DSPSE Lunar Orbit Operations

Major Activities: (Page 4 of 8)

- The Long Wavelength Infrared (LWIR) Camera Will Be Used To Take Images Of Thermal Gradients Occurring At The Terminators
  - Cyro Cooler Will Be On 30 Minutes Prior To Imaging
  - Camera Will Be On 10 Minutes Prior To Imaging
  - Images Will Be Taken $\pm 10^\circ$ Of Each Terminator
  - Camera Will Be Turned Off In Between The Terminators But The Cryo Cooler Will Remain On Between North & South Poles
  - Integration Time & Gain Will Be Varied With The Latitude & May Be Computed On Board
  - Readout Time: 5ms (TBD)

- During Lunar Mapping, The Star Trackers Will Not Be Used To Collect Scientific Data, But Will Be Used To Establish The Attitude Of The Spacecraft.
  - Algorithms Will Process Star Tracker Images On The R3000 To Update The Attitude Of The Spacecraft
  - Very Few Star Tracker Images Will Be Stored For Downlink
  - To Meet The High Accuracy Pointing Requirements, The Spacecraft Attitude Will Need To Be Updated Every 10 Seconds During Mapping
DSPSE Lunar Orbit Operations

Major Activities: (Page 5 of 8)

- Solar Panel Autotracking Will Be Inhibited During Imaging & Enabled In Between Imaging Sequences Or Every 10° Latitude
  - The Exact Method Is TBD, Will Determine The Best Method During Simulations & First 5 Days Of Lunar Orbit
  - Motion Must Be Scheduled With Image Sequence To Minimize Jitter
    -- If Jitter Caused By The Solar Array Drive Is < Allowed Value, The Solar Array Drive Can Be Left In Auto Track Mode
  - Desire To Have The Solar Array Axis (Y Axis) Perpendicular To The Sun Vector & The Solar Array Surface 90°±5° To The Sun Vector.
    -- Assumed The 20° Null Region Of Solar Panel Rotation (Back Of Solar Panels) Is In The +Z Axis Direction; Front Is In -Z Direction.
- Solar Panel Autotracking May Also Be Inhibited Whenever Attitude Slews Are > TBD° To Prevent Possibility Of Tracking Through Null Region
DSPSE Lunar Orbit Operations

Major Activities: (Page 6 of 8)

- The High Gain Antenna Pointing Requirement Is .2° From The Vector To The Center Of The Earth If Dumping To Pomonkey Or .2° From The Vector To A TGS If Dumping To A TGS.
- Attitude Updates Will Be Required Every 60 Seconds During High Gain Antenna Data Dumps.
- Transmitter Needs To Be Powered Off Before Switching Between Omni & High Gain Antennas
- To Allow Time For Battery Charging, May Turn Off Transmitter For Up To 60 Minutes Per Orbit - Requires Engineering Data To Be Stored & Dumped
- DSN Needs 1 Hour Tracking Data Per Orbit From Any DSN Site. Assumed:
  - This Data Is Available Using Both The Omni Antennas & High Gain Antenna
  - Will Provide ≈2 Hours Tracking During High Gain Data Dumps If DSN Site In View
  - Or, Will Provide ≈ 1 Hour Tracking During Mapping Using Omni Antenna If DSN Site Is In View
    - Due To The Omni Antenna Pattern, There May Be Times Of Marginal Communications For Ranging - ±20° Of The Poles
- Have Assumed Thermal Control System Can Meet Sensor Platform Requirements During All Portions Of The Lunar Mapping Phase.
DSPSE Lunar Orbit Operations

Major Activities: (Page 7 of 8)

- During Lunar Imaging, the spacecraft will use nadir pointing to meet sensor requirements for imaging
  - May need to inhibit reaction wheel attitude changes during actual imaging to minimize jitter
  - Best method will be finalized during the first 5 day checkout period
  - Attitude changes & attitude updates must be scheduled with the camera image sequences & positioning of the solar panels
- Attitude commands will be made to the guidance software, which will generate required attitude control parameters for the desired attitude & supply these parameters to the ACS software
  - Attitude parameters will be generated based on any attitude constraints, primary pointing requirements (nadir or earth pointing), & secondary pointing requirements (maximizing solar incidence angle on solar arrays)
  - ACS software will compare the guidance generated attitude parameters with the current attitude & generate the required commands to slew to the desired attitude.
    -- Reaction wheels or thrusters will be used for the slew depending on the amount of slew & time available for the slew
    -- Slew using the reaction wheels could take up to 30 min
DSPSE Lunar Orbit Operations

Major Activities: (Page 8 of 8)

  - Estimate ~120 - 130 Minutes To Downlink Data
  - Part Of This Time Will Occur With The Spacecraft In The Lunar Sun Shadow
  - Due To The Omni Antenna Pattern, There May Be Times Of Marginal Communications For Command & Downlink Of Engineering Data
  - Depending On The Orbital Geometry, The Moon Will Block RF Communications Between The Spacecraft & Earth
    -- When This Occurs On The Sunlit Side, Real-Time Downlink Via The Omni Antennas Will Be Blocked From 10 - 40 Min
    -- When This Occurs On The Dark Side, Real-Time Downlink Via Either The Omni Or High Gain Antennas Will Be Blocked From 30 - 73 Min
  - During Times Of Marginal Communications, When Pomonkey Is Not In View, & When There Are RF Blockages By The Moon, The Engineering Data Will Be Dumped Along With The Wide Band Data Using The High Gain Antenna.

- Limited Image Downlink Via The Omni Antennas During Lunar Mapping Possible When Orbital Geometry & Ground Station Visibility Permit

- Assumed The Spacecraft Can Be Commanded Via The Omni Antennas While Downlinking Data On The High Gain Antenna
DSPSE Lunar Orbit Operations

Lunar Orbit - Periselene -30° Latitude

1. Aposelene
2. Spacecraft Sunset
3. Spacecraft Sunrise
4. LWIR Cryo Cooler On
5. NIR Cryo Cooler On
6. LWIR Camera On
7. Wideband Dump Complete, End DSN Tracking
8. Turn On HiRes, NIR & UV/Vis Cameras
9. Begin LWIR Imaging
10. Begin HiRes, NIR & UV/Vis Imaging
11. LWIR Camera Off
12. Turn On Transmitter For Omni Downlink
13. Begin Laser Ranging
14. Periselene
15. End Laser Ranging
16. End NIR & UV/Vis Imaging & Turn Off NIR Camera & NIR Cryo Cooler
17. LWIR Camera On
18. Turn Off Transmitter & Discontinure Omni Downlink
19. Begin LWIR Imaging
20. End HiRes Imaging & Turn Off HiRes Camera
21. End LWIR Imaging & Turn Off LWIR & LWIR Cooler
22. Begin UV/Vis & Star Tracker Auto Nav Imaging
23. End UV/Vis Imaging & Turn Off UV/Vis Camera
24. Perform Momentum Dumps As Required
25. Point High Gain Antenna To Earth
26. Begin Wideband Data Dump & DSN Tracking

Tick Marks @ 5° Changes In Latitude

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Post Mapping Activities (8 Days):

- Observations Of Targets Of Opportunity;
  - Change Orbit (If Adequate Fuel) To Allow A Low Altitude Pass Over A Lunar Site Of Interest
    -- As Low As 50 Km, If That Can Safely Be Done - To Obtain Higher Resolution Images Of Lunar Surface Features Or Other Points Of Interest
    - There May Be Targets That We Will Image Without Changing The Orbit
- Sensor Activities (TBD)
- Preparations To Leave Lunar Orbit For Transfer To Geographos.
  - There Will Be At Least Two Orbit Adjust Maneuvers To Prepare For The Lunar Departure.
  - DSN Sites Will Supply Tracking Data For Orbit Determination To GSFC Who Will Compute The State Vector & Supply It To The DMOC
  - TAMP Will Verify Parameters, Develop Command Sequence, & Verify Using The OTB Spacecraft Simulator
  - The Departure Maneuver Operations Will Be Fully Rehearsed
    -- To Acquaint Operations Personnel With The Activities & Timing Of The Maneuver
    -- To Verify That The Activities And Sequences Can Be Smoothly Executed.
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Power Profiles: (Page 1 of 2)
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Key Operations & Engineering Team Activities:

- Continuous Orbit Determination & Control, Especially Because Of Effects From Unexpected Mass Concentrations & To Ensure Proper Phasing Between The First & Second Month's Mapping;
- Managing The Mapping, Communications, & Electrical And Thermal Energy Balance Associated With Each Lunar Orbit;
- Maintaining Synchronization Of Spacecraft Clock With UTC;
- Managing Large Distance To Spacecraft & Associated Transmission Times;
- Communicating Using The Wide Band & Omni Antennas From The Spacecraft;
- Managing Communications Blockage By Moon;
- Contingency Planning & Management;
- Replanning, Command Plan Generation & Uplink
- Managing Lunar Shadow Effects;
- Managing Operations Using A Single Commanding Station;
- Processing, Displaying, & Managing Large Quantities Of Transmitted Image Data;
- Monitoring Geographos Trajectory; Determining Time & Spacecraft Orientation For Injection Into The Geographos Transfer Trajectory;
- Preparing For The Departure Maneuver.
- Operations While In Lunar Orbit Will Be The Most Hectic, Extended Duration Effort During The Mission. Continuous Operations Activity Is Expected 24 Hours A Day, Seven Days A Week For The Entire Time In Lunar Orbit.
DSPSE Lunar Orbit Operations

Areas Requiring Further Study: (Page 1 of 3)

• How Fast Can We Do The Orbit Determination & Get A New Ephemeris To The Mission Planners
  - Time Is TBD

• How Much Tracking Data Is Needed For Ephemeris Generation Vs Orbit Determination Experimentation?
  - CSC Study Due April 93

• In The Event We Cannot Downlink The Entire Image Data For One Orbit, Can We Continue To Store The Remaining Data For Later Transmission To the Ground (Up To 40 Minutes Total For Perhaps 3 Passes)?
  - This Situation Will Be Managed By Several Methods Including:
    -- Partitioning The SSR To Allow Re-Dump Of Data On A Latter Orbit
    -- Reducing Or Eliminating Experiments
    -- Reducing Amount Of Images Recorded

• How Much Warm Up Time Is Required Before Using The Laser Ranging System?
  - TBD. Also There May Be A Heater That Needs To Be Turned On.
Areas Requiring Further Study: (Page 2 of 3)

- Does the spacecraft need to verify a ground station is ready to receive before beginning the wide band downlink?
  - To allow time for the ground stations to get lock up on the carrier & sync up on the data stream, will include several minutes of null data as a header before sending down the actual data.
  - The ground station & DMOC will have to monitor the downlink to determine if part of it needs to be saved & retransmitted on the next orbit.

- Coordination with DSN & RTS when they are needed for uplink.
  - Interfaces & procedures for interfacing with the DSN are TBD.
DSPSE Lunar Orbit Operations

Areas Requiring Further Study: (Page 3 of 3)

- How Will The Lunar Mapping Scenario Be Carried Out? I.E. What Scenario Will Be Used For Structuring & Uploading Command Scripts For Each Lunar Orbit. (Orbit Scenarios Are Very Similar From One Orbit To The Next With Main Differences Being Changes In Pointing Angles
  - Event Driven Or Time Driven
  - Events & Times Via Upload Or Based On On-Board Computed Data? Or Combination Of Both?
  - How Much On-Board Processing Is Required?
    -- Star Tracker
    -- Moon, Earth, TGS, Sun Pointing Vector Propagation
    -- Camera Integration Times & Gains
    -- Latitude Crossing Times
    -- Altitude

- Omni Antenna Pattern May Produce Marginal Communications Depending On Where The Spacecraft Is In Lunar Orbit & Where The Moon Is In Earth Orbit.
  - This May Impact Omni Data Downlink Times As Well As DSN Tracking Times - Especially Within ±20° Of The Poles.