Opportunistic MSPA: A Low-Cost Downlink Alternative for Deep Space Smallsats

Keeping the universe connected.

Douglas S. Abraham and Bruce E. MacNeal
Jet Propulsion Laboratory, California Institute of Technology

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Topics

- Challenges to Deep Space Smallsats
- Responding to the Challenges: Opportunistic MSPA
- OMSPA Pros & Cons
- What's Next?
- Appendix: Performance Analysis
  - Data Rates
  - Maximum Smallsat-Host Separation Distances

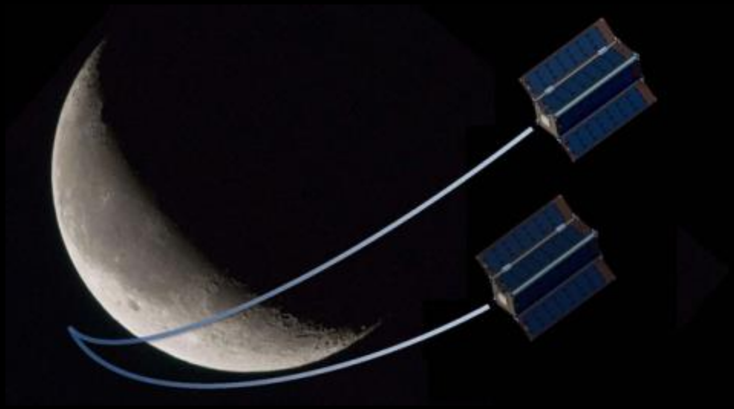
Smallsat Comm. Challenges (1/2)

DSN Communications-Cost Perceptions

$425M Discovery-Class Mission

“Antenna” Fee = **~1%** of Total Mission Cost w/o LV*

$5M Deep Space Cubesat



“Antenna” Fee = **~110%** of Total Mission Cost w/o LV*

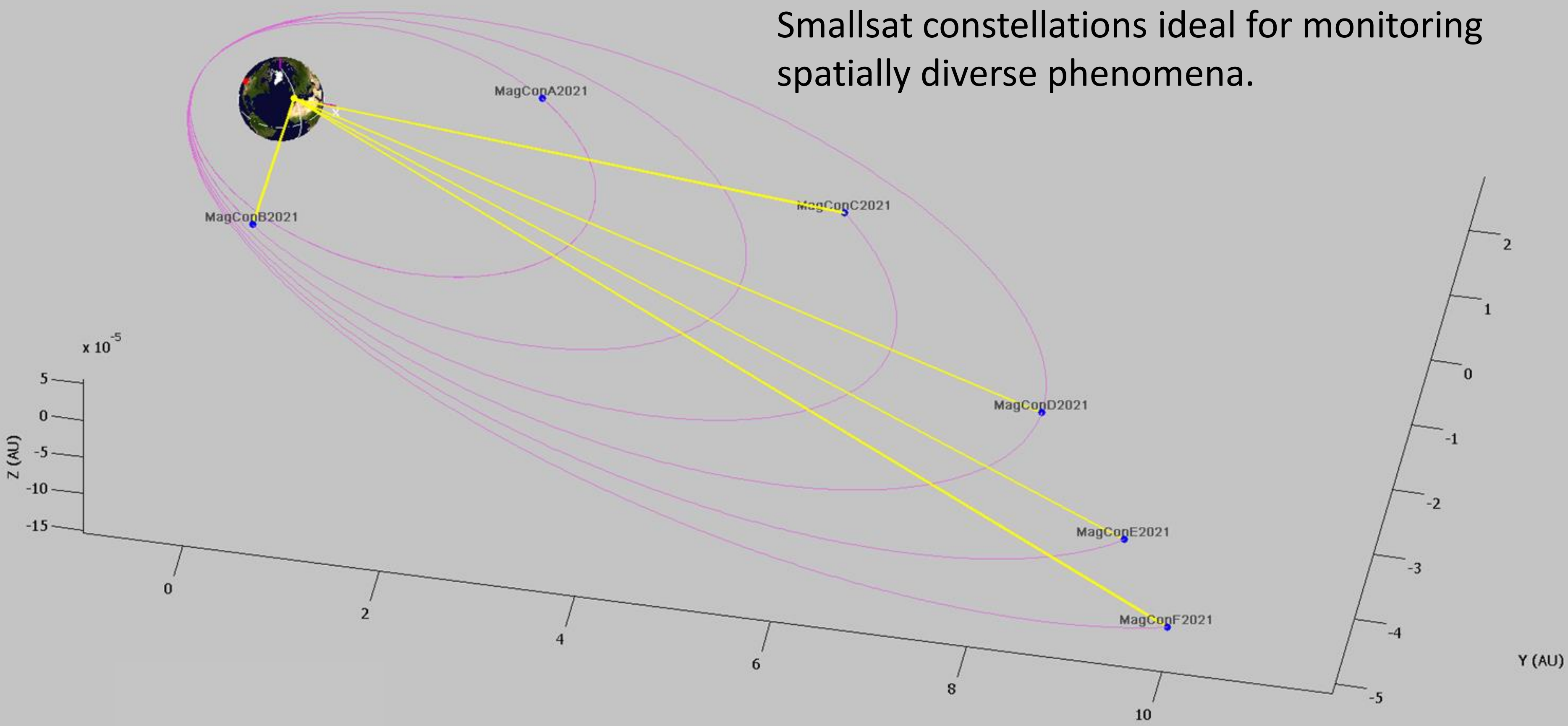
While antenna time is actually “free” to a NASA mission once it has won a competitively-bid opportunity, the mission may be very concerned with the cost during the competition.

*Assumes one 8-hour 34m pass/day for a year.

Smallsat Comm. Challenges (2/2)

Smallsat Constellation Support

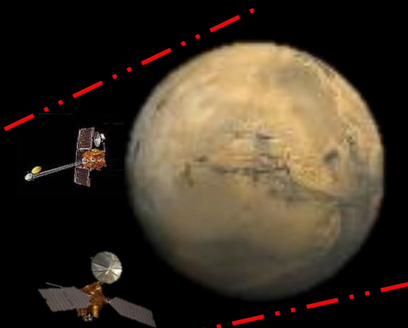
Smallsat constellations ideal for monitoring spatially diverse phenomena.



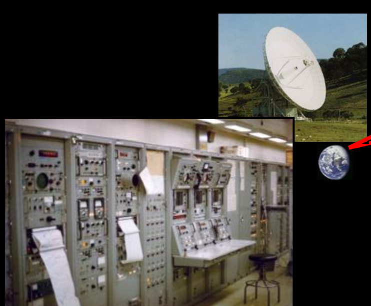
But, large inter-spacecraft distances can be problematic for proximity links, and direct communications with each spacecraft can tie up a large number of the DSN's antennas.

Responding to the Challenges (1/2)

Traditional MSPA (Multiple Spacecraft Per Antenna)



- Formally scheduled antenna sharing
  - Reduces downlink asset contention
  - Qualifies for lower aperture fees

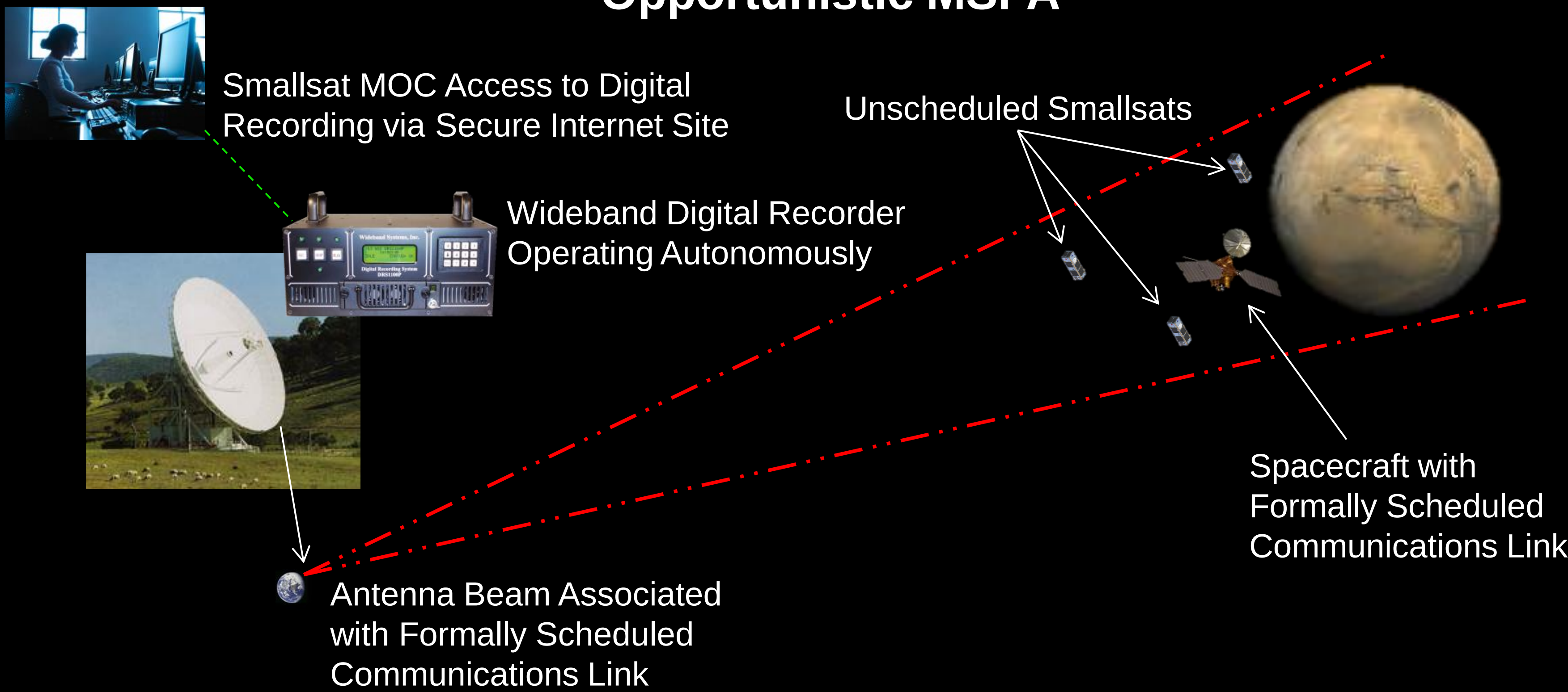


- Constraints
  - Supportable spacecraft number limited by receiver number.
  - Currently 2 applicable receivers per antenna.
  - Adding more receivers is a multi-million dollar endeavor.

In today's budget-constrained environment, adding lots of receivers to all of the DSN's antennas is probably cost prohibitive.

Responding to the Challenges 2/2

Opportunistic MSPA



Everything received through the antenna beam is digitally recorded. Smallsats would transmit open loop when in a host spacecraft's beam. Smallsat MOCs would retrieve relevant portion of digital recording for subsequent demodulation and decoding.

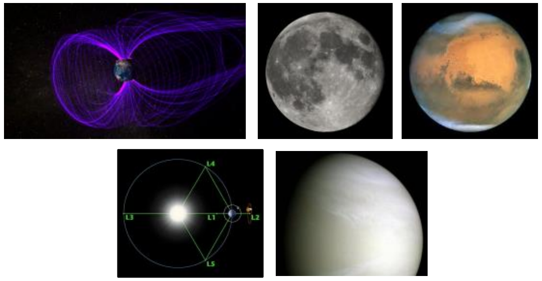
OMSPA Pros and Cons

- Pros
  - Enables DSN to service a much larger number of missions.
  - Enables support of large constellation missions.
  - Minimizes cost to the smallsat projects.
  - Minimizes cost to DSN to implement and operate.
- Cons
  - Adds data latency.
  - Only applies to routine science downlinks.
  - Requires a "host" spacecraft's ground antenna beam.
- Performance (see Bruce MacNeal's analysis in appendix)
  - At average lunar distance, supports up to hundreds of Mbps, with 100-200 km separation from host.*
  - At average Mars distance, supports up to a few kbps, with several Mars radii separation from host.*

*Assumes deep space, X-band smallsat with 0.5m HGA & 10 W transmitter.

What’s Next?

- **Series of Demonstrations**
  - FY’14 (Funded) – “Shadow” tracking of Mars spacecraft via Opportunistic MSPA.
    - Objective: Show readiness to proceed with demonstrations involving real smallsats.
  - FY’15 – FY’17 (Not Yet Funded) – assuming deep space smallsat missions available in this timeframe, demonstrate ability to support.
- **Operational Capability?**
  - Common Platform Era – DSN switch to selectable distribution of digitized IF; will enable dedicated antenna recording -- i.e., no competition for time on science and wideband VLBI receivers.



Appendix

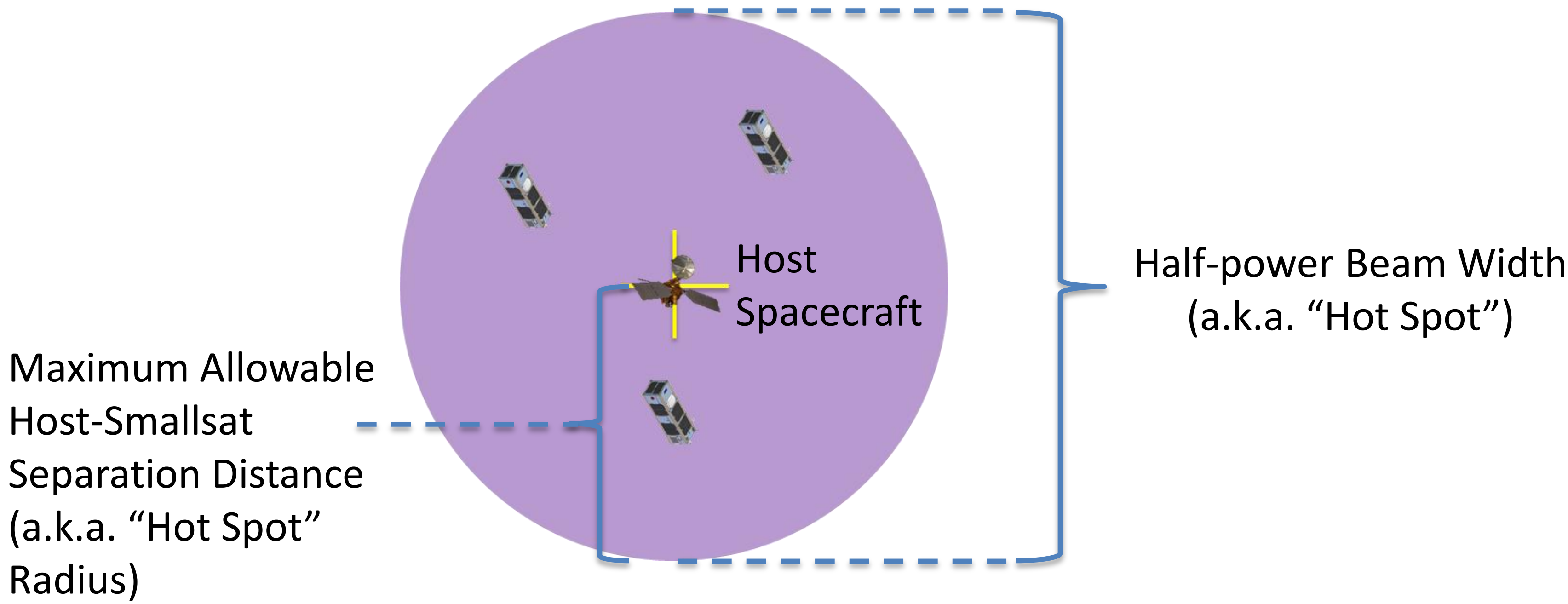
Performance Assessment

by

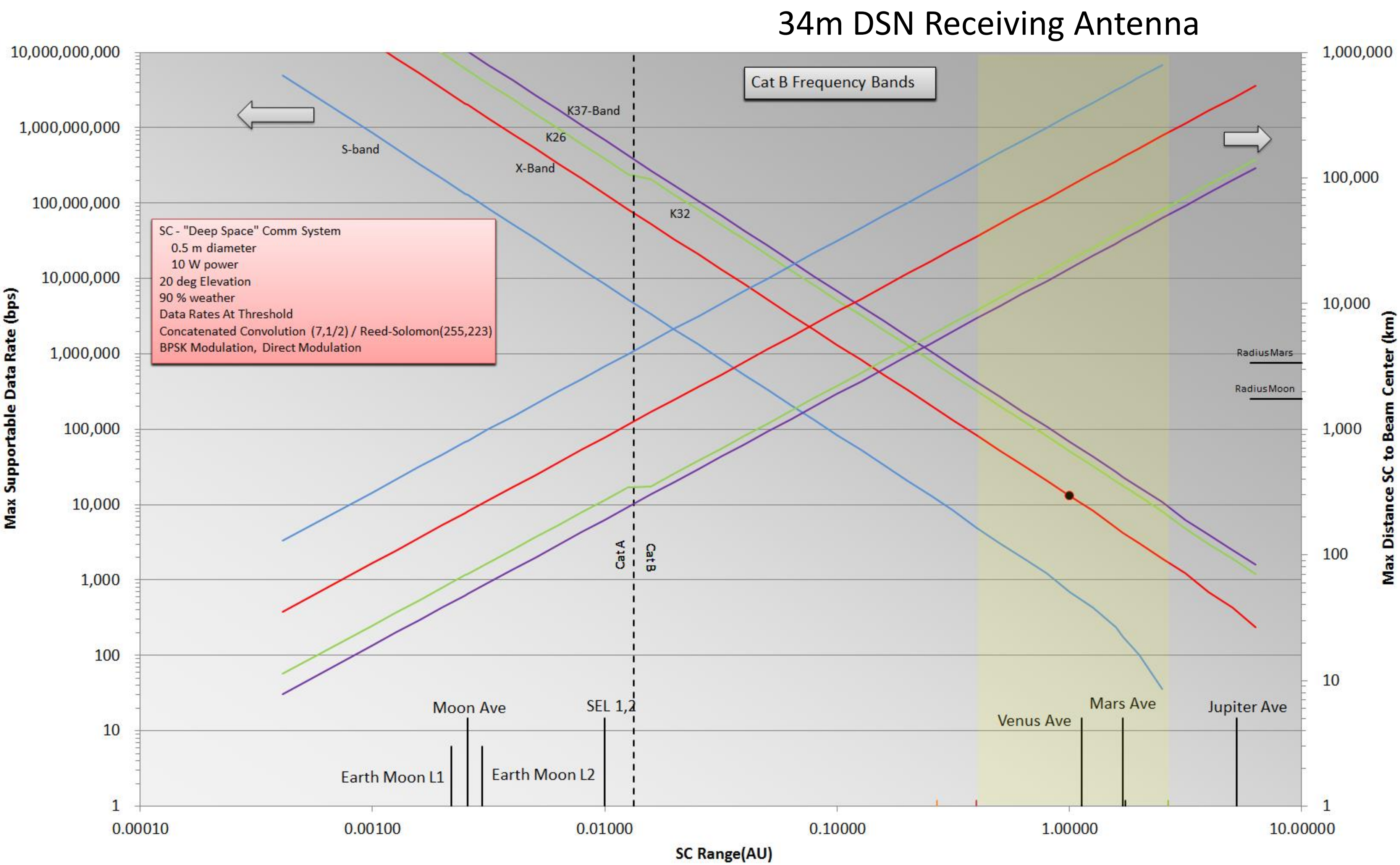
Bruce E. MacNeal

Key Performance Questions

- Supportable Data Rate?
- Max. Distance from Tracked Target?



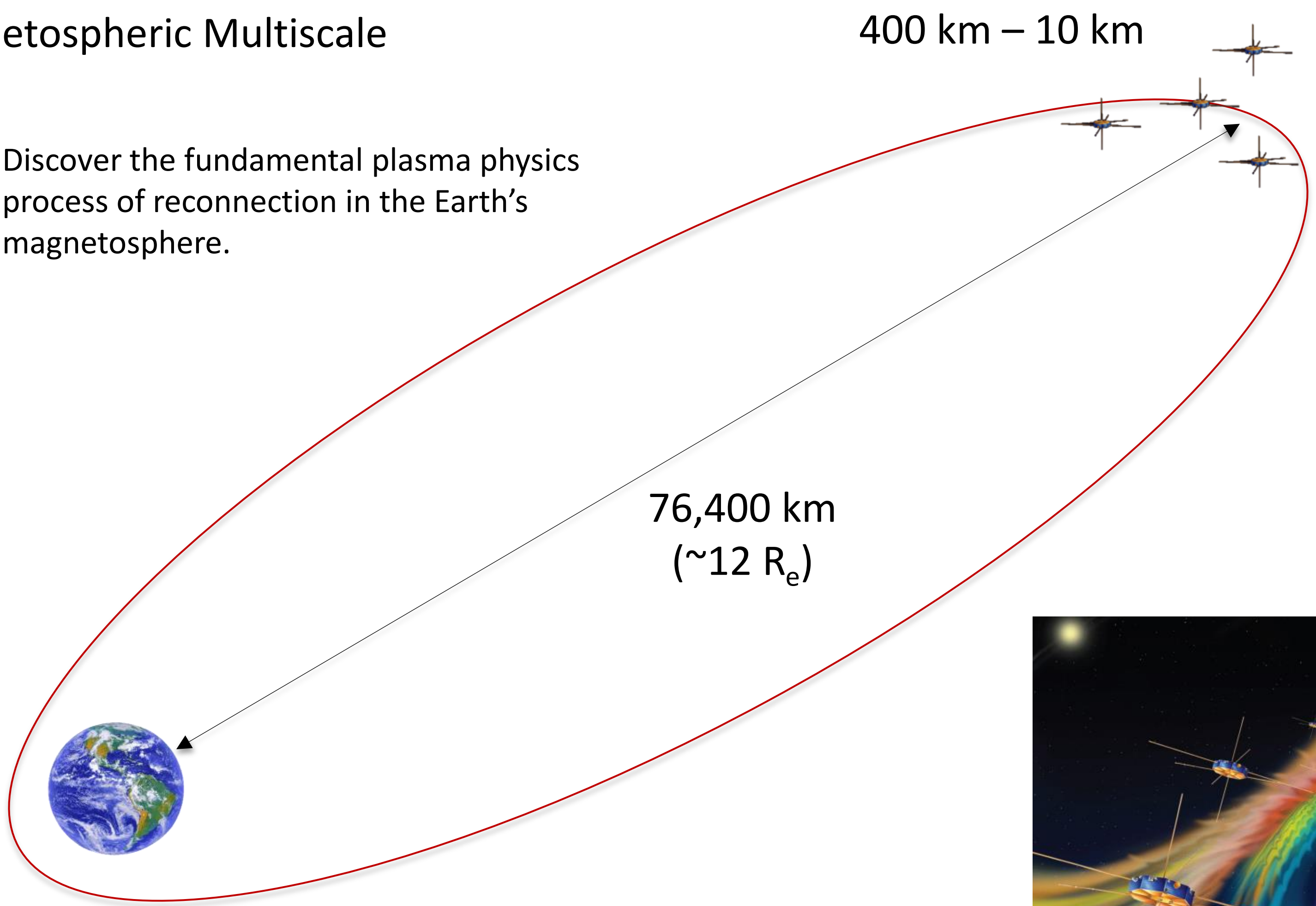
Supportable Data Rate and "Hot Spot" Radius

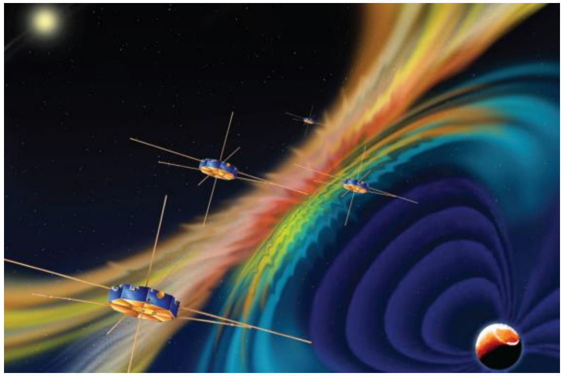


Example: MMS Constellation*

Magnetospheric Multiscale

Discover the fundamental plasma physics process of reconnection in the Earth's magnetosphere.

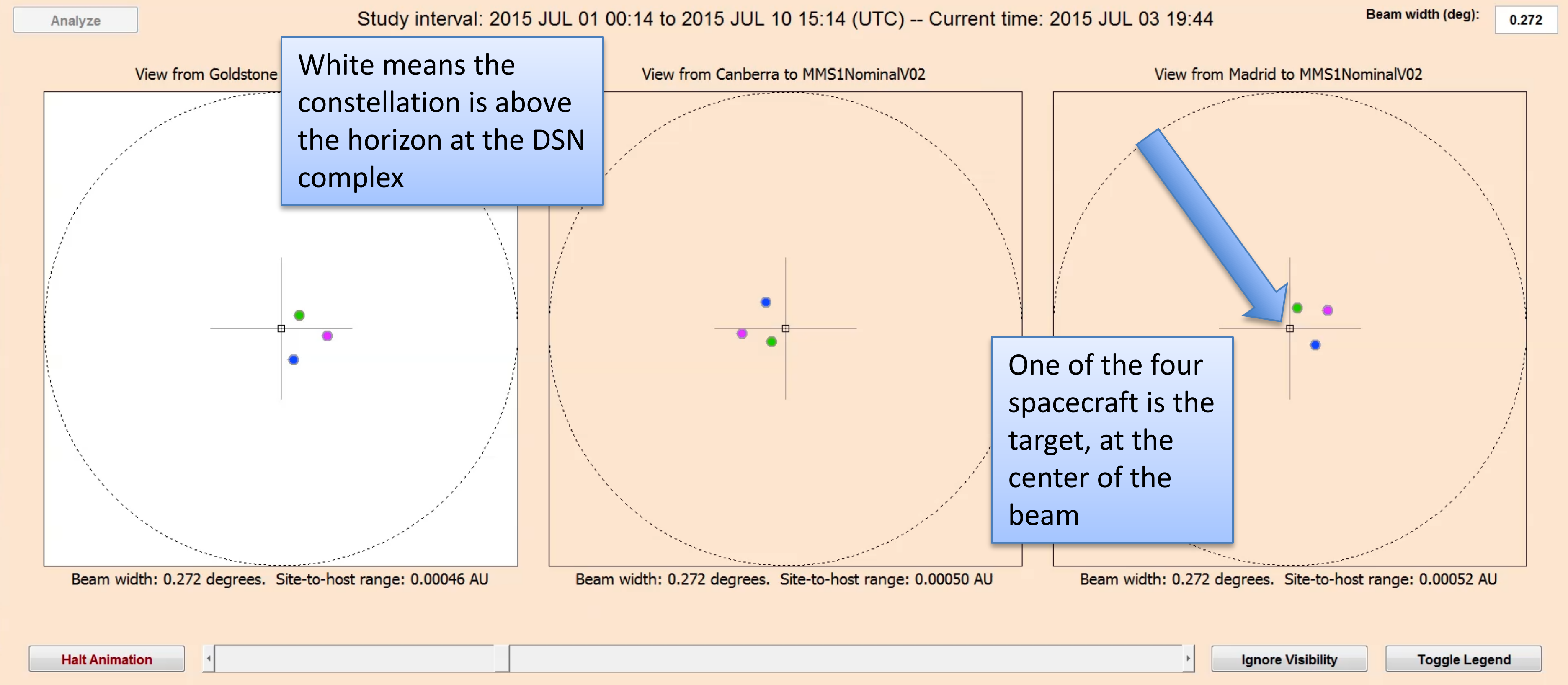




*Pre-decisional – for Planning and Discussion Purposes Only

OMSPA Tool from OTIE: MMS* Animation

Credit: Dave Heckman

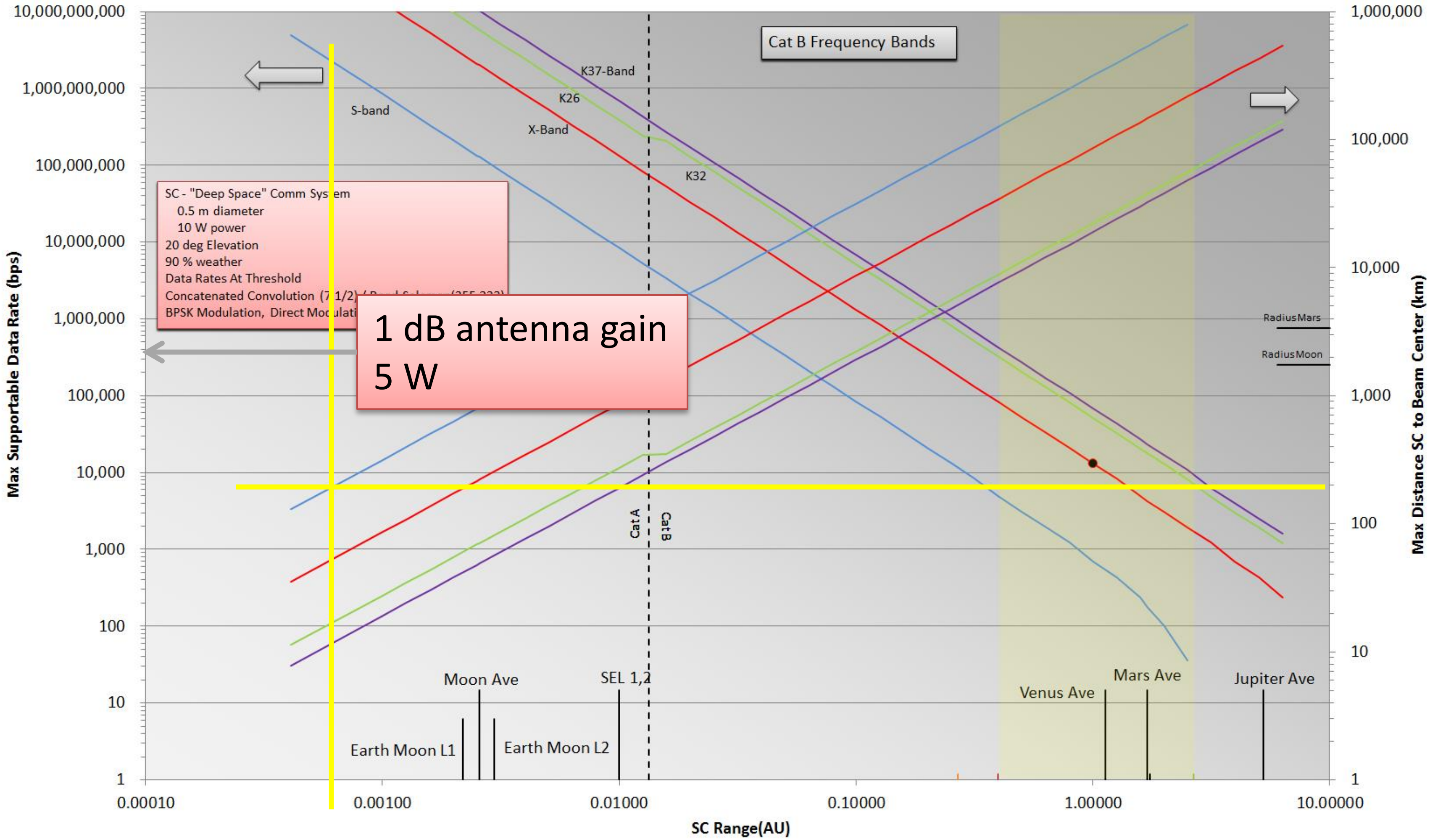


Beam intercept tool shows that all four spacecraft would be in the beam long enough to employ OMSPA for MMS*

*Pre-decisional – for Planning and Discussion Purposes Only

Supportable Data Rate and "Hot Spot" Radius for MMS*

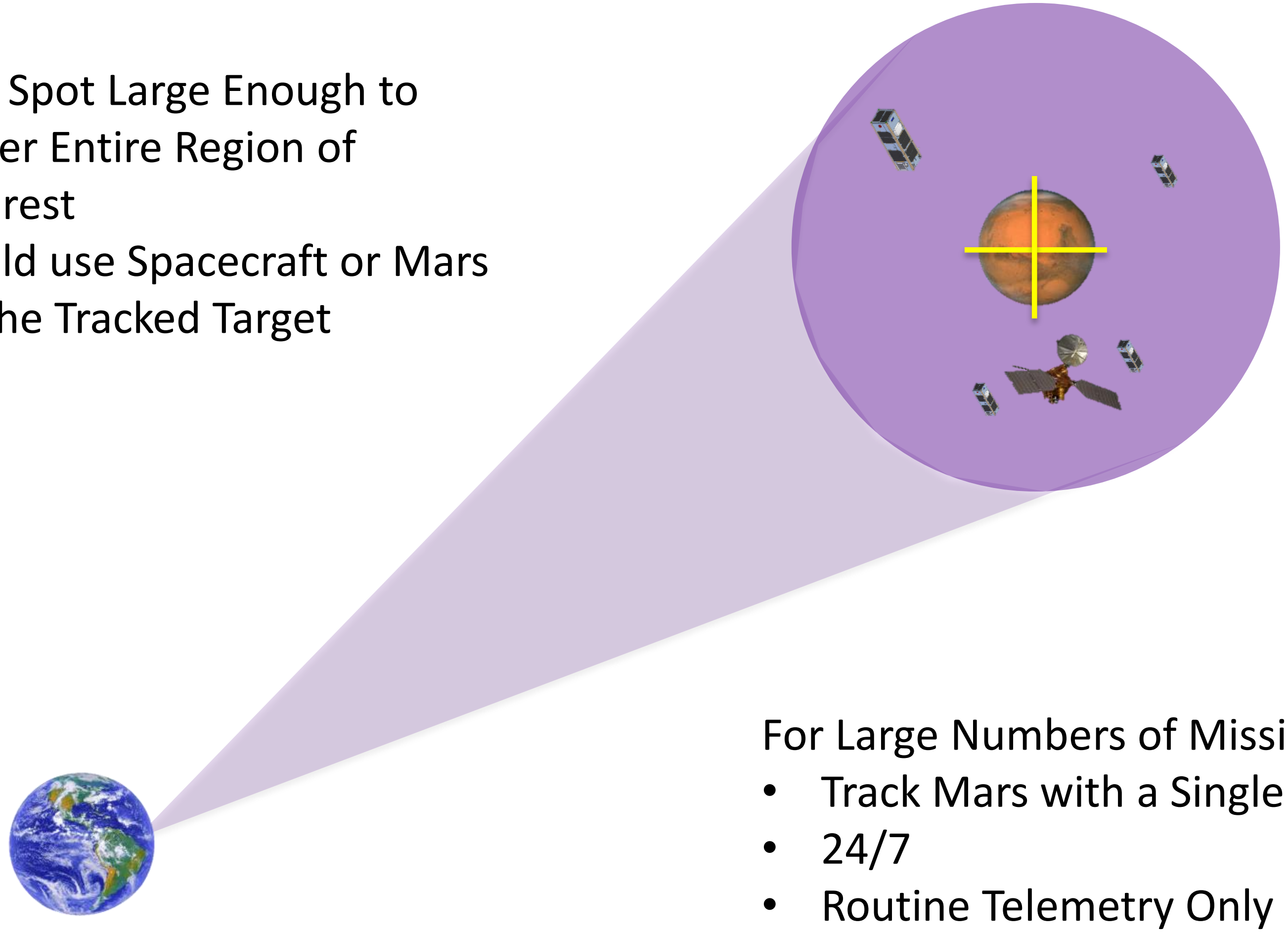
34m DSN Receiving Antenna



*Pre-decisional – for Planning and Discussion Purposes Only

Example: Mars

- Hot Spot Large Enough to Cover Entire Region of Interest
- Could use Spacecraft or Mars as the Tracked Target

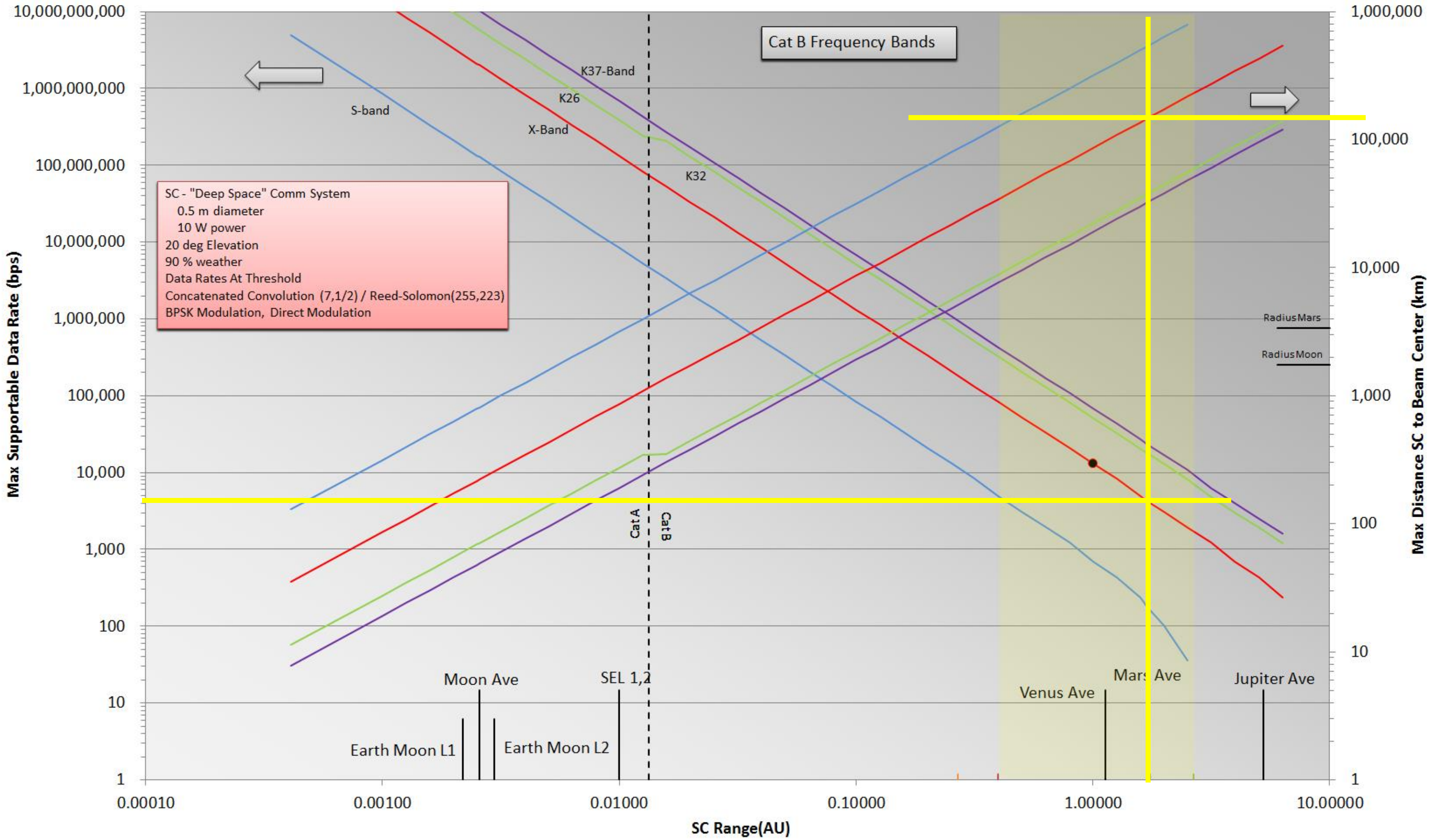


For Large Numbers of Missions at Mars:

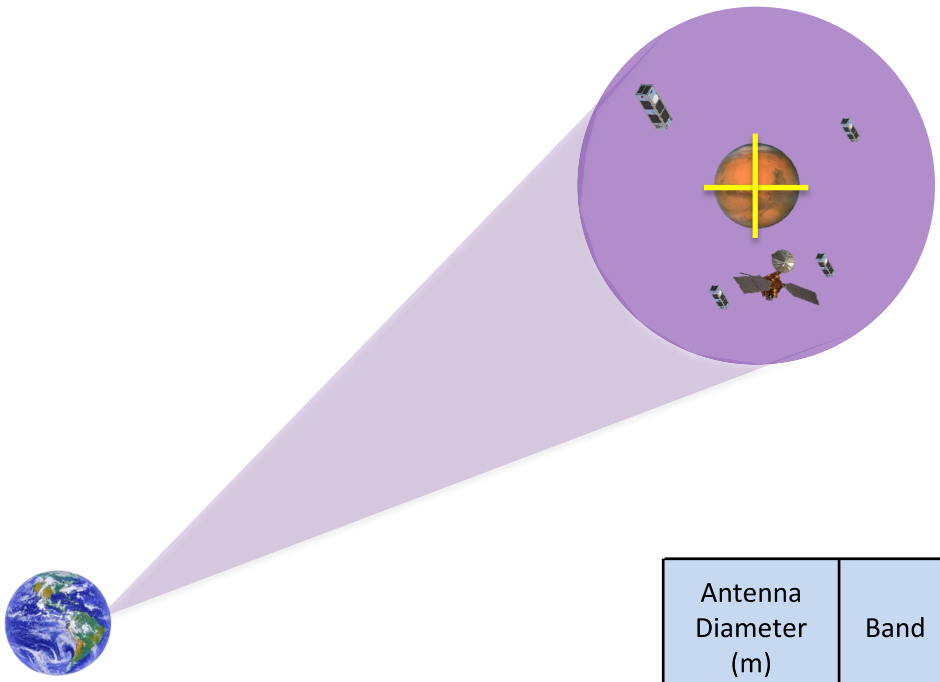
- Track Mars with a Single 34m Antenna
- 24/7
- Routine Telemetry Only

Supportable Data Rate and “Hot Spot” Radius for Mars

34m DSN Receiving Antenna



“Hot Spot” Mars



HPBW – 810-005
Mars distances determined
Over next 50 years (Horizons).

				”Hot Spot” Diameter (Mars Diameters)		
Antenna Diameter (m)	Band	Downlink Frequency (GHz)	HPBW (deg)	Mars Min	Mars Ave	Mars Max
70	S	2.295	0.1180	17	78	122
70	X	8.420	0.0320	5	21	33
34	S	2.295	0.2420	35	159	249
34	X	8.420	0.0660	10	43	68
34	K32	32.000	0.0170	2	11	18