



Current/Future TT&C at NASA

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End-to-End Information Systems

Group Supervisor

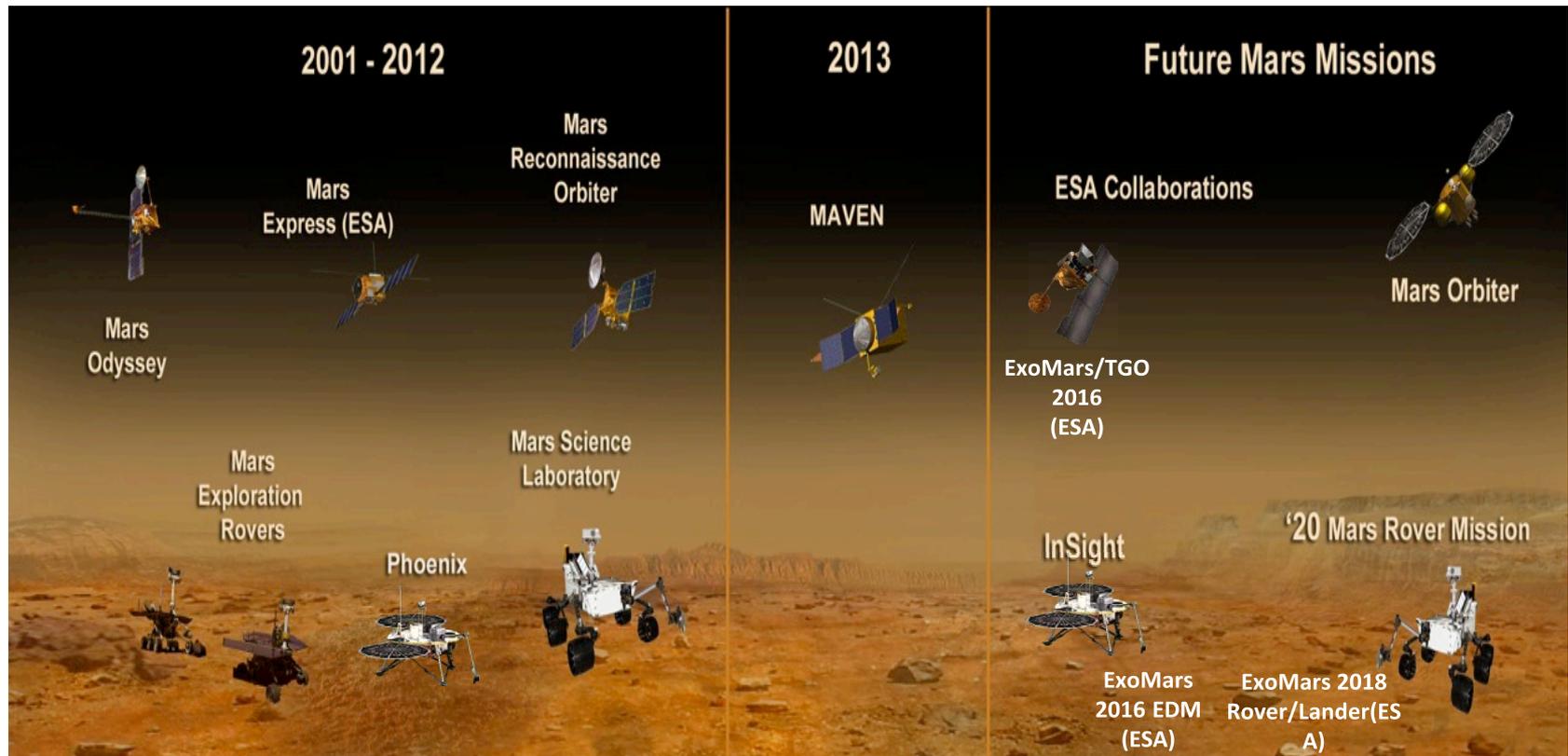
Jet Propulsion Laboratory

California Institute of Technology

10 September 2013



Mars Exploration Program



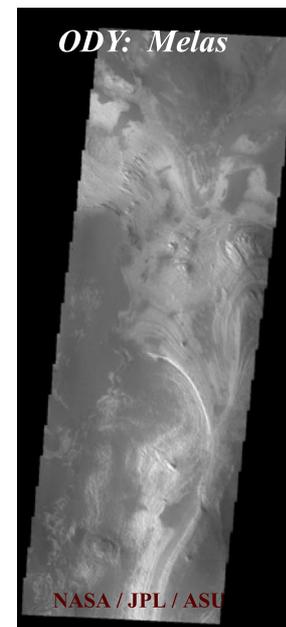
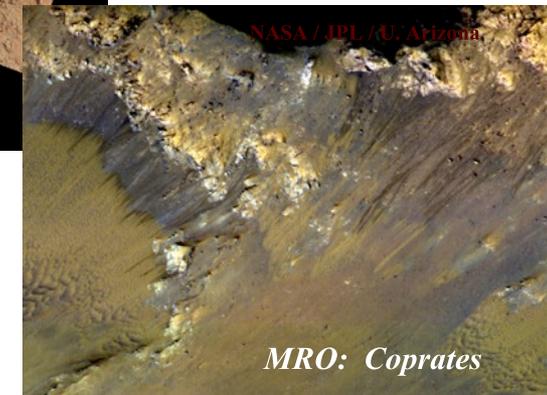
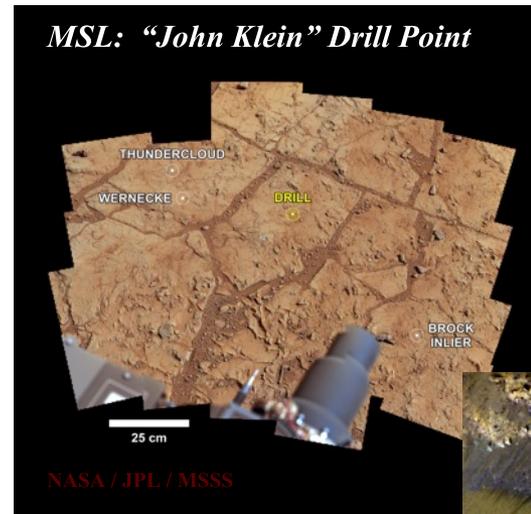


Mars Mission Plans



- NASA MAVEN – 2013
 - Mars Atmosphere and Volatile Evolution. Investigate the physics, chemistry, and dynamics of the upper atmosphere, the effects of solar wind and radiation, and the escape of volatiles to space
 - Partnership between the PI (UC Boulder), NASA/GSFC as the mission center, and Lockheed Martin as the spacecraft system contractor and carries Single String Electra relay payload
- NASA INSIGHT – 2016
 - Interior Exploration using Seismic Investigations, Geodesy and Heat Transport. Single geophysical lander on Mars to study its deep interior.
 - Re-flight of the Phoenix Lander with MAVEN Avionics; Planned as Relay only mission using CE-505 Radio
- ESA Trace Gas Orbiter (TGO) – 2016
 - Search for evidence of methane and other atmospheric gases that could be signs of active biological or geological processes.
 - NASA provides Orbiter Electra Radio payload
- ESA TGO Entry, Descent, and Landing Demonstrator Module (EDM) – 2016
 - ESA TGO delivers the EDM to the surface of Mars, to demonstrate key technologies for landing on Mars.
- ESA ExoMars Rover + Lander – 2018
 - Search for evidence of extant and extinct life featuring a deep drill up to 2 m to collect samples; Lander contains scientific instruments to investigate the Martian environment.
 - Two flight elements: Roscosmos built Lander delivers ESA Rover to the surface
- NASA Mars 2020 Rover

- **MAVEN:**
 - On schedule to launch this Fall 2013
 - Now in Environments Testing in Denver
- **MSL:**
 - Analyzing first drilled rock materials in Yellowknife Bay;
- **MRO:**
 - Detecting new areas of Recurring Slope Lineae (RSLs), e.g., in Valles Marineris
 - SHARAD returning to operations
- **ODY:**
 - Successful transition to Side B
 - Continuing to fill gores in THEMIS coverage
 - Drifting to later local times
- **MEX:**
 - Finished period of good radar coverage (periapsis in the dark)
- **MER-B:**
 - Finishing Cape York survey
 - Preparing to start move to Solander Point
- **INSIGHT**
 - Project enters Phase C in Fall 2013

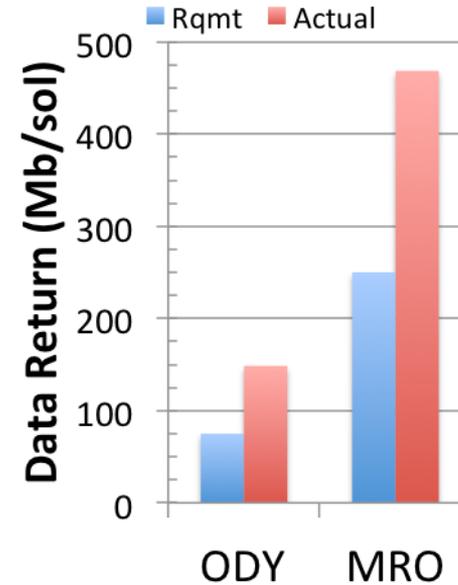




Mars Network Relay Performance



- Curiosity is returning large amounts of science data via an international network of Mars relay orbiters
 - Over **132 Gigabits** of data returned through Sol 238
 - Averaging over **1/2 Gb/sol**, well above MSL project requirements
- **MRO:**
 - High performance relay based on new Electra UHF Transceiver capabilities
 - Adaptive Data Rate (ADR)
 - Operations over Multiple Frequencies
 - Higher Data Rates ... up to 2 mbps
- **ODY:**
 - Real-time data return during MSL EDL
 - Continues to serve as the workhorse relay orbiter for Opportunity
- **MEX:**
 - Tracking of MSL carrier during EDL
 - Backup relay asset for Curiosity surface ops – conducting monthly demonstration relay passes to verify MSL-MEX telemetry and command functions



All Passes Through Sol 238

	ODY	MRO	Total
Total # Passes	438	425	863
Total Data Return (Gb)	32.5	99.8	132.3
Average # Passes/sol:	1.84	1.79	3.63
Average Return Data Vol/Sol (Mb)	136.68	419.31	555.99
Average Return Data Vol/Pass (Mb)	74.27	234.81	153.33

Over 500 Mb/sol average MSL data return



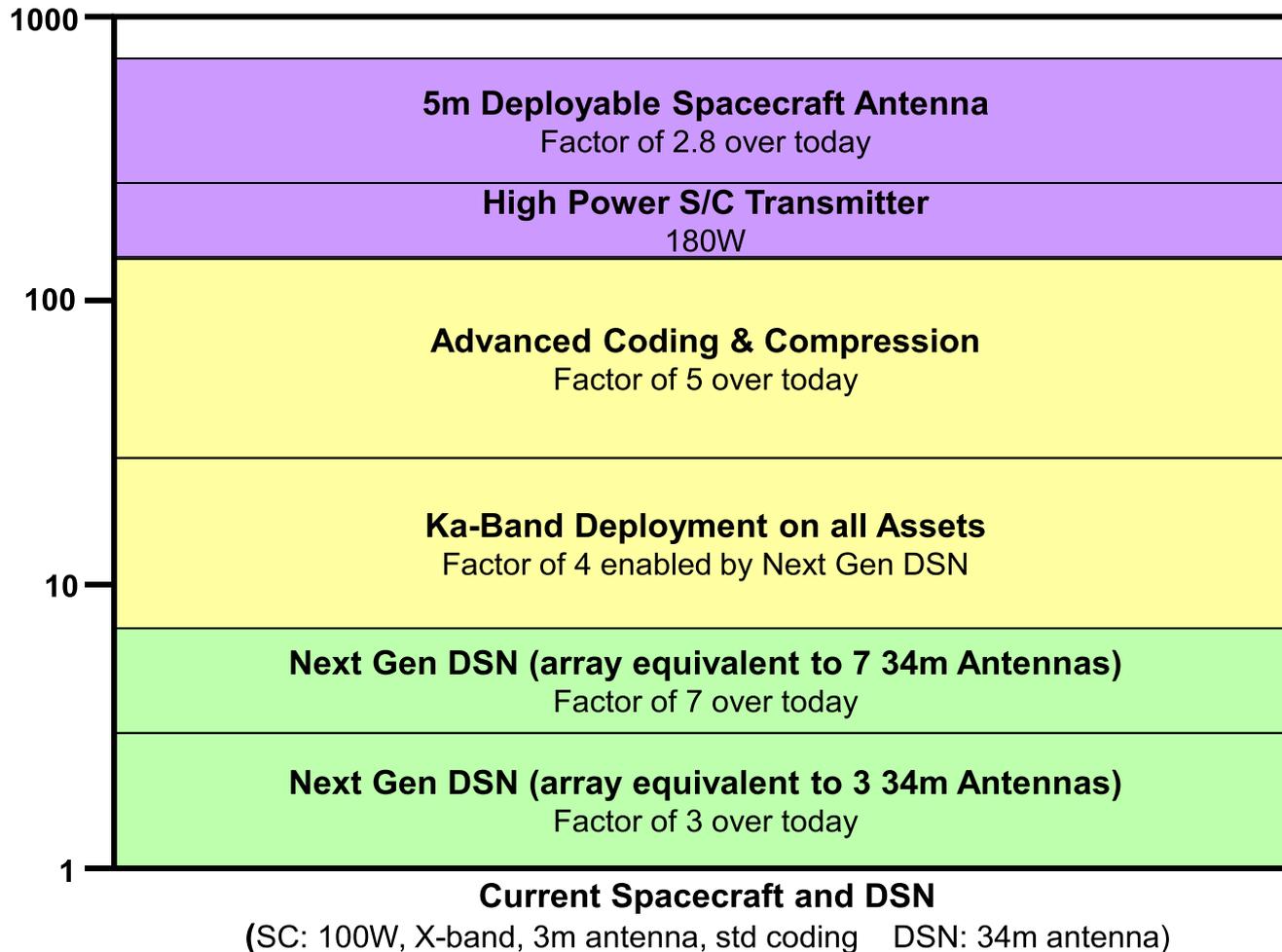
Future Mars Comm. Challenges



- ExoMars TGO 2016 is crucial to the continuation of Mars Network
 - Consider Existing Mars Orbiter ages by 2020
 - ODY 20
 - MRO 15
 - MAVEN 8
- Agency cross-support through CCSDS standards will continue to enable missions
 - After EDL, 4-SOL TGO EDM mission will be solely supported by NASA orbiters
 - CCSDS Optical Comm. WG begins in Fall 2013
- Near and Longer Term Challenges
 - InSight and MSL will be in close proximity – Separate Relay overflights will be allocated
 - Internetworking – Using Delay Tolerant Networking (DTN)
 - Higher Data Rates – Use of Optical Communication – Deep Space Optical Terminal (DOT) 2018 Demo
 - Data Rate Goal is $\frac{1}{4}$ Gbit/sec at minimum Mars Distance .4 AU (Factor 10x greater than Ka-band capability on MRO)
 - Spacecraft Optical Terminal of comparable mass & power as MRO Ka-band system

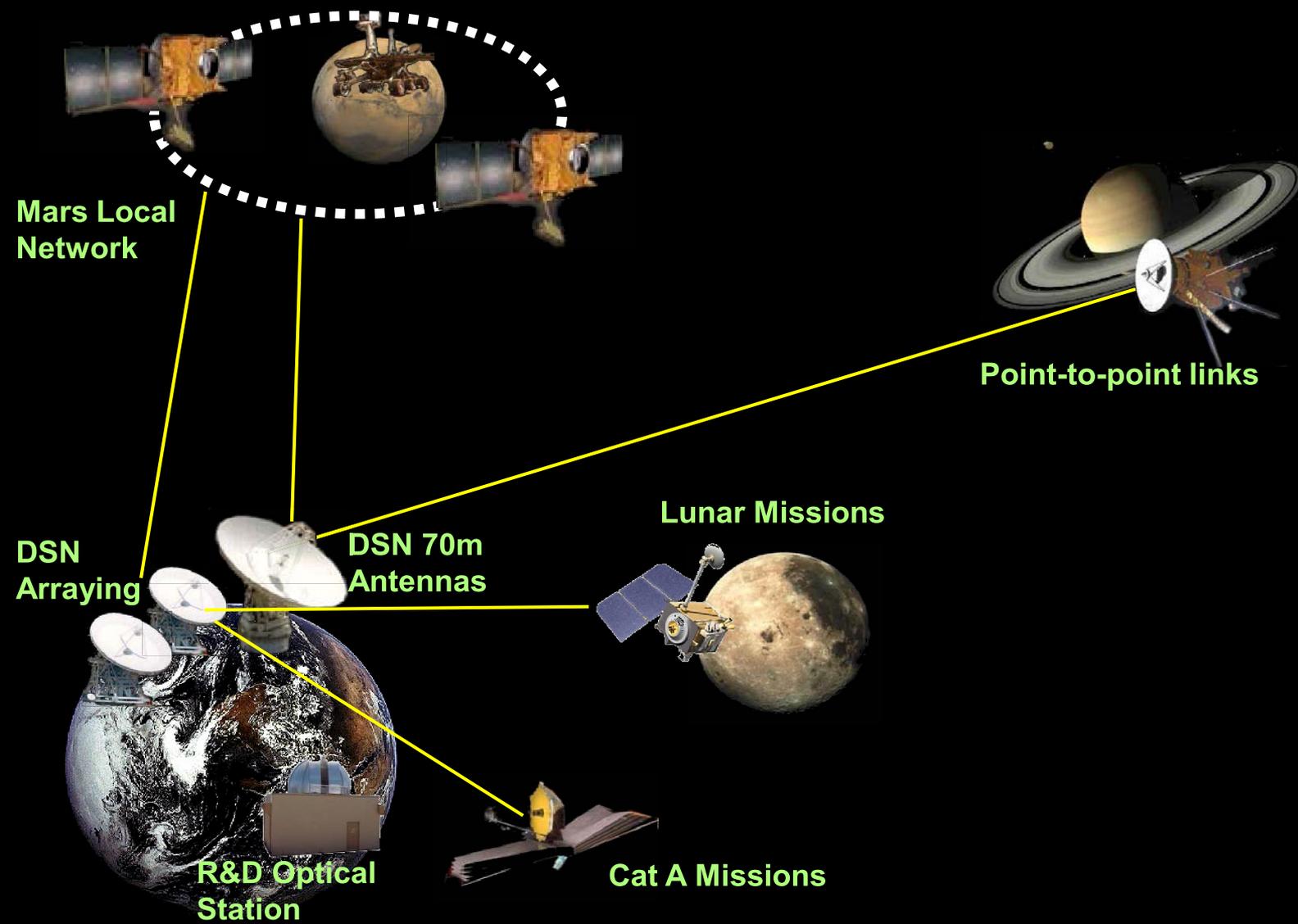


Possible Comm System Improvements





Current Architecture





“Garden of Interplanetary Delights” - 2025

