

**DSN Capabilities To Support  
Multi-Purpose Crew Vehicle (MPCV) Program  
- Exploration Missions (EM-1 & EM-2) -**

ESA-JPL TIM

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Wallace Tai, Caltech/JPL

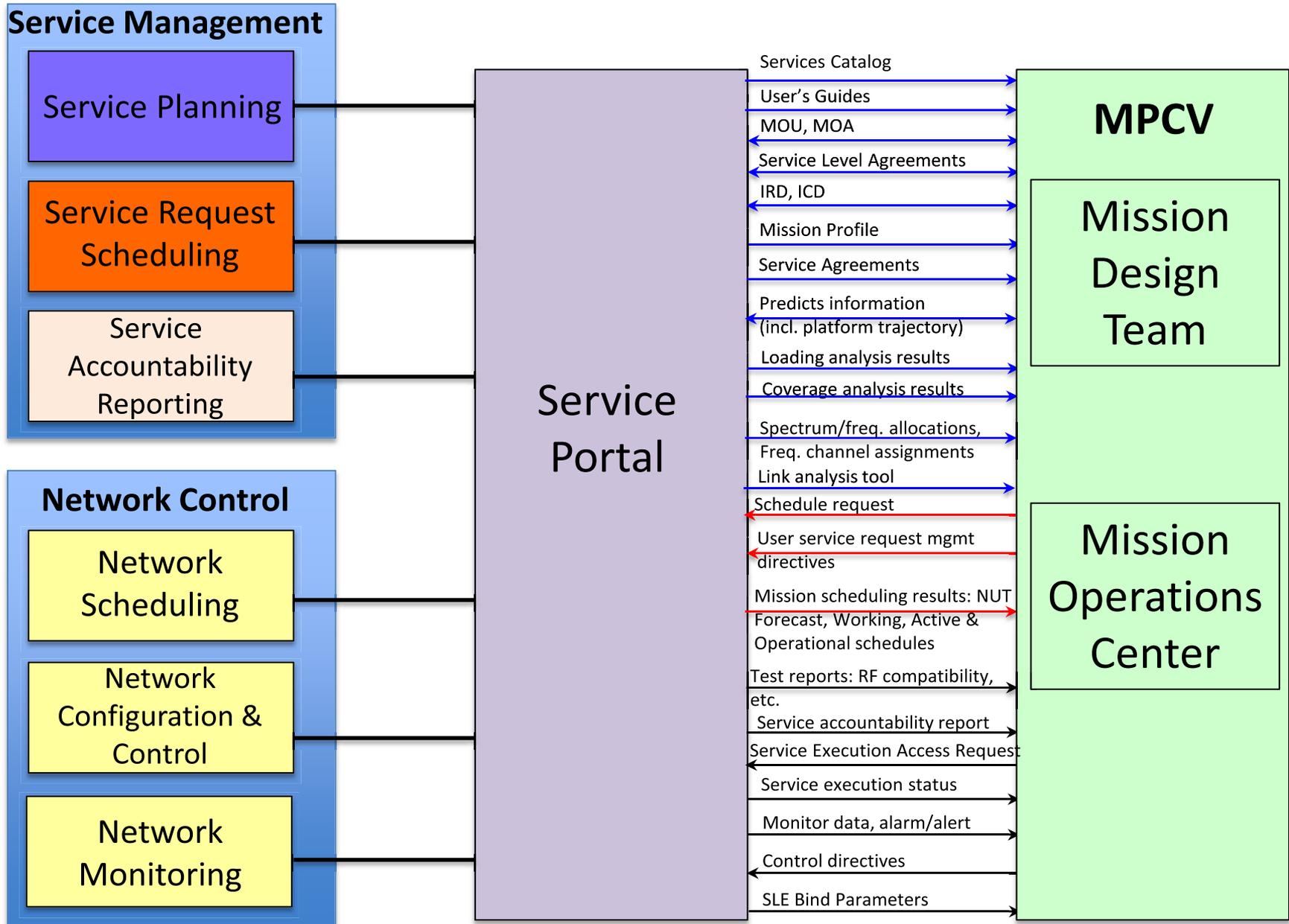
Forward Link Data Service – Key Attributes		Remark
Frequency Bands	Near-Earth S-band	Present capability
Antenna Types	34m BWG, 34m HEF	Present capability
Polarizations	RCP or LCP; No RCP/LCP simultaneity	Present capability
Modulation Types	BPSK directly on carrier (no ranging);	Present capability
	SS-UQPSK (with ranging)	New capability (not funded)
Forward link Data Rate	Maximum 256 kbps Minimum 7.8 bps	Present capability, with minor update can increase to 1Mbps
Forward Error Correction Code	LDPC rate 1/2 CCSDS Synchronization and Channel Coding (ref. CCSDS 131.0-B-2)	New capability, in the DSN plan, but yet to be funded
Data from MOC to DSN	<ul style="list-style-type: none"> <li>• Stream of AOS frames over a TCP/IP interface;</li> <li>• CCSDS Space Link Extension (SLE) Enhanced Forward CLTU Service (ref. CCSDS 912.11-O-1);</li> </ul>	New capability - minor extension from the current SLE CLTU capability; in the DSN plan, but yet to be funded
Data from DSN to Spacecraft	<ul style="list-style-type: none"> <li>• Encoded AOS frame per CCSDS AOS Space Data Link Protocol (ref. CCSDS 732.0-B-2)</li> </ul>	New capability - minor extension from the current TC capability; in the DSN plan, but yet to be funded

Return Link Data Service - Key Attributes		Remark
Frequency Bands	Near-Earth S-band	Present capability
Antenna Types	34m BWG, 34m HEF	Present capability
Polarizations	RCP or LCP; RCP/LCP simultaneity at some stations	Present capability
Modulation Types	OQPSK/SQPSK (no ranging)	Present capability
	SS-UQPSK, SQPN (with ranging)	New capability (not funded)
Return link Data Rate	Maximum: 6 Mbps Minimum: 10 bps (> 40 bps recommended for timely acquisition)	Present capability. We understand the EM-1 &-2 maximum rate is 3 Mbps
Forward Error Correction Code	LDPC rate 1/2 CCSDS Synchronization and Channel Coding (ref. CCSDS 131.0-B-2)	New capability, in the DSN plan, but yet to be funded
Data from DSN to MOC	<ul style="list-style-type: none"> <li>Stream of AOS frames over a TCP/IP interface;</li> <li>CCSDS Space Link Extension (SLE) RAF/RCF (ref. CCSDS 911.1-R-1.7 and 911.2-R-1.7); On-line timely/On-line complete/Off-line</li> </ul>	Present capability
Data from Spacecraft to DSN	<ul style="list-style-type: none"> <li>Encoded AOS frame per CCSDS AOS Space Data Link Protocol (ref. CCSDS 732.0-B-2)</li> </ul>	Present capability

Radiometric Data Service - Key Attributes		Remark
Frequency Bands	Near-Earth S-band	Present capability
Antenna Types	34m BWG, 34m HEF	Present capability
Tracking Data Types	Range, Doppler, Angle (mainly for initial acquisition during LEOP)	Ranging in TDRSS DG1 is assumed - New capability (not funded).
Modulation Types	SS-UQPSK, SQPN	Ranging in TDRSS DG1 is assumed - New capability (not funded)
Ranging Type	Pseudo-noise	
Range Accuracy (1 $\sigma$ Error)	1 meter	
Doppler Accuracy (1 $\sigma$ Error)	0.2 mm/s, 60s Compression	
Doppler Measurement Rate	0.1 second	
Data Latency	Doppler/Range: 5 minutes (95%)	
Data Modes (DSN to MOC)	Stream data mode File data mode	
Delivery Modes (DSN to MOC)	On-line; Off-line	
Interface standards	CCSDS Tracking Data Messages (TDM) for data contents/format, over NDM (Ref. 1: CCSDS 505.0-B-1 XML specification for navigation data messages);	Present capability.

# Service Management & Network Control Functions

## MPCV – DSN Interfaces



# DSN Support To HSF MPCV

## Lunar Missions Coverage Analysis Conclusions

- Requested by JSC MPCV project, a coverage analysis was performed on SCan network support to MPCV lunar missions: EM1, EM2, L2Flyby, and L2 Waypoint.
- Two sets of most feasibly ground station sites are considered:
  - DSN3: DSN Goldstone, Canberra, and Madrid
  - DSN6: DSN3 plus Usuda, Santiago, and Hartebeesthoek (HBK) stations
- Given the various mission trajectories, the coverage gap is less than 5%:
  - EM-1: DSN3 = 2%, DSN6 = 1.1%
  - EM-2: DSN3 = 4.39%, DSN6 = 3.92%
  - L2Flyby: DSN3 = 0.9%, DSN6 = 0.1%
  - L2Waypoint: DSN3 = 0.4%, DSN+HBK = 0% (100% coverage)
- The difference in coverage gap between DSN3 and DSN6 is less than 1%. The added benefit by additional stations is relatively minor.
- Only one critical event, TCM-4 in EM-2, would fall into the DSN gap. This gap can be eliminated by augmenting the DSN3 with HBK.
- The optimal choice of ground stations to support lunar missions is the 3 DSN sites augmented by HBK. The existing CSIR 13.2m station at HBK seems to be a good candidate.