CONTOUR Science Team Meeting
Mission Operations
April 29, 2002

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- Timelines

- Instrument Commanding/Procedures Preparations Status

- Mission Simulation and Test Strategy

- Mission Simulations Conducted
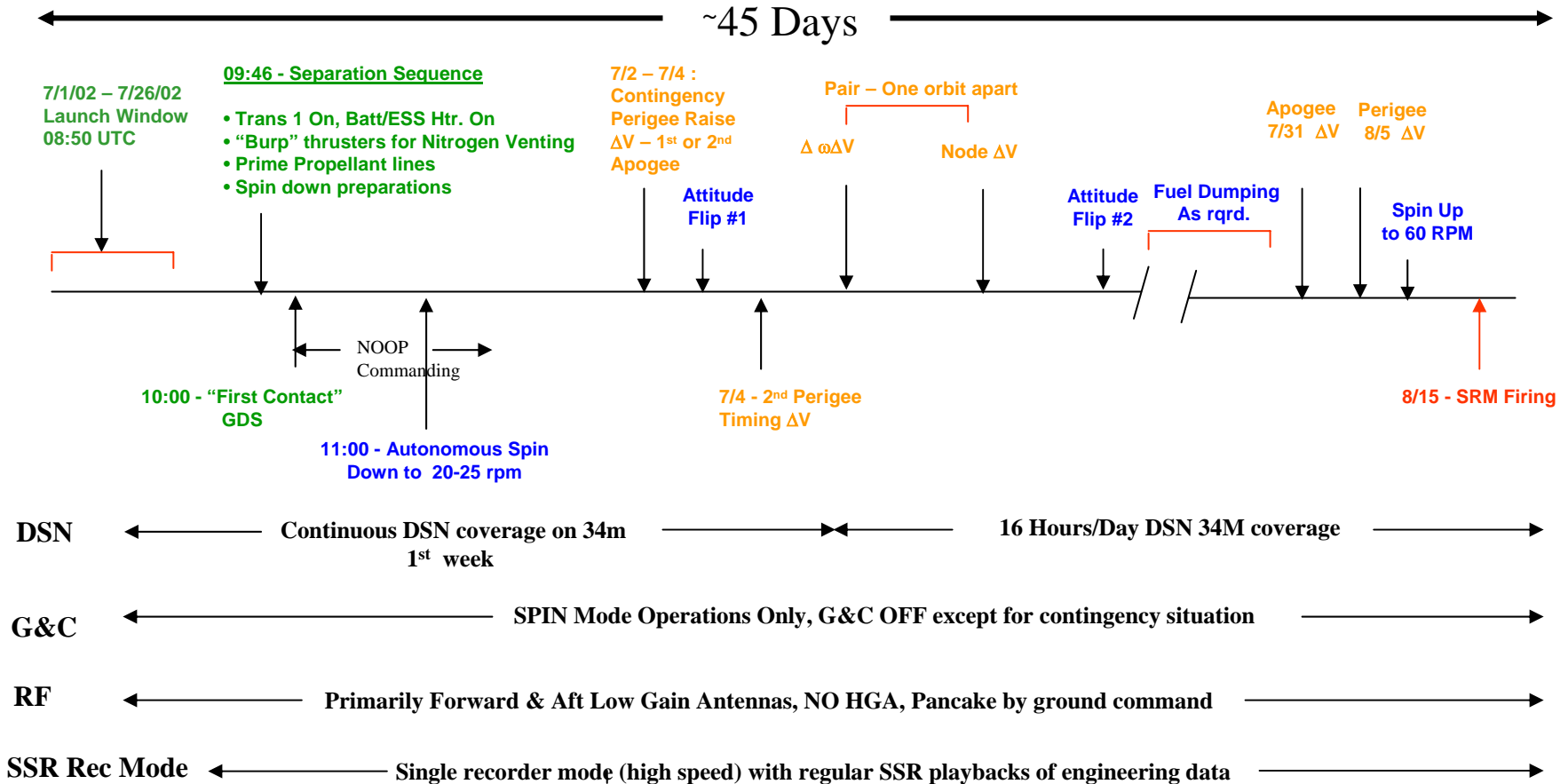
- Simulations Plans for May

COmet Nucleus TOUR

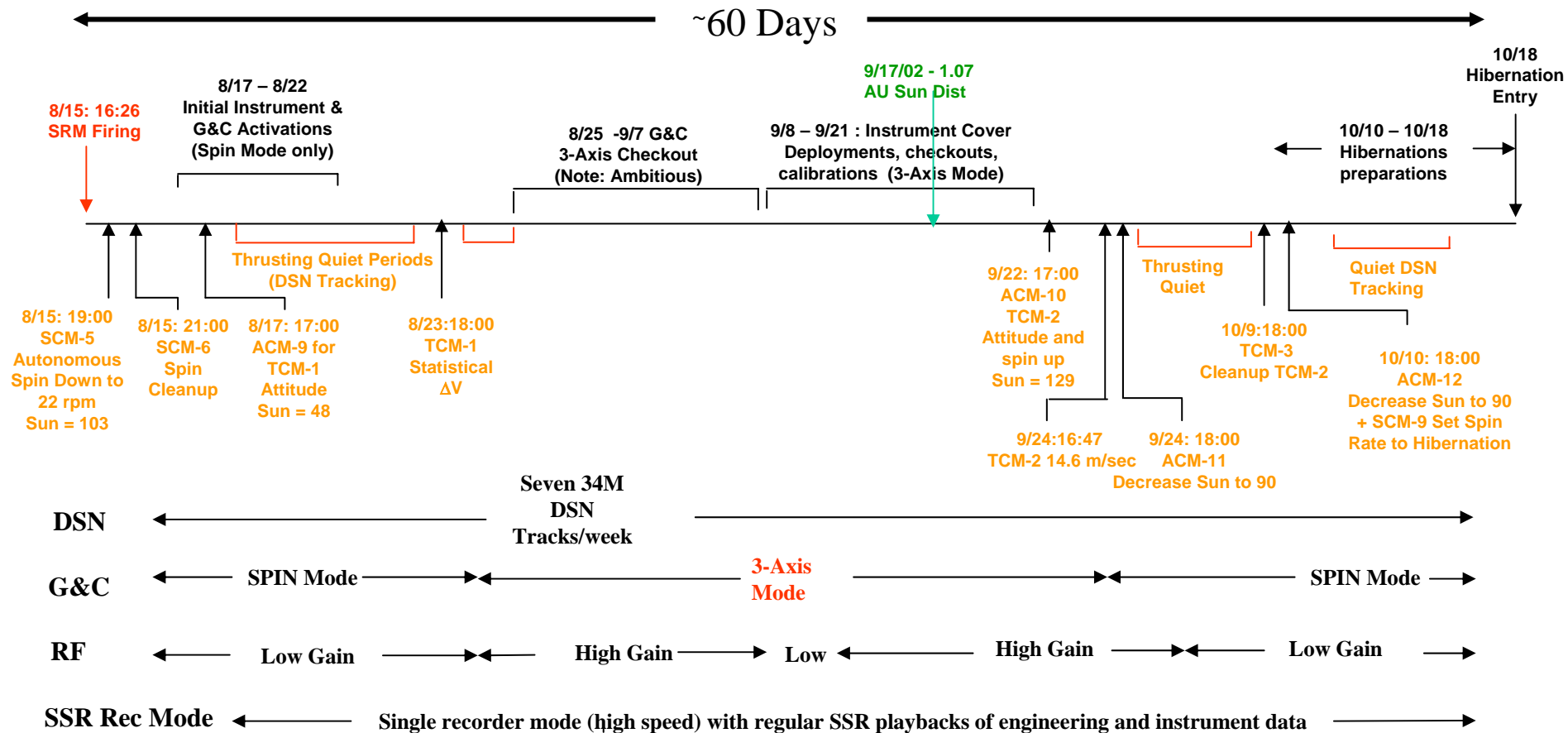## *Phasing Orbit Timeline*

Note : all times in UTC for 7/1/02 Launch

~45 Days

7/1/02 – 7/26/02 Launch Window 08:50 UTC

09:46 - Separation Sequence
- Trans 1 On, Batt/ESS Htr. On
- "Burp" thrusters for Nitrogen Venting
- Prime Propellant lines
- Spin down preparations

7/2 – 7/4 : Contingency Perigee Raise ΔV – 1st or 2nd Apogee

Pair – One orbit apart

Δ ωΔV

Node ΔV

Apogee 7/31 ΔV

Perigee 8/5 ΔV

Attitude Flip #1

Attitude Flip #2

Fuel Dumping As rqrd.

Spin Up to 60 RPM

NOOP Commanding

10:00 - "First Contact" GDS

11:00 - Autonomous Spin Down to 20-25 rpm

7/4 - 2nd Perigee Timing ΔV

8/15 - SRM Firing

DSN ← Continuous DSN coverage on 34m 1st week → ← 16 Hours/Day DSN 34M coverage →

G&C ← SPIN Mode Operations Only, G&C OFF except for contingency situation →

RF ← Primarily Forward & Aft Low Gain Antennas, NO HGA, Pancake by ground command →

SSR Rec Mode ← Single recorder mode (high speed) with regular SSR playbacks of engineering data →

Note: Diagram not drawn to scale

9/26/2003   M.Holdridge   3

COmet Nucleus TOUR

Post Phasing Orbit Timeline

Note : all dates are approximate and subject to review

~60 Days

9/17/02 - 1.07 AU Sun Dist

10/18 Hibernation Entry

8/17 – 8/22 Initial Instrument & G&C Activations (Spin Mode only)

8/15: 16:26 SRM Firing

8/25 -9/7 G&C 3-Axis Checkout (Note: Ambitious)

9/8 – 9/21 : Instrument Cover Deployments, checkouts, calibrations (3-Axis Mode)

10/10 – 10/18 Hibernations preparations

Thrusting Quiet Periods (DSN Tracking)

Thrusting Quiet

Quiet DSN Tracking

8/15: 19:00 SCM-5 Autonomous Spin Down to 22 rpm Sun = 103

8/15: 21:00 SCM-6 Spin Cleanup

8/17: 17:00 ACM-9 for TCM-1 Attitude Sun = 48

8/23:18:00 TCM-1 Statistical ΔV

9/22: 17:00 ACM-10 TCM-2 Attitude and spin up Sun = 129

10/9:18:00 TCM-3 Cleanup TCM-2

10/10: 18:00 ACM-12 Decrease Sun to 90 + SCM-9 Set Spin Rate to Hibernation

9/24:16:47 TCM-2 14.6 m/sec

9/24: 18:00 ACM-11 Decrease Sun to 90

Seven 34M DSN Tracks/week

DSN		
G&C	SPIN Mode	**3-Axis Mode**	SPIN Mode
RF	Low Gain	High Gain	Low	High Gain	Low Gain
SSR Rec Mode	Single recorder mode (high speed) with regular SSR playbacks of engineering and instrument data	

Note: Diagram __not__ drawn to scale

Note: Overview only. Karen Yetter of JPL MDAPT to provide details later

- First Week of post launch operations has near continuous DSN support for operations and contingencies.

- DSN Support is reduced to ~16 hours/day for remainder of Earth phasing orbits for flexibility of engineering data acquisition and expedite orbit/attitude maneuvers necessary for timely placement of SRM.

- Post SRM DSN support reduced to ~1 support/day.

Instrument Reusable Command Blocks

Subsystem/Event	Developed ?	Successfully Tested w/S/C ?	Under CM (in production area) ?
CIDA	Yes but may not be used	Multiple times	No
NGIMS	Yes but may need updates	Multiple times	No
CRISP	Yes but may need updates	Multiple times	No
CFI	Yes but may need updates	Multiple times	No

Subsystem and instrument STOL command scripts

Subsystem/Event	Developed ?	Successfully Tested w/S/C ?	Under CM ?
G&C Functional	Yes	Yes	Yes ?
S/C Flight S/W Loads	Yes – in S/W	Yes	Yes – in S/W
Ephemeris upload	Yes – in S/W	Yes	Yes – in S/W
Instrument Flight S/W Loads	Yes	Yes	Yes – in S/W
CIDA In-flight Functional	Parts	In Parts	Ready by June 1
NGIMS In-flight Functional	Yes	Yes	Yes ?
CRISP In-flight Functional	Parts	In Parts	No
CFI In-flight Functional	Parts	In Parts	No

MOps S/C Simulations Strategy

<u>*Strategy :*</u>

- Build and execute sequences using operational sequencing system (Seq_gen).
- Test plans and command sequences reviewed prior to execution time with:
  - S/C System Engineer
  - Subsystem engineering and/or instrument engineers
  - I&T invited
  - MOps team
- All sequences validated with S/C software simulator (flight rules) prior to loading.
- Sims from Dec 4, 2001 and on were all run from MOC.
- Minor changes to sequences needed to safeguard S/C systems depending on I&T stage (Latch valve cycling, catbeds, thruster valves, S&A …)
- All commands active for several of the April 2002 simulations in chamber at GSFC to verify proper propulsion system ops.
- All tests conducted with S/C.
- Brassboard simulator not available to Mission Ops until March 2002. CIDA and NGIMS are now incorporated into Brassboard simulator but CFI and CRISP are not. Consequently capability to test CFI and CRISP sequences post launch in question until instruments are integrated.

Mission Operation's Simulations to Date:

- Aug 22, 2001: First Mops Testing w/spacecraft: C&DH ops and portion of separation sequence.
- Aug 29 & 30th, 2001: Front End problems with commanding "large cmd loads".
- Sept 4, 2001: C&DH ops + TAC ops, 1st spin down.
- Sept 18, 2001: C&DH ops, partial separation sequence + nitrogen venting (propulsion commands).
- Sept 20, 2001: C&DH ops + Propulsion spin up test. Successful but noted Catbed loadbox light errors.
- Oct 8, 2001: C&DH ops + TAC Sun Sync Mode ops. No ESS pulse, incomplete operation.

Mission Operation's Simulations to Date:

- Oct 25, 2001: C&DH ops + TAC Sun Sync Mode ops. Completed operation.
- Nov 20, 2001: C&DH ops + Dual Mode Delta V (3axis + spin mode transition)
- Dec 4 & 5, 2001: 1st encounter simulation. C&DH, G&C, CFI, TAC.
- Mar 8, 2002: S/C full separation sequence including nitrogen venting, line priming, and auto spin down. Started in launch config. W/battery in discharge - thermal chamber.
- Mar 13, 2002: Encounter simulation – hot case.
- Mar 18, 2002: S/C full separation sequence including nitrogen venting, line priming, and auto spin down. Started in launch config. W/battery in discharge - thermal cycling.

Mission Operation's S/C Simulations

Apr 1-5: Mission Sim Week (mostly RF via DSN CTT) :

- Full S/C Separation sequence w/auto spin down and autonomy
- Contingency perigee raise maneuver
- 4 Part S/C "Flip" or spin axis precession
- SRM fire sequence - twice. Problem with first attempt – PFR.
- G&C functional checkout via R/T STOL scripts
- Dual Mode (3-Axis and Spin modes) , Component (axial and radial) Delta V.
- Instrument functional checkouts except CFI and CIDA. CIDA performed many times before.
- CRISP Tracking tests
- Encounter simulation
- IEM 2, G&C 2, and TAC 2 maneuvers and contingencies (i.e. turn G&C 's OFF), test sun angle limits exceeded, test spin rates exceeded, safemode entry and maneuver shutdowns …

Plans For May Mission Sims (May 13th – 20th):

- May 13th – 20th (except today - 15th) : (RF via DSN MIL) :
  - 2 High rate S/C 3-Axis Mode, DSN Tracks via MIL
  - 2 Low rate S/C Spin Mode, DSN Tracks via MIL
  - DSN Operations are "end-to-end" utilizing all software, procedures, and tables planned for post launch real-time operations.
  - CRISP Tracking tests incorporated into 3-Axis days as possible
  - Encounter simulation – Full day (May 20th)
  - Full S/C Separation sequence w/auto spin down and autonomy
  - CFI & CRISP Instrument Functional checkouts via real-time STOL
  - SRM Fire sequence

<u>*Lessons Learned :*</u>

– MOps end-to-end testing has uncovered many problems with ground system, spacecraft, and related networks previously undetected in functional and performance testing. Very worthwhile for MOps training as well !! Test time with S/C was very limited but most was made of time granted.

– Much of MOC S/W out of direct cmd/tlm path was not available pre-launch. Simulations were designed to work around these gaps in MOC capabilities and MOps prioritized the MOC software delivery order to minimize overall impact. However, certain key functions were not tested in mission sims including navigation file creation, command history reporting, S/C assessment (plotting …), G&C parameter examination, and S/C clock correlation. Ability to analyze and fully validate simulation results was hampered.

– Future missions should provide these ground system capabilities available to I&T and MOps prior to I&T start.