NASA OCT Communication and Navigation Systems Roadmap Overview for CCSDS

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Overview

- Top Technical Challenges
- NASA Communication and Navigation Infrastructure Requirements
- Technology Focus Areas
- Communication and Navigation Roadmap
- Technology Portfolio Discussion
- Links for Further Information

Top Technical Challenges

- Avoid communication from becoming a constraint in planning and executing NASA space missions
- Avoid navigation from becoming a constraint in planning and executing NASA space missions
- Minimize the impacts of latency in planning and executing NASA space missions
- Minimize user mass, power, and volume burden while improving performance
- Provide integrity and assurance of information delivery across the solar system
- Lower lifecycle cost of communications and navigation services
- Advancement of communication and navigation technologies beyond TRL-6

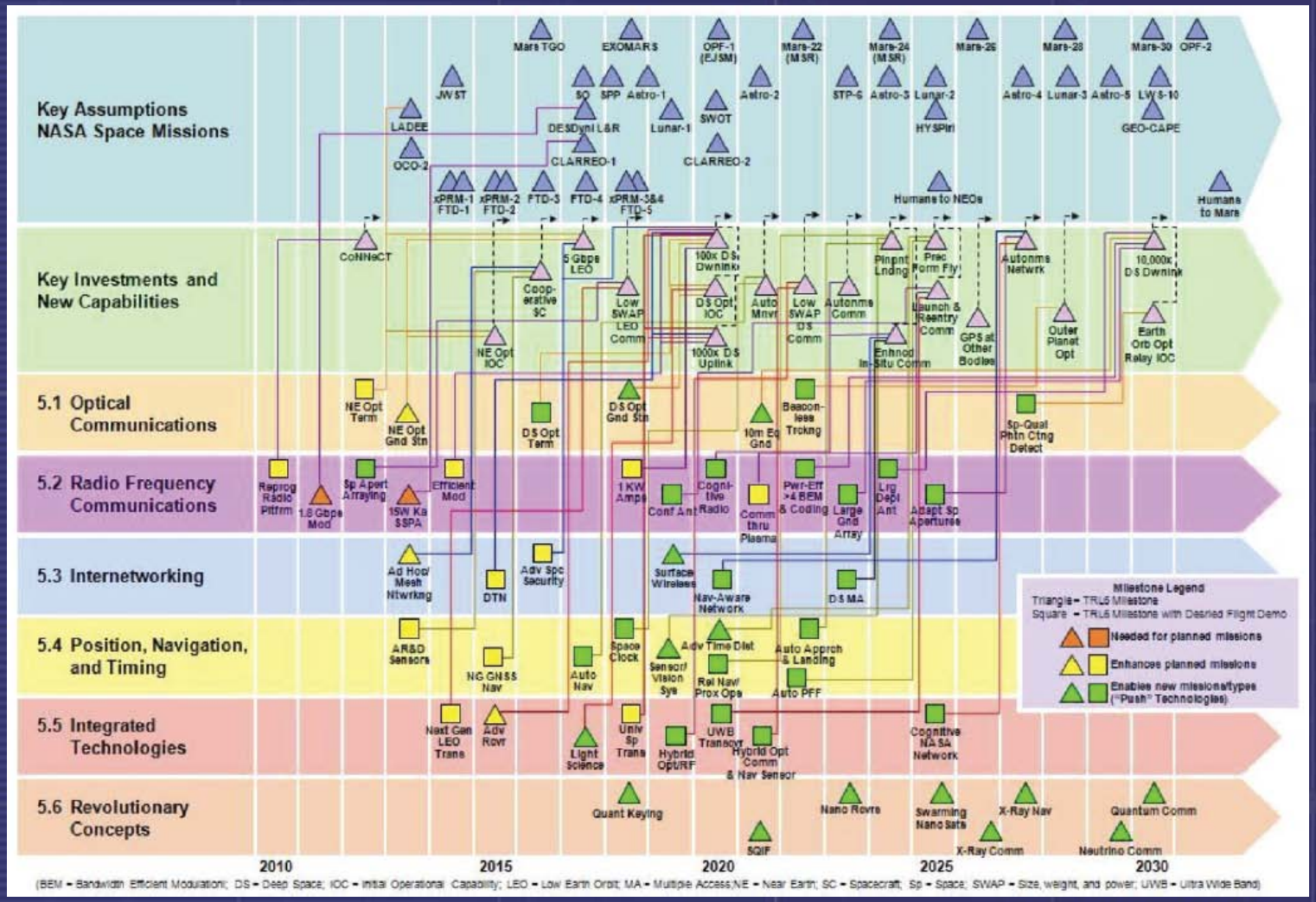
NASA Communication and Navigation Infrastructure Requirements

- Develop a unified space communications and navigation network infrastructure capable of meeting both robotic and human exploration mission needs
- Implement a networked communication and navigation infrastructure across space
- Provide the highest data rates feasible for both robotic and human exploration missions
- Assure data communication protocols for space explorations missions are internationally interoperable

Technology Focus Areas

- Optical Communications and Navigation
- Radio Frequency (RF) Communications
- Internetworking
- Position, Navigation, and Timing
- Integrated Technologies
- Revolutionary Technologies

Communication and Navigation Roadmap



Optical Communication and Networking

- Current Status: Migrate from Ka-band to optical communication which provides access to unregulated spectrum and will support the data rates that will be needed by the next generation of science instruments

- Major Challenges:
  - Low received photon density
  - Extraneous noise photons (i.e. from the Sun)
  - Precise acquisition and tracking due to narrow beam
  - Vibration/Jitter mitigation
  - Increasing laser lifetime and efficiency
  - Atmospheric Conditions

- Technology Area Breakdown:
  - Detector Development
  - Large Apertures
  - Lasers
  - Acquisition and Tracking
  - Atmospheric Mitigation

Radio Frequency (RF) Communication

- Current Status: Used on all of NASA's current space missions. Near-Earth missions drive the current state-of-the-art for data rate, data volume, and bandwidth efficiency. Deep space missions tend to drive power efficiency.

- Major Challenges:
  - Higher data return
  - Increased uplink rates
  - Spectrum allocation
  - In-situ surface wireless communication
  - Harsh environment communication (i.e. plumes, plasma, etc.)

- Technology Area Breakdown:
  - Spectrum Efficient Technologies
  - Power Efficient Technologies
  - Propagation
  - Flight and Ground Systems
  - Earth Launch and Reentry Communication
  - Antennas

Internetworking

- Current Status: Most space communication scenarios have involved fundamental point-to-point links, however there is a move towards a more internetworked architecture.

- Major Challenges:
  - Availability
  - Latency
  - Autonomous operations
  - Information assurance
  - Complex network topologies
  - Minimizing spacecraft burden

- Technology Area Breakdown:
  - Delay/Disruption Tolerant Networking (DTN)
  - Adaptive Network Topology
  - Information Assurance
  - Integrated Network Management

Position, Navigation and Timing

- Current Status: NASA currently relies on both ground-based and space based radiometric tracking, laser ranging, and optical navigation techniques. Quartz resonators and GPS (when available) are typically used for on-board time.

- Major Challenges:
  - Increased precision in absolute and relative navigation solutions
  - Reliance on Earth-based systems
  - Multi-hop communications
  - Fully autonomous approach and landing

- Technology Area Breakdown:
  - Timekeeping
  - Time Distribution
  - Onboard Autonomous Navigation and Maneuvering
  - Sensors and Vision Processing Systems
  - Relative and Proximity Navigation
  - Autonomous Precision Formation Flying
  - Autonomous Approach and Landing

Integrated Technologies

- Current Status: Most NASA communication systems are capable of performing communication and radiometrics, however they are not aware of their environment and do not react to it. There are only limited network level capabilities. RF and optical systems and developed and operated separately.

- Major Challenges:
  - Reducing user burden through integration of technologies
  - Reducing ground infrastructure through integration of technologies
  - Reducing cost through innovative systems-level analysis
  - Exploiting RF/optical communication links as science instruments

- Technology Area Breakdown:
  - Radio Systems
  - Ultra Wideband (UWB)
  - Cognitive Networks
  - Science from the Communication System
  - Hybrid Optical Communication and Navigation Sensors
  - Hybrid RF/Optical Technology

Revolutionary Concepts

- Current Status: Most prior NASA investments in communications and navigation have been in technologies that are based on electromagnetic principles, with a heavy dependence on Earth-based services.

- Major Challenges:
  - Develop new ways of approaching the key communications and navigation challenges
  - Achieve several orders of magnitude in increased performance or decreased user burden

- Technology Area Breakdown:
  - X-Ray Navigation
  - X-Ray Communications
  - Neutrino-Based Navigation and Tracking
  - Quantum Key Distribution
  - Quantum Communications
  - Superconducting Quantum Interference Filter Microwave Amplifier
  - Reconfigurable Large Apertures

For further information:

- http://www.nasa.gov/offices/oct/home/roadmaps/index.html
- http://www.nasa.gov/pdf/501623main_TA05-CommNav-DRAFT-Nov2010-A.pdf