Juno

A Jupiter Polar Orbiter

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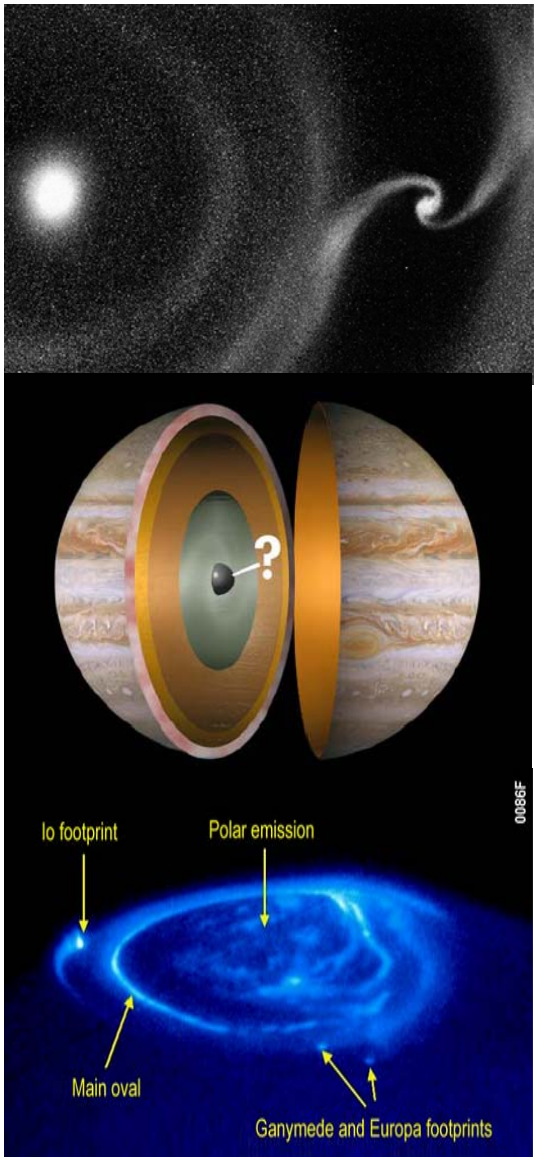
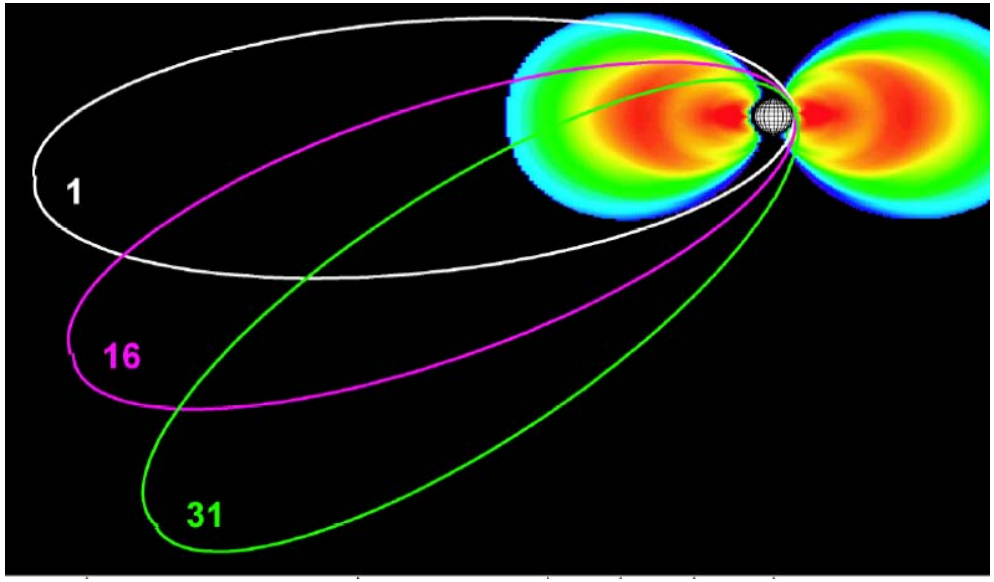
Juno will improve out understanding of the solar system by helping us understand the origin and evolution of Jupiter:

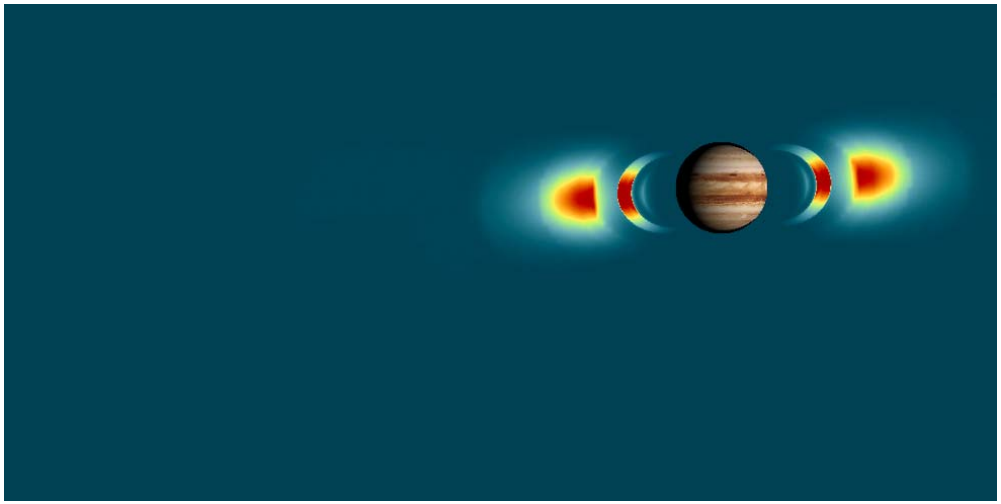
- Origin
  - Determine O/H ratio (water abundance) and constrain core mass to decide among alternative theories of origin.
- Interior
  - Understand Jupiter's interior structure and dynamical properties by mapping its gravitational and magnetic fields.
- Atmosphere
  - Map variations in atmospheric composition, temperature, cloud opacity and dynamics to depths greater than 100 bars.
- Polar Magnetosphere
  - Explore the three-dimensional structure of Jupiter's polar magnetosphere and aurorae.



Suite of instruments will collect data on:

- Jupiter's Gravity Field
- Jupiter's Magnetic Field
- Deep Atmosphere
- Aurora/Magnetosphere

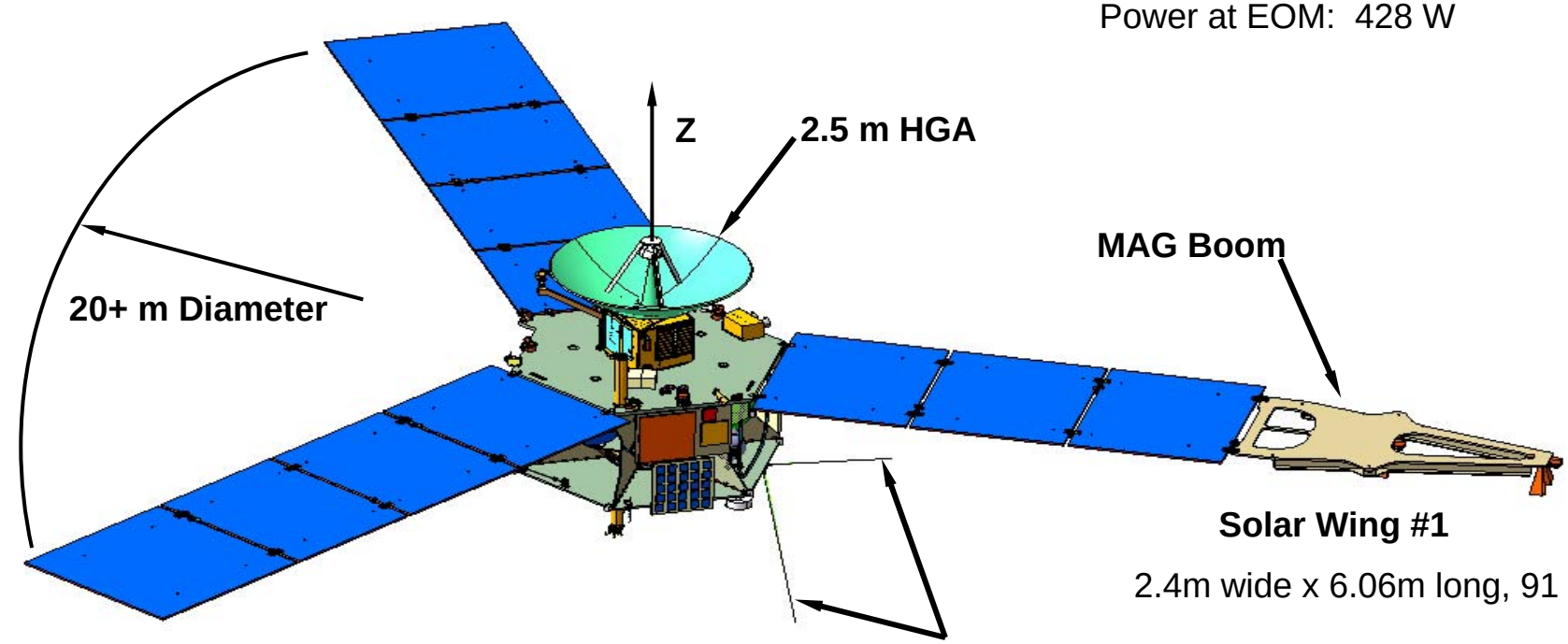




Gravity Science (JPL)
Magnetometer— MAG (GSFC)
Microwave Radiometer— MWR (JPL)
Energetic Particle Detector—EPD (APL)
Jovian Auroral Distributions Experiment— JADE (SwRI)
Waves (U of Iowa)
UV Spectrometer— UVS (SwRI)
Infrared Camera - JIRAM (ASI)
Visible Camera - JunoCam (Malin)

Juno Spacecraft Characteristics

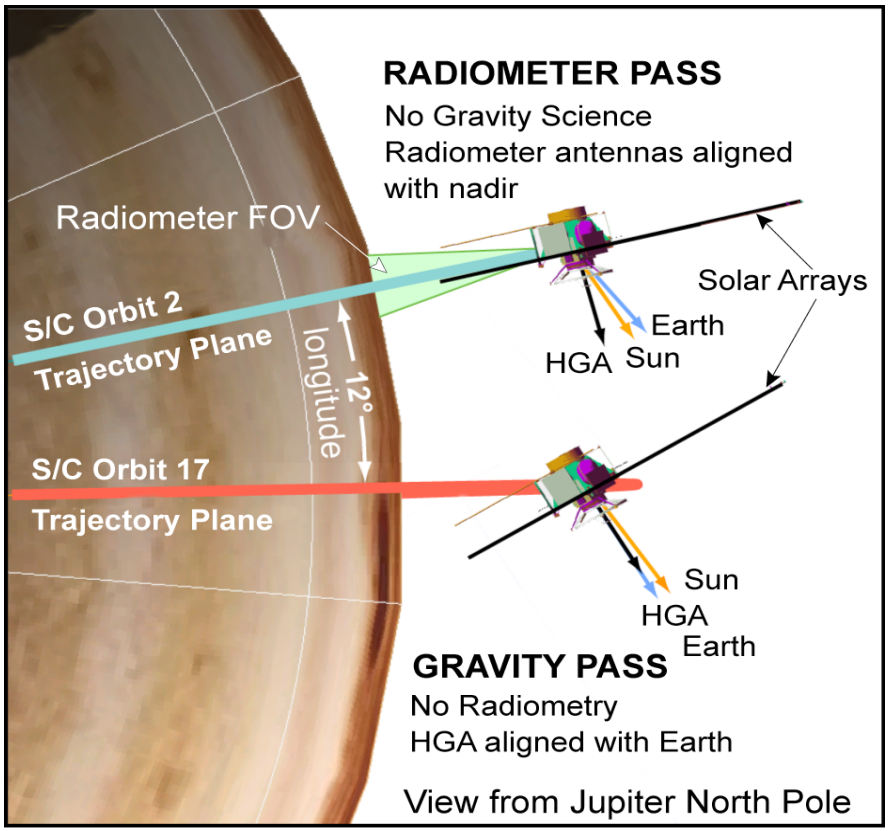
Power at 1 Au (theoretical): 15 kW
Power at JOI: 486 W
Power at EOM: 428 W



2.4m wide x 6.06m long, 91 Kg

Spacecraft: ~1600 Kg dry mass; 3625 kg wet mass

Science Orbits



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Two basic science modes for science orbits:

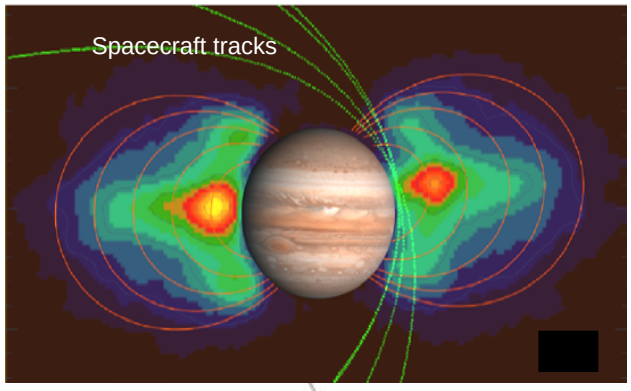
- **Radiometer science mode**
  - **gravity science off, rest of instruments on**
- **Gravity science mode**
  - **MWR, JIRAM, JunoCam off, rest of instruments on**

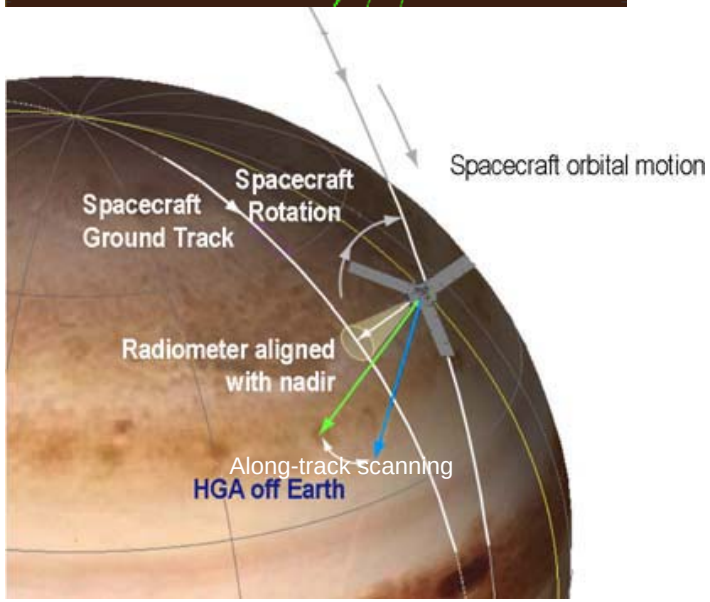
MWR determines water content and maps deep atmospheric dynamics

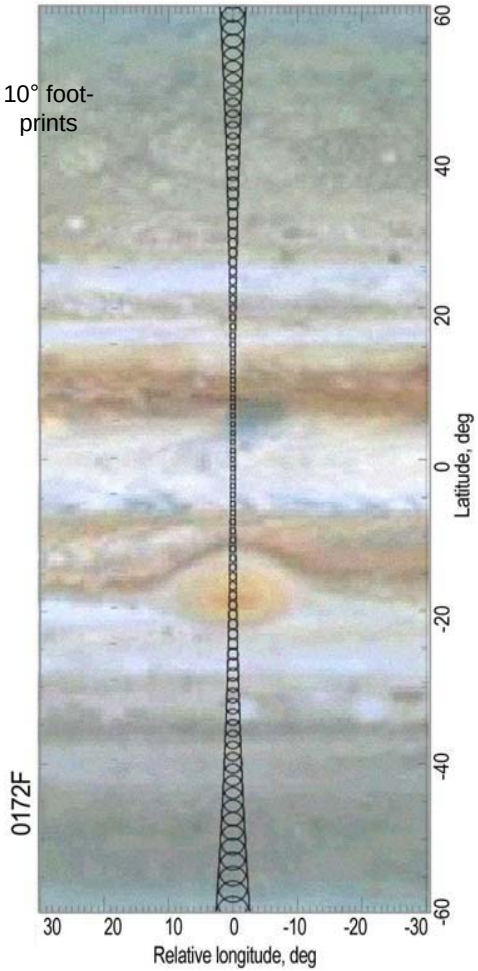
Jnique microwave measurements obtained

- **Avoids synchrotron**
- **High spatial resolution**

Emission angle dependence uniquely measured by along-track scanning

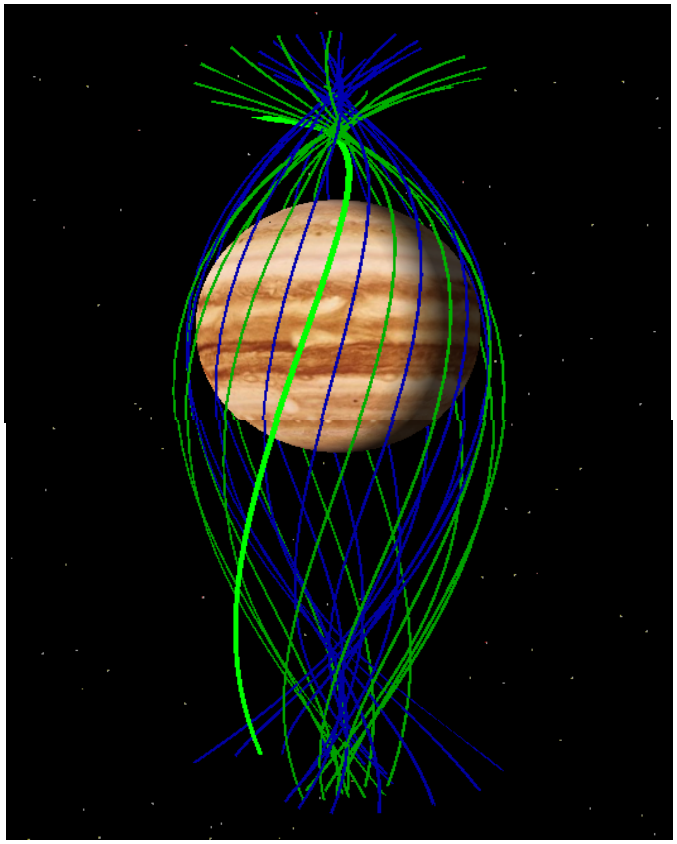


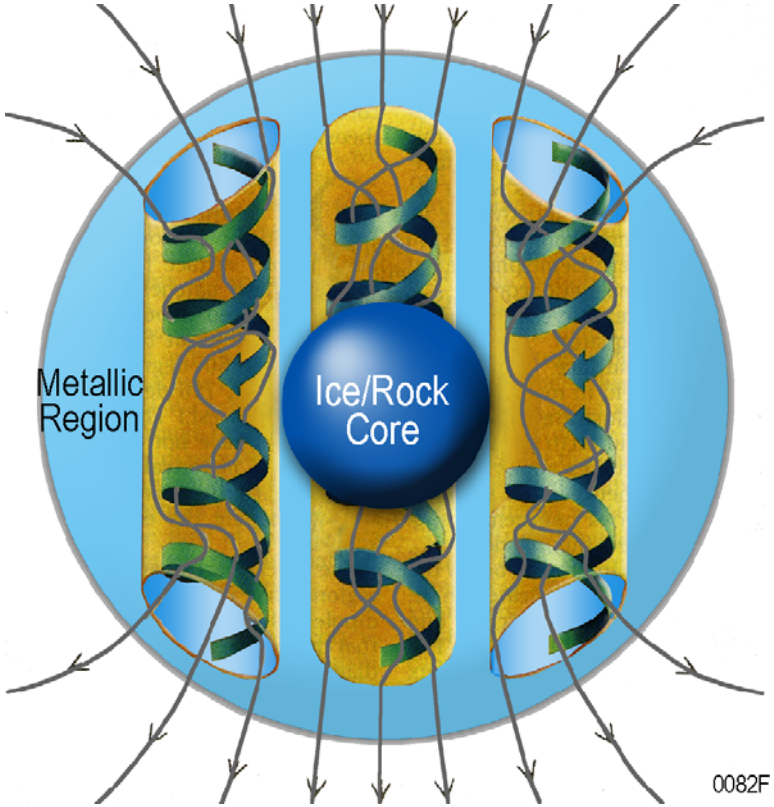




Juno's fundamental dynamo investigation has broad application

Juno's polar orbit provides complete mapping of planet's asymmetric and highly structured field





Precise magnetic field measurements unveil fundamental dynamo process

For Juno, Radio (Gravity) Science is part of Level 1 science

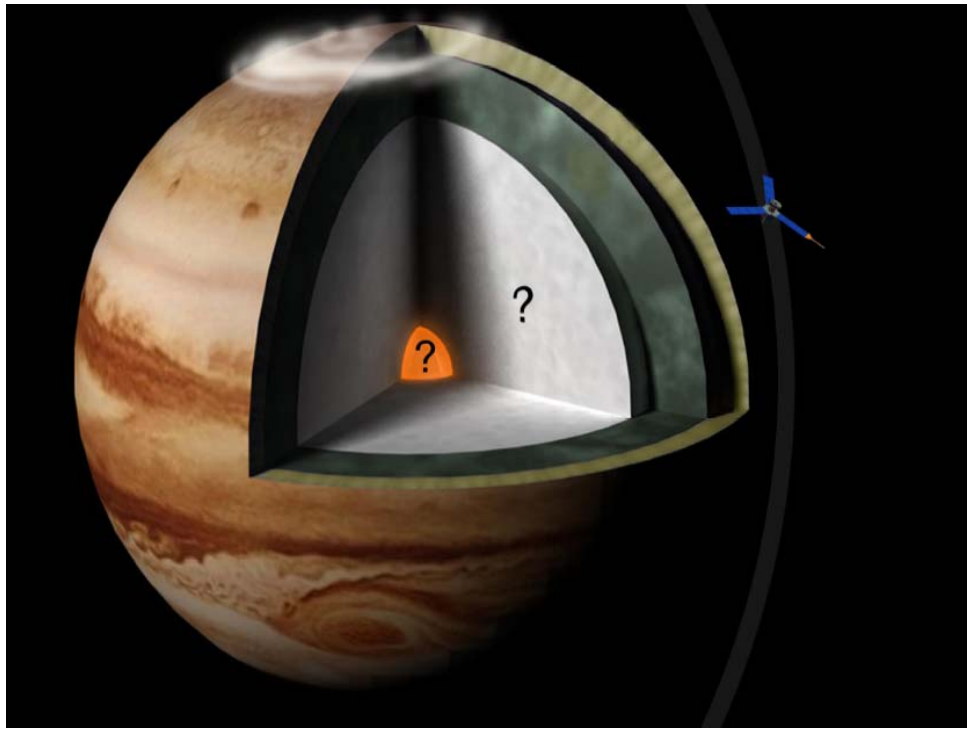
Precise Doppler measurements of spacecraft motion measure gravity field

Gravity field tells us about how the mass is distributed inside the planet

Tides provide further clues

X-Band and Ka-Band two-way Doppler from Goldstone

Water Vapor Radiometer to reduce atmospheric error contribution



Polar Magnetospheric Exploration

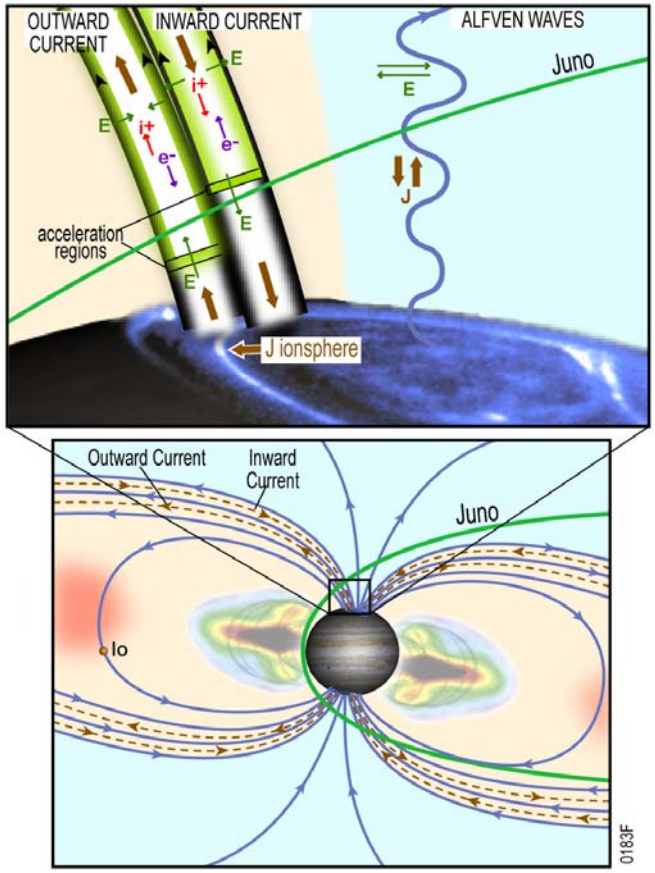
Location, Location, Location !

Juno passes directly through auroral field lines

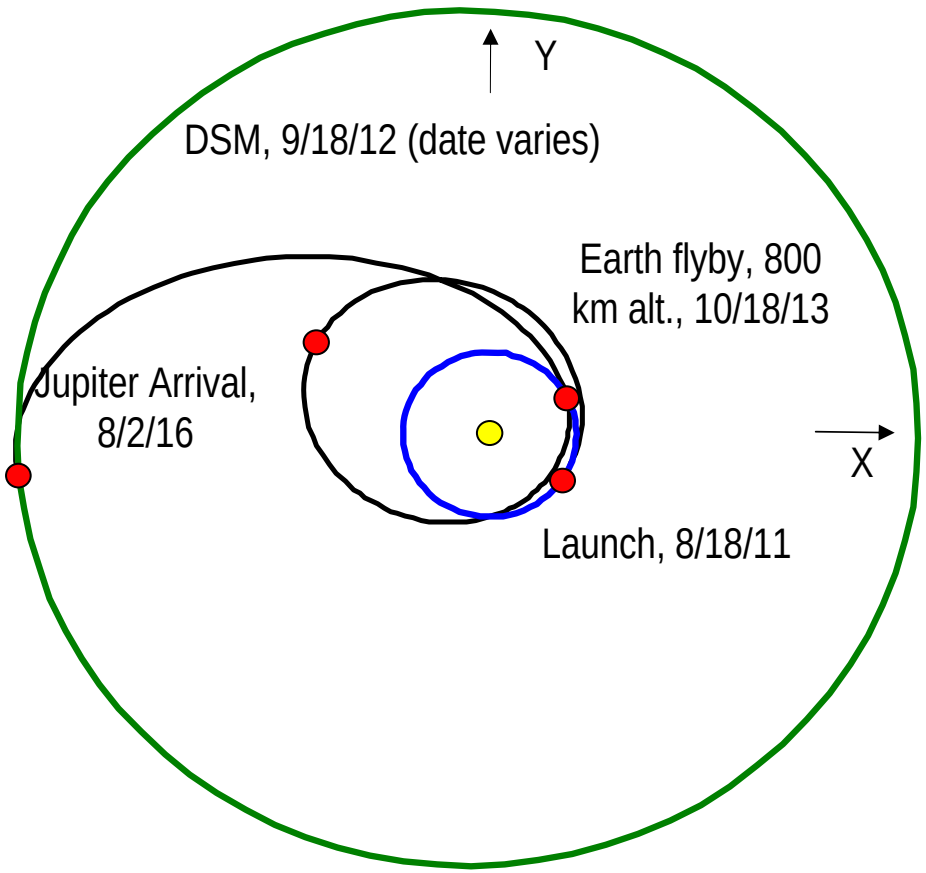
Measures particles precipitating into atmosphere creating aurora

Plasma/radio waves reveal processes responsible for particle acceleration

UV, IR images provides context for *in-situ* observations



Interplanetary Trajectory



View from above ecliptic plane with ecliptic X to right

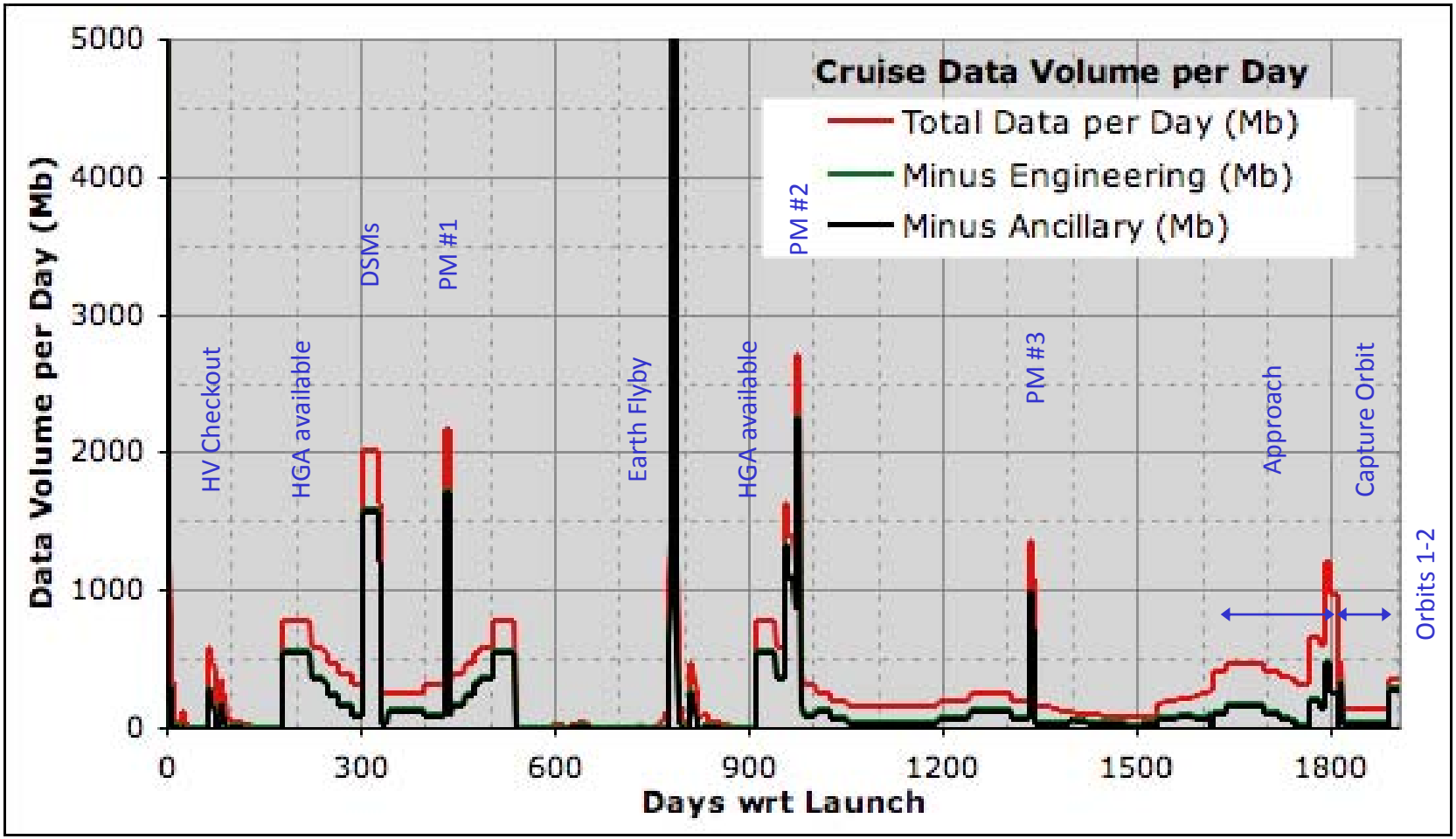
- Deep Space Maneuver (DSM)
  - 2 main engine burns, 33 minutes each
- Rehearsal for JOI (main engine, toroidal antenna)
- Earth flyby in October 2013
  - 800 km altitude
  - Rehearsal for Jupiter PJ science
- Jupiter arrival 8/3/16, L+5 yrs

Mission Animation

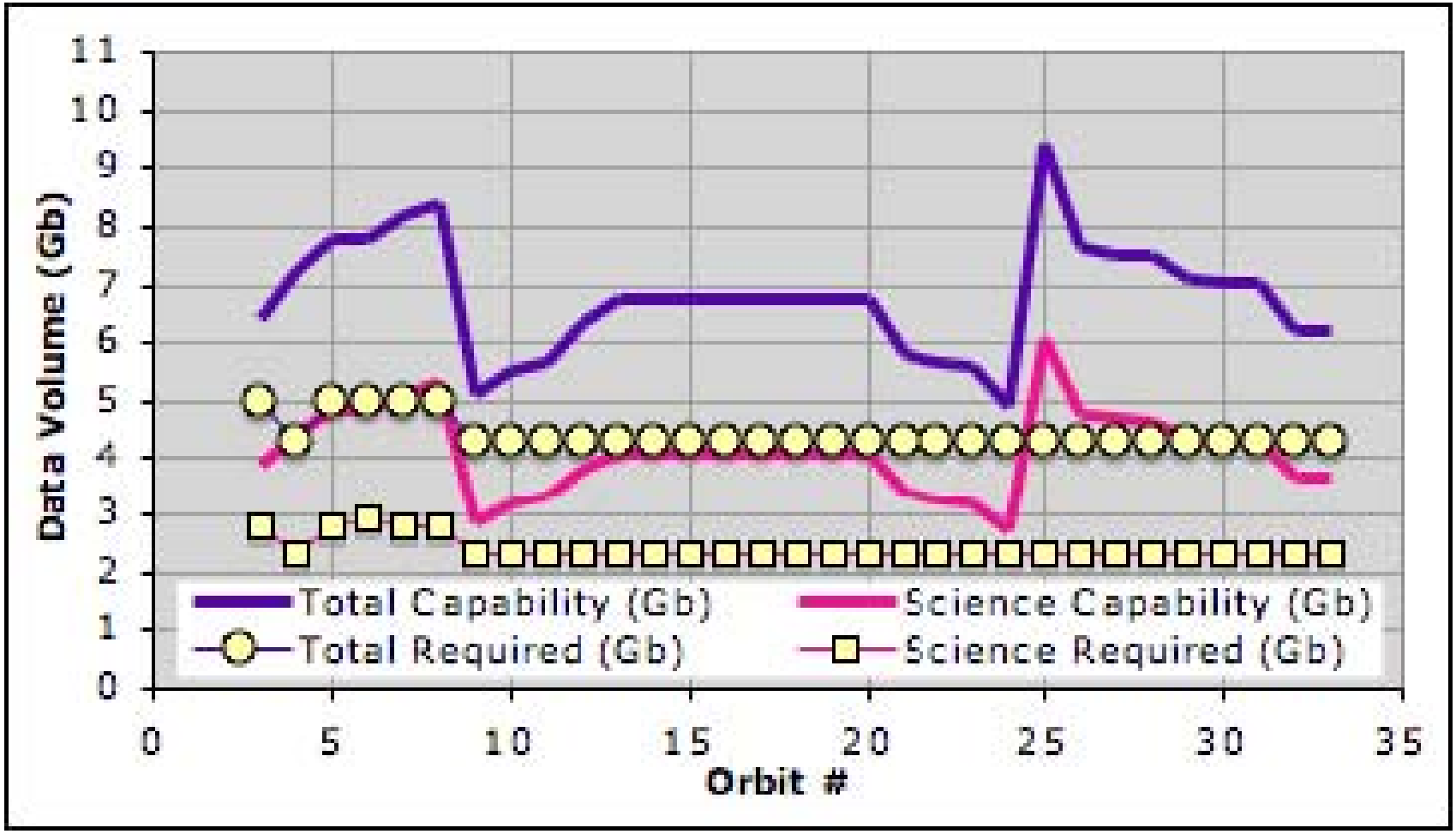
Key DSN and Data Return Characteristics

- **FS Antennas: HGA, MGA, F-LGA, A-LGA, Toroidal-LGA**
  - HGA used primarily at Jupiter, but available during Cruise
  - MGA, LGAs (F-, A-, Toroidal) used during cruise, near-Earth, and during maneuvers
  - Toroidal LGA used for tones during main engine burns (DSMs, JOI, PRM)
- **Telemetry: Turbo and R-S encoding mapped to data rates, X-band (no Ka-Band Telemetry)**
  - Retransmission used to meet data completeness requirements
- **Data Rates:**
  - Safe mode: 10 bps - 40 bps minimum
  - Cruise: 100 bps - 200K bps
  - Orbital Operations: 18K-50K bps into a 34m BWG, 12 kbps into DSS-25 during Gravity Science, max 200K bps into a 70-m
  - Command: 2K bps maximum
- **Navigation**
  - Cruise: Doppler, Range, DDOR
  - Orbital Ops: Doppler, Range
- **DSN antenna usage:**
  - 34-m net is prime, DSS-25 required for Ka up/down for gravity science
  - 70-m net (or equivalent) required for Tones reception over T-LGA, safe mode recovery, minimum science data return
  - Continuous coverage for: L to L+30 days, JOI-30 days to JOI
  - Critical event coverage: Initial Acquisition over Canberra, 70-m Goldstone/Canberra overlap for JOI
  - Orbital operations: 6 passes / 11 days, one of these passes is 70-m for early and late orbits.

Cruise Downlink Capability



Science Orbits Downlink Capability

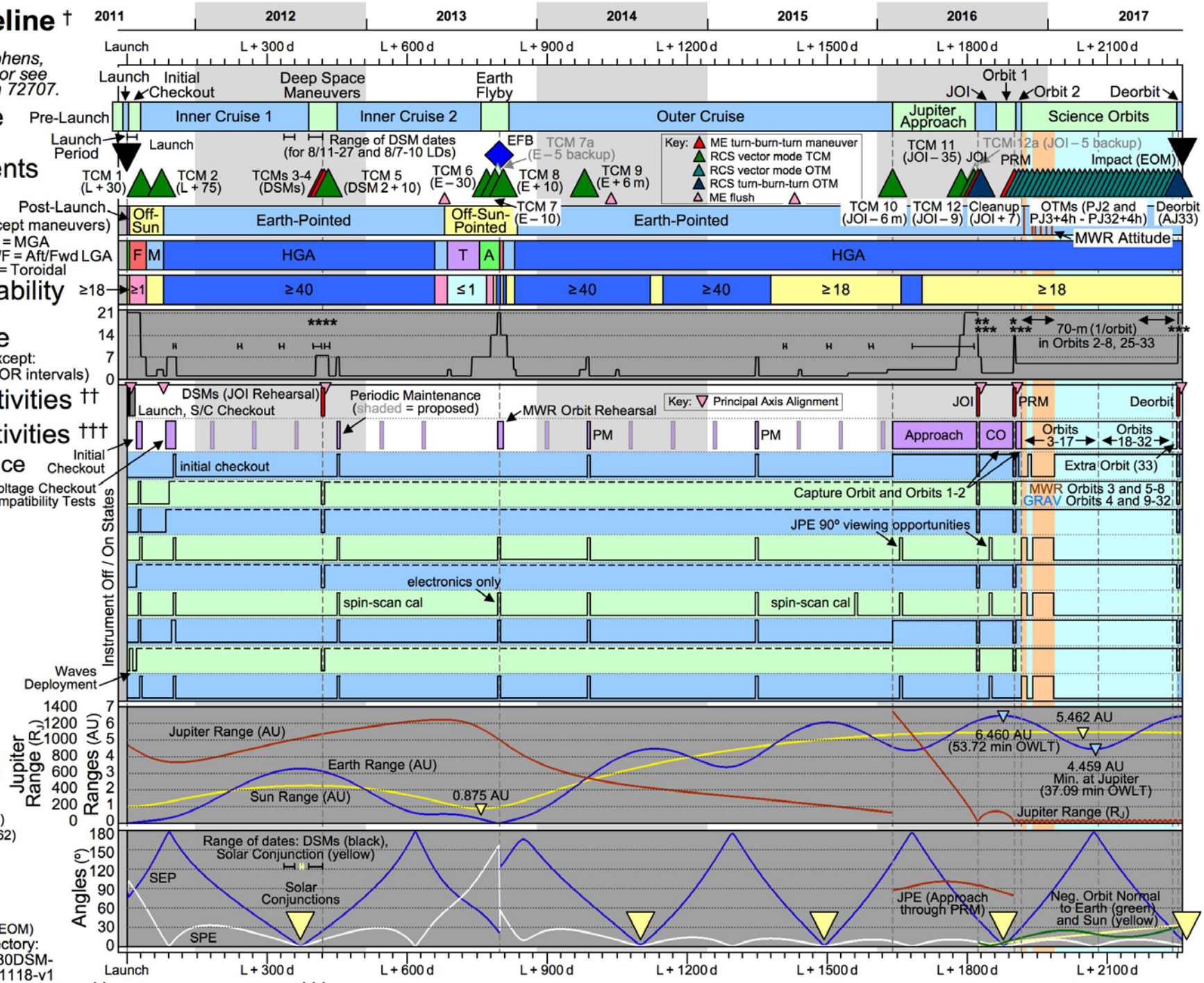


Backup Slides

Juno Mission Timeline †

1/13/2009

Contact Stuart Stephens, JPL 818-393-7807, or see DocuShare Collection 72707.



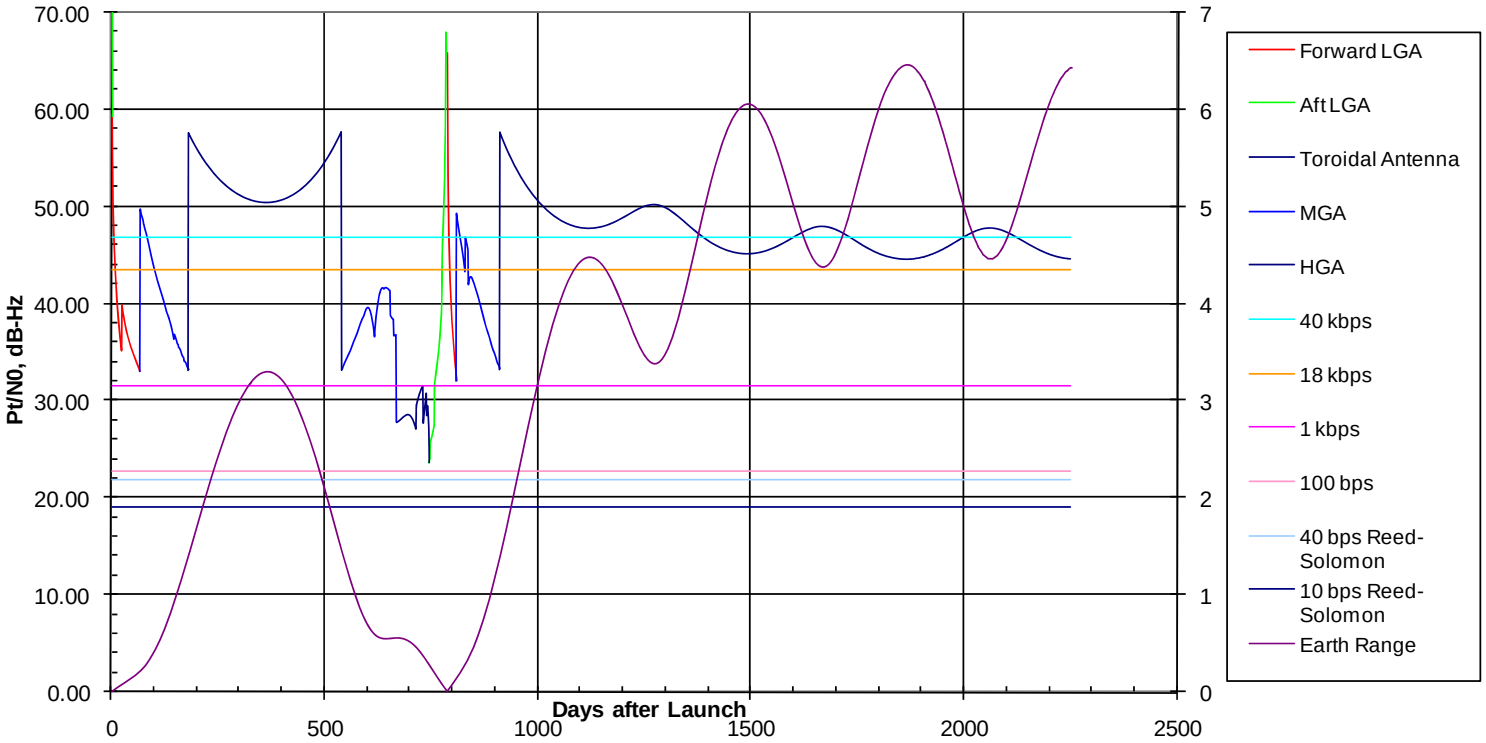
Launch = 8/7/11
DSM 1 = 9/28/12 (L+418)
DSM 2 = 9/30/12 (L+420)
EFB = 10/12/13 (L+797)
JOI = 8/3/16 (L+1823)
PRM = 10/19/16 (L+1900)
Impact = 10/16/17 (L+2262)
Solar conjunctions:
8/12/12 (L+371)
8/10/14 (L+1099)
9/8/15 (L+1493)
9/26/16 (L+1877)
10/26/17 (L+2272, post-EOM)
Baseline reference trajectory:
110807LD-120928-0930DSM-160803AD-to-pj34-r081118-v1

† For 8/7/11 launch date, start of 21-day launch period, 8/7 - 8/27.

†† Selected spacecraft activities. ††† In-work. PMs are required yearly; proposed PMs are shaded. Proposed continuous F&P cruise science is dashed. Approach and Early Orbits science is baselined but TBD. GRAV, JIRAM, MWR, UVS, and JunoCam are off for whole orbits or part of each orbit. JADE, JEDI, and UVS high voltages are off for TCMs and OTMs.

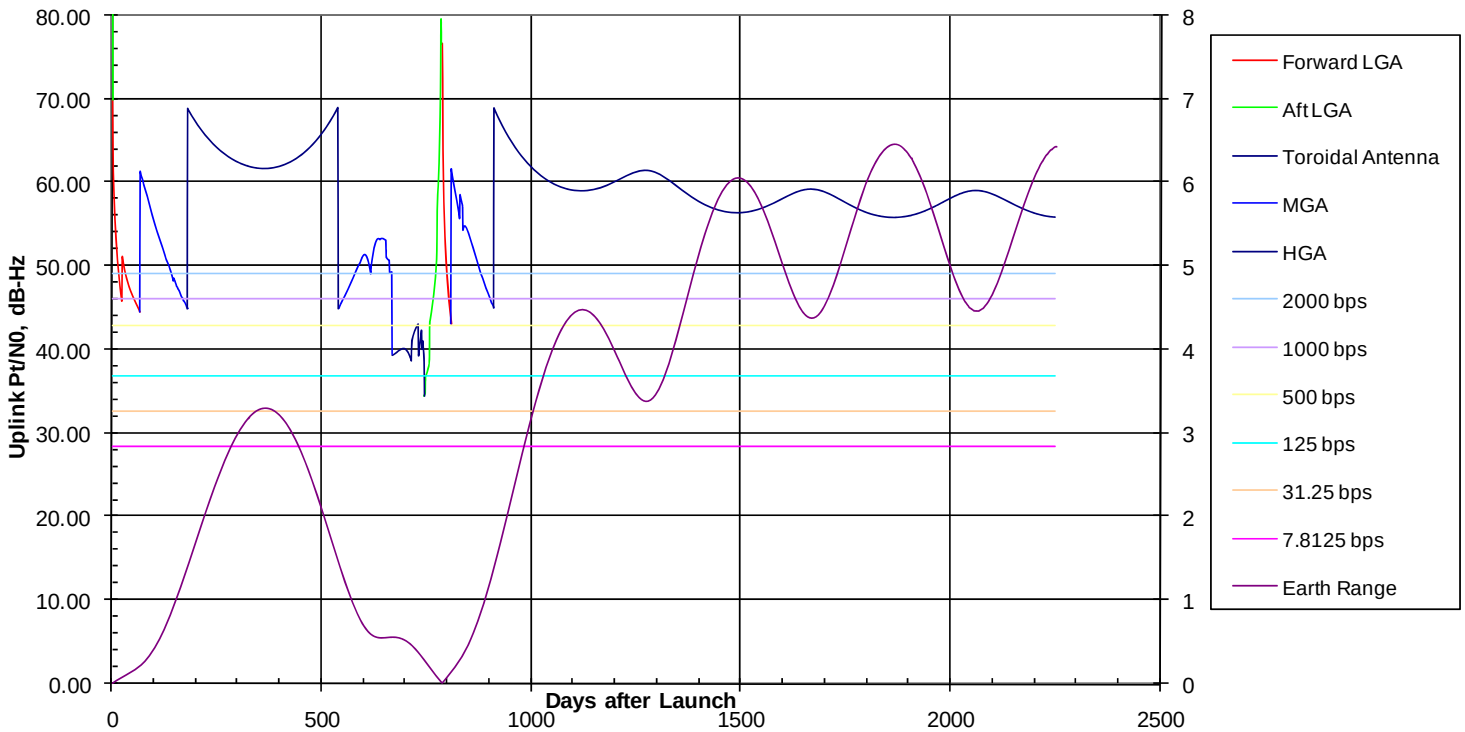
Downlink Telemetry Performance

JUNO (2011) Cruise Telecom Performance to DSS 34,
15 deg elevation angle, 2 sigma margin
PRM is Day 1889
3 dB coupler for Forward and Aft LGAs
Wider TLGA pattern



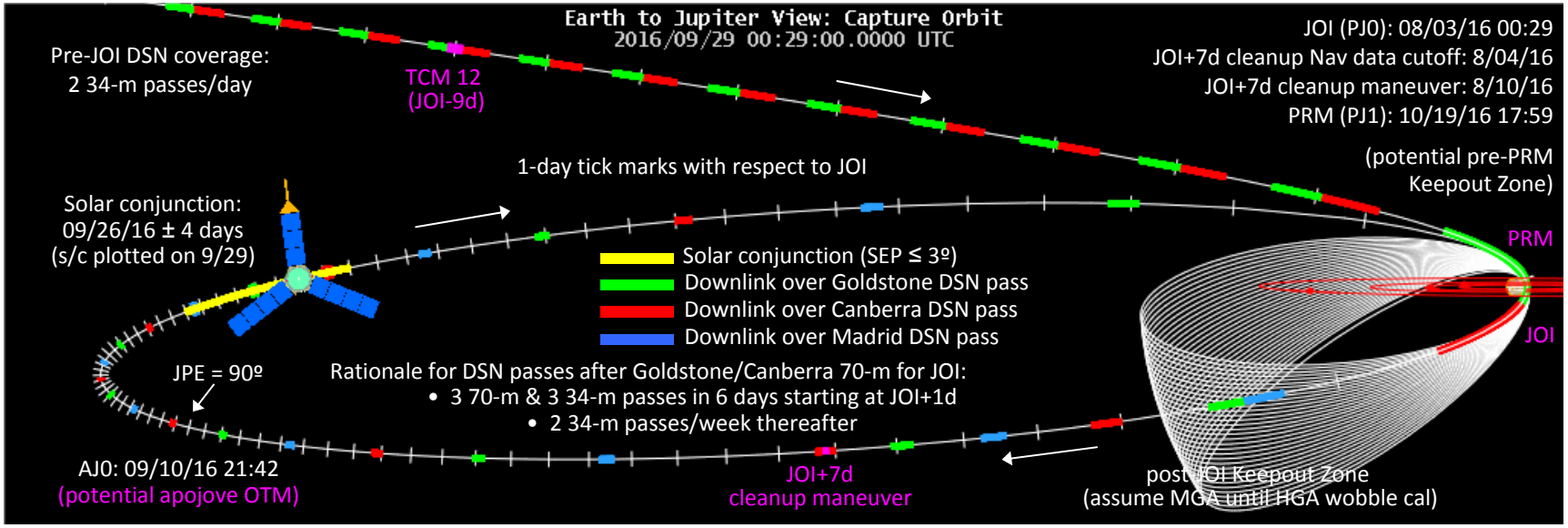
Uplink Command Performance

JUNO (2011) Cruise Uplink Performance from DSS 34,
15 deg elevation angle, 2 sigma margin, 3 dB ranging suppression
PRM is Day 1889
3 dB coupler for Forward and Aft LGAs
3 dB hybrid in lieu of coax switch

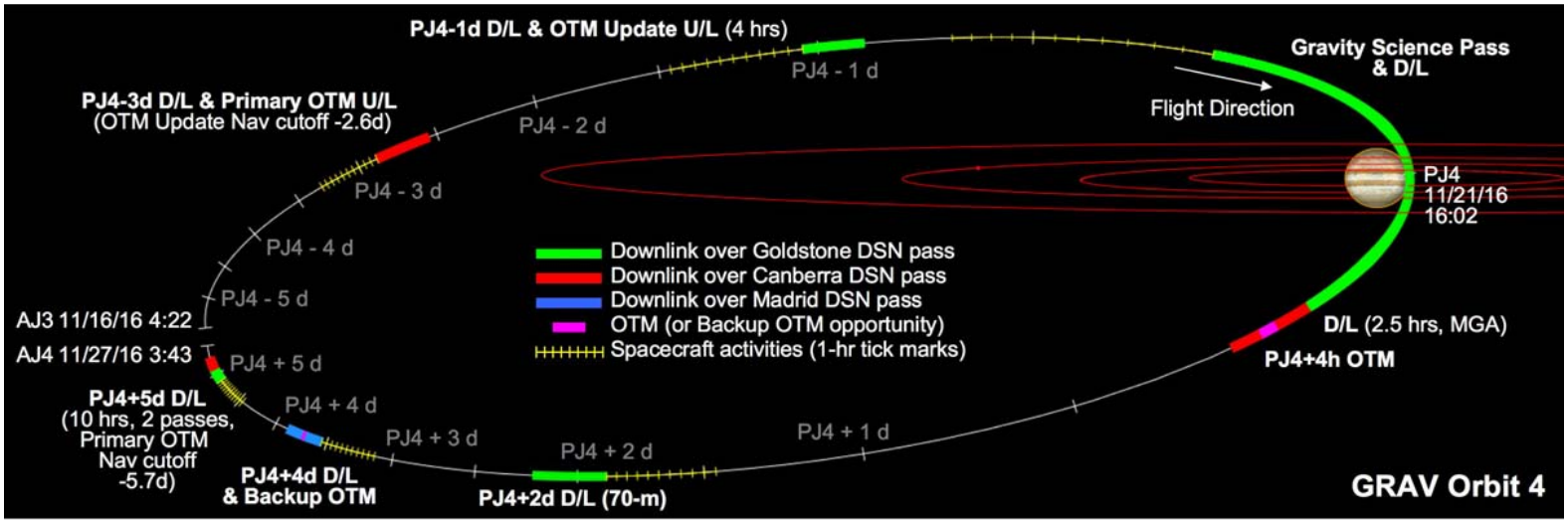


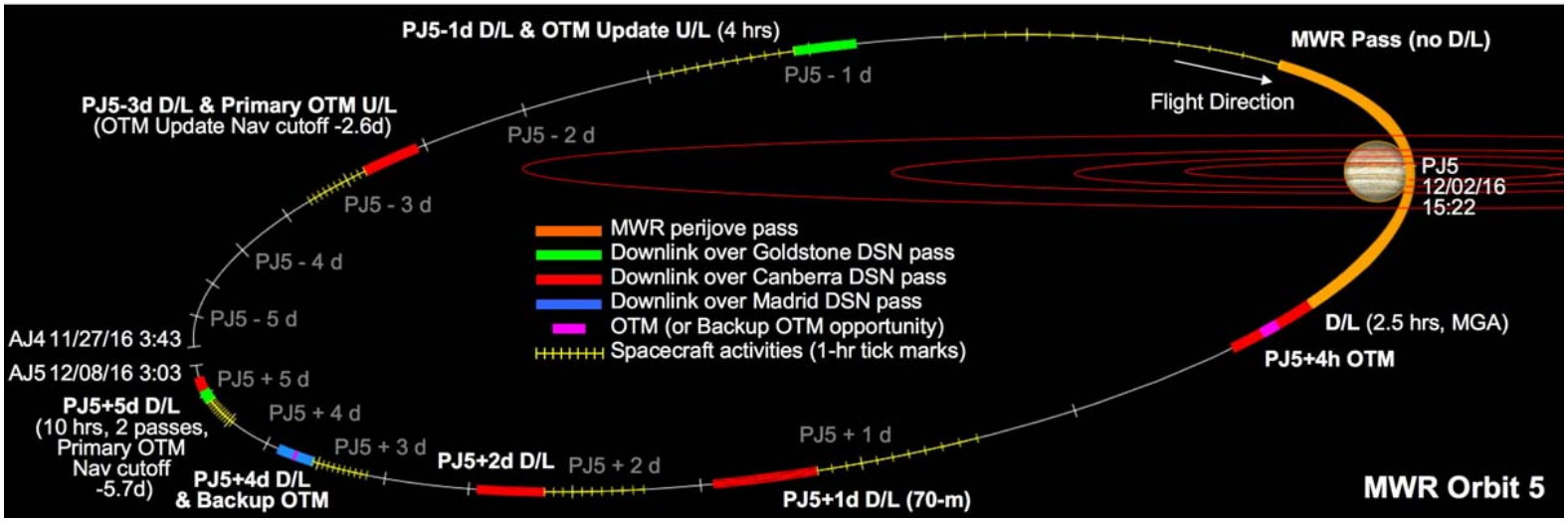
Capture Orbit [1/2]

- 78-day Capture Orbit geometry (Orbit 0 + 1st half of Orbit 1) :

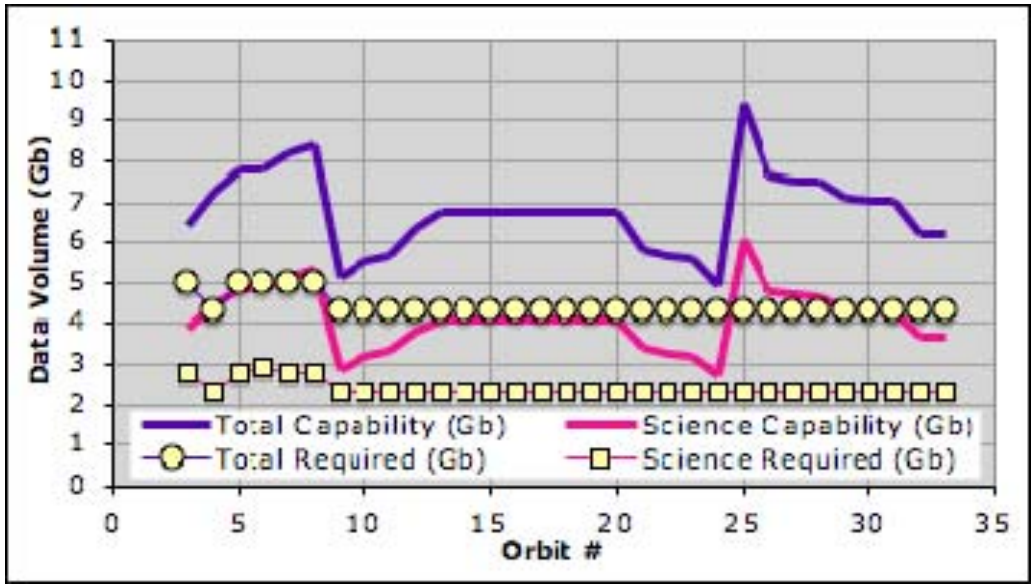


Orbit Templates

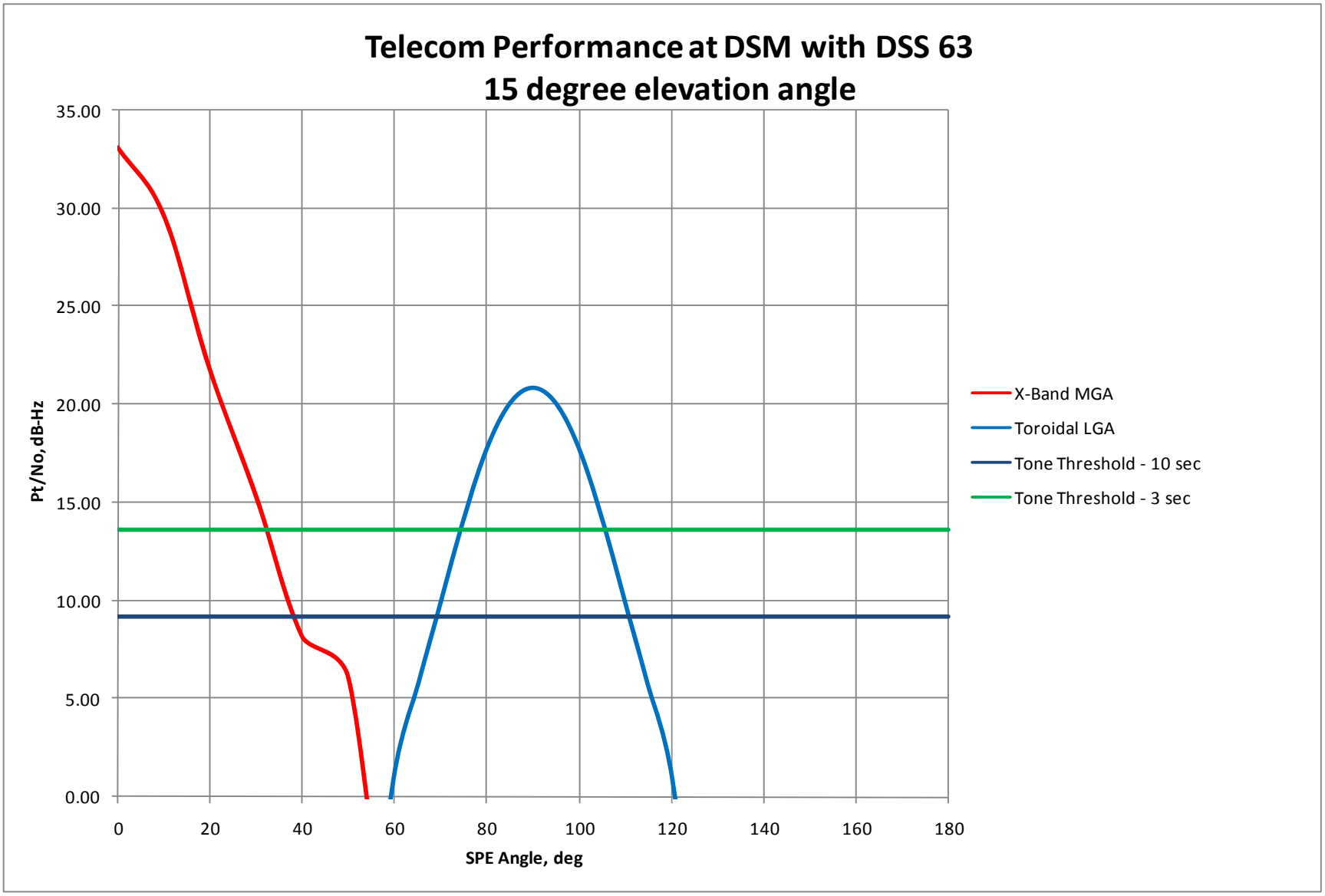


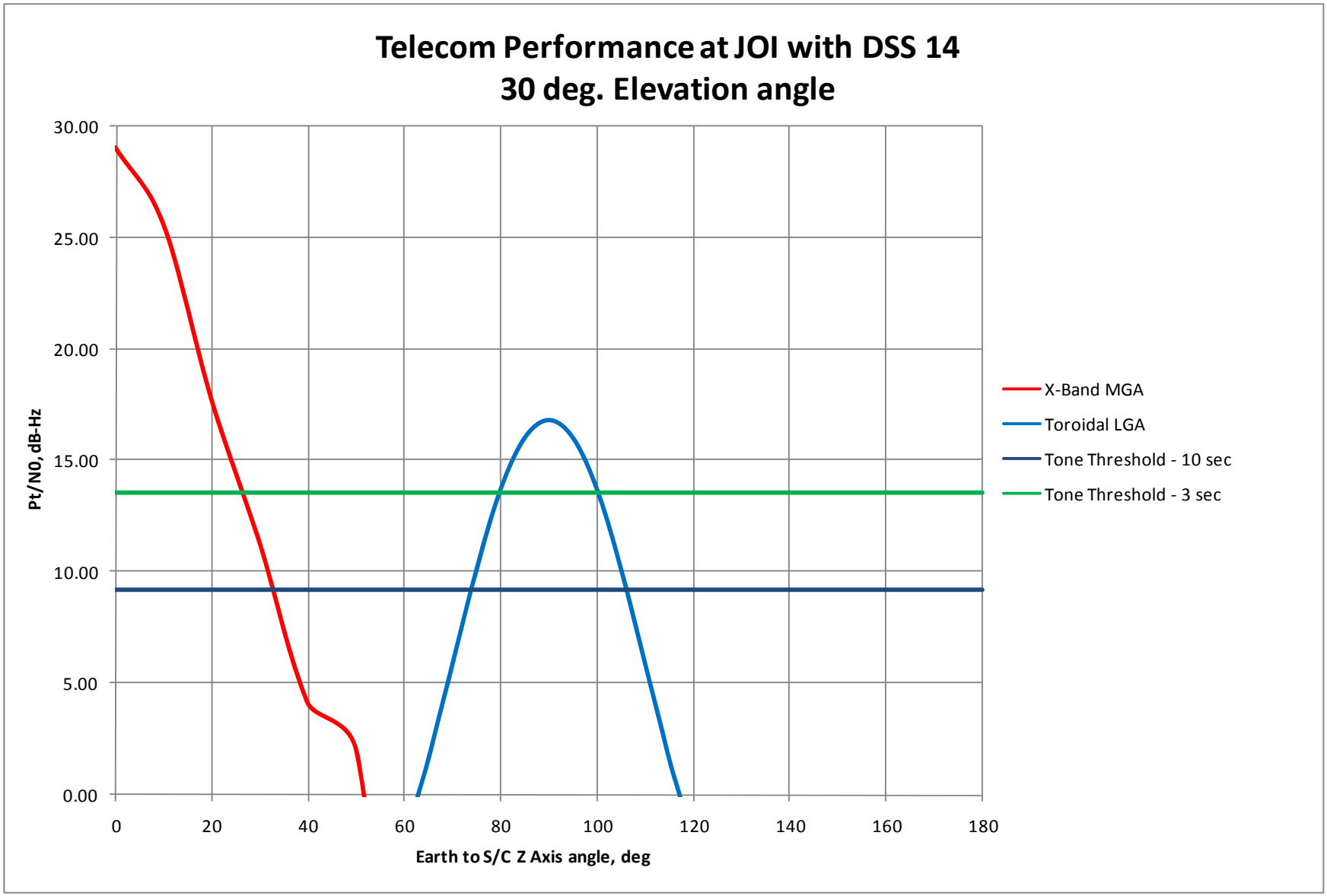


Downlink Capability



Orbit		70-m?	Data Volume (Gb = 1e9 bits)			
			Capability		Requirement	
#	Type	(1/orbit)	Total	Science	Total	Science
3	MWR	**yes**	6.4	3.9	5.0	2.8
4	GRAV	**yes**	7.2	4.4	4.3	2.3
5	MWR	**yes**	7.8	4.8	5.0	2.8
6	MWR	**yes**	7.8	4.8	5.0	2.9
7	MWR	**yes**	8.2	5.1	5.0	2.8
8	MWR	**yes**	8.4	5.3	5.0	2.8
9	GRAV	no	5.1	2.9	4.3	2.3
10	GRAV	no	5.5	3.2	4.3	2.3
11	GRAV	no	5.7	3.3	4.3	2.3
12	GRAV	no	6.4	3.8	4.3	2.3
13	GRAV	no	6.8	4.1	4.3	2.3
14	GRAV	no	6.8	4.1	4.3	2.3
15	GRAV	no	6.8	4.1	4.3	2.3
16	GRAV	no	6.8	4.1	4.3	2.3
17	GRAV	no	6.8	4.1	4.3	2.3
18	GRAV	no	6.8	4.1	4.3	2.3
19	GRAV	no	6.8	4.1	4.3	2.3
20	GRAV	no	6.8	4.1	4.3	2.3
21	GRAV	no	5.8	3.4	4.3	2.3
22	GRAV	no	5.6	3.3	4.3	2.3
23	GRAV	no	5.6	3.2	4.3	2.3
24	GRAV	no	4.9	2.7	4.3	2.3
25	GRAV	**yes**	9.4	6.1	4.3	2.3
26	GRAV	**yes**	7.6	4.8	4.3	2.3
27	GRAV	**yes**	7.5	4.7	4.3	2.3
28	GRAV	**yes**	7.5	4.7	4.3	2.3
29	GRAV	**yes**	7.1	4.4	4.3	2.3
30	GRAV	**yes**	7.0	4.3	4.3	2.3
31	GRAV	**yes**	7.0	4.3	4.3	2.3
32	GRAV	**yes**	6.2	3.7	4.3	2.3
33	GRAV	**yes**	6.2	3.7	4.3	2.3


Telecom Performance at DSM with DSS 63
15 degree elevation angle
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Pt/No, dB-Hz
0
20
40
60
80
100
120
140
160
180
SPE Angle, deg
X-Band MGA
Toroidal LGA
Tone Threshold - 10 sec
Tone Threshold - 3 sec


Telecom Performance at JOI with DSS 14
30 deg. Elevation angle
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Pt/N0, dB-Hz
0
20
40
60
80
100
120
140
160
180
Earth to S/C Z Axis angle, deg
X-Band MGA
Toroidal LGA
Tone Threshold - 10 sec
Tone Threshold - 3 sec

Telecom Performance

	Case	SC Antenna	SC Pointing	Coding	Earth Antenna	Data Rate	Margin over 2 sigma w/o Ranging	Margin over 2 sigma w/ Ranging	Comment
High Rate									
	Science Data Downlink	HGA	Earth	Turbo-Long Frame	Any 34m	18 kbps	1.45	1.15	DSS 34, 15 deg. elev angle, 6.4597 AU, L+2250, 0.25 deg. HGA pointing
	Ka Science	HGA	Earth	N/A	DSS 25	N/A	1.37	N/A	DSS 25, 21.9 deg. elev angle, 6.26 AU, Orbit 31, 0.25 deg. HGA pointing
Main Engine Maneuvers									
	DSM	Toroidal	DSM attitude	N/A	DSS 63	tones-3s	3.91	N/A	3 seconds, assume 10 degrees off, 15 deg. elev angle, 3.155 AU, new TLGA pattern
	DSM	Toroidal	DSM attitude	N/A	DSS 63	tones-10s	8.31	N/A	10 seconds, assume 10 degrees off, 15 deg. elev angle, 3.155 AU, new TLGA pattern
	JOI	Toroidal	JOI attitude	N/A	DSS 14	tones-3s	1.89	N/A	3 seconds, assume 2.0 degs off, 30 deg elev angle, 6.178 AU, new TLGA pattern
	JOI	Toroidal	JOI attitude	N/A	DSS 14	tones-10s	6.29	N/A	10 seconds, assume 2.0 degs off, 30 deg elev angle, 6.178 AU, new TLGA pattern
	PRM	Toroidal	JOI attitude	N/A	DSS 14	tones-3s	1.12	N/A	3 seconds, assume 4.0 degs off, 30 deg elev angle, 6.389 AU, new TLGA pattern
	PRM	Toroidal	JOI attitude	N/A	DSS 14	tones-10s	5.52	N/A	10 seconds, assume 4.0 degs off, 30 deg elev angle, 6.389 AU, new TLGA pattern
Nominal Cruise									
	Pre-DSM Cruise	MGA	Earth	Turbo-Long Frame	Any 34m	100 bps	10.82	10.52	DSS 34, L+181, R = 1.429 AU
	Post DSM, Pre EFB Cruise	Aft LGA	Sun	Turbo-Long Frame	Any 34m	100 bps	1.32	1.02	DSS 34, L+744, R = 0.27 AU
	Cruise-Max Range	HGA	Earth	Turbo-Long Frame	Any 34m	100 bps	22.27	21.97	L+ 1865, Max range = 6.4597 AU, DSS 34, HGA pointing of 0.25 degs
	Post-PRM	MGA	Earth	RS-Short Frame	Any 34m	10 bps	1.29	0.99	DSS 34, L+1889, range = 6.3894 AU, 15 deg. Elev angle, 2 deg. Pointing
	Post-PRM	HGA	0.5 deg off Earthpoint	RS-Short Frame	Any 34m	10 bps	22.21	21.91	DSS 34, L+1899, range = 6.3894 AU, 15 deg. Elev angle
	Post-PRM	HGA	1.0 deg off Earthpoint	RS-Short Frame	Any 34m	10 bps	3.27	2.97	DSS 34, L+1899, range = 6.3894 AU, 15 deg. Elev angle
Safe Mode									
	Worst Case	MGA	Sun-pointed	RS-Short Frame	70m	10 bps	6.93	N/A	DSS-63, L+1865, MGA angle = 5 degs, Range = 6.4597