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November 9, 2004
Refer to: 9110-04-14 AA:esb/yjb

TO: Distribution

FROM: Eugene S. Burke

SUBJECT: Minutes for the Joint Users Resource Allocation Planning Committee Meeting held September 16, 2004.

NEXT JURAP MEETING:
Thursday, November 18, 2004
JPL Bldg. 303, Room 411 1:00 p.m.

Attendees:

Andujo, A.	Compton, B.	Holmes, D.	O'Brien, G.
Bartoo, R.	Doody, D.	Jacobs, C.	Poon, P.
Benson, R.	Guduru, S.	Kuykendall, F.	Retana, J.
Berry, D.	Hall, J.	Kwok, A.	Satterlee, N.
Best, R.	Hampton, E.	Lacey, N.	Slade, M.
Brymer, B.	Ho, C.	Morris, D.	Wang, K.C.
Call, J.	Holladay, J.	Mottinger, N.	Ward, C.

The Joint Users Resource Allocation Planning Committee meets monthly to review the status of Flight Projects, the requirements of other resource users, and to identify future requirements and outstanding conflicts. The last regular meeting was held on June 17, 2004 at the Jet Propulsion Laboratory.

Introductory Remarks – G. Burke
Attendees were welcomed and new members introduced. The many painting activities being planned at Canberra and Madrid were discussed. Deconflicting these activities is ongoing and help from the Projects is greatly appreciated.

SPECIAL REPORTS

ZDD Calibration – D. Berry

There are 2 basic types of radiometric information that are used to solve the navigation equation: Doppler and Range. Doppler provides velocity, and Range provides distance. ZDD calibrations assist in the range determinations by providing accurate baseline information for DSN stations. The ZDD calibration determines the Antenna Reference Height and Test Transmitter Delay information, which is subtracted from the total distance to the spacecraft, giving a navigator accurate range to target information. In order to determine the Antenna Reference Height an 8-hour ZDD calibration should be performed annually at each 34 meter antenna and two 8-hour blocks at the 70 meter antennas. Mr. Berry discussed the constraints in performing the calibration at each antenna and stated that a ULP is being developed for RAPSO.

Reference Frame Calibration – C. Jacobs

Changes were discussed concerning the Catalog M&E and Clock Sync activities and the use of Ka-band 34Meter antennas as well as their increased requirements, explaining each of the activities and their importance to navigation accuracy.

Deep Impact Flyby – J. Call

The Deep Impact mission was presented, describing the technical aspects and the 36-week prime mission of the spacecraft. Also discussed were the DSN support requirements for the mission.

RARB Action Items – D. Morris

The status of the three August 2004 RARB Action Items are as follows:

Action Item #1: Pending
Directed at reducing heavy contention in July of 2006 at DSS-14 due, in part, to GSSR activities.

Action Item #2: Open
Directed at coordinating MGS, Odyssey and MEX coverage during the MRO Aerobraking period.

Action Item #3: Closed
Directed at the contention period in December 2006 where SOHO requires 70 meter support during its keyhole period.
Response: SOHO mission responded by clarifying specific support requirements during this period that are expected to resolve this contention.

Resource Analysis Team – N. Lacey

There are no changes to the Ongoing and Advanced Planning projects. Visit the following link for a complete listing: http://rapweb.jpl.nasa.gov/tmodmiss.pdf

There are no changes to the DSN Resource Implementation plan. Visit the following link for a complete listing: http://rapweb.jpl.nasa.gov/tmodplns.pdf

The Mid-Range scheduling RAP Team has completed schedule negotiation 25 weeks ahead of real-time with 10 weeks of conflict-free schedules. Conflict resolutions are required for ten weeks: Weeks 49 – 12. Schedule weeks 45 – 48 will be released to DSN scheduling on September 6, 2004.

The Resource Analysis Team has completed special studies for MESSENGER Post 2004 Requirements Study and Mars Global Surveyor Requirements Study.

DSN Downtime Forecast – A. Andujo

Changes to 2004 Downtime Schedule

- A request to extend the currently planned DSS-45 downtime by one week has been negotiated and scheduled.
- Painting activities for all Canberra antennas has been requested and is being negotiated.
- A painting activity is being planned for DSS-55.
- Jacking Pad installation at DSS-65 has been requested and is being planned.

Changes to 2005 Downtime Schedule:

- During the August RARB RAPSO successfully re-planned and secured downtime for DSS-15 ACR.

Changes to 2006 - 2009 Downtime Schedules:

- There are no changes planned for these years.

For a complete listing of Antenna Downtimes visit the following link for the RAPSO website: http://rapweb.jpl.nasa.gov/planning.htm

DSN Operations – J. Buckley

There was no presentation given at this month's JURAP.

Goldstone Solar System Radar – M. Slade

A proposal of four 2-station radar observations between DSS-14 and Green Bank Telescope (GBT) in support MESSENGER science goals was submitted and approved by NRAO. These supports have been scheduled in December and are conflict-free. GSSR observations of newly discovered Potentially Hazardous Asteroid (PHA) 2004_RZ164 have been tentatively scheduled at DSS-14 during December as well. The RARB action item regarding the heavy contention period in July of 2006 caused by the high overlap of viewperiods for Mars, Jupiter and Mercury was discussed. A meeting has been planned in December 2004 to discuss the 70 meter high contention; attendees will include Cassini, GSSR and Mars Mission representatives as well as other interested parties.

Radio Astronomy / Special Activities – G. Martinez

There was no presentation given at this month's JURAP, though presentation material is included with the Minutes.

FLIGHT PROJECTS REPORTS

Ulysses – B. Brymer

Ulysses spacecraft successfully completed its ninth Solar Conjunction and nominal spacecraft operations continue. Approximately 95% of all Telemetry data from the Solar Conjunction was recovered from the spacecraft; the 5% loss was due to a 6-hour maser failure at DSS-24.

Voyager – J. Hall
Mission Status for Voyager 1: Heliocentric Distance – 93.06 AU, RTLT – 25h49m34s and Major Activities were PMPCAL, DTR Playback, ASCAL and MAGROL.
The Mission Status for Voyager 2: Heliocentric Distance – 74.34 AU, RTLT – 20h29m36s. Both spacecraft are healthy and overall DSN support was good.

Cassini – D. Doody
The Cassini spacecraft successfully entered Saturn orbit on July 1st, 2004. All systems and operations occurred flawlessly except the Scaler Magnetometer which due to a commanding glitch did not turn on as planned. OTM 1 maneuver was cancelled due to near perfect insertion attitude. The DSN support during this critical event was excellent. Upcoming events for the mission include Iapetus and 2 Titan flybys and the Huygens Probe release.

WMAP, ACE, IMAGE, and Genesis – C. Ho for S. Waldherr
All of the four reported spacecraft are healthy and performing well, ACE will begin Lights Out Operations (Unattended supports) in October. The last maneuver performed resulted in a minor wobble in the spacecraft, but is being addressed by the projects. The projects are satisfied with DSN support.

Mars Global Surveyor – P. Poon
MGS is healthy and is completing its second extended mission this fiscal year, completing approximately 26,000 orbits of Mars. DSMS management has signed off on supporting the third 2-year extension.

Mars Odyssey – B. Mase / P. Poon
Odyssey is healthy and has completed its prime mission and has entered its extended mission phase. To date the spacecraft has completed more than 12,000 orbits of Mars. Recently the mission has suffered some problems due to MCD3 failures. DSMS has decided to support M01O with the MCD3's until they all break with the programs understanding.

Mars Exploration Rover – B. Compton
MER Rovers are healthy and operations have diminished as they are in Solar Conjunction. Due to power constraints the mission has decided to limit uplink operations to five days a week from October to November and return to seven days a week January - March. At this time the mission has proposed a six-month extension as the Rovers are still healthy and fully operational.

INTEGRAL, Mars Express and Rosetta – D. Holmes
Rosetta spacecraft has been in hiatus since early June, the DSN has just begun supporting one pass per week as the commissioning phase begins. All operations with the spacecraft are going well.

Operations for the Mars Express mission are going as expected. The spacecraft is currently operating at reduced operations in safe mode forcing the spacecraft to go into S-band due to the minimum Sun-Earth-Probe angle. All science activities have now been suspended until the due to the poor performance in S-band. The mission was able to complete Radio Science Solar Corona observations with mixed results due to station problems. The project will reconfigure the spacecraft on September 21st after exiting solar conjunction and resume science operations

by the 27th. The project is continuing its investigation into the problems with the MARSIS antenna deployment. Another deployment attempt will not be made before November 2004.

Goldstone performance has been fantastic in support of the INTEGRAL mission with a 99% data return. As viewperiod slide into the dayshift hours RFI from Fort Irwin is expected to cause support problems at Goldstone.

Hayabusa (MUSES C) – N. Mottinger
A mission overview explained the Hayabusa mission, a sample Earth-return mission launched May 9, 2003. The spacecraft will rendezvous with Asteroid 1989ML, fire a pellet at the surface and capture some of the particles disturbed by the pellet then return the samples to Earth in June of 2007. The spacecraft is powered by an ion engine one of four technologies being applied for testing to this mission. There have been some problems thermal issues with the power supply to the ion engine resulting in reduced usage of the system. The solar panels suffered ill effects from the Coronal Mass Ejection witnessed in late 2003, causing a 10% reduction in power production to the spacecraft. To compensate the project has redesigned the low-thrust profile which has affected some of the events planned for the mission.

Support requirements and as the timeline of future mission events were discussed.

Stardust - R. Ryan
There was no presentation given at this month's JURAP, though presentation material is included with the Minutes.

Chandra - K. Gage
There was no presentation given at this month's JURAP.

Spitzer Space Telescope – J. Hunt
There was no presentation given at this month's JURAP.

SOHO, Geotail and Cluster II – A. Chang
There was no presentation given at this month's JURAP.

Action Item Status
From 10 August 2004 RARB
(Resource Allocation Review Board)

September 16, 2004

David G. Morris

Action Item Summary

AI#	*Year*	*Month(s)*	*System*	*Responsible*	*Due Date*	*Status*
01	**2006**	**July-August**	**GSSR**	**M. Slade**	**09/16/2004**	**Pending**

ACTION: Coordinate with Scientist representing Mercury Radar Speckle Displacement Co-observation with Green Bank Telescope or Arecibo Observatory on recommendations to minimize contention in these months.

RESPONSE: (9/16/2004) This action item was needed to reduce heavy contention for DSS-14, since Mars, Jupiter, and Mercury are close together in the sky in July 2006. Prof. Margot is the PI for this observation and will be visiting JPL in December 2004. We are attempting to schedule a meeting with Cassini , Mars Odyssey, and other interested parties at that time.

Action Item Summary

AI#	*Year*	*Month(s)*	*System*	*Responsible*	*Due Date*	*Status*
02	**2006**	**August-September**	**Mars Missions**	**C. Edwards** **B. Mase** **K. Zamora**	**11/10/2004**	**Open**

ACTION: Coordinate MGS, Odyssey and MEX coverage during the MRO Aerobraking period.

RESPONSE:

Action Item Summary

AI#	*Year*	*Month(s)*	*System*	*Responsible*	*Due Date*	*Status*
03	**2006**	**December**	**SOHO**	**B. Dutilly**	**10/14/2004**	**Closed**

ACTION: During Antenna Keyhole activities, the recommendation is to use 34m antennas versus 70m antennas due to oversubscription of the 70m subnet. 26m antenna usage was not in question.

RESPONSE: (8/26/2004) SOHO requires a minimum of four(4) hours of 70M coverage every 45 hours of gap time during a keyhole event. The purpose is to dump the SSR during that pass otherwise critical science data will be lost. We will continue to negotiate the time and resources needed in the mid range period for 70M support.

Zero Delay Device (ZDD) Calibrations

David Berry
Navigation & Mission Design

July 30, 2004

Agenda

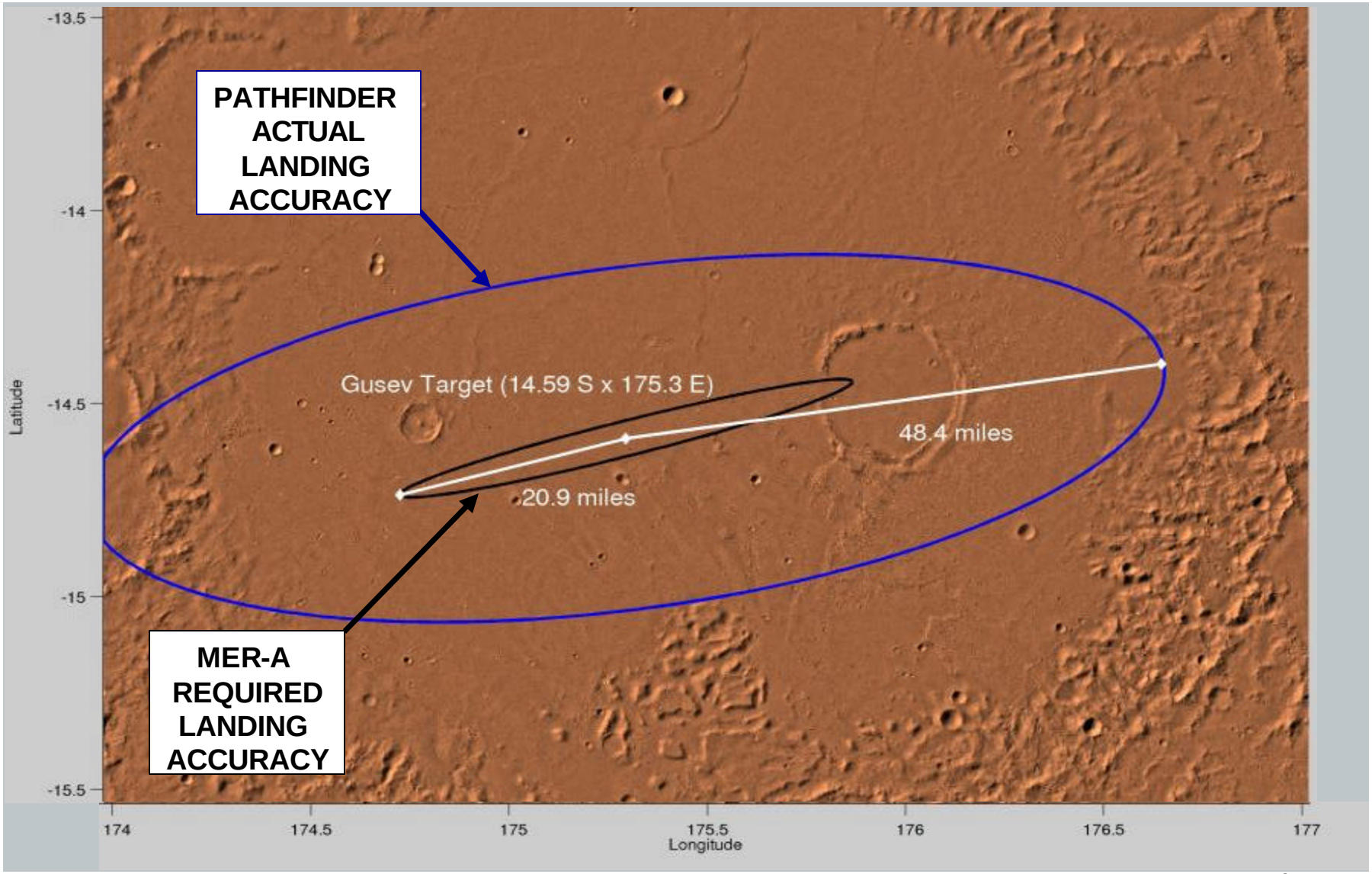
- Basic agenda: we hope to answer some questions for scheduling personnel (RAPSO, DSN, project schedulers, etc.)… for example:

- What is a ZDD Calibration?
- Why is it important?
- How long does it take? How much time must be allocated for the ZDD Calibration?
- When does it need to be done?
- What are the constraints?
- Who uses the output from the ZDD?
- What is the relative priority of the ZDD Calibration?

Why do missions use ranging measurements?

- Two basic types of radiometric data: Doppler and Range
- Doppler of the carrier frequency measures only part of the navigation problem
  - Doppler can resolve spacecraft velocity, but not distance.
  - Spacecraft distance is inferred from an orbit solution, but was not measured
  - Ranging gives absolute distance with a resolution determined by ranging signal strength
  - Orbit solutions from velocity and range have smaller error ellipses than velocity alone
- Spacecraft ranging is crucial for orbit determination for certain operations:
  - Flybys, EDL, pre/post maneuver, orbit insertions (& approach)
  - Allows reduced tracking operations while in cruise mode (one ranging measurement goes a long way)

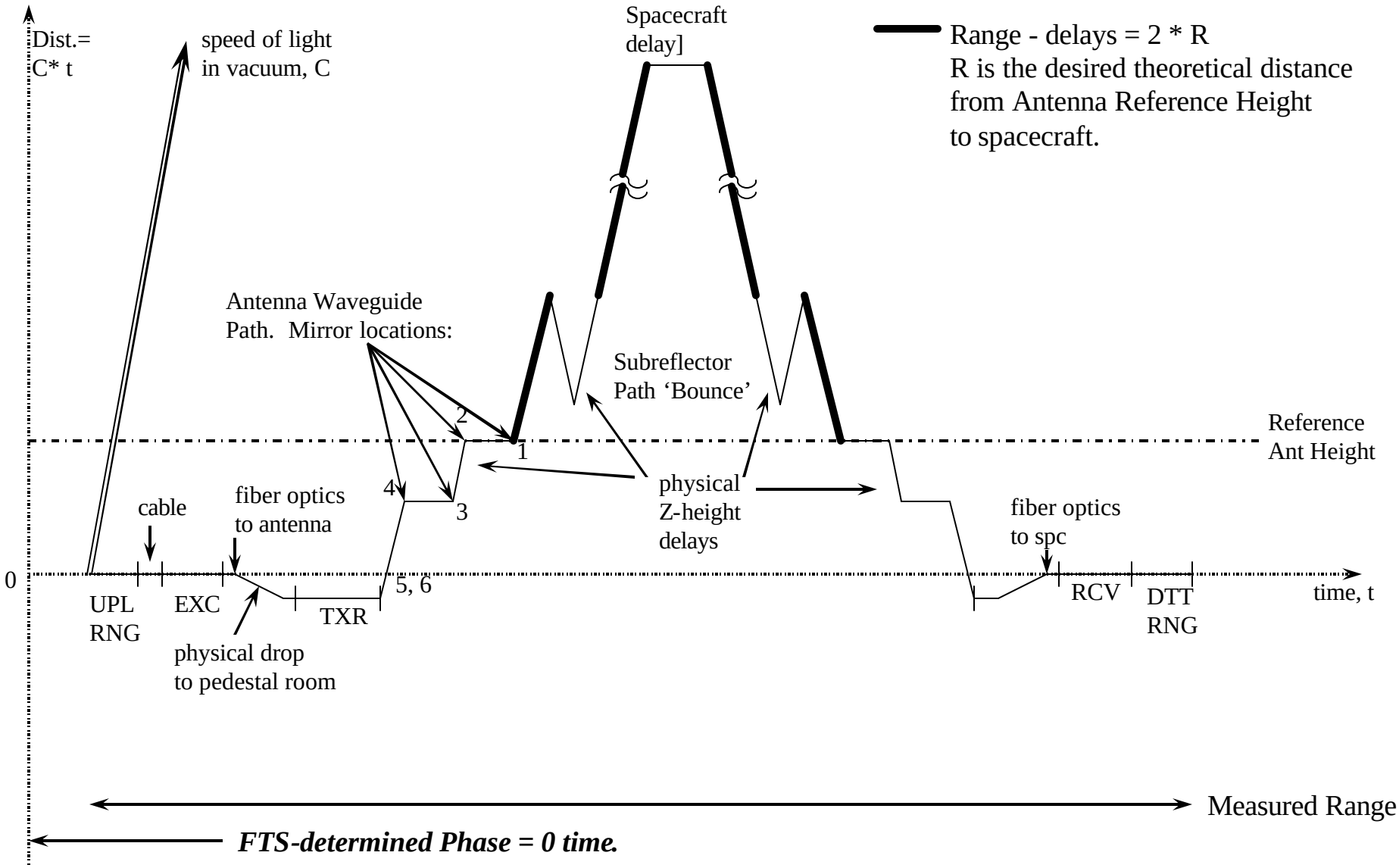
Why Navigation Needs Precise Tracking Data



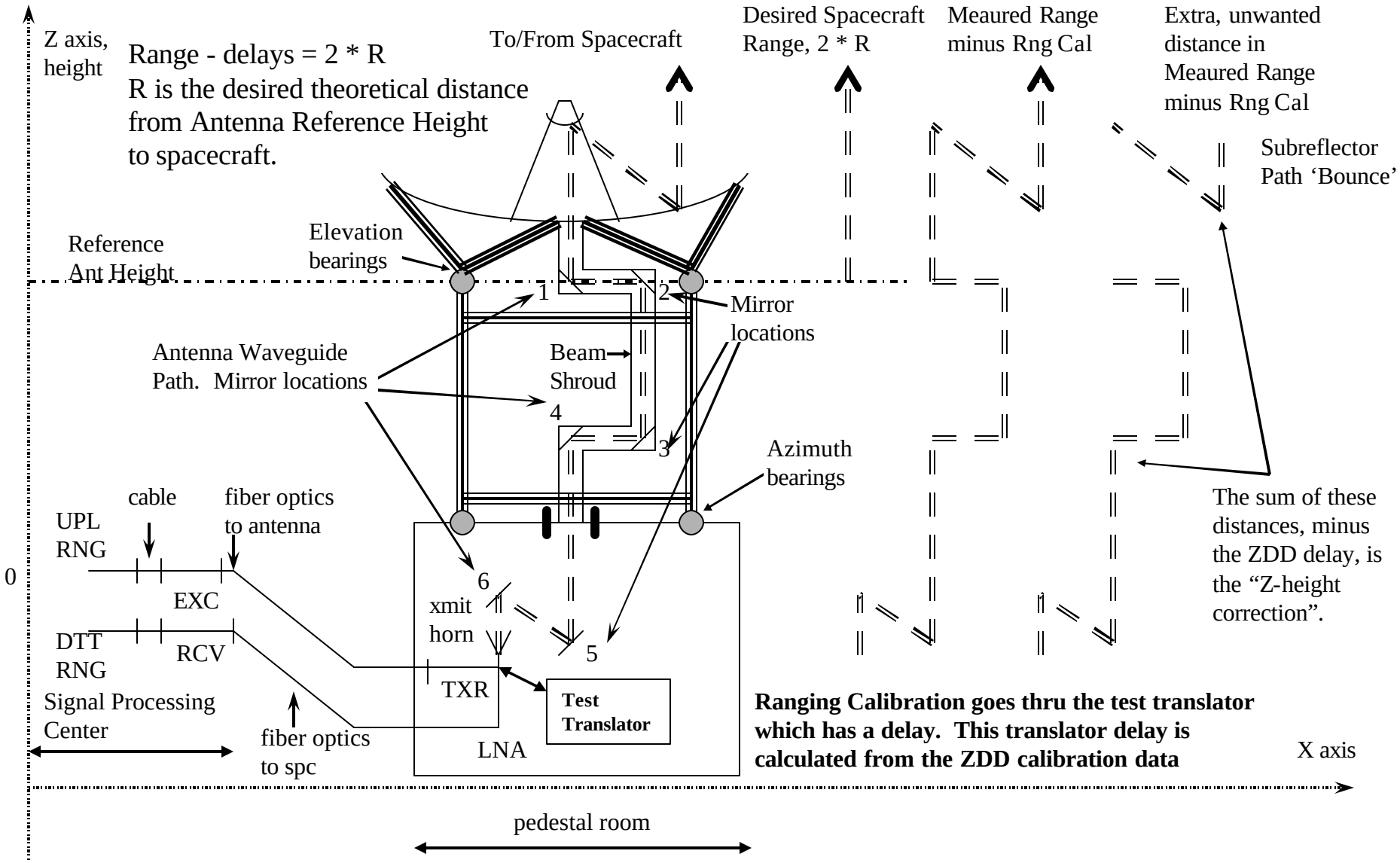
Calculating Spacecraft Range

- Navigation needs the ranging measurement between the Antenna Reference Height and the spacecraft
- This requires removing ground and spacecraft delays from the range measurements
- On each ranging track, the station performs a ranging calibration
- This is a measurement of <u>some</u> of the ranging delays in the station ground equipment
- Value must be subtracted from the measured spacecraft range
- If the ranging calibration has an error, the result may be useless
- Navigation also has to subtract the known “Z-height” distance of the station
- If the “Z-height” has an error, the result may be useless
- Z-height errors affect all spacecraft ranging on given signal path
- The Z-height is calculated using data from a ZDD calibration

Beam Wave Guide Example of NSP Ranging



Ranging Delays: Beam Wave Guide Example



What is a ZDD Calibration?

- The ZDD Calibration consists of specially modified ranging calibration procedures designed to allow calculation of the Test Translator delay
- The ZDD Calibration is performed by DSCC maintenance personnel at each 34 meter and 70 meter antenna (each uplink/downlink signal path combination)
- The data is processed back at JPL/Shamrock and used by TDDS in processing all ranging data collected during spacecraft tracking passes

How Big is a Range Unit?

- ZDD Calibration measures translator delay in range units
- 1 Range Unit = 2 * wavelength of the equivalent S-band freq
- For DSN frequencies this is roughly:
  - 0.95 nanoseconds
  - 11.2 inches
  - 28.4 centimeters
- Avg translator delay ~ 140 ns
- Std Dev translator delay ~34 ns

~1 Range Unit

When does a ZDD Calibration need to be done?

- ZDD Calibration is necessary whenever components of the signal path have changed, or once per year, whichever comes first
- An annual ZDD is like preventive maintenance… like taking your car in for a regular tune-up, or your own annual physical checkup
- Because this is done on an annual basis, it can, and perhaps should, be scheduled far in advance
- Because it is very difficult to obtain prime time for ZDD Calibrations in the short term (e.g., DSN 7 day, forecast, planning), scheduling far in advance by RAPSO makes a lot of sense, and may be the only successful approach for the long term

What are the Constraints?

Constraints on scheduling the ZDD Calibration involve:

1. **Normal Working Weekdays – if it's not weekdays, maintenance personnel must be called in on overtime**

2. **Daytime – if it's not daytime hours, maintenance personnel may have to work overtime shifts. There is also a safety issue at 70M/34 HEF which require lifting the ZDD onto the dish (with a crane) and personnel to climb onto the antenna structure**

3. **Continuous Blocks of Time – if it's not continous block of time, parts of the procedure might have to be done over. Overhead will be re-incurred when the process is resumed… generally an 8 hour block of time should be allocated**

4. **In general, ZDD calibration cannot be performed NIB. Antenna must be at stow, with transmitter radiating out the feed**

What is the relative priority of the ZDD Calibration?

- At the present time, there are a number of activities that require antenna time (per Ernestine Hampton)

- The following activities play a major role in the allocation of antenna time:
  - NCT global test time
  - major antenna downtime (reducing the number of available antennas)
  - 26 meter antenna phasing (4-hours attached at the end of each maintenance period)
  - 34 meter maintenance increased from 6 hours to 8 hours except for the Madrid antennas
  - increased Ground Based Radio Astronomy activities
  - additional Reference Frame Calibration for X/Ka-band simultaneous 24-hour supports
  - additional pre-calibration support for Genesis

What is the Relative Priority of the ZDD Calibration?

- **Relative Priorities* (?):**

- **Spacecraft tracking time**
- **Maintenance time**
- **TDN development time / Software testing time**

- **ZDD is “like preventive maintenance”… so it seems like it should have priority commensurate with maintenance**

*** Navigation perspective…**

Summary: Why is the ZDD Calibration Important?

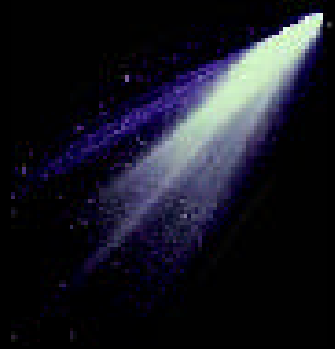
- Accurate ranging data is one of the most important data types used by spacecraft navigators (special emphasis on orbit insertion and EDL activities)
- Ranging calibration measures some delays, but not all
- The Z-Height Correction is part of the adjustments that are made to all raw ranging data measurements
- The ZDD Calibration is used to calculate a Z-Height Correction value for each unique signal path at the 34M and 70M antennas
- An accurate ZDD Calibration is essential in order for accurate ranging measurements

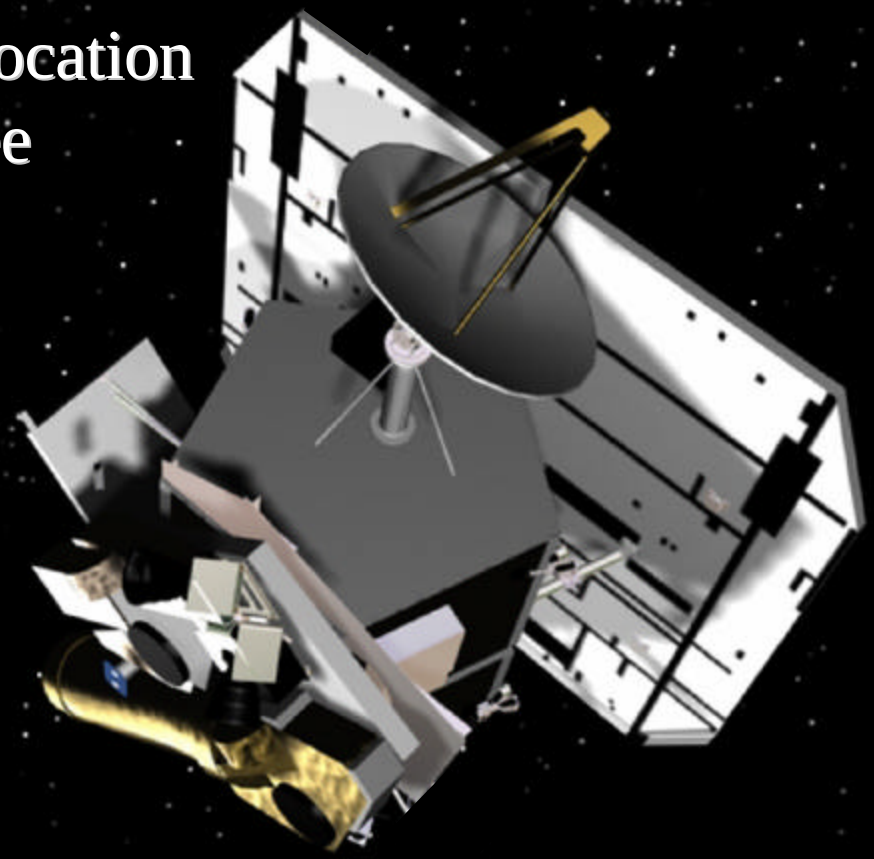
Acknowledgments

- **Material in this presentation was derived from materials developed by (in alphabetical order):**

- **Jeff Berner**
- **Scott Bryant**
- **Ernestine Hampton**
- **Sherill Hampton**
- **Jim Hodder**
- **Tomas Martin-Mur**
- **Gil Roldan**
- **Dong Shin**

Joint Users Resource Allocation Planning Committee





Deep Impact

Jared Call

Project Overview

- Deep Impact selected as 8th NASA Discovery Mission in July 1999, Phase A/B funding began November 1999
- Principal Investigator - Dr. Michael A'Hearn, University of Maryland, 12-member Science Team
- Project Manager - Rick Grammier, JPL
- Industrial Partner - Ball Aerospace & Technologies Corp.
  - Ball does most S/C and P/L flight hardware, most flight software
  - JPL provides mission design/navigation, mission operations (most of staff), fault protection and autonav software, and telecom hardware.
- Launch vehicle - Boeing Delta II (7925) under KSC contract

Flyby Spacecraft

- Substantial redundancy, dual RAD750 processors
- 3-axis attitude control (SIRU inertial sensor, star trackers, sun sensors)
- blow-down hydrazine propulsion (85 kg for maneuvers and RCS)
- X-band telecom (HGA, 2 LGA)
- S-band crosslink with impactor
- 7.5-m^2 solar panels, battery

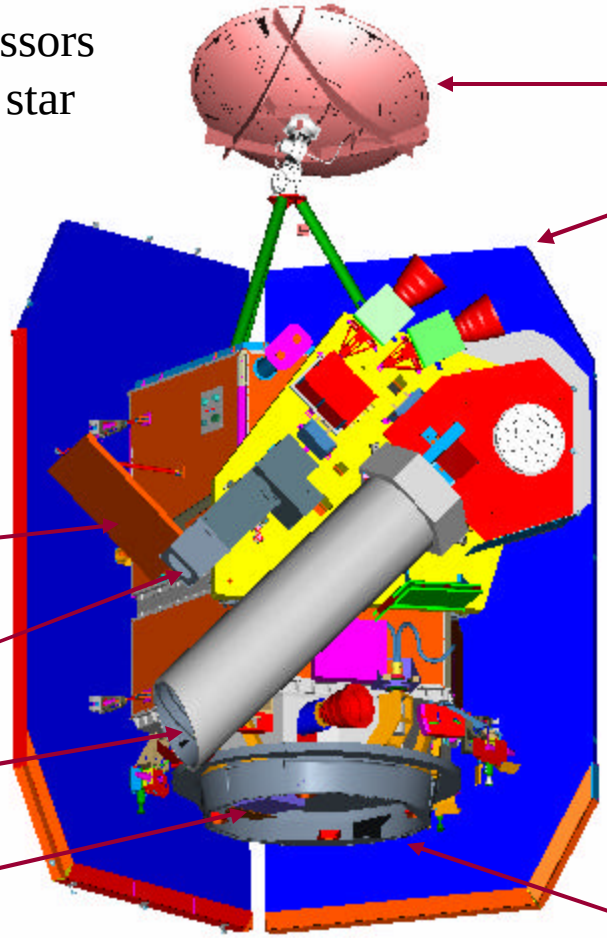
S-Band Crosslink Antenna

Instruments

Medium-resolution instrument - MRI
12-cm aperture, 10 µrad in visible

High-resolution instrument - HRI
30-cm aperture, 2 µrad IFOVin visible
plus infrared spectrometer

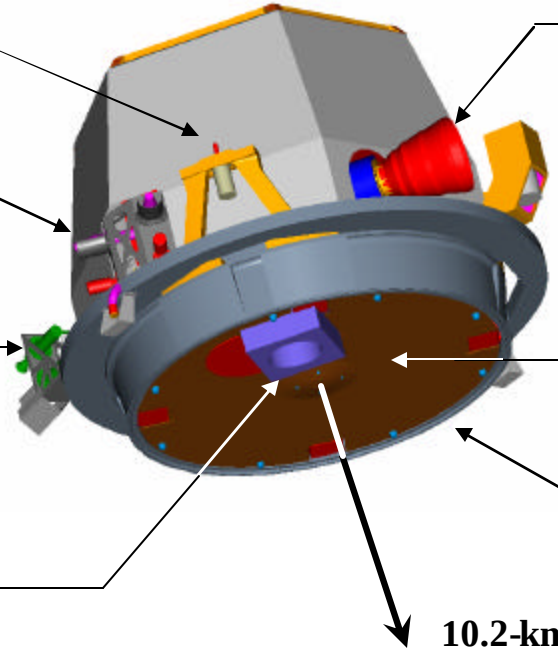
Impactor Target Sensor - ITS
same optics/CCD as MRI



Launch Configuration - Impactor Attached

Impactor

- Primarily single-string, single RAD750 processor
- 3-axis attitude control (SIRU inertial sensor, star tracker)
- blow-down hydrazine propulsion (8 kg for RCS and targeting)
- S-band crosslink with flyby S/C (64-kbps downlink)
- ITS imager feeds target images to *autonav* software, which computes target ephemeris and targeting maneuvers
- battery powered for 24-hour mission



362-kg dry mass

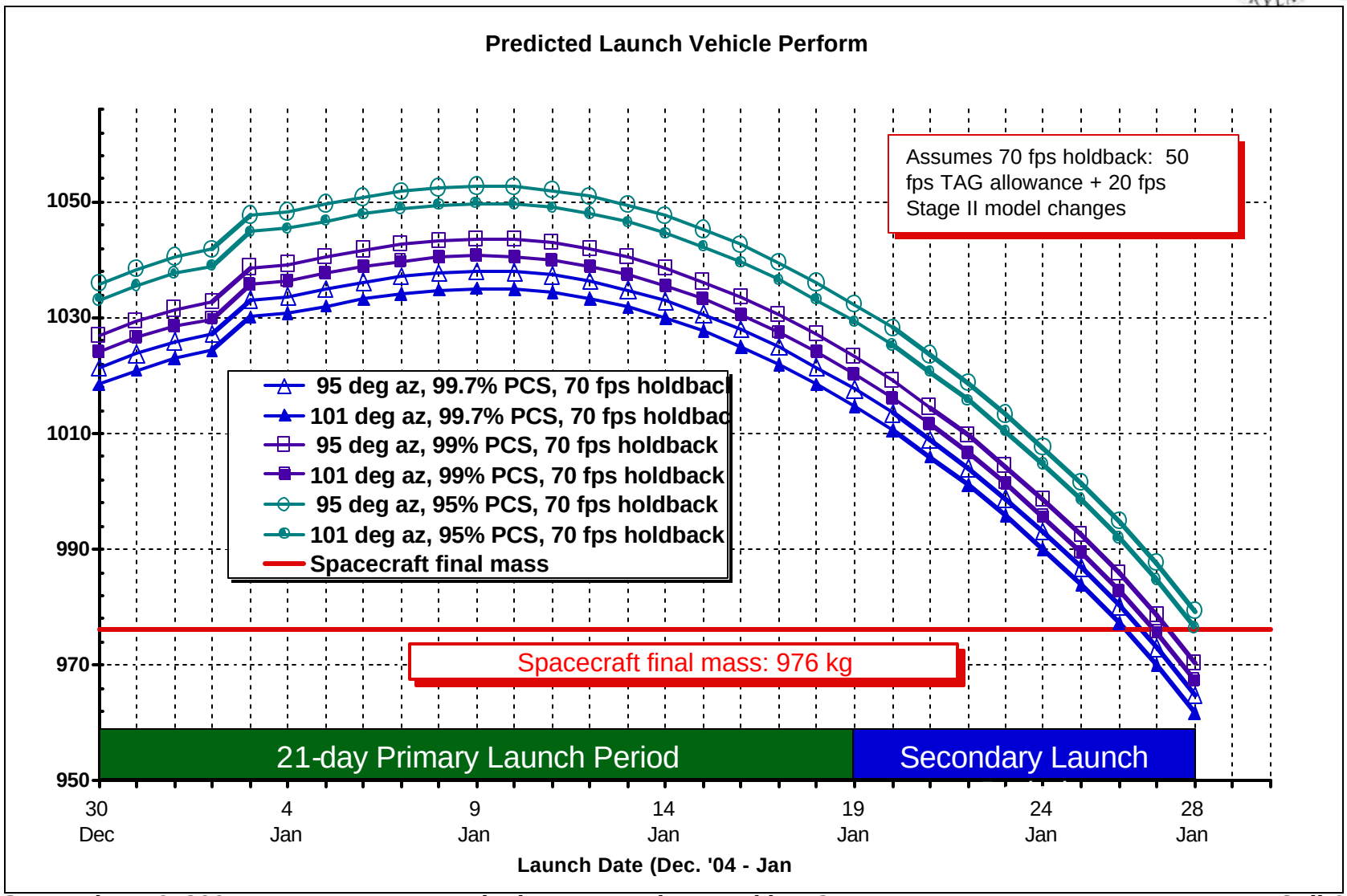
10.2-km/s Approach Speed to Tempel 1

Launch Strategy

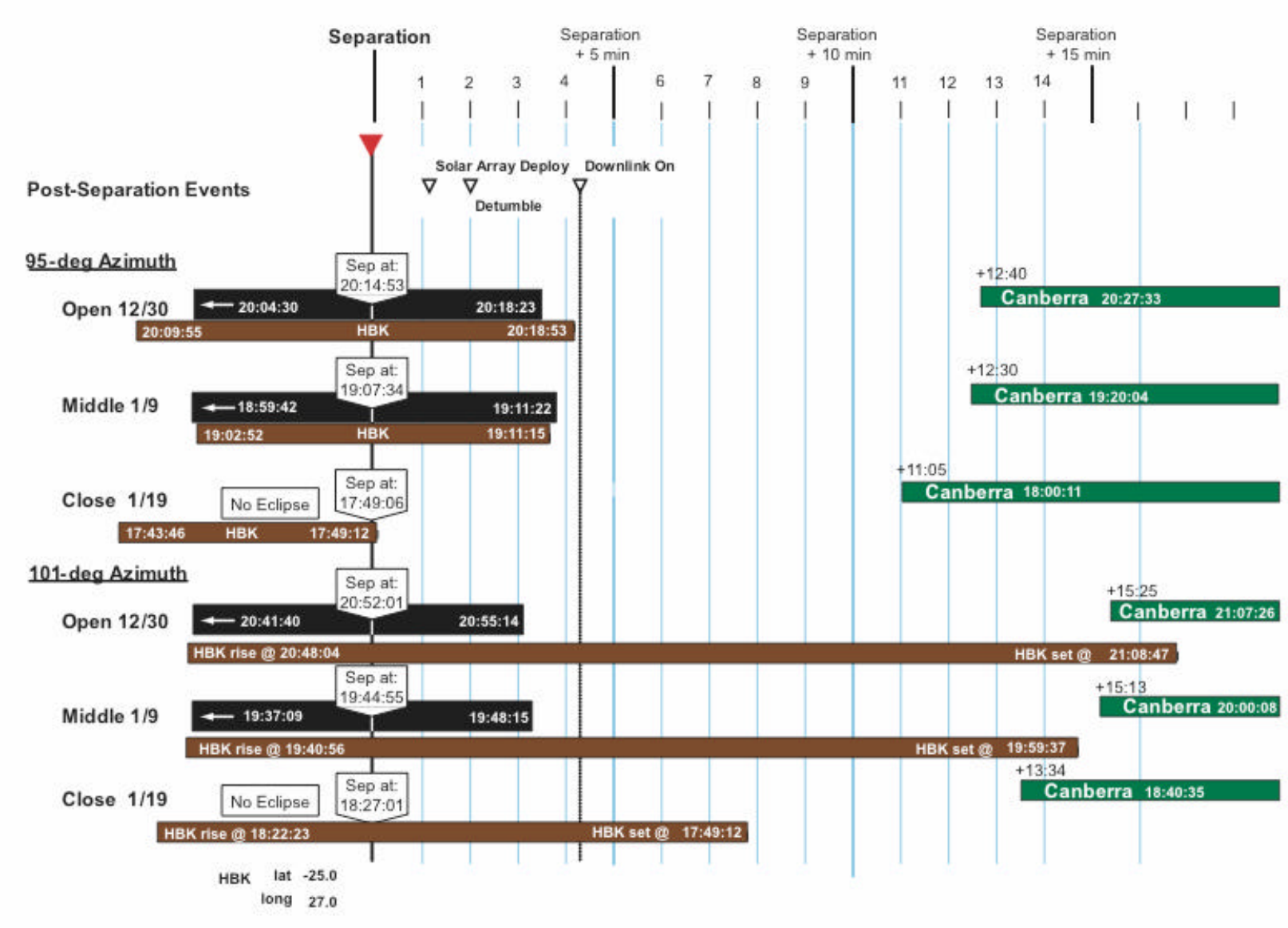
- **Launch Vehicle**
  - Boeing Delta II 7925, 2.9m PLF, CCAFS launch
  - Injected mass capability sufficient for ~1020 kg spacecraft
- **Launch Period**
  - Primary period: 21 days: Dec 30, 2004 – Jan 19, 2005
  - Secondary period, up to 9 additional days: Jan 20 - 28, 2005
  - Primary launch period centered on minimum C_3 requirement for July 4, 2005 Tempel-1 encounter
- **Launch Window**
  - Instantaneous window; predetermined launch azimuth
  - Azimuth: 1st window: 95°, 2nd window: 101°, (Δt = 39-40 min)
- **Launch Probability**
  - 21-day period with one attempt/day meets requirement for ≥ 99% probability of launch
  - NLS contract provides for 21 days
- **Launch Targeting**
  - C_3, DLA, RLA at TIP time (defined as 10 min. after Stage III ignition)
  - Injection accuracy accounted for in TCM design (TCM-1 ΔV_{99} ~54 m/s at L + 20 days)

Delta II 7925

Launch Period Performance

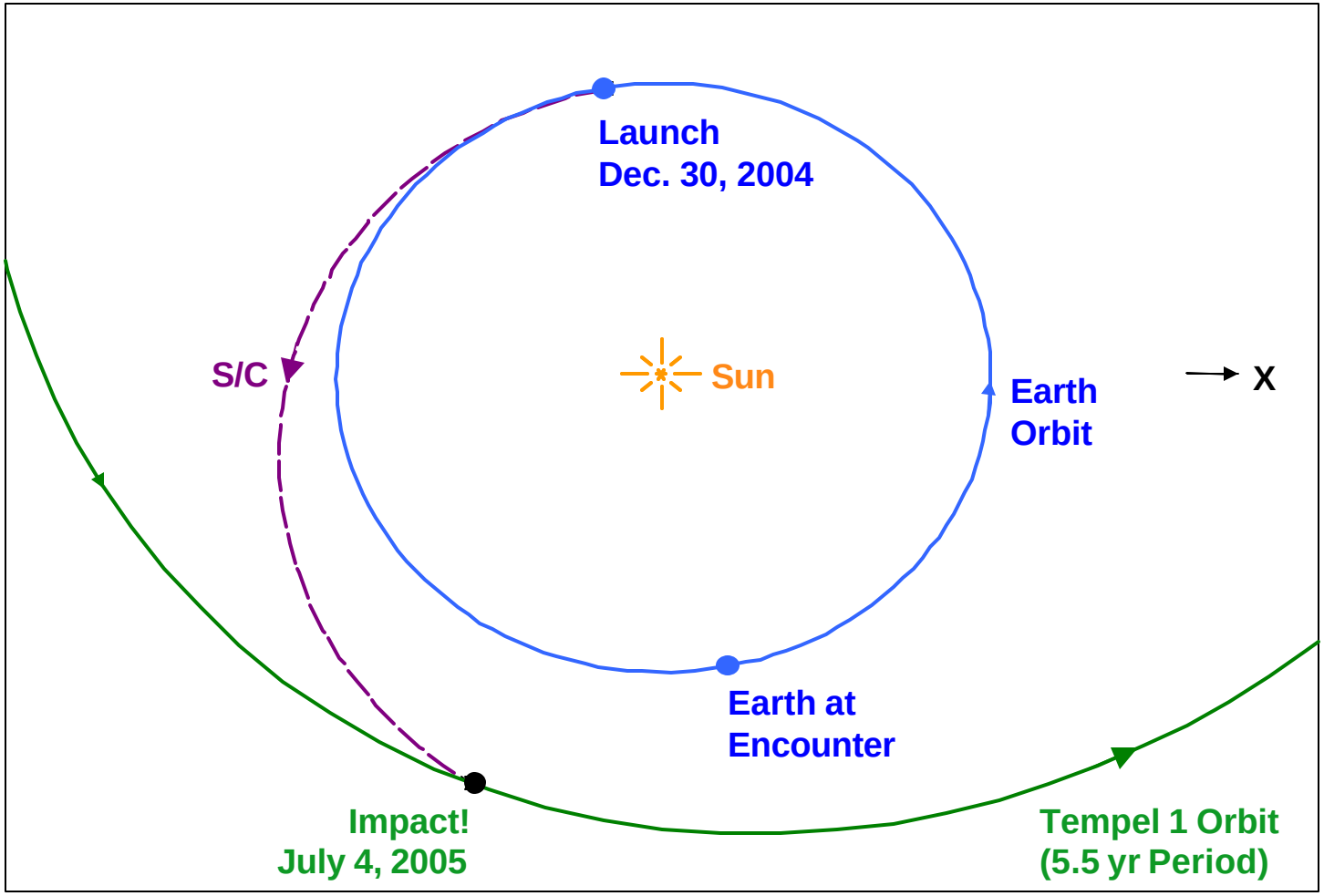


Initial Acquisition Timing

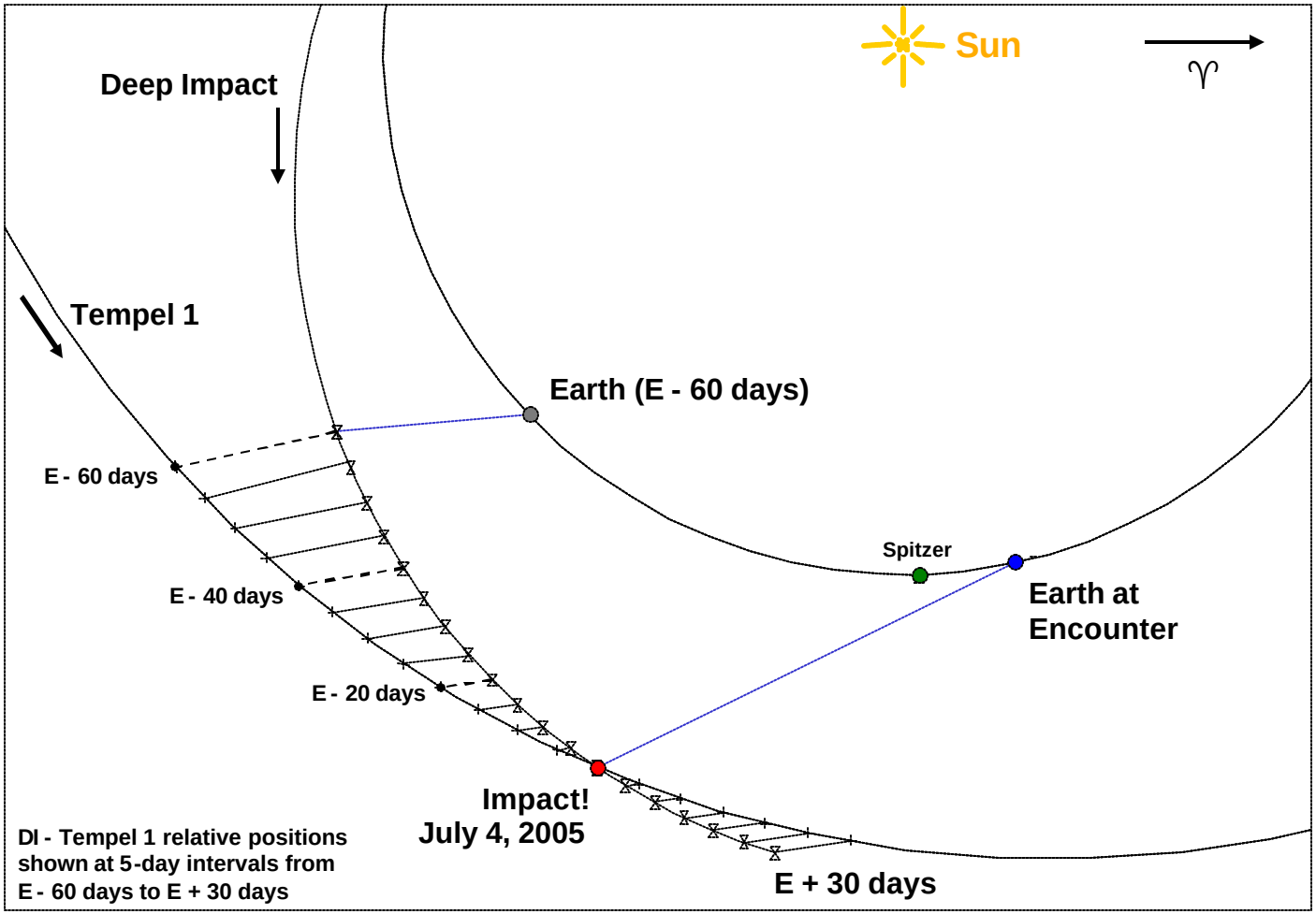


Interplanetary Trajectory

6-month direct trajectory meets Tempel 1 near perihelion



Approach Phase Geometry



Mission Phases

- Launch Phase (Liftoff to Transition to Inertial Pointing*)
  - Delta II (7925) launch vehicle
  - 21-day launch period, two launch azimuths per day

  * transition to Point state
- Commissioning Phase (Inertial Pointing to L + 30 days)
  - Spacecraft and payload checkout, TCM-1 to correct injection errors
  - Busy period with science calibrations and extensive *autonav* testing
- Cruise Phase (L + 30 days to E - 60 days)
  - TCM-2 to correct TCM-1 errors
  - Encounter Demonstration Tests in February and March 2005
- Approach Phase (E - 60 days to E - 5 days)
  - TCM-3A and -3B set encounter timing (possible HST timing adjustment)
  - Optical navigation campaign to precisely define approach trajectory
- Encounter Phase (E - 5 days to E + 1 day)
  - TCM-4 and -5 provide fine targeting, Impactor release at E - 24 hours
  - Impactor flight to impact, Flyby S/C imaging and playback (70m DSS)
- Playback Phase (E + 1 day to E + 30 days)
  - Low activity: residual playback and post-encounter assessment

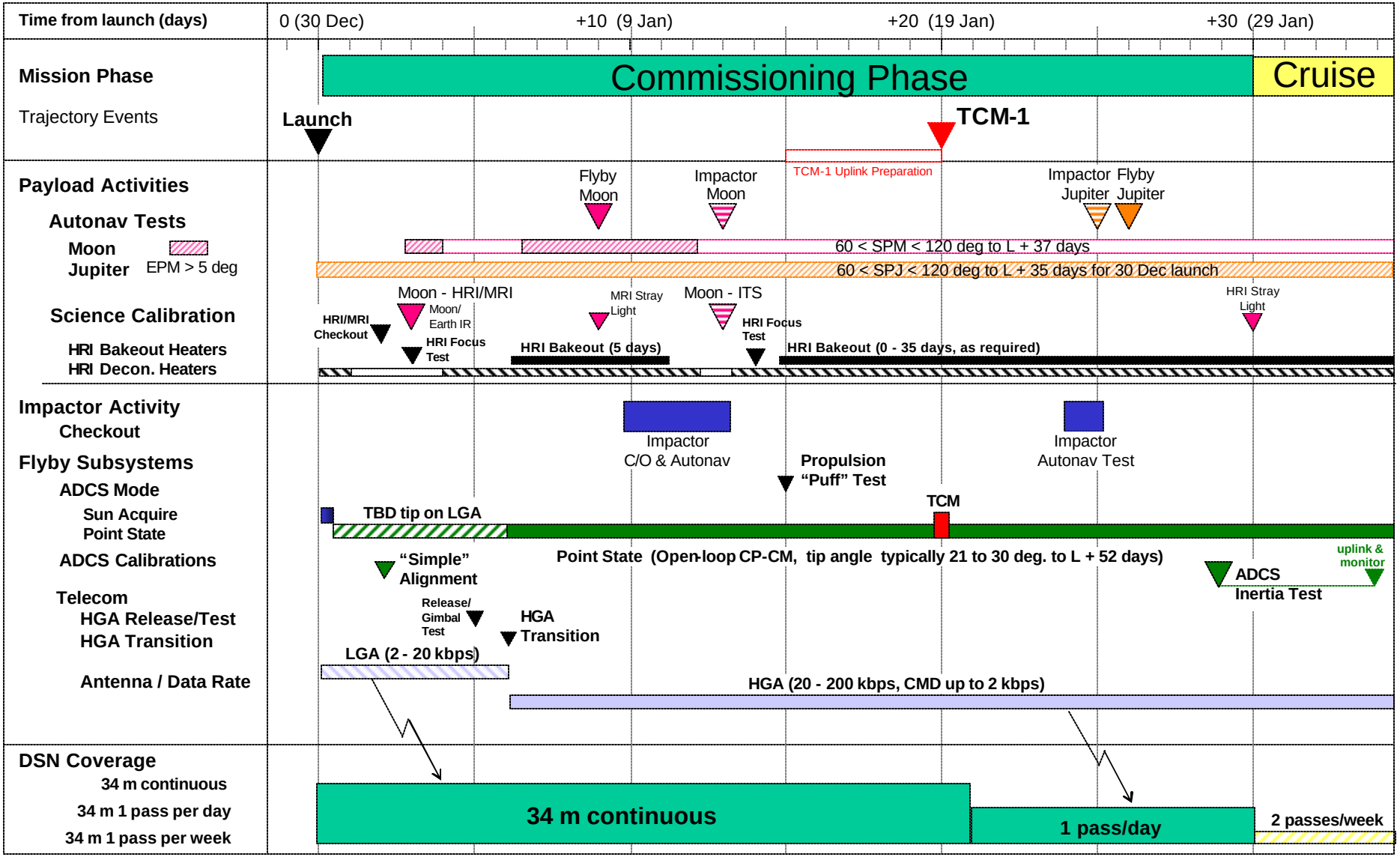
DSN Scheduling Strategy

- Launch/Commissioning Phase
  - Continuous Coverage 30 days
    - 34M BWG / HEF
    - 70M for TCM-1 (January 19)
- Cruise Phase
  - 2 8hr Command passes per week (34M)
  - Additional 34M passes for special activities (Science Cals, OpNav, TCMs, Impactor C/O, and navigation tracking passes)
  - Encounter Data Flow Demo - Simulation of the actual encounter, and requires 70M coverage 30 hours before the simulated encounter time, and an array at Goldstone (WK 12)

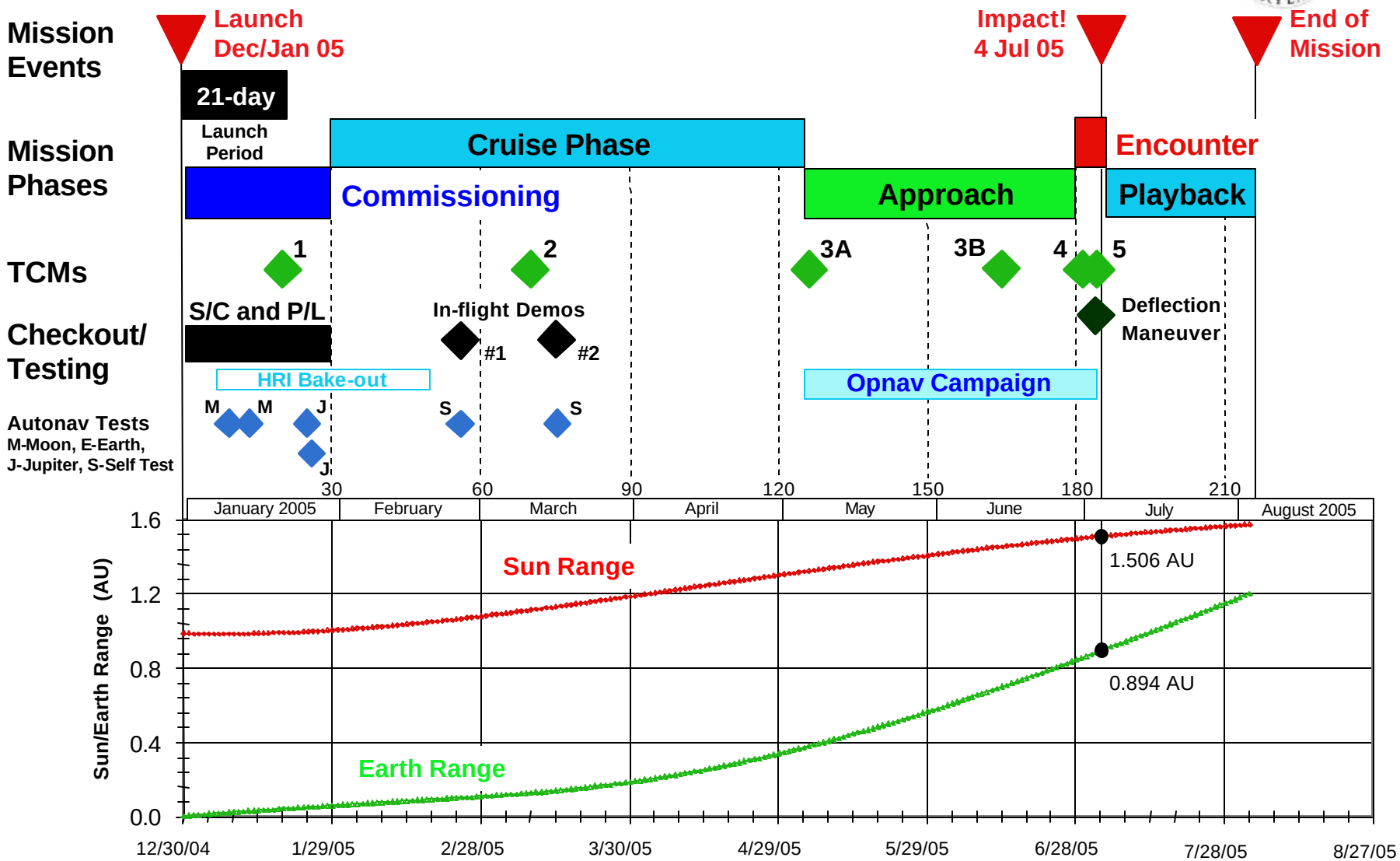
DSN Scheduling Strategy

- Approach Phase
  - 1 8 hr pass per day
  - Additional 34M passes required for special activities (Science Cals, TCMs, Impactor C/O and Calibration, and OpNav)
- Encounter Phase
  - Enc-10 days - Continuous 34M coverage with 1 70M station /day
  - Enc-7 days - Continuous 34M coverage with 2 70M stations /day
  - Enc-3 days - Continuous 70M coverage
- Playback Phase
  - 1-2 passes per week
  - Additional 34M passes required for possible special activities (Post Enc. Science Cal)

Commissioning Phase Timeline



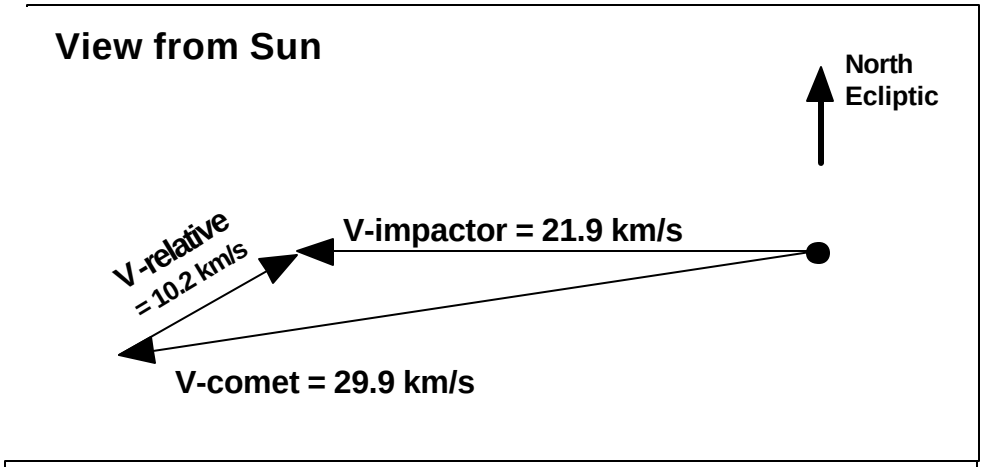
2005 Mission Timeline



Impact Digression

- Deep Impact - the original proposal was submitted in 1996, before anyone knew about Deep Impact - the movie. The second proposal was submitted in 1998.
- The impactor approach speed of 10.2 km/s is provided mainly by the comet overtaking the impactor at a much higher speed.
- The impactor is really small in comparison to the Tempel 1 nucleus*.

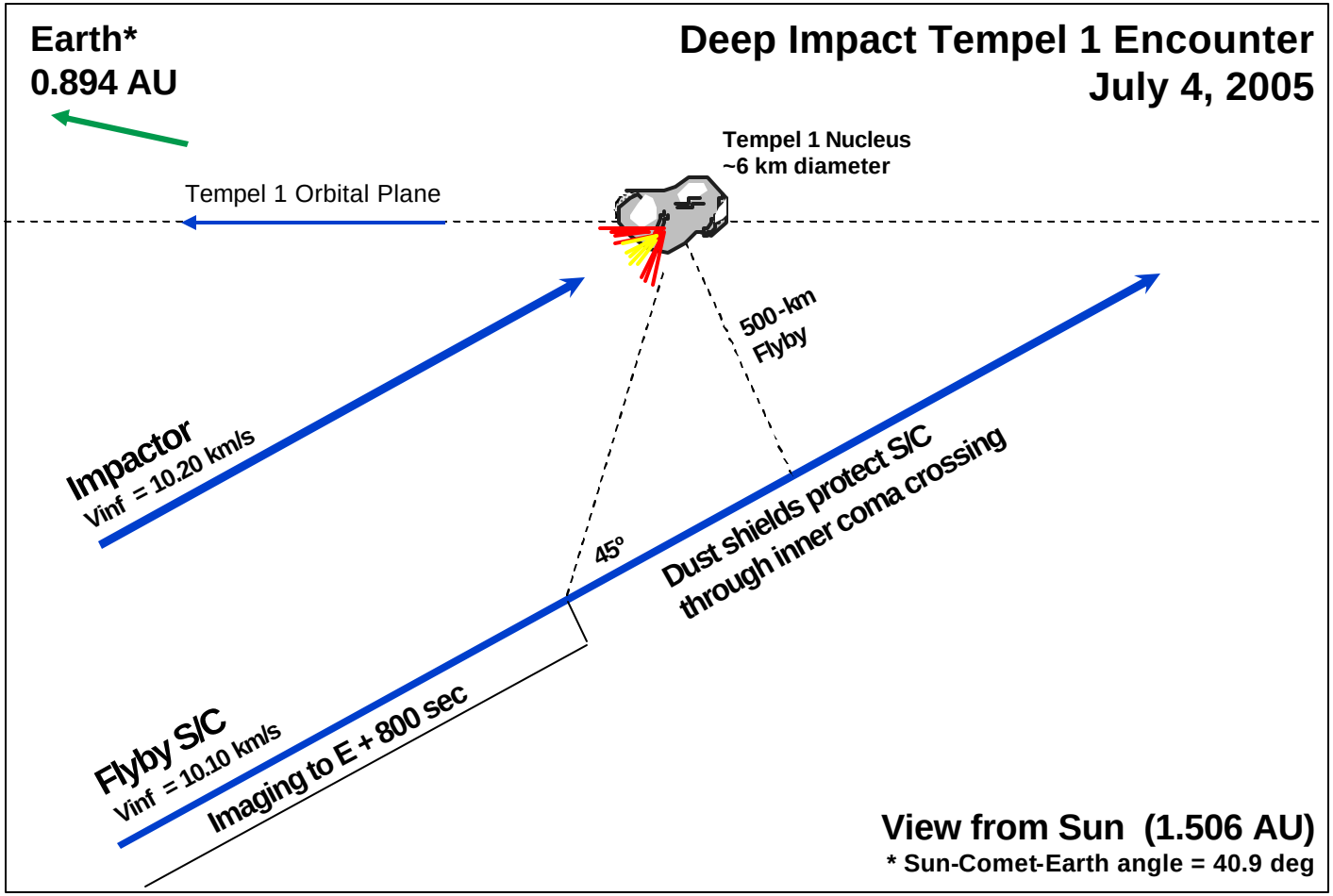
QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.



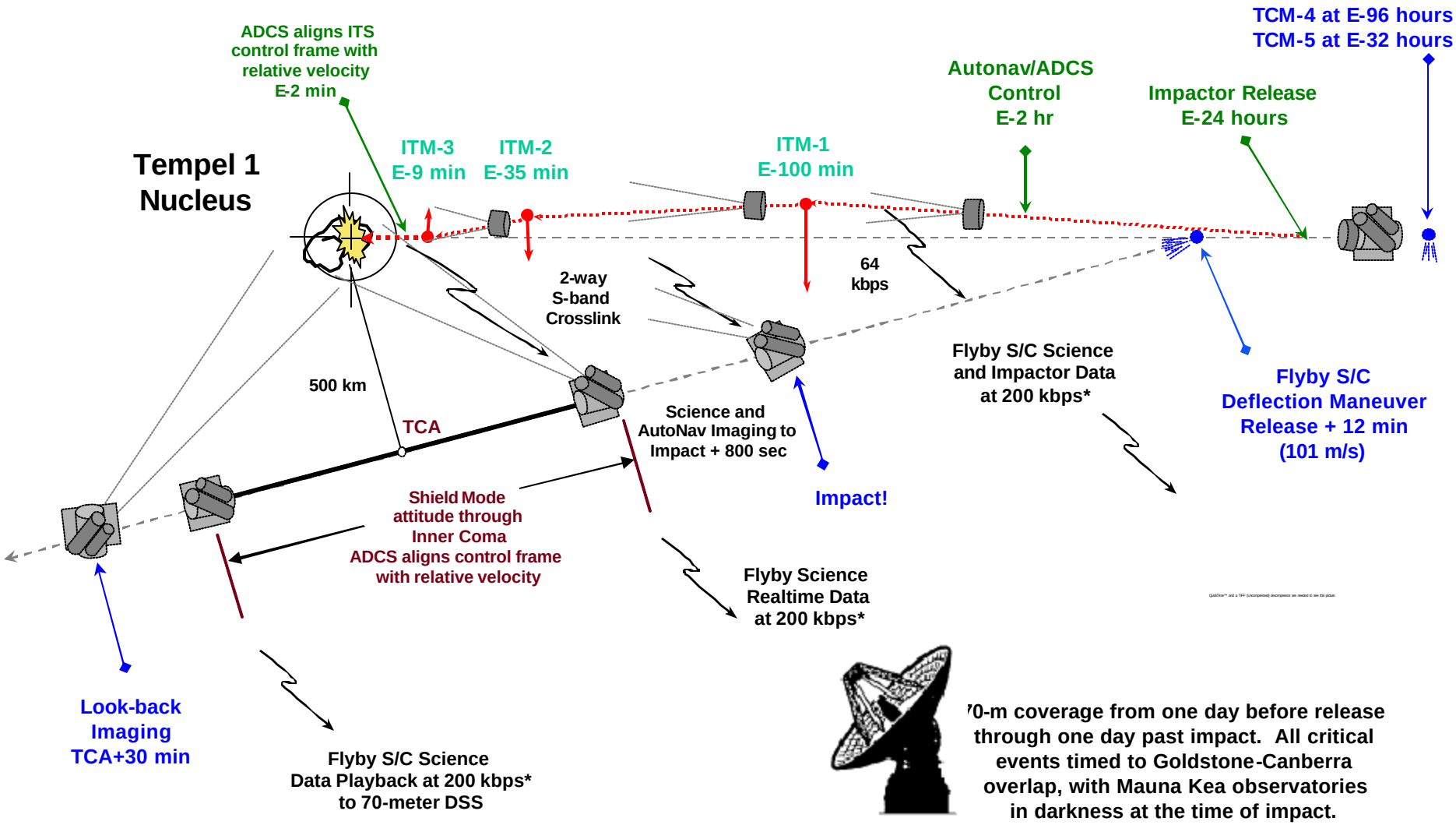
** The comparison between the mass of the impactor to that of the comet could be approximately represented by the comparison of the mass of a mosquito to that of a fully loaded Boeing 767 aircraft.*

Near-Encounter Trajectory

Flyby S/C deflection maneuver targets it 850-sec behind the impactor and 500-km below the nucleus



Encounter Schematic

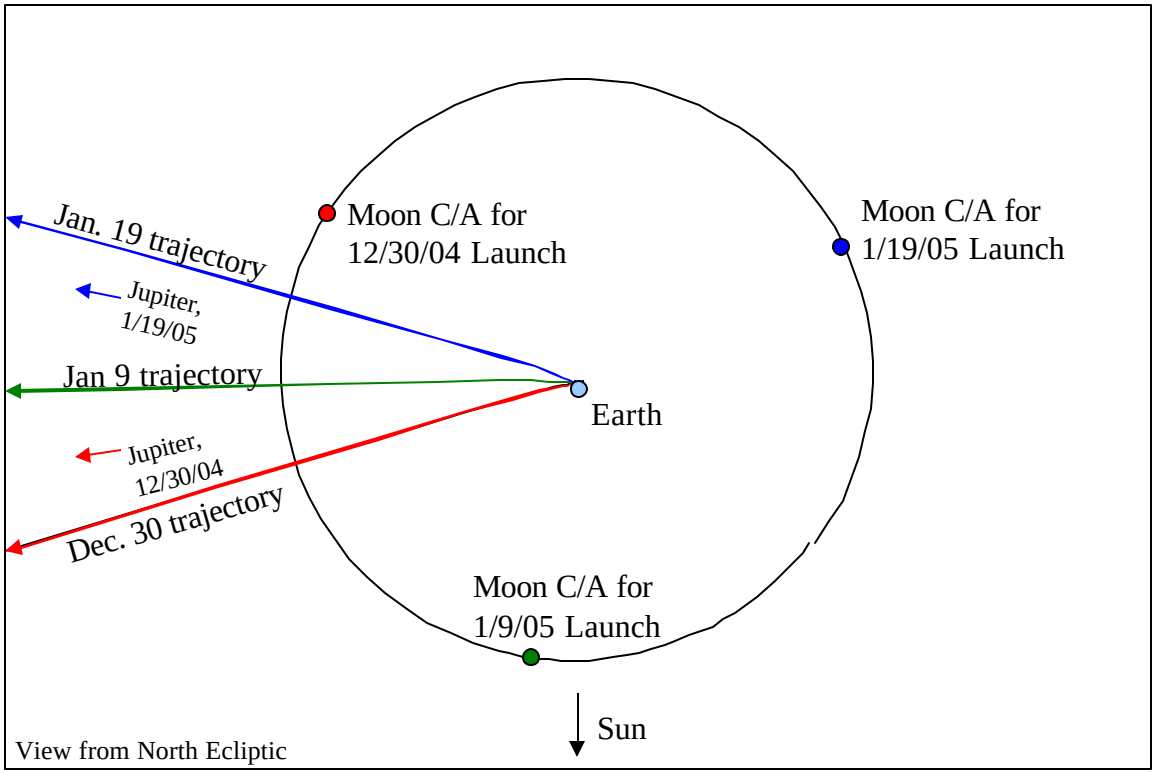


70-m coverage from one day before release through one day past impact. All critical events timed to Goldstone-Canberra overlap, with Mauna Kea observatories in darkness at the time of impact.

* data rates with Reed-Solomon encoding

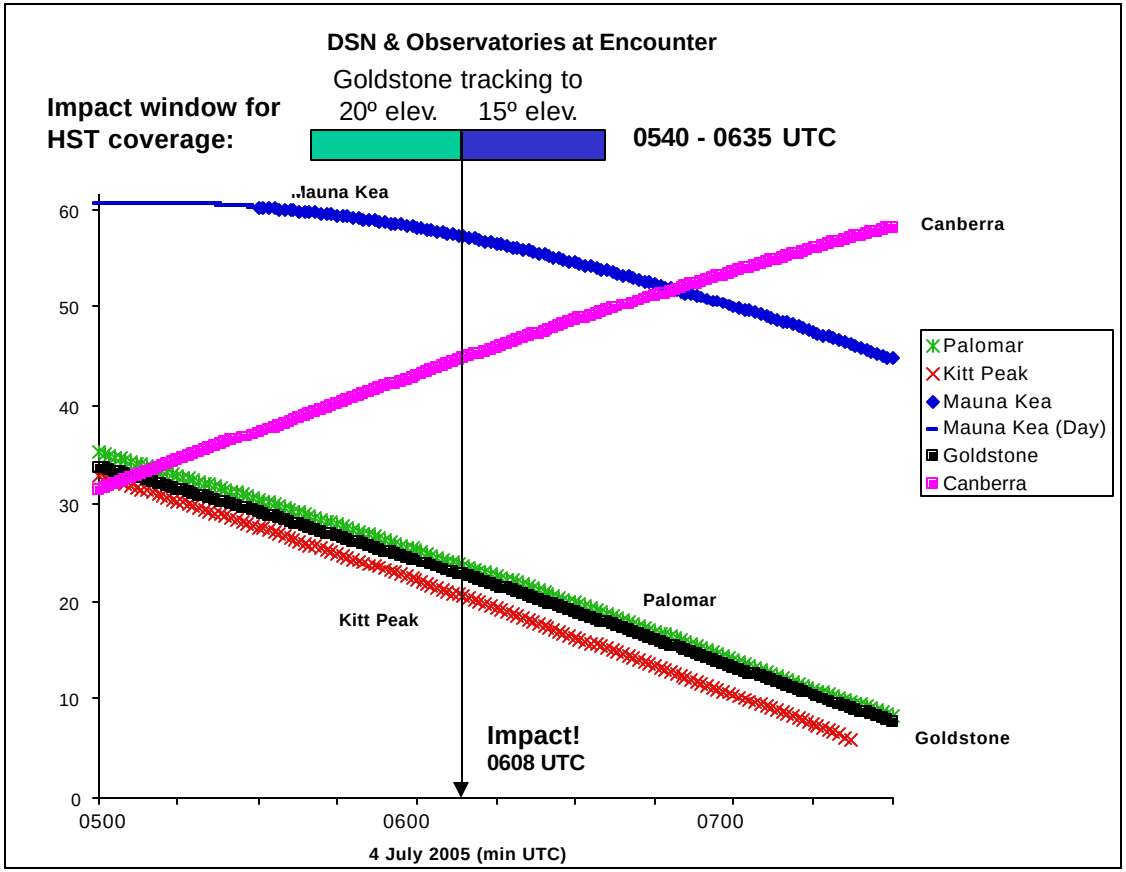
Near-Earth Trajectory Variation with Launch Date

- Lunar phase angle increases with later launch dates for science calibrations and autonav tests. Less time available.
  - closest lunar distance ~50,000 for January 2 and 3 launch dates



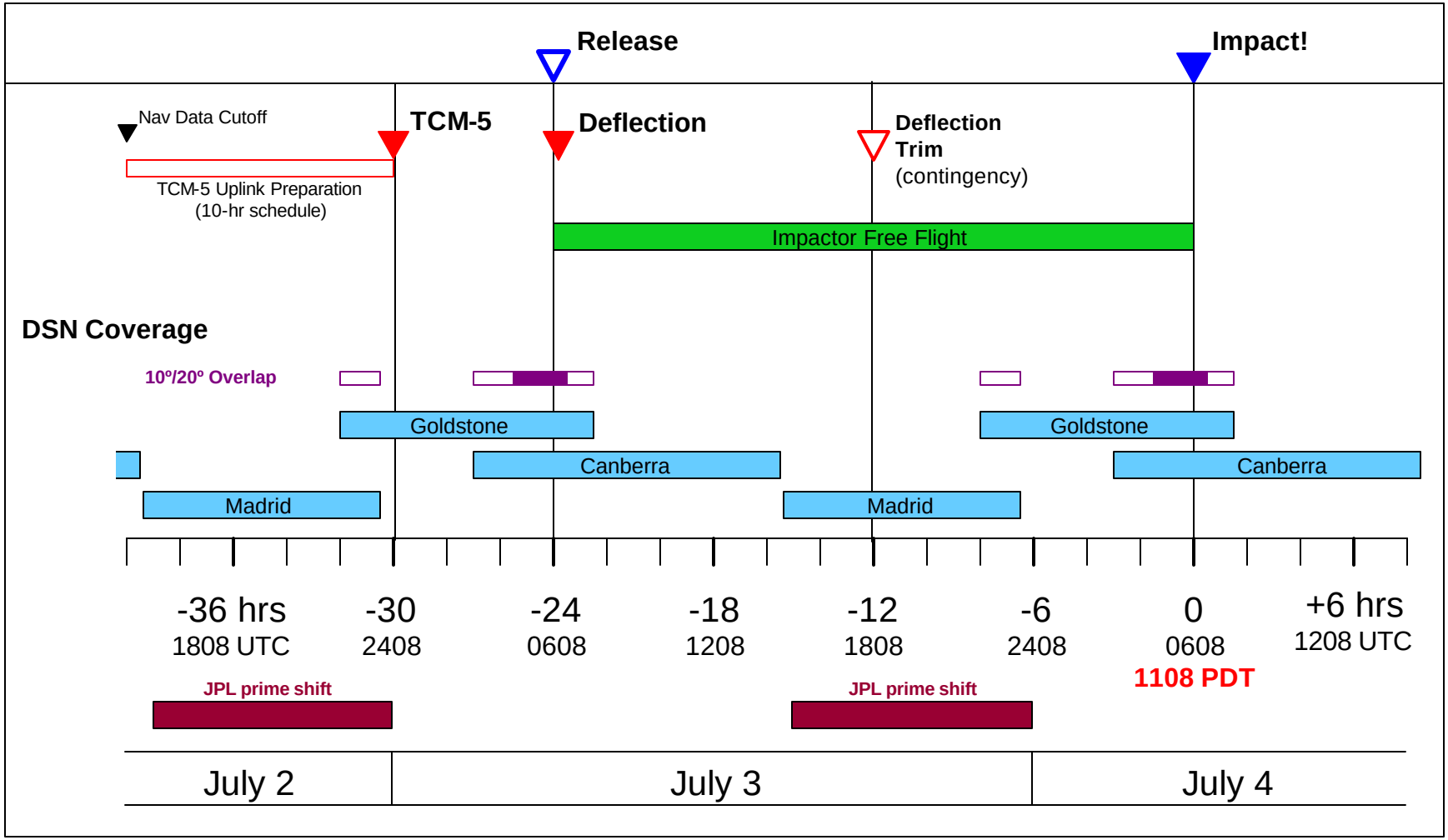
Encounter Timing

- Critical encounter events timed to Goldstone-Canberra tracking overlap and darkness at Mauna Kea observatories.



- Window for HST timing adjustment limited by darkness at Mauna Kea and min. tracking elev. at Goldstone
  - only about 28 min. (29% of orbit) to 20º elev.
  - only about 55 min. (57% of orbit) to 15º elev.
- HST observations may also be limited by South Atlantic Anomaly passages on critical orbit
- Proposals to other space-based observatories, including SIRTF will be made by the Science Team

Final Targeting/Release Event Timing



Questions
Comments
DEEP IMPACT
First Look Inside A Comet

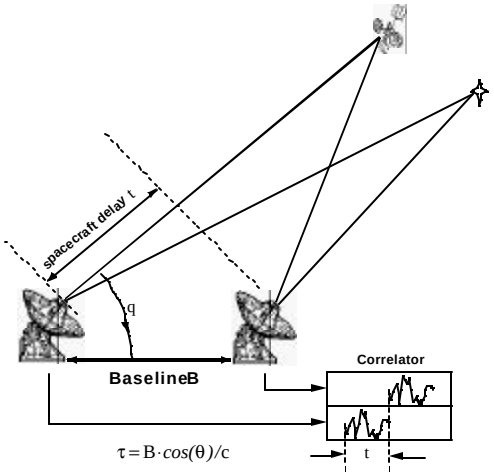
VLBI

What Is It?
What Can It Do?
What Should Schedulers know?

Chris Jacobs
Reference Frame Calibration Project
Section 335

16 September 2004
Presentation to JURAP

Outline

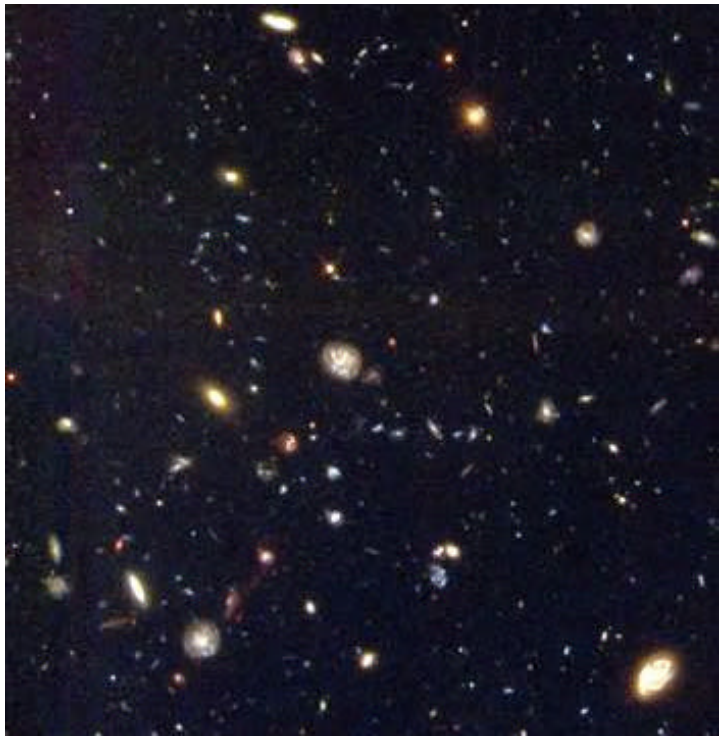


- What is VLBI?
- How does it help the DSN and its missions?
  - ?DOR navigation
  - Mars ephemeris
  - Calibrates: Earth Orientation, station locations
  - Physical Models for upcoming DSN array
- Where do the VLBI scheduling requirements come from?
  - Two stations at a time
  - Two baselines within 6 weeks (CA-Aust, CA-Spain)
  - 24 hour duration
  - S/X (HEFs) and X/Ka (BWGs)

Basis of VLBI: Point source at infinity

How Does VLBI work?

Extragalactic "nebulae" idea goes back to 18th c. ?



Credit: Hubble Deep Field, NASA, STScI.

- **Relies on point source at infinity -**
  Active Galactic Nuclei
  Concept: Navigate by "fixed" stars

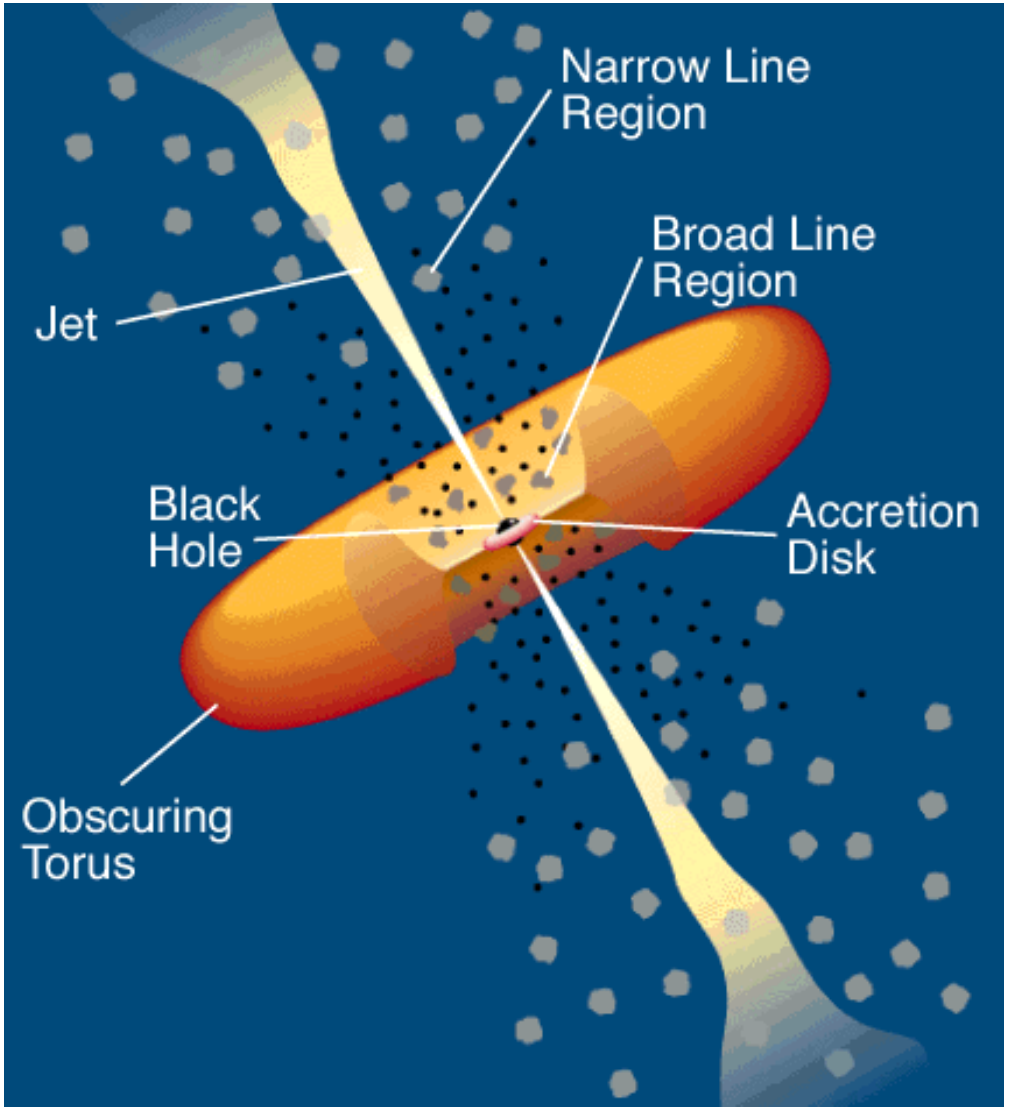
- **Advantages: sources don't move**

BUT . . .

- **The price to be paid is**

Very weak sources *1 Jy = 1.0E-26 watt/m**2/Hz*
need lots of square meters *=> 34 - 70m Antenna*
lots of Hz bandwidth *=> 10-100 Mbps*
low system temperature *=> Tsys = 20-40 Kelvin*

Natural Radio Source Schematic



Schematic of
Active Galactic Nuclei
Redshift z~ 0.1 to 5
Distance:
billions light years
Parallax = 0
Proper motion
< 0.1 nrad/yr

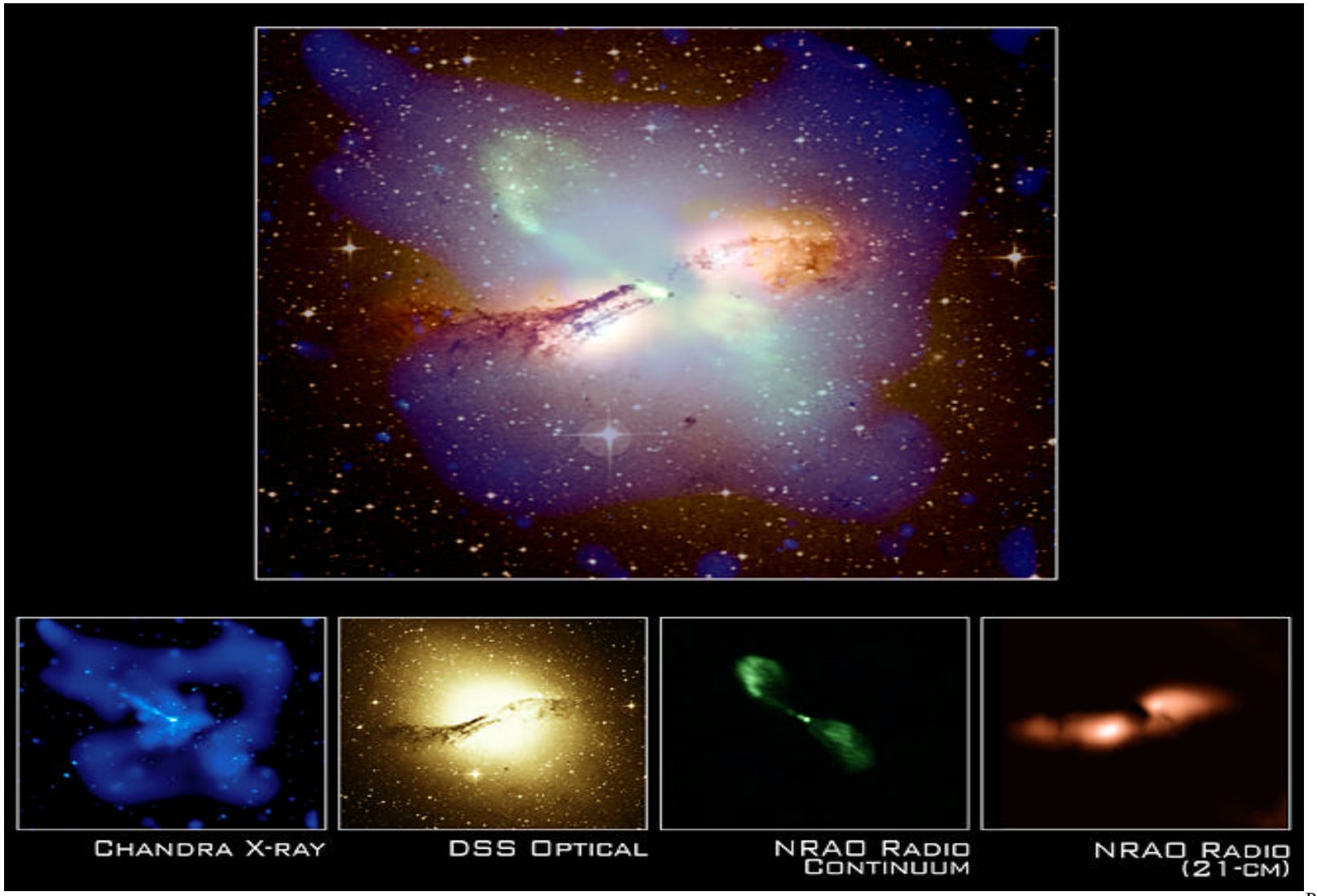
Centroid of radiation Gets closer to central engine (black hole) As one goes to higher Frequencies, therefore,

K/Ka/Q better than X

(Credit: C.M. Urry and P. Padovani)

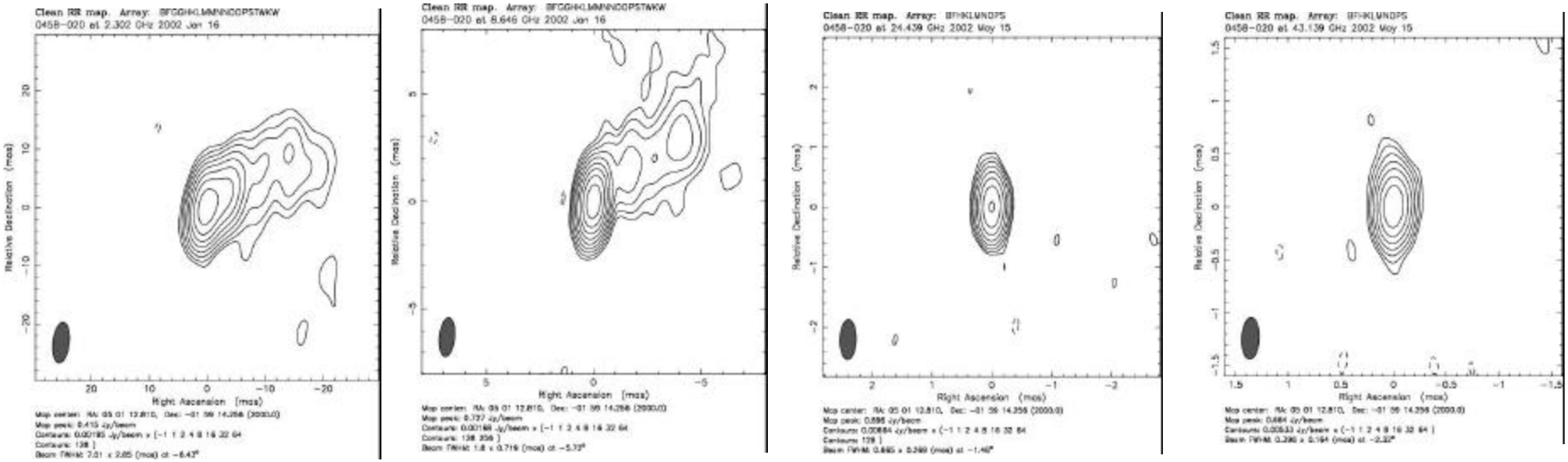
http://heasarc.gsfc.nasa.gov/docs/objects/agn/agn_model.html

Centaurus-A in X-ray, Optical, and Radio



Credits: X-ray (NASA/CXC/M. Karovska et al.); Radio 21-cm image (NRAO/VLA/Schiminovich, et al.),
Radio continuum image (NRAO/VLA/J.Condon et al.); Optical (Digitized Sky Survey U.K. Schmidt Image/STScI)

Source Structure vs. Frequency band



S-band	X-band	K-band	Q-band
2.3 GHz	8.6 GHz	24 GHz	43 GHz
13.6cm	3.6cm	1.2cm	0.7cm

The sources become better at Ka-band!

Ka-band
32 GHz
0.9cm

? DOR / VLBI Observation Geometry

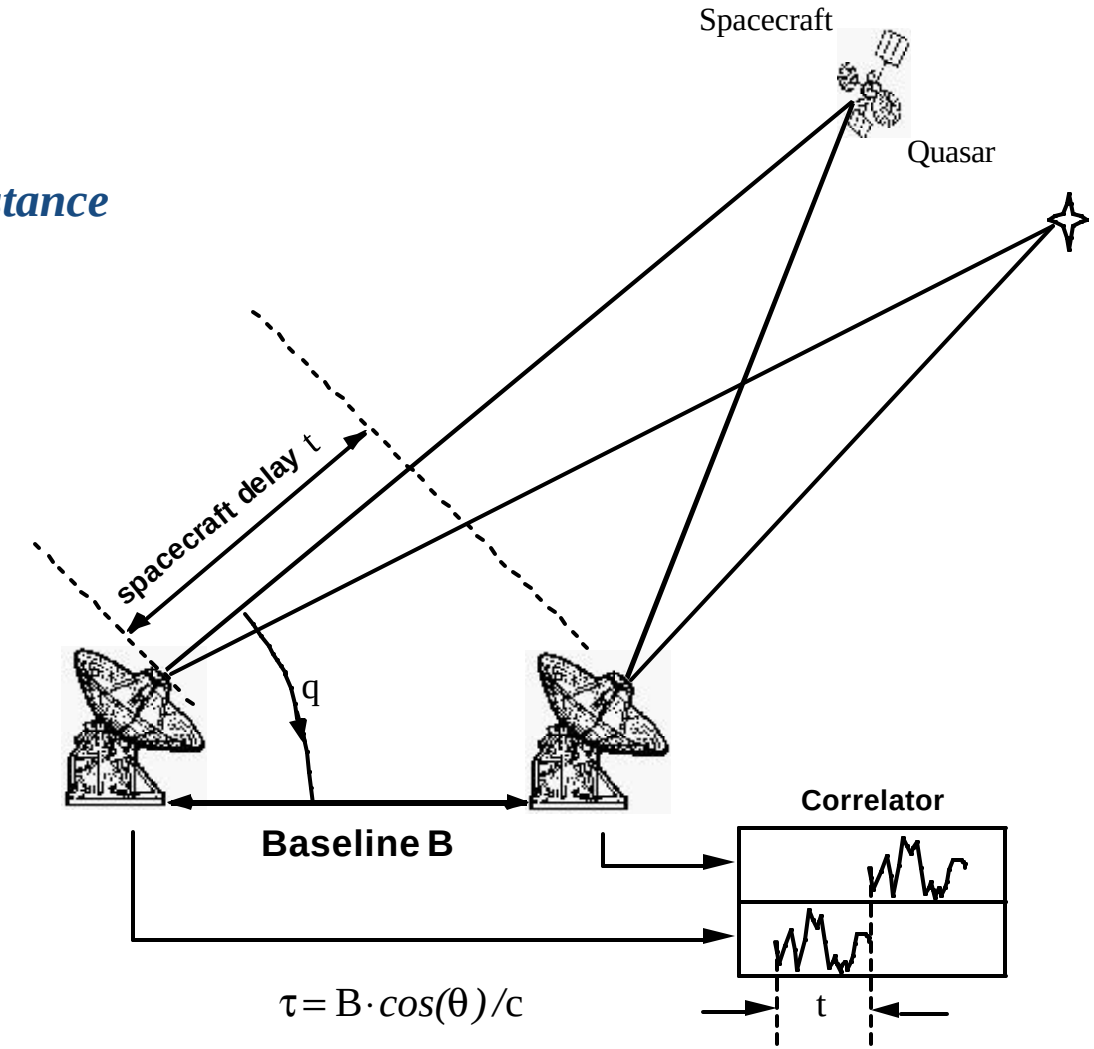
? DOR is complementary to Doppler and range!!!

Doppler/Range measure distance

?DOR measures angles

by cross-correlating signal from two (2) stations

-Double-differencing cancels large
-portion of common error sources
- *instrumental effects*
- *clock errors*
- *media effects*
- *baseline uncertainty*



$$\tau = B \cdot cos(\theta)/c$$

Credit: C.D. Edwards, J.S. Border, J.E. Patterson

Extragalatic Celestial Radio Frame

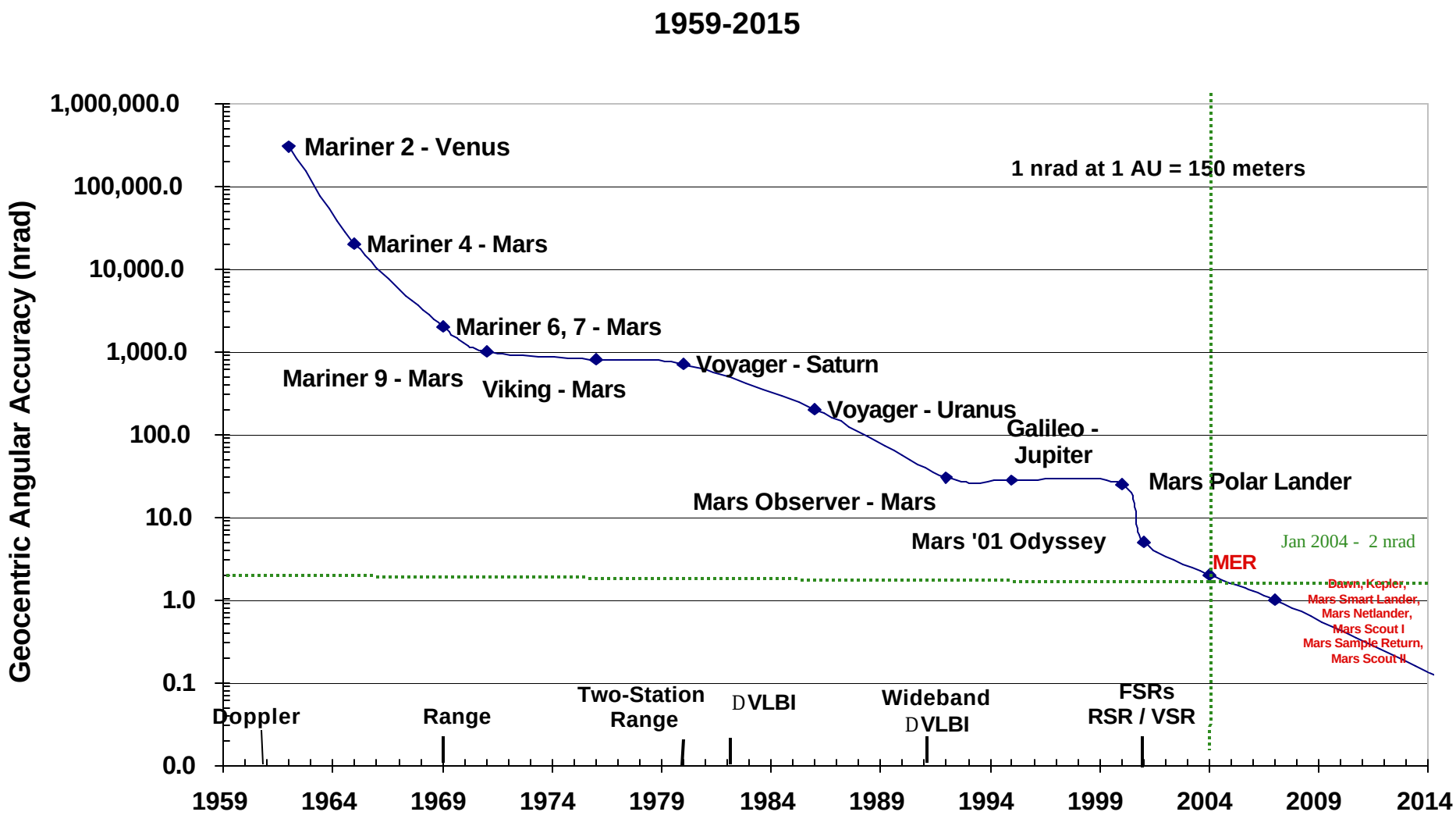
Why should you care?

- **Mars ephemeris/frame tie improves our knowledge of where the planets are located. This is needed for all missions.**

- **Earth Orientation determined relative to radio frame**
  - ***GPS constellation node drifts***
  - ***VLBI* calibrates UT1 component of Earth Orientation for all missions**

- **?DOR fiducials are sources from radio frame This helps naviagate many missions.**

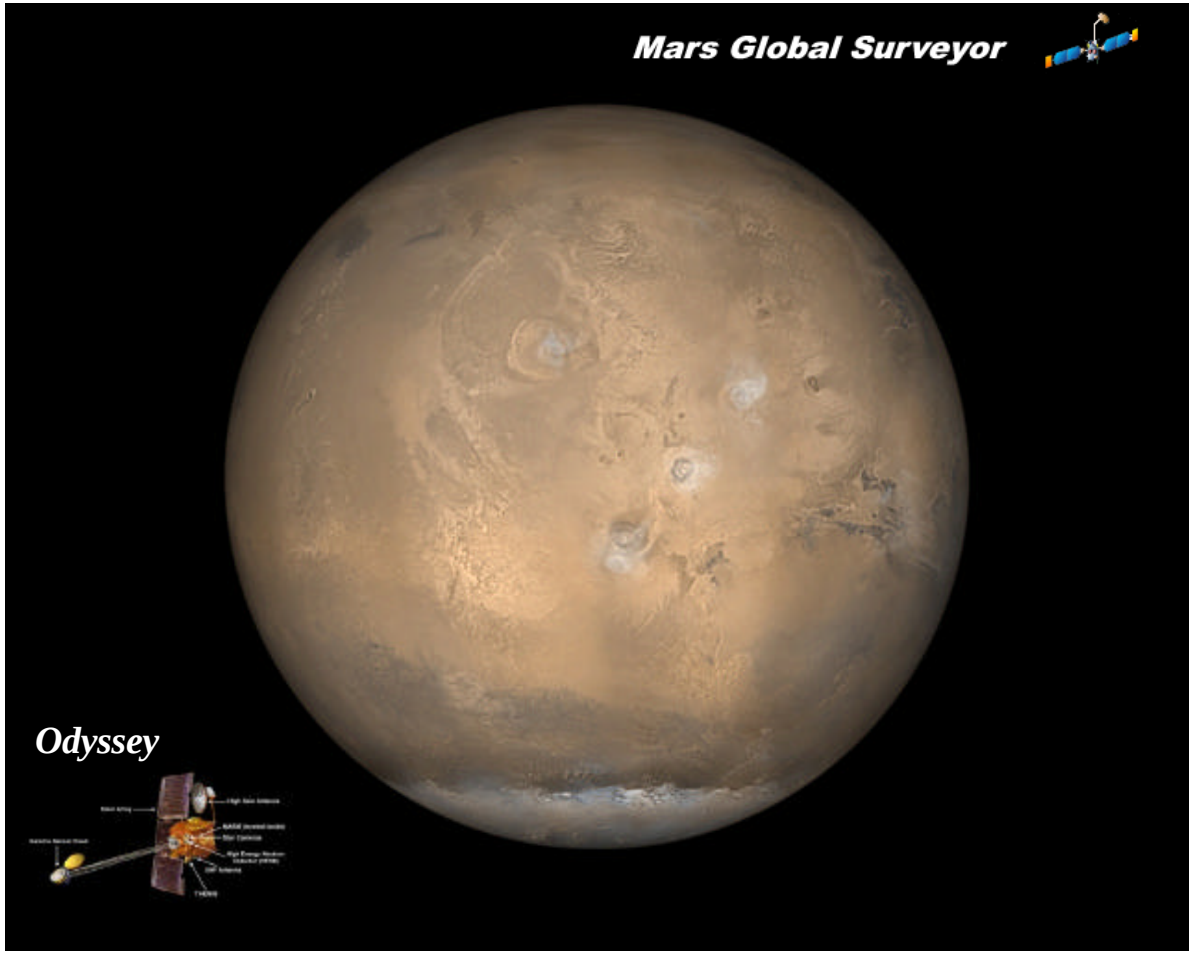
DSN Navigation System Accuracy



Credit: J.E. Patterson.

Mars Ephemeris/ Frame Tie

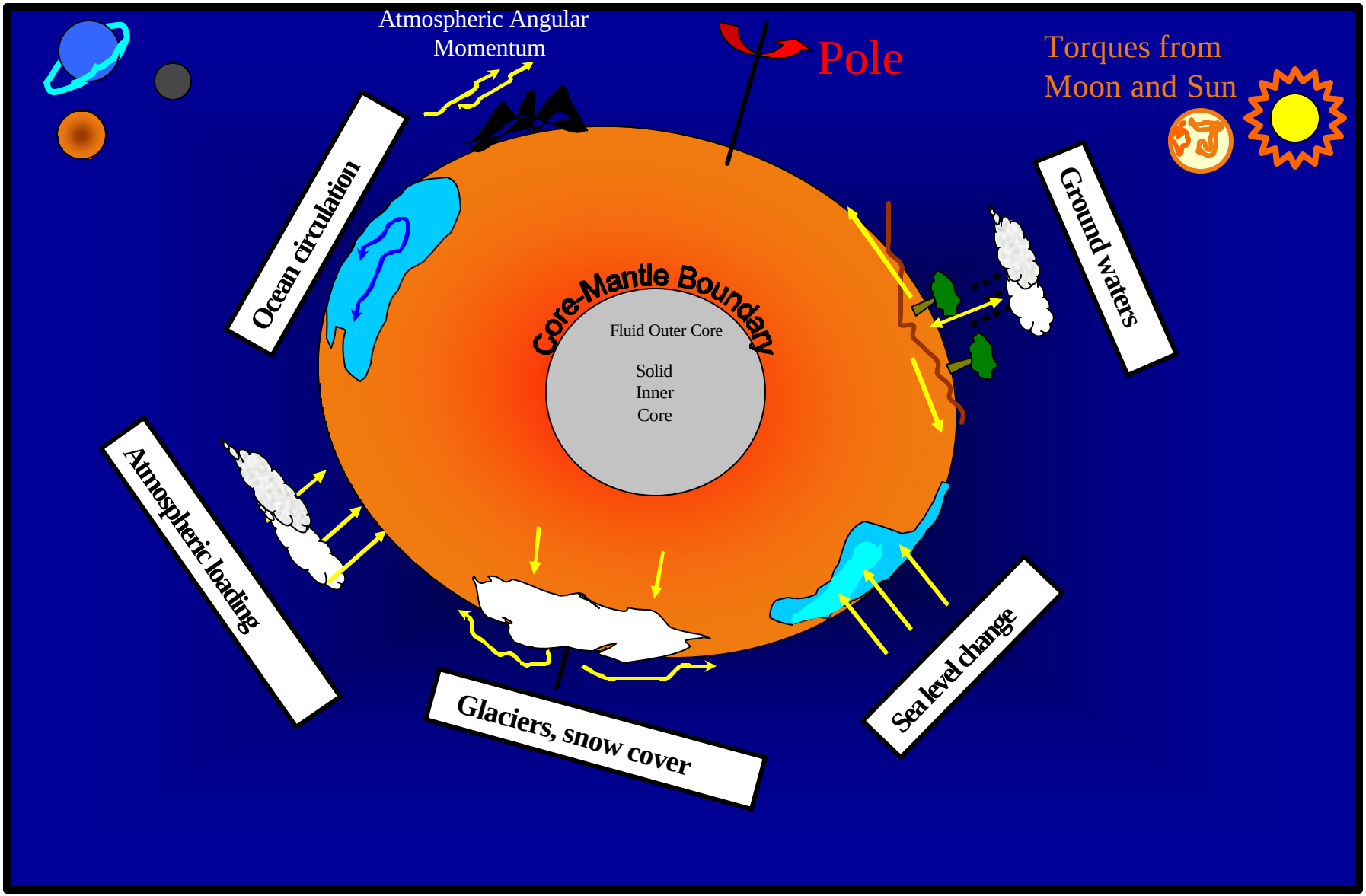
- **Jim Border *et al***
- **~ 40 ?DOR measurements**
  - **- MGS and**
  - **- Odyssey**
- **Mars residuals**
  - **3X improvement!!**
  - **1.5 part per billion**
- **More data on the way!!**
  - **Accuracy may improve to better than a part per billion.**



Credit: NASA, JPL/Caltech: www.jpl.nasa.gov

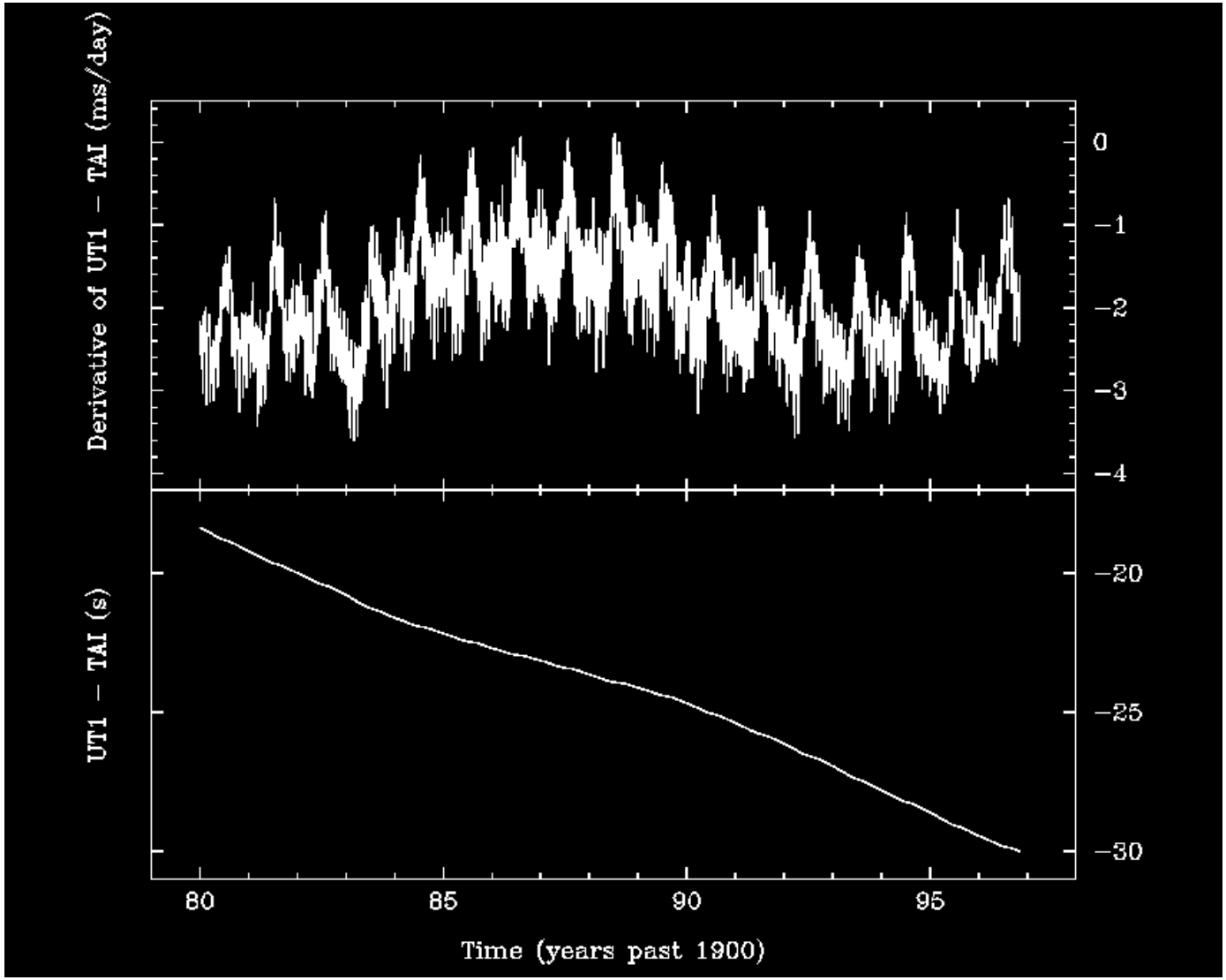
What is VLBI? What are its Scheduling Requirements?

Earth Orientation: UT1-UTC, Polar Motion X,Y, Nutation: Psi, Eps



Credit: After Kurt Lambeck et al, The Earth's Variable Rotation, Cambridge, 1980

LOD Spectrum, UT1 vs. TAI



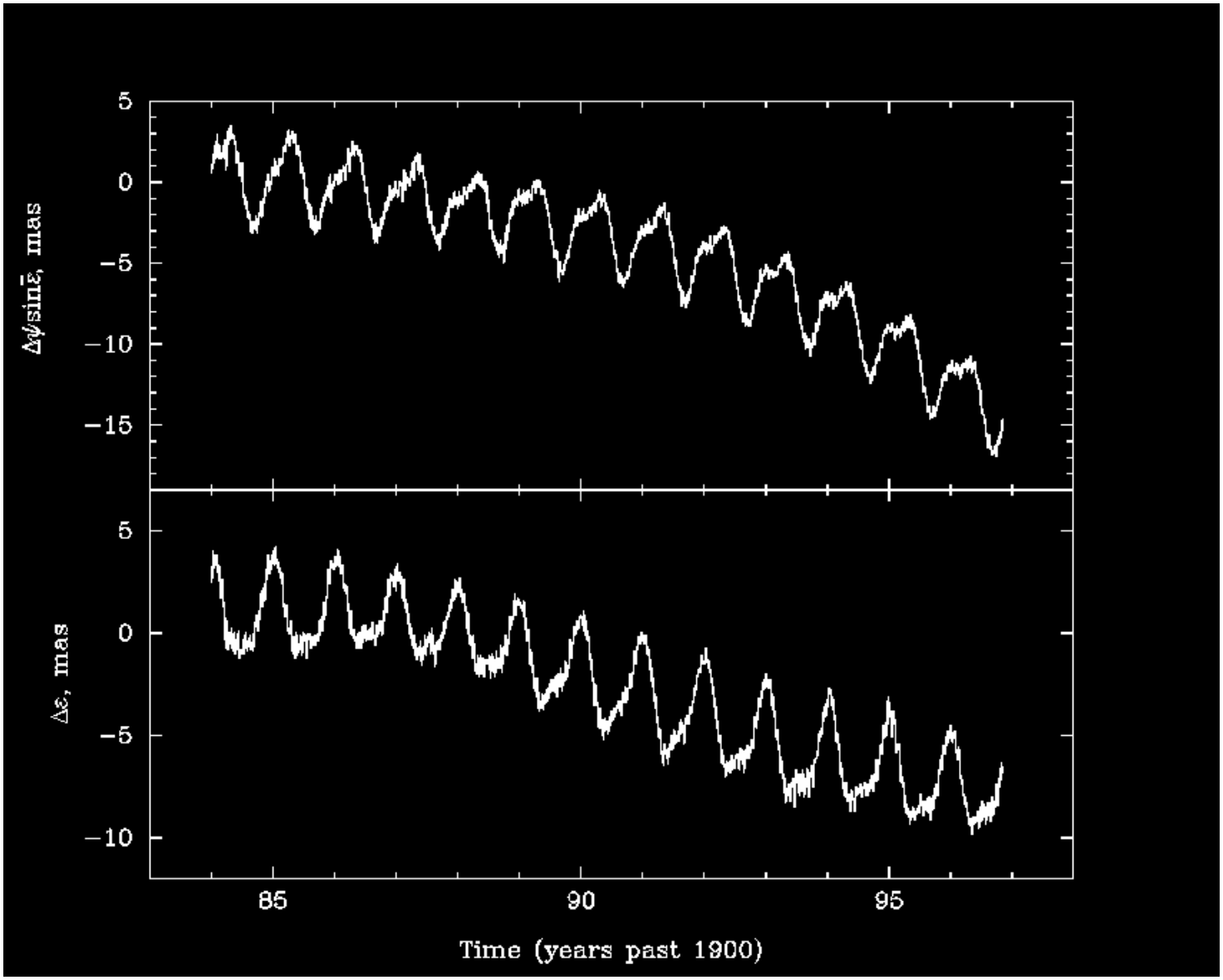
Length Of Day Spectrum

and

UT1 -- TAI

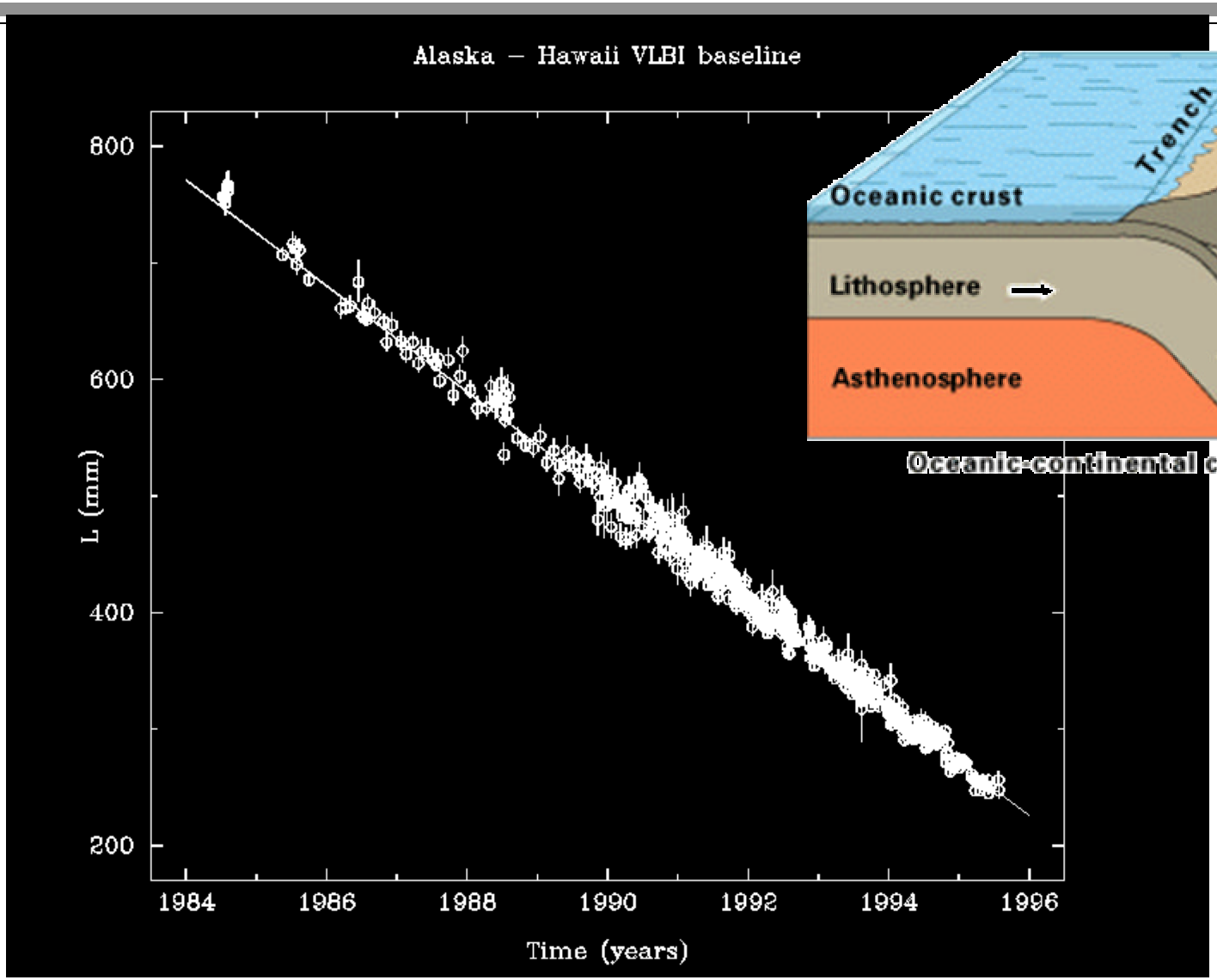
Credit Sovers, Fanselow, Jacobs, Rev Mod Phys 70, 4, Oct 1998.

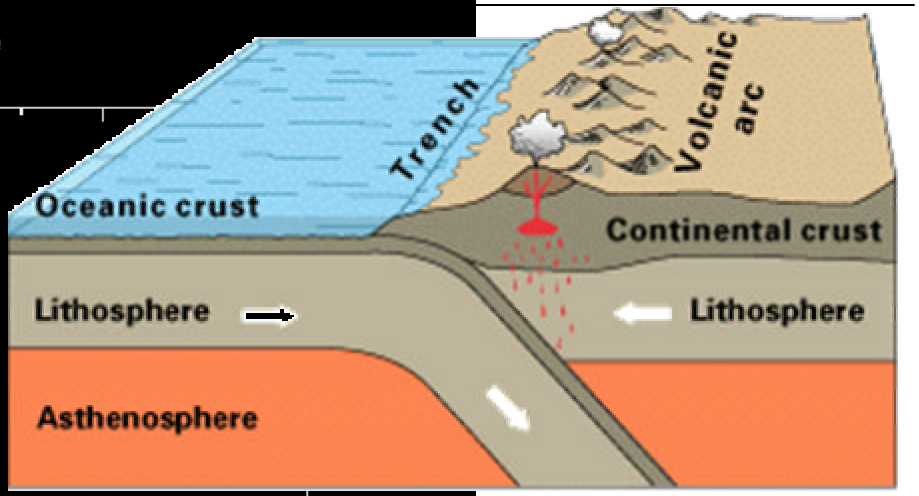
Nutation: Measured vs. IAU 1980



Credit Sovers, Fanselow, Jacobs, Rev Mod Phys 70, 4, Oct 1998.

Tectonic Motion





Oceanic-continental convergence

http://pubs.usgs.gov/publications/text/understanding.html

Tectonic Motion Calibrations

e.g.
Alaska -Hawaii

-46 mm/yr

7 mm scatter

Credit Sovers, Fanselow, Jacobs, Rev Mod Phys 70, 4, Oct 1998.

Site ties - Beam Waveguides (BWG)

Goldstone:
(Apollo site)

DSS 24
DSS 25*
DSS 26*

Canberra
DSS 34

Madrid
DSS 54
DSS 55

***=large ?**
from ground survey

Found and corrected ground survey vertical ERRORS:
0.5m DSS-25
0.7m DSS-26

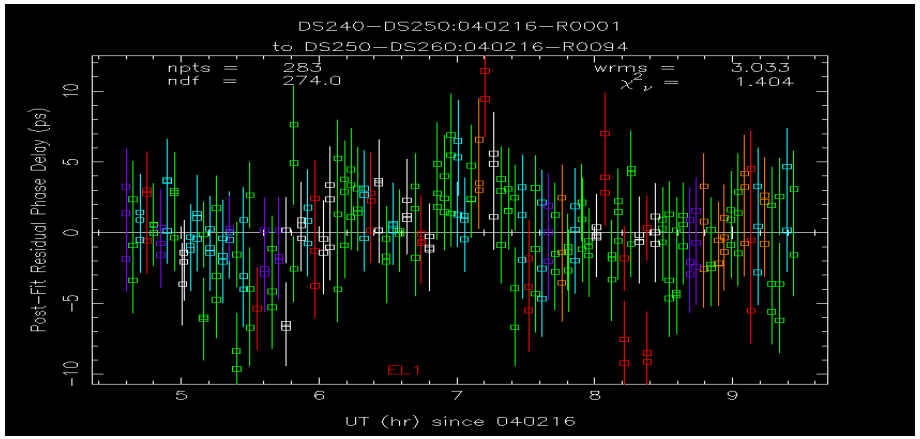
Direct Radiometric (VLBI) Now gives ~ cm accuracy

Uplink Array Studies

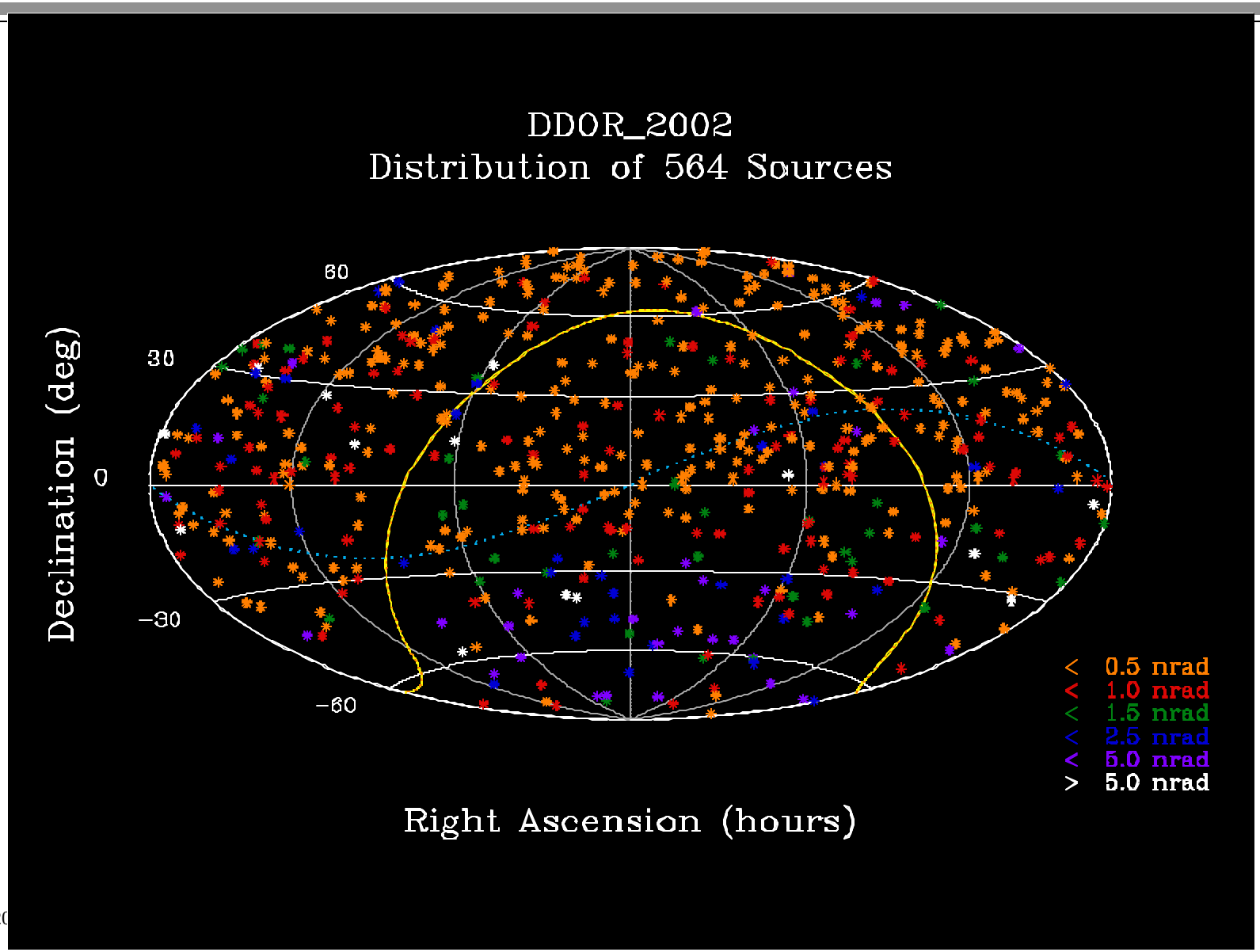
- ***DSN of the future will be arrays of 12 meter dishes.***

- **VLBI software as it exists can array 34m BWGs**

- **We are using VLBI to practice arraying.**



Current S/X-band Radio Catalog



The Future

- **Ka-band (32 GHz)**

  Compared to X-band (8.4 GHz):

  - 15 times less sensitive to the sun

  - 4 times sharper focus on reference points

  - 5-10 dB higher telemetry rates

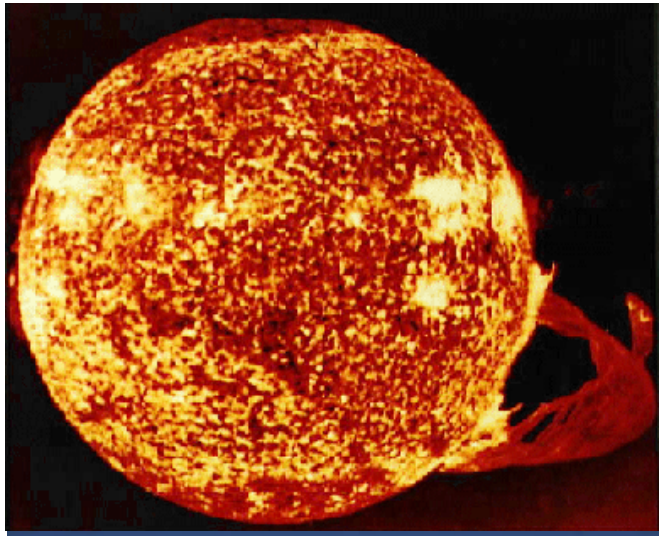
- **Water Vapor radiometers**

  - measure strength of 22 GHz water line

  - corrects for atmospheric turbulence

- **Accuracy to 1 part in 10 billion?**

  This would be ~15 meters at Mars.



Picture credits: 1) SOHO/ESA/NASA,
2) Naudet et al, TMO Progress Report 42-143, 15 Nov 2000
tmo.jpl.nasa.gov/tmo/progress_report/42-143/title.htm

Very Long Baseline Array (VLBA)

We collaborate and use non-DSN resources Whenever possible!

We are working to get Ka-band in the VLBA array to lower load on DSN!

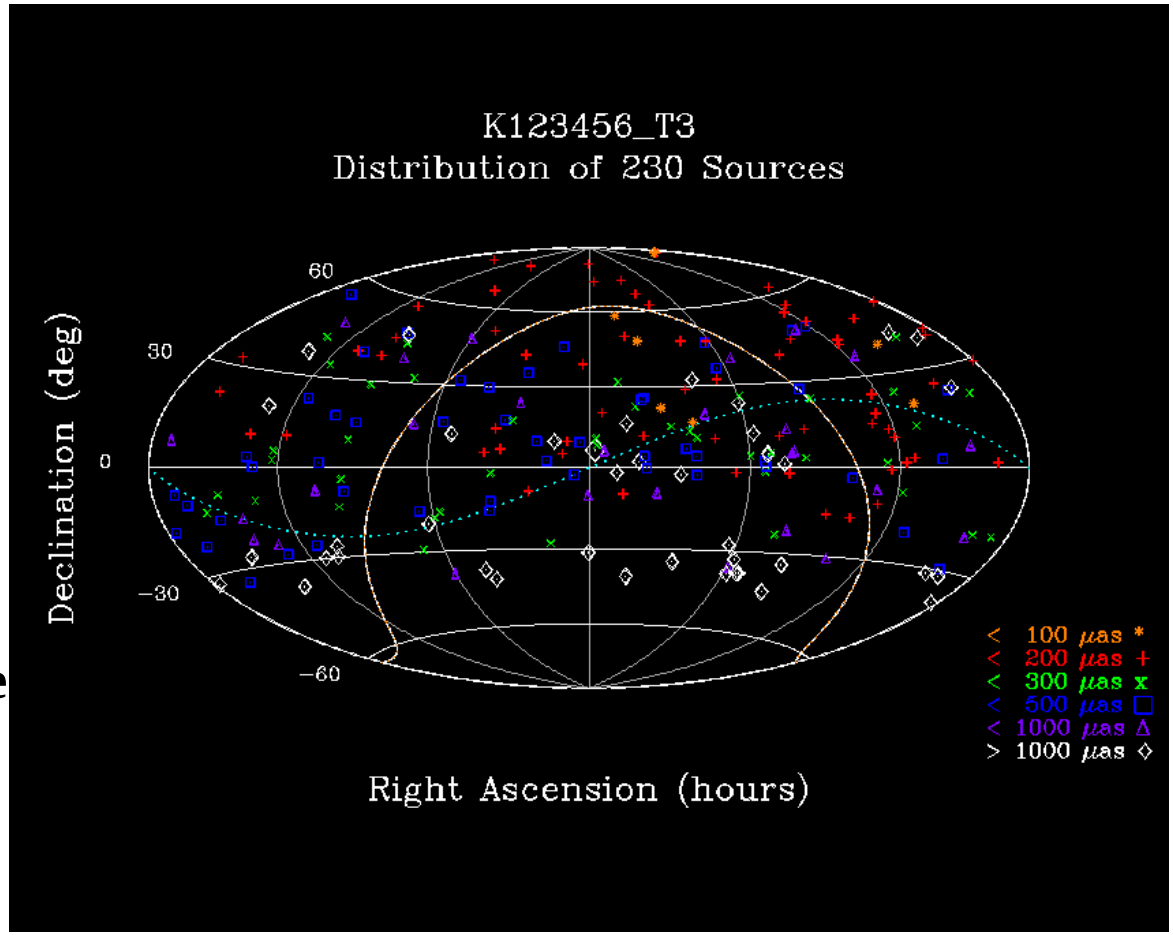
(photos credit NRAO/NSF/AUI http://www.aoc.nrao.edu/vlba/html/vlbahome/thesites.html)

24 GHz Celestial Reference Frame

Some questions about Ka-band can be answered Using data from the VLBA at nearby K-band 24 GHz.

Thus we use DSN Ka-band time only for what cannot be done elsewhere.

For example, the DSN has the world's only dual Band X/Ka antennas.



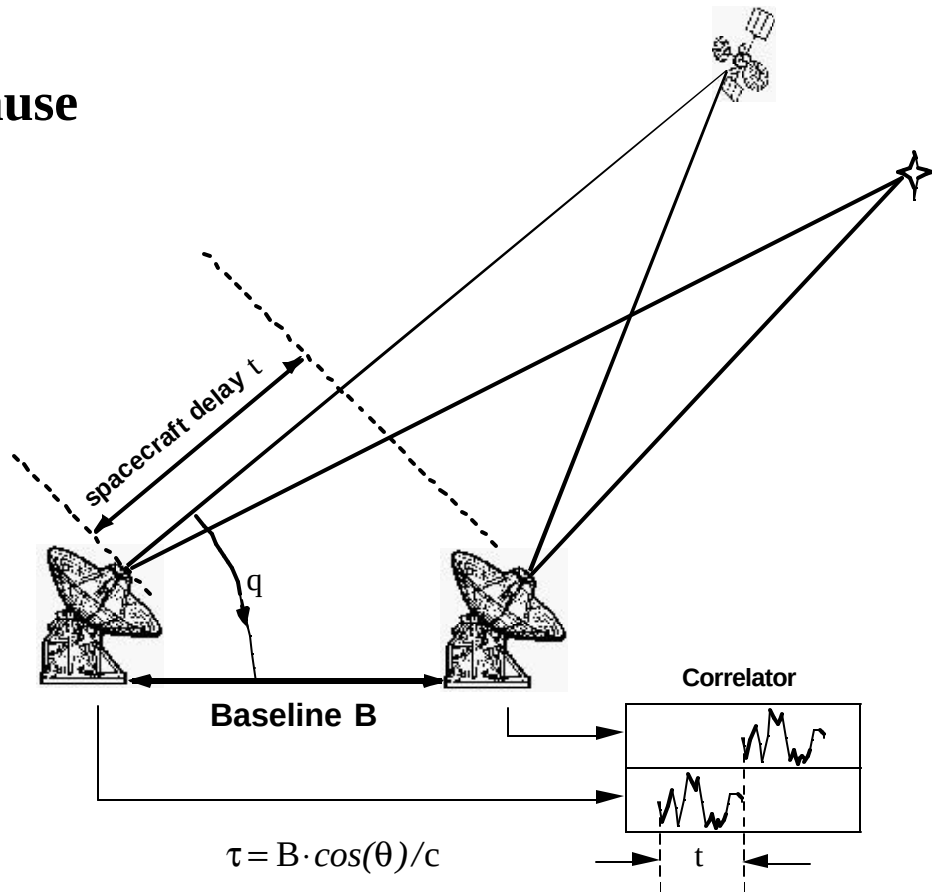
Credit: Jacobs et al, Proceedings of IVS General Meeting, Ottawa, Canada, Feb 8-12, 2004,
http://ivscc.gsfc.nasa.gov/meetings/gm2004/presentations.html

Where do the VLBI scheduling requirements come from?

- **Two stations at a time are need because**
  No VLBI signal exists until
  two stations are combined!

- **Two complimetary baselines**
  are needed within 6 weeks
  (CA-Aust, CA-Spain)

We no longer need back to back
baselines within a few days!



$$\tau = B \cdot cos(\theta)/c$$

Where do the VLBI scheduling requirements come from?

- 24 hour duration

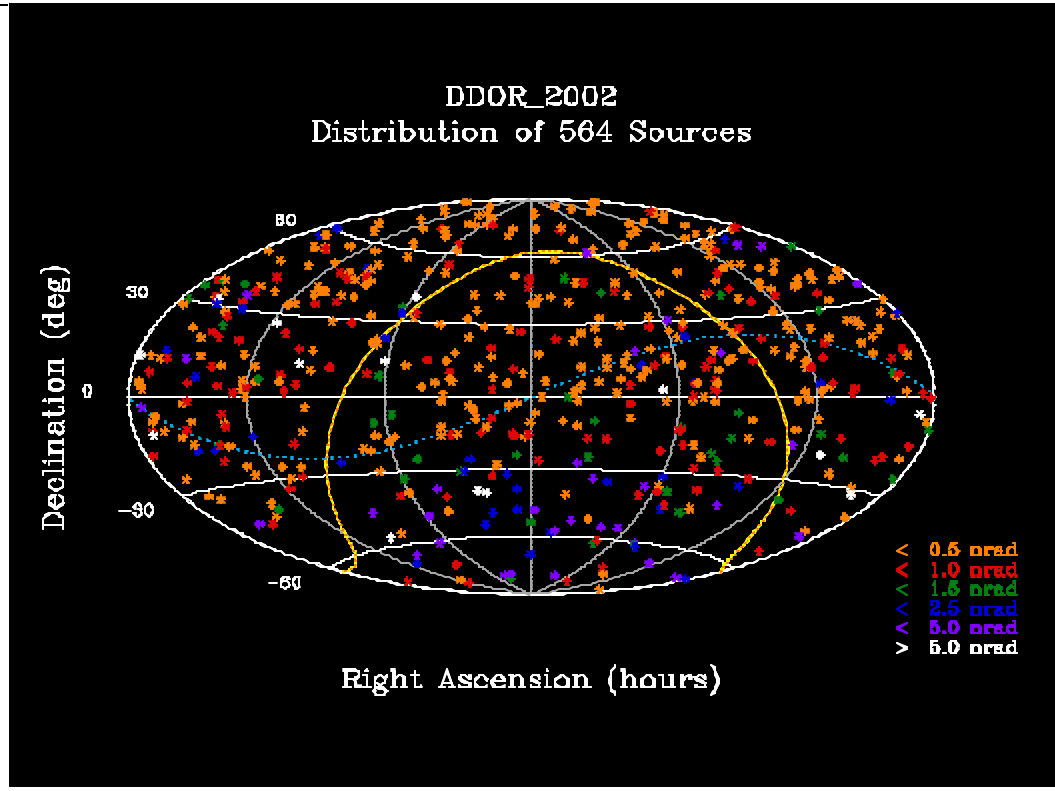
  We must cover full range of RA

- We must measure daily (24hr) signatures in data:

  pole direction

  tides

  atmosphere

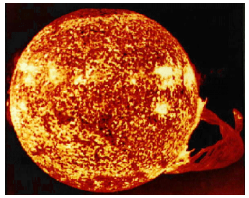


- 12 hour passes do NOT meet our requirements.

Where do the VLBI scheduling requirements come from?

- **S/X and X/Ka: S/X is still the standard for DSN navigation**

  X/Ka is a demo for MRO '05. It will be mainstream in a few years.



- **S/X uses 34m HEFs**

- **X/Ka uses 34m BWGs**

- ***We need a period of overlap with BOTH S/X and X/Ka.***

  This may need to last for 5 or more years!

Conclusions

- ***VLBI technique***

  Measures natural radio source (quasar) at edge of universe

  - measures angles on the sky
  - one part in a billion accuracy

- ***Benefits to Navigation***

  ?DOR => plane-of-sky positions

  Mars Ephemeris/Frame Tie

  Earth Orientation, Nutation

  Station locations - e.g. BWG ties

  Models for next generation DSN array

Scheduling Requirements

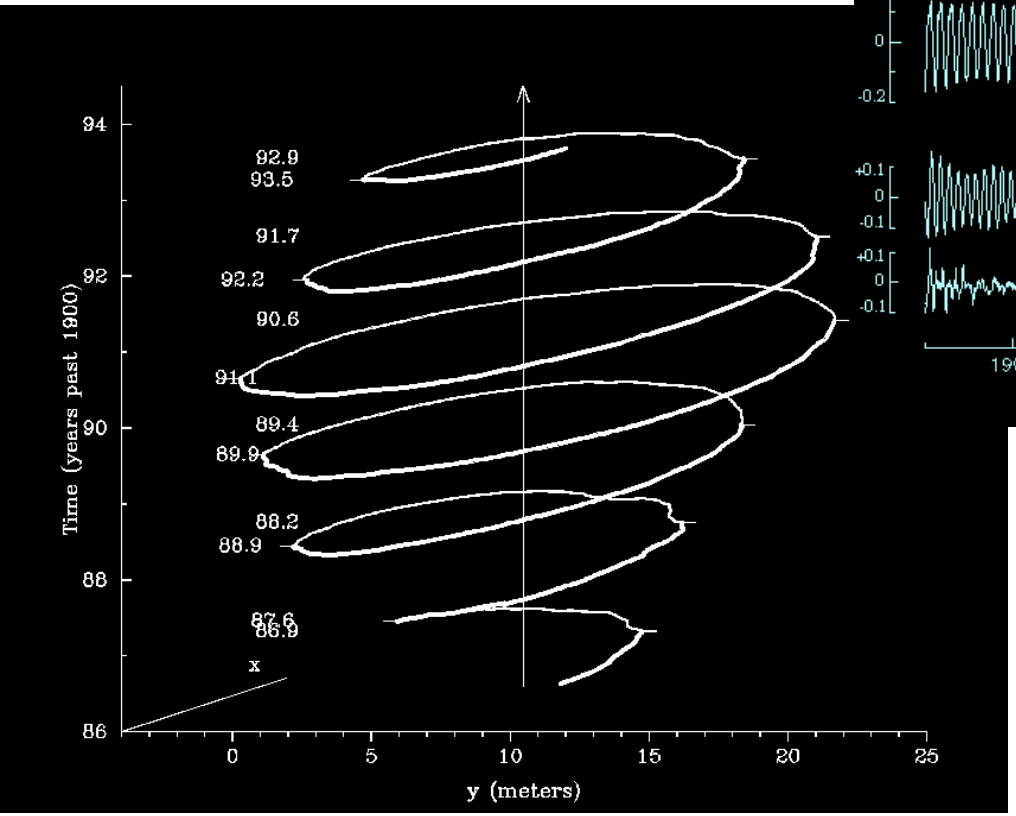
Two or more stations

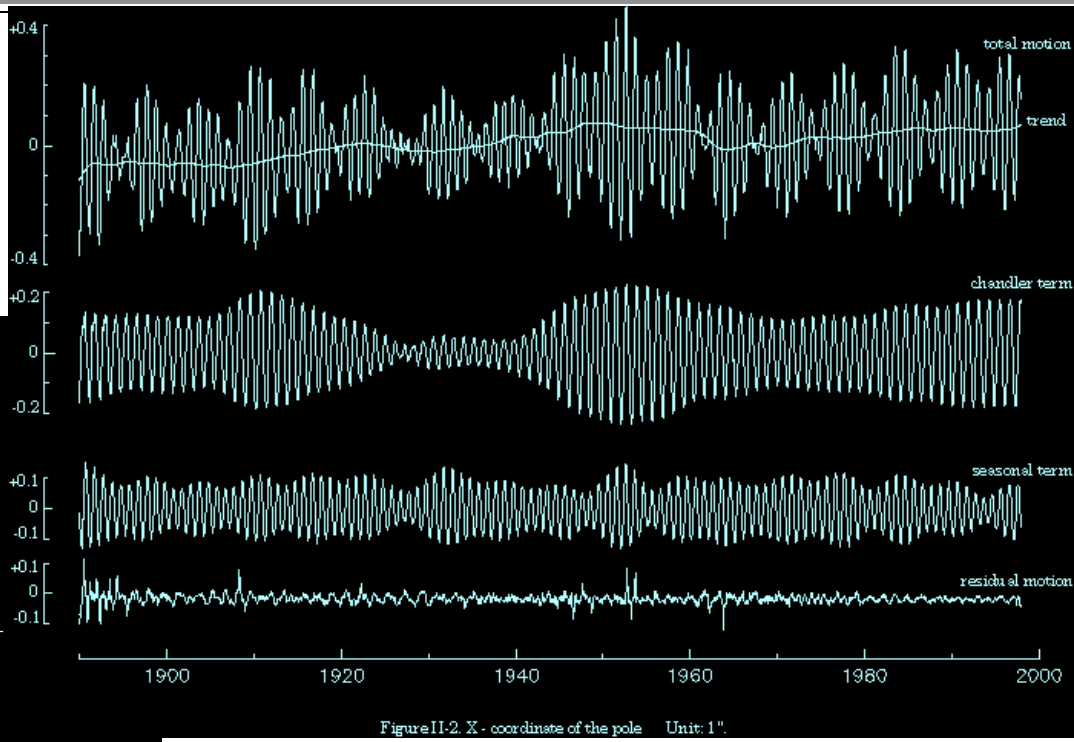
24 hours to cover sky, measure signatures

S/X on HEFs, X/Ka on BWGs

Polar Motion Spiral

Polar Motion vs. Time





(credit http://www.iers.org/iers/earth/)

Effect ~ 10 m

Calibrated to ~1cm
with
GPS + VLBI + …

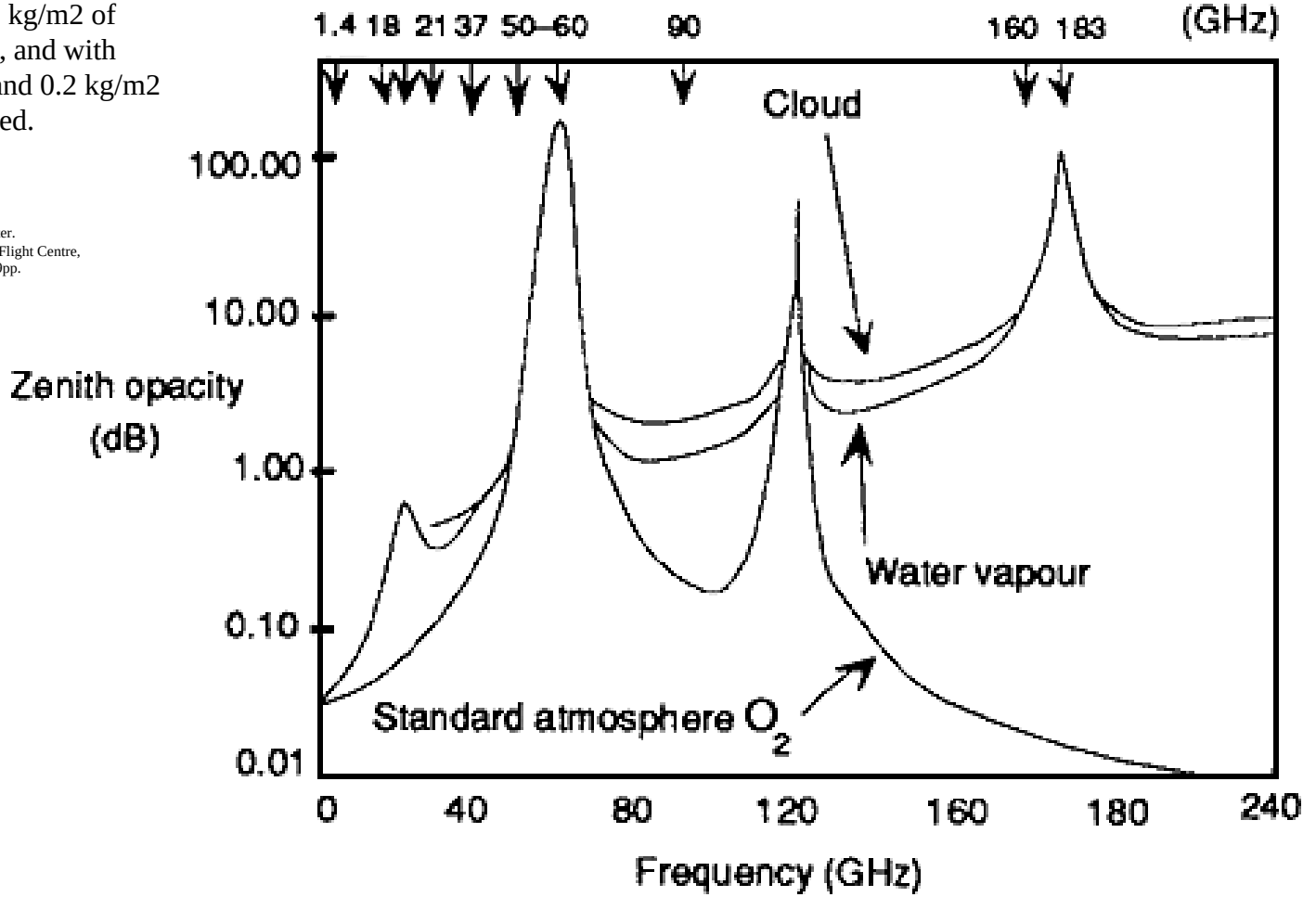
Credit Sovers, Fanselow, Jacobs, Rev Mod Phys 70,, 1998.

Why Ka-band?

The three curves show absorption in a dry atmosphere, in the same atmosphere with 20 kg/m2 of added water vapour, and with both water vapour and 0.2 kg/m2 of stratus cloud added.

Murphy, R. et al., 1987,
Earth Observing System Volume IIe:
HMRR High-Resolution
Multifrequency Microwave Radiometer.
Published by NASA, Goddard Space Flight Centre,
Greenbelt, Maryland 20771, USA, 59pp.

Valleys are microwave windows



Murphy, R. et al., 1987, Earth Observing System Volume IIe: HMRR High-Resolution Multifrequency Microwave Radiometer.
Published by NASA, Goddard Space Flight Centre, Greenbelt, Maryland 20771, USA, 59pp.

JOINT USERS RESOURCE ALLOCATION PLANNING COMMITTEE

Resource Analysis Team

September 16, 2004

Napoleon Lacey

Resource Allocation Planning & Scheduling Office (RAPSO)

– Ongoing / Approved Projects –

Project	Acronym	Launch or Start	EOPM	EOEM
DSN Antenna Calibration	DSN	--	--	--
DSS Maintenance	DSS	--	--	--
European and Global VLBI Syetems (EGS)	EVN	--	--	--
Ground Based Radio Astronomy	GBRA	--	--	--
Reference Frame Calibration	DSN	--	--	--
Space Geodesy	SGP	--	--	--
Voyager 2	VGR2	08/20/77	10/15/89	09/30/06
Voyager 1	VGR1	09/05/77	12/31/80	09/30/06
Goldstone Solar System Radar	GSSR	04/01/85	--	--
Ulysses	ULYS	10/06/90	09/11/95	09/30/06
Geotail	GTL	07/24/92	07/24/95	09/30/06
Wind	WIND	11/01/94	11/01/97	09/30/05
SOHO	SOHO	12/02/95	05/02/98	12/31/08
Polar	POLR	02/22/96	08/23/97	09/30/05
Gravity Probe B (non Spacecraft support)	GPB	06/01/96	05/30/05	11/01/05
Mars Global Surveyor	MGS	11/07/96	02/01/01	01/03/08
Advance Composition Explorer	ACE	08/25/97	02/01/01	09/30/10

– Ongoing / Approved Projects (continued) –

Project	Acronym	Launch or Start	EOPM	EOEM
Cassini	CAS	10/15/97	06/30/08	06/30/10
Stardust	SDU	02/07/99	02/15/06	- - -
Chandra X-ray Observatory	CHDR	07/23/99	07/24/09	07/24/14
Imager for Magnetopause-to-Aurora Global Exploration	IMAG	03/25/00	05/30/02	09/30/10
Cluster 2 - S/C #2 (Samba)	CLU2	07/16/00	02/15/03	02/28/06
Cluster 2 - S/C #3 (Rumba)	CLU3	07/16/00	02/15/03	02/28/06
Cluster 2 - S/C #1 (Salsa)	CLU1	08/09/00	02/15/03	02/28/06
Cluster 2 - S/C #4 (Tango)	CLU4	08/09/00	02/15/03	02/28/06
Mars Odyssey 2001	M01O	04/07/01	08/24/04	11/30/08
Wilkinson Microwave Anisotropy Probe	WMAP	06/30/01	10/01/03	09/30/08
Genesis	GNS	08/08/01	09/08/04	- - -
Advanced Tracking and Observational Techniques (ATOT)	MEGA	02/01/02	12/31/08	- - -
International Gamma Ray Astrophysics Lab	INTG	10/17/02	12/18/04	12/31/08
Hayabusa (MUSES - C)	MUSC	05/09/03	06/10/07	- - -
Mars Express Orbiter	MEX	06/02/03	02/11/06	08/03/08
Spirit (Mars Exploration Rover - A)	MER2	06/10/03	04/06/04	10/08/05
Opportunity (Mars Exploration Rover - B)	MER1	07/07/03	04/27/04	10/08/05

– Ongoing / Approved Projects (continued) –

Project	Acronym	Launch or Start	EOPM	EOEM
Spitzer Space Telescope (SIRTF)	STF	08/25/03	02/25/06	10/19/08
Rosetta	ROSE	02/26/04	12/31/15	- - -
Messenger	MSGR	08/03/04	03/19/12	- - -
Deep Impact	DIF	12/30/04	08/05/05	- - -
Mars Reconnaissance Orbiter	MRO	08/10/05	12/31/10	12/31/15
New Horizons	NHPC	01/11/06	04/17/16	TBD
Lunar - A	LUNA	02/01/06	09/02/06	- - -
Stereo Ahead	STA	02/11/06	05/16/08	- - -
Stereo Behind	STB	02/11/06	05/16/08	- - -
Space Technology 5	ST5	03/01/06	05/30/06	TBD
Dawn	DAWN	06/17/06	01/12/16	TBD

– Advanced / Planning Projects –

Project	Acronym	Launch or Start	EOPM	EOEM
Venus Express *	VEX	10/26/05	08/19/07	TBD
SELENE *	SELE	01/15/06	05/30/06	TBD
Kepler	KEPL	06/07/07	07/01/11	TBD
Phoenix	PHX	08/03/07	10/26/08	TBD
Mars Telecommunications Orbiter 2009	M09T	09/07/09	09/07/16	09/07/20
Mars Science Laboratory 2009	M09L	10/25/09	03/04/12	TBD
Space Interferometry Mission	SIM	02/14/10	08/30/20	TBD
James Webb Space Telescope	JWST	08/01/11	07/31/16	TBD
Mars Placeholder 2011	M11L	10/30/11	09/10/14	TBD
Mars Placeholder 2013	M13O	11/28/13	08/21/16	TBD

* DSN support may not be required for these missions

Resource Allocation Planning & Scheduling Office (RAPSO)

DSN Resource Implementation Planning Matrix by Complex

Complex	Station	Subnet	S-Band Down	S-Band Up	X-Band Down	X-Band Up	Ka-Band Down	Ka-Band Up	NSP
10	DSS-14	70M	✔	✔	✔	✔	N/A	N/A	✔
10	DSS-15	34HEF	✔	N/A	✔	✔	TBD	N/A	✔
10	DSS-16	26M	✔	✔	N/A	N/A	N/A	N/A	N/A
10	DSS-24	34B1	✔	✔	✔	✔	10/23/06	N/A	✔
10	DSS-25	34B2	N/A	N/A	✔	✔	✔	✔	✔
10	DSS-26	34B2	N/A	N/A	✔	✔	✔	N/A	✔
10	DSS-27	34HSB	✔	✔	N/A	N/A	N/A	N/A	01/31/05
40	DSS-34	34B1	✔	✔	✔	✔	04/11/05	N/A	✔
40	DSS-43	70M	✔	✔	✔	✔	N/A	N/A	✔
40	DSS-45	34HEF	✔	N/A	✔	✔	TBD	N/A	✔
40	DSS-46	26M	✔	✔	N/A	N/A	N/A	N/A	N/A
60	DSS-54	34B1	✔	✔	✔	✔	08/01/07	N/A	✔
60	DSS-55	34B2	N/A	N/A	✔	✔	✔	N/A	✔
60	DSS-63	70M	✔	✔	✔	✔	N/A	N/A	✔
60	DSS-65	34HEF	✔	N/A	✔	✔	TBD	N/A	✔
60	DSS-66	26M	✔	✔	N/A	N/A	N/A	N/A	N/A

N/A = Capability Not Planned xx/xx/xx = Capability Date Recently Change As of: 04/21/04

✔✔✔ = Capability Recently Exists ✔ = Capability Exists

Resource Allocation Planning & Scheduling Office (RAPSO)

- **RESOURCE NEGOTIATION STATUS**
  - 2004 WEEKS 45 - 48 (THRU 10/28/2004) WERE RELEASED TO DSN SCHEDULING ON 09/06/2004.
  - 2004 WEEKS 49 - 53 (THRU 01/02/2005) ARE DUE TO BE RELEASED TO DSN SCHEDULING ON 10/08/04.
  - 2005 WEEKS 01 - 10 (THRU 03/13/2005) ARE AWAITING CONFLICT RESOLUTION
- The Mid-range Scheduling process has negotiated schedules 25 weeks ahead of real-time. Currently, there are 10 weeks of conflict-free schedules. Conflict Resolution is required for the following fifteen (15) weeks: 49 through 10.

Resource Allocation Planning & Scheduling Office (RAPSO)

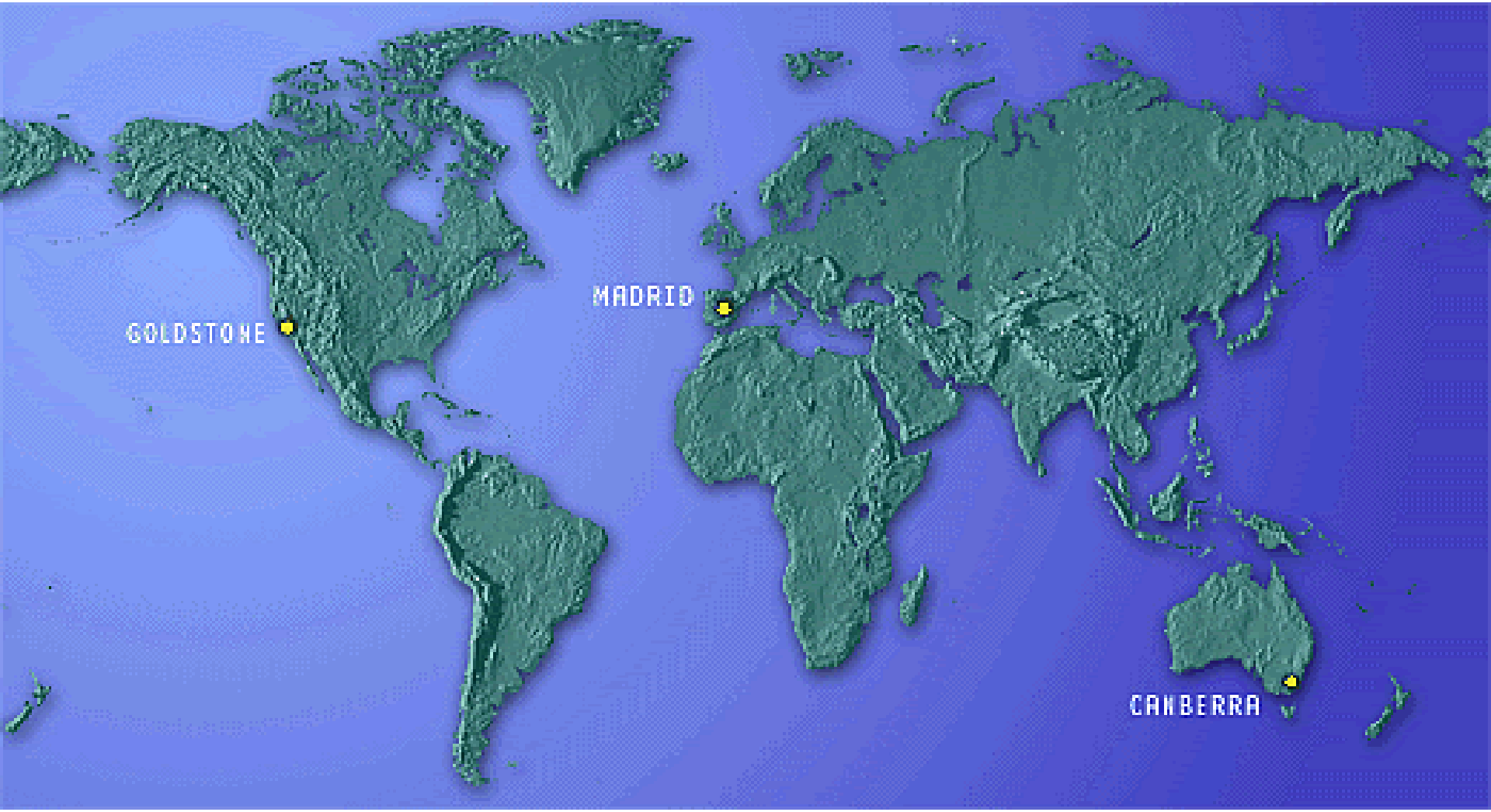
◆ COMPLETED SPECIAL STUDIES/ACTIVITIES

- Messenger Post 2004 Requirements
- MGS Updated Requirements

◆ ON-GOING SPECIAL STUDIES/ACTIVITIES

– DOWNTIME PLANNING
– MADB/TIGRAS TESTING AND TRAINING
– DSS-27 Closure Updated Study
– MRO Updated Requirements
– ROSETTA LOAD STUDY – POST 2004 REQUIREMENTS
– STEREO – NEW LAUNCH DATE (02/11/2006)
– VENUS EXPRESS – RADIO SCIENCE SUPPORT

DSN Antenna Downtime Status and Forecast



http://rapweb.jpl.nasa.gov/planning

Antenna Downtime Status and Forecast

Changes to 2004 Downtime Schedule

- It has been requested of Mid-Range scheduling to extend the currently scheduled Antenna Controller Replacement Task at DSS-45 by one week in order to accommodate all NIB tasks planned. An additional 6 days has been secured the task will now take place from August 9, 2004 0000z to December 11, 2004 0500z.
- It has been requested of Mid-Range scheduling to schedule Antenna Painting for Canberra Antennas, a plan is being developed to support these activities.
- It has been requested of DSN scheduling to schedule Antenna Painting for DSS-55. The priority of this task has been increased and has been scheduled in week 44 project negotiations are ongoing.
- It has been requested of DSN scheduling to schedule Jacking Pad installation at DSS-65 in preparation of the downtime tasks planned in February 2005. The requirements for this request are being developed.

- All previous requests have been negotiated and approved through the RARB, JURAP or Mid-Range Scheduling processes.

Antenna Downtime Status and Forecast

Changes to 2005 Downtime Schedule

- RAPSO has re-planned the DSS-15 Antenna Controller Replacement task that was cancelled in 2004. RAPSO has successfully acquired the 10 week period in 2005 starting in week 37 through week 46 (September 12, - November 20, 2005) during the August 2005 RARB.

- All previous requests have been negotiated and approved through the RARB processes.

Changes to 2006 Downtime Schedule

- There are no outstanding downtime requests for 2006. All previous requests have been negotiated and approved through the RARB processes.

Changes to 2007 Downtime Schedule

- There are no outstanding downtime requests for 2007. All previous requests have been negotiated and approved through the RARB processes.

Changes to 2008 Downtime Schedule

- There are no outstanding downtime requests for 2008.

Changes to 2009 Downtime Schedule

- There are no outstanding downtime requests for 2009.

Antenna Downtime Status And Forecast Schedule

DSN Antenna Downtime Report

Revised: September 3, 2004

2004							
Site	Description	Start	End	Duration (Days)	Weeks	Start DOY	End DOY
DSS 14	Antenna Controller Replacement	07/07/2004 00:00	12/07/2004 23:59	154	28 - 50	189	342
DSS 14	Hydrostatic Bearing	07/07/2004 00:00	12/07/2004 23:59	154	28 - 50	189	342
DSS 14	NIB - NSP Testing	07/07/2004 00:00	12/07/2004 23:59	154	28 - 50	189	342
DSS 46	26M Performance and Reliability Maint.	08/01/2004 22:00	08/04/2004 22:00	3	31 - 32	214	216
DSS 45	Life Extension	08/09/2004 00:00	12/11/2004 05:00	126	33 - 50	222	347
DSS 16	26M Performance and Reliability Maint.	08/10/2004 15:00	08/13/2004 15:00	3	33 - 33	223	225
DSS 66	26M Performance and Reliability Maint.	08/17/2004 06:00	08/20/2004 06:00	3	34 - 34	230	232
DSS 14	NIB - USC Installation	09/20/2004 00:00	10/03/2004 23:59	14	39 - 40	264	277
DSS 45	NIB - USC Installation	11/22/2004 00:00	12/05/2004 23:59	14	48 - 49	327	340

2005							
Site	Description	Start	End	Duration (Days)	Weeks	Start DOY	End DOY
DSS 27	NSP Implementation	01/03/2005 00:00	01/30/2005 23:59	28	01 - 04	003	030
DSS 27	NIB - USC Installation	01/10/2005 00:00	01/23/2005 23:59	14	02 - 03	010	023
DSS 63	USC Installation	01/17/2005 00:00	01/30/2005 23:59	14	03 - 04	017	030
DSS 26	USC Installation	01/24/2005 00:00	02/06/2005 23:59	14	04 - 05	024	037
DSS 65	Antenna Controller Replacement	01/31/2005 00:00	07/03/2005 23:59	154	05 - 26	031	184
DSS 65	NIB - USC Installation	01/31/2005 00:00	02/06/2005 23:59	7	05 - 05	031	037
DSS 65	Relocation	01/31/2005 00:00	07/03/2005 23:59	154	05 - 26	031	184
DSS 65	Life Extension	01/31/2005 00:00	07/03/2005 23:59	154	05 - 26	031	184
DSS 34	X/X-Ka Band	02/15/2005 00:00	04/10/2005 23:59	55	07 - 14	046	100
DSS 34	NIB - USC Installation	02/15/2005 00:00	03/06/2005 23:59	20	07 - 09	046	065
DSS 34	NIB - Azimuth Idler Bearing	02/15/2005 00:00	04/10/2005 23:59	55	07 - 14	046	100
DSS 15	USC Installation	04/25/2005 00:00	05/08/2005 23:59	14	17 - 18	115	128
DSS 25	USC Installation	05/30/2005 00:00	06/12/2005 23:59	14	22 - 23	150	163
DSS 24	USC Installation	06/27/2005 00:00	07/03/2005 23:59	7	26 - 26	178	184
DSS 55	USC Installation	07/04/2005 00:00	07/10/2005 23:59	7	27 - 27	185	191
DSS 54	USC Installation	07/11/2005 00:00	07/16/2005 23:59	6	28 - 28	192	197
DSS 43	Antenna Controller Replacement	07/18/2005 00:00	01/01/2006 23:59	168	29 - 52	199	001
DSS 43	NIB - USC Installation	07/18/2005 00:00	07/31/2005 23:59	14	29 - 30	199	212
DSS 43	Hydrostatic Bearing	07/18/2005 00:00	01/01/2006 23:59	168	29 - 52	199	001
DSS 15	Antenna Controller Replacement	09/12/2005 00:00	11/20/2005 23:59	69	37 - 46	255	323

2006							
Site	Description	Start	End	Duration (Days)	Weeks	Start DOY	End DOY
DSS 63	Antenna Controller Replacement	05/22/2006 00:00	09/03/2006 23:59	105	21 - 35	142	246
DSS 24	X/X-Ka Band	09/04/2006 00:00	10/22/2006 23:59	49	36 - 42	247	295
DSS 45	Antenna Controller Replacement	10/09/2006 00:00	12/10/2006 23:59	63	41 - 49	282	344

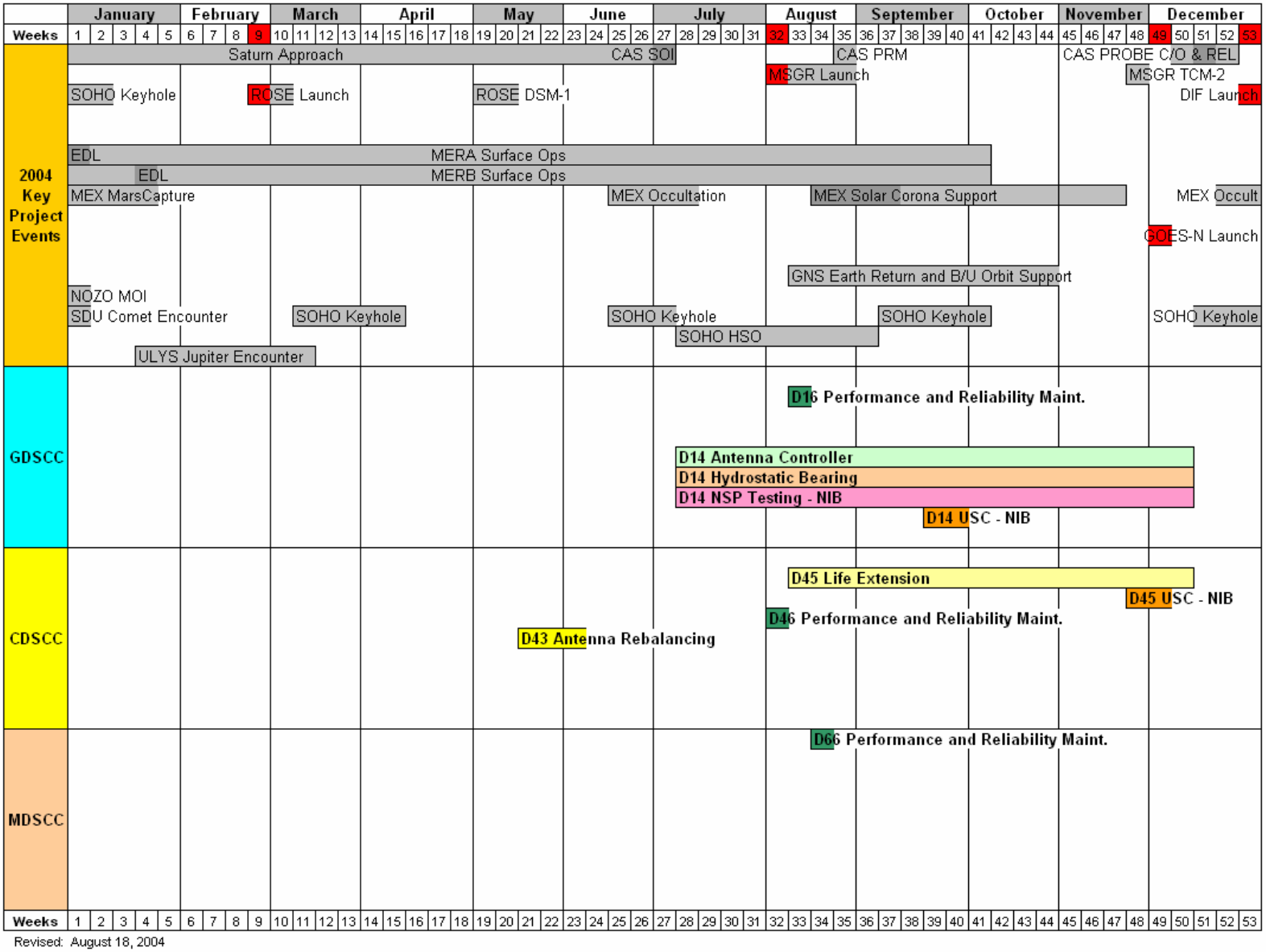
2007							
Site	Description	Start	End	Duration (Days)	Weeks	Start DOY	End DOY
DSS 54	X/X-Ka Band	06/04/2007 00:00	07/29/2007 23:59	56	23 - 30	155	210

http://rapweb.jpl.nasa.gov

Although every efort is made to ensure the accuracy of this Downtime Planning report, changes can and do occur.

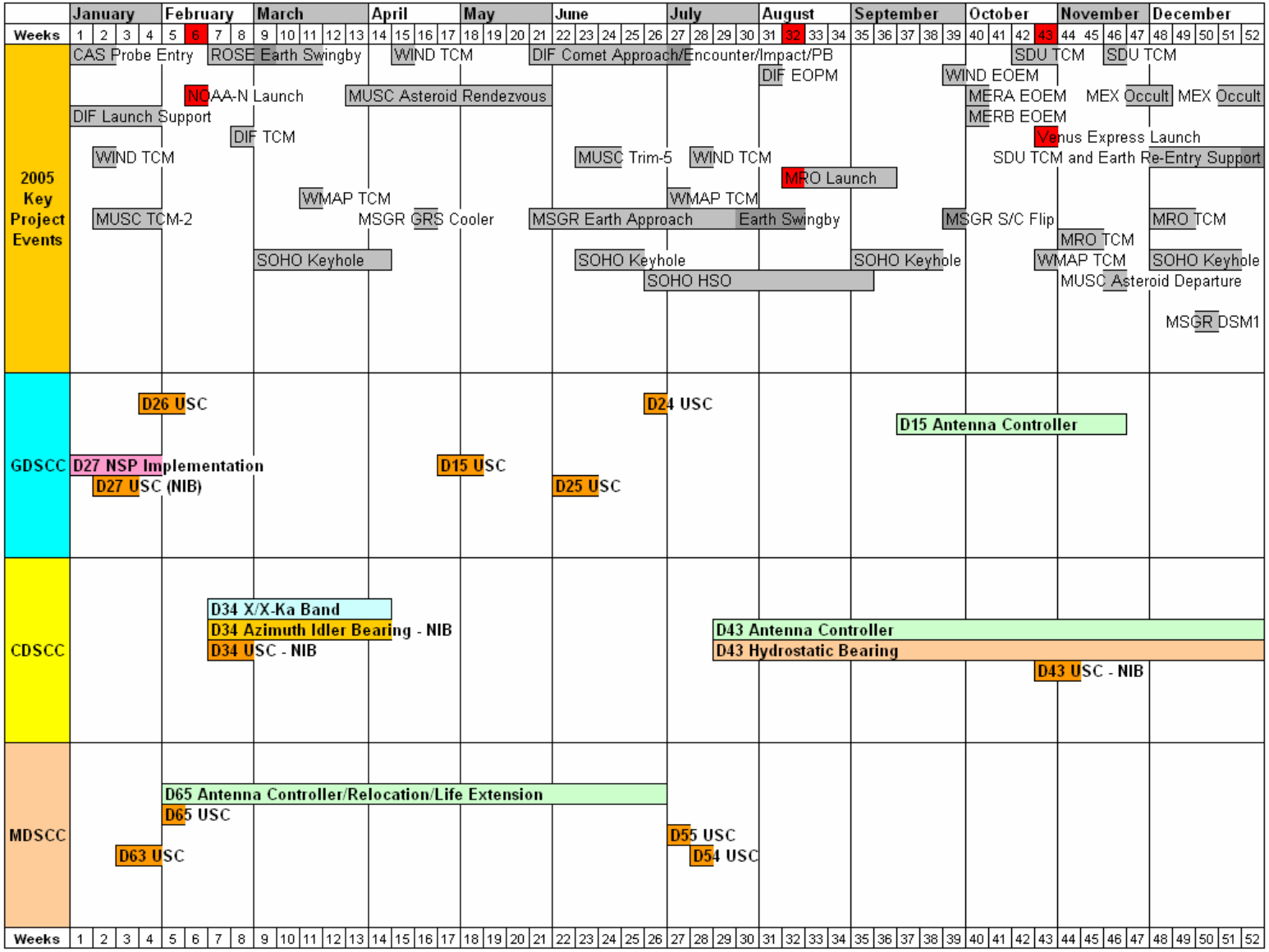
The DSN 7-Day Schedule takes precedence over this document.

Antenna Downtime Status And Forecast 2004

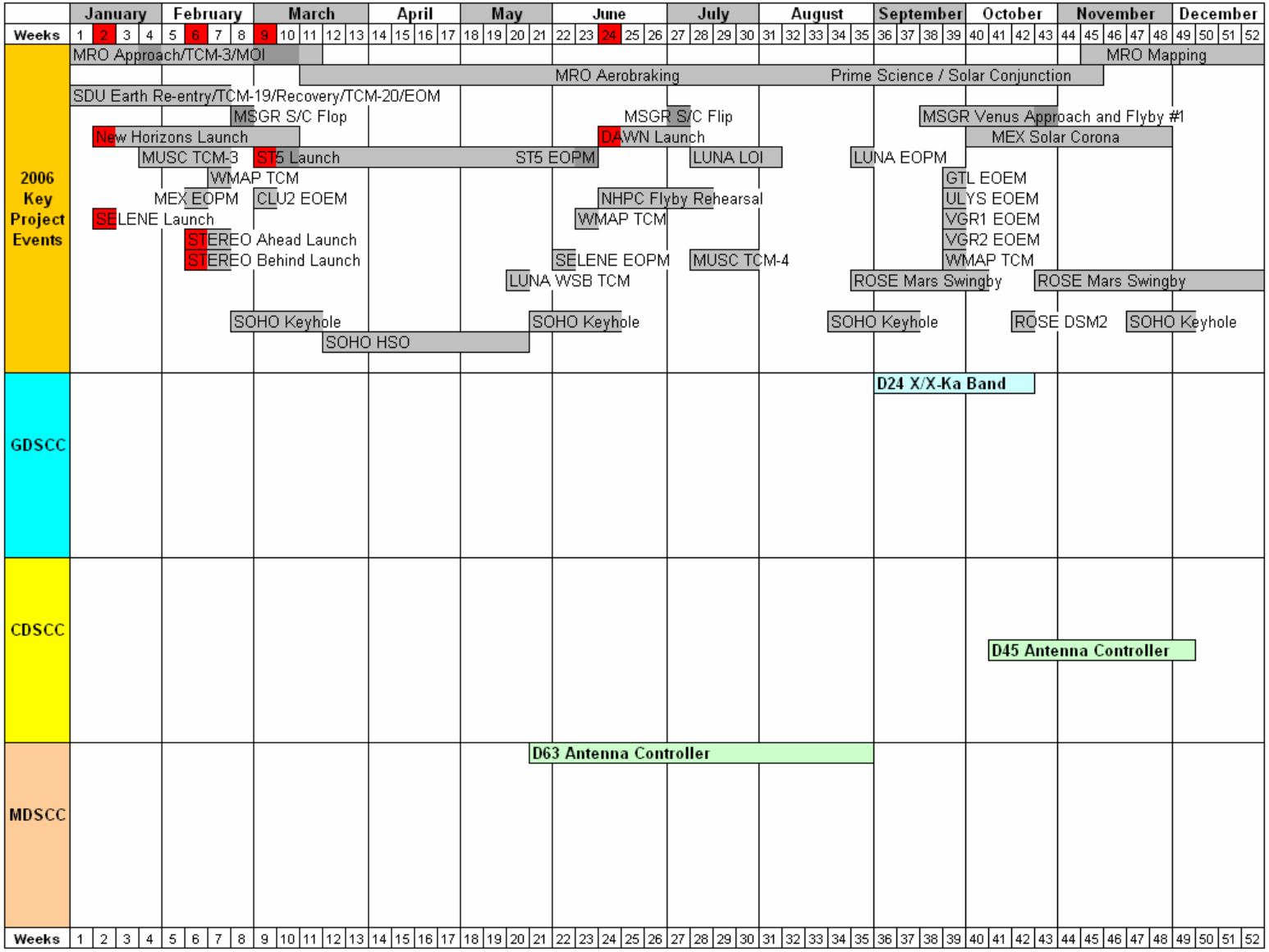


Revised: August 18, 2004

Antenna Downtime Status And Forecast 2005

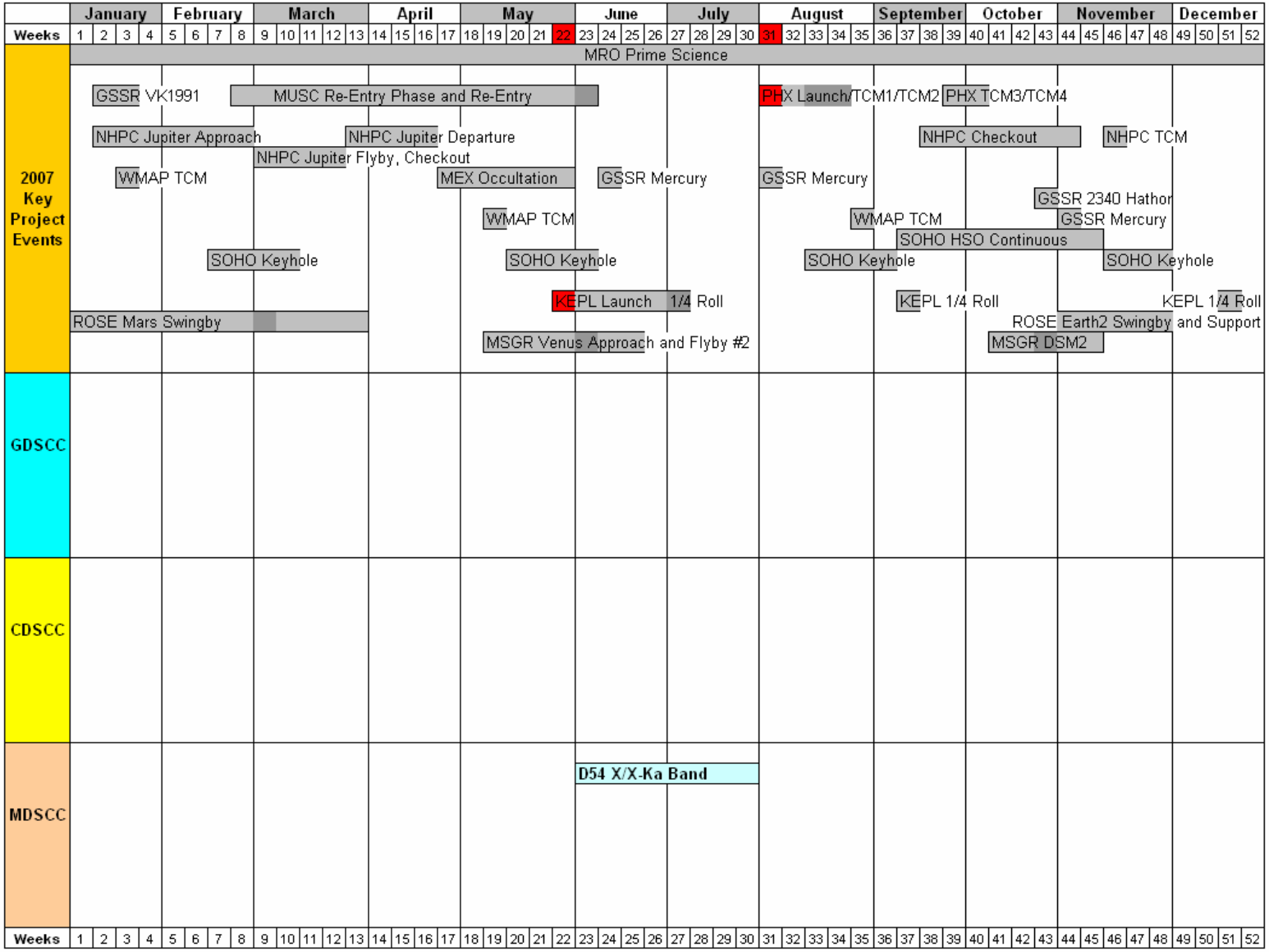


Antenna Downtime Status And Forecast 2006

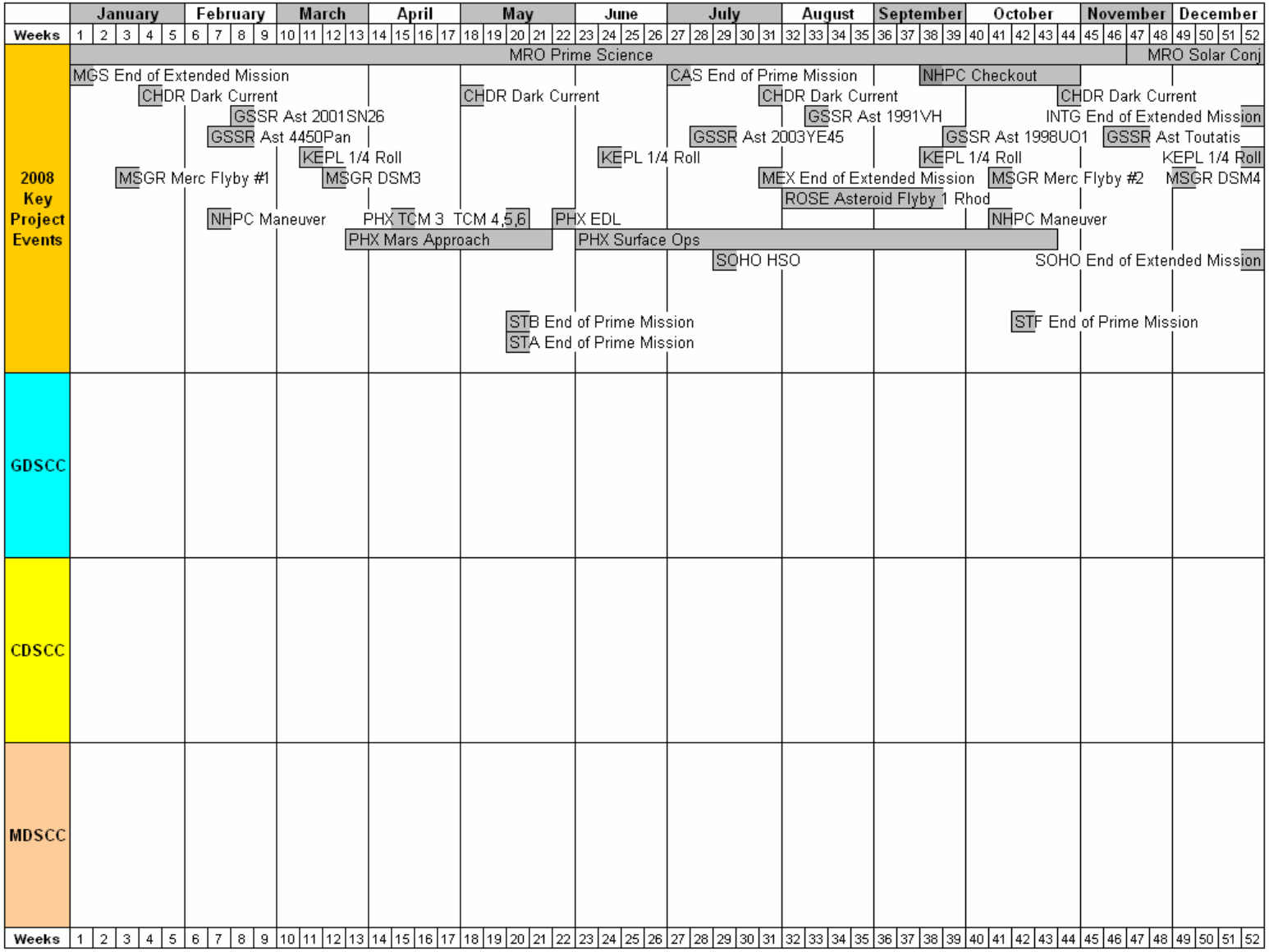


Revised: August 5, 2004

Antenna Downtime Status And Forecast 2007

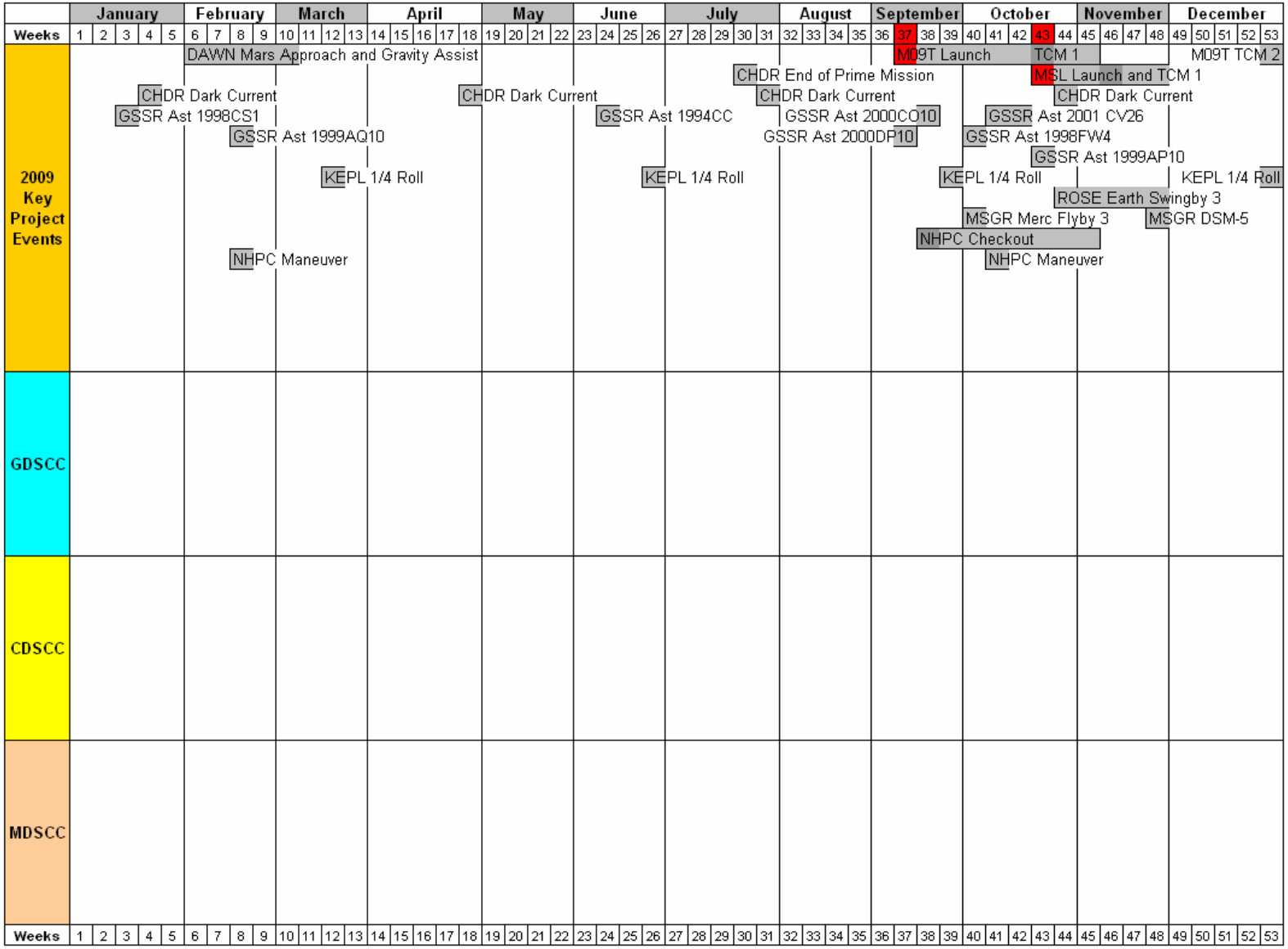


Antenna Downtime Status And Forecast 2008



Revised: July 19, 2004

Antenna Downtime Status And Forecast 2009



Revised: July 19, 2004

DSN Resource Implementation Planning Matrix by Complex

Complex	Station	Subnet	S-Band Down	S-Band Up	X-Band Down	X-Band Up	Ka-Band Down	Ka-Band Up	NSP
10	DSS-14	70M	✔	✔	✔	✔	N/A	N/A	✔
10	DSS-15	34HEF	✔	N/A	✔	✔	TBD	N/A	✔
10	DSS-16	26M	✔	✔	N/A	N/A	N/A	N/A	N/A
10	DSS-24	34B1	✔	✔	✔	✔	10/23/06	N/A	✔
10	DSS-25	34B2	N/A	N/A	✔	✔	✔	✔	✔
10	DSS-26	34B2	N/A	N/A	✔	✔	✔	N/A	✔
10	DSS-27	34HSB	✔	✔	N/A	N/A	N/A	N/A	01/31/05
40	DSS-34	34B1	✔	✔	✔	✔	04/11/05	N/A	✔
40	DSS-43	70M	✔	✔	✔	✔	N/A	N/A	✔
40	DSS-45	34HEF	✔	N/A	✔	✔	TBD	N/A	✔
40	DSS-46	26M	✔	✔	N/A	N/A	N/A	N/A	N/A
60	DSS-54	34B1	✔	✔	✔	✔	08/01/07	N/A	✔
60	DSS-55	34B2	N/A	N/A	✔	✔	✔	N/A	✔
60	DSS-63	70M	✔	✔	✔	✔	N/A	N/A	✔
60	DSS-65	34HEF	✔	N/A	✔	✔	TBD	N/A	✔
60	DSS-66	26M	✔	✔	N/A	N/A	N/A	N/A	N/A

N/A = Capability Not Planned xx/xx/xx = Capability Date Recently Change As of: 04/21/04

✔✔✔ = Capability Recently Exists ✔ = Capability Exists

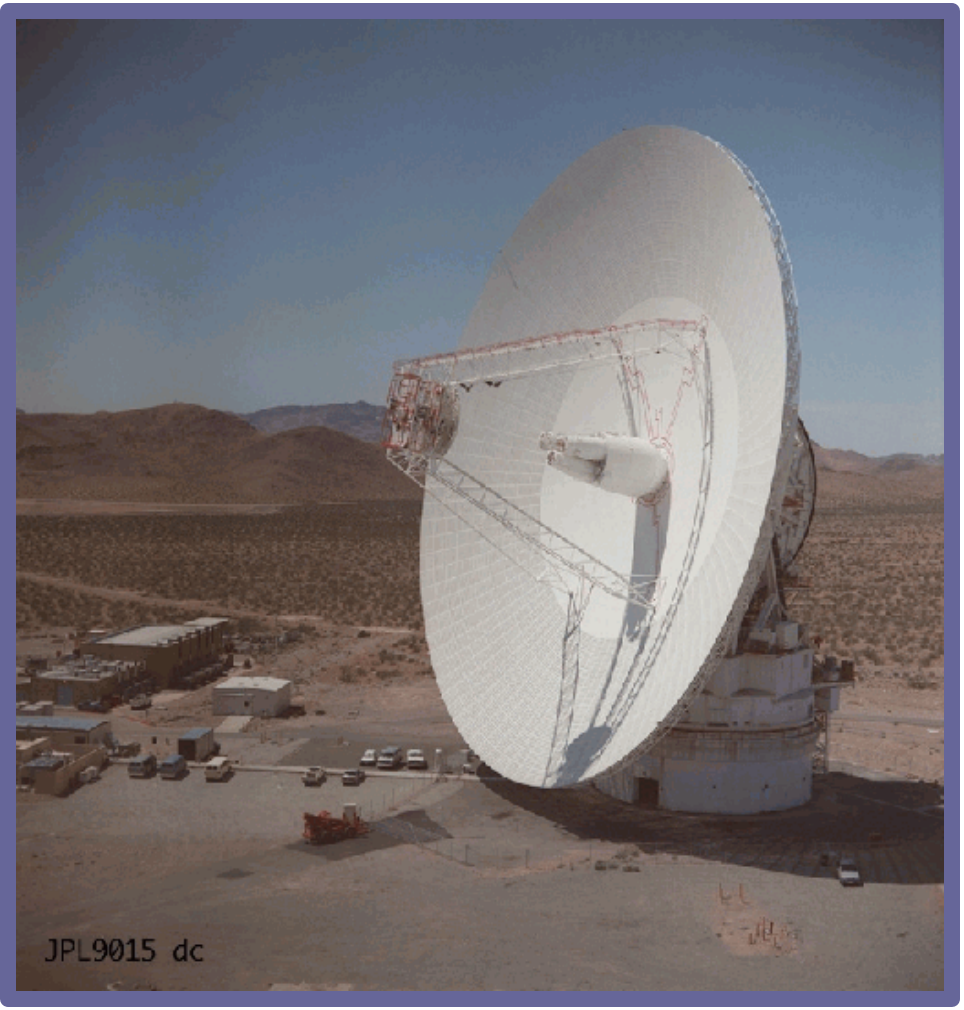
DSN Resource Implementation Planning Matrix by Subnet

Complex	Station	Subnet	S-Band Down	S-Band Up	X-Band Down	X-Band Up	Ka-Band Down	Ka-Band Up	NSP
10	DSS-16	26M	✔	✔	N/A	N/A	N/A	N/A	N/A
40	DSS-46	26M	✔	✔	N/A	N/A	N/A	N/A	N/A
60	DSS-66	26M	✔	✔	N/A	N/A	N/A	N/A	N/A
10	DSS-27	34HSB	✔	✔	N/A	N/A	N/A	N/A	01/31/05
10	DSS-24	34B1	✔	✔	✔	✔	10/23/06	N/A	✔
40	DSS-34	34B1	✔	✔	✔	✔	04/11/05	N/A	✔
60	DSS-54	34B1	✔	✔	✔	✔	08/01/07	N/A	✔
10	DSS-25	34B2	N/A	N/A	✔	✔	✔	✔	✔
10	DSS-26	34B2	N/A	N/A	✔	✔	✔	N/A	✔
60	DSS-55	34B2	N/A	N/A	✔	✔	✔	N/A	✔
10	DSS-15	34HEF	✔	N/A	✔	✔	TBD	N/A	✔
40	DSS-45	34HEF	✔	N/A	✔	✔	TBD	N/A	✔
60	DSS-65	34HEF	✔	N/A	✔	✔	TBD	N/A	✔
10	DSS-14	70M	✔	✔	✔	✔	N/A	N/A	✔
40	DSS-43	70M	✔	✔	✔	✔	N/A	N/A	✔
60	DSS-63	70M	✔	✔	✔	✔	N/A	N/A	✔

N/A = Capability Not Planned xx/xx/xx = Capability Date Recently Change As of: 04/21/04

✔✔✔ = Capability Recently Exists ✔ = Capability Exists

Goldstone Solar System Radar



Martin A. Slade

September 16, 2004

NASA Jet Propulsion Laboratory

Joint Users Resource Allocation Planning Committee Meeting

Goldstone Solar System Radar (GSSR)

- An Observing Proposal for two-station radar observations in support of MESSENGER science goals was submitted to NRAO for the Greenbank Telescope (GBT) in December 2004 (P.I.: Prof. Jean-Luc Margot, Cornell University). This proposal received very high rakings in NRAO's proposal process, and four tracks were allocated to Prof. Margot for the GBT in December. Goldstone Solar System Radar (GSSR) has four conflict-free days scheduled in support of these observations on Dec. 11, Dec. 13, Dec. 19, and Dec. 20, 2004.

- At the August 10 RARB, GSSR was assigned an action item involving similar MESSENGER science support observations in July, 2006. This action item was needed to reduce heavy contention for DSS-14, since Mars, Jupiter, and Mercury close together in the sky in July 2006. Prof. Margot will be visiting JPL in December 2004. We are attempting to schedule a meeting with Cassini , Mars Odyssey, and other interested parties at that time.

- Radar observations of newly discovered Potentially Hazardous Asteroid (PHA) 2004 RZ164 have been tentatively scheduled at DSS-14 during December 2004. Interferometric observations of this PHA with Arecibo Observatory are in the planning stage.

Interplanetary Network Directorate

Joint Users Resource Allocation and Planning Committee

Radio Astronomy & Special Activities

George Martinez

September 16, 2004

Time and Earth Motion Precision Observations (TEMPO)

- **Clock Sync**
  - **DOY 216**
    - **No problems were reported by either DSS-15 or DSS-65.**
    - **The data tapes were shipped to the JPL correlator for processing.**
  - **DOY 234**
    - **No problems were reported by either DSS-15 or DSS-65.**
    - **The data tapes were shipped to the JPL correlator for processing.**
- **Metrics**
  - **100.0% of data time utilized.**

Catalog Maintenance & Enhancement (Cat M&E)

- **DOY 220**
  - **No problems were reported by either DSS-15 or DSS-45.**
  - **Data tapes were shipped to the JPL correlator for processing.**
- **DOY 227**
  - **No problems were reported by DSS-15.**
  - **DSS-65 reported that the antenna went to brake twice.**
  - **Data tapes were shipped to the JPL correlator for processing.**
- **Metrics**
  - **99% of data time utilized.**

Space Geodesy Program (SGP)

- **IVS-T2032**
  - **The objective of the IVS-T2 sessions is to monitor the Terrestrial Reference Frame (TRF) via monthly sessions. All geodetic stations participate in at least three T2 sessions each year. These sessions replace the IRIS-S sessions observed in previous years.**
  - **No problems were reported by DSS-65.**
  - **The data tapes were shipped to the Bonn Correlator for processing.**

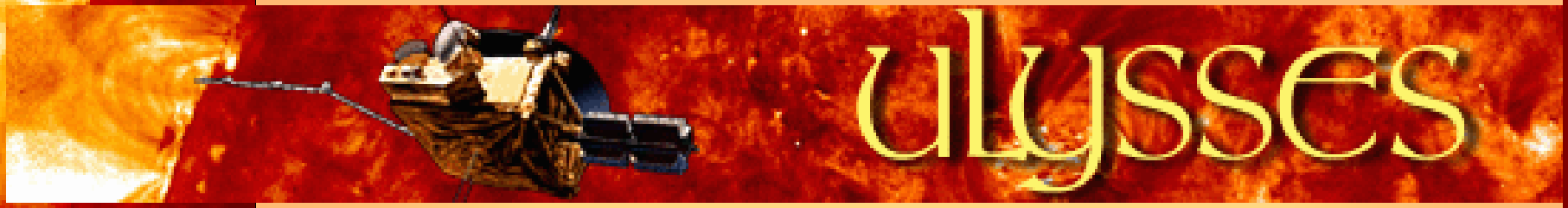
- **Metrics**
  - **100% of the data time was utilized.**

EVN & Global VLBI Systems (EGS)

- **EGS**
  - **The European VLBI Network (EVN) and Global Co-Observing Sessions (formally RAES) have combined to form the new project EVN & Global VLBI Systems (EGS).**
  - **The EGS nomenclature is currently active and is being used in the DSN Schedule.**

Advanced Tracking & Observational Techniques (ATOT)

- ATOT 01 began life as the first (and only) MEGA proposal for VLBI Imaging (shape and nature of sources) and Astrometry (positions of sources) in early 2003.
- It will observe all Southern Hemisphere sources of the International Celestial Reference Frame (ICRF) effort using the Australia Telescope National Facility (ATNF) Long Baseline Array (LBA).
- DSS-43 is essential in completing the accurate nature of the observations in order to navigate the next generation of astrometric satellites; the first of which is SIM.
- The requirements are as follows:
  - Astrometry
    - DSS-43 for a total of 240 hours:
      - 2 x 24 hours annually separated by 6 months.
      - Activity is ICRF ASTROM W-M4 F302
  - Imaging
    - DSS-43 for a total of 360 hours:
      - 3 x 24 hours annually separated by 4 months.
      - Activity is ICRF IMAGE A-S2 F302

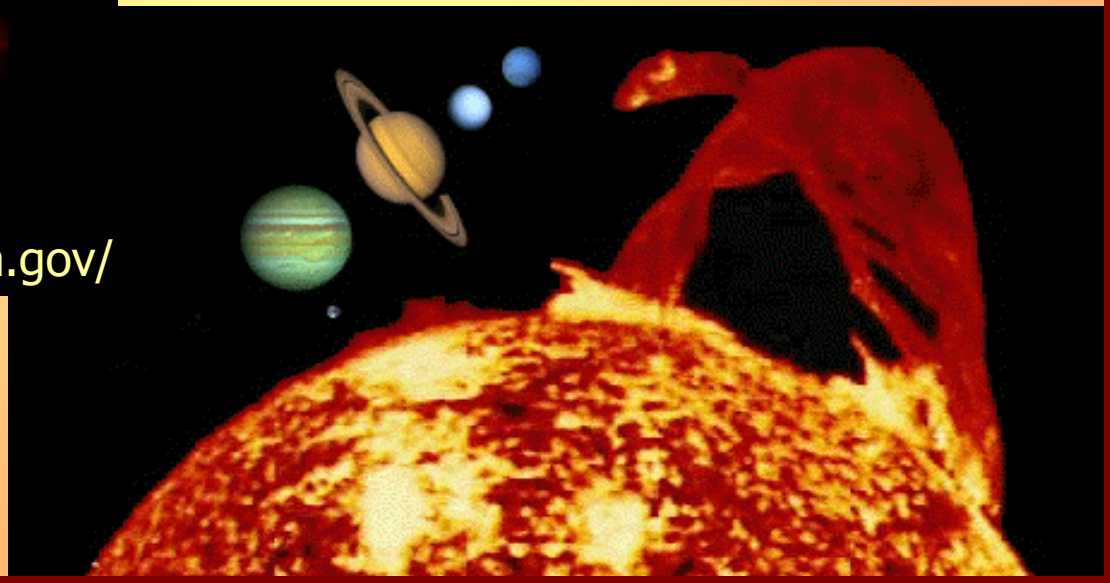


JOINT USERS RESOURCE ALLOCATION PLANNING COMMITTEE

B. Brymer

September 16, 2004

NASA Jet Propulsion Laboratory



ULYSSES

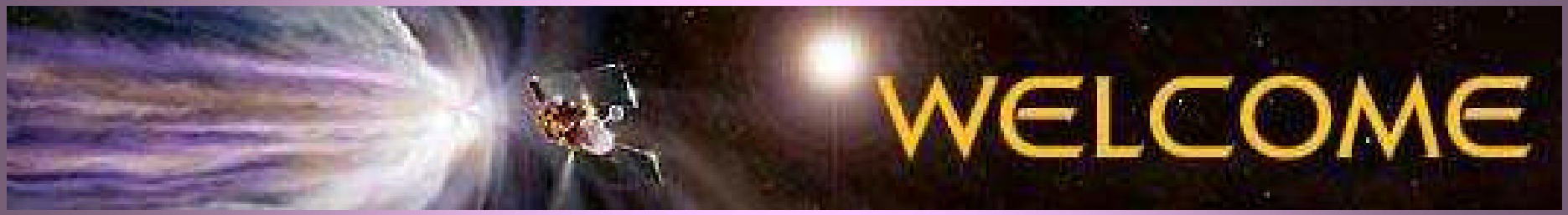
JOINT USERS RESOURCE ALLOCATION PLANNING COMMITTEE

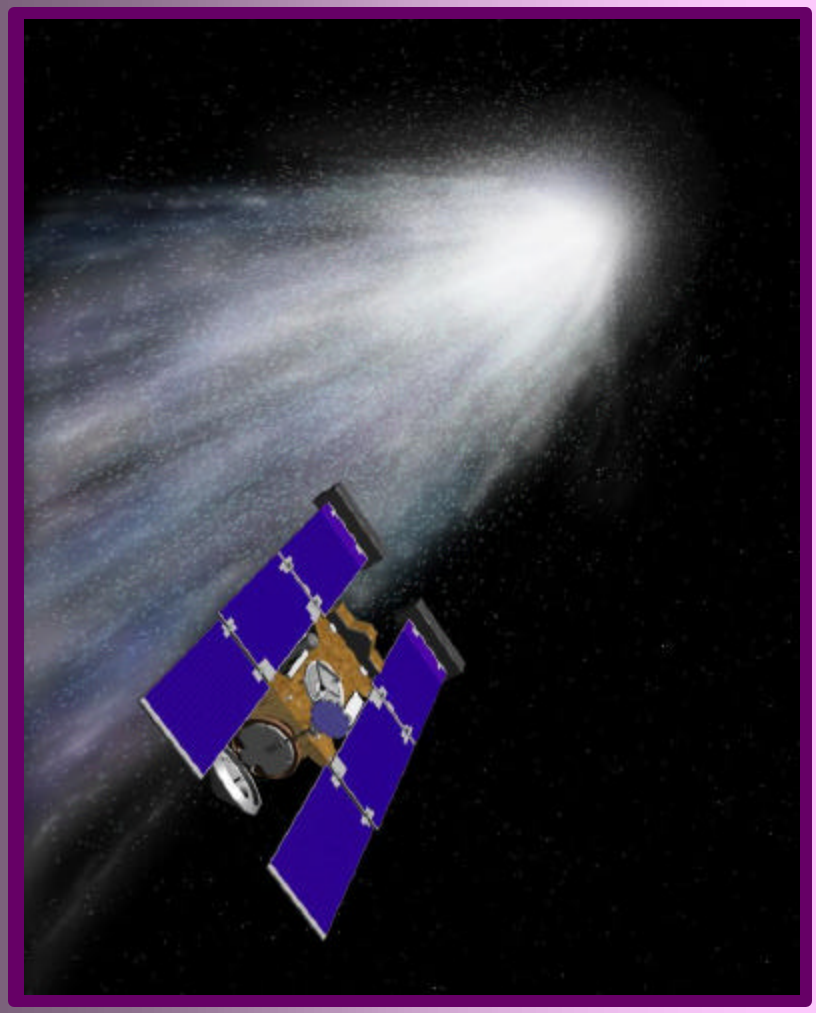
- ULYSSES SUCCESSFULLY COMPLETED ITS NINTH SOLAR CONJUNCTION, EXPERIENCING A MIN. SPE=0.38°/SEP=2.04°
- LOWER BIT RATES AND EXTENSIVE RECORDING ABOARD SPACECRAFT
- TELEMETRY RECOVERY FOR CONJUNTION CAMPAIGN RATED AT 95%, WHICH INCLUDES LOSS OF 6 HOURS OF DSS-24 SUPPORT DUE TO A FAILED MASER

ULYSSES

JOINT USERS RESOURCE ALLOCATION PLANNING COMMITTEE

- FOLLOWING THE NINTH ULYSSES SOLAR CONJUNCTION NOMINAL SPACECRAFT OPERATIONS HAVE RESUMED
- SPACECRAFT POWER AND THERMAL RECONFIGURATIONS AND INSTRUMENT CALIBRATIONS ARE PERFORMED AS REQUIRED
- SPACECRAFT EARTH-POINTING MANEUVERS ARE BEING PERFORMED ON A ROUTINE BASIS





STARDUST

JOINT USERS
RESOURCE ALLOCATION
PLANNING COMMITTEE

R. E. Ryan

September 16, 2004

NASA Jet Propulsion Laboratory

http://stardust.jpl.nasa.gov

STARDUST

Report to JURAP

STATUS

SPACECRAFT IS HEALTHY (9/16/04)

PRESENTLY 2.44 AU from EARTH

00:40:44 RTLT

2.67 AU from SUN

CRUISE MODE

ONE SHORT (power constrained) TRACK PER WEEK

(currently 2:45)

TELEMETRY BIT RATE IS 504 bps (on HGA/34 METER)

DSMS SUPPORT HAS BEEN GOOD THIS PAST PERIOD

http://stardust.jpl.nasa.gov

(there are some good shots, movies and information)

UPCOMING EVENTS

APHELION OF 2.68 AU FROM THE SUN

7 WEEKS CENTERED ON OCTOBER 2004

LIMITED COMMUNICATION BECAUSE OF POWER RESTRICTIONS

(long period of 3 hour duration tracks)

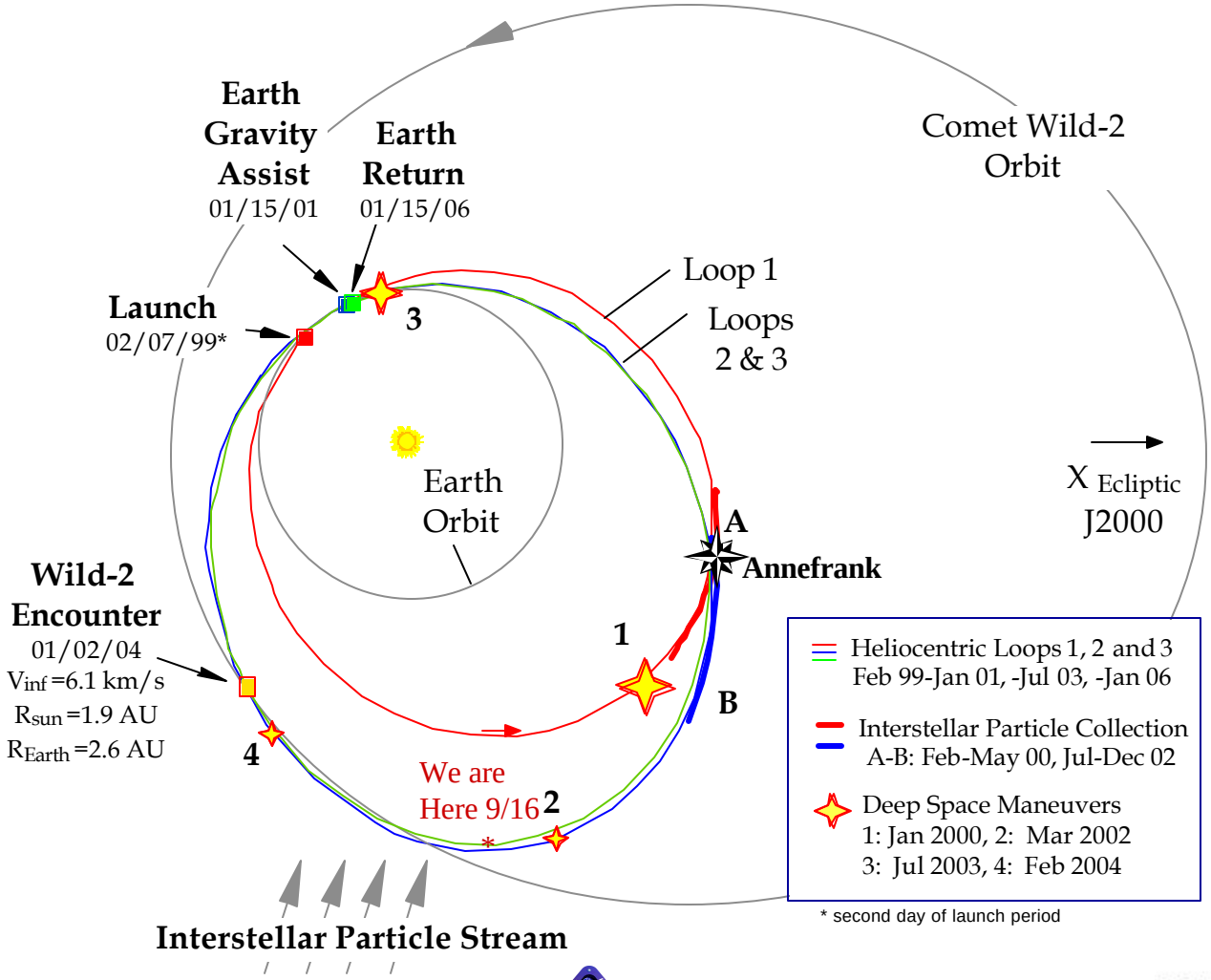
SUPERIOR CONJUNCTION JANUARY 30, 2005

UNDER 2 DEGREES FROM JANUARY 27 TO FEBRUARY 3

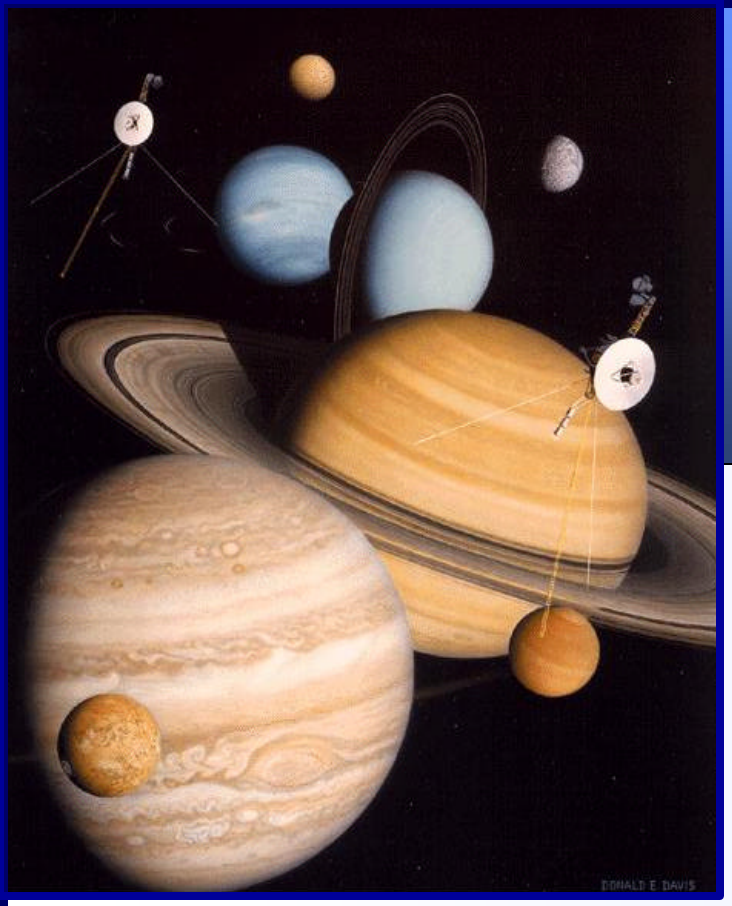
TCM 16 ON April 6, 2005

STARDUST

Report to JURAP



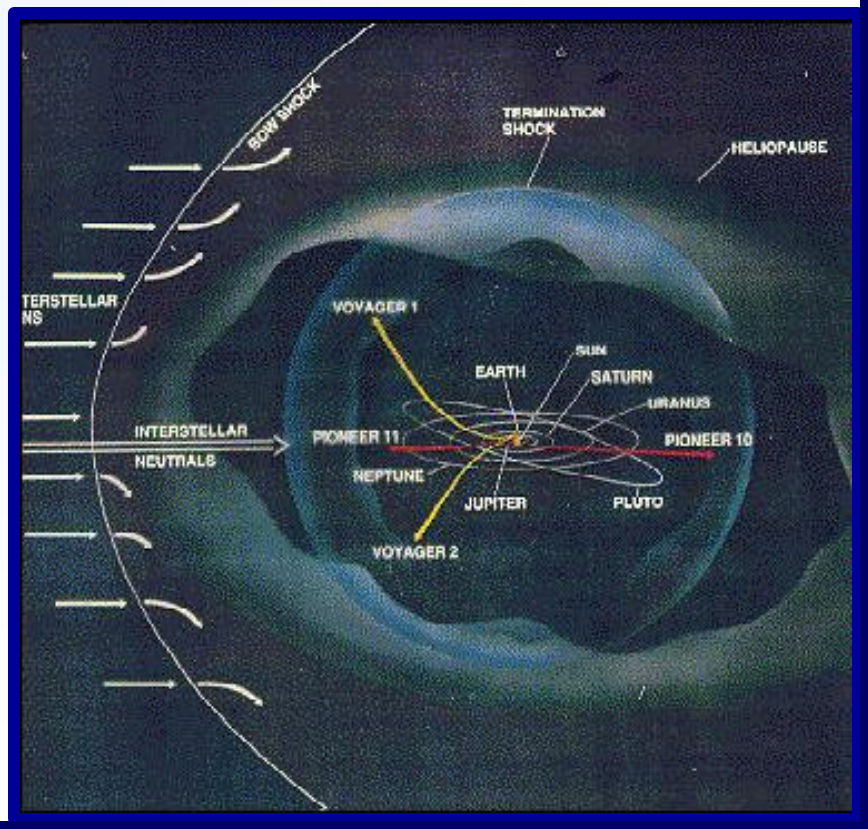
* second day of launch period



VOYAGER

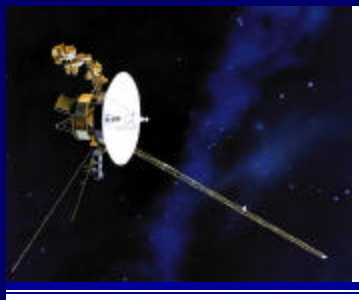
FLIGHT OPERATIONS

JOINT USERS RESOURCE ALLOCATION PLANNING COMMITTEE



Jefferson Hall
September 10, 2004
NASA Jet Propulsion Laboratory

http://voyager.jpl.nasa.gov



VOYAGER

FLIGHT OPERATIONS

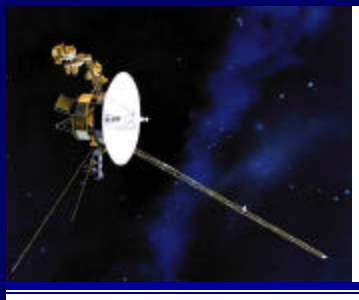
FLIGHT SYSTEM STATUS

VOYAGER 1

* HELIOCENTRIC DISTANCE – 93.06 AU, RTLT – 25h49m34s
* SPACECRAFT REMAINS HEALTHY
* MAJOR ACTIVITY: PMPCAL [FIELDS AND PARTICLES CALIBRATIONS], DTR PLAYBACK, ASCAL, MAGROL

VOYAGER 2

* HELIOCENTRIC DISTANCE – 74.34 AU, RTLT – 20h29m36s
* SPACECRAFT REMAINS HEALTHY



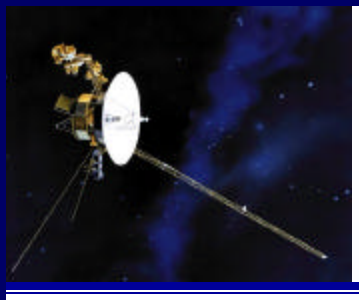
VOYAGER

FLIGHT OPERATIONS

GROUND SYSTEM STATUS

(June 12, 2004 thru September 10, 2004)

- DSN - OVERALL SUPPORT – GOOD
  - ? NUMEROUS SMALL OUTAGES ON VOYAGER 1 DUE TO WEATHER AND HARDWARE PROBLEMS
  - ? TWO SMALL OUTAGES AT DSS-43 ON VOYAGER 2 DUE TO HARDWARE PROBLEMS



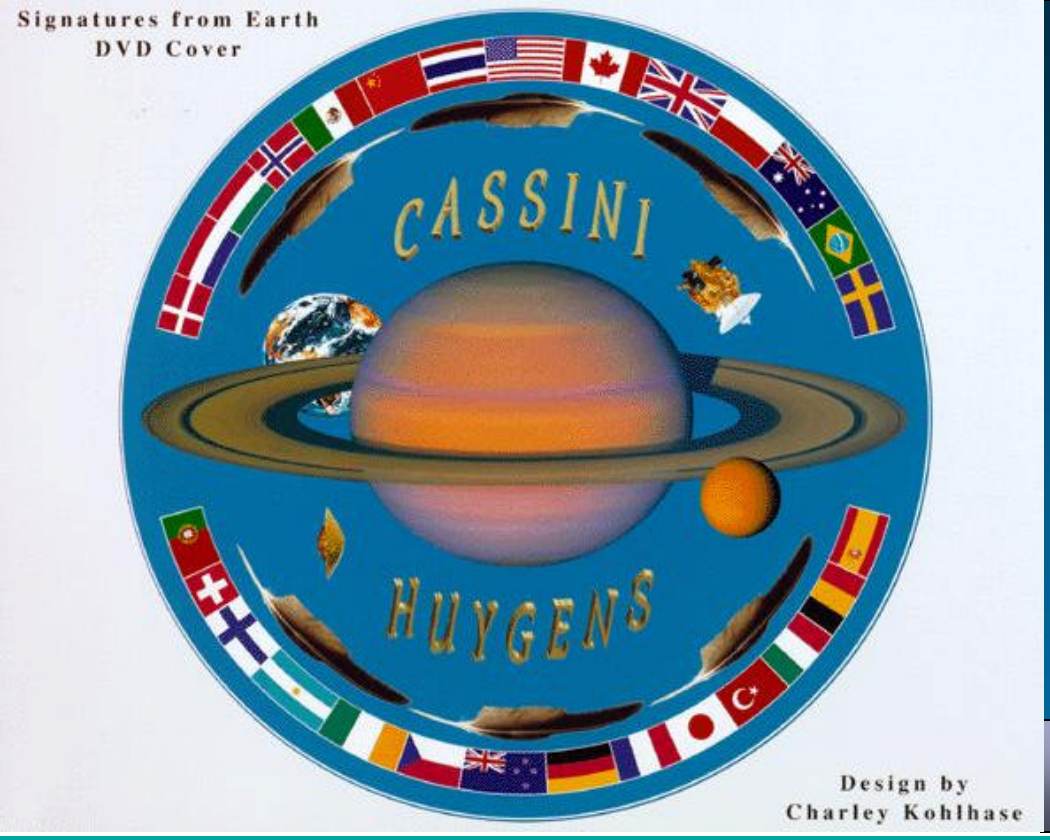
VOYAGER

FLIGHT OPERATIONS

TOTAL SUPPORT TIME, OUTAGE TIME, % OF OUTAGE TIME

S/C	SCHED. SUPPORT	ACTUAL SUPPORT	70M TIME	SIGNIFICANT OUTAGE TIME	% OF OUTAGE TIME
31	1296.6	1298.1	334.0	10.7(3.5)	1.1%
32	886.8	885.0	518.9	3.2(0.8)	0.45%

VOYAGER HOMEPAGE - http://voyager,jpl.nasa.gov



CASSINI

http://saturn.jpl.nasa.gov/cassini/index.shtml

Joint Users Resource Allocation Planning (JURAP) Committee Meeting

Dave Doody

September 16, 2004

NASA / Jet Propulsion Laboratory

Cassini / Huygens

- **Operating in Saturn Orbital Tour**
  - Successful Saturn Orbit Insertion and Trim June 30 PDT (July 1 UTC)
    - DSN Acquired carrier, between ring occultations, to display Doppler shift during 96-minute Main Engine Burn
    - DSN Acquired “Bonus” Telemetry with the 20-second “call home” following the burn
    - High-priority science included 61 images at closest range to the rings, all successfully returned
    - Orbit Trim Maneuver (OTM) - 1 was cancelled due to excellent SOI performance
    - Perichron Raise Maneuver executed successfully August 23 (51-minute Main Engine Burn)
    - OTM-3 executed nominally September 7 (3-second Main Engine burn)

- **Next Major Events**
  - Iapetus Distant Flyby October 16 through 19 (over 1 million km)
    - DSN Level-2 support scheduled
    - Doppler critical for characterizing Iapetus’ mass for Huygens release planning
  - Huygens Battery Depassivation Sunday September 19
  - Titan-A Flyby October 26 at 1200 km altitude
  - Titan-B Flyby December 13 at 2336 km altitude
  - Huygens Release December 24 PST (December 25 UTC)

Cassini / Huygens

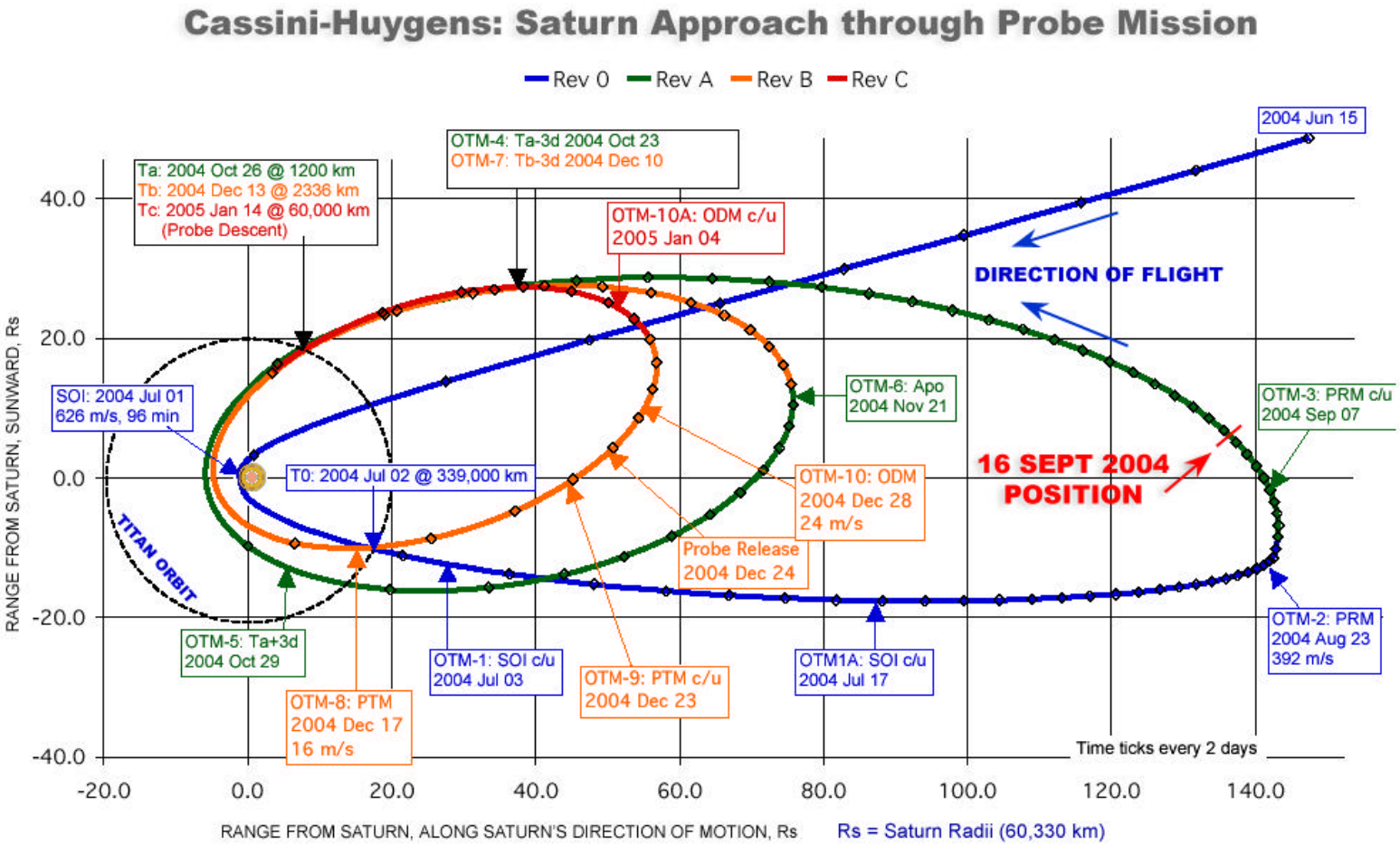
Ring images acquired shortly after Saturn Orbit Insertion

More: saturn.jpl.nasa.gov

Enke Gap

F Ring

Cassini / Huygens



Joint Users Resource Allocation Planning Meeting

September 16, 2004

Hayabusa / Muses-C

M. Jah / N. Mottinger

JPL

14 Sept 2004 09:42 PCT

Muses-C (Hayabusa) Revised DSN Support

Based on Mission Operations Plan received 23 August 2004 Revision caused by change in solar panel output after Coronal Mass Ejection in fall 2003.

The following table shows only the tracking that's been shifted.

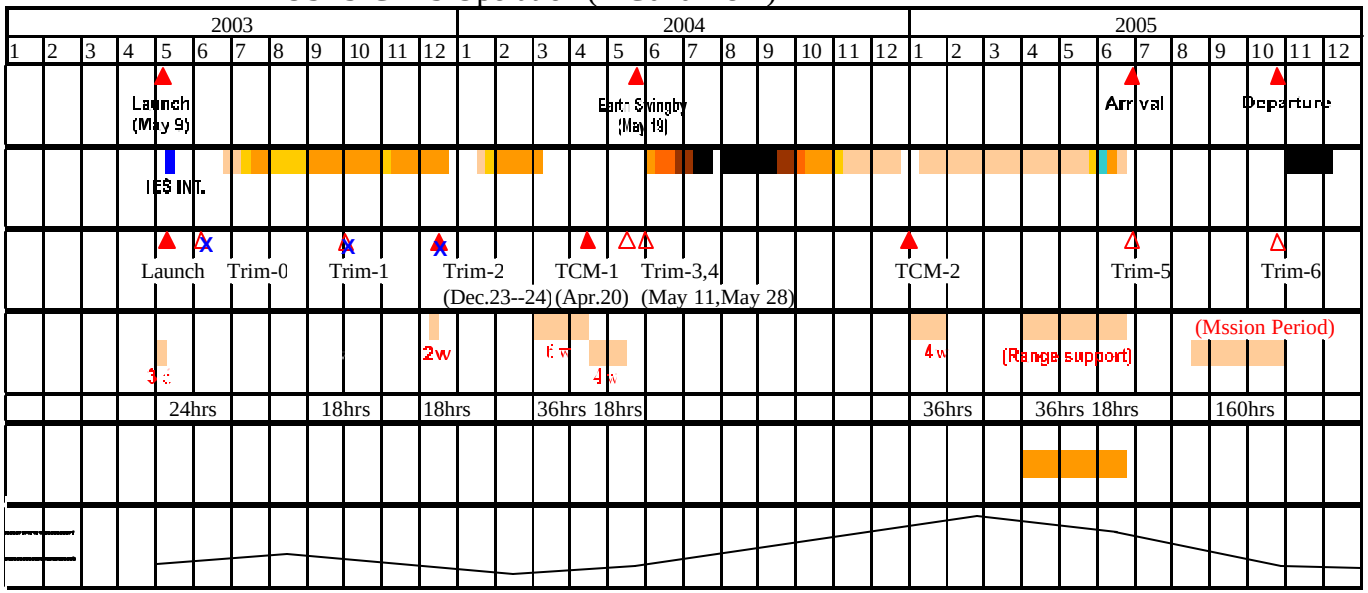
All tracking based on DMR support plan

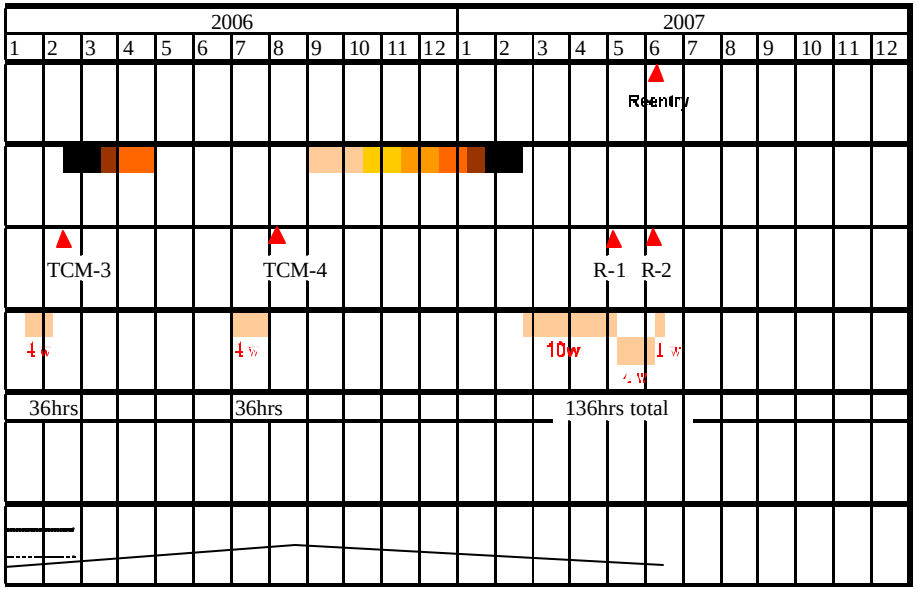
```
     Previous    New   Tracking
      ======================
       Wk      Wk
2005  13       23    1-4hr pass/wk   Rendezvous (approach) support
       14       24    |
       15       25    |
       16       26    |              (Then there is a gap as shown here.)
       17       30    |
       18       31    v
       19       32    4-3hr pass/wk   Trim -5
       20       33    |
       21       34    V
       22       --      Shift the support for this week to the Mission phase.

       36       35  2-8hr back to back passes/wk  Mission Phase
       37       36  4  |                          (Operations at the Asteroid)
       38       37  2  |
       40       39  4  |
       41       40  4  |
       43       42  2  |
                45  2  V

2006  28       27  4-3hr pass/wk TCM-4
       29       28    |
       30       29    |
               30     V New Tracking Request
```

MUSES-C IES Operation (MC040128-2)

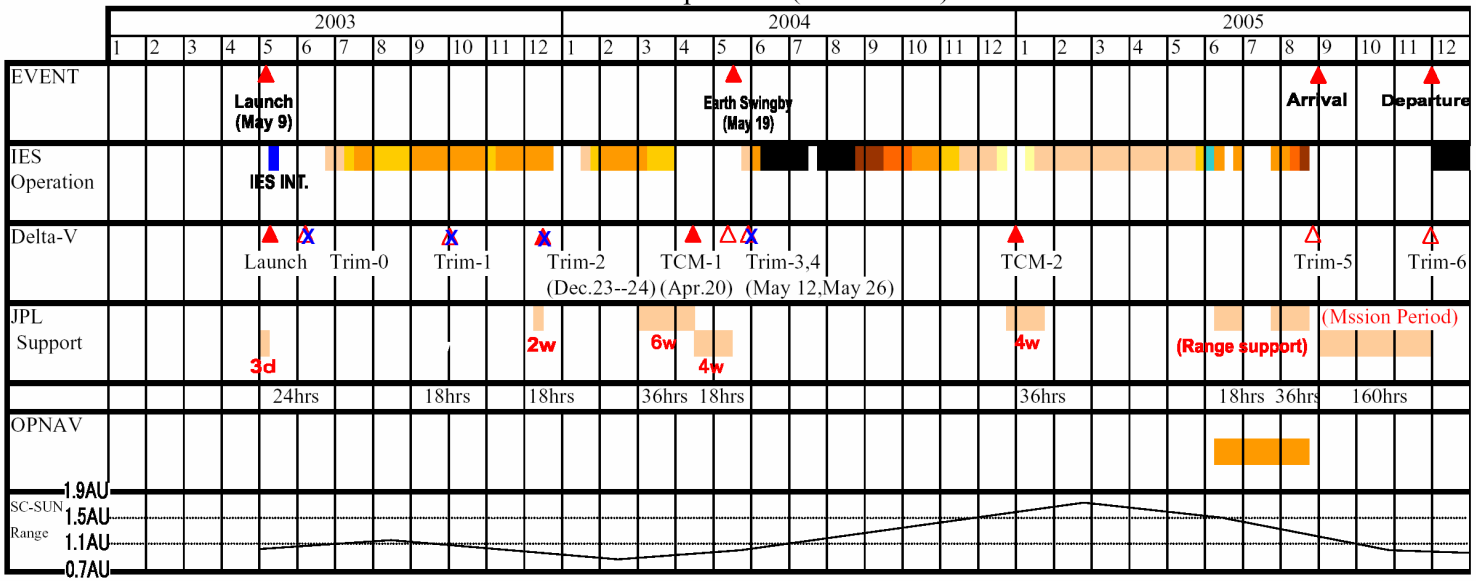


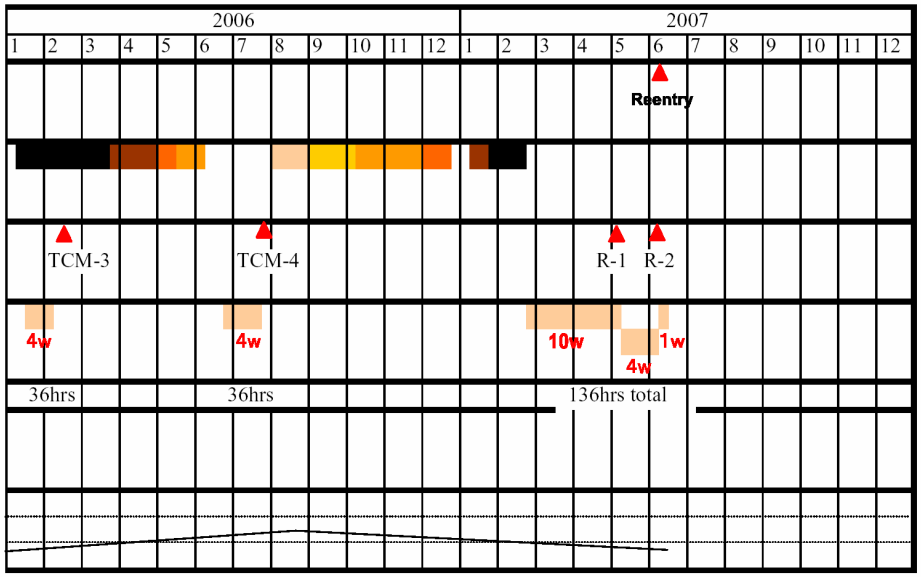


2004-01-31 update
2004-01-23 update
+Trim-2 canceled.
2003-10-08
+JPL Supprt update
(Dec.2003 1.5->2W)
2003-09-05 update
+Trim-1 canceled.

Ion Engine Operation Plan
(ISAS 16 August 2004 Update)

Table-2 MUSES-C IES Operation (MC040816)





2004-08-16 update
arrival/departure date changed.
Trim-4 canceled.
2004-03-24 update
2004-02-20 TCM date corrected.
2004-01-31 update
2004-01-23 update
+Trim-2 canceled.
2003-10-08

Interplanetary Network Directorate

MISION STATUS

for ACE, IMAGE, MAP and GENESIS

Carolina Ho

September 16, 2004

MISSION STATUS
For ACE, IMAGE, MAP and GENESIS

ACE

- The ACE spacecraft is performing well.
- ACE project is planning to go into unattended operations in October.
- No ACE Station Keeping maneuver is scheduled from now till week 48.
- Attitude maneuvers are only planned out for three weeks in advance.

IMAGE

- The IMAGE spacecraft is performing well.
- IMAGE has no maneuvers planned at this time.

MAP

- The MAP spacecraft is performing well.
- MAP's next Station Keeping Maneuver is in week 51.

GENESIS

- Genesis is healthy and performing well.
- Genesis will be performing a PTA maneuver. Next week TBD.
- This is being done to ease the sun pointing attitude management.
- The Off Earth angle will change from about 50 degrees to 90 degrees, but slowly improve.
- Downlink is currently LGA FWD/various bps and Uplink LGA FWD/2000 bps.

Report to the JURAP

September 16, 2004

Brad Compton &
Ben Toyoshima

MER as of 9/16/04

- Both rovers are healthy

- Currently in Solar Conjunction
- Rovers are parked, minimum science collection
- Conducting a No-op command experiment

- Looking forward to a six month extension
- October – December, go to 5 day per week uplink operation
- January – March, back to 7 day per week uplink operation

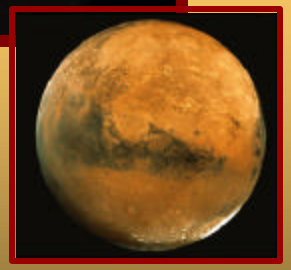
U.S. Participation in Europe's

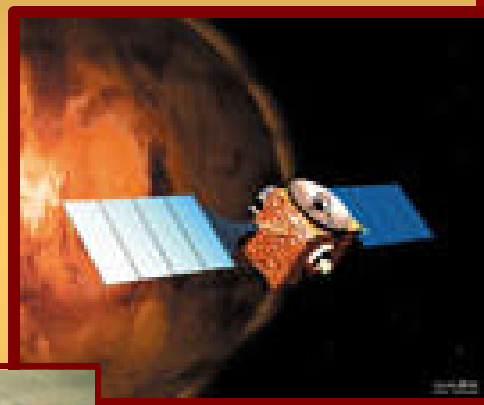
Mars Express

Jet Propulsion Laboratory
California Institute of Technology

Presentation to the

Joint Users Resource Allocation Planning (JURAP) Meeting





Dwight P. Holmes

September 16, 2004

http://www.sci.esa.int/marsexpress/

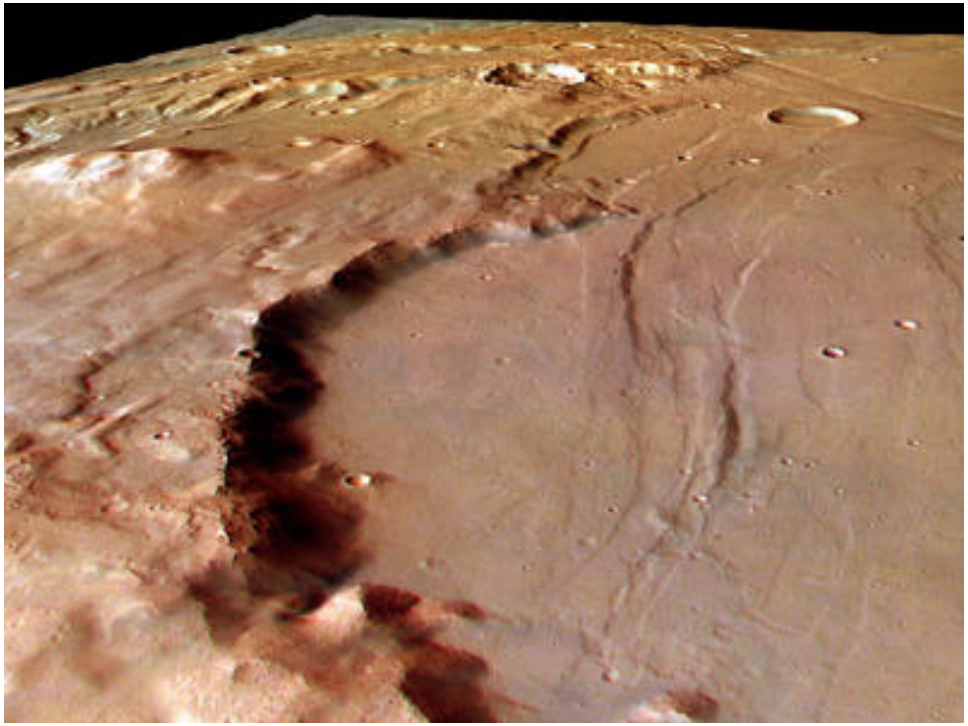
Operations

- **Mars reached minimum Sun-Earth_Probe angle on 15 September.**
  - **Mars Express has been configured for reduced operations because safe mode operations are conducted at S-band. ESA has minimized safe mode entry by significantly reduceing ops and turning off science.**
    - **S-band performance within a two week period of minimum SEP is expected to be very poor.**
  - **The Science that has been conducted is Radio Science Solar Corona observations at both Sb and Xb.**
    - **Support maximized 70 station coverage to be able to acquire both LHCP and RHCP components of the downlink signal.**
    - **First few Solar conjunction observations failed due to mis-configuration at the station.**
  - **Project intends to start reconfiguring the S/c on 21 September with full science operations on 27 September.**

SCIENCE

- Science has been in hibernation mode since late August for Solar conjunction.
- MARSIS antenna deployment investigation is continuing a JPL thermal vac with samples of the antenna boom material.
  - Will update models base on a reevaluation of material properties
  - Hinge buckling tests of MARSIS antenna material are underway at TRW-ASTRO, Carpenteria, California.
- MARSIS deployment not expected before November

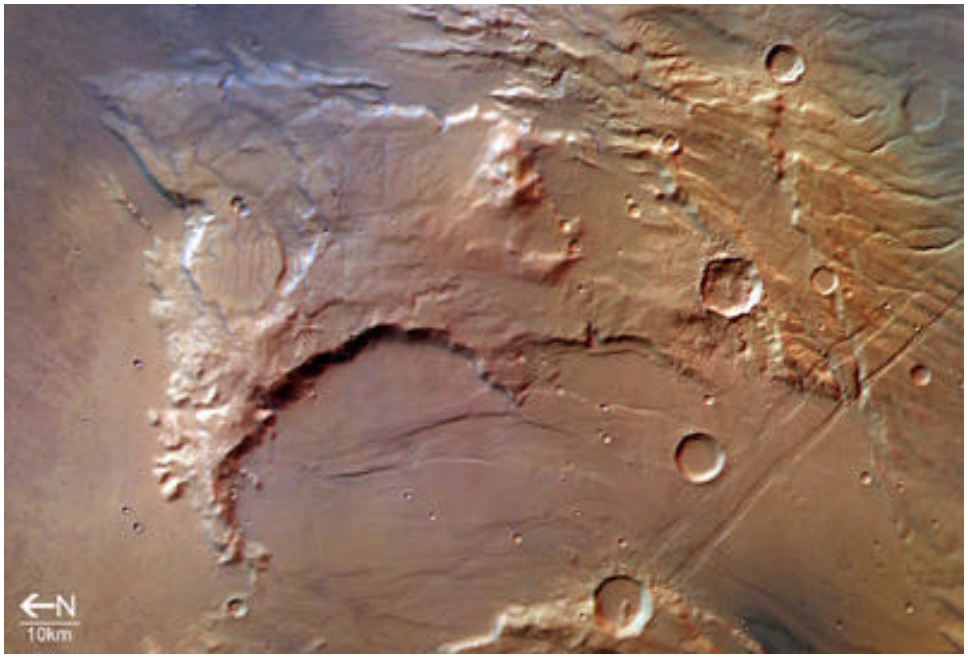
Science



- 10 September 2004 This is a perspective view, taken by the High Resolution Stereo Camera (HRSC) on board ESA's Mars Express spacecraft, of Solis Planum, in the Thaumasia region of Mars.

- The image was taken during orbit 431 on 23 May 2004 with a ground resolution of approximately 48 metres per pixel. The displayed region is located south of Solis Planum at a longitude 271° East and latitude of about 33° South. The large eroded impact crater, part of which is seen in the centre of this image, has a diameter of about 53 kilometres and its eastern crater rim is about 800 metres high. This view is looking south-east.

Science



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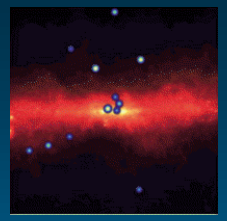
- diameter of about 53 kilometres and its eastern crater rim is about 800 metres high. The northern end of the higher region, upper left in this image, contains an almost circular plateau, which is 15 kilometres across.



INTEGRAL

http://sci.esa.int/home/integral/index.cfm

Joint Users Resource Allocation Planning (JURAP) Committee Meeting

Dwight P. Holmes

September 16, 2004

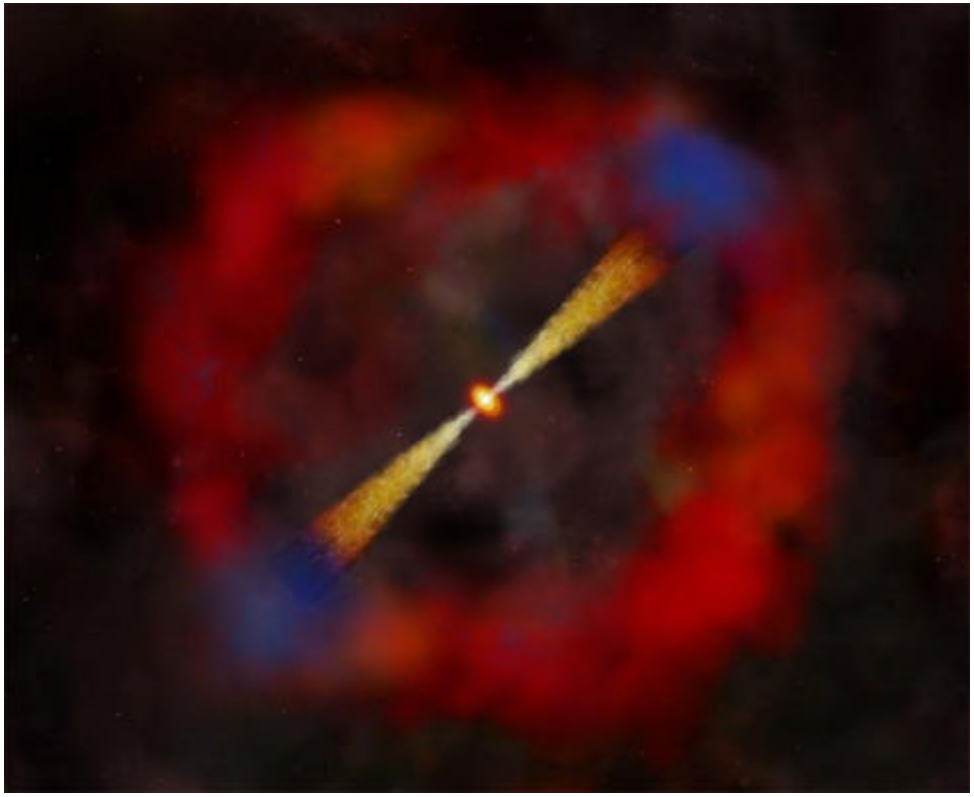
NASA / Jet Propulsion Laboratory

Integral Operations

- Goldstone performance during the past several months has been well above minimum required performance
- As we phase into day shift observation view periods, opportunity for impact by RFI from Fort Irwin will increase.
- INTEGRAL is currently in a Galactic Centre critical observation period which is expected to end by 18 October.
- Next major activity regarding the JPL/ESOC interface will be to update the TC&DM software on the SLE servers in DSOT.
  - In the process of making arrangements switch over and testing for all ESA missions connected to the SLE servers
- INTEGRAL has been updated to the OSCAR X navigation server. SPPA is still used as the single point of entry for all external product deliveries.

INTEGRAL

SCIENCE



GRB's in INTEGRAL's Field of View

The picture shows a model of a gamma-ray burst (GRB), like the one detected by on INTEGRAL on 3 December 2003 (GRB 031203). In this picture a jet of high-energy particles interacts with the surrounding matter.