DSPSE Operations

DSPSE Mission Operations Center (DMOC)
<table>
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<th>DSPSE Operations Agenda</th>
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<tr>
<td>• NRL Operations Approach</td>
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<td>• DMOC External Interfaces</td>
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<td>• DMOC Functional Responsibilities</td>
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<tr>
<td>- Mission Operations</td>
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<td>- Flight Operations</td>
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<td>- Ground Systems</td>
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<td>• DSPSE Organization &amp; Staffing</td>
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<tr>
<td>• DMOC Internal Interfaces</td>
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<tr>
<td>• DMOC Operations</td>
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<tr>
<td>- Mission Requirements &amp; Planning Process</td>
</tr>
<tr>
<td>- Prepass Operations</td>
</tr>
<tr>
<td>- Pass Operations (Lunar Mapping Scenario)</td>
</tr>
<tr>
<td>• Rehearsals &amp; Simulations</td>
</tr>
<tr>
<td>• Data Assessment</td>
</tr>
<tr>
<td>• Sensor Data Analysis</td>
</tr>
</tbody>
</table>
DSPSE Operations Approach

• NRL Has Sole Responsibility For DSPSE Operations
• All Operations Conducted From Central NRL Facility
• Network All Spacecraft Commanding Via Bent-Pipe Through Ground Station
  – Commands Verified On Test Bed / Spacecraft Simulator
• NRL Engineers That Designed, Built, & Tested Spacecraft Will Provide Real-Time Flight Operations Command & Control, Health & Welfare Monitoring, Trend Analysis
  – Implement Mission Operations Requirements
  – Provide Integrated Mission Timeline
• NRL Lead Mission Operations Team Defines Requirements To Accomplish Mission Objectives & Monitors Activities To Ensure Mission Objectives Are Satisfied
  – Trajectory Analysis & Maneuver Planning (TAMP)
  – Science Mission Operations & Planning (SMOP)
  – Data Assessment
• NRL Manages Physical Plant, External Communications, & Ground Station Network Interfaces To Support Flight & Mission Operations Personnel

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DMOC External Interfaces

Science Mission Operations & Planning (SMOP)

Trajectory Analysis & Maneuver Planning (TAMP)

Data Assessment (DA)

Ground Systems

Flight Operations

Mission Operations

SDIO

NRL Project Office

Deep Space Network

Jet Propulsion Lab (JPL)

Goddard Space Flight Center (GSFC)

Consolidated Satellite Test Center (CSTC)

AFSCN

Remote Tracking Station

PGS Pomomony, Maryland

BLOSSOM POINT

NAVSPASUR

VAFB (LEO Support)

NORAD

Goldstone, California

Canberra, Australia

Madrid, Spain

Remote Tracking Station

Ground Systems

DSPSE Mission Operations Center (DMOC)

Users

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OPS-01

CDR/OPSMDOC-4
DSPSE Operations

DMOC Functional Responsibilities
DMOC Functional Responsibilities (1 of 4)  
Overview

Program Director  
P. Regeon

DSPSE Operations  
D. Horan

Mission Operations  
D. Horan
- Trajectory Analysis & Maneuver Planning (TAMP)
- Science Mission Operations & Planning
- Data Assessment

Flight Operations  
M. Johnson
- Real-time Spacecraft Operations
- Integrated Scheduling
- Engineering

Ground Systems  
P. Klein
- Ground Station Network
- Test Bed
- Ground Systems Support

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Mission Operations
D. Horan

**Trajectory Analysis & Maneuver Planning**
- Orbit Determination
- Maneuver Planning
- Generate Orbit & Trajectory Data/Files
- Asteroid Orbit Determination
- Autonomous Navigation & Position Determination
- Navigation Flight Software Performance
- GSFC & JPL Orbits & Trajectory Interface

**Science Mission Operations & Planning**
- Experiment/Test Planning
- Attitude & Pointing Requirements
- Sensor H/W & Software Performance
- SAC Interface
- Sensor Procedure & Command Plan Development & Verification

**Data Assessment**
- Data Receipt, Formatting, & Routing
- Command Log Processing
- Telemetry Display
- Trend Data Support
- QA
- Sensor Image Processing & Calibration Data
- Quick Look Image Analysis

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DMOC Functional Responsibilities (3 of 4)  
Flight Operations

**Flight Operations Support**
- Execute Integrated Timeline
- Realtime GSN Coordination
- Coordinate External Communications Requirements With Ground Systems Controller

**Scheduling & Planning**
- Integrate TAMP, Engineering, & Science Planning Requirements Into Integrated Mission Timeline
- Develop Integrated Command Plan & Verify On OTB
- Conduct Daily Scheduling Meetings
- Ground Station Scheduling

**Spacecraft Engineering**
- Spacecraft Subsystem Health & Welfare Determination
- Trend Analysis
- Consumables Monitoring
- Subsystem Procedure & Command Plan Development & Verification

Flight Operations
M. Johnson

---

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DMOC Functional Responsibilities (4 of 4)

Ground Systems

Ground Systems P. Klein

Operational Test Bed
- H/W & S/W Operation
- Support Command Plan Verification
- S/C Simulation

Ground Systems Support
- Physical Plant
- DMOC H/W, S/W, & Network
- External Facility Communications

Ground Station Network
- External Command & Control Communications
- DSN Interface & Procedures
- AFSCN Interface & Procedures
- Pomonkey Interface & Procedures
Mission Operations

Organization & Staffing
Organization Staffing

• Staffing Varies With Mission Phase & Scheduled Activities
  – Lunar Mapping Phase Requires The Most Support (10 Per Shift Plus Support Staff)
    -- 70 Days, 24 Hours/Day, 7 Days Per Week
  – Staffing For Other Phases Is A Subset Of Lunar Mapping Phase Staffing
    -- Science Manager, Sensor Engineer, & Data Manager Are Required Only When Experiments/Tests/Observations Are Scheduled
    -- Operations Timeliner & Network Controller Are Single Shift Positions
    -- NRL & GSFC Orbit Analysts Required For Once A Day Orbit Determination, Maneuver Planning, Maneuver Execution, & Scheduled Autonav Experiments

• LLNL & NASA SAC Representatives Are Present At DMOC

• Additional Support Staff To Each Function (Engineering, TAMP, Ground Systems, Science Planning, Data Processing) Are Scheduled For Offline Support
  – Anomaly Resolution, Subsystem Engineering Support, Test/Experiment/Observation Planning, Command Plan Generation & Verification, Mission Status Reports, Trajectory Data Generation & Distribution
## Support Staff

<table>
<thead>
<tr>
<th>Personnel</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
<td>Data Handling</td>
</tr>
<tr>
<td></td>
<td>- Long Term Processing (Archiving) &amp; Distribution</td>
</tr>
<tr>
<td></td>
<td>- Show &amp; Tell (Show Business Material)</td>
</tr>
<tr>
<td></td>
<td>- Data Libraries &amp; Internal Distribution</td>
</tr>
<tr>
<td>1-2</td>
<td>Ground Systems Support</td>
</tr>
<tr>
<td></td>
<td>- S/W &amp; H/W</td>
</tr>
<tr>
<td></td>
<td>- Ground Stations</td>
</tr>
<tr>
<td></td>
<td>- OTB Operation</td>
</tr>
<tr>
<td>1</td>
<td>Scheduler &amp; Planner</td>
</tr>
<tr>
<td></td>
<td>- Integrated Schedules</td>
</tr>
<tr>
<td>1-2</td>
<td>Science Manager (Mission Planner)</td>
</tr>
<tr>
<td>2</td>
<td>Orbit Analyst (TAMP)</td>
</tr>
<tr>
<td>1-2</td>
<td>Sensor Scientist</td>
</tr>
<tr>
<td>1-2</td>
<td>Spacecraft Engineer</td>
</tr>
<tr>
<td>10-16</td>
<td>Total</td>
</tr>
</tbody>
</table>

### Plus:
- Management Personnel
- SAC Members (1-2)
- LLNL Personnel (2-4)
DMOC Control Room

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Mission Operations

DMOC Internal Interfaces
Mission Operations

Mission Requirements & Planning Process
Requirements Overview

- Mission Operations Requirements Define Activities Or Operational Parameters
  - Nominal Requirements
  - Special Requirements

- Mission Plan, Detailed Timelines & Command Plans Developed Prior To Launch

- Changes To The Mission Plan Addressed To At The Daily Scheduling Meetings

- Significant Mission Risk Or Programmatic Issues Referred To Mission Director
## Planning Timeline

<table>
<thead>
<tr>
<th>Complete Before:</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T - 1 Week</strong></td>
<td><strong>Resource Scheduling Process</strong>&lt;br&gt;• DSPSE Operations Support Schedule&lt;br&gt;• Coordination With DSN &amp; AFSCN</td>
</tr>
<tr>
<td><strong>T - 2 Days</strong></td>
<td><strong>Special Mission/Spacecraft &amp; Sensor Contingency Planning</strong>&lt;br&gt;• Mission Experiment/Spacecraft/Sensor Contingency Command File Generation&lt;br&gt;• Test Bed Validation &amp; Spacecraft Simulation Verification&lt;br&gt;• Experiment/Contingency Rehearsal (If Required)&lt;br&gt;• Replanning (If Required)</td>
</tr>
<tr>
<td><strong>T - 1 Day</strong></td>
<td><strong>Nominal Mission/Spacecraft &amp; Sensor Planning</strong>&lt;br&gt;• Mission Experiment/Spacecraft/Sensor Command File Generation&lt;br&gt;• Test Bed Validation &amp; Spacecraft Simulation Verification&lt;br&gt;• State Vector Operations&lt;br&gt;• All Command Script Files Transferred To Ground Stations For Upload&lt;br&gt;• Final Test Bed Checkout For Special Mission Experiment/Spacecraft/Sensor</td>
</tr>
<tr>
<td><strong>T - 12 Hours</strong></td>
<td><strong>Pass Plan Generation</strong>&lt;br&gt;• Coordination With Mission Planners &amp; Spacecraft Engineers On Operating Procedures&lt;br&gt;• Distribute Pass Plans To All Ground Resources</td>
</tr>
<tr>
<td><strong>T - 20 Minutes</strong></td>
<td><strong>Prepass Operations</strong></td>
</tr>
<tr>
<td><strong>T - 0</strong></td>
<td><strong>AOS</strong></td>
</tr>
</tbody>
</table>

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Spacecraft Operations Overview

- Spacecraft Mission Requirements
  - Trajectory Analysis & Maneuver Planning
  - Spacecraft Engineering
  - Science Mission Operations & Planning

- Spacecraft Contingency Planning → Resource Scheduling → Spacecraft Normal Operating Planning

- Command File Generation
- Test Bed Validation
- Pass Plan Generation
- DMOC & Ground Station

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Spacecraft Integrated Operations Planning

- **S/C Engineering**
  - Develops The S/C Bus Mission Requirements That Define Nominal & Special Operations
  - Nominal & Special Operations Planning Developed From Timeline Planning, Design, & Test Evaluation

- **Command File Generation**
  - S/C Engineering Requirements & Contingencies
  - S/C Command & Telemetry Systems On/Off
    - Supports Scheduled Requirements & Contingencies

- **DSPSE Operational Test Bed Validation**
  - Tests Commands Against S/C Simulator & Ground Station Systems

- **Pass Plan Generation**
  - S/C Bus & Experiment Mission Requirements
    - Pass Plan Templates Developed From S/C Bus Operations Design, Test, Evaluation & Experience
Mission Planning Process Overview

Mission Operations Plan

Mission Requirements

SC H&W Status & Resource Scheduling

Ground Network Status

TAMP

Maneuver Design (FDF/JPL)

Orbit/Trajectory Ephemeris

Visibility Windows

Input Data

Timeline Generation

Scheduler & Planner

Scheduling Activities

Command Script Generation

Pointing Functions Generation

Integrated Command Script/Pointing Verification On OTB

Verification Successful

< 24 Hours Before Execution?

Yes

No

Update Orbital Trajectory Ephemeris

~ 24 Hrs Prior To Execution

Deliver Timelines To Flight Ops For Upload

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Mission Planning Process (1 of 3)

- Integrated Timeline Planning Process Inputs
  - Mission Operation Plan: …………….. Detailed Plan Of The Mission Developed Prior To Launch & Modified As Needed After Launch
  - Mission Operations Requirements: … Approved Changes To The Mission Plan
  - S/C Health & Welfare Status,……….. Factors External To The Science Mission Trajectory Data, Resource Schedule, & Ground Network Status:

- Scheduling Activities
  - Daily Scheduling Meeting:…………….. Plans General S/C Timeline & Schedules Using The Mission Plan With The Above Inputs
  - Analyses Performed By Timeliner & TAMP To Optimize / Define The Detailed Timeline
  - Maneuver Requirements Sent To GSFC/JPL Trajectory Groups
Mission Planning Process (2 of 3)

• Timeline Generation

  – Input Data For Timeline Generation:
    -- Applicable Orbit/Trajectory Ephemeris Or Propagated Data
    -- Visibility/Shadow Windows

  – Output Data Includes:
    -- Text Form Of Spacecraft Commands & Associated Events/Activities
    -- Timeline Suitable For Generating Spacecraft Commands
    -- Spacecraft-To-Target Pointing Requirements To Generate Pointing Functions

  – Automated Scheduling Tools Are Under Evaluation
Mission Planning Process (3 of 3)

- Command Script & Pointing Functions Generation
  - Convert Timeline Into Spacecraft Commands For Upload
  - Outputs Spacecraft & Sensor Commands, & Pointing Function

- Integrated Command Script/Pointing Verification On Operational Test Bed (OTB)
  - Commands & Pointing Functions Will Be Tested & Verified
  - Timeline & Upload Command Will Be Regenerated Using The Latest Orbit/Trajectory Ephemeris Approximately 24 Hours Before The Execution
  - When Successfully Verified, Commands Are Sent To Flight Operations
Ground Station Support Scheduling Timeline

This Timeline Focus's On The Events Scheduled From Monday D+1 0000 GMT To Sunday D+7 2359 GMT.

Supports That Have To Be Scheduled after D-3, would be considered Emergency Supports.

A - Inputs Due To Scheduler/Planner For The Ground Station Strawman Schedule
B - DSN sends View Period Information
C - Submit Strawman Schedule Requests To DSN & AFSCN NLT D-19 (AFSCN Will Not Process Requests Until D-7)
D - DSN's Strawman Schedule Published
   - DSPSE Strawman Schedule Published
E - DSPSE Scheduling Meeting
F - Submit Forecast Schedule Request To DSN & AFSCN NLT D-12
G - DSN Schedule Coordination Teleconference
H - DSN's Forecast Schedule Published
I - DSPSE's Forecast Schedule Published
J - DSPSE Scheduling Meeting.
K - Submit 7-Day Schedule To DSN & AFSCN NLT D-7
L - DSN & AFSCN Schedule Coordination Teleconference
M - DSN's 7-Day Schedule Published
   - DSPSE's 7-Day Schedule Published
   - AFSCN's 7-Day Schedule Published

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CDR/OPSMOC-27
Inter-Agency Scheduling Processes (1 of 2)

Deep Space Network
- Request via RASM - 19 Days
- Published 17 Days Before First Event
- Generated by Scheduler/Planner
- Contains unknown conflicts with DSN & AFSCN projects

DSN Strawman Schedule
- Published 17 Days Before First Event
- DSN Agencies
- GSFC

Weekly Coordination Teleconference

DSN Forecast Schedule
- Published 10 Days Before First Event
- DSN Agencies
- GSFC

DSPSE Strawman Schedule
- Request via PAX - 19 Days
- Published 17 Days Before First Event
- Contains unknown conflicts with DSN & AFSCN projects

DSPSE Forecast Schedule
- Generated by Scheduler/Planner

AFSCN Resource Schedule Office
- Request via EAX - 12 Days

AFSCN 7-Day Schedule
- Published the Friday before the week of events

AFSCN

Weekly Coordination Teleconference

DSPSE

A

B

C

Air Force Satellite Communications Network

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CDR/OPSDMOC-28
Inter-Agency Scheduling Process (2 of 2)

- Published 3 Days Before First Event
- Generated by Scheduler/Planner
- Contains NO conflicts with DSN & AFSCN projects
- Published the 24 hours before the Day of event(s)
- Contains NO conflicts
Expedited Scheduling Process

Deep Space Network

DSN Operations Chief at NOCC

Goldstone
Canberra
Madrid

DSPSE Scheduler & Planner

Via Phone

Pomomkey

DSPSE Flight Operations

Via Phone

Air Force Resource Control Office

RTS

Air Force Satellite Communications Network
Mission Operations

Prepass Operations
Prepass Overview

• Prepass Activities To Be Started ≈ 20 min Prior To AOS
  – Verify DMOC Is Configured For Operations & Data Collection/Transfer
  – Establish Communications With All Ground Support Resources
  – Verify State Vector/Attitude File Has Been Processed/Loaded
  – Verify Command File Is Processed For Upload
  – Coordinate Pomonkey/DSN/AFSCN Operations
  – Review Pass Plan
Prepass Operations (1 of 2)

- Verify DMOC Is Configured For Operations & Data Collection/Transfer
  - COMET System Configured & Operational Personnel Are Ready For Operational Support
  - Data Assessment System/Personnel Configured & Ready For Data Collection
  - Systems Configured For Accelerometer Data Transfer To GSFC/JPL

- Establish Communications With All Ground Support Resources
  - DSN Support: Initiate NASCOM Link (GSFC, JPL, & Ground Site)
  - Pomonkey Support: Configure T1 Link/Channels
  - AFSCN Support: Initiate Dedicated NASCOM/AFCSTC Link For AFSCN To RTS

- Verify State Vector/Attitude File Has Been Processed/Loaded
  - Antenna Control File Is Processed Either At The DMOC Or Ground Station

- Verify Command File Is Processed For Upload
  - Command File Needs To Be Processed & Commands Generated On COMET Prior To Upload
Prepass Operations (2 of 2)

- Coordinate DSPSE/DSN/AFSCN Operations
  - Coordinate Command & Control From One Station To Another
    -- Such Coordination Includes Pomonkey Commanding & DSN Station Radiometric Tracking

- Pass Plan Review
  - Review Tracking/Command & Control Times With Ground Stations
  - Pomonkey Support: Review Pass Plan In Detail Information Pass Plan With AOS
Mission Operations

Pass Operations
(Lunar Mission Scenario)
Pass Operations Overview

- Monitor The H&W Of The Bus & Sensors; Verify Telemetry In Limits
- Monitor Science Sensors Images & Data
- Coordinate Data Transfer Collection
- Command/Telemetry Verification
- Coordinate DSPSE/DSN.AFSCN Handoff/Uplink Operations
- Coordinate Transfer Of Accelerometer Data From DMOC To GSFC/JPL
- Bentpipe Commanding To DSN.AFSCN Ground Sites
- Monitor S/C Attitude & Trajectory

CDR/OPSDMOC-36

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Lunar Orbit Operations

Periselene -30° Latitude, March 28, 1994

1. Aposelene
2. Stop Wideband Dump, Transmitter Off, Spacecraft Sunset
3. Equator
4. Spacecraft Sunrise, Transmitter On, Re-Start Wideband Dump
5. Wideband Dump Complete, Switch to Omni Antenna
6. Command S/C to go to Nadir Pointing
7. Start DSN Tracking
8. Begin LWIR Imaging
9. South Pole, Begin HiRes, NIR, & UV/Vis Imaging
10. Begin Laser Ranging
11. Periselene
12. Equator
13. End Laser Ranging
14. End NIR & UV/Vis Imaging & Turn Off NIR & UV/Vis Camera, & NIR Cryo Cooler
15. Stop DSN Tracking
16. North Pole, End HiRes Imaging & Turn Off HiRes Camera
17. End LWIR Imaging & Turn Off LWIR Camera & Cryo Cooler
18. Perform Momentum Dumps As Required
19. Point High Gain Antenna To Earth
20. Begin Wideband Data Dump
22. Aposelene

Tick Marks @ 5° Changes In Latitude
## Lunar Timeline (1 of 5)

<table>
<thead>
<tr>
<th>Event</th>
<th>Activity</th>
<th>Command Level</th>
<th>MET [h:m:s]</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Aposelene</td>
<td>Discontinue Wideband Dump</td>
<td>SSDR In Pause Mode</td>
<td>0.00</td>
<td>Pause P/B while in both moons &amp; RF shadow.</td>
</tr>
<tr>
<td></td>
<td>Transmitter Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 S/C Sunset</td>
<td>Transmitter On</td>
<td></td>
<td>47.68</td>
<td>Exit both moons &amp; RF shadow. **If necessary, continue Wideband Dump</td>
</tr>
<tr>
<td>3 Equator</td>
<td>Transmitter On</td>
<td></td>
<td>47.68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continue SSDR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turn on LWIR Cryo Cooler</td>
<td></td>
<td>90.85</td>
<td>30 min before LWIR Imaging.</td>
</tr>
<tr>
<td></td>
<td>Turn on NIR Cryo Cooler</td>
<td></td>
<td>96.04</td>
<td>30 min before NIR Imaging.</td>
</tr>
<tr>
<td></td>
<td>Turn on LWIR Camera</td>
<td></td>
<td>110.85</td>
<td>10 min before beginning image sequence</td>
</tr>
<tr>
<td>4 S/C Sunrise</td>
<td>Verify GS Receiver Lock</td>
<td>Continue Wideband Dump</td>
<td>82.70</td>
<td>Verify via voice from Ground Station or reception of real-time data</td>
</tr>
<tr>
<td></td>
<td>Turn on LWIR Cryo Cooler</td>
<td></td>
<td></td>
<td>at the DMOC then Re-Start Playback</td>
</tr>
<tr>
<td></td>
<td>Turn on NIR Cryo Cooler</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turn on LWIR Camera</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Wideband Dump Complete</td>
<td>Configure SSDR In Idle Mode</td>
<td></td>
<td>112.23</td>
<td>Switch Data rate in preparation of Omni Antenna Switch. Ground stations need to configure for Data Rate Switch. 128k to 125 bps</td>
</tr>
<tr>
<td></td>
<td>S/C Data Rate Switch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ground Systems Data Switch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Switch to Omni Antenna</td>
<td>Transmitter Off</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Switch to Omni Antenna</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transmitter On</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Verify Antenna Switch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Update attitude using star tracker.</td>
<td>Cmd Star Tracker to</td>
<td></td>
<td>For high accuracy pointing mode during Imaging, update attitude</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sample every 10 seconds</td>
<td></td>
<td>every 10 seconds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Command spacecraft to go to nadir pointing mode.</td>
<td>Begin active solar panel management.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**The solar panel auto track will be disabled during imaging sequences. Active solar panel management will lead the solar arrays every 20° change in latitude. If auto track jitter is small, auto track will be left enabled.</td>
</tr>
</tbody>
</table>

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## Lunar Timeline (2 of 5)

<table>
<thead>
<tr>
<th>Event</th>
<th>Activity</th>
<th>Command Level</th>
<th>MET (h:m:s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Start DSN Tracking</td>
<td>Configure SDR for Data Capture</td>
<td>120.95</td>
<td>Provide 1 hours of Tracking</td>
</tr>
<tr>
<td>8</td>
<td>Begin LWIR Imaging</td>
<td>120.85</td>
<td>10 min before terminator crossing to get thermal gradient across the terminator dark to light</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>South Pole</td>
<td>Begin HiRes camera Imaging. Begin NIR Imaging</td>
<td>125.87</td>
<td>Because of the narrow FOV of the Hi Res camera it will be left on from pole to pole.</td>
</tr>
<tr>
<td>10</td>
<td>Turn on Laser Ranging System</td>
<td>128.60</td>
<td>10 min before beginning image sequence</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Begin Laser Ranging @ 1 Hz</td>
<td>138.60</td>
<td>Will collect Laser ranging whenever altitude is &lt;500 km 1-20 min). Max Duration Time is 60 Min</td>
<td></td>
</tr>
</tbody>
</table>
## Lunar Timeline (3 of 5)

<table>
<thead>
<tr>
<th>Event</th>
<th>Activity</th>
<th>Command Level</th>
<th>MET (h:m:s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Equator</td>
<td></td>
<td>160.59</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Terminate Laser Ranging</td>
<td>Turn off Laser Ranging System</td>
<td>160.59</td>
<td>Altitude &gt; 500 km</td>
</tr>
<tr>
<td>14</td>
<td>Terminate Imaging &amp; Turn Off NIR &amp; UV/Vis Cameras.</td>
<td>Stop NIR Imaging</td>
<td>190.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stop UV/Vis Imaging</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turn Off NIR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turn Off NIR Cryo Cooler</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turn Off UV/Vis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>End DSN Tracking</td>
<td>Configure Transponder Oscillator to Normal Mode</td>
<td>197.34</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>North Pole</td>
<td>Terminate Imaging &amp; Turn Off HiRes Cameras.</td>
<td>Stop HiRes Imaging</td>
<td>214.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turn Off HiRes Imaging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Terminate Imaging &amp; Turn Off LWIR Cameras.</td>
<td>Stop LWIR Imaging</td>
<td>225.63</td>
<td>10° After terminator crossing to get thermal gradient across the terminator.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turn Off LWIR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turn Off LWIR Cryo Cooler</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Configure SSDR in Idle Mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Perform Momentum Management Procedure</td>
<td>Initiate Momentum Dump Thruster Sequence</td>
<td>Reaction Wheel Speeds are checked. If Speeds indicate that a Momentum Dump is required, a thruster sequence will be initiated.</td>
<td></td>
</tr>
</tbody>
</table>
Lunar Timeline (4 of 5)

<table>
<thead>
<tr>
<th>Event</th>
<th>Activity</th>
<th>Command Level</th>
<th>MET (h:m:s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Command spacecraft to go to wide band data dump mode</td>
<td></td>
<td></td>
<td>(-X axis ±/70° to center of Earth) Based on current attitude &amp; orbit, Guidance will generate required attitude control parameters for the desired attitude and supply these parameters to ACS.</td>
</tr>
<tr>
<td></td>
<td>Disable Solar Panel autotrack.</td>
<td></td>
<td></td>
<td>Guidance will generate desired attitude based on any attitude constrains, primary pointing requirements (nadir pointing), &amp; secondary pointing requirements (maximizing solar incidence angle on solar arrays).</td>
</tr>
<tr>
<td>T9</td>
<td>ACS begin to slew spacecraft to point to Earth.</td>
<td></td>
<td></td>
<td>ACS will take the desired attitude parameters from guidance, compare with current attitude, &amp; generate required commands to go to desired attitude. The reaction wheels or thrusters will be used depending on amount of slew and time available for the slew. The actual time to slew to the desired attitude will vary orbit to orbit.</td>
</tr>
<tr>
<td></td>
<td>ACS slew to Earth pointing attitude complete. (Allowed 15 min for slew)</td>
<td>258.87</td>
<td></td>
<td>ACS system will use the reaction wheels to point the spacecraft.</td>
</tr>
<tr>
<td></td>
<td>Enable Solar Panel Autotrack.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Switch to High Gain Antenna</td>
<td>Turn Off Transmitter</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Switch To High Gain Antenna</td>
<td>Turn On Transmitter</td>
<td>Verify Antenna Switch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Switch Data Rate to 128K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ground Systems Data Switch</td>
<td>Verify Data Rate Switch</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Configure SSDR for Playback mode</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
## Lunar Timeline (5 of 5)

<table>
<thead>
<tr>
<th>Event</th>
<th>Activity</th>
<th>Command Level</th>
<th>MET (h:m:s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Upload command scripts (attitude timelines, camera parameters, etc.)</td>
<td></td>
<td></td>
<td>This can be done anytime during the Wideband Dump. The upload can support 1 or more Rev's.</td>
</tr>
<tr>
<td>22</td>
<td>Aposelone</td>
<td></td>
<td>299.19</td>
<td>Start of Next Rev.</td>
</tr>
</tbody>
</table>

- **Event**: 21
- **Activity**: Upload command scripts (attitude timelines, camera parameters, etc.) as required.
- **Commands**: This can be done anytime during the Wideband Dump. The upload can support 1 or more Rev’s.
- **Event**: 22
- **Activity**: Aposelone
- **Time Log Dump**: The Tim Log can be dumped anytime during the Wideband Image dump. Once the tim log dump has been verified as successful, the tim log memory will be reset.
- **Monitor and perform Electrical & thermal energy balance maintenance prior to Communication and Moon Obscuration.**
Mission Operations

Simulations & Rehearsals
Mission Rehearsals Objectives

- **Mission Compatibility:** Exhaustively Check-Out All Operational Elements

- **Familiarize Personnel With The Activities & Sequences Needed To Support The Activity**

- **Ensure The Activities & Sequences Can Be Smoothly & Accurately Executed**

- **Learn The Spacecraft & Ground System**

- **Ensure Software Algorithms, Procedures, Command Plans, Spacecraft, Sensors, & Ground Operations Team Are Ready**

- **Demonstrate Mission Readiness**
## Incremental Phases For Mission Readiness

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand-Alone Testing</td>
<td>- Tests Each Operational Element (Flight Operations, TAMP, GS, Etc.)</td>
</tr>
<tr>
<td>Mission Rehearsals</td>
<td>- Highest Level Of Simulation (OTB)</td>
</tr>
<tr>
<td></td>
<td>- Involves All External Organizations</td>
</tr>
<tr>
<td>Operational Readiness Rehearsals</td>
<td>- Full Rehearsals Using Spacecraft</td>
</tr>
</tbody>
</table>
## Simulation & Compatibility Testing Interfaces

<table>
<thead>
<tr>
<th>SIMULATION ACTIVITY</th>
<th>DSPS MISSION OPERATIONS</th>
<th>GROUND STATION NETWORK</th>
<th>LAUNCH OPERATIONS</th>
<th>S/C</th>
<th>GSFC</th>
<th>JPL</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>FLT Ops</td>
<td>DA</td>
<td>TAM P</td>
<td>CAND</td>
<td>MAD</td>
<td>POM</td>
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<tr>
<td>STAND-ALONE (Element)</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>COMPATABILITY TESTS</td>
<td></td>
<td>X</td>
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<tr>
<td>GSN-FLT Ops (Comm)</td>
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<tr>
<td>FLT Ops-GSN (Pass Plan)</td>
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<td>X</td>
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<tr>
<td>GSN-OTB (Comm)</td>
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<td>X</td>
<td></td>
<td>X</td>
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</tr>
<tr>
<td>FLT Ops-GSN-OTB</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>End-To-End</td>
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<td>Network Data Flow</td>
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<tr>
<td>Mission Readiness</td>
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<tr>
<td>REHEARSALS</td>
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<td>Network Integration Test</td>
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<td>Launch Readiness</td>
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<tr>
<td>Launch Slip</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Off Nominal Insertion</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>SRM Misalignment</td>
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<td>X</td>
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<tr>
<td>SRM Observation</td>
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<td>X</td>
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<tr>
<td>Lunar Mapping</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Target Of Opportunity</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trans-Geographos</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<td></td>
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<tr>
<td>Flyby Rehearsal</td>
<td></td>
<td>X</td>
<td>X</td>
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</tbody>
</table>

CDR/OPSMOC-46

OPS-48

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Lunar Mapping Operational Readiness Rehearsals

- Initial 5 Days Devoted To Establishing The Proper Mapping Orbit & Demonstrating Operational Readiness
  - Verify Gain Settings & Exposure Times (Integration Time Settings) For Each Camera & Assess The Ability To Control These Settings
  - Determine The Range Of Altitudes For Which The LIDAR Operates Properly
  - Assess Jitter Effects From Spacecraft Pointing Activity, Filter Wheel Movement, Solar Array Movement, & Cryo Coolers
  - Assess Orbit Determination Accuracy & Error Studies
  - Assess On Board Maintained Pointing Vectors
  - Fine Tune The Operational Sequences For Lunar Mapping
    -- Command Scripts
    -- Mapping Data Collection
    -- Real-Time Downlink Of Sensor Images
    -- Downlink Of Wide Band Data
    -- Data Transfer, Processing & Display
  - Collecting High Quality Images & Altimetry Data
## Rehearsals

<table>
<thead>
<tr>
<th>Rehearsal Name</th>
<th>Number</th>
<th>S/C Or OTB</th>
<th>Description</th>
</tr>
</thead>
</table>
| Launch                          | 4      | OTB        | Practices For Launch
- Network Integration Test (NIT)
- Mission Readiness Test (MRT)   |
| Launch Slip                     | 2      | OTB        | Contingency For Launch Slip Of 24 Hours                                     |
| Off-Nominal Insertion           | 2      | OTB        | Contingency For Non-Nominal Insertion
Recompute Orbit & Maneuvers To 150 nm Circular |
| Low Earth Orbit                 | 4      | OTB        | Checkout Procedures Prior To TTI Burn                                       |
| SRM Burn                        | 2      | OTB        | TTI Burn Rehearsal                                                         |
| SRM Misalignment                | 2      | OTB        | Contingency For Misaligned TTI Burn
Compute Lunar Orbit & New Maneuver Sequences |
| SRM Observation                 | 2      | OTB & S/C  | Practice For SRM Observation                                               |
| Mid-Course Correction           | 2      | OTB        | Practice For New Maneuver                                                  |
| Lunar Mapping Rehearsal         | 4      | OTB & S/C  | Practice For Lunar mapping During Phasing Loops                            |
| Lunar Mapping Operational Readiness | 2  | S/C        | In Lunar Orbit: Demonstration Of Operational Readiness For Lunar Mapping |
| Target-Of-Opportunity           | 2      | OTB & S/C  | Practice For A Target-Of-Opportunity; e.g., Low Altitude Pass Over Lunar Site Of Interest |
| Lunar Deorbit                   | 2      | OTB & S/C  | Practice For The Preparation & Deorbit Maneuvers                           |
| Geographos Flyby                | 2      | OTB        | Practice For Flyby                                                         |
| Flyby Operational Readiness     | 2      | S/C        | Demonstration Of Operational Readiness For Flyby                           |

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### Mission Rehearsal Schedule

<table>
<thead>
<tr>
<th>Activity Name</th>
<th>1992</th>
<th>1993</th>
<th>1994</th>
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<tbody>
<tr>
<td></td>
<td>MON</td>
<td>TUE</td>
<td>WED</td>
</tr>
<tr>
<td>CDR</td>
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<tr>
<td>TRR</td>
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<tr>
<td>MRR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ILC</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Major Mission Operations Milestones**

- Ops Procedures Development
- Simulations Development
- Integrated Mission
- Launch
- LEO
- SRM Observation
- Lunar Mapping
- Target Of Opportunity
- Lunar Deorbit
- Geographos Flyby

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Mission Operations

Data Assessment
Introduction

• Solutions To The Data Processing Requirements
• DMOC Data Flow
• Process Flow For Lunar Mapping Phase
• Data Inputs, Data Products & Availability
• Processing Timelines For Day Of Lunar Mapping
• Hardware, Software & Procedures To Support The Timelines
• Schedules
## Solutions to the Processing Requirements (1 of 2)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Solution</th>
</tr>
</thead>
</table>
| Continuous Operations During Lunar Mapping Phase | • Data Processing Plan Will Outline Flows, Controls, Responsibilities, & Procedures  
                                                  • 24 hour Staffing To Support System Management & Data Processing & Analysis  
                                                  • Additional Staff On-Call In Case Of Emergencies |
| Assess The Integrity Of All Wideband Data         | • Software Module To Assess The Statistical Integrity Of The Sensor Image And Telemetry Data |
| Extract The Spacecraft Commands From Console Logs For Storage & Telemetry Correlations | • Software Module To Extract Commands From The Console Logs & Populate A Designated Data Base |
| Report & Trend The Wideband Sensor Telemetry     | • Software Module To Generate Hardcopy Sensor Telemetry Reports  
                                                  • Software Module To Generate Hardcopy Stripcharts Of Telemetry Values  
                                                  • COMET Hardware/Software Capability Of Generating Telemetry Stripchart Displays |
## Solutions to the Processing Requirements (2 of 2)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Solution</th>
</tr>
</thead>
</table>
| Archive Data On-Site | • Up To 25 Orbits (≈ 2.9 Gbytes) Will Be Archived On Magnetic Disk For Immediate Retrieval  
• All Raw Data Will Be Archived On Optical Or Magnetic Media For One Hour Retrieval |
| Ensure Quality & Accessibility Of Archived Mission Data | • On-Line Archival Of 25 Orbits  
• Data Server Designed To Be Redundant & Provide Timely Data Retrieval  
• Software Module To Provide On-Line Data Process Tracking |
| Format Data For The Science Community | • PDS Workstations To Provide Formatting & Validation Capability  
• Cooperation On Part Of Planetary Community To Help With PDS Design  
• Software Module To Parse Frames Into Image Files & Generate Image Labels (Headers)  
• Software Toolkit Available From PDS Central Node For Design & Validation Of PDS Formats |
| Maintain Configuration Control Of All Hardware & Software | • Configuration Management Plan Will Outline Capabilities, Controls, & Procedures  
• Existing CMS Will Be Ported From LACE To DSPSE  
• DSPSE Ground Systems Will Be Responsible For All Computer Hardware & Networks |
DMOC Data Flow

DSPSE
Mission Operations
Center

Contingency
DECNET
STATMUX

Real-Time
Primary
128 kbps
Async

Backup
Storage

COMET
MicroVAX

Dedicated
Ethernet

Primary
Storage

Parallel I/F

GSIP

Contingency
Parallel I/F

Monitor

DATA SERVER

Stripchart
Trending
Workstation

MicroVAX 3800

DOTB VAX
SOC VAX
TAMP VAX
Image Processing Workstations
LLNL Workstations
PDS Workstations
Technical Briefing Workstations
Science Working Group

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Sensor Data Process Flow For Lunar Mapping Phase

Ground Systems Network
  GSIP
    Timetag Frames

COMET
  Multicast Frames

Data Server
  Parse Into Image Files
  Statistical Integrity
  PDS Labels
  Sensor Reports

S&T
  Stripcharts
  Trending
  Displays & Hardcopy

SDA
  Pointing Assessment
  Sensor Characterization
  Calibration & Formatting

TAMP
  Trajectory Analysis & Mission Planning

SOC
  Spacecraft
  Health & Welfare

LLNL
  Sensor Validation

SWG
  Science Validation

Archival / Retrieval
  Tracking
  Console Logs
  Process Tracking

Technical Briefing
  Mission Information

S&T
  Stripcharts Trending

PDS
  Formatting Verification

Archival Centers

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CDR/OPSDA-6
## Data Processing Products & Availability (1 of 2)

<table>
<thead>
<tr>
<th>Data Input: Transport Frames</th>
<th>Data Product:</th>
<th>Availability:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensor Images</td>
<td>10 - 130</td>
</tr>
<tr>
<td></td>
<td>Sensor Telemetry</td>
<td>10 - 130</td>
</tr>
<tr>
<td></td>
<td>Spacecraft Telemetry</td>
<td>Per Orbit</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data Input: Sensor Image</th>
<th>Data Product:</th>
<th>Availability:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Image Archive</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td>Image Label In PDS Format</td>
<td>10 - 130</td>
</tr>
<tr>
<td></td>
<td>Statistical Integrity Report</td>
<td>134</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data Input: Sensor Telemetry</th>
<th>Data Product:</th>
<th>Availability:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Telemetry Hardcopy Report</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>Telemetry Stripchart Displays</td>
<td>10 - 130</td>
</tr>
<tr>
<td></td>
<td>Telemetry Stripchart Hardcopies</td>
<td>10 - 130</td>
</tr>
<tr>
<td></td>
<td>Statistical Integrity Report</td>
<td>134</td>
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</table>

**Availability Reference (Min):**
From Beginning Of Wideband Dump
### Data Processing Products & Availability (2 of 2)

<table>
<thead>
<tr>
<th>Data Input</th>
<th>Data Product</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ephemerides (S/C, Geographos)</td>
<td><strong>Mission Planning Data</strong>&lt;br&gt;(Station Contacts, Lighting, Pointing, etc)</td>
<td>per Orbit</td>
</tr>
<tr>
<td>Ground Station Console Logs</td>
<td><strong>Command Log Data Base</strong></td>
<td>per Orbit</td>
</tr>
<tr>
<td>Spacecraft Engineering</td>
<td><strong>Engineering Archive</strong>&lt;br&gt;Engineering Reports Including Attitude Stripcharts</td>
<td>per Orbit</td>
</tr>
</tbody>
</table>

**Availability Reference (Min):** From Beginning of Wideband Dump

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## Lunar Mapping Phase Processing Timeline

<table>
<thead>
<tr>
<th>Orbit Events</th>
<th>H/W</th>
<th>1</th>
<th>2</th>
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<tbody>
<tr>
<td>Orbits Sample Lunar Day</td>
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</tr>
<tr>
<td>Mapping</td>
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<tr>
<td>Wideband Dump</td>
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<tr>
<td>DATA</td>
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</tr>
<tr>
<td>S/C Engr</td>
<td>Server</td>
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<tr>
<td>Wideband</td>
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<tr>
<td>Ephemerides</td>
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<td>PROCESSING</td>
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</tr>
<tr>
<td>Orbital Directory Preparation</td>
<td>Server</td>
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</tr>
<tr>
<td>Parse Incoming into Image Files</td>
<td>Server</td>
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</tr>
<tr>
<td>Archive Raw Data to Optical</td>
<td>Server</td>
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<tr>
<td>Run Integrity</td>
<td>Server</td>
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</tr>
<tr>
<td>Generate Sensor Telemetry Reports</td>
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</tr>
<tr>
<td>Generate PDS Labels for Image Files</td>
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</tr>
<tr>
<td>Sensor Data Analysis</td>
<td>IPW(3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Validation</td>
<td>SWG(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensor Verification &amp; Calibration</td>
<td>LLNL(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical Briefing Preparation</td>
<td>TBWS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trajectory Analysis &amp; Mission Planning</td>
<td>TAMP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spacecraft Health &amp; Welfare</td>
<td>SOC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stripchart &amp; Trending</td>
<td>STWS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDS Verification &amp; Archival*</td>
<td>PDS(2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Estimates

---

Naval Research Laboratory  
Washington, DC 20375-5000
Data Server Processing Rates

- Incoming Wideband Data: 128
- Parse Images & PDS Labels:
- Statistical Integrity:
- Transfer Data Rate to Users: 2500
- Parse Images & PDS & Integrity: 606
- Images & PDS & Integrity & Transfer: 490
- Directory Preparation: 1500
- Archive to Optical Disk: 1000
- Sensor Telemetry Reports: 1000

Processing Rates Are Based On Simulated DSPSE Data And Hardware Specification Data Rates

Naval Research Laboratory
Washington, DC 20375-5000
Data Server Design Concept

- S&T
  - LLNL & SWG
  - SDA & TB & PDS
  - TAMP & SOC & OTB & 3800

- DEDICATED ETHERNET to COMET MICROVAX
  - ETHERNET (DECNET & TCP/IP)
  - ETHERNET (DECNET & TCP/IP)

- DATA SERVER
  - DISK FARM
  - TAPE ARCHIVAL
  - To GSIP (Backup Only)

- 8550 VAX
  - Parallel I/F to DATA SERVER
  - Ethernet I/F

- Star Coupler
  - Ethernet I/F
  - Ethernet I/F
  - Ethernet I/F

- HSC50
  - Ethernet I/F

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Washington, DC 20375-5000
### Software To Support The Processing Requirements (1 of 2)

<table>
<thead>
<tr>
<th>Module</th>
<th>Experience</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assess Statistical Integrity of Sensor Data</td>
<td>LACE</td>
<td>Modified / New</td>
</tr>
<tr>
<td>Extract Commands From Console Log &amp; Populate Data Base</td>
<td>LACE</td>
<td>Modified / New</td>
</tr>
<tr>
<td>Generate Hardcopy Sensor Telemetry Reports</td>
<td>LACE</td>
<td>Modified / New</td>
</tr>
<tr>
<td>Generate Hardcopy Stripcharts of Telemetry Values</td>
<td>LACE</td>
<td>Exists</td>
</tr>
<tr>
<td>Generate Stripchart Displays of Telemetry Values</td>
<td>LACE</td>
<td>Exists</td>
</tr>
<tr>
<td>Archival / Retrieval</td>
<td>LACE</td>
<td>New</td>
</tr>
<tr>
<td>Provide On-Line Data Process Tracking</td>
<td></td>
<td>New</td>
</tr>
<tr>
<td>Generate Image Labels for PDS</td>
<td>PDS Node</td>
<td>New</td>
</tr>
</tbody>
</table>
## Software To Support The Processing Requirements (2 of 2)

<table>
<thead>
<tr>
<th>Module</th>
<th>Experience</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toolkit for help in Design, Test and Verification of PDS Labels and Volumes</td>
<td>PDS Node</td>
<td>Exists</td>
</tr>
<tr>
<td>Configuration Management</td>
<td>LACE</td>
<td>Exists</td>
</tr>
<tr>
<td>Science Validation</td>
<td></td>
<td>SWG to Supply</td>
</tr>
<tr>
<td>Sensor Validation</td>
<td>LACE</td>
<td>Modified / New</td>
</tr>
<tr>
<td>Support Technical Briefings</td>
<td>LACE</td>
<td>Modified / New</td>
</tr>
<tr>
<td>Parse Transport Frames into Image Files</td>
<td>LACE</td>
<td>New</td>
</tr>
</tbody>
</table>

Naval Research Laboratory  
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Procedures To Support The Processing Requirements

- Data Processing Plan
- Software Development Schedules
- Hardware Acquisition And I&T Schedules
- Configuration Management Procedures
### Data Assessment Development Schedule

<table>
<thead>
<tr>
<th>Activity Name</th>
<th>1992</th>
<th>1993</th>
<th>1994</th>
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</thead>
<tbody>
<tr>
<td><strong>CRITICAL MILESTONES</strong></td>
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<td></td>
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</tr>
<tr>
<td>SRR</td>
<td>5/13/92</td>
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<tr>
<td>PDR</td>
<td>7/30/92</td>
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<tr>
<td>CDR</td>
<td>11/17/92</td>
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</tr>
<tr>
<td>TRR</td>
<td>8/15/93</td>
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<tr>
<td>MRR</td>
<td>12/15/93</td>
<td></td>
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</tr>
<tr>
<td>ILC</td>
<td></td>
<td></td>
<td>1/24/94</td>
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<tr>
<td><strong>SYSTEMS</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Requirements Specification Inputs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Processing Plan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HARDWARE</strong></td>
<td></td>
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</tr>
<tr>
<td>Requirements Specification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware Interfaces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware Upgrades</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Hardware Acquisitions</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Systems Integration &amp; Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compatibility Testing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SOFTWARE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software Development Plan Inputs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software Requirement Specification Inputs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interface Requirements Document</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software Test Plan Inputs</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Software Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software Coding</td>
<td></td>
<td></td>
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<tr>
<td>Software Integration &amp; Test</td>
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</tr>
</tbody>
</table>

OPS-30

Naval Research Laboratory
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Mission Operations

Sensor Data Analysis
Requirements

• Reduce All The Image Data Collected

• Provide Quick Look Analysis Of Images In Each Orbit To
  – Trajectory Analysis & Mission Planning Group
  – Monitor The State Of The Imaging Sensors
  – Assess Data Integrity

• In-Flight Sensor Characterization & Calibration
  – Ensure Instrument Response Is Well Understood Under All Measurement Conditions
  – Ensure Accuracy & Precision Of Calibration Matrices Are Well Known

• Provide Image Displays For Continuous Monitoring Of Mission Status, e.g.: Lunar Mapping

• Format The Output Data Using The Planetary Data System (PDS) Format

• Ensure Fault Tolerant Storage & Retrieval
Image Processing Functionality

- User Friendly Interface
  - Easy Retrieval Of Any Frame From Telemetry
  - Display Each Image With Engineering Header Information
  - Provide Instantaneous Intensity Readings Of Any Pixel
- Provide Histogram, Thresholding, Averaging, Centroiding, Background Subtraction, Pixel Location Of Max/Min DN Value, Frame Registration, Co-Adding, etc, For Any Area of Interest
- Evaluate Lunar Mapping Coverage
- Given An Uncompressed Image, Generate An Optimum Set Of Quantization Tables
- Automated Star Matching Against Star Catalogue On All Cameras
  - Report Matched & Unmatched Objects
  - Provide Angular Position Of The Identified Target Against Its Neighboring Stellar Objects (If Any) With An Accuracy Of 1/2 Pixel Or Less
  - Determine The RA & Dec Of The Identified Target
  - Easy Transfer Of The Results For Electronic Purposes
  - Display Catalogued Stellar Objects (Using Camera Perspective)
- Provide Annotated Color Output Copy For Selected Images
  - Hard Copy, Digital Formats, Video Segments
## Data Throughput

<table>
<thead>
<tr>
<th>Category</th>
<th>UV/VIS</th>
<th>LWIR</th>
<th>SWIR</th>
<th>High Res.</th>
<th>Star Tracker</th>
<th>Star Tracker</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MISSION AND SENSOR PARAM.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x-number of pixels</td>
<td>288</td>
<td>128</td>
<td>256</td>
<td>288</td>
<td>576</td>
<td>576</td>
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<tr>
<td>y-number of pixels</td>
<td>384</td>
<td>128</td>
<td>256</td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>384</td>
</tr>
<tr>
<td>total number of pixels</td>
<td>110592</td>
<td>16384</td>
<td>65536</td>
<td>110592</td>
<td>221184</td>
<td>221184</td>
<td>11920</td>
</tr>
<tr>
<td>Bits/pixel</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
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<td>8</td>
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<tr>
<td>Frames/Orbit or Frames/5Hr</td>
<td>1500</td>
<td>660</td>
<td>900</td>
<td>8840</td>
<td>10</td>
<td>10</td>
<td>11920</td>
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<tr>
<td>Estimated Total # of Orbits</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
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<td>Compression Ratio</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>16</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td><strong>UNCOMPRESSED DATA VOLUME</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncomp. Image Size (Mbytes)</td>
<td>0.111</td>
<td>0.016</td>
<td>0.066</td>
<td>0.111</td>
<td>0.221</td>
<td>0.221</td>
<td>0.745</td>
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<tr>
<td>Uncomp. Data Volume/Orbit (Gbytes)</td>
<td>0.166</td>
<td>0.011</td>
<td>0.059</td>
<td>0.978</td>
<td>0.002</td>
<td>0.002</td>
<td>1.218</td>
</tr>
<tr>
<td>Uncomp. Data Volume for Moon Mapp. (Gbytes)</td>
<td>49.766</td>
<td>3.244</td>
<td>17.695</td>
<td>293.290</td>
<td>0.664</td>
<td>0.664</td>
<td>365.322</td>
</tr>
<tr>
<td><strong>COMPRESSED DATA VOLUME</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Comp. Image Size (Mbytes)</td>
<td>0.027648</td>
<td>0.004096</td>
<td>0.016384</td>
<td>0.006912</td>
<td>0.055296</td>
<td>0.055296</td>
<td>1.66E-01</td>
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<tr>
<td>Comp. Data Volume/Orbit (Gbytes)</td>
<td>4.15E-02</td>
<td>2.70E-03</td>
<td>1.47E-02</td>
<td>6.11E-02</td>
<td>5.33E-04</td>
<td>5.33E-04</td>
<td>0.121</td>
</tr>
<tr>
<td>Comp. Data Volume for Moon Mapp. (Gbytes)</td>
<td>12.442</td>
<td>0.811</td>
<td>4.424</td>
<td>18.331</td>
<td>0.166</td>
<td>0.166</td>
<td>36.339</td>
</tr>
</tbody>
</table>

Down Link Time For A Whole Orbit  = 139 minutes  
# Of CDs For The Whole Lunar Mapping  = 75  
Downlink Bandwidth  = 16 Kbytes/sec

---

Naval Research Laboratory  
Washington, DC 20375-5000
## Instrument Calibration & Characterization

### SENSOR RADIOMETRIC RESPONSE CHARACTERIZATION

<table>
<thead>
<tr>
<th>Category</th>
<th>Sub category</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Responsivity</td>
<td>In-band Response</td>
<td>- measure spectral responsivity over a wide wavelength range (laboratory)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- regularly gather many frames of calibration star data in-flight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- determine spectra of known stars from other instrument measurements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- use in-flight data, laboratory data, and star spectra to update spectral responsivity estimates, if necessary</td>
</tr>
<tr>
<td>Detection Threshold</td>
<td></td>
<td>- based on noise and radiometric response characterization, determine instrument detection thresholds (noise equivalent counts, irradiance, radiance) as a function of instrument parameters (gain, int. time, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- determine S/N ratio under any measurement condition</td>
</tr>
<tr>
<td>Error Estimates</td>
<td></td>
<td>- estimate baseline calibration constant error bars (laboratory)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- update accuracy and precision estimates using calibration star measurements, if necessary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- check for systematic changes in calibration constants over time</td>
</tr>
<tr>
<td>Extraneous Signals</td>
<td>Out of Field Leakage</td>
<td>- determine off-axis rejection for point sources and uniform sources (laboratory)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- update estimates in-flight</td>
</tr>
<tr>
<td>Response Transients</td>
<td></td>
<td>- characterize instrument response transients due to changes in gain, filters, and other instrument parameters</td>
</tr>
</tbody>
</table>

### NOISE CHARACTERIZATION

<table>
<thead>
<tr>
<th>Category</th>
<th>Sub category</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal Independent Noise</td>
<td>Fixed Pattern</td>
<td>- generate baseline dark field matrices (laboratory)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- regularly generate dark field estimates in-flight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- characterize in-flight dark field variations with time (short term, long term)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- characterize dark field dependence on instrument parameters (gain, int. time, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- generate maps of spectral filter-dependent blemishes, if any</td>
</tr>
<tr>
<td></td>
<td>Temporal</td>
<td>- generate baseline dark field temporal stdv. matrices (laboratory)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- regularly measure temporal stdv. of dark frames in-flight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- characterize stdv. dependence on instrument parameters (gain, int. time, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- estimate contribution of each noise component (electron shot, quantization, etc.)</td>
</tr>
<tr>
<td>Signal Dependent Noise</td>
<td>Fixed Pattern</td>
<td>- determine baseline flat-field response and determine linearity (laboratory)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- generate baseline nonuniformity matrices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- regularly measure flat-field response in-flight and characterize any nonlinearities</td>
</tr>
<tr>
<td></td>
<td>Temporal</td>
<td>- regularly measure temporal stdv. as a function of intensity for point sources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- regularly measure temporal stdv. as a function of intensity for uniform sources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- determine contribution of each noise component (photon shot, photomultiplier, etc.)</td>
</tr>
</tbody>
</table>

### SPATIAL RESOLUTION CHARACTERIZATION

<table>
<thead>
<tr>
<th>Category</th>
<th>Sub category</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Spread Function</td>
<td></td>
<td>- determine baseline PSF (laboratory)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- regularly measure PSF in-flight (stars)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- characterize PSF dependence on instrument parameters and viewing geometry.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- predict PSF for any measurement condition</td>
</tr>
<tr>
<td>Pixel FOV (IFOV)</td>
<td></td>
<td>- determine baseline IFOV in laboratory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- verify IFOV using in-flight star field measurements</td>
</tr>
</tbody>
</table>

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**Imaging Sensor Signal Path**

Continuous-Discrete Imaging System

$L(x,\lambda,t)$ – Spectral Irradiance At Sensor Pupil Coming From Object Under Observation

$L_p(x,\lambda,t)$ – Spectral Irradiance At Sensor Pupil Not Related To Object Under Observation

$G$ – Conversion Constant, Digital Number Per Photoevent

$U(x[k])$ – Detector Nonuniformity At The k-th Pixel Location

$D(k,t)$ – Dark Field At The k-th Pixel Location

$N(k,t)$ – Temporal Noise Sources (Zero Mean), e.g. Thermal, Quantization (A/D)

$g(k)$ – Discrete Output Image In Digital Numbers At Pixel Location k
Data Reduction

Nominal Data Reduction

\[ g(k) \rightarrow \text{Image Decomp.} \rightarrow D^*(k,t) \rightarrow U^*(k) \rightarrow \frac{1}{(G,t)} \rightarrow \]

Additional Data Reduction

\[ L^*_p(k) \rightarrow \text{Clipping Or Statistical Discrimination} \rightarrow \times \rightarrow L^*(k,\lambda) \rightarrow \]

\[ g(k) - \text{Measured Discrete Image Value In Digital Number At Pixel Location } k \]
\[ U^*(k) - \text{Estimated Detector Nonuniformities At Pixel Location } k \]
\[ D^*(k,t) - \text{Estimated Dark Field At Pixel Location } k \]
\[ P^*(k) - \text{Estimated Number Of Photoevents At Pixel Location } k \]
\[ L^*_p(k) - \text{Estimated In-Band Path Radiance (pe/sec\cdot\text{pixel})} \]
\[ K(\lambda,...) - \text{Radiometric Conversion Function At Pixel Location } k \]
\[ \frac{1}{(G,t)} - \text{Conversion To Photoevents/sec} \]
\[ L^*(k,\lambda) - \text{Estimated Target Spectral Radiance With No Corrections For PSF Effects} \]
Sensor Data Analysis Products

- Image Data Displays
- Star Map Correlation
- Ground Projection
- Calibration Matrices
- Calibrated Images
Data Assessment Processing (1 of 2)

DSPSE Data Goes Through Two Processing Stages:

• Preprocessing Stage
  – Receive, Clean, Store, & Forward Telemetry

• Analysis Stage
  – Pointing Assessment
    -- Compute & Verify Amount Of Overlap Between Consecutive Images During Lunar Mapping On A Subset Of Images
    -- Correlate Observed Star Pattern On Any Camera To A Star Data Base
  – Sensor Characterization
    -- Monitor The State Of Each Sensor
    -- In Each Lunar Orbit Estimate The Calibration Matrices For Each Camera
  – PDS Image Formatting & Validation Of Calibration Matrices
Data Assessment Processing (2 of 2)

Archival Of All Data

- Storage Modality
  - Digital Media
    -- Rewritable Optical Disk, 4 Orbits/disk, For Internal Use
    -- 8mm Tape For Internal Use
    -- Final Product To Science Nodes On CD-ROM
  - Analog Media
    -- VHS &/Or Super VHS tape

- Content On Each Disk
  - Compressed Raw Image Data
  - Image Headers
    -- Camera Parameters, LOS Celestial Parameters, Image Statistics, etc

OPS-33
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Washington, DC 20375-5000

CDR/OPSSDA-10
Workstation Hardware Support & Interface

ETHERNET DECNET Protocol

---

**VAX**

---

**μVAX**

---

**VMS**

---

**High Throughput File Server**

---

**IPW 1**

---

**IPW 2**

---

**IPW 3**

---

**IPW 4**

---

**ETHERNET TCP/IP Protocol @ Least 100kb/sec**

---

**IPW Internal Architecture**

---

**Array Processor**

- 80 MFLOPS
- 8 Mbytes
- MSHELL & C

---

**Frame Grabber**

- 16 image frames
- 512 x 512 pix/image
- Integer Processor

---

**RGB Monitor**

---

**Video Signal RGB & Composite**

---

**Video Printer**

- Prints
- Transparencies

---

**Analog Storage**

PC - VCR (VHS/SVHS)

---

**Digital Storage**

- Hard Disk: 1.2 Gbytes
- Optical Disk: 0.6 Gbytes
- CD ROM: 0.6 Gbytes
- 9 Track Tape

---

**AT386 (or 486) PC**

- Multitasking System
- DOS, Win/NT, & DVX
- C & C++ Compilers

---

**AT Bus**

---

**RS232**

---

**SCSI**

---

**ETHERNET PCT/IP**

---

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Washington, DC 20375-5000
# Workstation Built In Functions

## Signal and Image Algebra
- array addition
- array subtraction
- array multiplication
- element by element multiplication
- element by element division
- array division
- array transpose
- array augmentation
- column augmentation
- assignment operator
- specify index range
- conjugate of array elements
- array inverse
- in place add
- in place multiplication
- sum of all array elements
- sum of array elements
- sum of rows
- sum of diagonal elements

## Elementary Mathematical Functions
- abs absolute value of array elements
- exp a raised to each array element
- fmod floating point modulus
- imag imaginary part of array elements
- int integral part of array elements
- log natural log of array elements
- log10 log base 10 of array elements
- nint nearest integer
- real real part
- sign sign of array elements
- sqrt square root of array elements
- median median along the rows
- mmedian nth moment along rows
- roccorr correlation coefficient
- var variance of array elements

## Random Number Generators
- randg gaussian random # generator
- randdir gaussian random # generator
- randa uniform random # generator

## Gaussian Density Related Functions
- gaussian Gaussian density function
- inversegaussian inverse of gaussian

## Ranking and Index Functions
- bdsrch binary threshold
- eqindex index of elements equal to #
- index index of non-zero elements
- reset resets values below threshold
- index of element <= #
- hindex index of elements <= #
- hmax maximum of array elements
- hmaxf maximum of array elements
- hmin minimum of array elements
- hminf minimum of array elements
- hsort sort array elements row wise
- clipclip clip values >= #
- clipclip clip values > #
- getindex index elements >= #
- getindex index elements > #
- glindex index elements within a range

## Data Processing and Formatting
- conv convolve 2-D to a 1-D array
- convol convolve row vector to image
- index 1d index of array elements
- maxmin maximum and minimum
- minf minimum array elements
- minf minimum array elements
- minof element by element minimum
- sort sort array elements row wise
- clipclip clip values >= #
- clipclip clip values > #
- getindex index elements >= #
- getindex index elements > #
- rindex index elements within a range

## Region of Interest Manipulation
- brect region segment between two points
- mbsmat return mouse button status
- mwdel mouse array window display
- pixel pixel value in frame buffer
- wdef define a region of interest
- wmove move a region of interest
- xvector extract vector along a line
- xvector extract vector along a line
- xline extract line coordinates
- xline extract line points

## Plotting 2-D and 3-D
- plot plot a vector, complex or real
- plot3d mesh plot or 3D plot of an array
- contour generate a contour plot

## System Level Commands
- dir executes the dos dir function
- exit exit the interpreter
- free erase an array from memory
- help brings up a help menu
- script copy standard .jv.o to a file
- show display variables information
- system invoke operating system

## Data Storage, Retrieval, Input, and Capture
- load load arrays from disk
- save save arrays to disk
- readf read file
- writed write to file

## Formatted Disk I/O of Scalars or Strings
- print print values to standard output
- input input a value from stdin

## Formatting Disk I/O of Arrays
- readf read array from disk
- writed write an array to disk

## Script files
- include execute a script file
- system system command

## Image Capture
- acqimage continuous video acquisition
- capture single image frame acquisition
- video continuous video acquisition

## Spatial Processing Operators
- Fourier Transform
  - fft 1-D Fourier transform
  - ifft inverse 1-D Fourier transform
  - ifft inverse 2-D Fourier transform

## FFT Related Windows
- blackw Blackman-Harris window
- hanning Hanning window

## Convolution, Filtering, and Cross-Correlation
- conv convolve an array with a kernel
- convolv convolve an array with a kernel
- ftx fast filtering with a triangular kernel
- ftx fast filtering with a 5x5 kernel
- ftx fast filtering with a 3x3 kernel
- spaf general spatial filter module
- score cross correlation function
- score cross correlation function

## Geometric Transformations
- rotate image rotation and translation
- shift image non-cyclic translation
- shifts image cyclic translation
- mirror mirror image rows
- mirrow mirror image columns
- warp quadratic or linear warp

## Image Display
- dt display frames
- intext overlay input text string
- select select image display parameters
- zoom zoom in and scroll

## Look-Up-Table Operations
- blut interactive level slice
- hequt uniform histogram equalization
- hyptut hyperbolic histogram equalization
- ilut input lookup table
- oltut output lookup table
- xlut apply LUT transformation

## Flow Control and Relational Operators
- while while statement
- if statement
- if-if else statement
- exit exit compound statement

## Other Useful Functions
- genemtor generate a 1-D or 2-D ramp
- airpy apply a filter
- genemtor generate a grid of points
- decimate decimate an array
- geometric geometric test
- genera generate a square identity array
- conv convolve an array
- nconv compute the sine function
- ones generate an array of all ones
- zeros generate an array of all zeros

---

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Ground Command & Control
Topics Of Presentation

- Introduction
- Ground Communication Network
- Pomonkey Ground Site
- Deep Space Network (DSN)
- Air Force Satellite Control Network (AFSCN)
- DSPSE Mission Operations Center (DMOC)
- Ground Software
Ground Command & Control

Introduction
## Ground Command & Control - Up/Downlink Requirements

### 70° Launch Inclination From WTR
Command Column Indicates Closure Of Command Uplink

<table>
<thead>
<tr>
<th>Launch/LEO</th>
<th>Telemetry</th>
<th>DSN 26 m</th>
<th>DSN 34S m</th>
<th>DSN 70 m</th>
<th>Pomonkey</th>
<th>AFSCN RTS</th>
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<tr>
<td></td>
<td>Max. Bit Rate (bps)</td>
<td>128K</td>
<td>Not Used</td>
<td>Not Used</td>
<td>128K</td>
<td>128K</td>
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<tr>
<td></td>
<td>S/C Antenna</td>
<td>Omni</td>
<td></td>
<td>Omni</td>
<td>Omni</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Command</td>
<td>Yes</td>
<td>Not Used</td>
<td>Not Used</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Lunar Mapping</td>
<td>Telemetry</td>
<td>128K</td>
<td>500</td>
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<td>128K</td>
<td>125</td>
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<td>Max. Bit Rate (bps)</td>
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<td>As Needed</td>
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<tr>
<td></td>
<td>S/C Antenna</td>
<td>High Gain</td>
<td>Omni</td>
<td>High Gain</td>
<td>Omni</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Command</td>
<td>Yes</td>
<td>Not Used</td>
<td>Not Used</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Geographos Encounter</td>
<td>Telemetry</td>
<td>Not Used</td>
<td>128K</td>
<td>250</td>
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<td>Max. Bit Rate (bps)</td>
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<td></td>
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<td></td>
<td>Not Used</td>
</tr>
<tr>
<td></td>
<td>S/C Antenna</td>
<td>Not Used</td>
<td>High Gain</td>
<td>Omni</td>
<td>High Gain</td>
<td>Omni</td>
</tr>
<tr>
<td></td>
<td>Command</td>
<td>No</td>
<td>Yes to =June</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**DSN Simultaneous Ranging Uses Same Antenna As T & C**

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Ground Command, Control, & Communications (1 of 2)

- **PRIMARY Command, Control & Communications For Low Earth Orbit & Lunar Mapping Phase**
  - Pipelines Spacecraft Command & Telemetry To DSPSE Mission Operations Center

- **Secondary Command, Control, & Communications For Low Earth Orbit & Lunar Mapping Phases; Primary For Asteroid Encounter Phase**
  - Existing DSN RF & Ranging Systems
  - Command & Telemetry Via NASCOM Datalink to DMOC

Pomonkey, MD

Deep Space Network

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Ground Command, Control & Communications (2 of 2)

Remote Tracking Station

- Alternate Command & Control During LEO & Lunar Mapping Phase
  - Access Via The AFSCN
  - Provides Complementary Geographical Coverage To Pomonkey Site
Lunar Mapping Mission

- DEEP SPACE NETWORK
  - SECONDARY COMMAND, CONTROL and RANGING

- AFSCN REMOTE TRACKING STATION
  - ALTERNATE COMMAND and CONTROL

- POMONKEY, MD
  - PRIMARY COMMAND, CONTROL and RANGING

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Asteroid Encounter

DEEP SPACE NETWORK

- PRIMARY COMMAND, CONTROL & RANGING DURING ASTEROID ENCOUNTER
- 1 kbps COMMAND
- 128 kbps TELEMETRY
Ground Network Interfaces

- DSN Command, Telemetry, & Tracking Via NASCOM Links To DMOC
  - 4800 Bit Block Data Format
  - Control Via ICD
- Pomonkey Command & Telemetry Data Via Fractional T-1 Links
  - Formats Controlled Via "DSPSE Data Formats, SSD-D-DS006"
- NORAD Ephemeris Data Via Existing Link
  - PME Format
- AFSCN RTS Command & Telemetry Via Fractional T-1 Link
Ground Command & Control Network

DSPSE Ground Network Sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Altitude [Meters Above Mean Sea Level]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pomonkey</td>
<td>38.557</td>
<td>-77.0575</td>
<td>54.9</td>
</tr>
<tr>
<td>Canberra</td>
<td>-35.397</td>
<td>148.981</td>
<td>659.5</td>
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<tr>
<td>Madrid</td>
<td>40.426</td>
<td>-4.248</td>
<td>796.8</td>
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<tr>
<td>DMOC</td>
<td>38.5</td>
<td>-77.0 (approx.)</td>
<td>0 (approx.)</td>
</tr>
<tr>
<td>VAFB</td>
<td>34</td>
<td>-121</td>
<td>0</td>
</tr>
</tbody>
</table>

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Each Mission Phase Has A Separate Set Of Requirements For The Ground Network. Throughout, DSN Assets Are Needed For Ranging &/Or Doppler Determination.

- **Launch/LEO (1/24/94 - 1/26/94)**
  - Pomonkey Is Primary T & C Site
  - DSN Is Secondary T & C Network
  - AFSCN RTS Is Alternate T & C Site
  - NORAD/SPACECOM is Primary Radar Ranging Network
  - All Sites Are Capable Of Providing Uplink & Downlink To S/C Omni Antenna

- **Earth-To-Lunar Transfer & Lunar Mapping (1/26/94 - 5/2/94)**
  - Pomonkey Is Primary T & C Site
  - DSN Is Secondary Telemetry Network, Primary Ranging Network, & Secondary Command Network
  - AFSCN RTS Is Alternate T & C Site
Ground Command & Control - Selected Implementation (2 of 2)

- Asteroid Flyby (5/2/94 - 8/31/94)
  - 34 m Standard Net Used For Uplink Commanding Through ≈ 6/94,
    70 m Net Used For Downlink
  - 70 m Net Used For Up & Downlink From ≈ 6/94 Through Encounter
  - DSN Is Primary Ranging Site
  - Pomoney & RTS Are Not Used
Ground Command & Control

Ground Communication Network
Ground Network Communications - Requirements

- Spacecraft Telemetry To DSPSE Mission Operations Center (DMOC) From All Ground Stations
  - High & Low Rate Data
  - Real-Time High Rate Image Data Is Not Required
- Pass Plans (Timed Command Execution Sequences) To Ground Stations
- Command Element Data To DSN
- Command Element Data To AFSCN RTS
- Spacecraft Ephemeris From NORAD Sites to DMOC During LEO
- Radio Metric Tracking Data From DSN To GSFC For State Vector Generation
- Calculated Spacecraft State Vectors To DMOC From GSFC
- Antenna Pointing Angles to Ground Stations
- Voice Between All Sites
Communications - Selected Implementation (1 of 2)

- Spacecraft Telemetry To DSPSE Mission Operations Center (DMOC)
  - Near Real-Time 128 kbps From Pomonkey & RTS After Data Collection
  - Real-Time 125 bps Housekeeping Data During Data Collection From Pomonkey
  - Telemetry Near Real-Time From DSN Via NASCOM

- Pass Plans To Ground Stations
  - DECNET To Pomonkey

- Command Element Data To DSN
  - Sent From DMOC
  - Formatted Data Bits Via NASCOM
  - Each Asset Uses On-Site Equipment To Generate RF Uplink

- Command Element Data To AFSCN RTS
  - Throughput Via Fractional T-1 Link

- Commands Generated On-Site At Pomonkey

- Spacecraft Ephemeris From NORAD To DMOC Via Existing Links

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• Radio Metric Tracking Data To GSFC's Flight Dynamics Facility (FDF) From DSN
  – Tracking Data Sent Directly To FDF From DSN Via Existing NASCOM Link

• State Vectors To DMOC From GSFC
  – Via NASCOM Data Link Using FDF's EPV or EPHEM Format
  – Throughput To Pomonkey
  – State Vectors Sent Directly To DSN Via Existing NASCOM Links

• Antenna Pointing Angles To Ground Stations
  – Generated On-Site At Pomonkey From State Vectors

• Voice Communication To DMOC
  – Dial-Up Voice To FDF
  – Dial-Up Voice To DSN/JPL & AFSCN/CSTC
  – Two 32 kbps, Full Duplex Phone Lines To Pomonkey & Launch Site
## Communications - Major Procurements

<table>
<thead>
<tr>
<th>Item</th>
<th>Mfg.</th>
<th>Quantity</th>
<th>Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSU/CSU</td>
<td>Black Box</td>
<td>10</td>
<td>2/1/93</td>
</tr>
<tr>
<td>Voice Bridge</td>
<td>Kentrox</td>
<td>1</td>
<td>2/1/93</td>
</tr>
<tr>
<td>Data Channel Card</td>
<td>TID</td>
<td>2</td>
<td>2/1/93</td>
</tr>
</tbody>
</table>

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Ground Communications - Interface Documentation

* Data Formats Document Addresses All Command & Telemetry Formats, State Vector Formats (PME & GSFC's EPV), NASCOM 4800 Bit Blocks
Redundant Communication Paths

- Spacecraft Telemetry To DMOC
  - Pommonkey Has Removable Data Storage Devices (Optical Disks) For Shipment Via Courier Or Overnight Delivery

- Pass Plans
  - Can Be Faxed Or Provided Over Voice Lines

- State Vectors & Radio Metric Tracking Data
  - Can Be Faxed, Provided Over Voice Lines, Or Taken By Courier From GSFC To Pommonkey

- Antenna Pointing Angles
  - Generated At Site Or From DMOC

- Voice
  - 2 Channels Where Bandwidth Allows
  - Dialup Capability
  - Redundancy Of Common Carrier Network
Ground Command & Control

Pomonkey
Ground Command & Control Organization - Pomonkey

- NRL Owned Satellite T & C Facility Located In Southern Maryland
Pomonkey Requirements (1 of 2)

Use Existing Hardware & Software For:

- **Spacecraft Uplink Commanding**
  - DSN Compatible
  - S-Band (2093.05 MHz), NRZ-M, 16 KHz Subcarrier
  - Not Encrypted
  - Fixed 1 Kbps Rate, DSPSE Formatted
  - On-Site Or Remote (DMOC) Command Capability

- **Spacecraft Downlink Telemetry**
  - DSN Compatible
  - S-Band (2273 MHz), Convolutionally Encoded (K=7, R=1/2 CCSDS Convention), BPSK, 1.7 MHz Square Wave Subcarrier
  - Selectable Data Rates: 125, 250, 500, 8K, 16K, 32K, 64K, 128 Kbps
  - Not Encrypted
  - Receive DSPSE Spacecraft Signal (5 W) From ≤ Lunar Distance

- **Spacecraft Tracking**
  - Receive State Vectors From DMOC & Generate Antenna Pointing Angles Through Lunar Phase
Pomonkey Requirements (2 of 2)

• Ground Processing
  – Process & Display Up To 4 Spacecraft Images For "Quicklook" Analysis On-Site
  – Display Spacecraft Housekeeping Telemetry Real Time
  – Record Downlink Data & Clock
  – Record Time Stamped Decommutated Data
  – Maintain Command & Telemetry Log Files
  – Send Telemetry to DMOC Near Real-Time

• Other
  – Station Time Accuracy To $\leq 1.5$ ms Of UTC/NBS
  – Redundancy Where Budget Allows
  – Participate In Network Simulations & Compatibility Testing.
  – Power Backup Of Key Components
  – Voice Communication To DMOC
  – DECNET Interface
Pomonkey Interfaces

**DMOC**
- State Vectors
- 1kbps Commands
- 128kbps Telemetry
- 32kbps Duplex Voice
- 9.6kbps DECNET

**Pomonkey**
- Generate Antenna Pointing Angles
- Receiving, Processing, & Distribution Of Telemetry
- Command Processing & Transmitting

**S/C**
- S-Band RF Uplink
  - DSN Compatible
  - 2kw
  - 1kbps

- Downlink
  - S-Band RF
  - ≤128kbps
  - K=7, Rate=1/2

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Pomonkey RF Schematic

Uplink (2093.05)

Downlink (2273.0)

RHC

RHC LHC

1.7 - 2.6 GHz

Feedhorn (NRL)

Transition (NRL / JPL Interfaces)

RJ

Polarizer

RJ

Cosine Taper

Upper OMJ

(2000 - 2120)

Lower OMJ

(2270 - 2300)

35 dB

2-Way Ranging

50 dB

80 dB (4K)

DIPLEXER

2.09 - 2.12, 2.27 - 2.30

2K 65 dB

PF Filter

Test Signal Noise Diode

LCP / RCP LNA

#2

To Receiver Selector Switches, Etc.

WG Loss = 0.4 dB

Power Load

Sample

VSWR 1.05

Notch Depth

100 dB @ 2.27 - 2.30

KPA (2KW)

Modulated Signal

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Pommonkey Processing Block Diagram

Pommonkey Ground Station Configuration

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Pomonkey - Operations Area Floor Plan
## Pomonkey Major Procurements

<table>
<thead>
<tr>
<th>Item</th>
<th>Mfg.</th>
<th>Quantity</th>
<th>Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPA</td>
<td>Aydin</td>
<td>1</td>
<td>5/15/93</td>
</tr>
<tr>
<td>Signal Generator</td>
<td>HP</td>
<td>1</td>
<td>3/1/93</td>
</tr>
<tr>
<td>DCEU</td>
<td>Silver</td>
<td>1</td>
<td>1/1/93</td>
</tr>
<tr>
<td>Pedestal Controller</td>
<td>HP</td>
<td>1</td>
<td>1/15/93</td>
</tr>
<tr>
<td>BPSK Subcarrier Demod</td>
<td>Decom</td>
<td>1</td>
<td>3/1/93</td>
</tr>
</tbody>
</table>
Pomonkey Antenna Controller Interfaces

Operator Terminal

DSPSE VAX

RS-232

HP A990 Computer

IEEE-488

Antenna Controller #1

IEEE-488

Antenna Controller #2

Switch

Antenna

Pomonkey Network (TCP-IP)

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# Pomonkey Rack Elevations (1 of 2)

**Notes:** Unless otherwise specified


2. Drawing OS-01003 Sheet Index:
   - Sheet 1 - Parts List
   - Sheet 2 - DSPSE G.S. Pomonkey Maryland System Layout
   - Sheet 3 - DSPSE G.S. Pomonkey Maryland Component Configuration
   - Sheet 4 - DSPSE G.S. Pomonkey Maryland Component Configuration

3. Rack System Reference Designations:
   - DSPSE Digital Rack = A1
   - DSPSE RF Rack = A2
   - DSPSE DSP Console = A3

## Parts List

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Quantity</th>
<th>Notes</th>
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<tr>
<td>DSPSE DIGITAL RACK</td>
<td>A1 / DIGITAL</td>
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<td></td>
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<tr>
<td>DSPSE RF RACK</td>
<td>A2 / DIGITAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSPSE DSP CONSOLE</td>
<td>A3 / DIGITAL</td>
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<td></td>
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Pommonkey Rack Elevations (2 of 2)
DSPSE G.S. POMONKEY MARYLAND MICROVAX CONFIGURATION

<table>
<thead>
<tr>
<th>ROW</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
<td>1</td>
<td>MJ7600 AF</td>
<td>KA630-AAA</td>
<td>CPU</td>
<td></td>
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<tr>
<td>2</td>
<td>MJ7600 BP</td>
<td>M5620</td>
<td>4-MB Memory</td>
<td></td>
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<tr>
<td>3</td>
<td>MJ7600 DP</td>
<td>M5630</td>
<td>4-MB Memory</td>
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<td>M6534</td>
<td>KEO11-AC</td>
<td>IEEE-488 Bus Controller</td>
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<tr>
<td>5</td>
<td>M7504</td>
<td>DEHIA (LAN 1/1)</td>
<td>CGD-200/1M</td>
<td>5451 Disk Card</td>
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<tr>
<td>6</td>
<td>N5104</td>
<td>DRV11</td>
<td>8-Asynchronous Lines (TX-Ports)</td>
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<tr>
<td>7</td>
<td>MJ5401 T0K50</td>
<td>KS0 Controller</td>
<td>GRANT</td>
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<tr>
<td>8</td>
<td>232285</td>
<td>TLM Transition Card</td>
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<td>9</td>
<td>MJ7645</td>
<td>RDA504-Q</td>
<td>Disk Controller Processor</td>
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<td>10</td>
<td>MJ765</td>
<td>RDA508-Q</td>
<td>Disk Controller SDI</td>
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<td>11</td>
<td>MJ765</td>
<td>DRV11 (TLM Card)</td>
<td>MJ765</td>
<td>DRV11 (OSIP I/F)</td>
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<tr>
<td>13</td>
<td>OPEN</td>
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INSTALL (TLM Card)
# DSPSE G.S. POMONKEY MARYLAND COMPONENT CONFIGURATION

## DIGITAL RACK (A1) - TGS #1 - POMONKEY MARYLAND

<table>
<thead>
<tr>
<th>Item</th>
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<th>Serial Number</th>
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<th>LACE ID No.</th>
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<td>2</td>
<td>46-2002-001</td>
<td>2-ergo</td>
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<td>46-2202-001</td>
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<td>842-1002-001</td>
<td>4-dss</td>
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<td>270-9001</td>
<td>5-buf</td>
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## GSSP CONSOLE (A3) - TGS #1 - POMONKEY MARYLAND

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## RF RACK (A2) - TGS #1 - POMONKEY MARYLAND

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<th>Serial Number</th>
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These tables represent the configuration of DSPSE G.S. POMONKEY MARYLAND components for the first rack, including digital, GSSP console, and RF racks. Each item includes a part number, description, quantity, manufacturer, serial number, property number, and LACE ID number.
Pomonkey Detailed Block Diagram (2 of 2)
NOTES: UNLESS OTHERWISE SPECIFIED

Pomoneky Cable Interconnect (2 of 16)
NOTES: UNLESS OTHERWISE SPECIFIED
2. SEE I/O PANEL 41 DETAIL ON SHEET 1.
3. SEE I/O PANEL 42 DETAIL ON SHEET 1.
4. SEE I/O PANEL 43 DETAIL ON SHEET 1.
5. THIS DRAWING, DS-30002, SUPERCEDES IACE CABLE INTERCONNECT 943-1035-001.

![Diagram of Pomonkey Cable Interconnect](image)

**Pomonkey Cable Interconnect (3 of 16)**

**Microvax Internal Cable Interconnect**

**I/O Panel Definitions**
Pomoneky Cable Interconnect (6 of 16)
NOTES: UNLESS OTHERWISE SPECIFIED
2. THIS DRAWING, DS-30003, SUPERCEDES LACE CABLE INTERCONNECT 845-1030-001.
NOTES: UNLESS OTHERWISE SPECIFIED
   W01, W02, AND W03 CABLES ARE SPLICED TOGETHER PRIOR TO ENTERING J19.
NOTES: UNLESS OTHERWISE SPECIFIED
2. THIS DRAWING, DS-55003, SUPERCEDES LACE CABLE INTERCONNECT 845-1058-001.
Pomonkey RF Receiver
### Pommonkey Receiver Modifications Requirements

<table>
<thead>
<tr>
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<th>LACE</th>
<th>DSPSE</th>
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<tbody>
<tr>
<td>Carrier Demod</td>
<td>BPSK</td>
<td>PM</td>
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<tr>
<td>Subcarrier Demod</td>
<td>N/A</td>
<td>BPSK</td>
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<tr>
<td>Ranging Capability</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>$f_R$</td>
<td>2286 MHz</td>
<td>2273 MHz</td>
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</table>

POMDSN·19

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Pomonkey Receiver Selected Implementation

- Split Channel PM Carrier Demodulator Preserves Ranging Capability
Pommonkey Transmitter
Pommonkey Transmitter Requirements

- 2 KW Output Power
- 2.09 - 2.12 GHz Frequency Range
- 0dBm ±5dB Power Input
- 3 MHz BW (-1dB pts)
- 1.2:1, Input & Output VSWR
- 208 VAC, 30, 60Hz Prime Power Input
- Remote Controllable
- Type N Female Power Amp Input
- Output WR430 Precision Rectangular Waveguide Flange
Pomonkey Transmitter Implementation

- Aydin Corporation
  Model 2200KS2.0D

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Pomonkey Transmitter Procurement Status

- Aydin Proposal Has Been Deemed Acceptable
- Contract Awarded By 12/1/92
Pomonkey Transmitter - Detailed Interfaces

MS3102D24-22P
(8 AWG)

AC

Type N

RF In

Aydin HPA

CPR430F WG Flange

RF Out

25D

RS232

Remote Control PC

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Pomonkey Transmitter Block Diagram

RF Input Module

RF Input

SSA

Drive Power

Klystron

Beam Power Supply

ARC Detector

Microprocessor Control / Display

Control PC

Output Power

REFL Power

Output Power / Sample
Pommonkey Transmitter Schematics (1 of 5)

Primary Power & HV Supplies

120 / 208V
3 Primary Line Input (Unregulated)

AC Line FLT
AC CUR XMFR
Main CKT BKR

Primary
Regulatory

TBI
Line MON
NEUT

Sensitivity Voltage
Voltage Regulator Panel

Reg 120 / 208V Beam CKT BKR

Beam HV PWR Supply

Klystron Cooling
Control Klystron Filament Low-Voltage Power Supplies

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Pomonkey Transmitter Schematics (2 of 5)

Primary Regulator

120 / 208V 3-Ø Y Ø A

T2-A

T1-A

1 Voltage Ratio

A1 WT Control CCA

WT Motor

Y SENS Raise V

Common Lower V

120V

NEUT

120VAC Reg Ø A

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HV Beam Supply

120 / 08 Vac. Reg. 3Ø Input

R1 K1

K2

3-PH Full-Wave Bridge CR1

E.S.

R2 R3

C1

L1

- HV

POMDSN-14

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Pomonkey Prototyping Results

- 30M Antenna RF Components Are "Off-The-Shelf" Units To Be Procured
- Download Of Antenna Pointing Angles From DSPSE VAX To HP Computer To Antenna Controller Test Was Successful
- Main Portion Of Ground Processing Design Is Presently Supporting LACE Program
DSPSE Command Encoder Unit
(DCEU)
DSPSE Command Encoder Unit (DCEU) Requirements

- Receive Uplink Data Or DCEU Commands From Ground Computer In Packets
- Check Integrity Of Packets Using Checksum
- Large Command Buffer, 32K Bytes
- Accept Multiple Command Buffers For Pipelining
- Send Status Messages Regarding Packet Reception/Transmission/DCEU Directives, Also DCEU Status Messages Regarding DCEU Health
- Add Programmable Preamble To Command Block Prior to Transmission
- Bi-Phase Shift Keyed (BPSK) Output, NRZ-M Coding, 1 Khz Data Rate, 16 Khz Subcarrier
- Additional Test Output To Emulate Command Output Of Transponder
- Separate Loopback Feature For Command Decoding. Decoded Data Converted To Asynchronous RS232
- Audio Tone During Transmission

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DCEU Block Diagram

16MHz OSC

BPSK

UP/DOWN

SINEWAVE

8MHZ CLK

LOUUP

SINEWAVE

FROM

NRZ-M

RCVLOCK*

CDULOCK*

DATA

CLOCK

DATA

CLOCK

DATA

CLOCK

8MHZ

LOOPBACK

DOUT

DATA

CLOCK

SCK

68HC11

MICRO

CONTROLLER

DATA ENCODER

68HC11

MICRO

CONTROLLER

DECODER

32KBYTE SRAM

8KBYTE EPROM

FRONT PANEL

DISPLAY

COMMAND/STATUS

PORT (RS232)

TXD

CTS

RXD

TXD

RXD

PORT (RS232)

32KBYTE SRAM

8KBYTE EPROM

DATA

CLOCK

SCK

DATA

CLOCK

SCK

INTR

INTR

DATA

CLOCK

8MHZ

FRONTPANEL

DISPLAY

68HC11

MICRO

CONTROLLER

DECODER

32KBYTE SRAM

8KBYTE EPROM

GREDEQ-07

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DC EU Data Outputs

Data
0 1 0 1 1 0 0 0 1 1 1 1 0

NRZ-L Data

Clock (1KHZ)

NRZ-M Data

62.5 usec (16KHZ)

BPSK
Pommonkey DCEU Prototyping Results

- DCEU Is Enhanced Version Of Previous Design
- Digital Portion Of DCEU Is Presently Supporting Spacecraft DSC Development
Ground Station Image Processor

(GSIP)
GSIP Requirements

- Self-Test Data Pattern Generator
- Programmable Frame Synchronizer
- Time Stamping Tied To IRIG-B Reference
- Data Decompression Using JPEG Standard
- Near Real-Time Image Transfer to DMOC
- DR11-W Interface to MicroVAX
- Local SCSI Disk Storage
- Real-Time Image Data and Camera Data Display
- Stripped Housekeeping Telemetry Interface
GSIP Selected Implementation

- LACE GSIP's To Be Modified For DSPSE
- GSIP At Pomonkey
- GSIP At DMOC

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GSIP Interfaces - Details

- DTS Inputs
  - IRIG-B Standard Yields Time Stamp Accuracy To < 1.5 ms
  - WB & Clock: RS 422

- μVAX Interfaces
  - Control: RS232
  - WB: DR11-W Interface

- PC Interface
  - Engineering Camera Data: Parallel Interface
  - Image Data: Image Display Interface
  - Control: RS232

- Communications Multiplexer
  - Housekeeping TLM: 2.4 K Baud Asynchronous
  - WB: 128 K Baud Asynchronous
Pomonkey GSIP Prototyping Results

- GSIP Is Modified Version Of Previous Design
- Modifications Currently Being Tested
  - Prototype Available 12/1/92
  - 1 Month To Delivered Unit
Ground Command & Control

Deep Space Network (DSN)
DSN Requirements

- Spacecraft Commanding, Telemetry Receipt, & Tracking For Entire Mission
- Communication With DMOC
  - Command Elements From DMOC
  - Telemetry To DMOC
  - Spacecraft Ephemeris To DMOC
  - Ranging Accuracies Obtainable: 2-5 m Ranging, 1mm/sec Range Rate
DSN Implementation

- LEO 26 m Net (U/D)
- Lunar Mapping 26 m Net (U/D)
- Transfer to Geographos 34 m (S) To ≈ June (U)
  70 m After June (U)
  70 m (D)
- Geographos 70 m (U/D)

U = Uplink  D = Downlink
All Information Transfer Is In 4800 Block Data Format

Control Via ICD

DSN Interface

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Interface Control Via ICD
# Major Procurements

<table>
<thead>
<tr>
<th>Item</th>
<th>Mfg.</th>
<th>Model</th>
<th>On Hand</th>
<th>Purchase</th>
<th>Loan From NASCOM</th>
<th>Estimated Delivery</th>
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<td>Blocker Deblocker</td>
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<td>712</td>
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<td>V.32 9600 Async Modem</td>
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DSN Interface - Tracking

DSN Tracking Support For DSPSE Mission

NOTES:

1 820-13/TRK2-17 Format

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DSN Interface - Telemetry

DSN Telemetry Support For DSPSE Mission

NOTES:
③ NASCOM 4800 Bit Block Format
DSN Command Support For DSPSE Mission

NOTES:
2 NASCOM 4800 Bit Block Format
DSN Interface Selected Implementation

JPL  

NASCOM

MSC

GSFC

NASCOM 9.6K Cmd / SV

256K TLM

261K

867

1st

9.6K

175

712

BED

Blocker

Deblocker

128K

Data

Clock

Data Switch

VAX

Rcdr

DOTB

FS

DMOC

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Washington, DC 20375-5320
# LEO Antenna Slew Rate

## Occurrences Of Maximum Antenna Rates & Accelerations For DSPSE In LEO

### Canberra 13

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<th>Date</th>
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<th>El Deg</th>
<th>X Deg</th>
<th>Y Deg</th>
<th>X dot Deg/sec</th>
<th>Y dot Deg/sec</th>
<th>X ddot Deg/sec^2</th>
<th>Y ddot Deg/sec^2</th>
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<td>-0.022</td>
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### Goldstone 16

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<th>El Deg</th>
<th>X Deg</th>
<th>Y Deg</th>
<th>X dot Deg/sec</th>
<th>Y dot Deg/sec</th>
<th>X ddot Deg/sec^2</th>
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POMDSN-25

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Ground Command & Control

Air Force Satellite Control Network (AFSCN)
AFSCN Requirements

- Alternate Telemetry & Command Site Through Lunar Phase
- Communications Link To DMOC
  - Command Elements From DMOC
  - Telemetry To DMOC
AFSCN RTS Interface

- Interfaces Controlled Via Formal ICD
Ground Command & Control

DSPSE Mission Operations Center (DMOC)
DMOC Requirements

- Spacecraft Operations Center
- Receive & Process Mission Engineering & Science Data
- Mission Planning & Simulation
- Central Communications Hub & Switch
  - Data
  - Voice
  - Video
- Conference Area
DMOC Implementation

- Refurbish LACE Facility To Meet DSPSE Requirements
## DMOC Major Procurements

<table>
<thead>
<tr>
<th>Item</th>
<th>Manufacturer</th>
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</thead>
<tbody>
<tr>
<td>Digital Voice Audio System</td>
<td>Clear-Com</td>
</tr>
<tr>
<td>2 Projectors With Screens</td>
<td>Sony</td>
</tr>
<tr>
<td>Hanging/Console Monitors &amp; VCR's</td>
<td>Sony/Panasonic</td>
</tr>
<tr>
<td>Video Drivers &amp; Switches (Composite)</td>
<td>Dynair</td>
</tr>
<tr>
<td>Video Drivers, Switches, Cables (VGA)</td>
<td>Blackbox</td>
</tr>
<tr>
<td>Operations &amp; Workstation Consoles</td>
<td>AMCO</td>
</tr>
</tbody>
</table>
DMOC Room Elevations (2 of 4)

- Passage Way to Computer Rooms
- Drop Ceiling with Recessed Fluorescent and Incandescent Lighting
- Multiscan Video Projector
- Fire Exit Door
- 20 Inch Hanging Monitor
- Computer Raised Floor
- 120 Inch Projector Screen
- Projector Wall Elevation - DMOC
- Worked With Workstations

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DMOC Room Elevations (3 of 4)

CONFERENCE ROOM WALL ELEVATION - DMOC
VIEWED FROM BEHIND OPERATIONS CONSOLE

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DMOC Room Elevations (4 of 4)

- Passage-way to computer rooms
- TBD
- Drop ceiling with recessed fluorescent and incandescent lighting
- Fire exit door
- 120 inch projector screen
- 120 inch projector screen
- Approx 10'-2" to 11'-6"
- Computer raised floor
- See fire exit door elevation

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DMOC Console Layout

TOP VIEW -- OPERATIONS CONSOLE

DMOC OPERATIONS CONSOLE LAYOUT
(PRELIMINARY)

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DMOC Workstation Layouts (2 of 2)
DMOC Status

- Current DMOC Area Transitioned From LACE To DSPSE
  DSC Breadboard Integration & Test

- Facility Mods Being Accomplished On A Non-interference basis

- Equipment Procurement Has Begun