Using Available DSN Tracking Coverage as a Design Parameter in Mission Proposals

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PRESENTATION

- Why Consider DSN Support when Designing a Mission
- Defining the JME Simulated Mission
- Considering the options
- Ranking the options
- Optimizing the Trajectories for Minimum Contention
- Final Ranking

Why Consider DSN Support when Designing a Mission

The ability to support tracking is a grading criteria

Defining the JME Simulated Mission

This is a fabricated Mission to show how tracking support can be considered as a part of the mission design process.

Trajectory Options

Only direct Earth-Jupiter Trajectories were considered in this analysis.

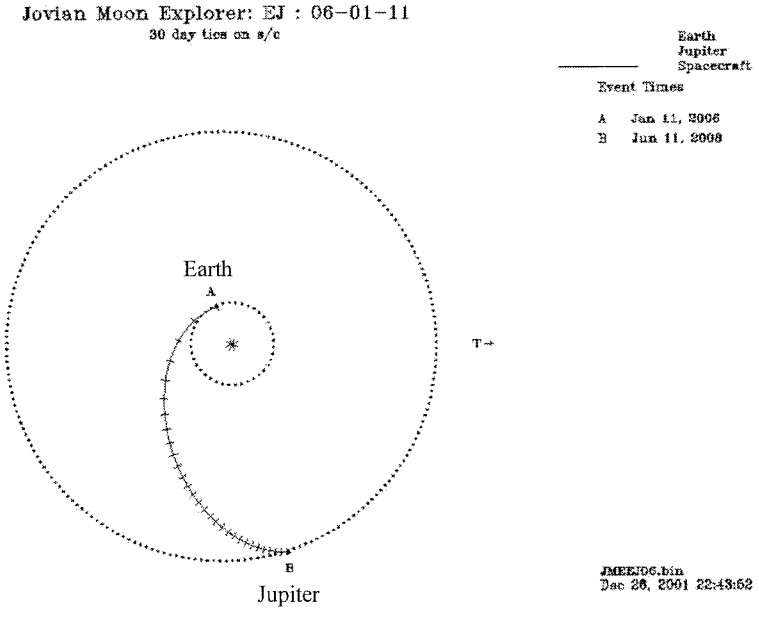


Figure 1: Example of The Direct Earth-Jupiter Trajectory

JME Launch Opportunities

Table 1: Direct Earth-Jupiter Launch Opportunities

Launch Date	Mission Duration (years)	Trajectory Launch C3 (km^2/s^2)	Deep Space Maneuver
12/21/2004	4.97	76.40	No
01/11/2006	4.16	75.90	No
02/13/2007	3.86	79.11	No
04/01/2008	4.93	76.93	YES
05/22/2009	5.43	82.77	No
06/06/2010	3.92	83.39	No
07/11/2011	4.15	80.06	No
08/14/2012	3.90	85.60	No
10/25/2013	6.52	87.54	No
10/20/2014	3.87	91.50	No
11/20/2015	3.96	88.42	No
12/23/2016	4.87	75.98	No
01/16/2018	4.09	76.28	No

Ranking the Options

Table 2: Various JME Rankings

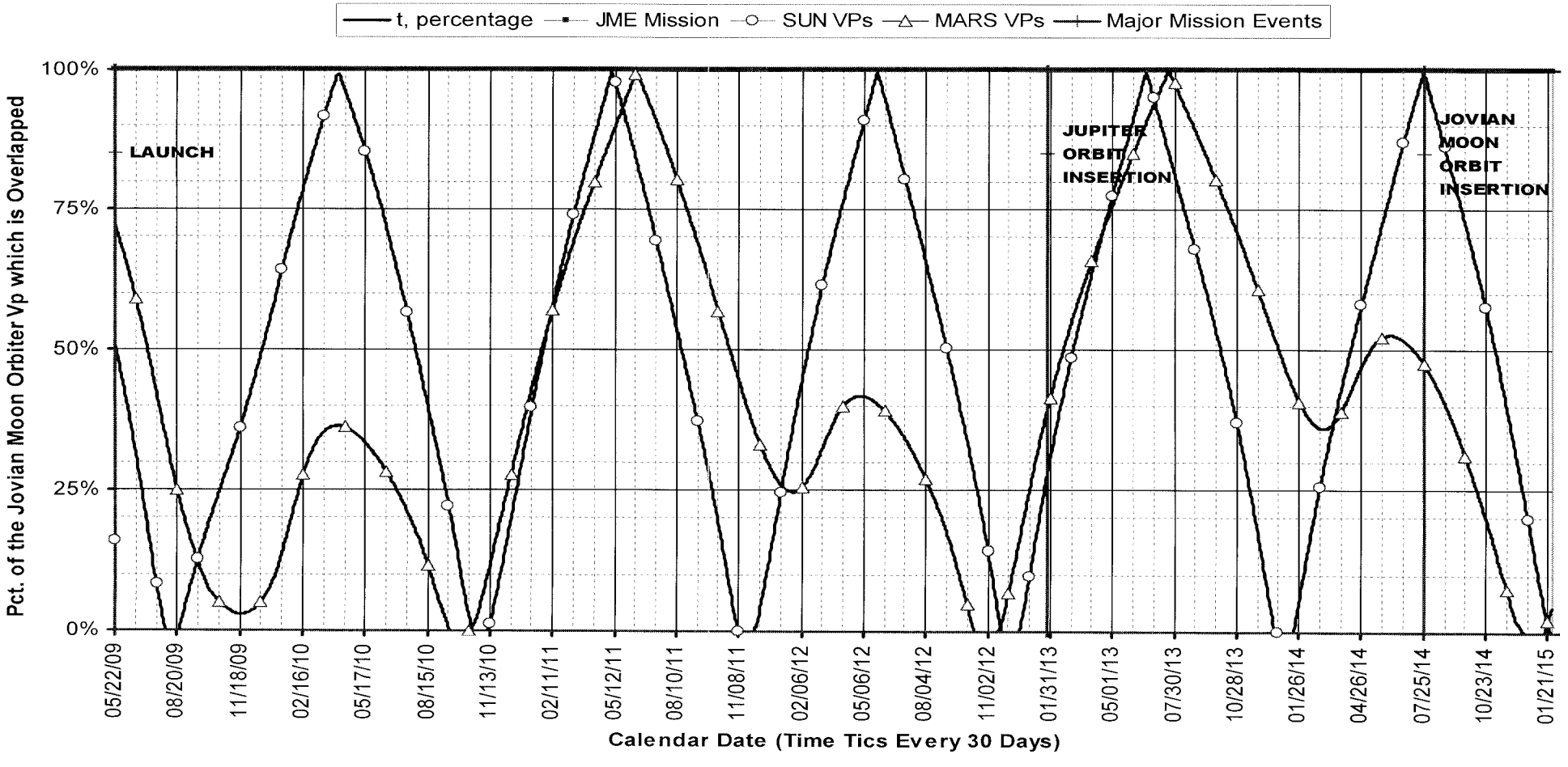
Launch Date	SC Mass Ranking	Duration Ranking
12/21/2004	- -	- -
01/11/2006	1)	8)
02/13/2007	4)	1)
04/01/2008	6)	10)
05/22/2009	7)	11)
06/06/2010	8)	4)
07/11/2011	5)	7)
08/14/2012	9)	3)
10/25/2013	10)	12)
10/20/2014	12)	2)
11/20/2015	11)	5)
12/23/2016	2)	9)
01/16/2018	3)	6)

Optimizing the Trajectories for Minimum Contention

- Limited flexibility in Launch or Jupiter Arrival
- Can alter Jovian Moon Arrival date to minimize contentione

The Geometric Overlap Between JME and Mars Viewperiods

Geometric Viewperiod Percentage Overlay:
JME (EJ - 05/22/2009) VPs Versus Sun & Mars VPs



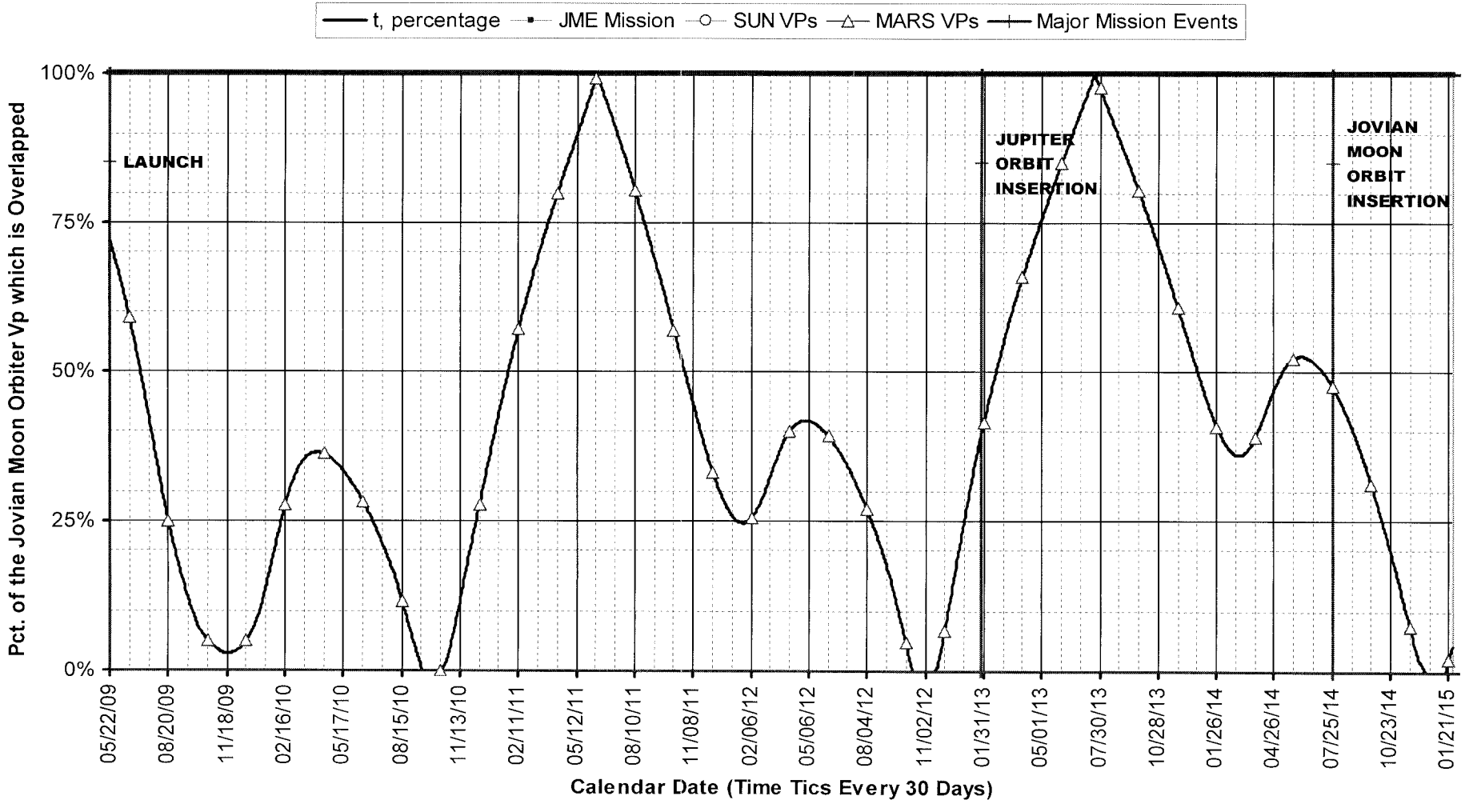
The Overlap Percentages

Table 3: JME Tracking Coverage Overlap between JME and Mars Viewperiods

Launch Date	Launch-L+30d	EJ Cruise	JOI - 30d JOI + 5d	Orbit Reduction	Moon Approach	Prime Mission	Extended Mission
12/21/2004	54.3%	26.3%	1.7%	50.8%	25.3%	10.6%	0.5%
01/11/2006	10.8%	41.5%	2.9%	52.8%	0.0%	0.0%	8.9%
02/13/2007	45.4%	22.2%	91.4%	22.6%	4.3%	15.8%	36.4%
04/01/2008	0.2%	43.6%	92.9%	33.1%	2.9%	18.5%	42.3%
05/22/2009	64.8%	34.6%	32.7%	64.0%	49.8%	44.1%	30.6%
06/06/2010	0.2%	48.6%	25.4%	53.6%	42.8%	36.8%	41.5%
07/11/2011	61.6%	40.8%	61.5%	33.2%	58.6%	69.3%	82.8%
08/14/2012	2.6%	57.2%	28.9%	54.8%	49.8%	46.6%	54.1%
10/25/2013	76.1%	54.0%	41.3%	34.7%	77.9%	87.2%	93.4%
10/20/2014	4.0%	60.2%	24.3%	53.7%	47.9%	40.6%	42.5%
11/20/2015	67.7%	44.4%	92.8%	35.6%	29.9%	41.7%	54.2%
12/23/2016	1.6%	50.1%	80.3%	52.7%	0.2%	1.4%	16.1%
01/16/2018	71.1%	41.9%	80.5%	35.5%	27.2%	36.8%	52.1%

The Repeating Cycle of Mars Overlaps

Geometric Viewperiod Percentage Overlay:
JME (EJ - 05/22/2009) VPs Versus Sun & Mars VPs



Optimizing Jovian Moon for Minimizing Arrival Overlap

Table 4: Tracking Coverage Overlap Between JME and Mars Viewperiods

	Contention for Optimized Jovian Moon Arrival Date							JMOI	Optimized
Launch Date	Launch-L+30d	EJ Cruise	JOI – 30d JOI + 5d	Orbit Reduction	Moon Approach	Prime Mission	Extended Mission	moved (days)	JMOI date
12/21/04	54.3%	26.3%	1.7%	47.0%	0.5%	0.0%	2.8%	65	11/14/09
01/11/06	10.8%	41.5%	2.9%	55.4%	0.5%	0.0%	2.8%	-24	11/14/09
02/13/07	45.4%	22.2%	91.4%	25.6%	1.8%	0.0%	9.0%	-63	07/24/10
04/01/08	0.2%	43.6%	92.9%	36.4%	3.3%	0.0%	16.2%	-49	10/17/12
05/22/09	64.8%	34.6%	32.7%	57.3%	2.9%	0.1%	17.0%	148	12/21/14
06/06/10	0.2%	48.6%	25.4%	53.3%	38.9%	36.4%	45.3%	16	02/20/14
07/11/11	61.6%	40.8%	61.5%	40.2%	2.9%	0.1%	17.0%	-167	12/21/14
08/14/12	2.6%	57.2%	28.9%	54.8%	49.2%	46.7%	54.6%	3	04/12/16
10/25/13	76.1%	54.0%	41.3%	34.6%	2.5%	0.0%	15.3%	-282	04/25/19
10/20/14	4.0%	60.2%	24.3%	53.5%	41.6%	39.6%	45.6%	24	06/26/18
11/20/15	67.7%	44.4%	92.8%	43.4%	2.5%	0.0%	15.3%	-105	04/25/19
12/23/16	1.6%	50.1%	80.3%	54.1%	2.4%	0.1%	11.0%	-14	07/22/21
01/16/18	71.1%	41.9%	80.5%	44.5%	2.4%	0.1%	11.0%	-121	07/22/21

Reduction that can be achieved by altering JME Arrival

Table 5: Tracking Coverage Overlap Improvement by Optimizing Jovian Moon Arrival Date

Negative Numbers indicate a reduction in viewperiod overlap

Launch Date	Launch-L+30d	EJ Cruise	JOI - 30d JOI + 5d	Orbit Reduction	Moon Approach	Prime Mission	Extended Mission	JMOI moved (days)	Optimized JMOI Date
12/21/04	0.0%	0.0%	0.0%	-3.8%	-24.9%	-10.6%	2.3%	65	11/14/09
01/11/06	0.0%	0.0%	0.0%	2.6%	0.5%	0.0%	-6.0%	-24	11/14/09
02/13/07	0.0%	0.0%	0.0%	3.1%	-2.5%	-15.8%	-27.3%	-63	07/24/10
04/01/08	0.0%	0.0%	0.0%	3.3%	0.5%	-18.5%	-26.1%	-49	10/17/12
05/22/09	0.0%	0.0%	0.0%	-6.7%	-46.9%	-44.0%	-13.6%	148	12/21/14
06/06/10	0.0%	0.0%	0.0%	-0.3%	-3.8%	-0.5%	3.7%	16	02/20/14
07/11/11	0.0%	0.0%	0.0%	7.0%	-55.7%	-69.2%	-65.7%	-167	12/21/14
08/14/12	0.0%	0.0%	0.0%	0.0%	-0.6%	0.1%	0.5%	3	04/12/16
10/25/13	0.0%	0.0%	0.0%	-0.1%	-75.3%	-87.2%	-78.1%	-282	04/25/19
10/20/14	0.0%	0.0%	0.0%	-0.2%	-6.3%	-1.0%	3.1%	24	06/26/18
11/20/15	0.0%	0.0%	0.0%	7.8%	-27.4%	-41.7%	-39.0%	-105	04/25/19
12/23/16	0.0%	0.0%	0.0%	1.4%	2.2%	-1.3%	-5.0%	-14	07/22/21
01/16/18	0.0%	0.0%	0.0%	9.1%	-24.8%	-36.7%	-41.1%	-121	07/22/21

Ranking the different Launch Windows

Table 6: Ranking of the Direct Earth-Jupiter Trajectory Options for the JME Mission

Overall Ranking	Launch Date	Trajectory Launch C3 (km^2/s^2)	Mission Duration (years)	JME/Mars Viewperiod Overlap: Orbit Reduction	Moon Approach	Prime Mission	Extended Mission	JMOI Date
	12/21/04	76.40	4.89	47.0%	0.5%	0.0%	2.8%	09/10/09
1)	01/11/06	75.90	4.07	55.4%	0.5%	0.0%	2.8%	12/08/09
2)	12/23/16	75.98	4.78	54.1%	2.4%	0.1%	11.0%	08/05/21
3)	02/13/07	79.11	3.78	25.6%	1.8%	0.0%	9.0%	09/25/10
4)	04/01/08	76.93	4.85	36.4%	3.3%	0.0%	16.2%	12/05/12
5)	01/16/18	76.28	4.01	44.5%	2.4%	0.1%	11.0%	11/20/21
6)	07/11/11	80.06	4.07	40.2%	2.9%	0.1%	17.0%	06/06/15
7)	06/06/10	83.39	3.83	53.3%	38.9%	36.4%	45.3%	02/04/14
8)	08/14/12	85.60	3.82	54.8%	49.2%	46.7%	54.6%	04/09/16
9)	11/20/15	88.42	3.88	43.4%	2.5%	0.0%	15.3%	08/08/19
10)	10/20/14	91.50	3.78	53.5%	41.6%	39.6%	45.6%	06/02/18
11)	05/22/09	82.77	5.35	57.3%	2.9%	0.1%	17.0%	07/26/14
12)	10/25/13	87.54	6.44	34.6%	2.5%	0.0%	15.3%	02/01/20

CONCLUSIONS

- It is possible to consider Tracking Coverage Support as part of the Mission Design Process
- Optimizing the Trajectory to minimize contentions will only increase the probability of being selected for further mission development/funding