MSC INTERNAL NOTE NO. 69-FM-121

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

APOLLO 10 (MISSION F) OPERATIONS REVIEW PRESENTED AT MSC ON APRIL 29, 1969

MISSION PLANNING AND ANALYSIS DIVISION

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HOUSTON, TEXAS
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FOREWORD

The purpose of this document is to present the slides used for the Apollo 10 (Mission F) Mission Planning Briefing given at the Operations Review at MSC, April 29, 1969.

The briefing was designed to give a detailed description of the evasive maneuver after TLI and a summary of the lunar orbit rendezvous navigation, mission abort plans, and alternate mission plans.

This document is published for general information; therefore, no detailed explanation of the slides is given. The scheduled Mission Planning and Analysis Division operational documents will explain and redefine this information. Please direct any questions concerning this briefing to D. H. Owen, Jr., Mission Planning and Analysis Division, extension 4101.
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<td>ALTERNATE MISSION PLANS - Rocky D. Duncan</td>
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<tr>
<td>RENDEZVOUS AND SEMISYNCHRONOUS ALTERNATE MISSION PLANS - Kenneth A. Young</td>
<td>45</td>
</tr>
</tbody>
</table>
Evasive Maneuver and Lunar Orbit Inclination Change

Ronald L. Berry
# POST TLI TIMELINE

<table>
<thead>
<tr>
<th>EVENT</th>
<th>TIME FROM TLI HRS:MIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLI CUTOFF</td>
<td>00:00</td>
</tr>
<tr>
<td>INITIAL CSM SEPARATION</td>
<td>00:25</td>
</tr>
<tr>
<td>EJECTION</td>
<td>01:30</td>
</tr>
<tr>
<td>EVASIVE MANEUVER</td>
<td>02:00</td>
</tr>
<tr>
<td>INITIATE DUMP SEQUENCE</td>
<td>02:10</td>
</tr>
<tr>
<td>DUMP</td>
<td>02:22</td>
</tr>
</tbody>
</table>
POST TLI TIMELINE

TLI + 20 SEC
LOCAL
HORIZONTAL
ORBIT RATE

TLI + 15 MIN
MANEUVER TO
SEPARATION
ATTITUDE

TLI + 25 MIN SC
INITIAL SEPARATION
(1 FPS)

TLI + 27 MIN
NULL SEPARATION
RATE AND PITCH
TO DOCKING
ATTITUDE

TLI + 90 MIN
LM WITHDRAWAL

TLI + 110 MIN
SPS EVASIVE
MANEUVER
~20 FPS

JENNESS/LMAB 2/17/69
G+P SUB PANEL/MARSHALL
Figure 1 - Planned motion of the CSM relative to the S-IVB for the Apollo 8 evasive maneuver.
Figure 2. - Actual motion of the CSM relative to the S-IVB for the Apollo 8 evasive maneuver.
Figure 3. – Actual motion of the CSM relative to the S-IVB for the Apollo 8 evasive maneuver.
Figure 4. - CSM range from the S-IVB for actual evasive maneuver of the Apollo 8 mission.
APOLLO 10 POST T, D, AND E EVASIVE MANEUVER DESIGN CONSIDERATIONS

- MINIMIZE RCS FUEL

- AVOID APOLLO 8 PROBLEMS

- EARLY SPS CONFIDENCE BURN DESIRABLE

- AVOID LOX SOLID PARTICLE CLOUD
(a) Vertical displacement versus horizontal displacement.

Figure 3. - RCS evasive maneuver. Dump sequence begins at $2^{\text{h}}\text{00 m}$. 

NOTE: Elapsed time from LM/CSM ejection
70° cone angle.
(b) Cross range versus horizontal displacement.

Figure 3. - Continued.
Figure 3 - Concluded.
APOLLO 10 POST T, D, AND E EVASIVE MANEUVER DESIGN

- SPS/GNCS/EXT ΔV THREE SECOND BURN (20 FPS)

- 30 MINUTES AFTER EJECTION

- PITCHED DOWN 75° - ALLOWS VISUAL OF S-IVB

- TLI BIASED 6 FPS OVERSPEED TO COMPENSATE
Figure 1 - SPS evasive maneuver, dump sequence begins at \( t = 30 \text{ sec} \).
Figure 1. - Continued.

(b) Cross range versus horizontal displacement.
NOTE: Elapsed time from LM/CSM ejection

Figure 1. - Concluded.
APOLLO 10 LUNAR ORBIT INCLINATION
CHANGE TO MATCH G

- APOLLO 10 LUNAR ORBIT NAVIGATION RESULTS
  MORE MEANINGFUL FOR G

- CREW OBSERVATIONS AND STRIP PHOTOGRAPHY
  MORE APPLICABLE FOR G

- SIMPLIFIES FLIGHT PLANNING
### APOLLO 10 LUNAR ORBIT INCLINATION CHANGE

<table>
<thead>
<tr>
<th></th>
<th>Site 2</th>
<th></th>
<th>Site 3</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>OLD</td>
<td>NEW</td>
<td>OLD</td>
<td>NEW</td>
</tr>
<tr>
<td><strong>MAY 72-1</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Launch Date</td>
<td>18</td>
<td>18</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Lunar Approach Azimuth, Deg</td>
<td>-95.25</td>
<td>-91.0</td>
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<tr>
<td>Lunar Orbit Inclination, Deg</td>
<td>5.3</td>
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<td>Midcourse ΔV, FPS</td>
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<td>56</td>
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<td>21</td>
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<tr>
<td>LOI-1 ΔV, FPS</td>
<td>2,843</td>
<td>2,965</td>
<td>2,851</td>
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<td>LOI-1 Plane Change</td>
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<td>1.3</td>
<td>9.0</td>
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<td>SPS ΔV Reserves</td>
<td>1,300</td>
<td>1,000</td>
<td>1,800</td>
<td>1,350</td>
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<td><strong>JUNE 72-1</strong></td>
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<tr>
<td>Launch Date</td>
<td>17</td>
<td>17</td>
<td>19</td>
<td>19</td>
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<tr>
<td>Lunar Approach Azimuth, Deg</td>
<td>-95.25</td>
<td>-91.0</td>
<td>-95.75</td>
<td>-89.0</td>
</tr>
<tr>
<td>Lunar Orbit Inclination, Deg</td>
<td>5.3</td>
<td>1.2</td>
<td>5.8</td>
<td>1.1</td>
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<tr>
<td>Midcourse ΔV, FPS</td>
<td></td>
<td>6</td>
<td></td>
<td>16</td>
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<tr>
<td>LOI-1 ΔV, FPS</td>
<td>2,847</td>
<td>2,940</td>
<td>2,872</td>
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<tr>
<td>LOI-1 Plane Change</td>
<td>0.5</td>
<td>6.1</td>
<td>1.3</td>
<td>6.8</td>
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<tr>
<td>SPS ΔV Reserves</td>
<td>1,800</td>
<td>1,600</td>
<td>1,900</td>
<td>1,550</td>
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</tbody>
</table>
LUNAR ORBIT NAVIGATION

Paul T. Pixley
F MISSION RENDEZVOUS NAVIGATION PLAN
POSTRENNEDVOUS LANDMARK TRACKING

1, 2 UNKNOWN LANDMARK
3, 4, 5 LANDING SITE LANDMARK

EARTH
ABORT TECHNIQUES

Charles T. Hyle
OPERATIONAL ABORT PLAN
APOLLO 10

OBJECTIVES

- POWERED FLIGHT MONITORING LIMITS
- PROVIDE ABORT TECHNIQUES WITHIN AVAILABLE ΔV
## Operational Abort Plan

### Monitoring Limits
- EDS
- FDO Trajectory

### Contingency Procedure Option
- ESS Mode IV
- Mode I, II
- RCS Deorbit
- Mode III

### Table

<table>
<thead>
<tr>
<th>Monitoring Limits</th>
<th>Launch</th>
<th>EPO</th>
<th>TLI</th>
<th>TLC</th>
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<tbody>
<tr>
<td>EDS</td>
<td>RATE - 10°/SEC</td>
<td>ALT. MISS.</td>
<td>ALT. MISS.</td>
<td>ALT. MISS.</td>
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<td>FDO Trajectory</td>
<td>ATT. DEV. - 45°</td>
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<td>Δt_b - +6 SEC</td>
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<th>Contingency Procedure</th>
<th>ESS Mode IV</th>
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<th>ALT. MISS.</th>
<th>ALT. MISS.</th>
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<tr>
<td>Mode I, II</td>
<td>SPS Deorbit</td>
<td>TLI + 90</td>
<td>DIRECT</td>
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<tr>
<td>RCS Deorbit</td>
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<tr>
<td>Mode III</td>
<td></td>
<td>TLI + 10</td>
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</tbody>
</table>
ABORT GEOMETRY DURING TLI/TLC
TIME OF ABORT MANEUVER

POST ABORT TRAJECTORY
ABORT AT:

35 HR
($\Delta V = 5000$ FPS)

25 HR
($\Delta V = 5750$ FPS)

EPO

TLI

FIXED ATTITUDE
ABORTS FROM TLI

TIME FROM TLI, HR

TLI C.O.
PLUS 90 MIN

[Diagram showing post abort trajectory with specific times and velocities]
ABORTS TO MPL-F MISSION-LAUNCH: MAY 18, 1969 72-1

IMPULSIVE ABORT DELTA VELOCITY, ΔV, FPS

TOTAL TRIP TIME, HR

GROUND ELAPSED TIME OF ABORT, HR
# Operational Abort Plan (Concluded)

<table>
<thead>
<tr>
<th>Monitoring Limits</th>
<th>LOI-1</th>
<th>LOI-2</th>
<th>Lunar Orbit</th>
<th>TEI</th>
<th>TEC</th>
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<tr>
<td>Rate - 10°/sec</td>
<td>Rate - 10°/sec</td>
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<tr>
<td>Tilt Dev. - 10°</td>
<td>Tilt Dev. - 10°</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \Delta t_b )</td>
<td>( \Delta t_b )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alt. Miss.</td>
<td>Alt. Miss.</td>
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<td>Alt. Miss.</td>
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<tr>
<td>Alt. Miss.</td>
<td>SPS (RTCC)</td>
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<tr>
<td>I (SPS)</td>
<td>MODE III, II, I</td>
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<tr>
<td>Contingency Procedure Option</td>
<td>DPS Abort</td>
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<tr>
<td>MODE I, II, III</td>
<td>DPS Mode III</td>
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<td>DPS Abort</td>
<td>EARLY TEI</td>
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<tr>
<td>P37</td>
<td>MODE I SPS (P37)</td>
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# Recommended Action for Problems During LOI

## Type

<table>
<thead>
<tr>
<th></th>
<th>Guidance and Control (IMU Drifts, etc)</th>
<th>Manual Takeover at 10°/sec or 10° Attitude Deviation and Complete LOI at Ignition Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>NON-SPS (ECS etc)</td>
<td>Complete LOI</td>
</tr>
<tr>
<td>3</td>
<td>SPS (PRESS etc)</td>
<td>Crew Chart Abort SPS at 15 minutes or DPS at Perilune (RTCC)</td>
</tr>
<tr>
<td>4</td>
<td>Inadvertent Shutdowns (CMC etc)</td>
<td>DPS Abort After 2 Hours (RTCC)</td>
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### SUMMARY OF LUNAR ORBIT INSERTION ABORT MODES

<table>
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<th>LOI SHUTDOWN RANGE</th>
<th>PREABORT TRAJECTORY</th>
<th>ABORT MODE</th>
</tr>
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<tbody>
<tr>
<td>0-120 SEC</td>
<td>LOI BURN ESCAPE HYPERBOLA</td>
<td>MODE I ABORT BURN ΔV₁</td>
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<tr>
<td>120-180 SEC</td>
<td>LOI BURN IMPACTING/EXTREMELY LONG PERIOD UNSTABLE ELLIPSE</td>
<td>MODE II ΔV₂ ΔV₁</td>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>180-NOMINAL CUTOFF</td>
<td>STABLE ELLIPSE LOI BURN</td>
<td>MODE III ΔV₁</td>
</tr>
</tbody>
</table>

Notes:
- MODE I: Aborted burn ΔV₁
- MODE II: Aborted burn ΔV₂, ΔV₁
- MODE III: Aborted burn ΔV₁
SUMMARY OF ABORT CAPABILITY FOR PREMATURE LOI SHUTDOWNS

- SPS ΔV (CSMLM)
- Nominal LOI-1 Shutdown
- Mode I LOI Ignition Plus 2 HR
- Mode II After 1 Rev
- Mode III Total ΔV

Total Abort ΔV, FPS

7 x 10^3

0:00 0:40 1:20 2:00 2:40 3:20 4:00 4:40 5:20 6:00
ALTERNATE MISSION PLANS

Rocky D. Duncan
LUNAR ALTERNATE MISSIONS

ALTERNATE 1

CONTINGENCY: NON NOMINAL TLI

ALTERNATE 1 A: DPS LOI

1 B: CSM ONLY -- LUNAR ORBITAL MISSION

1 C: CSM/LM FLYBY

ALTERNATE 2

CONTINGENCY: FAILURE TO PERFORM T.D. AND E

ALTERNATE 2: CSM ONLY -- LUNAR ORBITAL MISSION

ALTERNATE 3

CONTINGENCY: LM NO GO FOR RENDEZVOUS

ALTERNATE 3: DPS TEI

ALTERNATE 4

CONTINGENCY: LM NO GO FOR RENDEZVOUS OR DPS TEI

ALTERNATE 4: APS BURN TO DEPLETION
APOLLO 10 ALTERNATE MISSION LOGIC

T.O.E. SUCCESSFUL

MCC $\Delta V \geq 450$

MCC $\Delta V \geq 2600$

MCC $\Delta V \geq 5700$

"NOMINAL" MISSION

NO

YES

NO

YES

LM GO FOR DPS LOI

NO

NO

CSM ONLY L.O. ALTERNATE

MCC $\Delta V \geq 3300$

NO

YES

CSM/LM E.O. ALTERNATES

NO

CSM/LM SEMI SYNCHRONOUS

NO

CSM ONLY E.O. ALTERNATE

MCC $\Delta V \geq 8000$

NO

CSM ONLY SEMI SYNCHRONOUS

YES
ALTERNATE 1A

DPS LOI

● CONSTRAINTS
  ● LOI-2 MUST BE $\geq 40$ SEC SPS BURN
  ● NAR RECOMMENDS THIS NOT BE PERFORMED UNLESS SPS SUMP TANKS ARE FULL
  ● DPS SHOULD BE STAGED OR PROPELLANT VENTED WITHIN 20 MINUTES OF BURN

● IMPLICATIONS
  ● CONSIDER DPS LOI IF TL MCC $\Delta V \geq 460$ FPS AND $\leq 2,400$ FPS
  ● UPPER LIMIT CORRESPONDS TO FULL SPS SUMP TANKS
  ● LPO CAPABILITY
    $\approx$ 60 BY 1,500 TO 60 BY 700

● RECOMMENDATION
  ● A LM CHECKOUT EARLY IN TLC
ALTERNATE 1B

CSM - ONLY LUNAR ORBIT MISSION

PROFILE

- CSM/LM MCC FOR FREE RETURN
- LM TESTING DURING TLC
  - NO DPS BURN
  - APS BURN TO DEPLETION
- IN LPO, FOLLOW NOMINAL CREW REST/WORK CYCLE
- LOI DAY PRIMARILY DEVOTED TO PHOTOGRAPHY
- DOI DAY
  - 4 REV'S OF LANDMARK TRACKING
  - SPS DOI INTO 60 BY 8 N. MI. ORBIT FOR 3 REV'S OF MSFN TRACKING
- RETURN TO NOMINAL TIMELINE

---

SPS LOI 60 BY 170

---

SPS MCC

---

APS BURN TO DEPLETION
ALTERNATE 1C

CSM/LM FLYBY

- PROFILE
  - DOCKED MCC
  - PC - 5 HR -- DPS MCC TO CLA
  - PC + 2 HR -- UNMANNED APS BURN TO DEPLETION
  - SPS MCC FOR ASAP RETURN
CSM/LM FLYBY

DPS MCC TO CLA

SPS MCC FOR FAST RETURN

APS BURN TO DEPLETION
ALTERNATE 2

CSM - ONLY LUNAR ORBIT MISSION

- SAME AS ALTERNATE EXCEPT BROUGHT ABOUT BY FAILURE TO PREFORM T, D, AND E
ALTERNATE 3

DPS TEI

- PROFILE
  - LANDMARK TRACKING DURING NOMINAL TIMELINE RENDEZVOUS
  - DPS TEI NEAR END OF DOI DAY
  - DPS TEI ≈ 2,800 FPS FOR SLOW TE FLIGHT TIME
  - APS BURN TO DEPLETION FOLLOWING TEI
  - SPS MCC FOR FAST RETURN

- RECOMMENDATION
  - IF SUPERCRITICAL HELIUM REQUIRES EARLY TEI, THEN STAGE DPS AND RETURN TO NOMINAL TIMELINE
DPS TEI ON DO1 DAY

ANNUAL TIMELINE EVENTS

1 - AWAKE AND EAT
2 - BEGIN LM CHECKOUT
3 - DOI
4 - PHASING
5 - INSERTION
6 - CSI
7 - CDH
8 - TPI
9 - DOCKING
10 - APS BURN TO DEPLETION

TIME, G.T.T.

94:00
99:00
101:06
103:03
103:54
104:52
105:59
106:40
109:04

LANDMARK TRACKING

SUN

TEI PREPARATION
RENDEZVOUS AND SEMISYNCHRONOUS ALTERNATIVE MISSION PLANS

Kenneth A. Young
"F" EARTH ORBIT ALTERNATE MISSION FLOW CHART

**ORBIT CONDITION**

- LAUNCH
  - S-IVB INSERTION
    - YES
    - S-IVB REIGNITION
      - YES
      - $h_a > 4,000$
        - YES
        - $h_a > 10,000$
          - YES
          - ALTERNATE MISSION #
    - NO
      - MODE LV CAPABILITY
        - YES
        - CDI
        - YES
        - LM EJECTION
          - YES
          - ALTERNATE MISSION #
          - NO
            - NO
  - NO
    - ABORT

**LM CONDITION**

- NO LM
  - ALTERNATE MISSION #
    - 1
    - 2
    - 3
    - 4
"F." EARTH ORBIT ALTERNATE MISSION FLOW CHART (CONCLUDED)

ORBIT CONDITION

A

h_a > 25,000

YES

LUNAR CAPABILITY

YES

LUNAR MISSION

LM EJECTION

YES

LUNAR MISSION

LM CONDITION

NO

EJECTION

NO

LUNAR MISSION

NO

LUNAR MISSION

CONCLUDED ALTERNATE MISSION #

LPAD 5291 S
ALTERNATE MISSION EARTH ORBIT GUIDELINES

- LM TESTING TAKES PRIORITY OVER CSM TESTING
- A LUNAR MISSION TIMELINE IS DESIRABLE
- NO ADDITIONAL CREW TRAINING WILL BE NECESSARY
- RCS DEORBIT CAPABILITY WILL BE MAINTAINED
- COVERAGE FOR ALL SPS AND DPS MANEUVERS IS DESIRABLE
- COVERAGE FOR ALL LARGE LM MANEUVERS IS MANDATORY
- ALTERNATE MISSIONS WILL BE OPEN ENDED UP TO 10 DAYS
ALTERNATE MISSION #1
(LOW EARTH ORBIT CSM ONLY)

- SIMULATED LOI (100-400)
- FURTHER MCC'S TO APPROXIMATE LUNAR MISSION TIMELINE
- APPROXIMATELY A 10 DAY MISSION
ALTERNATE MISSION #2
(SEMISYNCHRONOUS WITH CSM ONLY)

- PHASING MANEUVER TO ADJUST ORBIT PERIOD TO G.E.T. SIMULATED LOI TRACK
- SIMULATED LOI (NEAR SEMISYNCHRONOUS)
- PHASING MANEUVER TO PLACE PERIGEE OVER RECOVERY ZONE AT A LATER TIME
- SPS TO SEMISYNCHRONOUS ORBIT
- FURTHER MCC'S TO APPROXIMATE LUNAR TIMELINE
- APPROXIMATELY A 10 DAY MISSION
ALTERNATE MISSIONS #3 & 4
(LOW EARTH ORBIT WITH RENDEZVOUS)

• PHASING MANEUVER TO INSURE TRACKING FOR Second Simulated PDI Maneuver
• SIMULATED DOI (1 HOUR PRIOR TO SIMULATED PDI)
• SIMULATED PDI
• PHASING MANEUVER TO INSURE TRACKING FOR SIMULATED LOI
• SIMULATED LOI (100-400 N. MI. ORBIT)
• TWO SPS MANEUVERS TO CIRCULARIZE AT 150 N. MI.
• LM ACTIVE RENDEZVOUS
• APS BURN TO DEPLETION (AGS CONTROLLED)
• FURTHER MCC'S TO COMPLETE LUNAR MISSION TIMELINE
• APPROXIMATELY 10 DAY MISSION

*IF TLI h_a ≤ 4000 N. MI. MANEUVERS 4 AND 5 COULD PRECEDE 1, 2, 3
ALTERNATE MISSION #5

- Phasing Maneuver to Insure Track for Simulated LOI
- Simulated LOI (Approximately Semisynchronous)
- Phasing Maneuver to Insure Tracking for PDI
- Simulated DOI (1 Hour Prior to Simulated PDI)
- Simulated PDI (Approximately Semisynchronous)
- APS to Depletion (AGS Controlled)
- Phasing Maneuver to Put Perigee Over Recovery Zone Later (40 Second Maneuver)
- SPS-(Semisynchronous)
- MCC's to Complete Lunar Mission Timeline
- Approximately a 10 Day Mission
<table>
<thead>
<tr>
<th>RENDEZVOUS ALTERNATE</th>
<th>CONTINGENCY SITUATION</th>
<th>DURATION OF RENDEZVOUS SEQUENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DPS - ONLY</strong></td>
<td>(1) UNABLE TO STAGE OR APS POWER LIMITED</td>
<td>7 1/2 HOURS (NOMINAL)</td>
</tr>
<tr>
<td>(1) CSM DOES BRAKING</td>
<td>(2) NO USABLE APS</td>
<td></td>
</tr>
<tr>
<td>(2) STAGE AFTER CDH, LM DOES TERMINAL PHASE</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>APS - ONLY</strong></td>
<td>DPS INOPERATIVE</td>
<td>5 1/2 HOURS (LIKE POI ABORT)</td>
</tr>
<tr>
<td>MAXIMUM RANGE = 100 N. MI.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>FOOTBALL</strong></td>
<td>APS AND DPS INOPERATIVE</td>
<td>3 1/2 HOURS</td>
</tr>
<tr>
<td>MAXIMUM RANGE = -60 N. MI.</td>
<td></td>
<td></td>
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</tbody>
</table>