

# CubeSat Technical Interchange Meeting 19 September 2016

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## Agenda

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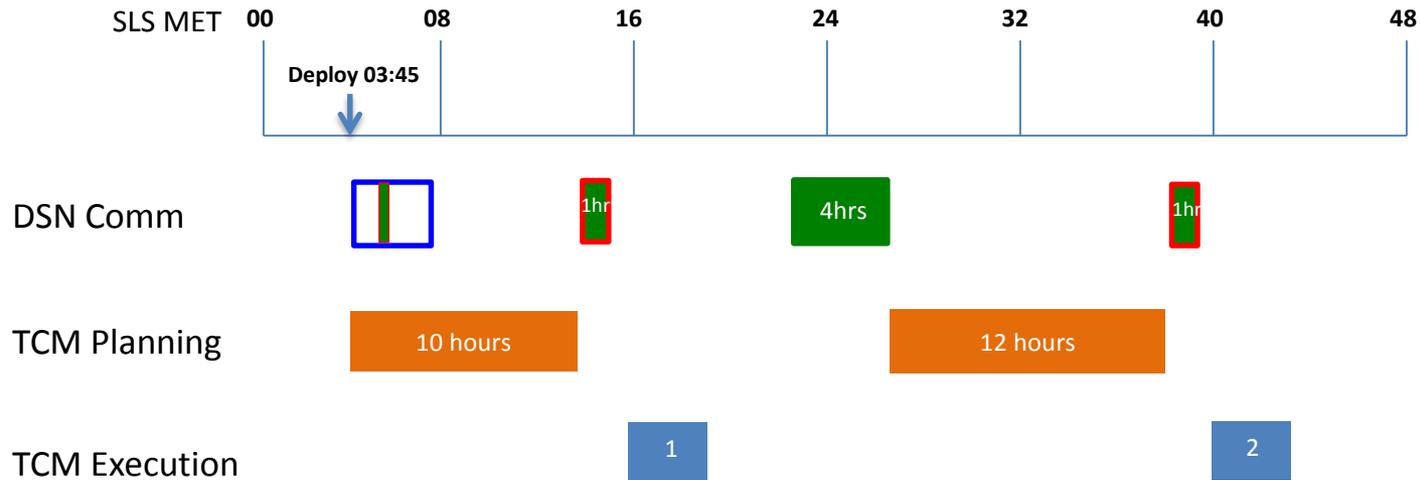
- DSN Uplink Swap and 4 spacecraft MSPA status
- Summary of CubeSat Mission Status as August
  - Bio Sentinel
  - Lunar Flashlight
  - Lunar IceCube
  - NEA Scout
  - LunaH MAP
  - CuSP
- Cubequest that want to potentially use the DSN
  - Alpha CubeSat, Xtraordinary Innovative Space Partnerships, Inc.
  - Heimdallr, Ragnarok Industries, Inc
  - Team Miles, Fluid & Reason LLC
  - Cislunar Explorers, Cornell University
  - MIT KitCube, Massachusetts Institute of Technology
  - SEDS, University of California- San Diego
  - G.O.A.T.S., Worchester Polytechnic Institute
  - CU-E3, University of Colorado – Boulder

## General Comments

- Any question to the DSN for the DSN Checklist?
  - Note that for Cubequest Challengers, the suggested time line will be condensed as appropriate, and will depend on if the challengers uses DSN for operations and or only validation.
- First 36 hours after separation for each CubeSat
  - Specifically focusing on need DSN service especially CubeSat after separation station view period
  - **Request information by target date of 29 September 2016**
- (For first 36 hours) DSN will need to also know, separation what is the pre-canned spacecraft sequence with out Command Loss timer and with Command loss timer?
  - What will be the period for spacecraft receiver on and off times?
  - What will be the period for the spacecraft transmit times?
- (For first 36 hours) DSN will also need to know what does spacecraft safe mode (if different then at separation)?

# Example

## NEA Scout First 48 Hours



TCM-1 based on ICPS state vector received at ~SLS MET 04:00

TCM-2 based on 4hr Doppler track

Key

- 2-way communication (Doppler)
- 4-MSPA (3.5hrs 1-way, 0.5hr 2-way)
- Critical Commanding

## General Comments

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- After launch phase, which mission if any may need a 70 meter due to link budget when antenna is off earth point?
- After launch phase, which mission is any may need a 70 meter due to link budget when antenna is off earth point?
  - Bio Sentinel
  - NEA Scout
  - ?
  - ?
- For spacecraft emergency, be aware that the DSN can take up to 2 hours to provide an antenna for support.
- Scheduling Service
  - MGSS MRSS Scheduling Service subsidized by NASA HQ proposal still to be determined. No updates since workshop from few months ago.

## Question and Open Forum

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- Open Forum and suggestions for next DSN TIM?

# EM-1 CubeSat Bus Stops (updated 8/24/2016)



To Helio

<u>Bus Stops</u>	<u>Distance (approx.)</u>	<u>Flight Time (approx.)</u>	<u>Approx. Temp.</u>
1	26,700 km	3 Hrs. & 34 Min.	13°C (55°F)
2	64,500 km	7 Hrs. & 51 Min.	-7°C (20°F)
3	192,300 km	3 Days, 6 Hrs. & 12 Min.	-29°C (- 20°F)
4	384,500 km	6 Days, 11 Hrs. & 57 Min.	-26°C (- 15°F)
5	411,900 km	7 Days, 0 Hrs. & 16 Min.	-29°C (- 20°F)



Van Allen Belts



<u>Bus Stops</u>	<u>Description</u>
1	First opportunity for deployment, cleared 1 <sup>st</sup> radiation belt
2	Clear both radiation belts plus ~ 1 hour
3	Half way to the moon
4	At the moon, closest proximity (~250 km from surface)
5	Past the moon plus ~12 hours (lunar gravitational assist)

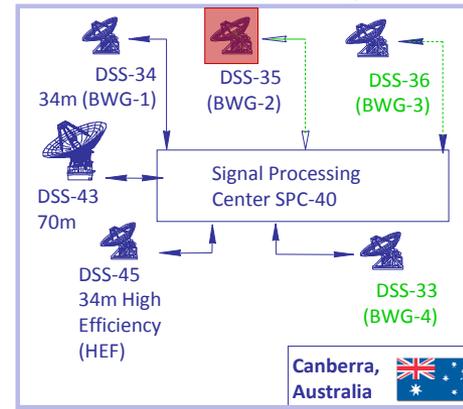
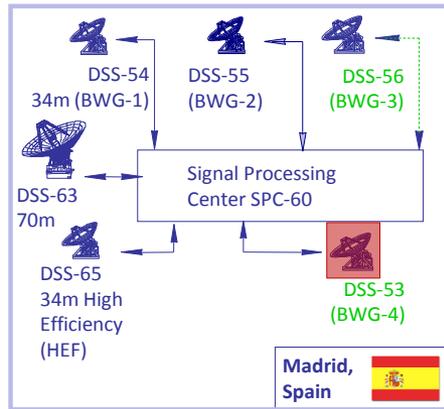
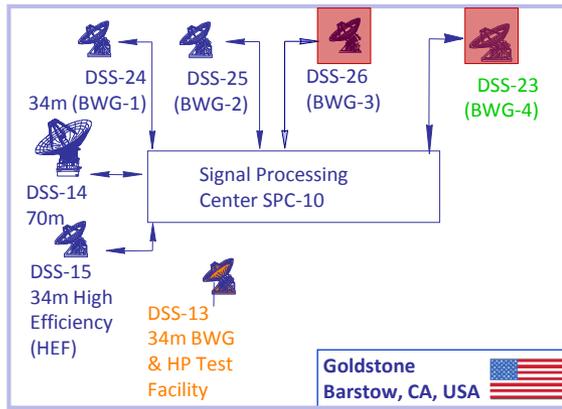
Note: All info based on a 6.5 day trip to the moon.

# Separation of Payloads Time Line

- **Bus Stop 1 about 3 hour & 34 minutes after launch**
  - Argo Moon
  - Bio Sentinel
  - Lunar Flashlight
  - Lunar IceCube
  - NEA Scout
  - Cube Quest #1 (DSN Support TBD)
  - ~~CubeQuest #2 (DSN Support TBD)~~
- **Bus Stop 2 about 7 hours & 54 minutes after launch (note SkyFire will not use DSN)**
  - Cube Quest #3 (DSN Support TBD)
  - LunaH Map
  - SLSLIM
  - Equuleus
- **Bus Stop 3 about 3 days 6 hours & 12 minutes after Launch**
  - CuSP
- **Bus Stop 5 about 7 days 16 Minutes after Launch**
  - **CubeQuest #2 (CU Boulder CU-E3 ) if selected**

Bus stop may change depending on selection

# DSN Resources



**LEGEND**

Future 34m BWG Antenna

New 80 kW Transmitter

**New Antennas**

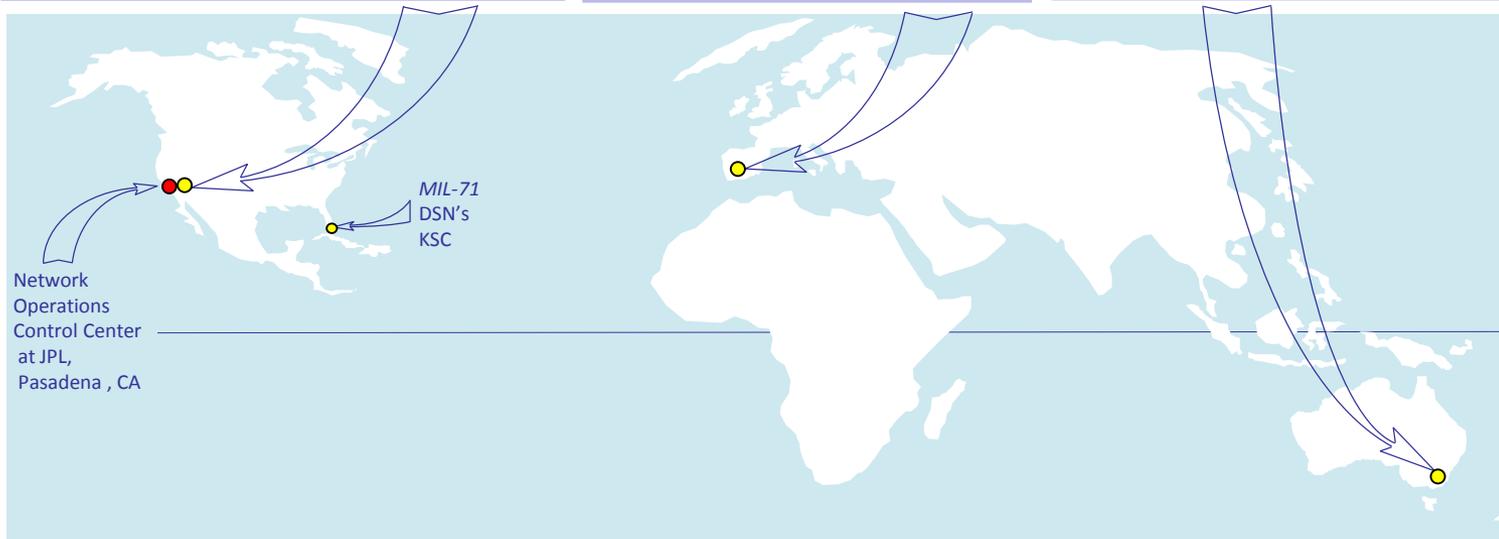
Operational Dates

- DSS-36 9/2016
- DSS-56 9/2019
- DSS-53 9/2020
- DSS-33 9/2022
- DSS-23 9/2024

**80 kW XTR**

Operational Dates

- DSS-26 9/2015
- DSS-53 9/2020
- DSS-35 9/2022
- DSS-23 9/2024



# DSN Station Capabilities

	DSS No.	Antenna Type	Location	Agency / Ops Org	S-Band Uplink Frequency (MHz)	S-Band Downlink Frequency (MHz)	X-Band Uplink Frequency (MHz)	X-Band Downlink Frequency (MHz)	Ka-Band Downlink Frequency (MHz)
	14	70m	Goldstone, California	NASA/DSN	2110 - 2118	2270 - 2300	7145 - 7190	8400 - 8500	-
Orion →	15	34HEF	Goldstone, California	NASA/DSN	2025 - 2120	2200 - 2300	7145 - 7190	8400 - 8500	-
Orion →	24	34B1	Goldstone, California	NASA/DSN	2025-2120	2200 - 2300	7145 - 7190, 7190 - 7235	8400 - 8500	25500 - 27000
CubeSat's →	25	34B2	Goldstone, California	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
CubeSat's →	26	34B3	Goldstone, California	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
Orion →	34	34B1	Canberra, Australia	NASA/DSN	2025-2120	2200 - 2300	7145 - 7190, 7190 - 7235	8400 - 8500	25500 - 27000, 31800 - 32300
CubeSat's →	35	34B2	Canberra, Australia	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
Orion →	36 (Oct 2016)	34B3	Canberra, Australia	NASA/DSN	2025-2120	2200 - 2300	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
	43	70M	Canberra, Australia	NASA/DSN	2110 - 2120	2270 - 2300	7145 - 7190	8400 - 8500	-
Decommissioned Nov 2016 →	45	34HEF	Canberra, Australia	NASA/DSN	2025 - 2110	2200 - 2300	7145 - 7190	8400 - 8500	-
Orion →	54	34B1	Madrid, Spain	NASA/DSN	2025 - 2110, 2110 - 2120*	2200 - 2300	7145 - 7190, 7190 - 7235	8400 - 8500	25500 - 27000, 31800 - 32300
CubeSat's →	55	34B2	Madrid, Spain	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
	63	70m	Madrid, Spain	NASA/DSN	2110-2118*	2270 - 2300	7145 - 7190	8400 - 8500	-
Orion →	65	34HEF	Madrid, Spain	NASA/DSN	2025 - 2110	2200 - 2300	7145 - 7190	8400 - 8500	-



# LunH-Map DSN Operations

## First Stations View based on LunH-Map view periods Based on Interim Trajectory from Secondary Payload Users Group **7 Oct 2018 Launch**

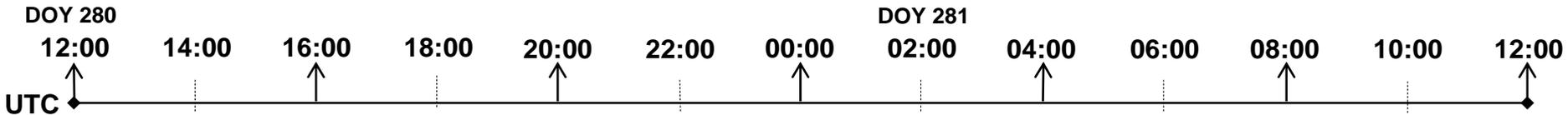
BOT 15:38:00 DSS-25 EOT 3:03:25

BOT 15:38:00 DSS-26 EOT 3:03:25

BOT 15:38:00 DSS-55 EOT 18:27:32

BOT 10:21:13 DSS-55 EOT 19:33:44

BOT 22:52:53 DSS-35 EOT 10:38:48



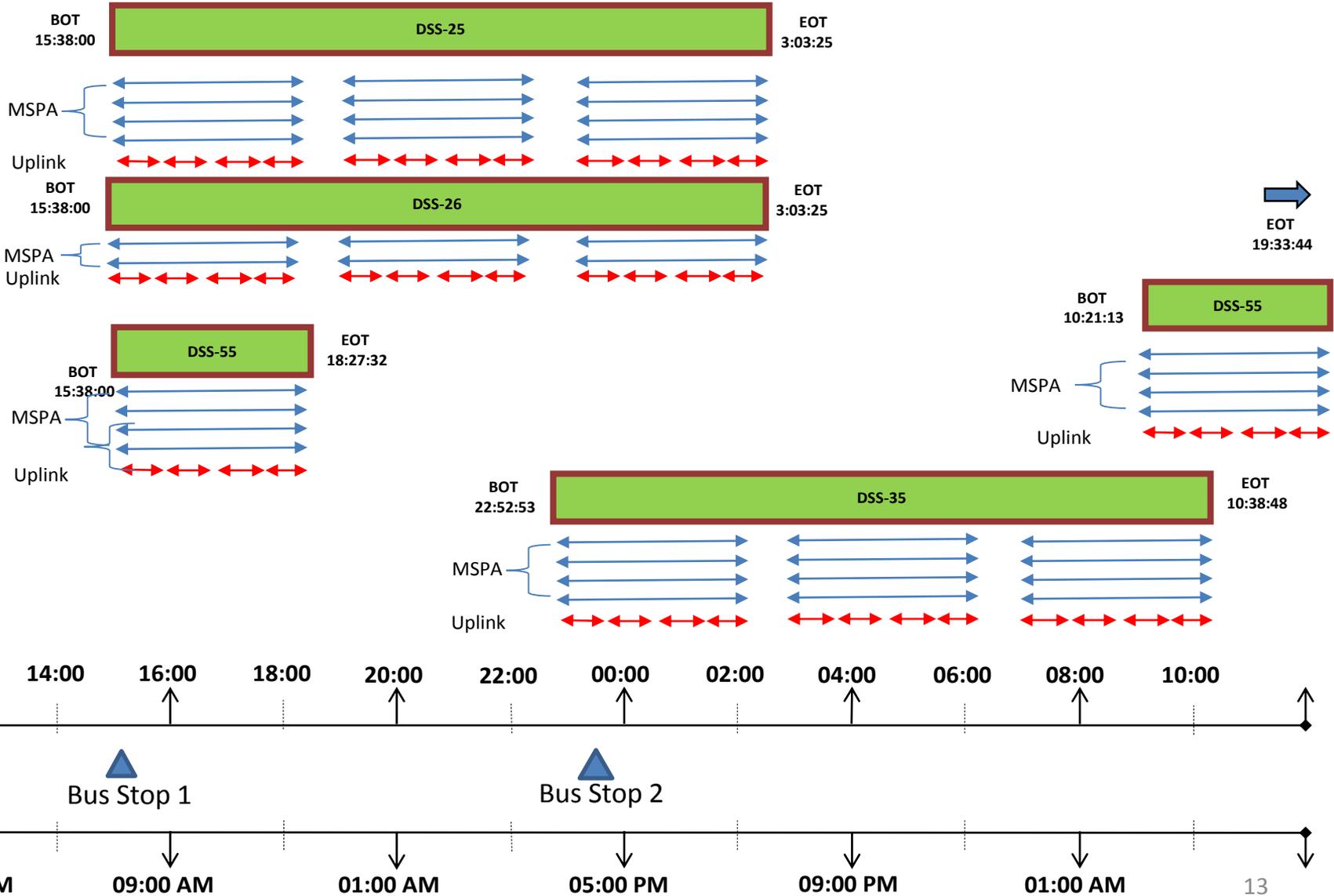
### LEVEL



## Antenna split resources Strategy Preliminary

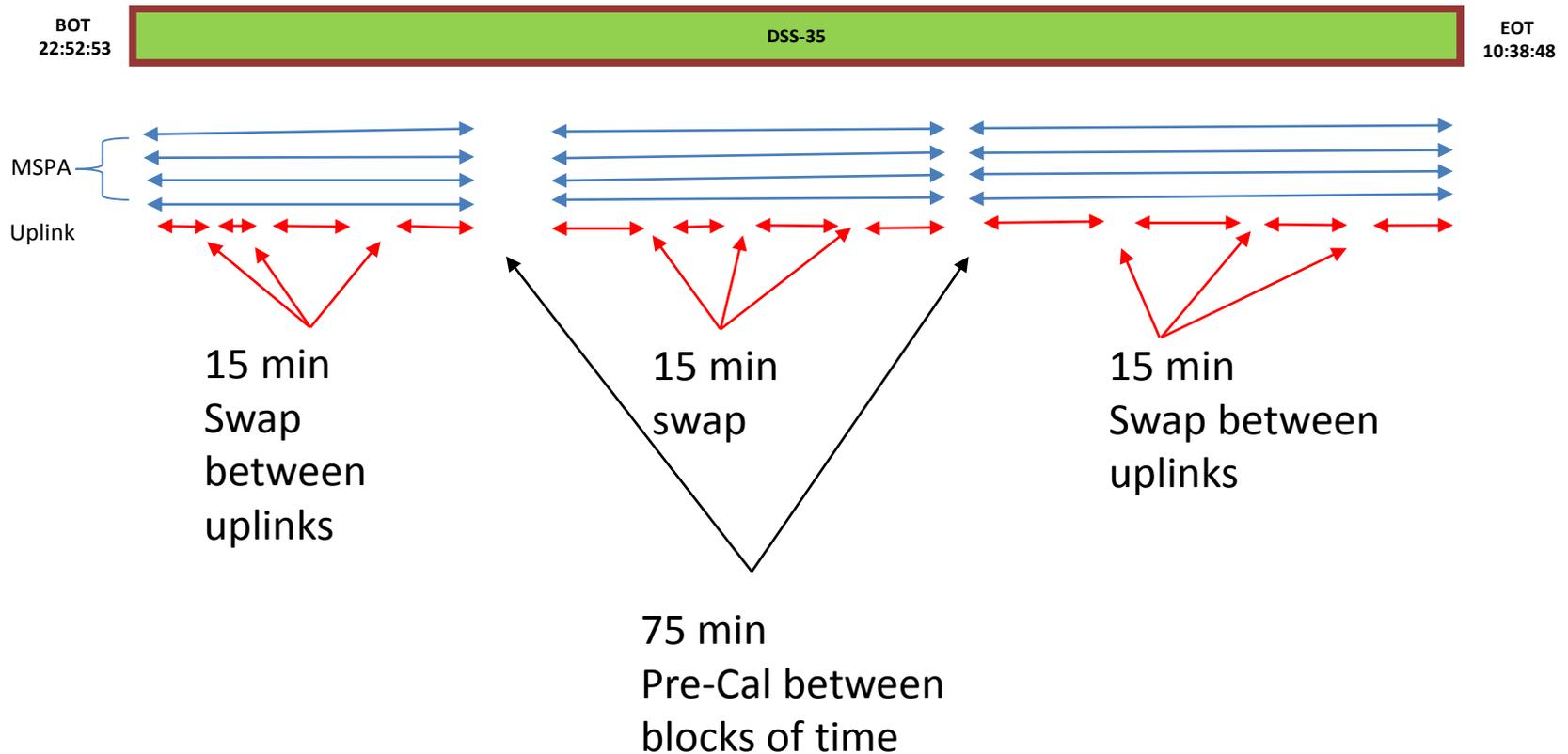
- **The Assumption is that the Orion will require 2 S-band antennas at each complex. One prime and one hot back up. With this assumption, there could be 2 antennas at Goldstone, and 1 antenna each at Canberra and Madrid available to support X-Band CubeSat's.**
- **There will be one antenna at each complex at Goldstone, Canberra and Madrid that will be able to support 4 space craft downlink, know as Multiple Spacecraft Per Aperture (MSPA) per scheduled block of time.**
- **This MSPA antenna can only support one uplink at time, but will be able to switch uplinks between up to 4 different spacecraft per scheduled block of time. Time swap uplinks is currently estimated to be 10 minutes.**
- **Between blocks of time, there will be a 75 minute pre calibration time (setup time). In the example of Goldstone where they could be 2 antennas scheduled for the CubeSat's support, one antenna would be set up with the 4 MSPA, the other antenna would support 2 MSPA.**
- **In the example of Canberra and Madrid, there would there would be one antenna each configured for 4 MSPA support.**

# Antenna split resources Strategy Preliminary



# Antenna split resources Strategy Preliminary

Details for a 4 spacecraft MSPA  
Note a 2 spacecraft MSPA same time between



# References

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**BACK UP SLIDES**

(To be used as a Guide only. Note Cubequest challengers schedule will be condensed as appropriate )

- **Launch minus 2 years: DSN Task Plan**
  - DSN User Loading Profile (ULP) provided by Mission
  - DSN Aperture Fee (Attributed cost only, not paid by Mission) developed together by Mission and MIM
  - DSN Tracking Telemetry & Command (TT&C) Costs provided by MIM
  - DSN MIM Costs provided by MIM
  - RF Compatibility costs provided by MIM
  - Communication Line (data/voice interface to JPL) cost if applicable provided by MIM
- **2 years out: Frequency Spectrum License submission (submitted by Mission, with DSN Spectrum office assistance dependent upon frequency band – DSN or Near Earth?)**
  - Spacecraft Trajectory information provided by Mission Navigation
  - Ground Stations that possibly may support provided by Mission
    - (recommend including Morehead State 21-meter antenna)

(To be used as a Guide only. Note Cubequest challengers schedule will be condensed as appropriate)

- **2 years out: Spacecraft ID** (DSN MIM can coordinate request)
  - CCSDS Spacecraft ID request
    - Reference <http://sanaregistry.org/r/spacecraftid/spacecraftid.html>
  - CCSDS version number
    - Reference CCSDS 320.0-B-6 Blue Book
    - Recommend version 1 (version 2 acceptable)
  - DSN Spacecraft ID
    - Reference DSN Doc 8201-13 Ops-6-21
- **2 years to 1 year: out DSN Service Agreement (DSA)** developed together by Mission and MIM
  - Draft DSA at Preliminary Design Review (PDR)
    - Includes Spacecraft Telecommunication parameters
    - Includes selection of DSN services
    - Includes DSN Costing
  - Final DSA prior to Critical Design Review (CDR)

(To be used as a Guide only. Note Cubequest challengers schedule will be condensed as appropriate)

- **2 years to 1 year out: reserve DSN Compatibility time with the DSN**
  - Input provided by Mission to the MIM who will negotiate resources as appropriate
    - With those using JPL IRIS Radio, this depends on Radio Delivery schedule. Looking around February 2017 time frame.
- **1 year out DSN Operations Interface Control Document (OICD)**
  - Need Mission Flight to Ground ICD (FGICD) or equivalent for DSN OICD input
  - Finalization of Mission interface to DSN services
    - Final selection of interface for tracking data
    - Final selection by Mission of what entity is doing scheduling
- **1 year to 6 months out, Mission Operations Center (MOC) available to interface with the DSN for data flows**
  - Communication lines in place for data flows (data/voice), this is worked between the MIM and the Mission
  - Project Scheduling representative start working with DSN for scheduling data flows, and DSN support request

(To be used as a Guide only. Note Cubequest challengers schedule will condensed as appropriate )

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- **1 year to 6 months out RF Compatibility test**
  - DSN RF Compatibility Information sheet filed out by Mission
  - Mission provide RF Compatibility test plan
  - Mission provide files for commands and telemetry to DSN
    - Used for preparing DTF-21 and DSN configuration tables also may be used for GDS and MOS data flows
  - DSN provide RF Compatibility test plan
  - End to End data flow with Mission Operations Center (MOC) and DSN included during this RF compatibility test period
  - DSN Compatibility test results test results released 30 calendars for signature after test completion.

(To be used as a Guide only. Note Cubequest challengers schedule will be condensed as appropriate )

- **5 months out start of Ground Data System (GDS) and Mission Operation Support (MOS) tests**
  - Usually done after DSN RF Compatibility test which includes the End to End data flow
  - Mission provided GDS test plan and requirements
    - Usually First tests will be with DSN DTF-21 followed by GDS tests with actual DSN stations
  - Mission GDS Schedule inputs for DSN Station tests about 1-2 months of starting GDS and MOS tests
- **1 month out launch rehearsal**
  - Submit schedule request to DSN for rehearsal about 2-3 months out
  - About 2 months out submit to DSN rehearsal plan (draft)
- **1 month out DSN Small Sat Readiness Review (SSRR) at JPL**
  - This is a DSN Peer review for readiness of the DSN to support launch/first acquisition of spacecraft

# DSN Mission Interface Document Tree

*DSN Controlling Documents*

DSN Service Catalog  
820-100

DSN Telecom Link Design  
Handbook 810-005

DSN Software Interface  
Specs 820-13

*Generic Mission Document*

DSN Mission Service Interfaces, Policies  
and Practices (MSIPP)  
875-001

**Service Agreement  
(DSA/PSLA)  
870-xxx**

**Mission-Specific Documents  
(signed by Project and DSN)**

**DSN- Operations Interface  
Control Document (OICD)  
875-xxx**

*DSN Internal Documents Mission-Specific*

DSN Mission specific  
Compat Test Plan,  
Procedures, Report  
872-xxx

DSN Network  
Operations Plan  
Mission Specific  
871-xxx

# Key Personnel

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- **Mission Interface Manager (MIM)**
  - the mission's agent to optimize DSN technical support and align customer service request with DSN standard services
- **Project Data System Engineer (PDSE)**
  - DSN processing lead for data delivery
- **Network Operations Project Engineer (NOPE)**
  - operational lead for DSN support
  - supported by team of operators, analysts (NOA), engineers (CDE, OE)
- **Mission Manager**
  - interacts with DSN to prepare and execute telecomm
- **Mission Scheduler**
  - the mission's agent to plan provide inputs and negotiate DSN tracking schedule
- **Mission Navigation**
  - Navigation that interact with DSN for delivering SPK (type 13) files for DSN support products (view periods, frequency predictions, antenna pointing)

# Important References

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- **DSN Commitments Office Website**
  - <http://deepspace.jpl.nasa.gov/advmiss/index.html>
- **DSN Mission Service Interfaces, Polices, and Practices (MSIPP) (875-0001)**
  - <https://pdms.jpl.nasa.gov/cmtools/DocProperties.aspx?objid=ydvnI2eent001sum70a--M5Y>
- **DSN Services Catalog (820-100)**
  - [http://deepspace.jpl.nasa.gov/advmiss/docs/DNS\\_Service\\_Catalog\\_820-100-E.pdf](http://deepspace.jpl.nasa.gov/advmiss/docs/DNS_Service_Catalog_820-100-E.pdf)
- **DSN Telecommunications Link Design Handbook (810-005)**
  - <http://deepspace.jpl.nasa.gov/dsndocs/810-005/index.cfm>
- **DSN External Interface Specification (820-013)**
  - <https://jaguar.jpl.nasa.gov/>