Observation Overview

- S100 Rev 278 RSS observations
  - Include
    - Gravity observation (24hrs in duration)
    - Periapse ring occultation
    - Distant chord ring occultation
  - 2-way/3-way mode
  - Periods of Telemetry OFF, Ranging OFF, 2-way/3-way mode (during occultations)
  - Playbacks planned during gravity observation when TLM is not off
  - 9 tracks scheduled
    - 6 DSN, 3 ESA

Science Highlights

Gravity Observation - From Luciano Iess

Rev 278 is the fourth of six orbits devoted to the determination of Saturn's gravity field and the mass of the B ring. The spacecraft will collect gravity and magnetic field data from a distance as close as 3000 km from the cloud level. Those data are crucial to build interior models of the planet and to determine the depth of zonal winds.

The Cassini radio science investigation will measure Saturn gravity field and the ring mass by means of range rate measurements enabled by the onboard X band (7.2-8.4 GHz) radio system, and the antennas of NASA's Deep Space Network and ESA's tracking network. The gravity determination is obtained by fitting the radial velocity of the spacecraft with accuracies of about 0.05 mm/s (at a time scale of 60 s) with a model of the spacecraft dynamics. Due to the large Doppler rate, the measurements are aided by predictions obtained from a model of the orbital dynamics.

Cassini orbital geometry is crucial for the gravity experiment. The highly eccentric 6-day orbit has a pericenter close to Saturn's clouds, within the inner edge of the rings. With Cassini passing between the rings and the planet, Cassini will be able to disentangle the strong acceleration due to Saturn's oblateness from that due to tiny pull of the rings. In addition, going close to Saturn Cassini will be affected by tiny density inhomogeneities inside the planet, thus providing clues on their structure.

Cassini gravity passes will be able to provide the density distribution inside Saturn. In particular, it will tell us how massive the core is (we are expecting something like 20 Earth masses of heavy elements in the central part of the planet). The gravity field of Saturn as measured by Cassini depends on how mass is distributed inside the planet. We may imagine that layers of different densities give different contributions to the total gravity. However, it is only the fast rotation of the planet that makes the shape oblate and generates sufficient latitudinal gravity variations to allow inferring the density profile at depth. We know the planet's bulk density from it's mass and radius. (Radius gives us the volume.) The gravity field yields the density as a function of radius in the H/He envelope of the planet. So, in a sense, since we know the density of the whole planet, and the density of the H/He envelope, we can infer that we are, or are not, "missing" mass in the deep interior of the planet, based on how dense the H/He mixture would be extended to very deep interior conditions. If we are missing mass, one can calculate out how much that is, and that is the core mass.

Science Highlights Cont'd

Gravity Observation Cont'd - From Luciano Iess

The tiny pull of the hemispherically asymmetric gravity field we'll also allow Cassini to tell us how deep the winds are inside Saturn. We know that the winds at the cloud level are up to 300 km/h strong, but we do not know if the flow goes down to just 100, or 1000, or even 10000 km. This is another important science goal of the Grand Finale.

The mass of the rings (concentrated mostly in the B ring) remains uncertain. Its value, generally expressed in terms of Mimas masses, bears crucial information on how and when the rings formed, and their relation with Saturn and its moons. Models predict that a large ring mass implies that the rings are old, dating back to the formation of the Saturnian system 4.5 billion years ago. A small mass implies that the rings are much younger, possibly formed by the impact with a comet.

By the end of July Cassini will tell us a lot about the interior structure and the formation of the Saturnian system. We are anxious to analyse the data, and proud to be part of this endeavor which sees the effort of so many people in the Project and the DSN.

Science Highlights Cont'd

Ring Occultations - From Essam Marouf

The Rev 278 RSS periapse and chord ring occultations are the fourth group in a unique Grand Finale (Proximal Orbits) campaign of Cassini radio occultations of Saturn's ring system. The campaign takes advantage of occultation track geometry that systematically sweeps across the ring system. Collectively, the occultation tracks capture a spread in: 1) Earth relative longitude , and 2) inertial ring longitudes. The first allows characterization of the virtual azimuthal ring asymmetry due to gravitational wakes known to permeate Rings A and B. The second allows characterization of true azimuthal ring asymmetry driven by ring dynamics, including sharp edges and resonant interaction with the satellites and with Saturn's interior structure. Also unique about the campaign is that the rings are close to their maximum opening angle (B~26-27°) as seen from the Earth, possible only near the 2017 epoch of the Proximal Orbits. The large *B*-angle allows maximum penetration of the radio signals of optically thick features, especially Ring B, the many density and bending waves everywhere, confined optically thick ringlets including the Ring C plateaus. Radio occultations enjoy the advantage of measurements using three coherent observation wavelengths (0.94, 3.6, and 13 cm; Ka-, X-, and S-band), allowing not only profiling of ring structure but also constraining the structures physical properties.

The Grand Finale campaign includes ring occultations on the 6 RSS gravity orbits (Revs 273, 274, 275, 278, 280 and 284) and two on Rings segments (Revs 276 and 282). The 6 on the gravity orbits include never before attempted close occultations observing the rings from a distance < ~1 RS near orbit periapse. Dubbed "periapse ring occultations," they start almost immediately after Cassini dives through the ring plane and are short in duration (< 26 m) but cover the complete main ring system. High spatial resolution scattered and direct signals measurements are expected because of the small HGA footprint and the small Fresnel scale, respectively. The collective ring coverage of the RSS Grand Finale occultations is unprecedented in the Cassini Mission.

DSN and ESA Antennas

- DSN Coverage

		Pre	BOT	EOT	Post					
17	160	1915	2045	0430	0445	DSS-55 CAS	TP RSS GRV/OC	L3	7197 N750	1A1
17	161	0115	0200	0700	0715	DSS-84 CAS	RSS GRAV/OCC		7197 0142	1A1
17	161	0225	0355	1225	1240	DSS-25 CAS	TP RSS GRV/OC	L3	7197 N748	1A1
17	161	0630	0800	2055	2110	DSS-35 CAS	RSS GRAV/OCC	L3	7198 0681	1A1
17	161	0655	0755	2055	2110	DSS-43 CAS	TP RSS GRV/OC	L3	7198 1647	1A1
17	161	1905	2035	0345	0400	DSS-55 CAS	RSS GRAV/OCC	L3	7198 N750	1A1
17	161	1905	1950	2300	2315	DSS-74 CAS	RSS GRAV/OCC		7199 0142	1A1
17	161	1935	2035	0345	0400	DSS-63 CAS	RSS GRAV/OCC	L3	7198 1647	1A1
17	161	2245	2330	0405	0420	DSS-84 CAS	RSS GRAV/OCC		7198 0142	1A1

- DSS-55, DSS-25, DSS-35, DSS-43, DSS-74, DSS-63 will be providing the uplink
- DSS-55 also supports downlink period immediately preceding the observation
- Awaiting to hear back from ESA about starting DSS-74 and second DSS-84 tracks earlier
  DSS-74 BOT at 1850 instead of 1950
  DSS-84 BOT at 2300 instead of 2330

DSN and ESA Antennas Cont'd

Receivers scheduled

- 2 closed-loop receivers per antenna
- DSN Open-loop receivers (RSRs, WVSRs, VSRs, PRSRs)
  - Conflict with Juno DDOR on WVSR at Madrid
  - They only need one side of one WVSR, so will use WVSR1A
- PRSR at Malargue and New Norcia
- Open-loop data are prime for occultations and gravity. Closed-loop data are also required for gravity
- Only RCP will be recorded
  - 2-way/3-way and 1-way modes

S100 Rev 278 Open-Loop Receiver Assignment

DSS Prdx Mode	Operator (S) Scripted By	Ops Machine	Open-loop Receiver	Channels	Subchannels	Bandwidths KHz
DOY 160						
55 1-/2-way	Jay (S)Elias	rsops2	RSR2 RSR1	RSR2A -> XRCP RSR1B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
25 1-/2-/3-way	Aseel/ Clement (S)Elias	rsops1	RSR1	RSR1A -> XRCP RSR1B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
25 1-/2-/3-way	Jay/Danny (S)Jay	rsops5	WVSR1	WVSR1A -> XRCP WVSR1B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
25 1-/2-/3-way	Jay (S)Jay	rsops5	WVSR2 Precision Mode	WVSR2A -> XRCP WVSR2B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
84 3-way	Aseel	rsops6/ psdg5	PRSR 168.96.250.72	PRSR -> XRCP	1, 2, 3, 4	1, 16, 50, 100
43 3-way	Clement/ Elias (S)Clement	rspos1	RSR1	RSR1A -> XRCP RSR1B -> SRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, **16** 1, 16, 50, 100
43 1-way	Danny/Jay (S)Danny	rsops4	WVSR1	WVSR1A -> XRCP WVSR1B -> SRCP	1, 2, 3 4 5, 6, 7, 8 1, 2, 3, 4 5, 6, 7, 8	1, 16, 50 **16** (with offset) 1, 16, 50, 100 (with offset) 1, 16, 50, 100 1, 16, 50, 100 (with offset)

STILL BEING WORKED

S100 Rev 278 Open-Loop Receiver Assignment

DSS Prdx Mode	Operator (S) Scripted By	Ops Machine	Open-loop Receiver	Channels	Subchannels	Bandwidths KHz
35 2-/3-way	Clement/ Elias (S)Clement	rsops1	RSR2	RSR2A -> XRCP RSR2B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, **16** 1, 16, 50, 100
35 2-/3-way	Danny/Jay (S)Danny	rsops4	WVSR2 Precision Mode	WVSR2A -> XRCP WVSR2B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
35 1-way	Danny (S)Danny	rsops3	VSR1	VSR1A -> XRCP VSR1B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	**1, 16, 50, 100** (with offset) **1, 16, 50, 100** (with offset)
74 2-/3-way	Aseel	rsops6/ psdg5	PRSR 134.159.181.84	PRSR -> XRCP	1, 2, 3, 4	1, 16, 50, **16**
63 1-/2-/2-way	Elias/ Clem[illegible] (S)El[illegible]s	rsops2	RSR2 R[illegible]R[illegible]	RSR2A -> XRCP R[illegible]R1B -> [illegible]	1, 2, 3, 4 1, 2, [illegible], 4	1, 16, 50, 100 1, 16, 50, 100
63 1-way	Jay/Danny (S)Jay	rsops5	WVSR1	WVSR1A -> XRCP WVSR1B -> SRCP	1, 2, 3, 4 5, 6, 7, 8 1, 2, 3, 4 5, 6, 7, 8	1, 16, 50, 100 1, 16, 50, 100 (with offset) 1, 16, 50, 100 1, 16, 50, 100 (with offset)
55 1-/3-way	Elias/ Clement (S)Elias	rsops2	RSR1/RSR2	RSR1A -> XRCP RSR2B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
55 1-/3-way	Jay (S)Danny	rsops5	PRSR	PRSR -> KRCP	1, 2, 3, 4	1, 16, 50, 100
55 1-way	Jay/Danny (S)Jay	rsops5	WVSR2	WVSR2A -> XRCP WVSR2B -> KRCP	1, 2, 3, 4 5, 6, 7, 8 1, 2, 3, 4 5, 6, 7, 8	1, 16, 50, 100 1, 16, 50, 100 (with offset) 1, 16, 50, 100 1, 16, 50, 100 (with offset)

STILL BEING WORKED

S100 Rev 278 Open-Loop Receiver Assignment

DSS Prdx Mode	Operator (S) Scripted By	Ops Machine	Open-loop Receiver	Channels	Subchannels	Bandwidths KHz
DOY 161						
84 1-/3-way	Aseel	rsops6/ psdg5	PRSR 168.96.250.72	PRSR -> XRCP	1, 2, 3, 4	1, 16, 50, 100
14 3-way	Clement (S)Clement	rsops1	RSR3	RSR3A -> XRCP RSR3B -> SRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
14 1-way	Danny (S)Danny	rsops4	WVSR1	WVSR1A -> XRCP WVSR1B -> SRCP	1, 2, 3, 4 5, 6, 7, 8 1, 2, 3, 4 5, 6, 7, 8	1, 16, 50, 100 1, 16, 50, 100 (with offset) 1, 16, 50, 100 1, 16, 50, 100 (with offset)
25 3-way	Clement (S)Clement	rsops1	RSR1	RSR1A -> XRCP RSR1B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
24 3-way	Clement Real-time	rsops2	RSR2	RSR2A -> XRCP RSR2B -> SRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
24 1-way	Danny Real-time	rsops4	VSR1	RSR1A -> XRCP	1, 2 3, 4	1, 16 1, 16 (with offset)
24 1-way	Danny Real-time	rsops4	WVSR2	WVSR2A -> SRCP	1, 2, 3, 4 5, 6, 7, 8	1, 16, 50, 100 1, 16, 50, 100 (with offset)
25 1-way	Danny (S)Danny	rsops4	WVSR2	WVSR2B -> KRCP	1, 2, 3, 4 5, 6, 7, 8	1, 16, 50, 100 1, 16, 50, 100 (with offset)

STILL BEING WORKED

Don't record
Same fgain throughout (use TLM off fgain)
Re-set fgain when TLM is off at 17:09:24 and don't change

DSN Open-Loop Receiver Status

Email from Danny on 4/12

Goldstone

RSR1 – Green (X-band power jumps observed on RSR1A)

RSR2 – Green with date rate != num_samples warnings

RSR3 – Green

VSR1A – "Orange" - DP Internal Error Error may occur; try restarting; reliability in question

VSR1B – "Red" - DP Internal Error Error may occur; try restarting; reliability in question

WVSR1 – Green w/ with fgain bug

WVSR2 – Green w/ with fgain bug

No PRSR

Canberra

RSR1 – Green

RSR2 – Green

VSR1 – Green

PRSR1 –Red

WVSR1 – Green w/ with fgain bug

WVSR2 – Green w/ with fgain bug

Madrid

RSR1A – Red but can be used by overriding dig vfy test

RSR1B - Green

RSR2A – Green

RSR2B – Digitizer test fails due to unknown cause. Can be used by overriding dig vfy test

VSR1 – Red

PRSR1 – Green

WVSR1 – Green w/ with fgain bug

WVSR2 - Green w/ with fgain bug

Real-Time Support

RSSG will be in Ops Room at 12:00 pm on Friday, June 9 (160/1900)

- Last post-cal ends at 9:05 pm on Saturday, June 10 (161/0405)
- 33 hours
- Will send engineering team support schedule soon

NOA support?

- Option to check beginning of DSS-55 support and return for Malargue support?

Predicts

- Last NAV OD delivery was on May 19
  - NAV doesn't have another one scheduled until June 12
- RSS will not be modifying the uplink predicts
- Lu: Can you please ask SPS to provide uplink predicts
- Elias and Danny will generate and verify the open-loop downlink predicts
- RSS usually uses three sets of downlink predicts in the open-loop receivers for occultations:
  - #1: Coherent (2-way/3-way)
  - #2: 1-way coherent:1-way predicts offset in real-time to coherent downlink frequency
  - #3: 1-way (no offset): For 1-way baseline and when the DST loses lock (for example, dense ring regions)
- If an additional receiver is available, will record in high precession mode for gravity
  - Like we did during Rev 273, Rev 274 and Rev 275

ORTs

Completed

ORT on DOY 153-154 (June 2-3) over DSS-55 and DSS-25, X- and Ka-band

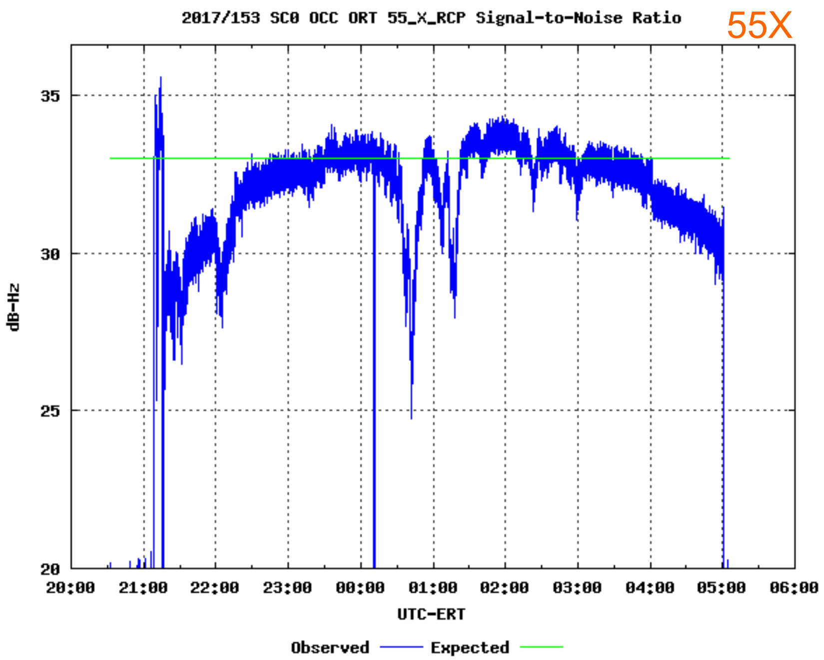
17 153 1945 2115 0500 0515 DSS-55 CAS RSS OCCORT MC 7190 N750 1A1

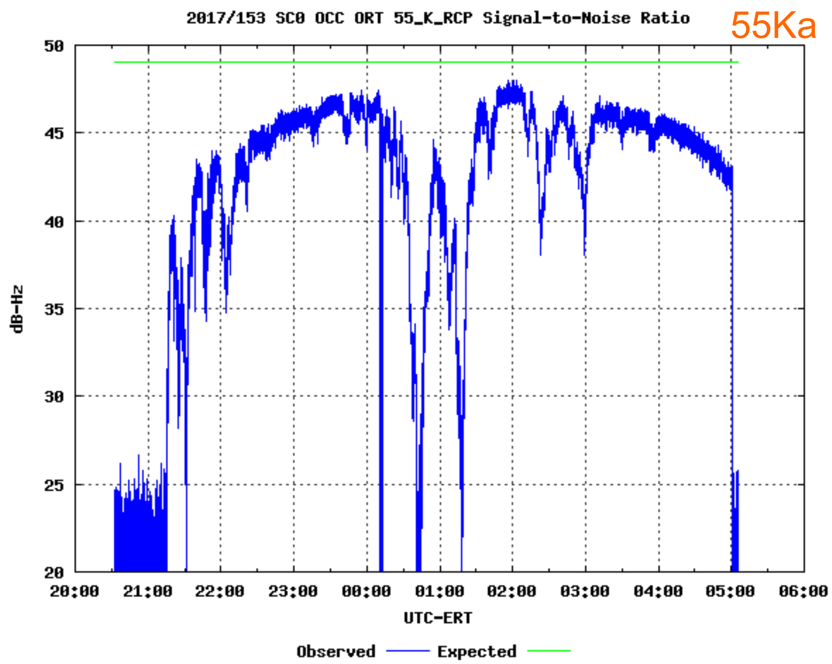
17 153 2015 2115 0500 0515 DSS-63 CAS TKG PASS 7190 N003 1A1

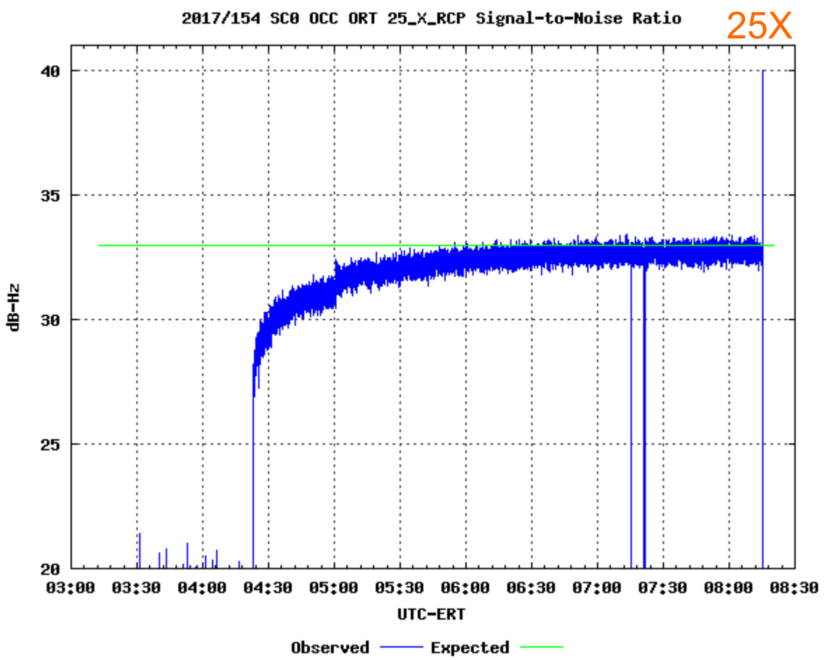
17 154 0310 0440 0815 0830 DSS-25 CAS TP RSS OCCORT MC 7190 N748 1A1

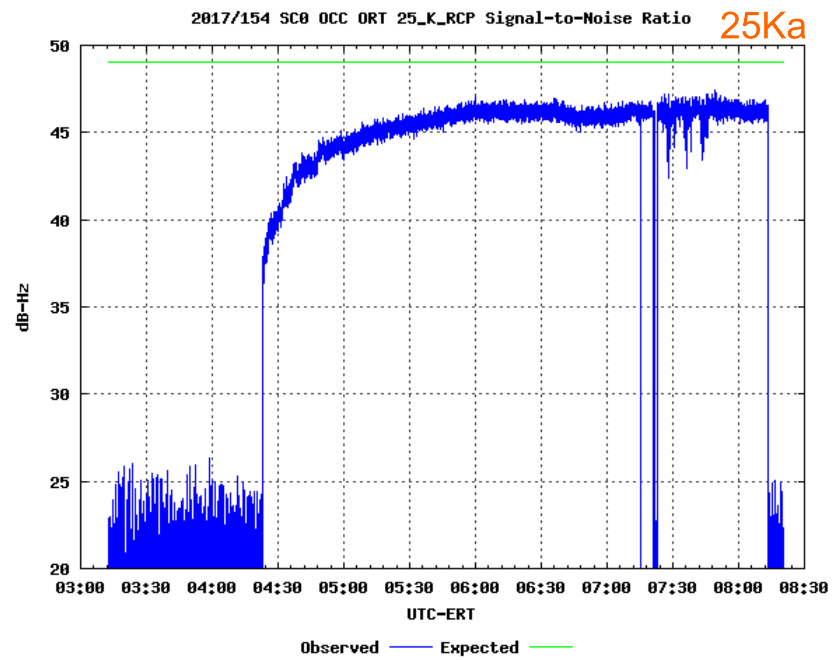
- DSS-63 and DSS-25 prime
- 55 and 25 Verified Monopulse and conducted on-point phase cals
- DSS-55:
  - High SNT – Noisy channel?
  - Conscan before Monopulse
    - improved Ka-band signal level by ~ 5 dB

ORTs Cont'd


2017/153 SC0 OCC ORT 55_X_RCP Signal-to-Noise Ratio
55X
dB-Hz
35
30
25
20
20:00 21:00 22:00 23:00 00:00 01:00 02:00 03:00 04:00 05:00 06:00
UTC-ERT
Observed
Expected


2017/153 SC0 OCC ORT 55_K_RCP Signal-to-Noise Ratio
55Ka
dB-Hz
50
45
40
35
30
25
20
20:00 21:00 22:00 23:00 00:00 01:00 02:00 03:00 04:00 05:00 06:00
UTC-ERT
Observed
Expected


2017/154 SC0 OCC ORT 25_X_RCP Signal-to-Noise Ratio
25X
dB-Hz
40
35
30
25
20
03:00 03:30 04:00 04:30 05:00 05:30 06:00 06:30 07:00 07:30 08:00 08:30
UTC-ERT
Observed
Expected


2017/154 SC0 OCC ORT 25_K_RCP Signal-to-Noise Ratio
25Ka
dB-Hz
50
45
40
35
30
25
20
03:00 03:30 04:00 04:30 05:00 05:30 06:00 06:30 07:00 07:30 08:00 08:30
UTC-ERT
Observed
Expected

Uplink Strategy

Uplink Strategy
- DSS-55, 18 kW, ramped, sweep
- DSS-25, 18 kW, ramped
  - No uplink transfer from DSS-55 to DSS-25
    - DSS-55 transmitter off limit 161/04:12:49 ERT
    - DSS-25 transmitter on limit 161/04:17:19 ERT
- DSS-35, 18 kW, ramped, no sweep
  - Uplink transfer from DSS-25
- DSS-43, 18 kW, ramped, no sweep
  - Uplink transfer from DSS-35
- DSS-74, 18 kW, ramped, no sweep
  - Uplink transfer from DSS-43
- DSS-63, 18 kW, ramped, no sweep
  - Uplink transfer from DSS-74

Four uplink transfers!

ESA/DSN uplink transfers during Rev 276 occultation were successful
- Back to old configuration

Misc

DSS-35 will be prime (2-way) during closest approach period

Subreflectors at DSN and ESA
- Fixed at DSS-35 during gravity
  - Move at start of chord occultation?
- Moving at all other stations

BLF
- Same as before

DKF
- Does not have the correct uplink or AOS/LOS times. Use times in RSS timeline
- DKF has playback times

Monopulse
- Per timeline
  - Stations to enable and disable Monopulse only when requested by RSS
- Rising stations - Wait for ~10 degrees elevation to enable Monopulse

4th Order Blind Pointing Models
- Data sent to David
- Graham Baines at Canberra has been checking the DSS-35 pointing model

Misc Cont’d

Timeline

- There will be a v2

Doppler Dynamics

- NOA-s: please check accelerations during periapse period
- Preference is to keep the same bandwidths throughout the support

Rev 278 is shared with CDA

- They picked secondary and offsets

DSS-43 Master Equatorial still red?

- There’s time to Conscan at beginning of DSS-43 support to check/improve pointing, but ensure that Conscan is disabled before start of periapse rings occultation

NOPEs

- Any other red/orange equipment?

RSSG

Ops room displays

- Started by first shift, updated as needed by later shifts

Danny

- Please check open-loop receivers status, availability and disk space