- **Hybrid Science / Comm Orbiters:** relay payloads on science spacecraft
  - Telecommunications, data relay, navigation, and timing services
  - Store & forward file and initial space internetworking
- **Dedicated Comm / Relay Orbiters:** scaled for higher availability
  - Extended space internetworking services
- **Integrated Service Portal**

## Performance

- **Scalable** architecture that can easily evolve to support human exploration phase
- Up to 6 Mbps **RF** data rates for near-term; Up to **150 Mbps** in long-term
- Potential for **optical** Trunk to Earth receivers (at least **100 Mbps @ 1 AU** return and 2 Mbps forward, extensible **up to 1 Gbps**)
- Can support **Earth-like** science around Mars
- **Radiometric** capabilities for **precision approach, landing, and surface roving**
- Forms a subnet of the DTN **Space Internetworking for coordinated Mars exploration**



# Integrated SCaN Roadmap

