LIQUID ROCKET BOOSTER INTEGRATION STUDY

REVIEWS AND PRESENTATIONS VOLUME IV OF V

FINAL REPORT PHASE I

NAS10-11475
NOVEMBER 1988

(NASA-CR-168746) LIQUID ROCKET BOOSTER INTEGRATION STUDY, VOLUME 4: REVIEWS AND PRESENTATION MATERIAL Final Report
(Lockheed Space Operations Co.) 959 p

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Unclas

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VOLUME I - EXECUTIVE SUMMARY

VOLUME II - STUDY SUMMARY

SECTION 1: LRBI Study Synopsis - An assessment of the study objectives, approach, analysis, and rationale. The study findings and major conclusions are presented.

SECTION 2: Launch Site Plan - An implementation plan for the KSC launch site integration of LRB ground processing. The plan includes details in the areas of facility activations, operational schedules, costs, manpower, safety and environmental aspects.

SECTION 3: Ground Operations Cost Model (GOCM) - The updating and enhancement of this NASA provided computer-based costing model are described. Its application to LRB integration and instructions for modification and expanded use are presented.

SECTION 4: Cost - Summary and Analysis of KSC Costs.

VOLUME III - STUDY PRODUCTS

The study output has been developed in the form of nineteen derived study products. These are presented and described in the subsections of this volume.

VOLUME IV - REVIEWS AND PRESENTATIONS

The progress reviews and oral presentations prepared during the course of the study are presented here along with facing page text where available.

VOLUME V - APPENDICES

Study supporting data used or referenced during the study effort are presented and indexed to the corresponding study products.
LIQUID ROCKET BOOSTER INTEGRATION STUDY

VOLUME IV OF V
REVIEWS AND PRESENTATION MATERIAL

KENNEDY SPACE CENTER
NAS10-11475

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NOVEMBER 1988
This volume contains the material presented at the MSFC/JSC/KSC Integrated Reviews and Working Group Sessions, and the Progress Reviews presented to the KSC Study Manager.

The December 16, 1987 charts were presented at MSFC to support the KSC Project Manager's announcement of the intent to contract with LSOC for the LRBI Study Contract. At the December Working Group Meetings MSFC and JSC requested that KSC host a special Working Group meeting in January 1988.

In response to the December request, KSC hosted the Working Group on the 20th through the 23rd of January. At this time, the LRBI team presented the initial impact assessment to the Working Group Team. This was followed with a station by station tour of KSC processing. This tour identified the significant impact areas and processing work stations to the MSFC/JSC study contractors.

The April 21-22 working sessions updated the total cadre of booster options under consideration of MMC and GDSS. At this update the KSC Ground Systems Impacts were expanded to reflect conflicts with the on-going STS mission. The specific areas reviewed were: access to the LRB at the PAD, the activation schedule, and the transition requirements.

A special cost Working Group meeting was held at MSFC on May 10, 1988. The principal presentations were by GDSS and MMC. Their cost methodology, cost modeling approach and initial life cycle cost were presented. The LRBI presentation provided the first KSC ROM costs. The costs presentation used the same discrete impacts as evaluated by the MSFC contractors.

The last three enclosures of this volume present the Progress Reviews for the period March 15 through December 15, 1988.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADP</td>
<td>Automatic Data Processing</td>
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<tr>
<td>A&amp;E</td>
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<td>Booster Liftoff Weight</td>
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<td>Booster Separation Motor</td>
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C                   Celsius
CAD                  Computer Aided Design
CALS                Computer Aided Logistics System
CCAFS               Cape Canaveral Air Force Station
CCB                 Change Control Board
CCC                 Complex Control Center
CCF                 Compressor Converter Facility
CCMS                Checkout, Control and Monitor Subsystem
CDDT               Countdown Demonstration Test
CDR                 Critical Design Review
CEC                 Core Electronics Contractor
CER                 Cost Estimating Relationships
CG                  Center of Gravity
CH4                 Methane
CITE                Cargo Integration Test Equipment
CM                  Construction Management
                    Configuration Management
C/O                 Closeout
                    Checkout
CONC                Concrete
C of F              Cost of Facilities
COMM                Communications
CPF                 Cost per Foot
CPF2                Cost per Square Foot
CPF3                Cost per Cubic Foot
CPM                 Critical Path Management
CPU                 Central Processing Unit
CR                  Control Room
Cryo                Cryogenic
C/S                 Contractor Support
CT                  Crawler Transporter
CY                  Calendar Year
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<td>IOC</td>
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<td>IPR</td>
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<td>IRD</td>
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<td>IUS</td>
<td>Interior Upper Stage</td>
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<td>Description</td>
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| K | Thousands
| K | Kelvin
| KLB | Thousands of Pounds
| KSC | Kennedy Space Center
| KW | Kilowatt
| LAC | Launch Accessories Contractor
| LC-39 | Launch Complex 39
| LCC | Life Cycle Cost
| LCH4 | Liquid Methane
| LESC | Lockheed Engineering and Science Company
| LETF | Launch Equipment Test Facility
| LEO | Low Earth Orbit
| LH2 | Liquid Hydrogen
| Li | Lithium
| LN2 | Liquid Nitrogen
| LNG | Liquid Natural Gas
| LO2 | Liquid Oxygen
| LOX | Liquid Oxygen
| LPS | Launch Processing System
| LRB | Liquid Rocket Booster
| LRB-HPF | Liquid Rocket Booster Horizontal Processing Facility
| LRBI | Liquid Rocket Booster Integration
| LRU | Line Replaceable Unit
| LSE | Launch Support Equipment
| LSOC | Lockheed Space Operations Company
| LUT | Launcher Umbilical Tower
| MAX | Maximum
| MECO | Main Engine Cutoff
| MDAC | McDonnell Douglas Astronautics Company
| MIL | Military
<table>
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<td>MIN</td>
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<td>MLP</td>
<td>Mobile Launch Platform</td>
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<td>MMC</td>
<td>Martin-Marietta Corporation</td>
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<td>MMH</td>
<td>Mono Methyl Hydrazine</td>
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<td>MOD</td>
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<td>MOU</td>
<td>Memorandum of Understanding</td>
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<td>Manpower</td>
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<td>Operating and Maintenance Documentation</td>
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PRC  Planning Research Corporation
PRD  Program Requirements Document
PRESS  Pressure, pressurization
PROP  Propellant
PRR  Preliminary Requirements Review
PSI  Pounds Per Square Inch
psia  Pounds Per Square Inch Absolute
psig  Pounds Per Square Inch Gage
PSP  Process Support Plan
PT&I  Payroll Taxes and Insurance
P&W  Pratt & Whitney Company

Q  Dynamic Pressure
QA  Quality Assurance
Q-Alpha  Dynamic Pressure x Angle of Attack
QC  Quality Control
QD  Quick Disconnect
QTY  Quantity

R  Ranking
RAM  Random Access Memory
RCS  Reaction Control System
R&D  Research and Development
RF  Radio Frequency
RFP  Request for Proposal
RIC  Rockwell International Corporation
ROM  Rough Order of Magnitude
RP-1  Propellant (Kerosene Related Petroleum Product)
RPL  Rated Power Level
RPS  Record and Playback System
RPSF  Rotation, Processing & Surge Facility
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VOLUME IV

REVIEWS AND PRESENTATIONS

1. INTEGRATED WORKING GROUP MEETING - December 16, 1987

2. INTEGRATED WORKING GROUP MEETING - January 20, 1988

3. INTEGRATED WORKING GROUP - April 21, 1988

4. COST WORKING GROUP MEETING - May 10, 1988

5. FIRST PROGRESS REVIEW - July 18, 1988

6. SECOND PROGRESS REVIEW - October 14, 1988

7. FINAL ORAL PRESENTATION - November 23, 1988
VOLUME IV

SECTION 1

INTEGRATED WORKING GROUP MEETING

December 16, 1987
LIQUID ROCKET BOOSTER (LRB)
INTEGRATION STUDY

LAUNCH PROCESSING ELEMENT
CONTRACTOR INTRODUCTION

G. ARTLEY
DEC. 16, 1987
OBJECTIVES

- LAUNCH SITE OPERATIONS AND FACILITY IMPACTS
- PRELIMINARY OPERATIONAL SCENARIOS
- DESIGN RECOMMENDATIONS
- OPERATIONALLY EFFICIENT LRB SYSTEM
- LAUNCH SUPPORT SYSTEM DEFINITION/GSE AND ASSOCIATED COST
- LAUNCH SITE SUPPORT PLAN
SCOPE

- DEPTH OF ANALYSIS TO FACILITATE CONFIGURATION COMPARISON
  - STRENGTHS AND WEAKNESSES
  - OPERATIONAL COST
  - ENVIRONMENTAL

- SPECIFIC DESIGN RECOMMENDATIONS
- ALL PHASES OF LAUNCH SITE PROCESSING
- IDENTIFY DESIGN ENHANCEMENTS
  - OPERATIONS
  - LIFE CYCLE COST

- PLAN DETAIL CONSISTENT WITH MSFC PHASE A STUDY
- OPERATIONAL CONCERNS
  - SAFETY
  - FACILITIES
  - SYSTEMS
  - PROCEDURES
  - MANPOWER
  - STS OPS
  - SCHEDULE
  - COSTS
LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

LOCKHEED CORPORATION
L.O. KITCHEN

MISSILES & SPACE SYSTEMS GROUP
D.M. TELLEP

LOCKHEED SPACE OPERATIONS COMPANY
E.D. SARGENT

LRB STUDY MANAGER
GORDON ARTLEY

DEPUTY MANAGER
BILL WARD

STUDY SPECIALISTS
CORPORATE RESOURCES

SPC TEAM
SUBCONTRACTORS

Administrative Organization
## SPC Technical Expertise

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**Expertise/Issue Matrix**
# LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

**LOCKHEED SPACE OPERATIONS CO.**
- STS Processing / Launch Operations / Facilities / Planning / Engineering / Logistics
- Contractor Team Management / Integration
- Launch Site Facility Activation / Support (PAD B / MLP 3) / RPBS / OMRF / VLS
- GSE / LSE Design / MDI Maintenance and Sustaining Engineering
- Propellant Handling / Testing / Launch Operations
- LPS System Software Development / Maintenance
- Data Management System Software
- Communication System Design / Development
- Quality / Safety / Reliability Analysis

**LOCKHEED CORPORATE**
- LEMSCO - Las Vegas Environmental Studies
- LEMSCO - White Sands
- Reaction Control System Tests
- Cryogenic Pump / Valve Component Test
- Flammability Studies / Tests
- Lockheed - Huntsville
- SSME Structural / Thermal Analyses
- SRB Structural / Gas Dynamic Models / Design Support
- USFQ Study Coordination

**GRUMMAN TECHNICAL SERVICES**
- LCC Computer / Electronic Systems Operations and Maintenance
- Instrumentation and Measurement Support of all LPS Systems
- Specialized Diagnostic System Development
- Telemetry / Ground Station Operations and Maintenance

**PAN AM**
- Operations Analysis / Processing Enhancements
- Reliability Centered Maintenance Programs
- CBS Ground Processing Efficiency Studies
- Reliability Control Programs
- Logistics Support Analysis
- Automated Work Control
- GSE / LSE Availability Studies

**ROCKETDyne**
- SSME Design / Development / Testing
- Main Engine Performance Upgrade / Enhancements
- Advanced Engine Development / Life Cycle Studies
- Large Expendable Liquid Booster Engines
- NSTL / KSC Engine Static Firing / Flight Certification
- Propulsion / Vehicle Integration / Flight Software / Launch Operations

Lockheed / SPC Team Capabilities
LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

- RECOVERY
  - RECOVERY SHIP
  - GSE/TOOLS
  - SAFING
  - HANDLING
  - COMMUNICATIONS
  - RTLS PROCEDURES

- DISASSEMBLY/INSPECTION
  - HANDLING/ACCESS
  - DISASSEMBLY AREA
  - BAPING AREA
  - HAZARDOUS MATT, DISPOSAL
  - HAZARDOUS GAS DETECTION
  - GSE REQUIREMENTS
  - COMMUNICATIONS

- REFURBISHMENT
  - FACILITIES
  - SHOPS
  - HANDLING
  - GSE/TOOLS
  - DEWATERING/CLEANING
  - REFURB REQUIREMENT FOR REUSABLE ELEMENTS

- LAUNCH
  - SUPPORT SERVICING REQ
  - PROPELLENTS (TRANSFER LOADOUT)
  - PNEUMATICS
  - INSTRUMENTATION
  - ELECTRICAL
  - UMBILICALS
  - HOLDOWN
  - ACCESS
  - SOUND SUPPRESSION
  - STRUCTURAL REQUIREMENTS
    - MLP
    - FSRS
    - ADDITIONAL STRUCTURES
    - ENVELOPE
    - FLAME TRENCH
    - LOOFING ROOM
    - LPS/SWING
    - LAUNCH COMMIT CRITERIA
    - MLP SEQUENCER
    - SAFETY
    - H2O
    - FIRE DETECTION
    - FIREX
    - RANGE SAFETY
    - BITE SAFETY
    - WEATHER PROTECTION
    - INTERFACE REQUIREMENTS
    - COMMUNICATIONS
    - ESCURSIONS
    - ICE INSPECTION

- TEST/CHECKOUT
  - END-TO-END REQUIREMENTS
  - CONTINGENCY
  - LEAK CHECK
  - FR (OPS/INS) REQUIREMENTS
  - GSE/TEST EQUIPMENT
  - COMMUNICATIONS
  - STRUCTURAL/ACCESS REQ

- ABORT/SCRUB
  - TURNAROUND REQUIREMENTS
  - Firing Room
    - Launch Commit Criteria
    - GSE SEQUENCER
    - DETANKING/SAFEING
    - PROCEDURES
    - SAFETY
    - COMMUNICATIONS
    - CERTIFICATION/TRAINING

- TRANSPORTATION TO THE SITE OF ELEMENTS
- RECEIVING AREA(S)
- HANDLING OF ELEMENTS
- STORAGE OF ELEMENTS
- ELEMENT REQUIREMENTS
  - GSE
  - ELECTRICAL POWER
  - ENVELOPE

- ASSEMBLY
  - ASSEMBLY AREA(S)
  - HANDLING
  - SHOPS
  - LRB REQUIREMENTS
    - GSE
    - ELECTRICAL POWER
    - TOOLING
    - STORAGE
    - TEST REQUIREMENTS
    - ENVELOPE

- INTEGRATION
  - STACKING/ALIGNMENT
    - HANDLING
    - ALIGNMENT
    - LRB REQUIREMENTS
      - GSE
      - ELECTRICAL POWER
      - INTERFACE REQUIREMENTS
      - COMMUNICATIONS
      - STRUCTURE/ACCESS REQ

ALL OPERATIONAL AREAS WILL CONSIDER
- SAFETY
- ENVIRONMENTAL
- COMMUNICATIONS
- PROCEDURES
- QUALITY
- LOGISTICS
- TRAINING

LRB Configuration Evaluation Areas of Impact
LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

Study Task Interrelationships
STUDY PRODUCTS

- LRB GROUND OPERATIONS PLAN.
- LRB PROCESSING TIMELINE ASSESSMENTS.
- LRB FACILITY REQUIREMENTS AND CONCEPTS FOR NEW FACILITIES.
- LRB LAUNCH SUPPORT EQUIPMENT DEFINITION.
- LRB GROUND SUPPORT EQUIPMENT DEFINITION.
- LRB MANPOWER.
- COST ESTIMATES INCLUDING TRANSITION.
- POTENTIAL IMPACTS TO ON-GOING LAUNCH SITE ACTIVITY.
- PRELIMINARY TRANSITION PLAN.
- POTENTIAL ENVIRONMENTAL AND SAFETY IMPLICATIONS.
- PROPELLANT ACQUISITION STORAGE AND HANDLING REQUIREMENTS.
- RECOMMENDED CHANGES TO LRB DESIGN FOR OPERATIONAL EFFICIENCY.
- RECOMMENDATIONS FOR FOLLOW-ON STUDY ACTIVITY.
Program Interface Definition
LIQUID ROCKET BOOSTER (LRB) INTEGRATION STUDY

MSFC LRB FEASIBILITY STUDY

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KSC LRB INTEGRATION STUDY

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LRB Integration and LRB Feasibility Schedule Relationship
# KSC LRB Integration Study

## Months - Basic + Option

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**KSC**

**MSFC**

**HQ**

---

**Lockheed**

Space Operations Company
• MSFC 14 x 14 Inch Trisonic Wind Tunnel
• .004 - scale SSLV model
• Instrumentation - 6 component balance (mated vehicle)
  3 component balance (orbiter right wing)
  1 component balance (each left elevon)
  9 base pressures
• Mach number range - 0.6 to 4.45
• Sector angle range - -10 to +10 deg (2 deg increments)
CONFIGURATION 1 - LRB Position Change

\[
D = 15 \text{ ft.}
\]

\[
\theta = 3.0, 7, 10 \text{ deg}
\]
ΔH = +2, +3 ft.

Δαi = -1, -2, -3 deg
CONFIGURATION 4 - Multi-Diameter LRB

$D_1 = 12.2 \text{ ft.}$

$D_2 = 15, 18 \text{ ft.}$

$L = 159 \text{ ft.}$
CONFIGURATION 5 - Twin Tank LRB

D = 12.2 ft.
L = 157 ft.
AERODYNAMIC TEST SCHEDULE

ALTERNATE LRB CONFIGURATIONS

TWT 711 - MSFC 14-INCH TRISONIC WIND TUNNEL

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<tr>
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<th>FEB 78</th>
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- Pretest planning
- Pretest conference
- Installation and checkout
- Hardware fabrication
- Testing:
  - Config. #1
  - Config. #2
  - Config. #3
  - Config. #4
  - Config. #5
- Analysis and Documentation

△
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<th>DESCRIPTION</th>
<th>HEIGHT</th>
<th>CENTER OF GRAVITY</th>
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<th>COMMENTS/PRODUCTS OF INERTIA - SLUGGE EFFECT</th>
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Total weight: 289872.2 kg.
Total height: 150.9 in.

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<table>
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<tr>
<th>DESCRIPTION</th>
<th>WEIGHT (CENTER OF GRAVITY-IN)</th>
<th>(MOMENTS/PRODUCTS OF INERTIA -slug<em>ft</em>ft)</th>
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<tr>
<td></td>
<td>LBS  X  Y  Z</td>
<td>IX  IY  IZ  PMX  PMY  PMZ</td>
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<td>OV-103,7)</td>
<td>150511 1059.1 -0.7 365.7</td>
<td>803763 5050253 5944194 8439 80714  610</td>
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<td>SSME X 3 INERT</td>
<td>20958 1495.0 -0.3 365.7</td>
<td>23407 19615 17665  -24 -324  190</td>
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<td>BUOYANCY</td>
<td>60 1156.0 -0.3 365.1</td>
<td>0 0 0 0 0 0</td>
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<td>CREW MODULE</td>
<td>4361 502.6 -2.7 387.0</td>
<td>2601 4039 3182  46  461  201</td>
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<td>ORBITER WITHOUT CONSUMABLES</td>
<td>176210 1097.2 -0.6 368.4</td>
<td>832085 6171524 6461150 11384 99681  -418</td>
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<tr>
<td>NON-PROP CONSUM AT SRB IGN</td>
<td>5397 977.6 3.4 342.8</td>
<td>9648 126404 127666  -1265 14994  -446</td>
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<td>MPS PROPellant AT SRB IGN</td>
<td>5166 1404.5 -6.8 352.7</td>
<td>4149 5527 5037  -1004 1041  -418</td>
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<tr>
<td>OMS FUEL LEFT</td>
<td>2854 1425.0 -71.4 498.0</td>
<td>196 220 230  -9  9  4</td>
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<tr>
<td>OMS FUEL RIGHT</td>
<td>2854 1425.0 -71.4 498.0</td>
<td>196 220 230  -9  9  4</td>
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<tr>
<td>OMS OXIDIZER LEFT</td>
<td>4746 1424.1 -109.1 458.8</td>
<td>382 359 452  23  10  7</td>
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<tr>
<td>OMS OXIDIZER RIGHT</td>
<td>4746 1424.1 -109.1 458.8</td>
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<td>PCS PROPellant - FWD</td>
<td>1950 317.8 5.4 365.2</td>
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<td>PCS PROPellant - AFT</td>
<td>4970 1345.9 0.0 470.3</td>
<td>6661 1022 9135  0  76  1</td>
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<td>ORBITER MODULE TOTAL AT SRB IGN</td>
<td>208993 1124.2 -0.2 377.4</td>
<td>932639 2113967 7397596 9442 244866  1423</td>
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<tr>
<td>CARGO MODULE</td>
<td>57410 1163.6 1.1 364.4</td>
<td>73094 237184 271869  -56 14 -10675  431</td>
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<td>CARGO BUOYANCY</td>
<td>30 1163.6 1.1 366.4</td>
<td>0 0 0 0 0 0</td>
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<tr>
<td>CARGO MODULE TOTAL</td>
<td>58000 1163.6 1.1 368.4</td>
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<td>ORBITER PLUS CARGO AT SRB IGN</td>
<td>266893 1125.7 0.1 379.0</td>
<td>957781 2402787 2684247 2930 237542  2709</td>
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<td>ET-023 ACT WT MDC 12/12/85</td>
<td>66621 1356.9 2.7 424.6</td>
<td>35906 3951655 3949302 3693 188466  7039</td>
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<td>ET BUOYANCY</td>
<td>175 1356.9 2.7 424.6</td>
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<td>MPS FUEL AT SRB IGN</td>
<td>239661 1607.6 0.0 400.0</td>
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<td>MPS Lox AT SRB IGN</td>
<td>166788 1729.8 0.0 -401.4</td>
<td>14408 4061374 4831370 136250 315710 -3341</td>
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<td>MPS Pressurant</td>
<td>481 1733.6 0.0 400.0</td>
<td>0 1734 1734  0  0  0</td>
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<td>ICE/FRST/LIQU AIR+2+TPS H2O</td>
<td>317 1862.6 2.6 424.5</td>
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<td>ET MODULE TOTAL AT SRB IGN</td>
<td>1665159 665.7 0.6 407.4</td>
<td>414294 4866540 4699404 132550 534345  4270</td>
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<td>SRB LEFT SEPARATION</td>
<td>186452 1602.6 -250.9 401.0</td>
<td>108161 1062494 11099475 -25231 6892  -493</td>
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<td>SRB LEFT INFLIGHT LOSSES</td>
<td>1186562 1896.8 -250.1 400.1</td>
<td>736224 35414985 35415390 1502 232  -2</td>
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<td>SRB LEFT AT IGN. RSRLM-001</td>
<td>1303015 1711.9 -250.6 400.2</td>
<td>923419 476262278 47630161 129607 2542  -456</td>
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<td>SRB RIGHT SEPARATION</td>
<td>186452 1603.6 -250.9 401.0</td>
<td>108161 1162494 11899475 25231 6892  -493</td>
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<td>SRB RIGHT INFLIGHT LOSSES</td>
<td>1186562 1896.8 -250.5 400.1</td>
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<td>SRB RIGHT AT IGN. RSRLM-001</td>
<td>1303015 1711.9 -250.6 400.2</td>
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<td>TOTAL MASS PROPERTIES AT SRB IGN</td>
<td>4538002 1414.6 0.2 419.5 48964421 32319007 353010325 208598 8839991 316789</td>
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ORBITER AND CARGO IN ORBITER COORDINATE SYSTEM, ET, SRB, AND SHUTTLE TOTAL IN SHUTTLE COORDINATE SYSTEM.
TO: NASA Headquarters  
   Attn: M/Director, National Space Transportation System  

FROM: GA/Deputy Director, National STS Program  

SUBJECT: Update to Space Transportation System (STS) Ascent Performance and Landing Weight Capability

The previously reported Shuttle ascent performance and landing weight capability (refer to letter TM4-87-010) has been updated to reflect changes to the allowable payload capability. Enclosed you will find updated versions of the Shuttle Ascent Performance Capability, the Shuttle Landing Weight Capability, and the associated Ground Rules and Assumptions. All previous versions of this material should be discarded. The only major updates involve Shuttle landing weight capability as summarized below.

Several changes to ascent performance capability have occurred in the last 4 months. However, the performance losses have been offset by performance gains and the STS ascent performance capability is essentially unchanged. The performance losses result from a 300-pound increase to the Orbiter system weight and a 300-pound performance loss because of an increase in the inert weight of the redesigned solid rocket motor. This 600-pound loss in ascent performance is offset by a 600-pound performance gain resulting from an adjustment to the main propulsion system propellant budget.

As a result of the 300-pound Orbiter system inert weight increase, the cargo landing weight capabilities have been reduced by 300 pounds. A significant increase in nominal end of mission (NEOM) landing weight capability results from increasing the NEOM landing weight limit to 230,000 pounds.

The incremental weight adjustment for an additional crew person (such as a payload specialist) has been increased to 500 pounds. This increase from 450 pounds accounts for individual crew escape equipment.

We hope this update is helpful in keeping abreast of the National Space Transportation System (NSTS) capability. Updates to the NSTS ascent performance and landing weight capability will be provided quarterly.

Original Signed By:  
RICHARD H. KOHRS

Richard H. Kohrs

3 Enclosures
### SHUTTLE ASCENT PERFORMANCE CAPABILITY

#### 11-20-87

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<tr>
<th></th>
<th>ETR</th>
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<tr>
<td></td>
<td>MAX. PERF. 28.5 DEG., 110 NM</td>
<td>MAX. PERF. 57.0 DEG., 110 NM</td>
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<td>MAX. PERF. 57.0 DEG., 110 NM</td>
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<td>SPACE STATION POLAR MISSION 140 NM</td>
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<td>o PRESTS 51-L CAPABILITY @ 104% SSME</td>
<td>61,400 LIMIT TO 54,300 BY DOWN WEIGHT</td>
<td>47,400</td>
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<td>o NEAR-TERM CAPABILITY @ 104% SSME</td>
<td>55,000 LIMIT TO 50,200 BY DOWNWEIGHTS</td>
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<td>PROB TO 6.0 LOADS ANALYSIS</td>
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<td>o ACHIEVABLE CAPABILITY 104% SSME</td>
<td>55,500</td>
<td>41,500</td>
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<td>PLANNED HARDWARE, MARGIN TESTING &amp; ANALYSIS</td>
<td>109% SSME</td>
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<td>60,500 LIMIT TO 57,700 BY DOWNWEIGHTS</td>
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<td>AFTER 6.0 LOADS ANALYSIS</td>
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<tr>
<td>o POTENTIAL CAPABILITY WITH THE ASRM (12,000 POUNDS)</td>
<td>104% SSME</td>
<td>61,500 *</td>
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<td>72,500 *</td>
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**NOTES:**
- CAPABILITY EQUIVALENT TO PAYLOAD PLUS ATTACH HARDWARE.
- SUBTRACT APPROXIMATELY 100 LB/ NM FOR INCREASED ALTITUDES.
- CAPABILITY SHOWN IS FOR ORBITERS OV-103, 104, & 105; SUBTRACT APPROXIMATELY 8,400 POUNDS TO USE ORBITER OV-107.

* THIS CAPABILITY CAN ONLY BE USED IF THE ORBITER ABORT LANDING WEIGHT LIMITS ARE CERTIFIED TO 258,100 POUNDS FOR THE 67,500-POUND CAPABILITY, AND 261,100 POUNDS FOR THE 72,500-POUND CAPABILITY. THIS IS A SIGNIFICANT INCREASE OVER THE CURRENT GOAL OF 248,000 POUNDS AND MAY REQUIRE SIGNIFICANT MODIFICATIONS TO THE STRUCTURAL DESIGN OF THE ORBITER. THE FEASIBILITY OF THESE MODIFICATIONS IS UNKNOWN.
<table>
<thead>
<tr>
<th>ORBITER CONFIGURATION</th>
<th>MAXIMUM PERFORMANCE</th>
<th>SPACE STATION (ETR)</th>
<th>SPACELAB</th>
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<tr>
<td>O CREW SIZE / DURATION</td>
<td>5 MAN / 4 DAY</td>
<td>5 MAN / 7 DAY</td>
<td>5 MAN / 7 DAY</td>
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<td>O CRYO (HARDWARE / FLUID LEVEL)</td>
<td>3 TANKS / 3 OFFLOADED</td>
<td>4 TANKS / 3 FULL</td>
<td>4 TANKS / 4 FULL</td>
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<td>OFF</td>
<td>FULL</td>
<td>FULL</td>
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<tr>
<td>O RMS</td>
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<td>ON</td>
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<th>SPACELAB</th>
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<td>CURRENT LANDING LIMITS</td>
<td>RTLS 240,000</td>
<td>NEOM 230,000</td>
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<td>ORBITER SYSTEM</td>
<td>AOA 240,000</td>
<td>NEOM 230,000</td>
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<tr>
<td>WEIGHT GROWTH PORTION</td>
<td>187,816</td>
<td>185,479</td>
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<tr>
<td>OF MANAGERS RESERVE</td>
<td>187,232</td>
<td>184,501</td>
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<td>NEAR TERM LANDING</td>
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<tr>
<td>WEIGHT CAPABILITY</td>
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<td>2,000</td>
</tr>
</tbody>
</table>

| 6.0 LANDING LIMITS                | RTLS 254,000        | NEOM 230,000 |
| ORBITER SYSTEM                    | AOA 248,000         | NEOM 230,000 |
| WEIGHT GROWTH PORTION             | 187,816             | 185,479   |
| OF MANAGERS RESERVE               | 187,232             | 184,501   |
| CAT 11 MODS AND NOMINAL           | 2,000               | 2,000     |
| WEIGHT GROWTH FOR THE MID 90'S    | 1,000               | 1,000     |
| ACHIEVABLE LANDING                | 63,184              | 41,521    |
| WEIGHT CAPABILITY                 | 57,768              | 42,499    |

**NOTES:**  
- RTLS and TAL are not limiting cases for Space Station and Spacelab configurations.  
- Capability shown is for orbiters OV-103, 104, & 105; subtract - 8,400 lbs when using orbiter OV-102. 
- Each additional crew person beyond the five person standard is chargeable to the cargo weight allocation and will reduce the payload capability by approximately 500 pounds.
**SHUTTLE PERFORMANCE**

**GROUND RULES AND ASSUMPTIONS**

11-20-87

<table>
<thead>
<tr>
<th>ORBITER CONFIGURATION:</th>
<th>MAXIMUM PERFORMANCE</th>
<th>SPACE STATION - ETR</th>
<th>SPACE STATION - WTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 CREW SIZE / DURATION</td>
<td>5 MAN / 4 DAY</td>
<td>5 MAN / 7 DAY</td>
<td>5 MAN / 7 DAY</td>
</tr>
<tr>
<td>0 CRYO (HARDWARE / FLUID LEVEL)</td>
<td>3 TANKS / 3 OFFLOADED</td>
<td>4 TANKS / 3 FULL</td>
<td>3 TANKS / 3 FULL.</td>
</tr>
<tr>
<td>0 FORWARD RCS</td>
<td>OFF</td>
<td>FULL.</td>
<td>FULL.</td>
</tr>
<tr>
<td>0 RMS</td>
<td>NO</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>0 RENDEZVOUS</td>
<td></td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

**NEAR-TERM CAPABILITY** - LATE 1980'S TO EARLY 1990'S

- 0 ASCENT SHAPING: Q - 790 FLUTTER BUFFET; Q alpha - 0.3250;
- 0 THE QUOTED CAPABILITY INCLUDES DISCOUNTS FOR MANAGER'S RESERVE AND FOR THE CREW ESCAPE SYSTEM, SRB REDESIGN, AND ORBITER MODIFICATIONS RESULTING FROM STS 51-L.

**ACHIEVABLE CAPABILITY** - EARLY TO MID 1990'S

- 0 ASCENT SHAPING: Q - 819 TPS; Q alpha - 0.3000; PERFORMANCE INCREASES BY:
  - 1500 LBS @ ETR
  - 2,300 LBS @ WTR
- 0 POTENTIAL WEIGHT GROWTH FOR CAT II MODS & NOMINAL WEIGHT GROWTH IN THE 1990'S;
  - PERFORMANCE DECREASES BY:
  - 1000 LBS @ BOTH SITES

**POTENTIAL CAPABILITY** - MID TO LATE 1990'S

- 0 SAME AS ACHIEVABLE CAPABILITY GROUND RULES
- 0 ADVANCED SRM: 12,000 LBS AS A PERFORMANCE INCREASE DESIGN GOAL.
  - FOR THIS ASSESSMENT WE ARE ASSUMING THAT THE ASRM REPLACES THE FWC SRM.

**NOTE:** - EACH ADDITIONAL CREW PERSON BEYOND THE FIVE PERSON STANDARD IS CHARGEABLE TO THE CARGO WEIGHT ALLOCATION AND WILL REDUCE THE PAYLOAD CAPABILITY BY APPROXIMATELY 500 POUNDS.
cc:
NASA Hq.: M/R. H. Truly
KSC, CM/J. T. Conway
TM/T. E. Utsman
R. B. Sieck
G. T. Sasseen
TP/C. D. Gay
TV/J. E. Smith
NSTS-KSC, MK/R. L. Crippen
MSFC, EE01/J. A. Lovingood
SA21/J. A. Lombardo
SA31/G. P. Bridwell
SA41/G. W. Smith
EE01/J. A. Lovingood
SA71/J. W. Kennedy
NSTS-MSFC, SA01/W. R. Marshall
M. M. Boze
USAF VAFB, WSMC, ST/Lt. Col. T. G. Martin
bcc:
JSC, AC/D. A. Nebrig
   AC3/C. E. Charlesworth
  CA/G. W. S. Abbey
   CB/F. H. Hauck
    DA/E. F. Kranz
EA/H. O. Pohl
FA/R. L. Berry
VA/R. A. Colonna
   D. M. Germany

NSTS-JSC, GA/J. F. Honeycutt
   B. D. O'Connor
GA2/J. B. Costello
GA3/M. E. Merrell
GM/D. C. Schultz
MJ/R. A. Thorson
TA/L. S. Nicholson
TM/A. A. Bishop
TM2/G. C. Nield
TM4/R. E. Matthews
VK/J. C. Presnell
   C. M. Vaughn
WA/R. W. Moorehead
   L. G. Williams
   T. T. Henricks

TM4/CMLarthers:el:11/13/87:31364
<table>
<thead>
<tr>
<th></th>
<th>ETR</th>
<th>WTR</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MAX. PERF.</td>
<td>MAX. PERF.</td>
<td>MAX. PERF.</td>
<td>MAX. PERF.</td>
</tr>
<tr>
<td></td>
<td>28.5 DEG.</td>
<td>57.0 DEG.</td>
<td>28.5 DEG.</td>
<td>68.0 DEG.</td>
</tr>
<tr>
<td>PRE STS 51.1%</td>
<td>61,400</td>
<td>47,400</td>
<td>45,930</td>
<td>48,600</td>
</tr>
<tr>
<td>CAPABILITY @ 104% SSME</td>
<td>LIMITED TO 54,300 BY DOWN WEIGHT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEAR-TERM</td>
<td>55,000</td>
<td>41,000</td>
<td>39,530</td>
<td>48,600</td>
</tr>
<tr>
<td>CAPABILITY @ 104% SSME</td>
<td>LIMITED TO 50,200 BY DOWNWEIGHTS PROIR TO 6.0 LOADS ANALYSIS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACHIEVABLE</td>
<td>55,500</td>
<td>41,500</td>
<td>40,030</td>
<td>48,600</td>
</tr>
<tr>
<td>CAPABILITY @ 104%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WITH CURRENTLY PLANNED HARDWARE, MARGIN TESTING &amp; ANALYSIS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>104% SSME</td>
<td>60,500</td>
<td>46,500</td>
<td>45,030</td>
<td>48,600</td>
</tr>
<tr>
<td>POTENTIAL</td>
<td>67,500 *</td>
<td>53,500</td>
<td>52,030</td>
<td>49,600</td>
</tr>
<tr>
<td>CAPABILITY @ 104%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WITH THE ASM (17,000 POUNDS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>104% SSME</td>
<td>12,500 *</td>
<td>58,500</td>
<td>57,030</td>
<td>54,600</td>
</tr>
</tbody>
</table>

NOTES:
- CAPABILITY EQUATES TO PAYLOAD PLUS ATTACH HARDWARE.
- SUBTRACT APPROXIMATELY 100 LB/NM FOR INCREASED ALTITUDES.
- CAPABILITY SHOWN IS FOR ORBITERS OV-101, 104, & 105; SUBTRACT APPROXIMATELY 8,400 POUNDS TO USE ORBITER OV-102.
- THIS CAPABILITY CAN ONLY BE USED IF THE ORBITER ABORT LANDING WEIGHT LIMITS ARE CERTIFIED TO 750,000 POUNDS FOR THE 67,500 POUND CAPABILITY, AND 763,000 POUNDS FOR THE 12,500 POUND CAPABILITY. THIS IS A SIGNIFICANT INCREASE OVER THE CURRENT GOAL OF 258,000 POUNDS AND MAY REQUIRE SIGNIFICANT MODIFICATIONS TO THE STRUCTURAL DESIGN OF THE ORBITER. THE FEASIBILITY OF THESE MODIFICATIONS IS UNKNOWN.
## LRB Reference Missions
### Shuttle Landing-Weight Capability

<table>
<thead>
<tr>
<th>Orbiter Configuration</th>
<th>Maximum Performance</th>
<th>Space Station (ETR)</th>
<th>SpaceLab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew Size / Duration</td>
<td>5 Man / 4 Day</td>
<td>5 Man / 1 Day</td>
<td>5 Man / 1 Day</td>
</tr>
<tr>
<td>Cryo (Hardware / Fluid Level)</td>
<td>3 Tanks / 3 Offloaded</td>
<td>4 Tanks / 3 Full</td>
<td>4 Tanks / 4 Full</td>
</tr>
<tr>
<td>Forward RCS</td>
<td>Off</td>
<td>Full</td>
<td>Full</td>
</tr>
<tr>
<td>RMS</td>
<td>Off</td>
<td>On</td>
<td>Off</td>
</tr>
</tbody>
</table>

### Maximum Performance Configuration

<table>
<thead>
<tr>
<th>Current Landing Limits</th>
<th>RTIS</th>
<th>AOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbiter System</td>
<td>240,000</td>
<td>240,000</td>
</tr>
<tr>
<td>Weight Growth Portion</td>
<td>187,816</td>
<td>187,232</td>
</tr>
<tr>
<td>of Managers Reserve</td>
<td>2,000</td>
<td>2,000</td>
</tr>
</tbody>
</table>

### Near Term Landing Weight Capability

<table>
<thead>
<tr>
<th>6.0 Landing Limits</th>
<th>50,184</th>
<th>50,768</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbiter System</td>
<td>254,000</td>
<td>248,000</td>
</tr>
<tr>
<td>Weight Growth Portion</td>
<td>187,816</td>
<td>187,232</td>
</tr>
<tr>
<td>of Managers Reserve</td>
<td>2,000</td>
<td>2,000</td>
</tr>
</tbody>
</table>

### Achievable Landing Weight Capability

<table>
<thead>
<tr>
<th>CAT II MOB's and Nominal Weight Growth for the Mid 90's</th>
<th>63,184</th>
<th>57,768</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievable Landing Weight Capability</td>
<td>41,521</td>
<td>42,499</td>
</tr>
</tbody>
</table>

**Notes:**
- RTIS and AOA are not limiting cases for Space Station and SpaceLab configurations.
- Capability shown is for orbiters OV-101, 104, & 105; subtract 8,400 lbs when using orbiter OV-102.
- Each additional crew person beyond the five-person standard is chargeable to the cargo weight allocation and will reduce the payload capability by approximately 140 pounds.
### LRB Reference Missions

#### Orbiter Configuration:
- **0 Crew Size / Duration**: 5 Man / 4 Day
- **0 Cryo (Hardware / Fluid Level)**: 3 Tanks / 3 Offloaded
- **0 Forward RCS**: Off
- **0 RMS**: No
- **0 Rendezvous**: No

#### Near Term Capability - Late 1980's to Early 1990's
- **0 Ascent Shaping**: Q - 790 Flutter Buffet; Q alpha - 1250
- **The quoted capability includes discounts for manager's reserve and for the crew escape system, SRB redesign, and orbiter modifications resulting from STS 51-L.**

#### Achievable Capability - Early to Mid 1990's
- **Q Ascent Shaping**: Q - 819 TPS; Q alpha - 3000; Performance increases by:
  - 11500 LBS @ ETR
  - 12,400 LBS @ WTR

#### Potential Capability - Mid to Late 1990's
- **Q Ascent Shaping**: Same as achievable capability ground rules
- **Advanced SRM**: 12,000 LBS as a performance increase design goal; for this assessment we are assuming that the ASRM replaces the EWC SRM.

#### Note:
Each additional crew person beyond the five person standard is chargeable to the cargo weight allocation and will reduce the payload capability by approximately 500 pounds.
## LRB Reference Missions

<table>
<thead>
<tr>
<th>SSME Design Goals</th>
<th>Max Perp. 28.5 Deg. 160 NM</th>
<th>Space Station 28.5 Deg 220 NM</th>
<th>Increased Performance Goal</th>
<th>Delta from Asm</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 RPM Design Goals</td>
<td>62500 ×</td>
<td>52030</td>
<td>12000</td>
<td>--</td>
<td>P.E., ALDRICH Memo</td>
</tr>
<tr>
<td>100%</td>
<td>67500 ×</td>
<td>57030</td>
<td>12000</td>
<td>--</td>
<td>P.E., ALDRICH Memo</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LRB BPM-1 50LE to 150 NM SSME</th>
<th>104%</th>
<th>58000</th>
<th>47530</th>
<th>7500</th>
<th>-4500</th>
<th>TDOP LRBPM-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRB BPM-2 70LE to 150NM SSME</td>
<td>104%</td>
<td>69000</td>
<td>56530</td>
<td>22500</td>
<td>10500</td>
<td>TDOP LRBPM-2</td>
</tr>
<tr>
<td>SSME</td>
<td>104%</td>
<td>73000</td>
<td>62530</td>
<td>22500</td>
<td>10500</td>
<td>FOR INFO ONLY</td>
</tr>
</tbody>
</table>

| Space Station Max SSME Capability Based on Shale Down Weight Limit SSME | 100% | 68470 × | 58000 | 21970 | 9970   | P.E., PPCB CR 403138 |

- Limited to 58000 lb by maximum AOA downweight constraint
- Limited to 58000 lb by contingency payload return downweight constraint
  P.E., PPCB CR 403138
RECOMMENDATIONS

O RETAIN 69KLB TO 160 NM CARGO WEIGHT FOR LRB BRM-2 TO REPRESENT MAXIMUM SPACE STATION PERFORMANCE CAPABILITY (EQUIVALENT TO 70KLB TO 150 NM)

O REVISE LRB BRM-2 CARGO WEIGHT TO REFLECT ASRM DESIGN PERFORMANCE GOAL (62500 LB TO 160 NM)
# LRB Reference Missions

## Shuttle Ascent Performance Capability

**11-20-87**

<table>
<thead>
<tr>
<th></th>
<th>ETR</th>
<th>WTR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max. Perf.</strong></td>
<td><strong>Max. Perf.</strong></td>
<td><strong>Max. Perf.</strong></td>
</tr>
<tr>
<td>28.5 Deg.</td>
<td>57.0 Deg.</td>
<td>68.0 Deg.</td>
</tr>
<tr>
<td>110 NM</td>
<td>110 NM</td>
<td>110 NM</td>
</tr>
<tr>
<td><strong>Space Station</strong></td>
<td><strong>Space Station</strong></td>
<td><strong>Space Station</strong></td>
</tr>
<tr>
<td>28.5 Deg.</td>
<td>220 Deg.</td>
<td>98.0 Deg.</td>
</tr>
<tr>
<td>110 NM</td>
<td>110 NM</td>
<td>110 NM</td>
</tr>
</tbody>
</table>

### Pre STS 51-L Capability @ 104% SSME
- Limited to 54,300 by down weight
- 61,600

### Near-Term Capability @ 104% SSME
- Limited to 50,200 by downweights prior to 6.0 loads analysis
- 55,000

### Achievable Capability @ 104% SSME
- With currently planned hardware, margin testing & analysis
- 55,500

### Potential Capability @ 104% SSME (12,000 pounds)
- With the ASRM
- 67,500

### Original Page is of Poor Quality

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**Notes:**
- Capability equates to payload plus attach hardware.
- Subtract approximately 100 lb/nm for increased altitudes.
- Capability shown is for orbiters OV-101, 104, & 105; subtract approximately 8,400 pounds to use orbiter OV-10.

---

**This capability can only be used if the orbiter abort landing weight limits are certified to 258,000 pounds for the 67,500 pound capability, and 264,100 pounds for the 12,500 pound capability. This is a significant increase over the current goal of 248,000 pounds and may require significant modifications to the structural design of the orbiter. The feasibility of these modifications is unknown.**
<table>
<thead>
<tr>
<th>ORBITER CONFIGURATION</th>
<th>MAXIMUM PERFORMANCE</th>
<th>SPACE STATION (ETR)</th>
<th>SPACELAB</th>
</tr>
</thead>
<tbody>
<tr>
<td>O CREW SIZE / DURATION</td>
<td>5 MAN / 4 DAY</td>
<td>5 MAN / 1 DAY</td>
<td>5 MAN / 1 DAY</td>
</tr>
<tr>
<td>O CRYO (HARDWARE / FLUID LEVEL)</td>
<td>3 TANKS / 3 OFFLOADED</td>
<td>4 TANKS / 3 FULL</td>
<td>4 TANKS / 4 FULL</td>
</tr>
<tr>
<td>O FORWARD RCS</td>
<td>OFF</td>
<td>FULL</td>
<td>FULL</td>
</tr>
<tr>
<td>O RMS</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>MAXIMUM PERFORMANCE CONFIGURATION</th>
<th>RTLS</th>
<th>AOA</th>
<th>NEOM</th>
<th>NEOM</th>
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<tbody>
<tr>
<td>CURRENT LANDING LIMITS</td>
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<td>240,000</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>ORBITER SYSTEM</td>
<td>187,816</td>
<td>187,232</td>
<td>185,479</td>
<td>184,501</td>
</tr>
<tr>
<td>WEIGHT GROWTH PORTION OF MANAGERS RESERVE</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NEAR TERM LANDING WEIGHT CAPABILITY</th>
<th>50,184</th>
<th>50,768</th>
<th>42,521</th>
<th>43,499</th>
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<tbody>
<tr>
<td>6.0 LANDING LIMITS</td>
<td>254,000</td>
<td>268,000</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>ORBITER SYSTEM</td>
<td>187,816</td>
<td>187,232</td>
<td>185,479</td>
<td>184,501</td>
</tr>
<tr>
<td>WEIGHT GROWTH PORTION OF MANAGERS RESERVE</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>CAT II MODS AND NOMINAL WEIGHT GROWTH FOR THE MID 90'S</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
</tbody>
</table>

| ACHIEVABLE LANDING WEIGHT CAPABILITY | 63,184 | 57,768 | 41,521 | 42,499 |

**NOTES:** RTLS AND AOA ARE NOT LIMITING CASES FOR SPACE STATION AND SPACELAB CONFIGURATIONS.

CAPABILITIES SHOWN IS FOR ORBITERS 0V 101, 104, & 105; SUBTRACT 8,400 LBS WHEN USING ORBITER 0V 102.

EACH ADDITIONAL CREW PERSON BEYOND THE FIVE PERSON STANDARD IS CHARGEABLE TO THE CARGO WEIGHT ALCATION AND WILL ELIMINATE THE CARGO CAPABILITY BY APPROXIMATELY 3000 LBS.
## LRB Reference Missions
**Shuttle Performance Ground Rules and Assumptions**

### Orbiter Configuration:

<table>
<thead>
<tr>
<th>Crew Size / Duration</th>
<th>Maximum Performance</th>
<th>Space Station - ETR</th>
<th>Space Station - WTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREW SIZE / DURATION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O CRP O (HARDWARE / FLUID LEVEL)</td>
<td>5 MAN / 4 DAY</td>
<td>5 MAN / 7 DAY</td>
<td>5 MAN / 7 DAY</td>
</tr>
<tr>
<td>O FORWARD RCS</td>
<td>3 TANKS / 3 OFFLOADED</td>
<td>4 TANKS / 3 FULL</td>
<td>3 TANKS / 3 FULL</td>
</tr>
<tr>
<td>O RMS</td>
<td>OFF</td>
<td>FULL</td>
<td>FULL</td>
</tr>
<tr>
<td>O Rendezvous</td>
<td>NO</td>
<td>ON</td>
<td>ON</td>
</tr>
</tbody>
</table>

### Near Term Capability - Late 1980's to Early 1990's

- **Ascent Shaping:** Q - 790 FLUTTER BUFFET, Q alpha - 1250;
- The quoted capability includes discounts for manager's reserve and for the crew escape system, SRB redesign, and orbiter modifications resulting from STS 51-L.

### Achievable Capability - Early to Mid 1990's

- **Ascent Shaping:** Q - 819 TPS, Q alpha - 3000; Performance increases by:
  - 1500 LBS @ ETR
  - 17,100 LBS @ WTR
- **Potential Weight Growth for CAT II Mods & Nominal Weight Growth in the 1990's:** Performance decreases by:
  - 1000 LBS @ BOTH SITES

### Potential Capability - Mid to Late 1990's

- Same as Achievable Capability Ground Rules
- **Advanced SRM:** 12,000 LBS as a performance increase design goal. For this assessment, we are assuming that the ASRM replaces the FW SRM.

### Note:
Each additional crew person beyond the five person standard is chargeable to the cargo weight allocation and will reduce the payload capability by approximately 500 pounds.
<table>
<thead>
<tr>
<th>O LRB BPM-1</th>
<th>O LRB BPM-2</th>
<th>O SPACE STATION MAX SSHE</th>
</tr>
</thead>
<tbody>
<tr>
<td>104% SSHE 62500</td>
<td>104% SSHE 67500</td>
<td>100% SSHE 68470</td>
</tr>
<tr>
<td>104% SSHE 52030</td>
<td>104% SSHE 57030</td>
<td>100% SSHE 58000</td>
</tr>
<tr>
<td>INCREASED PERFORMANCE GOAL</td>
<td>DELTA FROM ASRM</td>
<td>COMMENTS</td>
</tr>
<tr>
<td>12000</td>
<td>-</td>
<td>PE., ALDRICH MEMO</td>
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<tr>
<td>12000</td>
<td>12000</td>
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<tr>
<td>7500</td>
<td>-4500</td>
<td>100P LRPBM-1</td>
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<tr>
<td>22500</td>
<td>10500</td>
<td>100P LRPBM-2</td>
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<td>22500</td>
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</tr>
<tr>
<td>21970</td>
<td>9970</td>
<td>PE., PPCB OR 403138</td>
</tr>
<tr>
<td>17970</td>
<td>5970</td>
<td>PE., PPCB OR 403138</td>
</tr>
</tbody>
</table>

* LIMITED TO 50,000 LB BY MAXIMUM AOA DOWNWEIGHT CONSTRAINT
** LIMITED TO 50,000 LB BY CONTINGENCY PAYLOAD RETURN DOWNWEIGHT CONSTRAINT

PE., PPCB OR 403138
RECOMMENDATIONS

O RETAIN 69KLB TO 160 NM CARGO WEIGHT FOR LRB BRM-2 TO REPRESENT MAXIMUM
SPACE STATION PERFORMANCE CAPABILITY (EQUIVALENT TO 70KLB TO 150 NM)

O REVISE LRB BRM-2 CARGO WEIGHT TO REFLECT ASRM DESIGN PERFORMANCE GOAL
(62500 LB TO 160 NM)
JSC/LEMSCO TOOLS

- SIX DEGREE-OF-FREEDOM (DOF) TRAJECTORIES ARE GENERATED USING SPACE VEHICLE DYNAMICS SIMULATION (SVDS) PROGRAM WHICH IS USED FOR ASCENT FLIGHT DESIGN AND ANALYSIS AT THE JOHNSON SPACE CENTER ON UNISYS 1100 SERIES COMPUTER SYSTEM
  -- LRB/STS AERO DATABASE CAN BE IMPLEMENTED INTO SVDS, BUT WILL REQUIRE MODIFICATIONS TO THE AERO DATA PROCESSOR TO CREATE DATABASE
  -- GN&C FLIGHT SOFTWARE IS MODELLED IN SVDS
  -- MODIFICATIONS TO THE GN&C FLIGHT SOFTWARE IN SVDS CAN BE MADE FOR LRB/STS INTEGRATED STACK
  -- FORCE, MOMENT, C.G. AND ASCENT TRAJECTORY PARAMETERS TIME HISTORIES ARE OUTPUT FOR USE IN THE LOADS ANALYSIS PROGRAMS

- ORTHOGONAL AND STRUT LOADS CAN BE COMPUTED USING LOAD-CONVERT (LDCON) PROGRAM ON THE JSC/ADVANCED PROGRAMS OFFICE (APO) HARRIS-800 COMPUTER SYSTEM
  -- CURRENT ORTHOGONAL AND STRUT LOADS EQUATIONS CAN BE EMPLOYED IF LRBs ARE SIZED THE SAME AS CURRENT SRBs
  -- NEW ORTHOGONAL AND STRUT LOADS EQUATIONS WOULD HAVE TO BE DEVELOPED IF SIZING DIFFERENCES TO THE CURRENT STACK ARE INTRODUCED

- SHUTTLE LOAD INDICATOR (SLI) ANALYSIS CAPABILITIES EXIST USING JSC/APO SLI PROGRAM (ALSO ON THE HARRIS-800 SYSTEM)
  -- SLI PROGRAM ALGORITHMS CAN BE MODIFIED TO REFLECT NEW ALGORITHMS AND/OR NEW ALGORITHM COEFFICIENTS GENERATED VIA RESULTS FROM NASTRAN ANALYSIS AND EMPIRICAL TESTING
Current loads analysis data processing:

- **SVDS 6-DOF Simulation**
  - 81 parameters required for strut load computations

- **Load-Convert Program**
  - 91 parameters required for shuttle loads analysis

- **SLI Program**
  - Loads analysis mach range 0.6 - 2.2
NEW DATA REQUIRED FROM AN OUTSIDE SOURCE

- **SVDS - SIX-DOF ASCENT TRAJECTORY SIMULATION**
  -- LRB/STS AERO DELTA COEFFICIENTS (FROM MSFC)
  -- ESTIMATE OF C.G. FOR DRY LRBs (FROM MARTIN AND GENERAL DYNAMICS)
  -- ESTIMATE OF C.G. VS WEIGHT HISTORY OF EACH LRB TANK (FROM MARTIN AND GENERAL DYNAMICS)

- **LDCON - ORTHOGONAL & STRUT LOADS CALCULATION PROGRAM**
  -- STRUT LENGTHS AND GEOMETRY (FROM MARTIN AND GENERAL DYNAMICS) IF DIFFERENT FROM CURRENT STS
  -- AERODYNAMIC DATA FROM EMPIRICAL WIND TUNNEL TESTING (FROM MSFC)

- **SLI - SHUTTLE LOAD INDICATOR ANALYSIS PROGRAM**
  -- NEW LOAD INDICATOR COEFFICIENTS AND/OR ALGORITHMS FROM NASTRAN ANALYSIS AND EMPIRICAL WIND TUNNEL TESTING FOR ORBITER, ET AND LRBs (FROM LMSC/HUNTSVILLE)
LOADS ANALYSIS RECOMMENDATIONS

- USE SIMPLE LOAD INDICATORS FOR TESTING ALL CANDIDATE LRB/STS DESIGN CONFIGURATIONS
  -- ELEMENT WING ROOT BENDING, SHEER AND TORSION EQUATIONS
  -- ELEMENT TAIL ROOT BENDING, SHEER AND TORSION EQUATIONS

- PERFORM COMPLETE 6-DOF SHUTTLE LOADS INDICATOR ANALYSIS ON DESIGN FINALISTS
  -- JUST PRIOR TO DOWN-SELECT TO ASSIST IN DECISION PROCESS ON CLOSE CALLS
  -- AFTER DOWN-SELECT ON ALL DESIGN CONFIGURATIONS
LRB/STS SYSTEMS INTEGRATION TASK STATUS
PRESENTATION OVERVIEW

- STUDIES CONDUCTED
  --SUMMARY (Carter)
  --PERFORMANCE TRENDS (Kelly)
  --LOADS ANALYSIS CAPABILITIES (Fardelos)

- LRB ABORT CAPABILITIES SUMMARY (Blumentritt)

- INTEGRATION ISSUES (Akkerman)

- FY 88 MAJOR TASKS/SUBTASKS (McCurry)

- FY 88 SCHEDULE (McCurry)
SUMMARY

- **STS-26 CYCLE 1B**
  -- SIMULATION AND OPTIMIZATION OF ROCKET TRAJECTORIES (SORT)
  -- CONCEPTUAL ABORT REGION DETERMINATOR (CARD)
  -- SPACE VEHICLE DYNAMICS SIMULATION (SVDS)

- **"LAB RAT" BOOSTER (W. Kelly/LEMSCO)**
  -- PUMP-FED, LOX/METHANE
  -- SIZED ON IDEAL VELOCITY REQUIREMENTS (BURN TIME = 140 sec)
  -- T/W = 1.25 @ L.O.; 5 ENGINES (400K lbf CLASS)
  -- TOTAL THRUST PER BOOSTER = 1.8 Million lbf

- **"LAB RAT" BOOSTER**
  -- SORT/CARD

- **MARTIN MARIETTA CONFIGURATION # 1**
  -- SORT/CARD

- **MARTIN MARIETTA CONFIGURATION # 1, USING THE LRB BASE REFERENCE MISSION #2 (69K lbf TO 160 nm)**
  -- SORT
INTEGRATION ISSUES

- SYSTEM INTERFACES/AUTONOMY
- AERODYNAMIC LOADS
- LOAD PATHS/LOAD LIMITS
- ABORTS
- OPERATIONAL ISSUES
- ENVIRONMENTAL IMPACTS
- GROWTH POTENTIAL
SYSTEM INTERFACES/AUTONOMY

- ELECTRICAL POWER
  --NUMBER OF CIRCUITS
  --POWER AVAILABLE
  --ENERGY AVAILABLE

- AVIONICS
  --GN&C
  --EVENT SEQUENCING
  --TELEMETRY
  --HEALTH MONITORING
  --PROPELLANT UTILIZATION

- TVC
  --SUPPORTING SUBSYSTEM REQUIREMENTS
    • APU/HPU
    • FLEX LINES
    • GIMBAL HARDWARE
    • LIQUID INJECTION SYSTEMS
    --CONTROLLER LOGIC/MIXING
    --FAILURE IMPLICATIONS (ACTIVE/PASSIVE)
AERODYNAMIC LOADS

- STS PERFORMANCE TYPICALLY COUPLED TO LOADS
- LRB SIZE COUPLED TO STS PERFORMANCE AND STS LOADS
- PERFORMANCE INCREASE REQUIRED
- LOAD REDUCTION DESIRED
- REQUIREMENT APPEARS TO CONFLICT WITH DESIRE

- FACTORS
  --WING LOADING IS DOMINANT CONSTRAINT
  --ANGLE-OF-ATTACK (ALPHA) CAN BE ADJUSTED
  --DYNAMIC PRESSURE (Q, BAR) CAN BE ADJUSTED
  --BOOSTER GEOMETRY CAN BE ADJUSTED

- STATUS: PERFORMANCE INCREASE APPEARS TO BE ACHIEVABLE WITH LOAD REDUCTION
LOAD PATHS/LOAD LIMITS

- BOOSTER LOADS
  - STACK WEIGHT (PRESSURE-FED VS. PUMP-FED)
  - ATTACH-STRUT LOADS
    - THERMAL
    - PRESSURE
  - TWANG ABATEMENT (START-UP/SHUT-DOWN/LIFT-OFF)
  - ACOUSTIC/OVERPRESSURE/FLOW
  - RETRIEVAL/IMPACT LOADS

- ORBITER LOADS
  - TWANG REACTION LOADS
  - AERODYNAMIC-INDUCED LOADS

- ET LOADS
  - AFT LOX BULKHEAD
  - REACTION TO LRB THRUST LOADS (THRUST BEAM/INTERTANK PANELS)
ABORTS

- NO NEW ABORT MODES ARE PRESENTED

- LRB DESIGNED TO PROTECT FOR INTACT ABORTS, FOR ONE LRB ENGINE OUT AT LIFT-OFF**

- HOWEVER, ADDITIONAL OPPORTUNITIES TO USE CURRENT MODES

--PAD ABORT
  - WITH SSME OUT
  - WITH LRB ENGINE OUT**

--INTACT ABORT
  - WITH SSME OUT
  - WITH LRB ENGINE OUT**
    --RTLS, TAL, ATO, AOA

--ENHANCED NON-INTACT ABORTS
  - EXPAND SPLIT-S COVERAGE
  - IMPROVE FAST-SEP. CONDITIONS

** IF MULTIPLE ENGINES PER BOOSTER
ABORTS (CONCLUDED)

- EXTRA LRB/STS PERFORMANCE PROVIDES:
  --LATER NEGATIVE RETURN (LAST RTLS)
  --EARLIER PRESS-TO-TAL
  --EARLIER PRESS-TO-ATO
  --EARLIER PRESS-TO-MECO
  --OVERLAP OF ATO & RTLS MAY ELIMINATE TAL COVERAGE REQUIREMENT (FROM PERFORMANCE STANDPOINT)
OPERATIONAL ISSUES

- LAUNCH PROBABILITY (PRESENTLY ABOUT 85%)
  --WINDS ALOFT DRIVE Q.BAR, Q.BAR-ALPHA, SIDESLIP
  --DOWN-RANGE WEATHER

- EFFECTS OF LAUNCH SLIPS
  --STS IMPACTS (LITTLE "SLACK TIME" FOR MAKE-UP)
  --INTERFACING PROGRAM IMPACTS

- MISSION DESIGN/FLIGHT OPERATIONS
  --GENERIC MISSIONS (INCREASED PERFORMANCE ENVELOPE)
  --TIMING/DAY-OF-LAUNCH FLEXIBILITY
  --REDUCED RECONFIGURATION LEAD TIME

- TURNAROUND SEQUENCING/TIMELINE
  --VAB SCHEDULE
  --SAFETY CONSTRAINTS
ENVIRONMENTAL IMPACTS

- BECOMES MORE AN ISSUE DAILY
  --MORE PEOPLE/CLOSER
  --LAUNCH FACILITY/TEST FACILITY

- SRBs GENERATE PROBLEMS
  --NORMALLY "ON COMMAND"
  --ACCEPT RESULTS RATHER THAN CONSTRAIN ON TIME & WINDS

- HYPERGOLICS DO NOT GENERATE AS MUCH OF A PROBLEM, BUT
  --SPILLS CAN BE UNTIMELY
  --EFFECTS MORE SPECTACULAR AND FAR-REACHING

- LOX/HYDROCARBON MOST COMPATIBLE FLUIDS
  --SPILLS CAN BE A PROBLEM
  --EFFECTS MORE LOCALIZED
  --NORMAL OPERATION ENTIRELY ACCEPTABLE
GROWTH POTENTIAL

- PERFORMANCE MARGIN NORMALLY USED FOR OTHER BENEFITS
  CAN BE USED OCCASIONALLY FOR HEAVY LOADS
  --FLY HIGHER Q.BAR
  --ACCEPT REDUCED ABORT MARGINS
  --ACCEPT HIGHER SSME STRESS/WEAR
  --ACCEPT LOWER LAUNCH PROBABILITY
  --ACCEPT LAUNCH DATE/TIME CONSTRAINTS
  (GO BACK TO TODAY'S MODE OCCASIONALLY)

- PRODUCT IMPROVEMENT FEATURES
  --METALIZED PROPELLANTS
  --TANK QUALITY/OPERATING PRESSURE INCREASES
  --BURNER EFFICIENCY IMPROVEMENTS
  --PRESSURIZATION SYSTEM REFINEMENTS

- CARGO CARRIER FOR HAZARDOUS MATERIALS/BULK ITEMS

- POTENTIAL USE WITH OTHER CORE VEHICLES (MULTIPLE UNITS)
FY 88 MAJOR TASKS/SUBTASKS

(1) SYSTEM INTERFACE TRANSACTION IDENTIFICATION & ANALYSIS

(2) ASCENT/ABORT PERFORMANCE ANALYSIS

(3) SYSTEMS INTEGRATION ANALYSIS OF CANDIDATE LRB DESIGNS

(4) LRB PROGRAMMATIC ANALYSIS

(5) FLIGHT PLANNING/MISSION OPS. ANALYSIS

(6) AERO LOADS ANALYSIS
    --ANALYSIS TOOL MODIFICATION
    --LOADS ANALYSIS/VERIFICATION
    --ORBITER STRUCTURES ASSESSMENT
FY 88 MAJOR TASKS/SUBTASKS (CONTINUED)

(7) STS AERO DATABASE MODIFICATION
   --ANALYSIS TOOL MODIFICATION
   --DATABASE MODIFICATION/VERIFICATION

(8) VEHICLE SIMULATION TOOL MODIFICATION/VERIFICATION
   --3-DOF TOOLS
   --6-DOF TOOLS

(9) HOLD-DOWN/LAUNCH DYNAMICS ANALYSIS

(10) HEATING ANALYSIS
     --AERO HEATING
     --PLUME HEATING

(11) SEPARATION DYNAMICS ANALYSIS
     --ANALYSIS TOOL DEVELOPMENT
     --DYNAMICS ANALYSIS
FY 88 MAJOR TASKS/SUBTASKS (CONTINUED)

(12) ROCKWELL (DOWNNEY) INTEGRATION ASSESSMENT
----CERTIFICATION PLAN DEVELOPMENT (MATED-VEHICLE)
----VALIDATION OF JSC INTEGRATION ASSESSMENT (MATED-VEHICLE)
----AERO LOADS ANALYSIS SUPPORT

(13) STSOC INTEGRATION ASSESSMENT
----FACILITIES/RESOURCES IMPACT ASSESSMENTS (COMPLETION-FORM & LOE)

(14) MARTIN MARIETTA MICHOUD INTEGRATION ASSESSMENT
----ET STRUCTURES/SYSTEMS IMPACT ASSESSMENTS

(15) PHASE A INTEGRATION REPORT
----PRELIMINARY REPORT
----FINAL REPORT

(16) LRB PHASE B RFP DEVELOPMENT

(17) LAUNCH VEHICLE INPUT/OUTPUT SYSTEMS ANALYSIS TEMPLATE DEVELOPMENT
FY 88 MAJOR TASKS/SUBTASKS (CONCLUDED)

(18) LRB APPLICATIONS ANALYSIS FOR ADVANCED LAUNCH VEHICLES
     --CORE VEHICLE SIZING CONFIGURATION & PERFORMANCE ANALYSIS
     --LRB SYSTEM REQUIREMENTS ANALYSIS
     --LRB/CORE VEHICLE INTERFACE REQUIREMENTS ANALYSIS
     --PROGRAMMATIC ANALYSIS

(19) LRB UTILIZATION TRADE STUDIES

(20) SRB UTILIZATION/DESIGN IMPROVEMENTS
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<tr>
<th>MILESTONES</th>
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Note: ORIG. APPL. 11/24/87  LAST CHANGE 12/02/87
Page 3 of 3 STATUS AS OF 12/02/87

Johnson Space Center - Houston, Texas

J.B. McCurry/LEMSCO 12/16/87
ASCENT PERFORMANCE TRENDS FROM PARAMETRIC STUDIES

- PROCEDURES
- TOOLS EMPLOYED
- SELECTED RESULTS
PERFORMANCE, COST AND TECHNOLOGY RISKS

- PERFORMANCE DEFINED BY MINIMUM REQUIREMENTS ON TWO POINT DESIGNS AT 28.5 DEGREE INCLINATION 150-NMI ORBIT
  -- 70K-LBM PAYLOAD AT 100% SSME THROTTLE
  -- 59K-LBM PAYLOAD AT 104% SSME THROTTLE

- COST REQUIREMENTS ARE BASED PREDOMINANTLY ON MINIMIZING COST PER FLIGHT AND DDT&E

- ADVANCED TECHNOLOGY TENDS TO DRIVE UP DDT&E WHILE COSTS PER FLIGHT ARE UNCERTAIN
  -- THEN WHY CONSIDER ADVANCED TECHNOLOGY?

- POSSIBLE ADVANCED TECHNOLOGY PAYOFFS:
  -- PROVIDING MORE BENIGN ORBITER ASCENT ENVIRONMENT (E.G. LOWER DYNAMIC LOADS, LESS FREQUENT SSME OVERHAUL, ETC.)
  -- OPPORTUNITIES FOR SYSTEM GROWTH (E.G. NOMINAL REQUIREMENTS ACHIEVED WITH FUEL OFFLOAD, AND FLAT PERFORMANCE CURVES FOR ALTITUDE AND INCLINATION VARIATIONS)

- LOW TECHNOLOGY DISADVANTAGES:
  -- POSSIBLE COMBINATION OF DISADVANTAGES OF SOLIDS AND LIQUIDS
  -- GROWTH MARGINS BECOME SMALLER
LAUNCH

- Interactive, inputs adjust Shuttle or SDV SRB/LRB defaults

- Static thermodynamic engine analysis to determine liquid engine parameters by fuel type, mixture ratio, chamber pressure and nozzle expansion with one dimensional equilibrium flow calibrated with recent design studies.

  Reference: AIAA 83-1189, W. Kelly

- 3-DOF trajectories, closed or open loop throttle and pitch profiles, iterative (3-5 trials) upper stage guidance based on analytical partials in earth relative frame to minimum fuel target (h,v, γ).

  Reference:

  MSFC TMX-53464, 25 May 1966, L. R. Dickey

P3DLN

- Interactive, inputs adjust shuttle or other vehicle defaults.

- Fewer engine analysis features than LAUNCH program

- More comprehensive and accurate trajectory and targeting with rapid convergence in inertial frame, analytical partials for choices among 13 target parameters.

- Applications: dog-leg ascent maneuvers west coast launches, winds and no winds effects.
LRB PERFORMANCE CALCULATION RUDIMENTS

\[ \frac{m_{\text{MECO}}}{m_{\text{ig}}} = \exp(-\Delta v_{\text{ideal}}/g \ I_{\text{sp,eff}}) \]

\[ \Delta v_{\text{ideal}} = f(v_i, v_o, \Delta v_{\text{grav}}, \Delta v_{\text{eng}}, \Delta v_{\text{drag}}, \Delta v_{\text{tv}}, v_i - v_o + \sum \Delta v_i) \]

\[ v_i = 25,680 \text{ fps} \quad v_o = 1337 \text{ fps} \quad \Delta v_{\text{grav}} > 4000 \text{fps} \quad \Delta v_{\text{ideal}} > 29000 \]

\[ \Delta v_{\text{ideal}} = \Delta v_{\text{ideal-1}} + \Delta v_{\text{ideal-2}} \quad \Delta v_{\text{ideal-2}} > 20,000 \text{ fps}. \]

\[ \frac{m_{\text{MECO}}}{m_{\text{sep}}} = \exp(-\Delta v_{\text{ideal-2}}/g I_{\text{sp,SSME's}}) \quad \frac{(T/W)_{\text{sep}}}{(3 \text{SSME*throttle)/wgt}} > 1.0 \]

\[ = \frac{(m_{\text{orb}} + m_{\text{pl}} + m_{\text{ET}} + m_{\text{prop,margin}})/(m_{\text{orb}} + m_{\text{pl}} + m_{\text{ET}} + m_{\text{prop,sep}})}{\text{fixed variable fixed variable}} \]

\[ m_{\text{sep}}/m_{\text{ig}} = \exp(-\Delta v_{\text{ideal-1}}/g I_{\text{sp,av}}) \]

\[ = (m_{\text{orb}} + m_{\text{pl}} + m_{\text{ET}} + m_{\text{prop,sep}} + m_{\text{Srb/Lrb}})/(m_{\text{orb}} + m_{\text{pl}} + m_{\text{ET}} + m_{\text{prop}} + m_{\text{Srb/Lrb}} + m_{\text{prop,boosters}}) \]

\[ (T/W)_{\text{ig}} > 1.1 \text{ or } 1.2 \quad Q_{\text{max}} > 700 \text{ or } 750 \text{ psf.} \]
INTRODUCTION TO PLOTS OF PERFORMANCE TRENDS

- THE MAJORITY OF FIGURES WERE GENERATED WITH LAUNCH PROGRAM ON IBM-COMPATIBLE PC WITH LOTUS 1-2-3 PLOT PACKAGE

- THE AIM OF THE PROGRAM: TO CONNECT SIMPLE TRAJECTORY, GUIDANCE AND ENVIRONMENT MODELS WITH SIMPLE PROPULSION, STRUCTURES AND OTHER DESIGN FORMULATIONS IN A PRELIMINARY DESIGN SCHEME

- WHILE LAUNCH SIMULATIONS ARE ACKNOWLEDGED AS ONLY CUTS ABOVE STATIC CALCULATIONS, THE PROGRAM CAN ACT AS A FIRST PASS FILTER FOR CONFIGURATIONS BEFORE MORE DETAILED MODELING

- TRAJECTORY AND PARAMETRIC PLOTS DISPLAY DATES GENERATED (JULY-SEPTEMBER 87) TO TRACK
  --SIMULATION FEATURES, INPUT AND OUTPUT CORRECTIONS
  --METHOD USED TO DETERMINE MINIMUM LRB PERFORMANCE REQUIREMENTS

- WHILE LITERAL ADAPTATION OF TRAJECTORY DATA DERIVED IN THESE BROAD ANALYSES COULD VIOLATE MANY STS CONSTRAINTS DISCUSSED ELSEWHERE, IT IS POSSIBLE THAT MANY VIOLATIONS COULD BE ALLEVIATED IN SUBSEQUENT FOCUSED STUDIES
28OCT87 CH4 LRB IDEAL VELOCITY SIZING

GROSS LIFT-OFF WEIGHT (LBS) (MILLIONS)

SECOND STAGE IDEAL VELOCITY (FPS)

0 31K + 31.5 o 32K
28oct87 CH4 LRB IDEAL VELOCITY SIZING
28OCT87 CH4 LRB IDEAL VELOCITY SIZING

DYNAMIC PRESSURE MAXIMUM (PSI)

SECOND STAGE IDEAL VELOCITY (FPS)

\[ \text{20.8, 21, 21.2, 21.4, 21.6, 21.8, 22} \]
LRB ENGINE PERFORMANCE - ILLUSTRATIVE EXAMPLE

VARIED MIXTURE RATIO AND CHAMBER PRESSURE EFFECTS

LIQUID CH₄·O₂  5.5 PSI FIXED EXIT PRESSURE

2.0 < MIXTURE RATIO < 4.0  1000 < Pc < 4000 psi.

Maxima

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<th>MR</th>
<th>lsp vac</th>
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SUMMARY AND CONCLUSIONS

- WITHOUT A DIRECTED SEARCH THROUGH PARAMETRIC BOOSTER CONFIGURATIONS, THE LIKELIHOOD OF DESIGNING A SATISFACTORY BOOSTER IS DECREASED.

- "LOW TECHNOLOGY" SRB EMULATORS CANNOT MEET SRB VOLUME LIMITS WITH LIQUID FUELS AND "HIGH TECHNOLOGY" (OR EXCESS LIFT) SOLUTIONS SHIFT TRAJECTORIES INTO NEW REGIONS.

- FOR PERFORMANCE ANALYSIS CONFIGURATION SEARCH TRADES CAN BE MADE ON LEVEL OF SIMULATION DETAIL VS. NUMBER OF CONFIGURATIONS STUDIED.
VOLUME IV

SECTION 2

INTEGRATED WORKING GROUP MEETING

January 20, 1988
LIQUID ROCKET BOOSTER (LRB)
KSC IMPACT
TECHNICAL WORKING GROUP MEETING AT KSC

ADVANCED PROJECTS & TECHNOLOGY OFFICE

KSC

80113-01G

JAN. 20, 1988
G. ARTLEY

Lockheed
Space Operations Company
AGENDA

• INTRODUCTION  GORDON ARTLEY
• BASELINE  L. PAT SCOTT
• REQUIREMENTS  R. KEITH HUMPHRIES / STEVE BLACK
• IMPACTS  GREGORY DEBLASIO / ROGER LEE
• SUMMARY  GORDON ARTLEY
• SPLINTER MEETING  JAN. 21, 1988 1430 HRS
LIQUID ROCKET BOOSTER (LRB)
KSC IMPACT

JAN. 20, 1988
G. ARTLEY

KSC LRB INTEGRATION STUDY
MONTHS - BASIC + OPTION

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LRB INTEGRATION SCHEDULE
OBJECTIVES

• DEFINE SRB BASELINE

• DISCUSS LRB REQUIREMENTS/SCENARIOS

• IDENTIFY MAJOR LAUNCH SITE IMPACTS
AGENDA

• INTRODUCTION  GORDON ARTLEY

• BASELINE  L. PAT SCOTT

• REQUIREMENTS  R. KEITH HUMPHRYES / STEVE BLACK

• IMPACTS  GREGORY DEBLASIO / ROGER LEE

• SUMMARY  GORDON ARTLEY
SRB BASELINE

TASK 1

OUTLINE

- SRB BASELINE FLOW OVERVIEW
- GENERIC SRB FLOW PROJECTED TO 1993
- MINI-SCHEDULES EACH SRB FACILITY
- SRB MULTIFLOW 93-94 TIME FRAME
- FACILITY PLANNING/UTILIZATION/CONSTRAINTS
- GSE FOR SRB PROCESSING/OMI PROCEDURES
- TRANSITION PLANNING (94-98)
BASIS FOR:

- COST DELTAS AND MANPOWER ASSESSMENTS
- FACILITY EVALUATIONS (INCLUDING MODS)
- TRANSITION PLANNING (FOR MIXED FLEET OPS)
- DEVELOPMENT OF LRB FLOW SCHEDULES
## 1994 SRB Processing Baseline Summary

### (97 Day Flow)

**18 January 1988**

<table>
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<th>DAYS</th>
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| 4 | 3 | 2 | 1 |

### Aft Skts AT RPSF

| 17 | Booster Buildup - RPSF |

| 12 | 6 | Inspection/Offload - RPSF |

| 21 | Stack - VAB |

### Fwd Skt Aisle Xfer

| 13 | ET MATE & C/O - VAB |

| 5 | Integrated Operations - VAB |

| 15-16 | Pad Operations |

| 7 | Retrieval Operations |

| 10 | Parachutes to PRF |

### Disassembly Operations

| 10 | Fwd Skt Xfer to USBI Refurb |

| 10 | Aft Skt Xfer to USBI Refurb |

| 10 | Start Seg Xfer |

| 10 | Spent Seg Onload to Railcars |

### Note:

- Remanufacturing at Utah Not Shown
- USBI Refurb ARF and Parachute Repack Not Shown
### SRB Inspection/Offload Baseline for 1994

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- **LFC Inspection/Offload**: Complete on 20 Jan 1994
- **Horizontal Grain Inspection (Local Clear)**
- **Video Inspection Tack (Local Clear)**
- **Offload/Rotation/Ring Removal (Local Clear)**
- **NDE Testing Tack (Local Clear)**
- **Lower Tack Inspection (Local Clear)**
- **Xfer to Pallet/Ring Removal (Local Clear)**
- **Top Tack Insp (Local Clear)**
- **Xfer to Surge/VAB (Local Clear)**

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**Original Page Quality**: 80113-01Q

**Space Operations Company**
SRB STACKING/JOINT CLOSEOUT

SRB STACK BASELINE FOR 1994

15 JANUARY 1988

| DAYS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| SHIFTS | LAB STACK | LAB HARDWARE INSTALL/TENSION | FAB HARDWARE INSTALL/TENSION | LAC STACK | LAC VAB XFER AISLE OPS (LOCAL CLEAR) | LAC VAB HI-BAY OPS (TOTAL CLEAR) | LAC VAB HI-BAY OPS (LOCAL CLEAR) | RAC STACK | LFC STACK | RFC STACK | LF STACK | RF STACK | LFA MATE | RFA MATE | PLATFORM MATE | SBG ALIGNMENT | SRB JOINT CLOSEOUT | ET MATE PREPS | READY FOR SRB/ET MATE |
| XFER AISLE OPS | DEPLOY ENCLOSURE/EST PURGE | TANG/CLEVIS/CLEAN/REGREASE | V2 FILLER/0' RING INSTL | APPLY J-SEAL ADHESIVE | LEVEL SEB/MATE/PIN | VAB HI-BAY OPS (TOTAL CLEAR) | J-SEAL INSPECTION | JOINT LEAK CHECK | VAB HI-BAY OPS (LOCAL CLEAR) | SRB JOINT CLOSEOUT | HEATER STRIP INSTL | TEMP SENSOR INSTL | WEATHER SEAL INSTL | HEAT CONFIDENCE TEST | CORK INSTL | KSGA APPLICATION |

Page 1 of 1

80113-01S

Space Operations Company
# ET/SRB MATE & CLOSEOUT

**ET/SRB MATE & CLOSEOUT BASELINE FOR 1994**

**15 JANUARY 1988**

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### GENERIC PAD OPERATIONS FOR 1994

**18 JANUARY 1988**

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**Page 1 of 1**
# SRB RETRIEVAL/DISASSEMBLY BASELINE FOR 1994

15 JANUARY 1988

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<td>▲ OFFLOAD CHUTES &amp; FRUSTRUM</td>
<td>▲ OFFLOAD SB/PLACE ON DOLLIES/H2N4 LK CK</td>
<td>▲ RMV FWD SKIRT/FLT RECORDERS</td>
<td>▲ SRB WASHTOWN/PREPS FOR DISASSY</td>
<td>▲ INITIAL TPS PNVL</td>
<td>▲ NOZZLE DEMATE</td>
<td>▲ AFT SKT DEMATE/XFER TO USBI</td>
<td>▲ REM ETA RING CVRS</td>
<td>▲ REM CABLES</td>
<td>▲ REM AFT IEA/INSPI &amp; CLEAN CONN</td>
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SRB MULTIFLOW
'93-'94 TIMEFRAME

EXAMPLE MULTIFLOW (STS-080)
SEPT 1993 LAUNCH
OMIs FOR SRB PROCESSING

• RPSF
  • B5308 - SRB ROTATION, PROCESSING AND SURGE FACILITY (RPSF) OPERATIONS
  • B5309 - AFT BOOSTER ASSEMBLY - RPSF
  • B5305 - AFT BOOSTER ASSEMBLY ELECTRICAL BUILDUP

• VAB
  • B5303 - STACKING AND ALIGNMENT OPERATIONS
  • B5307 - SRB CABLE INSTALLATION/CHECKOUT AND PRE-POWER ELECTRICAL CHECKS
  • B1009 - SRB TVC/GSE CONNECTION (VAB/PAD) - (LPS)
  • B1019 - SRB GSE HYDRAULIC SYSTEM DISCONNECT/CLOSEOUT
  • B7009 - SRB HOLDDOWN STUD TENSION INTEGRITY VERIFICATION
  • B5304 - SRB SYSTEMS INSTALLATION AND CLOSEOUT, PRE-ET MATE

• PAD
  • B1016 - SRB HYDRAZINE SERVICING
  • B2038 - HYDRAZINE SERVICE CART LOADING AND DRAIN
  • B1037 - SRB AFT SKIRT PURGE SYSTEM CONNECTION AND C/O
  • B2040 - SRB TVC/APU LUBE OIL SERVICE - PAD
  • B5306 - SRB POST-ET MATE AND PAD CLOSEOUT
**LRB TRANSITION PLANNING**

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**ISSUES:**

- IMPACTS TO ON-GOING LAUNCH OPERATIONS
- FACILITY/GSE ACTIVATION/MODS TO SUPPORT 94 LRB LAUNCH
- INTEGRATION OF LRB WITH OTHER PROGRAM CHANGES (STS-C, SPACE STATION, ETC)
- FULL ACTIVATION OF LRB SUPPORT SYSTEMS REQUIRED PRIOR TO INITIAL LAUNCH
- FEASIBILITY OF MIXED FLEET LAUNCHES
NEAR-TERM GOALS FOR BASELINE TASK

JAN. 20, 1988
P. SCOTT

- DEVELOP COSTS/MANPOWER PARAMETERS FOR BASELINE SRB FLOWS
- BEGIN LRB FLOW MODELLING
- INTEGRATE PHASE A CONTRACTOR DATA FROM DOWN-SELECT CHECKLIST
- EVALUATE ON-GOING LAUNCH IMPACTS
AGENDA

- INTRODUCTION
  GORDON ARTLEY

- BASELINE
  L. PAT SCOTT

- REQUIREMENTS
  R. KEITH HUMPHRYES / STEVE BLACK

- IMPACTS
  GREGORY DEBLASIO / ROGER LEE

- SUMMARY
  GORDON ARTLEY
TASK II LRB REQUIREMENTS

APPROACH

- DEVELOP CHECKLIST
  - BY AREAS OF IMPACT
  - BY SYSTEM

- CHECKLIST TO PHASE A CONTRACTORS
  - EACH CANDIDATE CONFIGURATION

- ANALYZE CHECKLIST RESPONSES
  - COMMON
  - UNIQUE
LIQUID ROCKET BOOSTER (LRB)
INTEGRATION STUDY
JAN. 20, 1988
K. HUMPHRYES

RECEIVING/HANDLING
- TRANSPORTATION TO THE SITE OF ELEMENTS
- RECEIVING AREA(S)
- HANDLING OF ELEMENTS
- STORAGE OF ELEMENTS
- ELEMENT REQUIREMENTS
  - GSE
  - ELECTRICAL POWER
  - ENVELOPE

ASSEMBLY
- ASSEMBLY AREA(S)
- HANDLING
- SHOPS
- LRB REQUIREMENTS
  - GSE
  - ELECTRICAL POWER
  - TOOLING
  - STORAGE
  - TEST REQUIREMENTS
  - ENVELOPE

INTEGRATION
- STACKING/MATING
- HANDLING
- ALIGNMENT
- LRB REQUIREMENTS
  - GSE
  - ELECTRICAL POWER
  - INTERFACE REQUIREMENTS
  - COMMUNICATIONS
  - STRUCTURE/ACCESS REQ

TEST/CHECKOUT
- END-TO-END REQUIREMENTS
  - CONTINUITY
  - LEAK CHECK
- FR IPS(SW) REQUIREMENTS
- GREISTE TEST EQUIPMENT
- COMMUNICATIONS
- STRUCTURAL/ACCESS REQ

ABORT/SCRUB
- TURNAROUND REQUIREMENTS
- FIRING ROOM
  - LAUNCH COMMAND CRITERIA
  - GPS SEQUENCER
  - DETANKING/SAFING PROCEDURES
  - SAFETY
  - COMMUNICATIONS
  - CERTIFICATION/TRAINING

FRF REQUIREMENTS
- HOLDOWN
- EXCURSIONS
- PROCEDURES
- FIRING ROOM REQ
- ADDITIONAL INSTRUMENTATION

LAUNCH
- SUPPORT SERVICING REQ
  - PROPELLANTS (TRANSFER/LOADVENT)
  - PNEUMATICS
  - INSTRUMENTATION
  - ELECTRICAL
  - UMILS/CABLES
  - HOLDOWN
  - ACCESS
  - SOUND SUPPRESSION

- STRUCTURAL REQUIREMENTS
- MLP
- ISS/SRS
- ADDITIONAL STRUCTURES
- ENVELOPE
- FLAME TRENCH
- LODD/FIRING ROOM
- LP(SW)/HW-M
- LAUNCH COMMAND CRITERIA
- GPS SEQUENCER
- SAFETY
- HDGS
- FIRE DETECTION
- FFSX
- RANGE SAFETY
- SITE SAFETY
- WEATHER PROTECTION
  - INTERFACE REQUIREMENTS
  - COMMUNICATIONS
  - EXCURSIONS
  - ICE INSPECTION

RECOVERY
- RECOVERY SHIP
  - GSE/TOOLS
  - SAFETY
  - HANDLING
  - COMMUNICATIONS
  - RTLS PROCEDURES

DISASSEMBLY/SAFEING
- HANDLING/ACCESS
- DISASSEMBLY AREA
- SAFEING AREA
- HAZARDOUS MAT DISPOSAL
- HAZARDOUS GAS DETECTION
  - GSE REQUIREMENTS
  - COMMUNICATIONS

REFURBISHMENT
- FACILITIES
  - SHOPS
  - HANDLING
  - GSE/TOOLS
  - DEWATERING/CLEANING
  - REPAIR REQUIREMENT FOR REUSABLE ELEMENTS

LRB CONFIGURATION EVALUATION AREAS OF IMPACT

80113-01K
TYPICAL CHECKLIST ITEMS

- RECEIVING/HANDLING
  - How will booster/components arrive?
  - What support equipment will be required at receiving area?

- ASSEMBLY
  - What level of assembly will be required at launch site?
  - Who will accomplish assembly?

- INTEGRATION
  - What fixtures are required to bring booster to vertical?

- TEST/CHECKOUT
  - What increase in data handling capability by the F/R will be required?

- LAUNCH
  - What is configuration of LRB tank vents?
TYPICAL CHECKLIST ITEMS (CONT'D)

- **RECOVERY**
  - WHAT ADDITIONAL SHIP SIDE EQUIPMENT WILL BE REQUIRED (POWER, PURGE, ETC.)?

- **DISASSEMBLY SAFING**
  - WHAT TYPE AND AMOUNT OF RESIDUALS NEED BE ADDRESSED AT GROUND RECOVERY AREA?

- **REFURBISHMENT**
  - WHAT WILL BE THE LEVEL OF REFURBISHMENT REQUIRED AT KSC?
LIQUID ROCKET BOOSTER (LRB)
KSC IMPACT

AGENDA

GORDON ARTLEY
L. PAT SCOTT
R. KEITH HUMPHRIES / STEVE BLACK
GREGORY DEBLASIO / ROGER LEE
GORDON ARTLEY

- INTRODUCTION
- BASELINE
- REQUIREMENTS
- IMPACTS
- SUMMARY
PROCESS OPERATION REQUIREMENTS

- INTRODUCTION
- LRB GROUND PROCESSING OVERVIEW
- TEST AND CHECKOUT OPERATIONS SUMMARY
- LRB VEHICLE DESIGN RECOMMENDATIONS FOR GROUND PROCESSING
- GROUND SYSTEMS DESIGN RECOMMENDATIONS FOR LRB
- ISSUES AND QUESTIONS
INTRODUCTION

THIS PRESENTATION IS BASED ON THE CONCEPT OF PROCESSING A MAJOR LIQUID FUEL PROPULSION SYSTEM AS AN STS FLIGHT ELEMENT THROUGH KSC. IT IS CONSISTENT WITH EXISTING STS LAUNCH OPERATIONS CONCEPTS AND BASED ON THE LESSONS OVER THE LAST 25 YEARS.
TEST AND CHECKOUT OPERATIONS SUMMARY RECOMMENDATIONS

• ENGINE SHOP
  • RECEIVE/INSPECT NEW DELIVERY ENGINES
  • PERFORM STAND ALONE ENGINE REFURBISHMENT, MAINTENANCE AND CHECKOUT

• LRB ASSEMBLY FACILITY
  • RECEIVE/INSPECT NEW DELIVERY LRB FLIGHT HARDWARE
  • PERFORM LRB SYSTEMS REFURBISHMENT, MAINTENANCE AND INDIVIDUAL SYSTEMS CHECKOUT
  • PERFORM LRB AFT/PROPULSION SYSTEMS BUILDUP* AND TEST (ENGINE AND LRB PROPULSION SYSTEM INTEGRATION)
  • PERFORM LRB INTEGRATED SYSTEMS TEST*

*ASSUMES LRB IS TRANSPORTED TO VAB AS COMPLETE ELEMENT
TEST AND CHECKOUT OPERATIONS SUMMARY RECOMMENDATIONS

• LRB CHECKOUT STATION
  • "MINI" LPS SYSTEM TO SUPPORT ALL LRB POST-FLIGHT SAFING, TEST AND CHECKOUT OPERATIONS UP TO READY FOR TRANSFER TO VAB.

• LRB RECOVERY FACILITY
  • INITIAL RECEIVING, INERT PROPELLANT SYSTEMS AND SAFE ORDNANCE.
  • POWER, DATA AND COMMAND CAPABILITY REQUIRED.
  • RECEIVE/INSPECT RETURN FROM FLIGHT HARDWARE AFTER INERT/SAFING
TEST AND CHECKOUT OPERATIONS SUMMARY RECOMMENDATIONS

- VAB (STS INTEGRATED) OPERATIONS
  - MATE LRB TO MLP
  - MATE ET TO LRBs
  - MATE ORBITER TO ET
  - PERFORM SHUTTLE INTEGRATED TEST TO VERIFY BASIC ORBITER/ET/LRB AND MLP AVIONICS/FLUIDS INTERFACES
• STS PRELAUNCH PAD OPERATIONS

  • PAD SHUTTLE INTERFACE TEST: VERIFY BASIC STS VEHICLE TO LAUNCH PAD FLUID, PROPELLANT AND AVIONICS INTERFACES.

  • SHUTTLE HYPERGOLIC PROPELLANT SERVICING: PERFORMS ORBITER OMS/RCS, APU PROPELLANT SERVICING AND LRB APU PROPELLANT SERVICING. (LRB HYPERGOL SERVICE)

  • TERMINAL COUNTDOWN DEMONSTRATION TEST: VERIFIES LAUNCH TEAM READINESS AND FLIGHT CREW TIMELINE. NO CRYOGENIC PROPELLANT LOAD OR APU ACTIVATION. AVIONICS ARE IN PRE-FLIGHT CONFIGURATION WITH GROUND LAUNCH SEQUENCER UNTIL CUTOFF DECLARED AT APPROXIMATELY T-5 SECONDS.

  • FINAL SHUTTLE ORDNANCE CONNECTION: PERFORMS ALL FINAL RANGE SAFETY, HOLDDOWN POST AND PAYLOAD ORDNANCE PRE-LAUNCH CONNECTIONS. ORBITER AND LRB AFT SECTIONS CLOSE-OUT FOR FLIGHT.
TEST AND CHECKOUT OPERATIONS SUMMARY RECOMMENDATIONS

- LAUNCH COUNTDOWN OPERATIONS
  - ORBITER/ET/LRB AVIONICS PREFLIGHT SYSTEMS ACTIVATION
  - ENGINE PREFLIGHT SYSTEMS ACTIVATION, SOFTWARE LOAD AND VERIFICATION
  - FINAL ORBITER CREW MODULE PREFLIGHT CONFIGURATION
  - ORBITER PRSD CRYOGENIC PROPELLANT SERVICING
  - ROTATING SERVICE STRUCTURE RETRACT
  - ET/LRB PROPELLANT SERVICE (IF LRB CRYOGENIC PROPELLANTS)
  - TERMINAL COUNTDOWN/LAUNCH
GROUND SYSTEMS DESIGN

RECOMMENDATIONS FOR LRB

- MAJOR NEW PROPELLANT LOADING SYSTEM REQUIRED AT PAD TO BE APPROXIMATELY SAME ORDER OF MAGNITUDE COMPLEXITY (OPERATIONALLY) REGARDLESS OF TYPE FUEL/OXIDIZER USED.

- LIFT OFF UMBILICALS TO PROVIDE GROUND POWER, COMMANDS AND DATA FOR PRE-LAUNCH MONITOR AND TEST.

- LRB RECOVERY AND TEAR DOWN FACILITY WILL REQUIRE SIGNIFICANT GSE TO SUPPORT COMMAND/DATA/POWER FOR INERT PURGING AND SAFING.

- LRB CHECKOUT STATION (MINI-CCMS/LPS) TO SUPPORT ALL LRB RECOVERY, BUILDUP AND PRE-VAB (MATE) TEST ACTIVITIES.

- LCC/LPS BE EXPANDED TO INCORPORATE NEW FIRINGROOM CONSOLES AND ASSOCIATED HARDWARE/SOFTWARE TO ACCOMMODATE LRB AND LRB CX39 SUPPORT EQUIPMENT.
LRB VEHICLE DESIGN RECOMMENDATIONS
FOR GROUND PROCESSING

- LRB SYSTEMS DESIGN SHOULD BE AS INDEPENDENT AS POSSIBLE FROM ORBITER AVIONICS.

- SELF-CONTAINED POWER AND DATA TELEMETRY SYSTEMS
- INDEPENDENT LRB INSTRUMENTATION HARDLINE VIA UMBILICAL
- INDEPENDENT GROUND ELEC POWER VIA UMBILICAL
- ORBITER AVIONICS I/F ONLY FOR GNC, SAFETY/FLIGHT CRITICAL COMMANDS AND DATA

- PROVIDE FOR STAND ALONE LRB INTEGRATED TEST.
ISSUES AND QUESTIONS

• INTEGRATION
  • ORBITER AVIONICS SYSTEMS CAPABILITY FOR EXPANSION LIMITED WITHOUT MAJOR REDESIGN/MOD EFFORT.

• LAUNCH
  • PROPELLANT SUPPLY CAPABILITIES (VENDOR).
  • IF HYPERGOLIC BOOSTER, WHAT SAFETY CONSTRAINTS WILL THERE BE ON PAYLOAD INTEGRATION AND OTHER ORBITER/ET PAD WORK?
  • WHAT ARE PLANS FOR PROPELLANT SERVICING UMBILICALS?
  • DRAMATIC INCREASE IN LAUNCH SYSTEMS COMPLEXITY.
  • SAFETY ISSUES IN LAUNCH PAD POST-ENGINE START SHUTDOWN.
  • HOW TO MAINTAIN SAME CONFIDENCE/RELIABILITY FOR SUCCESSFUL ENGINE START/LIFTOFF WITH 11 LIQUID ENGINES VERSUS 3 LIQUID ENGINES AND 2 SRBs.

• RECOVERY
  • IF SEA LANDING, HOW TO INSURE LRB SAFE TO HANDLE/TOW? (IN-FLIGHT INERT CAPABILITY?)
AGENDA

- **INTRODUCTION**
  - GORDON ARTLEY

- **BASELINE**
  - L. PAT SCOTT

- **REQUIREMENTS**
  - R. KEITH HUMPHRYES / STEVE BLACK

- **IMPACTS**
  - GREGORY DEBLASIO / ROGER LEE

- **SUMMARY**
  - GORDON ARTLEY
LIQUID ROCKET BOOSTER (LRB)
GROUND FACILITIES & SYSTEM IMPACTS

JAN. 20, 1988
G. DEBLASIO

LAUNCH
- SUPPORT SERVICING REG
  - PROPELLENTS (TRANSFER/LOADVENT)
  - PNEUMATICS
  - INSTRUMENTATION
  - ELECTRICAL
  - UMBILICALS
  - HOLDOWN
  - ACCESS
  - SOUND SUPPRESSION
- STRUCTURAL REQUIREMENTS
  - MLF
  - FSARES
  - ADDITIONAL STRUCTURES
  - ENVELOPE
  - PLANE TRENCH

ABORT/SCRUB
- TURNAROUND REQUIREMENTS
  - Firing Room
    - Launch Comm Criteria
    - QLS Sequencer
  - DETANKING/SAFING
  - SAFETY
  - COMMUNICATIONS
  - CERTIFICATION/TRAINING

FRF REQUIREMENTS
- HOLDOWN
- EXCURSIONS
- PROCEDURES
- FIRE ROOM REG
- ADDITIONAL INSTRUMENTATION

TEST/CHECKOUT
- END-TO-END REQUIREMENTS
  - CONTINUITY
  - LEAK CHECK
- FR (LPS)W) REQUIREMENTS
- GSE/TEST EQUIPMENT
- COMMUNICATIONS
- STRUCTURAL/ACCESS REG

RECOVERY
- RECOVERY SHIP
- GSE/TOOLS
- SAFETY
- HANDLING
- COMMUNICATIONS
- RLTS PROCEDURES

DISASSEMBLY/SAFING
- HANDLING/ACCESS
- DISASSEMBLY AREA
- SAFING AREA
- HAZARDOUS MATT. DISPOSAL
- HAZARDOUS GAS DETECTION
- GSE REQUIREMENTS
- COMMUNICATIONS

REFURBISHMENT
- FACILITIES
  - SHOPS
  - HANDLING
  - GSE/TOOLS
  - DEWATERING/CLEANING
  - REFURB REQUIREMENT FOR REUSABLE ELEMENTS

ALL OPERATIONAL AREAS WILL CONSIDER
- SAFETY
- ENVIRONMENTAL
- COMMUNICATIONS
- PROCEDURES
- QUALITY
- LOGISTICS
- TRAINING

LRB CONFIGURATION EVALUATION AREAS OF IMPACT
LRB MODEL AND ASSUMPTIONS

LRB MODEL

- LOX/RP1 (PRESSURE FEED)
- 175' LONG X 14.2' DIAMETER
- TANK ASSEMBLY, AVIONICS PACKAGE, ENGINES RECEIVED AT KSC SEPARATELY
- ALL LRB SERVICES PROVIDED IN AFT
- THREE ACCESS PLATFORM AREAS (NOSE, MID-BODY, AFT) AND ENGINE ACCESS NEEDED FOR THE LRB WHEN IN THE VERTICAL POSITION
- LRBs ASSEMBLED AND TESTED - HORIZONTALLY
- RECOVERY OF AVIONICS AND ENGINES (TANKS EXPENDABLE)
- REFURBISHMENT BY ELEMENT CONTRACTOR

ASSUMPTIONS

- LAUNCH RATE DURING TRANSITION - 14 PER YEAR
- AT THIS TIME GROUND RULE OUT IMPLEMENTATION OF ASRM OR SHUTTLE DERIVATIVES
- DURING TRANSITION DUAL LAUNCH CAPABILITY OF SRB AND LRB CONFIGURED STS
LIQUID ROCKET BOOSTER (LRB)
GROUND FACILITIES & SYSTEM IMPACTS

LRB RECEIVING/STORAGE

DRIVERS

0 INADEQUATE FLOOR SPACE IN VAB HIGH BAYS 2 AND 4 AND LOW BAY FOR HORIZONTAL PROCESSING
0 ET PROCESSING OF 12 TO 14 FLIGHTS PER YEAR
0 SRB STACKING IN HIGH BAYS 1 AND 3 REQUIRES CLEARING HIGH BAYS 2 AND 4

IMPACTS

0 SITE LOCATION (APPROXIMATELY 10 ACRES)
0 NEW RECEIVING AND STORAGE BUILDING. REQUIRED (3 HORIZONTAL STORAGE CELLS APPROXIMATELY 75,000 SQ. FT.)
0 BONDED STORAGE AREA FOR FLIGHT ELEMENTS
LRB PROCESSING (ASSEMBLY/CHECK-OUT)

DRIVERS

- INADEQUATE FLOOR SPACE IN VAB HIGH BAYS 2 AND 4 FOR HORIZONTAL PROCESSING
- ET PROCESSING OF 12 TO 14 FLIGHTS PER YEAR
- SRB STACKING IN HIGH BAYS 1 AND 3 REQUIRES CLEARING HIGH BAYS 2 AND 4
INTERNATIONAL EXPLOSION INCIDENTS: REVIEW AND LESSON LEARNED

IMPACTS

1. SITE LOCATION (APPROXIMATELY 10 ACRES)
2. NEW ASSEMBLY AND CHECK-OUT FACILITY
   - EACH STORAGE CELL EQUIPPED FOR HORIZONTAL ASSEMBLY AND CHECK-OUT
   - ENGINE INSTALLATION AND CHECK-OUT
   - OFFICE/PERSONNEL SUPPORT SPACE
   - AVIONICS SHOP 10,000 SQ. FT. (APPROXIMATELY)
   - ENGINE SHOP 20,000 SQ. FT. (APPROXIMATELY)
   - MACHINE SHOP
   - ELECTRONICS SHOP
3. INDEPENDENT MINI-LPS (CONTROL ROOM AND SOFTWARE)
LRB STORAGE AND PROCESSING

FLIGHT LRB

FORWARD ASSEMBLY

TANK ASSEMBLY

ENGINES AND ASSOCIATED HARDWARE

ALL ELEMENTS RECEIVED ON TRANSPORT DOLLIES WITH HANDLING EQUIPMENT

RECEIVING

STORAGE (BONDING)

ASSEMBLY

CHECK OUT (INDEPENDENT MINI-LPS)

TO STACKING

LRB INTEGRATION & PROCESSING FACILITY

HANDLING EQUIPMENT

ENGINE SHOP

AVIONICS SHOP

FLIGHT LRB TRANSFERRED TO STACKING ON TANK ASSEMBLY TRANSPORTER
LRB RECEIVING/STORAGE/PROCESSING

ISSUES

- ELEMENTS HANDLING
  - MODS TO BARGE FOR TIE DOWNS
  - TRANSPORTER MUST MATE TO KSC ET TOWING VEHICLE
  - HANDLING FIXTURES FOR AVIONICS/ENGINES
  - STRONG BACK/SLINGS
  - VERTICAL LIFT PLATFORM FOR ENGINE/AVIONICS INSTALLATION
STACKING/VEHICLE INTEGRATION

DRIVER

- INCOMPATIBLE STACKING/VEHICLE INTEGRATION OPERATION IN HIGH BAYS 1 AND 3 FOR LRB AND SRB

- LAUNCH SCHEDULE AND PROCESSING REQUIREMENTS OF SRB AND LRB CONFIGURED STS

- LRB HIGH BAYS 1 AND 3 MODIFICATION IMPLEMENTATION SCHEDULE

IMPACT

- REQUIRES A FOURTH MLP FOR LRB - 1994

- MODIFIED MLP FOR LRB - 1995

- REQUIRES A NEW BOOSTER STACKING FACILITY - 1993

- IMPLEMENTATION OF MODIFICATION SCHEDULE VS. PROCESSING SCHEDULE

- VAB PLATFORM MODIFICATIONS FOR LRB - ADD EXTENDABLES FOR SRB
# LRB Transition Plan

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**Stacking Facilities**

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STACKING/VEHICLE INTEGRATION

ISSUES

- LRB STIFFNESS
- LRB HANDLING/LIFTING EQUIPMENT DESIGN AND PRODUCTION
STACKING/VEHICLE INTEGRATION/launch

MLP

DRIVER

0 WEIGHT LIMITATION OF EXISTING MLP

0 MEETING LAUNCH SCHEDULE OF LRB AND SRB CONFIGURATIONS REQUIRES A FOURTH MLP

0 COMMON MLP CANNOT SUPPORT BOTH LRB AND SRB

- LRB CONFIGURATION AND CONNECTION POINTS
- VEHICLE ENGINE FIRING SEQUENCES
- LRB ENGINE SERVICING REQUIREMENTS
STACKING/VEHICLE INTEGRATION LAUNCH

MLP

- NEW HOLD-DOWN POSTS
- NEW HAUNCH
- NEW LRB ENGINE SERVICE PLATFORM
- NEW HIMS AND CABLE FOR LPS
- NEW LRB SERVICE UMBILICALS
- PIC SYSTEM
- ENLARGÈ BOOSTER FLAME HOLE (PRESSURE FEED)
STACKING/VEHICLE INTEGRATION/LAUNCH

MLP

ISSUES

0 GOX VENT CAPABILITY
0 LOX LOADING/REVERT/DRAIN CAPABILITY
0 RP1 LOADING/DRAIN CAPABILITY
NEW STACKING FACILITY

DRIVER

- INCOMPATIBLE INTEGRATION STACKING OPERATIONS IN HIGH BAYS 1 AND 3 FOR LRB AND SRB

- INCOMPATABLE LAUNCH SCHEDULE AND PROCESSING REQUIREMENTS OF SRB AND LRB CONFIGURED STS

- LRB HIGH BAYS 1 AND 3 MODIFICATION IMPLEMENTATION SCHEDULE
NEW STACKING FACILITY

IMPACTS

- NEW FACILITY WITH ACCESS FOR PROCESSING
- MLP/CRAWLER SCHEDULE
- STAGING AREA - PREPARATION WORK
- SITE LOCATION
LAUNCH PAD

• DRIVERS
  • MEETING LAUNCH SCHEDULES USING TWO PADS FOR BOTH LRB AND SRB
  • LRB PAD MODIFICATION IMPLEMENTATION SCHEDULE
  • ENGINE FIRING SEQUENCES AND DURATIONS PRIOR TO LIFTOFF
  • LRB GOX VENT CONFIGURATION
  • SCRUB/TURNAROUND
  • FRF
LAUNCH PAD

• IMPACTS
  • NEW RP1 FACILITY AND SYSTEM
  • NEW LOADING SYSTEM FOR LOX (CAPACITY)
  • NEW UMBILICALS (LOADING, GOX VENT, ELECTRICAL)
  • RELOCATION/MODS OF EXISTING UMBILICALS (HYDROGEN VENT GOX ARM, TSM)
  • NEW GOX VENT UMBILICAL SYSTEM
  • NEW OR MODIFICATION OF EXISTING ACCESS PLATFORM
  • NEW FLAME DEFLECTORS/PROTECTION SYSTEM
  • ICE SUPPRESSION
  • LPS-GLS AND OTHER CCMS SOFTWARE
LAUNCH PAD

ISSUES

- DRIFT CURVES AND LAUNCH OVER-PRESSURES
- SOUND SUPPRESSION SYSTEM REQUIREMENTS
- FIREX SYSTEM SUPPORT REQUIREMENTS FOR ENGINE SHUT-DOWN/NO LIFT-OFF
LRO RECOVERY

DRIVER
- RETRIEVAL OF FLIGHT ELEMENTS FROM OCEAN

IMPACTS
- NEW BARGE WITH CRANE AND TUGS
- ENVIRONMENTAL/SAFETY REQUIREMENTS IF HYPERGOL POWERED TVC UNIT USED
- NEW SLIP/DOCKING FACILITIES FOR UNLOADING
- GROUND TRANSPORT AND HANDLING FOR RECOVERED ELEMENTS
LIQUID ROCKETS BOOSTER (LRB)
GROUND FACILITIES & SYSTEM IMPACTS
JAN. 20, 1988
G. DEBLASIO

LRB DISASSEMBLY/SAFING

DRIVER
  ∙ DISASSEMBLY OF FLIGHT ELEMENTS

IMPACTS
  ∙ HAZARDOUS MATERIAL AND PYROTECHNIC DISPOSAL
  ∙ LOCATION
  ∙ NEW HANDLING EQUIPMENT REQUIREMENTS
  ∙ NEW DEWATERING EQUIPMENT
LRB ELEMENT DESIGN CONSIDERATION

RECEIVING/STORAGE/ASSEMBLY/CHECK-OUT

- ASSEMBLED AND PROCESSED HORIZONTALLY
- TRANSPORTERS AND DOLLIES CAPABLE OF SUPPORTING STORAGE AND PROCESSING (ASSEMBLY AND CHECK-OUT)

STACKING

- LRB ASSEMBLY STRONG ENOUGH TO BE ROTATED AND LIFTED ONTO THE MLP

LAUNCH AREA (PAD/MLP)

- DO NOT VENT CRYOGENICS AT THE NOSE TO AVOID A VENT ARM
- FILL/DRAIN/VENT CAPABILITIES/REQUIREMENTS AT THE AFT
- VERTICAL ENGINE CHANGE-OUT CAPABILITY

RECOVERY

- DO NOT USE HYPERGOL POWERED TVC UNITS

PAGE 27
NEAR TERM STUDIES

- CONCEPT FOR INTEGRATED LRB PROCESSING FACILITY
- ADDRESS THE MLP AND VAB STACKING NEEDS MODIFICATIONS AND NEW CONSTRUCTION REQUIREMENTS
- PARALLEL LPS FOR LRB. (INCLUDING H/W SAFING)
- LPS IMPACTS OF PUMP FEED
- DELTA IMPACTS FOR LOX/LH2 (PRESSURE & PUMP FEED)
- DELTA IMPACTS FOR HYPERGOL (PRESSURE & PUMP FEED)
LIQUID ROCKET BOOSTER (LRB)
KSC IMPACT

JAN. 20, 1988

AGENDA

• INTRODUCTION
  GORDON ARTLEY

• BASELINE
  L. PAT SCOTT

• REQUIREMENTS
  R. KEITH HUMPHRYES / STEVE BLACK

• IMPACTS
  GREGORY DEBLASIO / ROGER LEE

• SUMMARY
  GORDON ARTLEY
ENVIRONMENTAL/SAFETY IMPACTS

$\text{N}_2\text{O}_4/\text{MMH}$ PROPELLANTS
ENVIRONMENTAL IMPACTS

- Air Quality
  - Capacity of current emission controls (scrubbers) to meet LRB requirements
  - Ignition by-products
  - Ozone depletion concerns

- Water Quality
  - Minimal impact in immediate vicinity of the launch pads other than non-contained spills or non-detected leaks
  - Possible impact to marine life if residuals escape from LRBs in the recovery area
ENVIRONMENTAL IMPACTS CONT'D

- Hazardous Waste
  - Increase in quantity of hypergols used will likely result in increase of hazardous waste generated
  - Disposal of hypergol waste presents unique problems
  - Capacity of current disposal methods (fire training on site and incineration off site) may not be adequate if large quantities are generated

- Other Environmental Impacts
  - Increased production will impact environmental requirements at the manufacturing sites
ENVIRONMENTAL IMPACTS CONT'D

- New concept will require Environmental Impact Statement with extensive development effort

  - Other Environmental Concerns

    - Propellant or LRB delivery by barge creates concern that increased barge traffic may affect endangered species
SAFETY IMPACTS

0 Personnel Protection

- Increased use of hypergols increases the risk of personnel exposure to toxic chemicals

- Scape suit requirements will increase substantially

- Current clean zone for hypergol operations in the pad areas may require expanding

- Possible exposure of personnel to hypergols during recovery and disassembly

- Large spills or catastrophic explosions could expose large numbers of people to toxic vapors

- Current vapor detection and monitoring system will require expansion
SAFETY IMPACTS CONT'D

- Fire Detection/Protection
  - Current Fire Detection/Protection system at the pads not adequate for LRB requirements

- Transportation
  - Transporting projected quantities of hypergols from manufacturing sites over public highways and through populated areas significantly increases the risk of exposing the public to toxic chemicals
OTHER CONCERNS

- Current trend is toward more stringent regulatory requirements

- Community Right-To-Know Law

CONCLUSION

- The projected use of huge quantities of MMH and $\text{N}_2\text{O}_4$ as primary propellants for the LRB raise serious environmental and safety concerns, which make them highly questionable from an environmental and safety standpoint
AGENDA

• INTRODUCTION
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• BASELINE
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• IMPACTS
  GREGORY DEBLASIO / ROGER LEE

• SUMMARY
  GORDON ARTLEY
IMPACT SUMMARY

- NEW SRB STACKING FACILITY OR ADDITIONAL VAB HIGH BAY
- FOURTH MLP REQUIRED
- NEW INTEGRATED LRB PROCESSING FACILITY/PROCEDURES/GSE/STANDALONE LPS TO SUPPORT
- NEW FLAME DEFLECTOR REQUIRED
- NEW LPS, PMS AND COMMUNICATION SYSTEMS REQUIRED
- VAB PLATFORM AND MLP MODS WILL INTERRUPT PROCESSING/LAUNCH RATE
- NEW ACCESS TOWERS REQUIRED ON PAD OR MLP
- OVER-WEIGHT RSS LIMITS NEW ACCESS MODS
- NEW CONSOLES, FIRING ROOM/RECERTIFICATION
ISSUE - SUMMARY

- COMPLEXITY OF TERMINAL COUNTDOWN - 7 OR 11 LIQUID ENGINES VERSUS 3 SSME AND 2 SRB ENGINES
- PROPELLANT HANDLING/STORAGE/ENVIRONMENTAL
- SCENARIO FOR RECOVERY, DISASSEMBLY AND REFURBISHMENT
- ENGINE ACCESS AND REMOVAL AT THE PAD
- ENGINE SEQUENCE AND TIMING BEFORE LIFTOFF
- WATER REQUIREMENTS - DEFLECTOR/FIREX/SOUND SUPPRESSION
- LAUNCH DRIFT CURVES VERSUS NEW UMBILICALS/STRUCTURES
- EXPANSION OF FIRING ROOMS/LPS CAPABILITIES
- TWANG EFFECTS VERSUS TSM AND NEW UMBILICALS
- PRE-MATE LPS PROCESSING IN HORIZONTAL MODE
NEAR TERM STUDY TASKS

- SUPPORT NASA DOWN SELECTION
- PRELIMINARY OPERATIONAL SCENARIOS
- MODIFICATION SCHEDULE OPTIONS: VAB - MLP - PAD
- SYSTEM LEVEL IMPACT ANALYSIS AND ASSESSMENTS
- MITIGATE HYPERGOL SCENARIO OPTIONS
VOLUME IV

SECTION 3

INTEGRATED WORKING GROUP

April 21, 1988
- FACILITY ACTIVATION SCHEDULE
  - LRB FIRST FLOW REQUIREMENTS
- MIXED FLEET OPERATIONS
- TRANSITION AND LRB BUILD-UP RATE
- INTEGRATION WITH OTHER PROGRAMS (STS-C, SPACE STATION, ASRM, ETC.)
- NEW LRB HORIZONTAL PROCESS FACILITY
- NEW MLP DESIGNED / BUILT FOR LRB
- PAD MODS FOR LOX / RP-1 PROPELLANTS
- VAB MODS FOR LRB (PLATFORMS, ETC)
- NEW / MOD GROUND SOFTWARE FOR LRB
- NEW / MOD GROUND SUPPORT EQUIPMENT
- ADDITIONAL FACILITIES TO SUPPORT LRB
- LAUNCH RATE BUILD-UP
GENERIC LRB PROCESS FLOW

**LRB BARGE ON DOCK KSC**

3. OFF LOAD AND INSTALL IN C-O CELL (LRB HORIZONTAL PROCESS FACILITY)

8. LRB STAND ALONE CHECK-OUT

6. LRB/MLP MATE (VAB HB 3)

11. ET MATE/C-O

5. ORBITER MATE/INTEG C-O

A. STS MOVE TO PAD

8. LRB UNIQUE

20. LRB UNIQUE

A. LAUNCH

**SUMMARY**

53-DAY GENERIC LRB PROJECTED PROCESS FLOW (SRB PROJECTED FLOW = 78 DAYS)

DELTA = 25 WORK DAYS
# LRB Integration Study
## KSC Facility Activation Schedule

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- **Δ Preliminary Design Requirements Available**
- **Design**
- **Δ Final Design Requirements Available**
- **Construction**
- **Activation**
- **OPS Certification**
- **TTV Activation**
- **OPS Certification**
- **1st LRB Flow**
- **1st LRB Launch**
NEW LRB HORIZONTAL PROCESS FACILITY

• OFFLINE STAND ALONE CHECKOUT / NO VAB INTERFERENCE
• RECEIVING / INSPECTION / TEST & CHECKOUT OPS
• ALL PROCESSING ON DELIVERY TRANSPORTER
• NEW GSE / TEST EQUIPMENT / TOWING TUG
• STAND ALONE LPS / CONTROL SYSTEM
• WORKSTANDS / ACCESS PLATFORMS / HORIZONTAL ENGINE CHANGEOUT
• CONTINGENCY ENGINE SERVICE SHOP
• NEW BATTERY LAB / CONTINGENCY AVIONICS SERVICE
• NEW LRB LOGISTICS SUPPORT REQUIRED
• SURGE / STORAGE CAPABILITY REQUIRED
• OFFLINE REPAIRS / MODS / LRU CHANGE OUT PROVISIONS
- INTEGRATION CELL PLATFORM REVISIONS
- NEW SERVICING EQUIPMENT / GSE
- NEW ROTATION AND LIFTING FIXTURES
- ET MATE, ORBITER MATE PROCEDURES UNCHANGED
- NO HIGHBAY STRUCTURAL MODS OR DOOR MODS
• NO LAUNCH UMBILICAL TOWERS
• NEW LIFT-OFF UMBILICAL DESIGN
• NEW LPS INTERFACE / HIMs
• ENGINE REMOVAL / REPLACEMENT PROVISIONS
• NEW HOLDDOWN SYSTEM DESIGN
• NEW PROPELLANT LOADING / VALVES / CONTROL SYSTEM
• NEW BOOSTER FLAME HOLES / PLUME CLEARANCES
• REDESIGN: POWER / HGDS / INSTRUMENTATION / LPS / COMM
• REVISED WATER DELUGE / SOUND SUPPRESSION / FIREX SYSTEMS
• NO ADDED TOWERS / SWING ARMS
• NO LRB HYDRAZINE, HYDRAULICS REQUIREMENTS
• ON BOARD LOX VENT SYSTEM (NO COOLIE CAP)
• NEW FUEL SYSTEM (RP-1, CH4, ETC)
• AUGMENTED LOX STORAGE SYSTEM / PUMPING SYSTEM REQUIRED
• NEW DESIGN FLAME DEFLECTOR / FLAME TRENCH MOD
• REVISED WATER DELUGE / DEFLECTOR, TRENCH COOLING
• REVISED MLP-TO-PAD INTERFACE
• MODIFIED ACCESS PROVISIONS: LRB AFT SKIRT, INTERTANK, FORWARD ASSEMBLY
LCC MODS SUMMARY

- NEW FIRING ROOM CONFIGURATION / REVISED CONSOLES
- NEW LRB GROUND SOFTWARE DEVELOPMENT / VERIFICATION
- NEW SAFING / ABORT PROVISIONS
- NEW LRB OMIs AND AUTOMATED LOADING PROCEDURES
- NEW COMM PROVISIONS / OTV
- NEW PHOTO-OPTIC CONTROL / TIMING DESIGN
- RF DOWNLINK (?)
- REVISED INTEGRATION / SAFING CONSOLES
- SIMPLIFIED ORBITER I/F REQUIRES EXTENSIVE LRB HEALTH MONITORING SYSTEMS CHECKOUT
INDEX TO DRAWING
79K20788

APRIL 21, 1988
G. ARTLEY

1. PCR ELEVATIONS AND DRAWING INDEX
   1A. PLATFORM GUIDE RAIL PLANS I
   1B. PLATFORM GUIDE RAIL PLANS II
   1C. GENERAL ARRANGEMENT PLAN

2. ACCESS PLATFORMS - PLAN AND ELEVATIONS
   3. ACCESS PLATFORMS - REMOV. HANDRAILS - DETAILS

4. ACCESS PLATFORMS - GUIDE/SLIDE SHOE ASSEMBLIES

5. OAA HINGED GUIDE RAIL - LIFTING BOOM

5A. OAA HINGED GUIDE RAIL - LIFTING BOOM DETAILS

6. PLATFORM WINCHING SYSTEM - PLANS AND DETAILS

7. PLATFORM WINCHING SYSTEM - SHEAVE MOUNTING DETAILS

8. PLATFORM WINCHING SYSTEM - JIB FRAMING DETAILS

8A. PLATFORM WINCHING SYSTEM - AIR WINCH PIPING SCHEMATIC ISOMETRIC

9. -Y FIXED GUIDE RAIL - DETAILS

10. +Y FIXED GUIDE RAIL - DETAILS

11. -Y PIVOTED GUIDE RAIL - PLANS AND ELEVATIONS
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12. OAA HINGED GUIDE RAIL - DETAILS
13. PLATFORM ACCESS LADDER DETAILS
14. GUIDE RAIL BRACING - DETAILS I
15. GUIDE RAIL BRACING - DETAILS II
16. OAA HINGED GUIDE RAIL - LATCH AND PIN
17. +Y HINGED GUIDE RAIL - HINGE AND LIFTING CONNECTION
18. OAA HINGED GUIDE RAIL - LATCH AND PIN DETAILS
19. MISCELLANEOUS DETAILS
20. +Y HINGED GUIDE RAIL EXTENSION - GENERAL ARRANGEMENT
21. RCS ROOM/ACCESS PLATFORM - SERVICE FLIP-UP
22. +Y HINGED GUIDE RAIL - EXTENSION
23. +Y HINGED GUIDE RAIL EXTENSION - HINGE ASSY.
24. +Y HINGED GUIDE RAIL EXTENSION LIFTING SYSTEM
25. -Y PIVOTED GUIDE RAIL - DETAILS I
26. +Y HINGED GUIDE RAIL EXTENSION - LIFTING SYSTEM DETAILS
27. -Y PIVOTED GUIDE RAIL - DETAILS II
28. -Y PIVOTED GUIDE RAIL - THRUST BEARING BRACKET

NOT IN CONTRACT
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29. -Y PIVOTED GUIDE RAIL - RADIAL HINGE
30. -Y PIVOTED GUIDE RAIL - THRUST BEARING HINGE
31. -Y PIVOTED GUIDE RAIL - RADIAL HINGE BRACKET
32. +Y FRAMING CONNECTION DETAILS
33. +Y HINGED GUIDE RAIL EXTENSION - ACCESS CATWALK
   34. -Y HINGED GUIDE RAIL EXTENSION - DETAILS I
   35. -Y HINGED GUIDE RAIL EXTENSION - DETAILS II
   36. -Y HINGED GUIDE RAIL EXTENSION - DETAILS III
   37. -Y HINGED GUIDE RAIL EXTENSION - DETAILS IV
   38. -Y HINGED GUIDE RAIL EXTENSION - DETAILS V
   39. -Y HINGED GUIDE RAIL EXTENSION - DETAILS VI
   40. -Y HINGED GUIDE RAIL EXTENSION - DETAILS VII

41. RAIN WATER RUNOFF DRAIN - I
42. RAIN WATER RUNOFF DRAIN - II
43. AFT IEA ACCESS PLATFORM FOR RIGHT SRB
44. AFT IEA ACCESS PLATFORM FOR RIGHT SRB - SECTIONS AND DETAILS

NOT IN CONTRACT
PLAN - EL 148'-4" (TOP OF STEEL)
3/16" = 1'-0"
LIQUID ROCKET BOOSTER (LRB) KSC IMPACTS

MAY 10, 1988

LRB PROCESSING SUMMARY

- BARGE DELIVERY
- NEW LRB HORIZONTAL PROCESSING FACILITY
- NEW ET HORIZONTAL PROCESSING FACILITY
- NEW MLP
- NEW INTEG. CELL
- VAB MODS
- PAD MODS
- OPF/ORBITER PROCESSING UNCHANGED
- VAB MODS
- LCC MODS
- LETF SUPPORT

Lockheed
Space Operations Company
SCENARIO GROUNDRULES: (GENERAL)

- LRB TRANSITION IS PLANNED TO YIELD MIN IMPACTS TO ON-GOING KSC FLIGHT OPS

- FIRST-LINE FACILITY ACTIVATIONS WILL SUPPORT 1996 FIRST FLIGHT AND A BUILD-UP TO AN ANNUAL 4 LRB LAUNCH RATE

- A FIVE-YEAR TRANSITION TO FULL FLIGHT RATE OF 14 IS PLANNED OVER 1996 TO 2000. SECOND AND THIRD LINE FACILITY ACTIVATIONS ARE PLANNED TO SUPPORT THIS BUILD-UP

- SHARED FACILITY UTILIZATION FOR THE MIXED FLEET OPS ARE PLANNED TO SUPPORT SHUTTLE LAUNCH MANIFEST DURING TRANSITION
LIQUID ROCKET BOOSTER (LRB)  
KSC IMPACTS  
MAY 10, 1988

KSC COST ELEMENT BREAKDOWN

NON-RECURRING

1. FIRST-LINE FACILITY ACTIVATION FOR IOC
   - LRB HORIZ PROCESS FAC  
   - NEW MLP  
   - VAB HB4 MOD  
   - PAD MOD  
   - LETF / LCC MOD  
   ELEMENTS: DESIGN  
              CONSTRUCTION  
              *TTV / ACTIVATION  
              OPS CERTIFICATION /  
              VALIDATION

2. SECOND / THIRD-LINE FACILITY ACTIVATION FOR TRANSITION
   - 2ND MLP (MOD EXISTING)  
   - 2ND INTEG CELL (MOD HB3)  
   - 3RD MLP (MOD EXISTING)  
   - 2ND PAD MOD  
   ELEMENTS: DESIGN  
              CONSTRUCTION  
              *TTV / ACTIVATION  
              OPS CERTIFICATION /  
              VALIDATION

3. GSE AND LSE (ALL SITES)

4. GROUND SOFTWARE / LPS DEVELOPMENT

5. ORBITER / ET MODS TO ACCOMMODATE LRB
   * TTV = TERMINATE, TEST AND VERIFICATION
RECURRING

6. BOOSTER PROCESSING MANPOWER
   • TECHNICIANS
   • ENGINEERING
   • QUALITY / SAFETY
   • PLANNING / SCHEDULING
   • TRAINING / CERTIFICATION

7. OPERATIONS SUPPORT MANPOWER *
   • LOGISTICS SUPPORT - SPARES PROVISIONING
   • BASE OPERATIONS (EG&G)
   • FACILITY AND GSE O&M
   • COMM
   • LPS / SOFTWARE

8. ON-GOING LRB MODIFICATIONS

NOTE: LRB PROCESSING MANPOWER BASED ON A POST-IOC ASSESSMENT WITH NO LEARNING CURVE CURRENTLY APPLIED.

* NASA/KSC CIVIL SERVICE ALLOTTED COST ARE INCLUDED IN OPERATIONS SUPPORT MANPOWER
# LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

**MAY 10, 1988**

## LRB LAUNCH SITE COST ELEMENTS

<table>
<thead>
<tr>
<th>NON-RECURRING</th>
<th>DESIGN</th>
<th>CONSTRUCTION</th>
<th>TTV ACTIVATION</th>
<th>OPS CERTIFICATION</th>
<th>TOTAL COST (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST LINE FACILITIES</td>
<td>MLP</td>
<td>5.6</td>
<td>62</td>
<td>21.8</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>LRB HORIZ. PROC. FAC.</td>
<td>1.0</td>
<td>13.5</td>
<td>1.7</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>VAB MOD (HB-4)</td>
<td>0.8</td>
<td>10.0</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>PAD MOD (A OR B)</td>
<td>3.3</td>
<td>37</td>
<td>14</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>LETF / LCC</td>
<td>0.5 / 2.0</td>
<td>6.3 / 3.0</td>
<td>-</td>
<td>1.2 / 1.0</td>
</tr>
<tr>
<td></td>
<td>ET HORIZ PROC FAC</td>
<td>0.8</td>
<td>11.0</td>
<td>1.4</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**TOTAL = $205M**
## LRB LAUNCH SITE COST ELEMENTS

<table>
<thead>
<tr>
<th>Non-Recurring</th>
<th>Design</th>
<th>Construction</th>
<th>TTV Activation</th>
<th>Ops Certification</th>
<th>Total Cost (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SECOND/THIRD LINE FACILITIES</strong></td>
<td>2ND MLP (MOD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>35.5</td>
<td>13.2</td>
<td>1.3</td>
<td>$53</td>
</tr>
<tr>
<td></td>
<td>VAB HB-3 MOD</td>
<td>0.2</td>
<td>2.4</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>PAD MOD</td>
<td>3.3</td>
<td>37</td>
<td>14</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>3RD MLP (MOD)</td>
<td>3.0</td>
<td>35.5</td>
<td>13.2</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>LETF/LCC</td>
<td>0.5</td>
<td>1.0</td>
<td>3.5</td>
<td>$5</td>
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<tr>
<td></td>
<td></td>
<td>0.5</td>
<td>1.5</td>
<td>1.0</td>
<td>$3</td>
</tr>
</tbody>
</table>

**TOTAL = $173M**
## LRB Launch Site Cost Elements

### Non-Recurring

<table>
<thead>
<tr>
<th>GSE/LSE (All Sites)</th>
<th>Handling Fixtures</th>
<th>Engine GSE</th>
<th>Leak Pressur.</th>
<th>Elec C-0</th>
<th>Access</th>
<th>Other Mech.</th>
<th>Totals (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HORIZ. PROC. FAC.</td>
<td>3</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>$28</td>
</tr>
<tr>
<td>MLP's (3)</td>
<td>5</td>
<td>20</td>
<td>5</td>
<td>15</td>
<td>3</td>
<td>2</td>
<td>$50</td>
</tr>
<tr>
<td>VAB (2)</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>5</td>
<td>1</td>
<td>-</td>
<td>$9</td>
</tr>
<tr>
<td>PAD's (2)</td>
<td>-</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>$8</td>
</tr>
<tr>
<td>ET PROC. FAC.</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1.5</td>
<td>-</td>
<td>$3.5</td>
</tr>
<tr>
<td><strong>Totals (M)</strong></td>
<td><strong>$10</strong></td>
<td><strong>$35</strong></td>
<td><strong>$9</strong></td>
<td><strong>$32</strong></td>
<td><strong>$8.5</strong></td>
<td><strong>$4</strong></td>
<td><strong>$98.5M</strong></td>
</tr>
</tbody>
</table>
**LIQUID ROCKET BOOSTER (LRB)**

**KSC IMPACT**

**MAY 10, 1988**

<table>
<thead>
<tr>
<th>SKILL MIX</th>
<th>RATIO</th>
<th>MANHOURS</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRB PROCESSING</td>
<td>1.00</td>
<td>11,744</td>
<td>$355,392</td>
</tr>
<tr>
<td>VAB OPS</td>
<td>0.36</td>
<td>3,632</td>
<td></td>
</tr>
<tr>
<td>PAD OPS</td>
<td>0.42</td>
<td>4,680</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL TECHNICIANS</strong></td>
<td></td>
<td>20,056</td>
<td>$355,392</td>
</tr>
<tr>
<td>ENGINEERING</td>
<td>0.89</td>
<td>17,850</td>
<td>366,814</td>
</tr>
<tr>
<td>FAC &amp; GROUND SUPPORT</td>
<td>1.14</td>
<td>22,864</td>
<td>393,258</td>
</tr>
<tr>
<td>LOGISTICS</td>
<td>0.53</td>
<td>10,630</td>
<td>172,095</td>
</tr>
<tr>
<td>QUALITY</td>
<td>0.38</td>
<td>7,621</td>
<td>139,393</td>
</tr>
<tr>
<td>SAFETY</td>
<td>0.08</td>
<td>1,604</td>
<td>29,346</td>
</tr>
<tr>
<td>PP&amp;C</td>
<td>0.22</td>
<td>4,412</td>
<td>78,892</td>
</tr>
<tr>
<td>OVERHEAD</td>
<td>0.42</td>
<td>8,424</td>
<td>162,574</td>
</tr>
<tr>
<td>GRUMMAN</td>
<td>0.71</td>
<td>14,240</td>
<td>281,235</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
<td></td>
<td>107,701</td>
<td>$1,979,000</td>
</tr>
<tr>
<td>BASE SUPPORT - EG&amp;G</td>
<td>1.60</td>
<td>32,090</td>
<td>$513,434</td>
</tr>
<tr>
<td>NASA - CS</td>
<td>1.92</td>
<td>38,508</td>
<td>847,165</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
<td></td>
<td>70,598</td>
<td>$1,360,599</td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td></td>
<td>178,298</td>
<td>$3,339,599</td>
</tr>
</tbody>
</table>

**COMMENTS AND ASSUMPTIONS:**

1. MHRS AND COST FOR PROCESSING LRBs FROM RECEIPT THRU LAUNCH
2. ALL SKILL MIXES ARE RATIOED TO TECHNICIANS
3. MHRS AND COST ARE BASED ON THE LRB PROCESSING FLOW
4. EG&G BASE SUPPORT ASSUMES 20% SUPPORTS CARGO AND 80% SUPPORTS SHUTTLE ELEMENT PROCESSING
5. THE NASA/KSC CIVIL SERVICE VALUES HAVE THE SAME ASSUMPTIONS AS THE EG&G BASE SUPPORT ASSUMPTION IN ITEM #4
6. A NON-RECOVERABLE LRB IS ASSUMED IN THE ABOVE TABLE
LIQUID ROCKET BOOSTER (LRB)
KSC IMPACT

MAY 10, 1988

CURRENT SRB PROCESSING MANHOURS AND COST

<table>
<thead>
<tr>
<th>SRB ACTIVITY/LOC</th>
<th>MANHOURS</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRB PROCESSING</td>
<td>18,603</td>
<td>$311,191</td>
</tr>
<tr>
<td>SRB STACKING</td>
<td>10,240</td>
<td>$181,008</td>
</tr>
<tr>
<td>VAB INTEGRATION</td>
<td>5,095</td>
<td>$88,728</td>
</tr>
<tr>
<td>PAD PROCESSING</td>
<td>18,575</td>
<td>$343,842</td>
</tr>
<tr>
<td>SRB SHOPS/SE MAINT</td>
<td>3,378</td>
<td>$54,264</td>
</tr>
<tr>
<td>SRB OPS SUPPORT</td>
<td>6,898</td>
<td>$179,466</td>
</tr>
<tr>
<td>INTEG OPS SUPPORT</td>
<td>7,961</td>
<td>$164,167</td>
</tr>
<tr>
<td>RPSF - MAINT</td>
<td>2,818</td>
<td>$54,488</td>
</tr>
<tr>
<td>VAB - MAINT</td>
<td>4,639</td>
<td>$90,196</td>
</tr>
<tr>
<td>PAD/MLP - MAINT</td>
<td>276</td>
<td>$5,661</td>
</tr>
<tr>
<td>SAFETY</td>
<td>5,377</td>
<td>$114,630</td>
</tr>
<tr>
<td>OVERHEAD</td>
<td>4,183</td>
<td>$90,407</td>
</tr>
<tr>
<td>SPC (LSOC) SUPPORT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRB PROCESSING</td>
<td>1,120</td>
<td>$23,016</td>
</tr>
<tr>
<td>SRB STACKING</td>
<td>784</td>
<td>$16,111</td>
</tr>
<tr>
<td>VAB INTEGRATION</td>
<td>254</td>
<td>$5,220</td>
</tr>
<tr>
<td>PAD PROCESSING</td>
<td>5,704</td>
<td>$109,146</td>
</tr>
<tr>
<td>OPS SUPPORT</td>
<td>814</td>
<td>$14,888</td>
</tr>
<tr>
<td>GRUMMAN</td>
<td>3,997</td>
<td>$78,936</td>
</tr>
<tr>
<td>SUBTOTAL</td>
<td>100,716</td>
<td>$1,925,365</td>
</tr>
<tr>
<td>BASE SUPPORT - EG&amp;G</td>
<td>32,090</td>
<td>$513,434</td>
</tr>
<tr>
<td>NASA/KSC - CS</td>
<td>38,508</td>
<td>$847,165</td>
</tr>
<tr>
<td>SUBTOTAL</td>
<td>70,598</td>
<td>$1,360,599</td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td>171,314</td>
<td>$3,285,964</td>
</tr>
</tbody>
</table>

* 95% CONFIDENCE

COMMENTS AND ASSUMPTIONS:
1. MORTON THIOKOL PROCESSING MANHOURS AND COST BASED ON THE PAST 14 MISSIONS
2. SPC (LSOC) DATA BASED ON THE PAST THREE MISSIONS
3. ALL SPC MANHOUR AND COST DATA IS PWO AND WBS DATA
4. EG&G AND NASA/KSC CS MANHOUR AND COST DATA ASSUMES 80% OF MANHOURS AND COST SUPPORTS SHUTTLE ELEMENT PROCESSING AND 20% SUPPORTS CARGO OPS AT KSC
5. ALL LSOC SUPPORT IS ENGINEERING
MANHOURS EXCEPT 1/2 OF PAD PROCESSING AND THE OTHER HALF IS TECHS AND ALL OPS SUPPORT IS QUALITY PEOPLE
**LIQUID ROCKET BOOSTER (LRB) KSC IMPACT**

**MAY 10, 1988**

<table>
<thead>
<tr>
<th>KSC SRB RETRIEVAL/REFURBISHMENT</th>
<th>MANHOURS</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRB RETRIEVAL/OPS</td>
<td>7,539</td>
<td>$153,164</td>
</tr>
<tr>
<td>SRB RETRIEVAL VESSEL</td>
<td>6,450</td>
<td>134,425</td>
</tr>
<tr>
<td>HANGAR AF OPS</td>
<td>12,379</td>
<td>247,195</td>
</tr>
<tr>
<td>USBI - KSC OPS</td>
<td>88,043</td>
<td>1,678,048</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>114,411</strong></td>
<td><strong>$2,212,832</strong></td>
</tr>
</tbody>
</table>

**NOTES:**

1. IT IS ASSUMED THE USBI - KSC OPS IS STAFFED APPROXIMATELY THE SAME AS MORTON THIOKOL AT 400 PEOPLE

2. THIS $2.2M SRB LAUNCH SITE COST IS AVOIDED BY THE USE OF EXPENDABLE LRBs
# LIQUID ROCKET BOOSTER (LRB)

## KSC IMPACT

**MAY 10, 1988**

**KSC LIFE CYCLE COSTS FOR LRB**

<table>
<thead>
<tr>
<th>COST ELEMENT</th>
<th>UNIT COST</th>
<th>QTY</th>
<th>TIME SPAN</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NON-RECURRING</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. FIRST-LINE FACILITY</td>
<td>$205M</td>
<td>1</td>
<td>91-95</td>
<td>$205M</td>
</tr>
<tr>
<td>2. SECOND/THIRD-LINE FAC.</td>
<td>173M</td>
<td>1</td>
<td>96-00</td>
<td>173M</td>
</tr>
<tr>
<td>3. GSE/LSE</td>
<td>98.5M</td>
<td>1</td>
<td>91-95</td>
<td>98.5M</td>
</tr>
<tr>
<td>4. GROUND S/W - LPS</td>
<td>20M</td>
<td>1</td>
<td>91-95</td>
<td>20M</td>
</tr>
<tr>
<td>5. ORBITER/ET MODS</td>
<td>TBD</td>
<td></td>
<td></td>
<td>TBD</td>
</tr>
<tr>
<td>**TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>$496.5M</td>
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</table>

**RECURRING**

<table>
<thead>
<tr>
<th>COST ELEMENT</th>
<th>UNIT COST</th>
<th>QTY</th>
<th>TIME SPAN</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. BOOSTER PROC. MANPOWER</td>
<td>$3.34M/FLOW</td>
<td>81</td>
<td>96-06</td>
<td>270.6M</td>
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<tr>
<td>7. OPERATIONS SUPPORT MANPOWER</td>
<td>(INCLUDED IN ABOVE)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. ON-GOING LRB MODIFICATIONS</td>
<td>TBD</td>
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</table>

**LCC GRAND TOTAL = $767.1M**
### LIQUID ROCKET BOOSTER (LRB) KSC IMPACT

#### KSC LAUNCH RATE PROJECTIONS

<table>
<thead>
<tr>
<th>BOOSTER VEHICLE</th>
<th>DATE</th>
<th>MLP's</th>
<th>VAB INTG. CELLS</th>
<th>PADS</th>
<th>ORB</th>
<th>FLT RATE</th>
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<tbody>
<tr>
<td>RSRB</td>
<td>EARLY 90'S</td>
<td>2</td>
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<td>LATE 90'S</td>
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<td>24*</td>
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</tbody>
</table>

*ORBITER PROCESSING FORECAST STILL LIMIT ULTIMATE LAUNCH RATE TO 14 PER YEAR
LRB TRANSITION ISSUES/CONCERNS

- MIXED FLEET OPERATIONS (SRB AND LRB)
- MAJOR SEPARATE BOOSTER FACILITIES
  - LRB HORIZONTAL PROCESS FACILITY
  - MLP
  - PAD
- MAJOR SHARED FACILITIES
  - VAB INTEG CELLS
  - LCC (FIRING ROOMS)
- OPF AND ORBITER OPS UNCHANGED AND NOT IMPACTED
- MANPOWER REQUIREMENTS DURING TRANSITION
- FIRST-LINE FACILITY ACTIVATIONS NEED EARLY START FOR ASSURED 1996 FIRST LAUNCH
- SECOND-LINE FACILITY ACTIVATIONS TO BE PHASED TO SUPPORT STS MANIFEST/LRB LAUNCH RATE BUILDUP
- MINIMUM 5-YEAR TRANSITION TO FULL LAUNCH RATE CAPABILITY (14 PER YEAR
- ON-GOING SRB LAUNCH CAPABILITY = IMPORTANT BACKUP
LRB TRANSITION ISSUES/CONCERNS (CONT'D)

- LRB RETRIEVAL, DISASSEMBLY, REFURBISHMENT REQUIRE DEFINITION

- LRB GROUND SOFTWARE (LPS) CHANGES REQUIRE DEFINITION

- THE PRIME CONCERN IS THE TRANSITION OF LRB AND ITS INTEGRATION WITH OTHER EMERGING PROGRAMS AT KSC (i.e., ASRM, ALS, SHUTTLE "C", ETC.)
AGENDA

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

GORDON ARTHUR
JERRY LEFEBVRE
GREG DEBLASIO
KEITH HUMPHRIES
PAT SCOTT

II. SUMMARY

III. PLANS, PRODUCTS AND MODEL
A) END Project Integration
B) Base Line Requirements
C) Impact Analysis
D) Plans, Products and Model

INTRODUCTION
LRB STUDY TEAM MEMBERS

THE LRB STUDY TEAM IS COMPRISED OF EFFORTS AT THREE NASA CENTERS. THE
LEMSCO STUDY AT JSC IS LED BY JIM MCCURRY AND DAVE BLUMENRETT SUPPORTING
JIM AKKERMANN IN THE LEVEL II INTEGRATION AND LRB SYSTEM PERFORMANCE EVALUATIONS. OUR TEAM AT LSOC IS LED BY GORDON ARTLEY AND REPORTS TO BILL
DICKINSON FOR ALL THE LRB LAUNCH SITE INTEGRATIONS ISSUES. THE LRB PHASE A
FLIGHT HARDWARE STUDIES AT MSFC ARE HEADED BY TOM MOBLEY AT MMC/MICHOND AND
KEN NUSS AT GDSS. NED HUGHES, LRB CHIEF ENGINEER, COORDINATES THESE
STUDIES, REPORTING TO LARRY WEAR, LRB PROGRAM MANAGER. THE TOTAL STUDY
PROGRAM REPORTS THROUGH ADVANCED PROGRAM DEVELOPMENT UNDER DARRELL
BRANSCOME TO THE OFFICE OF SPACE FLIGHT, NASA/HQ. THE INTERCENTER TECHNICAL
WORKING GROUP MEETS EVERY TWO MONTHS ON MAJOR LRB ISSUES AT VARIOUS
PRE-ARRANGED SITES.
STUDY OBJECTIVES

THE LIQUID ROCKET BOOSTERS WOULD PROVIDE ADDITIONAL PAYLOAD CAPACITY FOR THE SHUTTLE SYSTEMS AS WELL AS AN ON PAD HOLD-DOWN AN ENGINE CUT-OFF CAPABILITY PRIOR TO LAUNCH RELEASE TO ALLOW VERIFICATIONS OR PROPER SYSTEM PERFORMANCE. THE LRB SYSTEM MAY HAVE APPLICATIONS FOR FUTURE SPACE VEHICLES. KSC HAS, SEPARATE FROM LRB CONSIDERATIONS, DEVELOPED A GROUND OPERATIONS COST MODEL (GOCM) WHICH PROVIDES MACRO BUDGETARY ESTIMATES OF KSC GROUND OPERATION COSTS. THE GOCM IS CONSIDERED USEFUL IN THE CONDUCT OF EARLY CONFIGURATION TRADE STUDIES WHICH CONSIDER GROUND COST IMPACT BUT DOES NOT, IN ITS PRESENT CONFIGURATION, PROVIDE ADEQUATE RESOLUTION TO CONSIDER DETAIL DESIGN SENSITIVE COST DRIVERS.
REQUIREMENTS FOR LRB IMPLEMENTATION AND OPERATION

1. Develop launch site support plan defining manpower

6. Develop preliminary LSE cases for LRB processing

5. Utilize the GROUND OPERATIONS COST MODEL (GOCM) in the

4. Assist in the development of an operationally efficient LRB system

3. Provide flight hardware design recommendations

2. Develop preliminary operational scenarios for selected

1. Develop launch site operational and facility MDRAPS for

STUDY OBJECTIVES

FIRST PROGRESS REVIEW

JULY 1988

LIQUID ROCKET BOOSTER INTEGRATION
METHODOLOGY/STUDY TASKS

THE RESPONSIBILITY ASSIGNMENT MATRIX (RAM) DISPLAYED HERE RELATES THE NINE STUDY TASKS TO THE SIXTEEN STUDY PRODUCTS, SHOWING THE TASK AND TASK-LEAD FOR THE PRODUCTION OF EACH PRODUCT. THESE IDENTIFIED RESPONSIBILITIES ENABLE QUICK REFERENCE AND TRACKING OF THE STUDY EFFORT TOWARD MEETING THE EARLIER STATED OBJECTIVES.
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RAF
FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION
ADVANCED PROJECTS
KSC
"Technology Office"
AUG 1988
PAGE 4
KSC LRB INTEGRATION SCHEDULE

THIS IS THE FIRST QUARTERLY REVIEW, BASED ON THE CONTRACT ATP IN MID-MARCH. INFORMAL COORDINATION WITH MSFC BEGAN IN OCTOBER. THE DOWN-SELECTED BOOSTER CONFIGURATIONS ON JUNE 29 & 30 HAVE PROVIDED A FRAMEWORK FOR THE FIRST FORMAL PRESENTATION TO KSC. SCHEDULE CHANGES HAVE BEEN MADE IN RESPONSE TO CHANGES IN STUDY EMPHASIS BY MSFC. PROGRESS, OPEN QUESTIONS AND PLANS FOR EACH OF THE FOUR TASK PACKAGES WILL BE DISCUSSED IN SECTION II OF THIS REVIEW.
AGENDA

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

JULY 1988
Space Operations Company

Lockheed

OPEN ISSUES / NEAR TERM PLANS

• GENERIC FLOW / LAUNCH SITE COST ASSESSMENTS
• FACILITY ACTIVATION / TRANSITION PLAN
• LRB PRELIMINARY PROCESSING SCENARIO
• LRB DESIGN RECOMMENDATIONS
• MSFC PHASE A CONFIGURATIONS

LRB PROJECT INTEGRATION

FIRST PROGRESS REVIEW

JULY 1988

Liqid Rocket Booster Integration

KSC ADVANCED PROJECTS

A TECHNOLOGY OFFICE
LRB PROJECT MILESTONES

MAJOR MILESTONES ARE IDENTIFIED HERE WITH REFERENCE TO OUR KSC STUDY. LRB PROJECT PARTICIPANTS ARE ORGANIZED INTO A THREE-CENTER TECHNICAL WORKING GROUP WHICH HAS PERIODICALLY CONVENEED AND REVIEWED MAJOR PROJECT ISSUES, SUBJECTS SUCH AS VEHICLE AERODYNAMIC PROPERTIES, LAUNCH SITE INTEGRATION, PROJECT COST ANALYSIS AND PHASE A STUDY REVIEWS HAVE BEEN ADDRESSED. OUR STUDY TEAM AT KSC IS AN ACTIVE MEMBER OF THIS GROUP AND HOSTED THE JANUARY 88 KSC REVIEW. PREPARATION AND SUPPORT FOR THESE ACTIVITIES HAS REQUIRED A SIGNIFICANT AMOUNT OF OUR RESOURCES IN THE STUDY TO DATE. TECHNICAL INTERCHANGE WITH THE OTHER NASA CENTERS AND THEIR CONTRACTORS HAS BEEN VERY VALUABLE IN THE PERFORMANCE OF OUR LAUNCH SITE INTEGRATION PLANNING.
MSFC PHASE A SELECTED CONFIGURATIONS

The "down-selected" LRB configurations from the MSFC studies are summarized here. There are six in all and consist of three different propulsion concepts. Because of the selection of LOX/RP1 for both pump fed and pressure fed vehicles, we at the launch site have chosen this propellant for initial impact analysis. Where other propellant or vehicle design features cause impact at the launch site those "deltas" will be identified and documented, but our "baseline" for all major trades is the LOX/RP1 pump fed configuration. The reusability issue is still in evaluation at KSC and will continue concurrent with the MSFC Phase B study. Currently, both contractors and MSFC have selected the expendable LRB concept.
<table>
<thead>
<tr>
<th>Expansion Split</th>
<th>LOX/RP-1</th>
<th>LOX/RP-1</th>
<th>MNC</th>
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<tr>
<td>LOX/CH4</td>
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</tr>
<tr>
<td>Lox Feed</td>
<td>Pump Fed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Press Feed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contractor</td>
<td></td>
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</table>

Launch Site Baseline for Initial Evaluations

MSC Phase A Selected Configurations
HYDRAZINE

- Flight control via electro-mech TVC / no hydraulics / no

INTERFACES

- All boosters are designed to existing orbiter / ET

GROUND SUPPORT

- Press feed test bed program has begun at MSC with MAC & A

WEIGHT OF PRESS FEED BOOSTERS EXCEED SRB LEVELS

FORWARD, EXPENDABLE

- All selected configurations are 4-engine, LOX tank

CONFIGURATION DETAILS

---

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

JULY 1988

ADVANCED PROJECTS

KSC TECHNOLOGY OFFICE
ENGINE DEVELOPMENT - NO EXISTING ENGINE FOUND SUITABLE

ALL SELECTED CONFIGURATIONS REQUIRE NEW LOW-COST

70K PAYLOAD TO 150 NM 28.5° INCLINATION

DESIGN BASED ON ATO WITH ONE LRB ENGINE OUT AT LIFTOFF

ALUMINUM - LITHIUM TANK MATERIALS

DOWN SYSTEM IS MODIFIED POSTS CONCEPT

LIFT-OFF UMBILICALS / NO VENT ARMS EXCEPT H2 AND CH4 / HOLD

PROPELLANT OPTIMIZATION

LIFT-OFF / IGNITION SEQUENCE STAGED FOR MIN BASE MOMENT

CONFIGURATION DETAILS (CONT)
## Properties of Selected GDSS LRB Concepts

<table>
<thead>
<tr>
<th>LRB</th>
<th>LO2/RP-1 PUMP</th>
<th>LO2/CH4 PUMP</th>
<th>LO2/LH2 PUMP</th>
<th>LO2/RP-1 PRESS FED</th>
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<td>149.5</td>
<td>150.5</td>
<td>190.4</td>
<td>199.5</td>
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<td>DIA (FT)</td>
<td>14.06</td>
<td>15.0</td>
<td>16.16</td>
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<tr>
<td>STRUCTURE</td>
<td>MONOCOQUE</td>
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<tr>
<td>MATERIAL</td>
<td>AL-LI</td>
<td>AL-LI</td>
<td>AL-LI</td>
<td>AL 2219 - T6</td>
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<tr>
<td>PRESSURANT</td>
<td>AUTOG</td>
<td>AUTOG</td>
<td>AUTOG</td>
<td>TRIDYNE (He/H2/O2)</td>
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<tr>
<td>CHAMBER PRESS</td>
<td>1275 psia (NLP)</td>
<td>758 psia (RLP)</td>
<td>2366 psia (NLP)</td>
<td>334 psia (NLP)</td>
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<td>ISP (VAC)</td>
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<td>337</td>
<td>427</td>
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<td>6.0</td>
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<td>106.9</td>
<td>108</td>
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<td>SINGLE (24IN)</td>
<td>SINGLE (24IN)</td>
<td>SINGLE (24IN)</td>
<td>CONCENTRIC (24IN)</td>
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## MMC - LRB Vehicle Configurations

### Properties

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<th>Property</th>
<th>Pump Fed LOX/RP1</th>
<th>Press Fed LOX/RP1</th>
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<tr>
<td>OXID TANK VOLUME</td>
<td>10,769 FT³</td>
<td>12,012 FT³</td>
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<tr>
<td>FUEL TANK VOLUME</td>
<td>5,796 FT³</td>
<td>6,328 FT³</td>
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<td>FEED LINES - LOX</td>
<td>17 IN. DUAL</td>
<td>25.5 IN. DUAL</td>
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<td>STRUCTURE</td>
<td>MONOCOQUE</td>
<td>MONOCOQUE</td>
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<tr>
<td>MATERIAL</td>
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<tr>
<td>INERT WEIGHT</td>
<td>116,665 LB</td>
<td>199,520 LB</td>
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<tr>
<td>TOTAL WEIGHT (BLOW)</td>
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<td>1,300,860 LB</td>
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<td>1300 EPL</td>
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<td>THRUST S.L. (EA.)</td>
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<td>750 KLB</td>
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<tr>
<td>ISP (VAC)</td>
<td>322 SEC</td>
<td>320 SEC</td>
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</tbody>
</table>
MMC - LAB VEHICLE CONFIGURATIONS

FIRST PROGRESS REVIEW

LIQUID ROCKET BOOSTER INTEGRATION

July 1988
KSC LRB DESIGN RECOMMENDATIONS

DURING THE COURSE OF OUR STUDY WE HAVE SUPPORTED THE ORGANIZATION OF A LAUNCH SITE WORKING GROUP MEETING AT KSC IN JANUARY 88, TWO WORKING GROUP MEETINGS AT MSFC (ONE ON COSTS, ONE ON AERO LOADS) AND VISITS TO MMC, MICHoud AND GDSS - SAN DIEGO ON THE SUBJECT OF BOOSTER PROCESSING REQUIREMENTS. AT EACH OF THESE INTERFACE MEETINGS WE TOOK THE OPPORTUNITY TO IDENTIFY LRB DESIGN RECOMMENDATIONS THAT WOULD ENHANCE LAUNCH SITE OPERATIONS. SHOWN HERE ARE SOME OF THE MORE SIGNIFICANT FLIGHT VEHICLE DESIGN ISSUES IDENTIFIED, SOME (BUT NOT ALL) HAVE BEEN INCORPORATED INTO THE SELECTED LRB CONFIGURATIONS.
MAKE BOOSTER AUTONOMOUS WITH MINIMUM ORBITER INTERFACES

- Facilitate Vertical and Horizontal Checkout
- No Flame Trench (Concrete) Mods at Pad
- LOX/RP-1 Propellants Have Minimum Pad Impacts
- Use Expendable Design
- Facilitate Engine R/R in Vertical On MLP
- Locate Avionics Lugs In Aft Skirt Area
- Maximum LRB Diameter Less Than 16 Feet
- Use Lift-Off Umbilicals - No Swinging Arms or LUT
- No Hydraulics/No Hydrazine

KSC-LRB Design Recommendations.

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

July 1988
LRB ANNUAL LAUNCH RATE CAPABILITY

THE ANNUAL LRB/SRB LAUNCH RATE CAPABILITY DURING THE 5-YEAR TRANSITION OF LRB IS PLANNED TO SUPPORT A CONTINUING 14 LAUNCHES PER YEAR STS MANIFEST. INCREMENTAL FACILITY ACTIVATIONS FOR LRB ARE PLANNED AFTER IOC TO SUPPORT THE PLANNED LRB LAUNCH RATE BUILD-UP. SRB SUPPORTED LAUNCHES WILL DECLINE ACCORDINGLY DURING THIS PERIOD.

AT KSC THE PLANNED IOC (FIRST LINE) FACILITY ACTIVATIONS ARE SCHEDULED OVER THE 1991 TO 1996 TIME FRAME LEADING UP TO THE "INITIAL ACTIVATION COMPLETE" POINT.
Facility Activation / Transition Plan

Complete
Initial Activation
Facilities
Horiz Process
H-4 Converted
First Line
New MLB, 1st Pad Mod
Second Line
2nd MLB Converted
Third Line
1st LP Converted
14
12
9
6
3

Capability Rate
Launch
LRB Annual

First Progress Review
Liquid Rocket Booster Integration

July 1988

Space Operations Company

8070A-011M
GENERIC LRB/SRB PROCESS FLOW COMPARISON

TYPICAL TIMELINES FOR STS PROCESSING ARE COMPARED TO SHOW THAT LRB PLANNED FLOW TIME FROM RECEIPT TO LAUNCH IS 25 DAYS SHORTER THAN THE MID-90'S PROJECTION FOR SRB/ASRM. THIS RESULTS IN INCREASED LAUNCH RATE CAPABILITY FOR THE LIQUID-BOOSTED STS AFTER FULL TRANSITION. DIFFERENCES ARE DUE MAINLY TO THE SHORTENED BUILD-UP AND STACKING TIMES REQUIRED BY LRB.

A DETAILED LRB PROCESS FLOW FROM BARGE DELIVERY THROUGH LAUNCH HAS BEEN DEVELOPED. IT IDENTIFIES OVER 100 TASKS WITH SEQUENCE, MANPOWER AND SHIFT DURATIONS. THIS MODEL HAS BEEN NETWORKED IN ARTEMIS AND WILL BE USED IN OUR CONTINUING ANALYSIS EFFORTS TO ASSESS OPERATIONAL EFFICIENCY, MULTIFLOW INTEGRATION, AND FACILITY UTILIZATION.
KSC LAUNCH RATE PROJECTIONS

KSC LAUNCH RATE PROJECTIONS VS. FACILITIES ARE SUMMARIZED HERE FOR KNOWN BOOSTER CONFIGURATIONS (RSRB, ASRB, AND LRB). CURRENT FORECASTS FOR ORBITER PROCESSING TIMES OF 51 DAYS IN THE OPF LIMIT EFFECTIVE LAUNCH RATES, HOWEVER THE BOOSTER AND INTEGRATED VEHICLE CAPABILITIES ENABLE ANNUAL RATES UP TO 24 PER YEAR BY THE YEAR 2000. CURRENT PLANNED LRB FACILITY ACTIVATIONS THRU TRANSITION SUPPORT THE 20 PER YEAR CAPABILITY.

THESE RESULTS ARE PRELIMINARY FORECASTS; MORE DETAILED MULTIFLOW ARTEMIS ANALYSIS WITH OUR REFINED LRB FLOW MODELS WILL BE PERFORMED TO ESTABLISH MORE ACCURATE FLIGHT RATE CAPABILITIES.
Using a 21-day stack time, the VAB H3 & H81 utilization is near 100%. At a launch rate of 14 per year, 14 per year (assuming 4-orbiter fleet, 3 OPF and 61-day flows), orbiter processing forecast still limit ultimate launch rate to 10.

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**Date**

**Vehicle Booster**

<table>
<thead>
<tr>
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<th>MLFLS</th>
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<th>Orb Pad</th>
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<td>FLR rate</td>
<td>FLR rate</td>
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</table>

**KSC Launch Rate Projections**

FIRST PROGRESS REVIEW

JULY 1988

LIQUID ROCKET BOOSTER INTEGRATION
KSC LIFE CYCLE COSTS FOR LRB

A PRELIMINARY LRB LAUNCH SITE COST ASSESSMENT WAS PERFORMED TO SCOPE THE MAJOR COST ITEMS AND TO SUPPORT THE MAY 10 COSTING REVIEW AT MSFC. SUMMARIZED HERE ARE THE MAJOR COST ELEMENTS COMPRISING BOTH NON-RECURRING AND RECURRING COSTS AT KSC. ELEMENTS ARE FACTORED BY 40% FOR COMPARISON WITH THE OTHER PROGRAM INPUTS: (CONTRACTOR FEE=10%, GOVT. SUPPORT=5%, MGMT. RESERVE=25%). COSTS ARE IN CONSTANT FY 87 DOLLARS AND REPRESENT TOTAL LIFE CYCLE INCLUDING A FIVE-YEAR ACTIVATION PHASE AND A TEN-YEAR OPERATIONAL PHASE.

OUR GROUND OPERATIONS COST MODEL (GOCM) DEVELOPMENT WILL RESULT IN A MORE FLEXIBLE COST MODELING APPROACH AND THE ABILITY TO EVALUATE AND CORRELATE PROGRAM COST APPROACHES SUCH AS THIS ASSESSMENT. DETAILED COST ELEMENTS SUPPORTING THIS SUMMARY ARE AVAILABLE FOR REVIEW.
KSC Life Cycle Costs for Lab

July 1988

First Progress Review

Liquid Rocket Booster Integration

Total LCC Cost does not include recovery, disassembly or refurbishment.

Recyclable/Recert Costs at The Launch Site.
Cost Elements also does not include recovery, disassembly or refurbishment.

LCC Grand Total = $1,125.6M.

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<th>Cost Element</th>
<th>Time Span</th>
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<tr>
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<td>2. Second/third-line FAC.</td>
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<td>3. GSE/LSF</td>
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<td>4. Ground S/W - LPS</td>
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<td>5. Orbiter/ET mods</td>
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<td>6. Booster Proc, Manpower</td>
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<td>7. Operations Support</td>
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<td>8. On-going Lab Modifications</td>
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Non-Recyclable
5. Cost Assessment Reﬁnements / Analyses
4. Mixed Fleet Integration / Shared Facilities
3. Launch Site Veriﬁcation / Validation
   • OM Development / Test Team Training
   • Ground Software Mods / New Lab Software
   • Facility / GSE Mods and Activation
2. SRB - TO - LRB Transition Planning
1. Recovery / Disassembly Option

Open Issues:

FIRST PROGRESS REVIEW
July 1988
LIQUID ROCKET BOOSTER INTEGRATION
OPERATIONS COST MODEL (OCOM)

4. Refine Launch Site Cost Assessments Per Contractor

CONFIGURATION

3. Coordinate LRB Launch Site Processing Scenarios

(due mid-July)

2. Support follow-up technical working group meetings

FUNCTIONS

1. Continue MSC / JSC and Contractor Coordination

NEAR TERM PLANS:

FIRST PROGRESS REVIEW

JULY 1988

LIQUID ROCKETS BOOSTER INTEGRATION
AGENDA

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

JULY 1988

GORDON ARLEY

II. SUMMARY
D) PLANS, PRODUCTS AND MODEL
C) IMPACT ANALYSIS
B) BASELINE REQUIREMENTS
A) LAB PROJECT INTEGRATION

II. PROGRESS

GORDON ARLEY

I. INTRODUCTION

JERRY LEBEBRE

GREG DEBELASIO

KEITH HUMPHREYS

PAT SCOTT
The objective of defining the SRB baseline is to provide a basis of comparison for LRB with parameters of manpower, cost, schedule and safety/environmental.

Using historical data from previous STS processing, we have compiled a baseline for the RSRS processing through 2006. This baseline reflects the changes made in requirements and procedures after 51L with an appropriate learning curve. We have included processing schedules, manpower and cost which is to be used for comparison with the LRB and for transition planning, while based on actual data.

These parameters are estimates with some degree of uncertainty due to our lack of experience with the new (present) requirements and procedures.
SRB PROCESSING MANHOURS AND COST

SCHEDULE

BASELINE SRB PROCESSING

TASK 1 - SRB BASELINE DEFINITION

FIRST PROGRESS REVIEW

JULY 1988

LIQUID ROCKET BOOSTER INTEGRATION
THE SHADeD LINES ENCLOS THE PORTION OF THE SRB PROCESSING FLOW WHICH IS COMPARABLE TO AN EXPENDABLE LRB. THE RESOURCES, FACILITIES AND COSTS ASSOCIATED WITH THIS PORTION OF THE SRB PROCESSING ARE USED AS A BASELINE OF COMPARISON. THE PORTION OUTSIDE THE SHADeD LINES CAN BE AGGREGATED WITH OTHER ELEMENTS OF LIFE CYCLE COST TO MAKE PROGRAMMATIC TRADES WITH LRB MANUFACTURING.
SCHEDULE

The bars reflect the current elapsed time (days) projections for SRB processing in the 1996 time frame. Post 51L processing changes have been incorporated with a learning curve. The bars are nominal, success-oriented times. The inspection/offload bar is segmented to show the six day serial time span. Pad operations includes three days for vertical payload integration.
SRB PROCESSING MANHOURS AND COST

IN DEFINING BASELINE COST AND MANHOURS FOR SRB WE ARE PRIMARILY INTERESTED IN THE
PRE-LAUNCH, GROUND PROCESSING FOR COMPARISON WITH LRB. OTHER SUPPORT SUCH AS BASE
OPERATIONS IS ASSUMED TO BE THE SAME FOR ANY FLIGHT CONFIGURATION AND IS,
THEREFORE, NOT PRESENTED.

THE COST AND MANHOUR DATA ARE BASED ON SPC ACTUALS FROM PREVIOUS MISSIONS. SPC
COST AND MANHOUR DATA ARE PWO AND WBS DATA. LSOC SUPPORT IS ENGINEERING EXCEPT
"PAD PROCESSING" HALF OF WHICH IS TECHNICIANS AND "OPS SUPPORT" WHICH IS QUALITY.
THE PRESENTED NUMBERS ARE STATISTICALLY DERIVED. THEY ARE THE UPPER LIMITS OF
THREE STANDARD DEVIATIONS AND THEREFORE REPRESENT A 95% PROBABILITY THAT THE COSTS
WILL NOT BE HIGHER. THIS IS BELIEVED TO BE A CONSERVATIVE APPROACH, IN THAT
ALLOWANCES FOR POST 51L REQUIREMENT INCREASES HAVE NOT BEEN MADE AND THEIR EFFECTS
ARE NOT YET CLEARLY QUANTIFIED.
Space Operations Company

$1,925,365
78,936
14,888
109,146
5,704
254
784
1,220
266
90,407
114,630
5,664
79,160
54,488
261
79,176
6,908
3,728
343,842
88,728
1,008
18,603
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100,716
3,997
814
5704
254
784
1,220
4183
5377
276
4699
2188
791
6908
3728
18775
5095
10240
18603
311191

GRUMMAN

MANUFACTURING
OPS SUPPORT
PAD PROCESSING
VAB INTEGRATION
SRB STAGING
SRB PROCESSING
SRB (LSOC) SUPPORT
OVERHEAD
SAFETY
PAD/MLP - MAINT
VAB - MAINT
PSF - MAINT
INTEG OPS SUPPORT
SRB OPS SUPPORT
SRB SHOPS/SE MAINT
SRB PROCESSING
VAB INTEGRATION
SRB STAGING
SRB PROCESSING
SRB ACTIVITY

SRB PROCESSING MHS AND COST (PER FLIGHT)

TASK 1 - SRB BASELINE DEFINITION

FIRST PROGRESS REVIEW

JULY 1988
FINAL REPORT

FINALIZE DATA AND FORMAT FOR

• WORK PLAN FOR NEXT PERIOD

• OPEN QUESTIONS AND ISSUES - NONE

TASK 1 - SB BASELINE DEFINITION
TASK 2 - LRB REQUIREMENTS

THE OBJECTIVE OF THIS TASK IS TO DEFINE ALL THE SIGNIFICANT LRB REQUIREMENTS AS THEY APPLY TO LAUNCH SITE PROCESSING. THESE REQUIREMENTS ARE THOSE THAT ARE LEVIED UPON THE LAUNCH SITE BY VIRTUE OF THE LRB DESIGN/CONFIGURATION AND THOSE THAT KSC WOULD REQUIRE OF THE MANUFACTURER(S). THESE REQUIREMENTS ARE BEING DEFINED/DEVELOPED THROUGH CLOSE COORDINATION WITH THE KSC STUDY MANAGER, MSFC, JSC AND THE PHASE A CONTRACTORS. THE DATA WAS ASSEMBLED FROM RESPONSES TO OUR REQUIREMENTS CHECKLIST, LRB TECHNICAL WORKING GROUP PRODUCTS AND VARIOUS RELATED DOCUMENTS.
REQUIREMENTS DEFINITION

A REQUIREMENTS CHECKLIST WAS PRODUCED AND SUBMITTED TO THE PHASE A CONTRACTORS. FOR SPECIFIC INFORMATION ABOUT EACH PROPOSED LRB CONFIGURATION, IT INCLUDES PHYSICAL PROPERTIES, GENERAL REQUIREMENTS AND SPECIFIC REQUIREMENTS WITH RESPECT TO THE TEN AREAS OF IMPACT* AS DEFINED IN THE STUDY PLAN. ALL OF THE PERTINENT ISSUES, SUCH AS HORIZONTAL VS. VERTICAL PROCESSING AND STAND ALONE TESTING, ARE COVERED. PRIOR TO RECEIVING THESE DATA, THE STUDY TEAM DEVELOPED A LOX/RP1 GENERIC BASELINE FOR A PUMP AND A PRESSURE FED CONFIGURATION. THIS ALLOWED US TO PROCEED WITH VARIOUS STUDY ELEMENTS WHICH WERE DEPENDENT UPON CONFIGURATION DATA. WE ATTEND ALL OF THE VARIOUS WORKING LRB SESSIONS AND VISITED THE PLANTS OF GDSS MMC TO OBTAIN DATA AND INFLUENCE THE DESIGNS. THE REQUIREMENTS HAVE BEEN SORTED INTO CATEGORIES OF CONFIGURATION-COMMON AND CONFIGURATION-DEPENDENT.

- AREAS OF IMPACT-RECEIVING/HANDLING, ASSEMBLY, INTEGRATION, TEST/CHECKOUT, LAUNCH, ABORT/SCRUB, FRF, RECOVERY, DISASSEMBLY/SAFING, REFURBISHMENT.
INTEGRATE DATA FROM CONTRACT DOCUMENTATION

WORKING SESSIONS / VISITS WITH PHASE A CONTRACTORS

- EXPENDABLE

- PUMP FEED / PRESSURE FEED

- LOX/RP1

GENERAL BASELINE CONFIGURATIONS

- 10 AREAS OF IMPACT

- ISSUES

- REQUIREMENTS CHECKLIST

TASK 2 - LRB REQUIREMENTS

JULY 1988
CONFIGURATION - COMMON REQUIREMENTS

These are the requirements that are common to the six "down-selected" LRB configurations. GDSS has proposed an "on site" manufacturing facility. The site could be on the barge canal in which case the boosters would arrive at LC39 via barge or it could be an LC39 location. In either case, no significant difference in requirements is seen at this time with respect to receiving/handling. On site manufacturing, however, may preclude the need for a LRB horizontal processing facility (HPF).

Launch, abort/scrub and FRF are combined. We found no common or unique requirements that discriminate between these areas of impact.

Recovery, disassembly/safing and refurbishment are combined. They have no current requirements because all six current LRB configurations are expendable.
None

And Refurbishment
Recovery, Disassembly / Safing

- LH2 Pump Arm Mod
- LH2 Vent Arm Mod
- Rework Crawlerway
- New HEG And Fire Ex
- Flame Deflector / Trench - TBD
- No LH2 Hydrostatic TGC
- One New MLI, Two Modified MLPS
- Additional LOX And New Fuel Faculties
- No LH3 Box "Benign Cap"

Launch, Abort / Scrub And FPR

- No Tank Interior Work
- Propellant consoles
- 3 X SRB LPS Inclunding New Engine And
- MINI-LPS For HPP
- New RNA & CTS Software
- New B. And S. OMIs, Some New Y. OMIs

Test and Checkout

Configuration - Common Requirements

Task 2 - LRB Requirements

First Progress Review
Liquid Rocket Booster Integration

New Hold Down Concept
SRB / LRB Compatible Orifpiaer Hardware
No Booster Uplift Or IF Interface
LRB GSE
Engine Change Capability After Stacking
Standalone During Processing (Mini LPS)

Integration

ET Processing Facility (ETP)
Horizontal Processing Facility (HPF)
Minimal

Assembly

Goss On-Site Manufacturing
A Purge GSE
Self Contained Transporter Electrical
Integration
Dedicated Transporter THRU
Barcode Receiving (2 LR3s Per)

Receiving / Handling
CONFIGURATION - DEPENDENT REQUIREMENTS


THE LAUNCH PADS WILL REQUIRE THE MOST EXTENSIVE REWORK, THE GDSS LOX/RP1 PUMP-FED CAUSES THE LEAST REQUIREMENTS FOR KSC ESPECIALLY IF ON-SITE MANUFACTURING IS EMPLOYED.
## Task 2 - LRB Requirements

### Configuration-Dependent Requirements

**First Progress Review**

**Liquid Rocket Booster Integration**

**July 1988**
BEGIN FINAL REPORT FORMATTING

COMPLETE ALL DATA POINTS

FREEZE DATA WITH PHASE-A FINAL

• WORK PLAN FOR NEXT PERIOD

CONFIGURATIONS PLEASE STAND UPI

WILL THE REAL DOWNSELECTED?

OPEN QUESTIONS AND ISSUES

TASK 2 - LAB REQUIREMENTS

FIRST PROGRESS REVIEW

LIQUID ROCKET BOOSTER INTEGRATION
LRB PROCESSING SUMMARY

THE LRB PROCESSING SCENARIO BEGINS AT KSC WITH BARGE DELIVERY, AND HORIZONTAL TRANSPORTER TOW TO THE NEW LRB PROCESSING FACILITY. HERE ALL STAND-ALONE BOOSTER CHECKOUT AND TESTING IS CONDUCTED. THE CONVERSION OF VAB/HB4 TO A FULL INTEGRATION CELL PERMITS LRB TRANSITION WITHOUT IMPACT TO ON-GOING SHUTTLE LAUNCHES.

THE NEW ET HORIZONTAL PROCESSING FACILITY RELOCATES THE ET CHECKOUT AND STORAGE ACTIVITY SO THAT HB4 CAN BE USED. A NEW MLP CUSTOM-BUILT FOR LRB WILL BE CONSTRUCTED TO SUPPORT THE LRB IOC.

PAD MODS FOR OUR "BASELINE" LRB ARE MOSTLY ASSOCIATED WITH EXPANDED LOX CAPABILITY AND THE NEW FUEL STORAGE AND PUMPING SYSTEM. THE LAUNCH EQUIPMENT TEST FACILITY WILL BE MODIFIED TO SUPPORT THE VALIDATION OF THE NEW LRB LAUNCH SUPPORT EQUIPMENT.

THE LAUNCH CONTROL CENTER FIRING ROOMS WILL BE MODIFIED TO SUPPORT THE NEW CONSOLES AND GROUND SOFTWARE FOR LRB PROCESSING AND LAUNCH OPERATIONS.
SCENARIO GROUND RULES

BASIC GROUND RULES HAVE BEEN ESTABLISHED FOR THE PLANNED LRB SCENARIO AT THE LAUNCH SITE. CERTAIN FACILITIES ARE REQUIRED PRIOR TO IOC (FIRST LINE) AND ADDITIONAL FACILITY MODS AND ACTIVATION (SECOND AND THIRD LINE) ARE REQUIRED TO SUPPORT THE FULL TRANSITION AND LRB LAUNCH RATE BUILD UP.
TRANSACTION

ARE PLANNED TO SUPPORT SHUTTLE LAUNCH MANIFEST DURING
SHARED FACILITY UTILIZATION FOR THE MIXED FLEET OPERATIONS

ARE PLANNED TO SUPPORT THIS BUILD-UP
OVER 1996 TO 2000. SECOND AND THIRD LINE FACILITY ACTIVATIONS
A FIVE-YEAR TRANSITION TO FULL FLIGHT RATE OF 14 IS PLANNED
FLIGHT AND A BUILD-UP TO AN ANNUAL 3 LR/ LAUNCH RATE
FIRST-LINE FACILITY ACTIVATIONS WILL SUPPORT 1996 FIRST
KSC LAUNCH OPERATIONS
LR/ TRANSITION IS PLANNED TO YIELD MIN IMPACTS TO ONGOING
SCENARIO GROUNDRULES

TASK 3 - PRELIMINARY SCENARIOS

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

July 1998
SCENARIO FEATURES

THROUGH OUR INTEGRATION EFFORTS WITH THE OTHER NASA CENTERS AND THE LRB PHASE A CONTRACTORS WE HAVE BEEN ABLE TO DEVELOP THE MOST LIKELY SCENARIO. AT THIS TIME, WE ENVISION ONLY TWO MAJOR PROCESSING ALTERNATIVES, ONE IS OFF-SITE (NOT LC39) MANUFACTURE AND THE OTHER USES ON-SITE MANUFACTURE.

THE BOOSTERS ARE RECEIVED BY BARGE (OFF-SITE MANUFACTURE) AND MOVED TO THE HPF FOR ASSEMBLY, TEST AND CHECKOUT. BOOSTERS, ET AND ORBITER ARE TAKEN TO THE VAB HB 3 OR 4 FOR INTEGRATION ON A NEW OR MODIFIED MLP. THE INTEGRATED STACK IS MOVED TO THE PAD FOR INTEGRATED TESTING, PROPELLANT LOADING, FRF AND LAUNCH.
- PAD PROCESSING
- NEW MLP / MOD TWO MLP
- VAB HB 3 / 4
- ET PROCESSING FACILITY
- LRH HORIZONTAL PROCESSING FACILITY (WITH SURGE)
- BARGE DELIVERY OR LC-39 MANUFACTURE

- SCENARIO FEATURES

TASK 3 - PRELIMINARY LRH SCENARIOS
THE LRB FLIGHT RATE IS SHOWN TO FOLLOW A RAMP OF 3, 6, 9, 12, 14 FLIGHTS PER YEAR. SRB IS ASSUMED TO DECREASE AT A COMPLEMENTARY RATE (11, 8, 5, 2, 0 RESPECTIVELY) TO MAINTAIN A CONSTANT FLIGHT RATE OF 14 PER YEAR DURING THE TRANSITION PERIOD. transition is to OCCUR OVER THE FIVE YEAR PERIOD 1996-2000. OTHER RAMPING SCHEMES ARE BEING PROPOSED BY OTHER GROUPS. HOWEVER, THE ONE SHOWN IS GROUND RULED FOR THIS STUDY AND IS THE BASIS FOR OUR LRB IMPLEMENTATION PLANS. NO EFFECTS OF OTHER PROGRAMS (ASRM, ALS, SHUTTLE II, SHUTTLE C) ARE SHOWN.
TASK 3 - PRELIMINARY LRB SCENARIOS

FIRST PROGRESS REVIEW

JULY 1988

LIQUID ROCKET BOOSTER INTEGRATION
CONFIGURATION
- Identify all major deltas for each processing scenarios and
- Finalize processing scenarios and
- Work plan for next period
- HPF vs on-site manufacturing
  - (common or separate)
  - String for HPF and ETPF
- Open questions and issues

TASK 3 - Preliminary LRB Scenarios
GORDON ARLETT

SUMMARY

GORDON ARLETT

AGENDA

FIRST PROGRESS REVIEW

LIQUID ROCKET BOOSTER INTEGRATION

July 1998
NEAR-TERM PLANS •

OPEN ISSUES / PROBLEMS •

SAFETY / ENVIRONMENTAL •

LET •

LC-39 •

LCC •

PROPPELLANT FACILITIES •

LAUNCH PAD •

MLP •

INTEGRATION FACILITY (VAB) •

LRB AND ET PROCESSING FACILITY •

PROGRESS / RESULTS / STATUS •

IMPACT ANALYSIS

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

July 1988
LRB/ET PROCESSING FACILITY

THE GROUNDRULE, PRESENTED IN THE BASELINE AND SCENARIO PLANNING, OF INTRODUCING LRBs TO KSC WITHOUT IMPACTS TO EXISTING FACILITIES AND OPERATIONS DRIVES A REQUIREMENT TO STUDY AN OFF-LINE LRB PROCESSING FACILITY. THIS SCENARIO ALSO SHOWS THAT TO MAINTAIN THE PLANNED LAUNCH RATE A THIRD INTEGRATION CELL IN THE YAB IS REQUIRED. A STUDY TO PROVIDE AN OFF-LINE ET PROCESSING FACILITY IS ALSO BEING CONDUCTED.
4 LPS REQUIREMENTS
- ET / LRB PROCESSING FACILITY CONTROL CENTER
- LRB / ET PROCESSING FACILITY - Siting
- ET PROCESSING FACILITY LAYOUT
- LRB PROCESSING REQUIREMENTS
- LRB PROCESSING FACILITY LAYOUT

FIRST PROGRESS REVIEW
LIQUID ROCKETS BOOSTER INTEGRATION

July 1988
THE OFF-LINE FACILITY FOR PROCESSING AND STORAGE OF LRBs WILL PROVIDE FOR LRB COMPONENT & SUBSYSTEM FINAL CHECKOUT AND FLIGHT CERTIFICATION, LRU REPLACEMENT AND ENGINE REMOVAL/INSTALLATION, SPACE FOR GSE AND MINI-LPS IS PROVIDED ALONG WITH AN ENGINE SHOP, BATTERY SHOP AND LRU STORAGE.

THE PROPOSED FACILITY WILL PROVIDE THE CAPABILITY TO PROCESS A LRB PAIR FOR FLIGHT AND STORE TWO PAIRS OF LRB BOOSTERS.

THE FACILITY WILL REQUIRE UTILITIES AS FOLLOWS:

PNEUMATICS:
- GNE DISTRIBUTION, GN2 DISTRIBUTION, COMPRESSED AIR DISTRIBUTION, BREATHING AIR DISTRIBUTION SYSTEMS, ECS AC POWER, DC POWER (CONTROLS)
- FIRE WATER, HALON, DRY CHEMICAL (AS REQUIRED)
- PA SYSTEM, OIS (VOICE RECORDER SYSTEM)
- POTABLE WATER, SEWAGE

ELECTRICAL:
- COMMUNICATIONS:
- UTILITIES:
LRB PROCESSING REQUIREMENTS

THE GSE REQUIRED TO SUPPORT VARIOUS FUNCTIONAL PROCESSING TASKS FOR THE LRB BOOSTERS (AVIONICS, TANKS AND ENGINES) IS BEING COMPILED.

THE CONTROLS/SOFTWARE-HARDWARE REQUIREMENTS ARE ALSO BEING COMPILED INCLUDING THE CONTROL ROOM REQUIREMENTS.
LAB PROCESSING REQUIREMENTS

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

July 1998
ET PROCESSING FACILITY LAYOUT

TO ALLOW VAB HB4 TO BE USED FOR STS/LRB INTEGRATION, ET STORAGE AND PROCESSING MUST BE MOVED TO AN OFF-LINE FACILITY. THE PROPOSED FACILITY CAN BE COMBINED WITH THE NEW LRB PROCESSING FACILITY AND SHARE OFFICE, SHOP AND CONTROL ROOM SPACE.

THE FACILITY UTILITY REQUIREMENTS WILL BE THE SAME AS LRB AND WILL BE SHARED.

ALL OPERATIONS PRESENTLY PERFORMED ON THE ET IN HB4 CAN BE ACCOMPLISHED IN THE HORIZONTAL POSITION.
ET/LRB PROCESSING FACILITY - SITING

THE SITE SELECTION TRADE STUDY FOR THIS FACILITY IS IN PROGRESS. FOUR (4) LC-39 AREA SITES ARE UNDER REVIEW.

1. SOUTH OF THE LOGISTICS FACILITY ON CONTRACTOR'S ROAD
2. SOUTH OF THE TURN BASIN ADJACENT TO THE PRESS SITE
3. SOUTHWEST OF THE VAB AND EAST OF MFF, CURRENTLY A PARKING LOT
4. NORTH OF THE VAB AND EAST OF THE OMRF

PRIMARY TRADE SELECTION CRITERIA INCLUDES -

1. SSV INTEGRATION FACILITY PROXIMITY
2. TURN BASIN PROXIMITY
3. BLAST DANGER AREA (QUANTITY/DISTANCE)
4. LAUNCH DANGER AREA
5. ENVIRONMENTAL IMPACTS
6. ET & LRB TOW ROUTES
7. LC-39 AREA CONGESTION
8. AVAILABILITY OF UTILITIES/SERVICES
9. DEMOLITION AND RELOCATION OF EXISTING FACILITIES
10. SITE PREPARATION COSTS

ANY SITE IN THE DIRECTION OF SWARTZ ROAD IS PREFERRED TO ELIMINATE CONGESTION AND TRAFFIC CONCERN AND IMPACT TO CURRENT UTILITIES AND SERVICES IN THE LC39 AREA.
ET/LRB PROCESSING FACILITY CONTROL CENTER & LPS REQUIREMENTS

LRB PROCESSING FUNCTIONS IN THE NEW FACILITY INCLUDE COMPONENT AND SUBSYSTEM CHECKOUT, WITH LPS SUPPORT. TO AVOID A LCC IMPACT, AN INDEPENDENT CONTROL ROOM CONCEPT CONFIGURED LIKE A MINI-LCC, IS UNDER REVIEW.

EACH OPERATIONS SYSTEM ENGINEER WILL BE REQUIRED TO HAVE A CONSOLE WHILE PERFORMING FUNCTIONAL TESTING OF BOTH SETS OF LRB'S. CHECKOUT WILL INCLUDE ENGINE, AVIONICS, INSTRUMENTATION, POWER & GIMBALING TESTS. LISTED BELOW IS A GENERAL LIST OF EQUIPMENT REQUIRED FOR THE LRB/ET FACILITY CONTROL ROOMS:

0 1 - O.L.S.A
0 1 - HARDWARE INTERFACE MODULE (HIM)
0 1 - COMMON DATA BUFFER
0 1 - SCRS
0 1 - CPS4
0 1 - V & DA
0 5 - CONSOLES (CPU INCLUDED) FOR: PROPELLANTS, GUIDANCE, INSTR/HAZ, POWER, RANGE SAFETY/COMM, DPS, INTEGRATION, MASTER
0 1 - FEP

ET HORIZONTAL PROCESSING CAN BE SUPPORTED WITH THIS EQUIPMENT AS WELL.
LIQUID ROCKET BOOSTER INTEGRATION
FIRST PROGRESS REVIEW
JULY 1988

INTEGRATION FACILITY

- VAB PLATFORMS (HB-3) MODIFICATION
- VAB EXIT / PLATFORM INFRINGEMENT
- VAB HIGH BAY 4
- VAB HIGH BAY 4 CRAWLERWAY
VAB PLATFORMS (HB 3)

THE PLATFORM MODIFICATIONS AT VARIOUS LEVELS IS DEPENDENT ON THE LENGTH AND DIAMETER OF THE LRB. THE WORST CASES FOR LENGTH ARE THE GDSS LOX/LH2 PUMP-FED AND GDSS LOX/RP1 PRESSURE-FED CONFIGURATIONS. THE DIAMETERS OF ALL LRB CONFIGURATIONS IMPACT THE EXTENSIBLE PLATFORMS/FLIP-UPS ENCOUNTERED. THE PRESENT REQUIREMENT FOR CLEARANCE OF STEEL TO FLIGHT HARDWARE IS 6" (STATIC).

USING THE MMC LOX/RP1 PUMP-FED CONFIGURATION AS A BASELINE, IT IS NOTED THAT EXTENSIVE MODIFICATIONS ARE REQUIRED. ALL FLOORS OF PLATFORM LEVELS "D," "E," & "F" WILL REQUIRE MODIFICATIONS. THE FLIP-UP/EXTENSIBLE PLATFORMS WILL REQUIRE REDESIGN TO PROVIDE DUAL CAPABILITY, LRB OR SRB. FOR THE GDSS LOX/LH2 PUMP-FED AND GDSS LOX/RP1 PRESSURE-FED CONFIGURATIONS, MODIFICATIONS TO PLATFORM "C" WILL BE REQUIRED.
Typical Modification

(ROOF OF PLATFORM - NOT SHOWN)

Remove Structure
This Area

CUT BACK
CUT BACK

CLEARANCE
FOR VEHICLE EXIT

HINGE 90° BACK TO
MODIFY FLIP-UP 10

VAB PLATFORM (HB-3) MODIFICATION

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

JULY 1988
VAB HB 3 EXIT/PLATFORM INFRINGEMENT

A MINIMUM CLEARANCE OF 1' - 6" WILL BE REQUIRED FOR FLIGHT HARDWARE TO STRUCTURE DURING VAB EGRESS. ALL LRB CONCEPTS IMPACT THE RETRACTED PLATFORM/FLIP-UPS AT PLATFORMS "D," "B," & "E." THE GDSS LOX/LH2 PUMP-FED AND GDSS LOX/RP1 PRESSURE-FED CONFIGURATIONS WILL IMPACT PLATFORM "C".
PLAN VIEW

LO2 / RP-1 PUMP FED (MGC)

EXISTING EXTENSIBLE WORK PLATFORM

VAB EXIT / PLATFORM INTEGRATION

FIRST PROGRESS REVIEW

JULY 1988

LIQUID ROCKET BOOSTER INTEGRATION

ADVANCED PROJECTS
VAB HIGH BAY DOOR CLEARANCE

- All LRB Configurations clear the VAB doors

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<th>LRB TYPE</th>
<th>BOOSTER DIA</th>
<th>CLEARANCE</th>
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<tr>
<td>GDSS LO2/RP1 (PUMP FED)</td>
<td>14'-1&quot;</td>
<td>6'-8&quot;</td>
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<tr>
<td>GDSS LO2/RP1 (PRESSURE)</td>
<td>15'-0&quot;</td>
<td>5'-9&quot;</td>
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<tr>
<td>GDSS LO2/LH2</td>
<td>16'-2&quot;</td>
<td>4'-7&quot; (SHOWN)</td>
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<td>GDSS LO2/CH4</td>
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<td>MMC LO2/RPI (PUMP FED)</td>
<td>15'-4&quot;</td>
<td>5'-5&quot; (SHOWN)</td>
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<td>MMC LO2/RPI (PRESSURE)</td>
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<tr>
<td>PRESENT SRB</td>
<td>12'-2&quot;</td>
<td>8'-7&quot; (SHOWN)</td>
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VAB HIGH BAY 4

DEMOLITION OF EXISTING VEHICLE ACCESS STRUCTURES IS REQUIRED. THIS INCLUDES REMOVAL OF SRB WORK STANDS AND ET CHECKOUT CELLS (ET CHECKOUT EQUIPMENT WILL BE MOVED TO THE NEW ET FACILITY AND THE SRB WORK STANDS CAN BE RELOCATED TO VAB HB2 AS BACKUP TO THE RPSF.)

NEW ORBITER, ET, AND LRB ACCESS PLATFORMS WILL BE PROVIDED. THE PLATFORM SYSTEM WILL BE SIMILAR TO THOSE IN HB 1/3 BUT WILL BE CUSTOMIZED TO PROVIDE ACCESS TO THE ORBITER, ET AND LRB. THE LRB ACCESS WILL INCLUDE AFT SKIRT, INTERTANK AREA AND NOSE. THE REQUIRED ORBITER/ET ACCESS WILL INCLUDE THE 2ND AND MAIN FLOOR OF PLATFORM "D" (WILL ALSO PROVIDE ACCESS TO LRB AFT SKIRT), ROOF & 2ND FLOOR OF PLATFORM "B" AND MAIN FLOOR OF PLATFORM "E."

THE TWO LONGEST BOOSTER CONFIGURATIONS WILL REQUIRE ADDITIONAL PLATFORMS SIMILAR TO "C" IN HB 1/3.

THE HIGH BAY WILL REQUIRE INSTALLATION OF GSE TO PERFORM INTEGRATION TESTING OF THE ET/ORBITER IDENTICAL TO HB 1/3. NEW LRB INTEGRATION TEST GSE WILL ALSO BE INSTALLED.
In order to use VAB HB-4 as a STS/IBB integration facility, reactivation of the high bay craneway is required.

The OPF modular housing, OPF East parking lot and a section of the orbiter towway will be demolished.

Parallel power, communication and mechanical services will be installed prior to the demolition or abandonment in place of existing services.

Demolition of the OPF modular housing will displace approximately 100 personnel and will require siting of alternate work space.

Further study is required to concept an intersection of the crane way and orbiter tow way.
A MAJOR CONCERN FOR MODIFICATION OF THE MLPS IS IMPACTS TO THE G-20 GIRDER. G-20 IS THE PRIMARY STRUCTURAL MEMBER OF THE GIRDER SYSTEM. ANOTHER CONCERN WITH THE SSME AND BOOSTER EXHAUST HOLE ARRANGEMENT IS THE IMPACT ON THE SIZE OF THE SSME EXHAUST HOLE. FURTHER STUDY IS REQUIRED FOR BOTH CONCERNS.
Hold Down Concepts

Comparison for MDC Press Fed LO2 / RPI

MDC Pump Fed LO2 / RPI

Comparison for Other GSS LRB Boosters

GSS Pump Fed LO2 / RPI

MLP Exhaust Hole Modification

MLP
MLP EXHAUST HOLE MODIFICATION (GDSS)

GDSS PUMP-FED LO2/RP1

The existing MLP requires major modification of the booster exhaust holes. New girders are required to support the holddown system on the northside. The exhaust holes for all configurations are to be enlarged to 4 1/4 1/2" x 27'6 1/4". There are some concerns on design feasibility of girders placed in the exhaust holes. These girders would require extensive blast protection and in case of "ignition and no-go" may require major refurbishment. Engine gimbal angles of ±6 degrees can be accommodated in the redesign.
<table>
<thead>
<tr>
<th>SUPPORTS</th>
<th>HAUNCH SIZE &amp; LOCATION OF NEW GIRDERS</th>
<th>FROM 6 LRG RELEASE MECH GIRDERS TO SUPPORT LOCATION OF NEW</th>
<th>G-25 AND G-4 TO G-6-22 AND G-24</th>
<th>G-10 TO RELOCATED G-20 IMPACT TO GIRDERS</th>
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MODIFICATIONS TO MLR FOR GDSR LRG CONCEPTS

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

JULY 1988

KSC ADVANCED PROJECTS

TECHNOLOGY OFFICE
MLP EXHAUST HOLE MODIFICATION (MMC)

MARTIN MARIETTA PUMP-FED LOX/RP1

THE EXISTING MLP EXHAUST HOLES WILL BE ENLARGED FOR LRB EXHAUST. (41'-4 1/2" X 29' 0"), NEW GIRDER WILL BE INSTALLED REPLACING GIRDER G-22, 23, 24 & 25. RECONFIGURATION OF THE BLAST SHIELD STRUCTURE WILL BE REQUIRED. A MAJOR CONSTRAINT FOR REDESIGN OF AN EXITING MLP IS NO CHANGE IN LOCATION OF THE G-20 GIRDER BECAUSE OF MLP STRUCTURAL INTEGRITY AND SSME EXHAUST HOLE INFRINGEMENT.

ENGINE GIMBAL ANGLES OF ±6° PRESENT NO PROBLEM FOR STRUCTURAL CLEARANCE FOR THE PUMP FED CONFIGURATION. THE MINIMUM CLEARANCE IS APPROXIMATELY 2'-0". THE G20 GIRDER IS IMPACTED BY THE PRESSURE FED CONFIGURATION.
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<td>22.0 1/2&quot;</td>
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Modifications to MLP for Martin LRB Concepts

First Progress Review
Liquid Rocket Booster Integration

July 1988
HOLD DOWN MECHANISM (GDSS) LAYOUT

A CONCEPTUAL LAYOUT FOR HOLD DOWN MECHANISMS LOCATES THE HOLD DOWN POINTS ON THE CENTERLINE AXIS OF THE LRB ON THE ZERO DECK OF THE MLP. DESIGN ANALYSIS FOR SIZE AND LOADS IS REQUIRED. THIS ANALYSIS WILL REQUIRE THE DRIFT PROJECTIONS, FINAL WEIGHT OF LRB AND SKIRT DETAILS. THE GIRDER WHICH CROSSES THE EXHAUST HOLE WILL BE LOCATED BASED ON DRIFT PROJECTIONS WHEN AVAILABLE.
HOLD DOWN MECHANISM (GDSS)

SOFT RELEASE CONCEPT

THE HOLD DOWN DEVICE DESIGN IS SIMILAR TO THE HOLD DOWN SYSTEM USED ON SATURN V. THE RELEASE SYSTEM WILL CONSIST OF THE FOLLOWING MAJOR COMPONENTS:

1. HOLD DOWN HOUSING
2. HOLD DOWN ARM
3. AFT SKIRT SHOE
4. COUNTERWEIGHT/DIE
5. HOLD DOWN STUD BOLT & PYRO-NUT
6. EXTRUSION PINS AND NUT

HOLD DOWN POST/HAUNCH (MMC) LAYOUT

A CONCEPTUAL LAYOUT, FOR HOLD DOWN POSTS AND HAUNCHES, LOCATES THE HOLD DOWN POINTS 45° TO THE CENTERLINE AXIS OF THE LRB, IN THE MLP EXHAUST HOLE. THIS IS SIMILAR TO THE SRB CONFIGURATION. DESIGN ANALYSIS FOR SIZE AND LOADS IS REQUIRED. THIS ANALYSIS WILL REQUIRE THE DRIFT PROJECTIONS, FINAL WEIGHT OF LRB AND SKIRT DETAILS.
HOLD DOWN POST / HAUNCH (MCC) LAYOUT

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

JULY 1988
HOLD DOWN POST WITH SOFT RELEASE (MMC)

THE SOFT RELEASE SYSTEM CONCEPT USED ON APOLLO WITH THE HOLD DOWN SYSTEM
USED PRESENTLY WAS CHOSEN FOR THIS STUDY. IN THIS ARRANGEMENT A PRE-SHAPED
BILLET OF MALLEABLE MATERIAL HAS A DIE EXTRUDED THROUGH IT TO PROVIDE A
SLOW, DAMPED RELEASE OF THE LRB.

1. THE TENSIONING OF THE HOLD DOWN STUD WILL BE THE SAME PROCEDURE FOR
   SRB'S
2. PLACE THE LOWER RETAINER OVER THE PYRO-NUT
3. ATTACH THE LOWER RETAINER TO THE LRB FOOT
4. PLACE THE BILLET ON TOP OF THE LOWER RETAINER
5. THREAD THE DIE TO THE HOLD DOWN STUD
6. ATTACH THE UPPER RETAINER TO THE LOWER RETAINER

AT LAUNCH THE RESTRAINT FORCE IS RELEASED FROM THE PYRO-NUT AND THE LOAD
PATH PROCEEDS FROM THE HOLD DOWN STUD TO THE DIE, FROM THE DIE TO THE
BILLET WHICH IN TURN RESTS ON THE LOWER RESTRAINT AND finally TO THE LRB
FOOT. AT THIS POINT THE ASCENDING STS CAUSES THE DIE TO BE EXTRUDED
THROUGH THE BILLET thus PROVIDING A SOFT RELEASE. AFTER THE EXTRUSION
PROCESS THE HOLD DOWN STUD, WITH THE ATTACHED DIE, FALLS THROUGH INTO THE
HOLLOW OF THE HOLD DOWN POST WHILE THE PYRO-NUT AND THE OTHER ELEMENTS
ABOVE IT ARE CAPTURED BETWEEN THE UPPER AND LOWER RESTRAINT HOUSING.
WEATHER PROTECTION SYSTEM
LAUNCH PAD ACCESS PLATFORMS
LRB UMBILICAL SYSTEMS
ET H2 VENT
GOX VENT
PAD UMBILICAL SYSTEMS
FRAME DEFLECTORS
LAUNCH PAD

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION
PAD FLAME DEFLECTORS

PAD FLAME DEFLECTORS

MAJOR MODIFICATIONS ARE REQUIRED TO THE MAIN FLAME DEFLECTOR FOR BOTH THE SRB AND THE SSME SIDES. THIS WILL INVOLVE SHIFTING THE SEPARATION LINE BETWEEN THE FLAME DEFLECTORS SOUTH TO ACCOMMODATE THE NEW CONFIGURATION. SIMILARLY MAJOR MODIFICATIONS ARE REQUIRED TO THE SIDE FLAME DEFLECTORS. THIS WILL INVOLVE HAVING THE CAPABILITY OF EFFECTIVELY DIRECT THE BLAST PRESSURE TO THE FLAME TRENCH AND THE STRENGTH TO WITHSTAND THE DIRECT BLAST PRESSURE. IN ADDITION TO THAT, AN EVALUATION OF THE FOUNDATIONS FOR THE SIDE FLAME DEFLECTORS IS REQUIRED TO DETERMINE THEIR CAPACITIES FOR THE NEW LOADS.
PAD UMBILICAL SYSTEMS

THE UMBILICALS REVIEWED FOR IMPACT INCLUDE THE GOX VENT, OMBUU, OAA, HYPERGOL UMB(S), ET H₂ VENT AND TSM(S).

THE GOX VENT IS AFFECTED BY THE HEIGHT OF THE GDSS LO₂/LH₂ AND GDSS LO₂/RP1 PRESSURE-FED CONFIGURATIONS. EITHER ONE WILL REQUIRE EXTENSIVE MODIFICATION AND CONCEPT CHANGE FOR THE ARM.

THE ET H₂ VENT IS EFFECTED BY ALL LRB CONFIGURATIONS. EXTENSIVE MODIFICATION, RELOCATION AND CONCEPT CHANGES WILL BE REQUIRED.

THE OMBUU, OAA & HYPERGOL UMB HAVE NO IMPACT BY THE LRB.

THE TSM WILL BE UNEFFECTED BASED ON THE ASSUMPTION THAT VEHICLE EXCURSIONS REMAIN UNCHANGED.

IF EXCURSIONS AND DRIFTS ARE AFFECTED THE TSM(S), OMBUU AND OAA WILL REQUIRE ADJUSTMENT. SINCE THE OAA AND ET VENT HAVE LIMITED EXCURSION CAPABILITY THE IMPACT WILL BE EXTENSIVE.

ALL CHANGED/MODIFIED UMBILICAL SYSTEMS WILL REQUIRE RE-QUALIFICATION AND ACCEPTANCE TESTING AT THE LETF.
GOX VENT

THIS UMBILICAL IS UNAFFECTED BY THE DIAMETER INCREASES FOR ANY OF THE SIX (6) LRB CONCEPTS, HOWEVER; LRB LENGTHS OVER 170 FEET HAVE HARD INTERFEERENCE WITH THE EXISTING STRUCTURE, THE GDSS LO2/RP-1 (PRES) AND LO2/LH2 ARE INCOMPATIBLE WITH THE CURRENT GOX VENT. TO PROVIDE GOX VENTING CAPABILITY WITH THESE LRB'S WOULD REQUIRE EXTENSIVE MODIFICATION TO THE UMBILICAL.

THIS CONCEPT USES AS MUCH OF THE EXISTING ARM AND ASSOCIATED COMPONENTS AS POSSIBLE, BUT REQUIRES A NEW OR MODIFIED HOOD ASSEMBLY, A NEW AFT ARM SEGMENT, NEW HINGE AND HINGE ACTUATING MECHANISM, AND STRUCTURAL ADDITIONS TO THE FIXED SERVICE STRUCTURE (FSS). ADDITIONALLY, A MODIFICATION OF THIS MAGNITUDE WILL REQUIRE LETF REQUALIFICATION AND VALIDATION TESTING.
ET H2 VENT

THE MOST SIGNIFICANT CONCERN DEALS WITH VEHICLE DRIFT CLEARANCE TO THE ET VENT SUPPORT STRUCTURE. THE SRB DRIFT PATH PAST THE ET VENT OCCURS AS THE SKIRT PASSES THE 222'6½" LEVEL.

THE MINIMUM CLEARANCE IS 2.7 FEET. ASSUMING A SIMILAR DRIFT FOR THE LRB'S AND USING THE LARGER SKIRT DIAMETER, THE STRUCTURE TO VEHICLE RELATIONSHIP IS SHOWN.

ALL THE LRB CONFIGURATIONS SHOW INTERFERENCE AT THE 222'6½" LEVEL.
ET H2 VENT

This figure shows the required relocation of the ET vent structure to obtain a two (2) foot clearance for the GDSS LO2/RP-1 Pump configuration.

Relocating the structure will necessitate lengthening the vent line by approximately five (5) feet, this is turn will make it necessary to modify the lower level of ET vent structure and decel unit since the vent line will extend lower while in the retracted position.

Lengthening the vent line will aggravate the already marginal pyro bolt load for the ET vent ground umbilical carrier plate. To provide adequate vehicle drift clearance to the ET vent will require extensive modification of the umbilical, and complete LETF requalification & validation testing.
ET VENT STRUCTURE RELOCATION FOR LAB DRIFT CLEARANCE
ET H2 VENT

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

July 1988
**TO ACCOMODATE THE LRB NEW UMBILICAL SYSTEMS WILL BE REQUIRED. THE SYSTEMS WILL REQUIRE QUALIFICATION TESTING AT THE LETF.**

**LRB / LAUNCH UMBILICAL SYSTEMS SUMMARY**

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IA-29A

**Lockheed**

**Space Operations Company**
LAUNCH PAD ACCESS PLATFORMS

TO MAINTAIN DUAL LAUNCH CAPABILITY FOR LRB AND SRB THE EXISTING PLATFORM SYSTEM REQUIRES MODIFICATION TO ACCOMMODATE THE DIAMETERS OF BOTH BOOSTERS.

ACCESS MUST BE MAINTAINED FOR FORWARD SRB, ET/ORBITER AND TPS REQUIREMENTS. NEW ACCESS REQUIREMENTS FOR LRB WILL INCLUDE: FORWARD, INTERTANK, AND AFT.

MORE DETAILED STUDIES ARE REQUIRED FOR EACH LRB CONFIGURATION TO DETERMINE THE FEASIBILITY AND EXTENT OF THESE MODIFICATIONS.

FOR THE GDSS LOX/LH₂ AND GDSS LOX/RP1 PRESSURE-FED, FORWARD ACCESS FROM THE RSS ROOF WILL IMPACT THE LOAD LIMITATIONS OF THE RSS. THE SRB AFT INTEGRATED ELECTRONIC ASSEMBLY (IEA) PLATFORMS CAN BE STOWED FOR LRB LAUNCH CONFIGURATIONS.
WEATHER PROTECTION SYSTEM

MAJOR MODIFICATIONS WILL BE REQUIRED. FOR EXAMPLE, SWING CLEARANCE FOR THE -Y CURTAIN WALL IS REDUCED TO 8" FOR MMC LOX/RP1 PUMP FEED. THE HINGE POINT FOR ROTATING THE CURTAIN WALL WOULD NEED TO BE MODIFIED TO PROVIDE ADEQUATE CLEARANCE OF 1'-6" MINIMUM. A DETAILED STUDY IS REQUIRED TO DETERMINE THE EXTENT AND FEASIBILITY OF THE REQUIRED MODIFICATIONS.
PROPELLANT STORAGE

The cryogenic (LO2 and LH2) propellant requirement for the 6 LRB configurations have been reviewed for impact analysis and concepts for transfer are being developed.

The RPI propellant requirements for the 4 LRB configurations have been reviewed and the concepts for transfer are being developed.

Analysis and review of the methane propellant requirement has started.

Quantity/distance requirements for launch pad storage facilities have been determined for the various propellants.
LOX TRANSFER & STORAGE

THREE CONCEPTS FOR TRANSFER ARE BEING STUDIED BASED ON FAST FILL:

0 HOLD EXISTING TIME LINE - LRB LOADED BY INDEPENDENT PUMP AND 8" CROSS-COUNTRY LINE (PREFERRED.)

0 USE EXISTING 1M PUMP AND 6" CROSS-COUNTRY LINE AND INCREASE LOADING TIME LINE.

0 HOLD EXISTING TIMELINE - LRB AND ET LOADED BY INDEPENDENT PUMP AND 10" CROSS-COUNTRY LINE, EXISTING SYSTEM USED FOR SRB/ET CONFIGURATION.

THE PREFERRED CONCEPT MAINTAINS THE TIMELINE AND PROVIDES A NEW TRANSFER SYSTEM FOR LRB USING A 8" VJ LINE AND 5M PUMPS. THIS WILL ALLOW INDEPENDENT LOADING OF LRB & ET. THE PRESENT STORAGE DOES NOT PERMIT A SCRUB/TURNAROUND WITHOUT REPLENISH OF STORAGE VESSEL. THEREFORE, A SECOND LOX TANK IS REQUIRED.

PRESENT LOX VESSEL REPLENISH CAPABILITY PERMITS 210,000 GAL/WEEK (42,000 GAL/DAY). ADDITIONAL TANKERS WOULD ALLOW ACQUISITION OF 84,000 GAL/DAY.
LH2 TRANSFER AND STORAGE

LH2 TRANSFER CAN BE ACHIEVED USING THE EXISTING 10\" CROSS-COUNTRY LINE WITH LRB LOADING EQUIPMENT CONNECTED UPSTREAM OF ET LOADING EQUIPMENT.

THE PRESENT STORAGE DOES NOT PERMIT LOADING OF LRB/ET AND AN ADDITIONAL STORAGE VESSEL MUST BE PROVIDED.

THE DOUBLING OF THE STORAGE DOES NOT PERMIT A SCRUB/TURNAROUND.

THE PRESENT LH2 VESSEL REPLENISH CAPABILITY PERMITS 200,000 GAL/WEEK, THEREFORE DOUBLING THE FILL STATIONS AND TANKER FLEET WILL BE REQUIRED.
RP1 TRANSFER AND STORAGE

THE CONDITION OF THE STORAGE VESSELS ON PAD B IS UNKNOWN (PAD A VESSELS REMOVED) AND HAVE NOT BEEN MAINTAINED. BASED ON THE FACT OF LACK OF MAINTENANCE AND THAT EPA REGULATIONS FOR UNDERGROUND FUEL STORAGE HAVE BEEN TIGHTENED, THE STUDY IS PROCEEDING ON THE ASSUMPTION NEW VESSELS ARE REQUIRED. THE TRANSFER LINES ON BOTH PADS HAVE ALSO NOT BEEN MAINTAINED AND THE CONDITION IS UNKNOWN. A COST TRADE FOR REPLACEMENT OR REFURBISHMENT IS REQUIRED TO DETERMINE WHICH APPROACH IS COST EFFECTIVE AND WILL PROVIDE A SAFE TRANSFER SYSTEM INTO THE 21ST CENTURY.

THE APOLLO CONCEPT OF THREE 85,000 GALLON VESSELS IS SUFFICIENT FOR ALL LRB CONFIGURATIONS.

AN OPTION TO PROVIDE A CENTRAL RP1 STORAGE FACILITY BETWEEN THE PADS ON BEACH ROAD HAS BEEN CONSIDERED. THIS OPTION REQUIRES TRANSFER OF RP1 ACROSS WET-LANDS WHICH WILL REQUIRE AN ENVIRONMENTAL IMPACT STUDY.
FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

July 1988

KSC
ADVANCED PROJECTS
At the present time firing room (FR) 1, 2, & 3 have a maximum capacity of 15 consoles/CPU(s) each due to space and software limitations. Additional consoles/CPU(s) may be required to support an integrated STS/ERB stack while maintaining STS/ERB capability. Options for integrating ERB requirements into the LCC is to utilize consoles in FR 2 to tie in with FR 1 and 3 or develop software capability to share existing consoles. Expansion of the software to accommodate ERB requirements is required.
To test Shuttle SRB stack FR 2 is not required.
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Simulations development and to perform software convert FR 4

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LCC Firing Rooms

First Progress Review
Liquid Rocket Booster Integration

July 1988
• MLP PARKSITE #2
• OTHER SERVICE / UTILITY IMPACTS
• LC-39 POWER REQUIREMENTS

LC-39
LC39 POWER REQUIREMENTS

THE ADDITIONAL LOAD REQUIREMENTS TO SUPPORT LRB WILL REQUIRE THE EXPANSION OF THE C-5 SUBSTATION. ADDITIONAL TRANSFORMERS AND SWITCHING PANELS WILL BE NEEDED.

EMERGENCY GENERATOR POWER PANELS WILL NEED TO BE EXPANDED TO SUPPORT THE ADDITIONAL EMERGENCY POWER REQUIREMENTS.

THE LCC AND LRB/ET PROCESSING FACILITY WILL REQUIRE ADDITIONAL UPS.

THE PAD LOX AND FUEL SITES, MLP PARKSITE AND LRB/ET PROCESSING FACILITY WILL REQUIRE ADDITIONAL SUBSTATIONS.

ADDITIONAL FEEDERS WILL BE REQUIRED FOR ALL NEW SITES AND EXPANDED SITES FOR BOTH FACILITY AND EMERGENCY POWER.
<table>
<thead>
<tr>
<th>LC-39 Power Requirements</th>
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<tbody>
<tr>
<td>FIRST PROGRESS REVIEW</td>
<td>LIQUID ROCKET BOOSTER INTEGRATION</td>
</tr>
<tr>
<td>JULY 1988</td>
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<table>
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<th>Component</th>
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<tr>
<td>N/A</td>
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<tr>
<td>N/A</td>
<td>2-13,8 kV Feeders</td>
</tr>
<tr>
<td>N/A</td>
<td>MLF 1, 2 AND/OR 3</td>
</tr>
<tr>
<td>N/A</td>
<td>NEW MLF</td>
</tr>
<tr>
<td>3-6000kV</td>
<td>TBD</td>
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<tr>
<td>N/A</td>
<td>MLF PWR</td>
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<td>PAD LOX</td>
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<tr>
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<td>WLP PARK SITE (2)</td>
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<tr>
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<td>FACILITY</td>
</tr>
<tr>
<td>1-480V @ 400 kV Feeders</td>
<td>FACILITY</td>
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<tr>
<td>2-200A Substation (Double)</td>
<td>FACILITY</td>
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<tr>
<td>4-480V @ 400 kV Feeders</td>
<td>FACILITY</td>
</tr>
<tr>
<td>4-480V @ 400 kV Feeders</td>
<td>FACILITY</td>
</tr>
<tr>
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<td>GENERATOR</td>
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<tr>
<td>UPS</td>
<td>EMERGENCY</td>
</tr>
<tr>
<td>UPS</td>
<td>EMERGENCY</td>
</tr>
<tr>
<td>UPS</td>
<td>SITES</td>
</tr>
</tbody>
</table>
MLP PARKSITE #2

DUE TO THE REQUIREMENT FOR CONSTRUCTION AND ACTIVATION OF A NEW MLP, REACTIVATION OF MLP PARKSITE #2 IS MANDATORY. INITIALLY, THE PARKSITE WILL BE DEDICATED AS A CONSTRUCTION SITE FOR THE NEW MLP, REQUIRING INSTALLATION OF MOUNT MECHANISMS. DURING THE ACTIVATION PHASE OF THE NEW MLP, PARKSITE REQUIREMENTS ARE MORE SOPHISTICATED. THIS INCLUDES INSTALLATION OF ACCESS TOWERS, POWER, COMMUNICATIONS, AND VARIOUS MECHANICAL UTILITIES.
MLP PARKSITE #2

Site No. 2

ASPHALT PAD

Access Tower (NEW)

Access Tower (NEW)

Pad Unit (NEW)

Air Handling Unit (NEW)

Chilled Water Pump (NEW)

Flex Pump

MLP PARKSITE #2

Launched Road

7/98

FIRST PROGRESS REVIEW

LIQUID ROCKET BOOSTER INTEGRATION

KSC ADVANCED PROJECTS

80708-01X21
LAUNCH EQUIPMENT TESTING FACILITY (LETF)

THE LAUNCH EQUIPMENT TEST FACILITY (LETF) PROVIDES THE CAPABILITY FOR THE OPERATIONAL QUALIFICATION AND CERTIFICATION OF LAUNCH SUPPORT EQUIPMENT (LSE). THE FACILITY TESTS LSE BY SIMULATION OF VEHICLE MOTION (BEFORE LAUNCH, AT LIFT-OFF, DURING FLUID FLOW) AND VERIFIES THE SYSTEM FOR OPERATIONAL PERFORMANCE, EMERGENCIES, HOLDS AND OTHER CONTINGENCIES.

THE LRB LSE WILL REQUIRE SUCH QUALIFICATION AND CERTIFICATION. THE LSE IDENTIFIED FOR TESTING INCLUDE THE TWO LOX FILL & DRAIN (F/D) UMBILICALS, TWO FUEL F/D UMBILICALS, TWO FUEL VENT UMBILICALS, TWO POWER/INSTRUMENTATION UMBILICALS AND THE EIGHT HOLDDOWN DEVICES FOR EACH MLP/PAD.

THE REQUIRED REDESIGN OF THE ET H₂ VENT WILL ALSO REQUIRE RE-QUALIFICATION AND CERTIFICATION. THE GOX VENT ARMS AND ALL TSMs WOULD REQUIRE RE-TEST IF MODIFICATIONS OR CHANGES ARE MADE.

THE IMPACT TO THE FACILITY INCLUDES ADDITION OF TOWERS/INTERFACE SIMULATORS FOR THE LRB LSE TESTS. MODIFICATIONS TO THE EXISTING ET/SHUTTLE SIMULATORS MAY BE REQUIRED.
SAFETY/ENVIRONMENTAL IMPACTS

SAFETY AND ENVIRONMENTAL IMPACTS ARE BEING ADDRESSED FOR EACH LRB CONFIGURATION AND PROCESSING CONCEPT. THESE IMPACTS ARE BASED ON RESEARCH OF APPLICABLE SAFETY AND ENVIRONMENTAL RULES, REGULATIONS, STANDARDS AND CODES; DATA PROVIDED BY THE MARSHALL PHASE "A" STUDY CONTRACTORS; AND STUDY GROUNDRULES (PUMP FED LOX/RP-1 PROPELLANTS).

THE SAFETY IMPACTS ARE ADDRESSED FROM A STANDPOINT OF THOSE THAT WOULD BE GENERIC TO ANY PROGRAM OF THIS NATURE AND THOSE THAT ARE FELT TO BE UNIQUE TO THE LRB. IMPACTS FROM AN ENGINEERING, OPERATIONAL AND INDUSTRIAL SAFETY POINT OF VIEW ARE BEING ADDRESSED.

THE ENVIRONMENTAL IMPACTS ADDRESSED ARE THOSE WHICH WOULD BE GENERATED BY ANY MAJOR PROGRAM OF THIS TYPE.
NEW LOW ROUTE VS USING EXISTING LOW WAYS

(5) LRB LOW ROUTE

- Centralized Storage Facility for RP-1 Between the Pads
- Additional Propellant Storage Requirements within Pad Compound
- Quantity Distance Requirements
- Added Capability for Abort Modes After Liftoff
- To Release
- Ability to Perform Health Verification of Booster Engines Prior

(4) Flight Safety/Abort Enhancements

(3) Corrosion Control

Problems (Increased Life Expectancy of GSE and Reduction in
Cleaner Combustion by Products / Draastic Reduction in Acid Cloud

(2) Major Environmental Enhancements

- Eliminates Need for APS
- Reduced Stacking Operations
- No Live Propellants in VAB
- Major Ground Safety Enhancements

(1) Significant Items which are being Addressed in the Study Are

Significant Environmental Impacts

July 1988

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

80708-01BK

ADVANCED PROJECTS

TECHNOLOGY OFFICE

KSC
EXISTING SOFTWARE LIMITATIONS TO SUPPORT LRB

TCC - SPACE LIMITATIONS OF EXISTING FIRING ROOM

VAB - ACCESS TO VAB HB 4 WITH CRAWLERWAY

PRESSURE FORWARD AREA

WEIGHT LIMITATIONS OF RSS FOR ACCESS TO GSSS LOX/LH2 AND LOX/RP-1

NEW TOWERS FOR LRB H2 OR CH4 VENTS

MOD TO THE TRENCH

FLAME TRENCH DEFLECTORS AND SIDE DEFLECTORS CONCEPT WITHOUT

MARGINAL

AND PLACING THE ET H2 VENT (PYRO BOLT LOADS ARE ALREADY

AND WORST CASE LRB ENGINE OUT FOR DESIGNING

PAD - WEIGHT & STRUCTURAL LIMITATION OF RSS FOR CANTILEVER OF GSSS VENT

PAD - GSSS LRB HOLDDOWN

PAD - WEIGHT & STRUCTURAL LIMITATION OF RSS FOR CANTILEVER OF CROSS GIRDER

PAD - DRIFT DATA FOR HOLDDOWN CONCEPTS (CROSS GIRDER PLACEMENT FOR

G-20)

EXHAUST HOLE CAUSED BY MMC PRESSURE-FED (CLEARANCE OF GIRDER

IMPACTS TO MLP STRUCTURAL INTEGRITY AND INFRINGEMENT ON SSME

ISSUES

FIRST PROGRESS REVIEW

JULY 1988

LIQUID ROCKET BOOSTER INTEGRATION
SITING OF PROPELLANT STORAGE

ENVIRONMENTAL: SITING OF LRB / ET FACILITY AND TOWAWAY ACCESS.

ENVIRONMENTAL: DURABILITY OF LSE / GSE

MAINTAINABILITY: DURABILITY OF LSE / GSE

MECHANISMS USING VEHICLE EXCURSION AND LAUNCH DATA

TEST PROGRAM FOR ALL REDESIGNED AND NEW UMBILICAL

(ANALYSIS)

RELIABILITY: FAILURE MODE AND EFFECTS ANALYSIS SYSTEM ASSURANCE

QUALITY: CERTIFICATION OF PRESSURE VESSELS AND SYSTEMS

HAZARD ANALYSES

AT KSC

HANDLING AND STORAGE OF CH4 AS A NEW PROPELLANT

SAFETY: PROPELLANT QUANTITY / DISTANCE REQUIREMENTS

ISSUES (CONT)
FACILITY ACTIVATION SCHEDULE


THE CURRENT CRITICAL PATH TO 1ST LRB LAUNCH IS THE DESIGN, ADVANCED PROCUREMENT, CONSTRUCTION, ACTIVATION AND OPERATIONAL CERTIFICATION OF A NEW MLP AND THE RE-ACTIVATION OF MLP PARKSITE #2.

THE PRIMARY SCHEDULE CONCERN WITH THIS PLAN, IS THE POTENTIAL MISSION RATE IMPACT TO SRB FLIGHTS, DURING CONSTRUCTION, ACTIVATION AND OPERATIONAL CERTIFICATION OF THE FIRST LAUNCH PAD.
FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

KSC FACILITY ACTIVATION CONCEPTUAL PLAN

2ND & 3RD LINE FACILITIES

July 1988
NEAR TERM PLANS

- COMPLETE LRB/ET PROCESSING FACILITY REQUIREMENT CONCEPT
- COMPLETE LRB/ET PROCESSING FACILITY SITING TRADE STUDY
- REFINE VAB HB-4 REQUIREMENTS AND DESIGN CONCEPTS INCLUDING CRAWLERWAY IMPACTS
- CONCEPT MULTI BOOSTER PLATFORMS FOR VAB HB-3 INCLUDING EXIT INFRINGEMENTS
- REFINE MLP HOLDDOWN CONCEPTS
- DEVELOP PAD FLAME DEFLECTOR CONCEPTS
- COMPLETE PROPELLANT STORAGE, TRANSFER & ACQUISITION STUDY
- ADDRESS GROUND SOFTWARE IMPACTS
AGENDA

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION
JULY 1988

KSC ADVANCED PROJECTS
TECHNOLOGY OFFICE
TASK 9 - GROUND OPERATIONS COST MODEL

TASK 8 - FINAL REPORT

TASK 7 - FOLLOW-ON RECOMMENDATIONS

TASK 6 - LAUNCH SITE PLANS

PLANS, PRODUCTS AND MODELS

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

JULY 1988
LAUNCH SITE PLANS, FOLLOW-ON RECOMMENDATIONS AND FINAL REPORT

LAUNCH SITE PLANS AND DOCUMENTS, FOLLOW-ON RECOMMENDATIONS AND FINAL REPORT (TASK 6, 7, 8 RESPECTIVELY) DERIVE THEIR SOURCE DATA FROM THE OTHER STUDY TASKS. THE FINAL ASSIMILATION OF THEIR DATA INTO FORMAL DOCUMENTS IS NOT SCHEDULED UNTIL THE LATTER PART OF THE YEAR. ROUTINE ASSESSMENT OF THE STUDY TASKS INDICATE DATA GENERATION IS ON OR AHEAD OF SCHEDULE. FOR INSTANCE A DRAFT LRB SAFETY IMPACT REPORT HAS BEEN COMPLETED.
SOFTWARE
INSTRUCTIONS
RECOMMENDATIONS
USER'S MANUAL
TASK 9 STUDY PRODUCTS

THE LAB INTEGRATION STUDY

THE INCORPORATION OF LESSONS LEARNED FROM
OF THE GCOM TO THE STS / KSC PROGRAMS THROUG
EXPAND AND ENHANCE THE UTILITY AND RELEVANCY

LOSC TASK 9
GROUND PROCESSING COSTS
PARAMETRICALLY GENERATES STS / EQUIVALENT
DEVELOPED BY NASA

GROUND OPERATIONS COST MODEL

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

July 1988
GOCM IS A PARAMETRIC MODEL

Currently, major emphasis is being placed on collection of existing cost data for STS resources. GOCM cost estimating relationships (CERS) will be evaluated and updated with respect to LRB configurations/support scenarios. Additional LRB CERS shall be incorporated into GOCM as a module for significant and/or sensitive cost elements needing either modification or incorporation. GOCM will be used in the LRB costing and will be evaluated for its relevancy and utility.

The mix of cost generation techniques employed on a program varies with program maturity. Initially during phase "A" (conceptual evaluation/study) an all up parametric technique is employed which provides only moderate confidence in accuracy. This is the point where GOCM is believed to have utility and will be tested for relevancy, accuracy and ease of use on the LRB program. Soon to follow as the program advances in phase "A" and/or transitions into phase "B" certain cost drivers and/or cost elements sensitive to design/planning decisions will require greater confidence in their accuracy. These elements will require examination in greater detail and the employment of engineering estimates (analogy). Select cost elements which are deemed very sensitive and significant may transition early to direct engineering and detail estimates. Such elements may be crucial to budget planning and/or trade studies. These type estimates will be conducted outside the GOCM model and will be evaluated for incorporation into GOCM as a module. Such modules however, may no longer be totally parametric in nature. Careful consideration must be given to the techniques for incorporation.

Generation of software changes will continue. The draft manual will be completed in the next quarter. Generation of the software instructions will commence late next quarter.
Completeness and overall model utility

Task 9 emphasis is on booster cost accuracy,

May lessen model generality and utility

Providing greater sensitivity to detail design features

Few inputs required

Inputs are fundamental in nature

Quick and easy to use on a macro level

Phase A cost estimating tool

GCM is a parametric model

July 1988

First Progress Review

Liquid Rocket Booster Integration
TASK 9 OVERVIEW; APPROACH AND STATUS

LSOC TASK 9 IS ON SCHEDULE. HARDWARE, SOFTWARE AND PERSONNEL ARE IN PLACE AND ARE PROCEEDING QUICKLY FROM SOFTWARE, HARDWARE, AND PROGRAM FAMILIARITY TO THE COST/GOCM EVALUATION PHASE. COST ESTIMATING RELATIONSHIP (CER) DATA COLLECTION HAS BEEN INITIATED. WE WILL SOON INITIATE CER/MODEL MODIFICATIONS AND DEVELOPMENT. PRODUCT DEVELOPMENT IS IS ON TARGET. THE USER'S MANUAL IS MOVING TOWARDS COMPLETION OF THE FIRST DRAFT. A PRELIMINARY SET OF RECOMMENDATIONS IS IN PROCESS.

FUTURE EFFORTS ARE DIRECTED AT ASSESSING AND WHERE NECESSARY IMPROVING GOCM FOR LRB/SRB REALISM AND COMPLETENESS AND THE PREPARATION OF PRODUCTS.
FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

JULY 1988
<table>
<thead>
<tr>
<th>Tasks</th>
<th>Project Products</th>
<th>Milestones &amp; Inputs to Basic Study</th>
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</thead>
<tbody>
<tr>
<td>Provide Instructions</td>
<td>Input to Lab Study Final Report</td>
<td>Milestones &amp; Inputs to Basic Study</td>
</tr>
<tr>
<td>Provide User's Manual</td>
<td>GEN doc option II Recommendations</td>
<td></td>
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<tr>
<td>Provide COCOM Software</td>
<td>Execute Modified COCOM W/LAB Configuration</td>
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<tr>
<td>Project Products</td>
<td>Develop Instr. for Program Maintain</td>
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<td>USER Manual for Model Oper</td>
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<td></td>
<td>COLLECT BASELINE DATA COSTS</td>
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<td>ANALYZE COCOM &amp; SYMPOTOM SOFTWARE</td>
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<td>MONTHLY Project Reports</td>
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**KSC Ground Operations Cost Model Schedule**

**FIRST PROGRESS REVIEW**

**LIQUID ROCKET BOOSTER INTEGRATION**

**July 1988**
RESULTS OF MODEL EVALUATION

EVEN WITH THE COMPLETION OF THE GOCM USER'S MANUAL GOCM WILL REMAIN USER UNFRIENDLY. THE DISK OPERATING SYSTEM LIMITS THE MEMORY AVAILABLE TO SYMPHONY, WHICH MUST REMAIN RAM RESIDENT. ALTHOUGH EXPANDED MEMORY CARDS ARE AVAILABLE, MOST USERS DO NOT HAVE THEM INSTALLED. THIS REQUIRES GOCM TO BE ARBITRARILY (AND AWKWARDLY) PARTITIONED TO FIT IN STANDARD MEMORY.

CURRENTLY GOCM DOES NOT CONSIDER SHARING RESOURCES BETWEEN VARIOUS FLIGHT CONFIGURATIONS. FOR INSTANCE; THE RSRB PHASE OUT AND LRB PHASE IN CAN NOT BE CONSIDERED BY GOCM. THIS LIMITS GOCM UTILITY TO SINGLE VEHICLE OPERATIONS.

GSE AND FACILITY MODIFICATIONS ARE NOT CURRENTLY TAKEN INTO ACCOUNT IN GOCM. WITH THE ADVENT OF GROSS FACILITY MODIFICATIONS TO SUPPORT THE LRB, THE ABILITY FOR GOCM TO CONSIDER THEM IN LIEU OF REPLACEMENT IS DEEMED NECESSARY FOR ACHIEVING COST REALISM. ALTHOUGH SOME OF THE MODIFICATIONS MAY NOT INDIVIDUALLY BE CONSIDERED COST DRIVERS, COLLECTIVELY THEY MAY BECOME A SIGNIFICANT COST DRIVER.

GOCM DOES NOT PROVIDE SEGREGATED GROUND PROCESSING AND FACILITY COSTS FOR THE LRB/SRB STS ELEMENTS. THIS DOES NOT ALLOW EASY COMPARISON OF GOCM LRB/SRB GENERATED COSTS WITH THOSE DEVELOPED INDEPENDENTLY IN TANK 4.
IE PAD, MLP CONFIGURATION CHANGES
ADD CERS FOR GSE / FACILITY MODIFICATIONS
IE BOOSTERS, ET, ORBITER
ENHANCE MODEL TO REPORT SEGREGATED VEHICLE COSTS
SCENARIOS IE LTB / SRB / ASRM / ALS
EXPAND MODEL CAPABILITY TO CONSIDER MIXED FLEET

MORE USER FRIENDLY
MORE EFFICIENT USE OF HARDWARE
EXPLORE SPREADSHEET (SYMPHONY SOFTWARE) ALTERNATIVES

RECOMMENDATIONS

RELEVANT TO KSC GROUND PROCESSING
REALISTIC COSTS
CONSISTENT RESULTS
COM IS A SO PhISTICATED MODEL

RESULTS OF MODEL EVALUATION AND RECOMMENDATION

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

JULY 1988
EARLY IDENTIFIED COST CONCERNS

THE MLP WAS IDENTIFIED EARLY IN THE STUDY TO BE A SENSITIVE KSC COST DRIVER. TECHNICAL IMPACTS ARE STILL BEING ASSESSED FOR SOLUTIONS WHICH MAY SIGNIFICANTLY IMPACT SCHEDULE AND COSTS. ADDITIONAL REQUIRED DATA IS BEING GATHERED BEFORE THE ISSUE OF WHETHER TO BUILD NEW MLPS VERSUS MODIFICATION OF EXISTING MLPS IS ADDRESSED.

GOCM IS UNDER STUDY TO DETERMINE IF IT ADEQUATELY ADDRESSES NEW TYPE FACILITY COSTS, NONRECURRING FACILITY ACTIVATION COSTS, AND THE NONRECURRING GROUND PROCESSING TRANSITION COSTS.

DURING THE NEXT QUARTER TASKS 4 AND 9 WILL JOINTLY INVESTIGATE GROUND PROCESSING MANPOWER REQUIREMENTS. IT IS BELIEVED THAT THE MANPOWER ESTIMATES TO DATE ARE SUCCESS ORIENTED, AND MAY NOT BE REALISTIC. A SIMILAR FEAR EXISTS REGARDING LEARNING CURVES. HISTORICAL SHUTTLE PROCESSING DATA WILL BE EXAMINED AND AN EMPIRICAL LEARNING CURVE WILL BE DERIVED FOR EVALUATION AND POSSIBLE INCORPORATION INTO GOCM.
May not be substantiated by actual data.

Success oriented Ground Processing and Learning curves.

- Ground Processing Transition Cost
- GE / Facility Activation Cost
- Horizontal Processing Facility

Identify New Cost Elements:

- Identify MLP sensitive cost drivers - MOD vs NEW

Early Identified Cost Concerns

First Progress Review

Liquid Rocket Booster Integration
KSC GOCM TOTAL STS LRB VS SRB COSTS

The current ground operations cost model (GOCM) was used to estimate the total STS costs at KSC for the current SRB baseline configuration and the LRB baseline configuration for RP1/LOX. The SRB configuration assumed baseline technology, parachute recoverable boosters, a payload of 65K lbs and STS configured facilities. The LRB configuration assumed advanced technology, expendable boosters, a payload of 75K LRBs, and new facilities required for processing consisting of: LRB processing, ET processing integration bay, and MLP.

Common factors chosen for comparison of both configurations included the following:

1. Either SRB or LRB launches (no mixed fleet operations).
2. No launches until 1996 with a ramp rate of 3, 6, 9, 12, 14 ... 
3. A flight hardware surge factor of 15%.
4. Escalation rate of 0%.
6. Manpower rate of $186 per shift.
7. Work schedule of 6 days per week at 3 shifts per day.
8. Facility utilization of 85%.
9. No learning curve (100%).

It can be seen that costs are higher for the LRB configuration at first due to the new facilities required to support launch. As the launch rate increases second and/or third line facilities are added to support both LRB and SRB configurations. Steady state costs are achieved as steady state launches occur in the year 2001. Total costs are less for the LRB configuration due to shorter processing times and are not sensitive to booster recovery costs.

Lockheed
Space Operations Company
LIQUID ROCKET BOOSTER INTEGRATION
FIRST PROGRESS REVIEW
JULY 1988

KSC G0CM - TOTAL STS SRB VS LRB COSTS

Lockheed
Space Operations Company
PM-9

LAUNCHES 0 0 0 0 3 6 9 12 14 14 14 14 14 14 14

MILLIONS

0 200 400 600 800
KSC GOCM - STS DELTA LRB VS SRB COSTS

AS NOTED PREVIOUSLY, ONCE STEADY STATE LAUNCHES ARE ACHIEVED IN THE YEAR 2001, LRB BOOSTERS WOULD BE LESS EXPENSIVE TO OPERATE AT KSC BY APPROXIMATELY 100 MILLION DOLLARS PER YEAR. HOWEVER, DURING THE START UP YEARS, BETWEEN 1995 THROUGH 2000, VARIOUS FACILITIES ARE COMING ON LINE AND ADDING COSTS AT KSC. THE FOLLOWING IS A BREAKDOWN OF FACILITIES REQUIRED TO SUPPORT THE LAUNCH RATE MODEL FOR EITHER LRB OR SRB CONFIGURATION:

1996  LRB  A NEW LIQUID BOOSTER C/O BAY, TO SUPPORT LRB PROCESSING.  
       A NEW ET CHECKOUT FACILITY TO MAKE ROOM FOR A NEW INTEGRATION BAY.  
       A NEW INTEGRATION BAY.  
       A NEW MLP  
        SRB  NO FACILITIES REQUIRED.  

1997  LRB  NO FACILITIES REQUIRED.  
       SRB  NO FACILITIES REQUIRED.  

1998  LRB  A SECOND MLP.  
       SRB  NO FACILITIES REQUIRED.  

1999  LRB  A SECOND VEHICLE INTEGRATION BAY.  
       SRB  A THIRD VEHICLE INTEGRATION BAY.  

2000  LRB  A SECOND LIQUID BOOSTER C/O BAY.  
       SRB  A FORTH MLP.  

NOTE: THE CURRENT MODEL DOES NOT CONSIDER MODIFICATIONS. THEREFORE, THE LAUNCH PADS ARE NOT TAKEN INTO ACCOUNT.
KSC GOCM - LRB vs SRB CUMULATIVE COSTS

COMPARATIVE AND SOURCE DATA COLLECTION (2ND ITERATION)

SPC GROUND PROCESSING DATA IS BEING COLLECTED. THIS INCLUDES THE EXAMINATION OF KSC/WBS AND ORGANIZATIONAL DATA WHICH WILL BE USED TO ALLOCATE/VERIFY THE PAST BUDGETARY/FISCAL EXPENDITURES. ADDITIONAL GSE/FACILITY COST TO PROCESS THE NEW BOOSTER CONFIGURATIONS ARE BEING DEVELOPED THROUGH THE REVIEW OF SIMILAR EXISTING ITEM AND THEIR COSTS, COMPLEXITY FACTORS, DOLLARS PER FT$^3$ OR FT$^2$, OTHER EXTRAPOLATION TECHNIQUES, AND ENGINEERING BUDGETARY COST ESTIMATES. COST ESTIMATES FOR SIGNIFICANT GSE/FACILITY MODIFICATIONS ARE BEING DEVELOPED IN A MANNER SIMILAR TO THAT DESCRIBED ABOVE.
COMPARATIVE AND SOURCE DATA COLLECTION

- CALIBRATE GOCM ACCURACY AND COMPLETENESS

- ANALYSIS OF KSC WBS AND ORGANIZATIONAL DATA TO ALLOCATE AND VERIFY EXISTING MANPOWER RESOURCES

- REQUIRED ADDITIONAL GSE / FACILITY COSTS TO PROCESS NEW VEHICLE CONFIGURATIONS ARE BEING DEVELOPED

- COST ESTIMATING FOR SIGNIFICANT GSE / FACILITY MODIFICATIONS IS UNDERWAY
AGENDA

I. INTRODUCTION

II. PROGRESS

A) Lab Project Integration
B) Baseline Requirements
C) Impact Analysis
D) Plans, Products and Model

III. SUMMARY

Jerry LeFebvre
Greg DeBlasio
Keith Humphreys
Pat Scott

Gordy Allen

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

July 1988
LRB PROJECT INTEGRATION

ALTHOUGH THE MSFC CONTRACTORS HAVE COMPLETED THE FINAL REPORT FOR THEIR PORTION OF THE STUDY, THEY HAVE RECEIVED A SIX-MONTH EXTENSION. THE WORKING GROUP INTEGRATION WILL THEREFORE CONTINUE THROUGH DECEMBER. THE KSC STUDY WILL REQUIRE MAJOR REVISION TO ACCOMMODATE FURTHER DOWN-SELECTION AND/OR UP-SELECTION. THE EXPENDABLE BOOSTER HAS BEEN BASELINED AT THIS TIME. THE WORKING GROUP HAS EXPRESSED TECHNICAL AND COST CONCERN WITH THIS DECISION. THE PRE-INTEGRATION PROCESS OF THE LRB RELIES ON THE SHIPPING CONFIGURATION. ADDITIONAL BASELINING IS REQUIRED TO EVALUATE THE IMPACT OF "SHIP TO SHOOT" OR SUBASSEMBLY SCENARIOS. THE TRANSITION TO THE LRB REMAINS THE MOST SIGNIFICANT DRIVER TO KSC. THE SYNERGISTIC EFFECT OF FUTURE MULTIPLE PROGRAMS HAS NOT YET BEEN FULLY EVALUATED IN LIGHT OF ASRM, ALS, SHUTTLE C AND SHUTTLE DERIVATIVES. COORDINATION WITH THE WORKING GROUP WILL CONTINUE THROUGH THE REMAINDER OF THIS YEAR. NEXT PERIOD THE LAUNCH PROCESSING SCENARIOS WILL BE FINALIZED. THESE SCENARIOS WILL BE TAILORED TO THE SIX BOOSTER OPTIONS AND THE OPTIMUM FACILITY/GROUND SYSTEMS CONFIGURATIONS. ADDITIONAL DATABASE WILL ENABLE MORE REFINED AND AUTOMATED COST ESTIMATING TO ENHANCE COST/BENEFIT ANALYSES.
Refine cost assessments

Finalize the launch site scenario requirements

Coordination with the working group actions

Mixed fleet integration at launch site

Transition planning to support baseline

Interface of the element contractor with launch site

Recovery / reuse vs expendable

Options to provide control of revisions

Formalize baselines for configuration

Working group

The working group will continue for another six months via the

The MSC Phase A study. However, this funding

The project integration is completed for

LB Project Integration

July 1988

First Progress Review

Liquid Rocket Booster Integration
LRB BASELINE REQUIREMENT

THE TEST TEAM WILL JOINTLY EVALUATE THE COMBINATION OF REQUIREMENTS, FACILITIES/GROUND SYSTEMS AND PROCESSING PROCEDURES ESSENTIAL TO EACH OPTION CONFIGURATION. THE BASELINE PARAMETERS MUST BE FROZEN IN ORDER TO GENERATE THE FINAL PRODUCT. THIS PRECLUDES MAJOR MODIFICATIONS TO THE PROCESSING SCENARIO OR FACILITIES. THE ULTIMATE ELEMENT CONTRACTOR MAY HAVE AN OPTION TO FINALIZE ASSEMBLY AND CHECKOUT OF THE LRB AT OR NEAR KSC. THIS REQUIREMENT WOULD APPRECIABLY ALTER THE SCENARIO OF THE PRE-INTEGRATION PROCESSING. DURING THE ENSUING PERIOD THE REQUIREMENTS DATA WILL BE CONSOLIDATED BY CONFIGURATION OPTION AND SCREENED FOR INCORPORATION INTO THE APPROPRIATE 16 PRODUCTS. THE SCENARIO EFFORT WILL FOCUS ON THE FINALIZATION OF THE TIMELINES AND THE PROCESSING MANPOWER FOR EACH OF THE CONFIGURATION OPTIONS.
INTO SCENARIOS
INTEGRATION AND REFINEMENT OF BOTH CURRENT AND
ADDITIONAL DATA INTO FINALIZED PRODUCTS
AT OR NEAR KSC FACILITIES / ACTIVITIES
CONCEPT FOR LAB ON-SITE ELEMENT CONTRACTOR
WORKING GROUP
MSC EXTENDED PHASE A STUDIES AND PROGRAM
GENERATION OF NEW OR REVISED REQUIREMENTS FROM
FINAL BOOSTER OPTIONS
ARE UNDER FULL TEAM REVIEW TO INTEGRATE THE
THE BASELINE, REQUIREMENTS AND SCENARIOS TASKS
THE BASELINE REQUIREMENT

FIRST PROGRESS REVIEW
LIQUID ROCKET BOOSTER INTEGRATION

July 1998

A TECHNOLOGY OFFICE
ADVANCED PROJECTS

80708-01CE
IMPACT ANALYSIS

USING THE LOX/RP-1 CONFIGURATION OPTIONS AS A BASELINE, A SERIES OF TRADE STUDIES ARE NEARING COMPLETION. THESE STUDIES INCLUDE ANALYSIS ACROSS ALL STATION SETS. THE PRINCIPAL EFFORT HAS BEEN TO ADDRESS THE MAJOR FACILITIES AND GROUND SYSTEMS. THE INITIAL COST DATA HAS BEEN DERIVED ALONG WITH ENVIRONMENTAL AND SAFETY INFLUENCES. CONSIDERABLE CONCEPT DATA HAS BEEN CRAFTED FOR NEW AND MODIFIED PROPELLANT STORAGE HANDLING/TRANSFER SYSTEMS. THIS DATA WILL BE AUGMENTED TO APPLY TO EACH OF THE CONFIGURATION OPTIONS. LRB TRANSITION DURING AN ON-GOING 14-FLIGHT PER YEAR SHUTTLE PROGRAM PRESENTS TWO PARAMOUNT CONCERNS. THERE IS NO AVAILABLE TIME FOR A REQUIRED LRB ACTIVATION PROGRAM. IN ADDITION, ALL USABLE LAUNCH FACILITIES ARE FULLY COMMITTED TO THE CURRENT MISSION. THE BOOSTER DIAMETER AND LENGTH HAVE IMPOSED EXCESSIVE MANDATES ON THE CONFIGURATION OF THE MLP, UMBILICALS/SWING ARMS, ACCESS PLATFORMS AND DEFLECTORS/FLAME TRENCH. THE IMPACT ANALYSIS FOR ALL STATION SETS WILL BE COMPLETED BY MID-SEPTEMBER. THE DETAIL DATA CREATED WILL BE THE FOUNDATION OF THE 16 DELIVERABLE PRODUCTS.
Delta for all options
Approaches for all station sets and
Finalize the impacts and design

Stand-alone processing
Pad booster access
deflection / flame trench
Booster length
Booster diameter

Lab transition vs. available mod and activation periods

Impacts to shuttle manifest

Recommended solutions
Identified and baselined for final analysis and
The major impacts to facilities and LSE have been

Impact analysis

First progress review
Liquid rocket booster integration

July 1988
PLANS, PRODUCTS AND MODEL

THE GOCM STUDY IS ON SCHEDULE. THE USERS MANUAL IS IN PROCESS. SOFTWARE ADEQUACY HAS BEEN INVESTIGATED AND MODIFICATIONS ARE IN PROCESS, PRELIMINARY GOCM COST ESTIMATES HAVE BEEN PRODUCED. GOCM COST ESTIMATING RELATIONSHIPS (CERS) MUST BE ANALYZED FOR ACCURACY AND COMPREHENSIVENESS. THE ESTABLISHMENT AND CONFIRMATION OF AN HISTORICAL DATABASE IS ESSENTIAL FOR THE TRANSLATION OF PAST DATA TO FUTURE PLANS. THE COST TO BOTH SINGLE FLIGHT ELEMENTS AND THE IMPACT OF MODIFICATIONS/ACTIVATION TO REQUIRED FACILITIES/GROUND SYSTEMS WILL BE REFLECTED IN LIGHT OF NASA PROGRAMS. THIS DATA WILL BE CORRELATED WITH THE LRB STUDY ASSESSMENTS.
LIQUID ROCKET BOOSTER INTEGRATION
FIRST PROGRESS REVIEW
JULY 1988

PLANS, PRODUCTS AND MODEL

STATUS: GOCM AND SYMPHONY SOFTWARE ANALYSIS COMPLETE
BASELINE DATA COLLECTION IN PROCESS
GOCM LRB BASELINE COST ESTABLISHED BY RUNNING
EXISTING MODEL

CONCERNS: EVALUATION OF COST ESTIMATING RELATIONSHIPS
WITH HISTORICAL DATA

NEXT PERIOD PLANS: ASSEMBLAGE AND EXTRAPOLATION OF HISTORICAL DATA
GENERATION OF DRAFT PLANS AND PRODUCTS
AGENDA

I. INTRODUCTION
   Gordon Artley

II. STUDY PROGRESS
   A. ACHIEVEMENT SUMMARY
   Pat Scott
   B. ENGINE PROCESSING STUDY
   Glen Waldrop
   C. LRB/ET PROCESSING EVALUATION
   Greg DeBlasio
   D. SAFETY & ENVIRONMENTAL
   Roger Lee
      IMPLICATIONS
   E. GOCM STATUS
      Stephen Schneider

III. SUMMARY
     Gordon Artley
PLANNED WORK

AT THE 1ST PROGRESS REVIEW (JULY), THE FOLLOWING WORK PLAN WAS PRESENTED FOR THE SECOND PERIOD:

1. CONTINUE TO SUPPORT AND RESPOND TO THE INTEGRATED WORKING GROUP

2. REFINE GROUND PROCESSING SCENARIOS AND INCORPORATE TIMELINES AND PROCESSING MANPOWER

3. CONTINUE THE IMPACT/ANALYSIS AND DESIGN APPROACH FOR ALL STATION SETS TO MEET LRB OPTION

4. ASSEMBLE APPROPRIATE HISTORICAL DATA AND EXERCISE/CALIBRATE THE COST MODEL

5. GENERATE PLANS AND PRODUCT DRAFTS

6. REFINE LIFE-CYCLE COSTS AND PREPARE DETAIL STATION SET LEVEL COST ESTIMATES
IN ORDER TO PROVIDE A STATUS, THE FOLLOWING SIGNIFICANT SUBJECTS WILL BE ADDRESSED:

FIRST, WE HAVE EVALUATED THE MOST RECENT LRB CONFIGURATIONS AND ASSESSED THEIR IMPACT TO THE PROCESSING SCENARIO. SECOND, WE HAVE EXPANDED THE LAUNCH SITE SCENARIOS TO INCLUDE THE TRANSITION PLAN FOR PHASING IN LRBs. THIRD, WE HAVE MODIFIED THE PROCESSING FLOW TO MEET THE LATEST LRB REQUIREMENTS. FOURTH, WE HAVE PROVIDED A SUMMARY OF THE INFLUENCES OF THE LRB WORKING GROUP'S WORK ON ASCENT AND ABORT PERFORMANCE, LAUNCH TOWER CLEARANCE AND VEHICLE EXCURSION. IN ADDITION, WE WILL REVIEW THE WORKING GROUPS ANALYSIS OF LRB APPLICATIONS TO ALTERNATE VEHICLES, AND THE IMPACT TO GROUND PROCESSING.

SELECT TOPICS HAVE BEEN CHOSEN TO REVEAL KEY ISSUES AND IMPACTS. FIRST, AN LRB PROCESSING ASSESSMENT HAS SHOWN THE SIGNIFICANCE OF PROVIDING AN INTEGRATED VEHICLE WITH 11 LIQUID ENGINES VERSUS THE CURRENT 3. SECOND, THE INTEGRATION OF HI-BAY 4 FOR LRB INTEGRATION WILL PROVIDE THE FIRST IN A SERIES OF INFLUENCES TO DECENTRALIZE BOTH THE LRB AND THE ET PRE-INTEGRATION PROCESSING. THIRD, WE HAVE RECOGNIZED THE SIGNIFICANT SAFETY AND ENVIRONMENTAL IMPLICATION TO LRB PROCESSING THAT COULD BE AN IMPORTANT COST CONSIDERATION, A TIME INFLUENCE AND A DESIGN DRIVER. FOURTH, THE SENSITIVITY OF LRB TO COST HAS HIGHLIGHTED THE IMPORTANCE OF THE DEVELOPMENT OF THE GROUND OPERATIONS COST MODEL AND ITS APPLICATION TO LRB.
STUDY PROGRESS

STATUS SUMMARY

- BASELINE, SCENARIO AND WORKING GROUP INFLUENCES

SELECTED STUDY TOPICS

- LRB ENGINE PROCESSING ASSESSMENT
- ET AND LRB PROCESSING IMPACTS
- SAFETY AND ENVIRONMENTAL IMPLICATIONS
- GROUND OPS COST MODEL DEVELOPMENT
LIQUID ROCKET BOOSTER INTEGRATION
SECOND PROGRESS REVIEW

LRB INTEGRATION SCHEDULE - REVISED SEPT. 6, 1988

MONTHS - BASIC STUDY

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PROJECT STUDY TASKS

1. BASELINE
2. LRB REQUIREMENTS
3. LRB SCENARIOS
4. IMPACT ANALYSIS
5. DESIGN RECOMMENDATIONS
6. LAUNCH SITE PLANS
7. FOLLOW-ON RECOMMENDATIONS (OPTIONS/PROPOSALS)
8. FINAL REPORT
9. GROUND OPERATIONS COST MODEL

9/6/88 % COMPLETE
## AGENDA

### I. INTRODUCTION

Gordon Artley

### II. STUDY PROGRESS

<table>
<thead>
<tr>
<th>Section</th>
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<tr>
<td>A. ACHIEVEMENT SUMMARY</td>
<td>Pat Scott</td>
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<tr>
<td>B. ENGINE PROCESSING STUDY</td>
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<tr>
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<td>Greg DeBlasio</td>
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<td>Roger Lee</td>
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<tr>
<td>E. GOCM STATUS</td>
<td>Stephen Schneider</td>
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</tbody>
</table>

### III. SUMMARY

Gordon Artley
A. ACHIEVEMENT SUMMARY

1. STUDY BASELINE ASSESSMENT
2. LRB TECHNICAL WORKING GROUP ACTIVITIES
3. ALTERNATE LRB APPLICATIONS
1. STUDY BASELINE ASSESSMENT

- LRB CONFIGURATION UPDATE
  - LRB PROPOSED ENGINE POSITIONS
- BASELINE LAUNCH SITE SCENARIO
  - TRANSITION PLAN OVERVIEW
- LRB PROCESSING FLOW UPDATE
LRB CONFIGURATION UPDATE

• MSFC LRB STUDIES
  - MARTIN (2): LOX/RP-1 PUMP-FED/PRESSURE-FED
  - GENERAL DYNAMICS (3): LOX/RP-1 PUMP/PRESSURE
    LOX/LH2 PUMP-FED

• FINAL REPORT PRESENTATION: JUNE 88

• MSFC CONTRACTS EXTENDED TO JAN 89
  - CONTINUING CONFIGURATION REFINEMENTS
SUMMARY OF LRB PHASE A FINDINGS (REF. GDSS/MMC)

- LRB SHOULD BE EXPENDABLE BOOSTER
- ALL CONFIGURATIONS ARE 4-ENGINED
- NEW LOW-COST ENGINE DEVELOPMENT REQUIRED
- LOX/RP-1 IS FAVORED PROPELLANT
- BOTH PUMP AND PRESSURE-FED OPTIONS ARE VIABLE (PRESSURE-FED REQUIRES TECHNOLOGY DEVELOPMENTS)
- ALL SELECTED CONFIGURATIONS CAN BE FLOWN WITHIN CURRENT STS CONSTRAINTS
- LRB WILL IMPACT KSC "MODERATELY"
LRB CONFIGURATION UPDATE

MARTIN MARIETTA

0 PUMP-FED CONFIGURATION HAS REMAINED UNCHANGED. DUAL 17-INCH FEED LINES ROUTE THE LOX AROUND THE RP-TANK. FORWARD THRUST ATTACH POINT IS LOCATED IN LRB FORWARD SKIRT AREA. AFT ATTACH IS IN MID-TANK AREA WHERE LOWER TRANSVERSE LOADS ARE DISTRIBUTED THROUGH A DEEP RING STIFFENER WITHIN THE TANK. DIAMETER AND LENGTH DIMENSIONS ARE CLOSEST TO SRB.
Vehicle Configuration Summary - Pump-Fed 6/16/88

Vehicle Dimensions
- Length (in) 1,810.7
- Diameter (OD - in) 183.0
- Engine Exit Area (in²) 7,359

Propellant Tank Volumes (Ft³)
- LO2 10,769
- RP-1 5,796

Weight (lb)
- Structure 73,500
- Propulsion System 33,410
- Other Subsystems 9,695

Inert Weight 116,665

Usable Impulse Propellant
- LO2 701,302
- RP-1 268,698
- Residuals Gases and Liquids 5,335

Glow 1,092,000
LRB CONFIGURATION UPDATE

MARTIN MARIETTA

Pressure-fed configuration is significantly larger, tank wall thicknesses are approximately 1-inch. Engine chamber pressure of 800 psi require tank pressure of 1000 psi and pressurization system of 3000 psi. Higher propellant loading increases gross lift off weight to 1,3 M pounds which is heavier than current SRB. Higher engine thrust is required (approximately 750K each,) resulting in 3M lbs per booster.
Vehicle Configuration Summary - Pressure-Fed 6/16/88

Vehicle Dimensions

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<th>Dimension</th>
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<td>Length (in)</td>
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<tr>
<td>Diameter (OD - in)</td>
<td>194.0</td>
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<td>Engine Exit Area (in^2)</td>
<td>9,365</td>
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Propellant Tank Volumes (Ft^3)

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<th>Volume</th>
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<tr>
<td>LO2</td>
<td>12,012</td>
</tr>
<tr>
<td>RP-1</td>
<td>6,328</td>
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Weight (lb)

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<td>143,160</td>
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<tr>
<td>Propulsion System</td>
<td>44,030</td>
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<td>Other Subsystems</td>
<td>12,330</td>
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<td>Inert Weight</td>
<td>199,520</td>
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Usable Impulse Propellant

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<td>LO2</td>
<td>782,084</td>
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<tr>
<td>RP-1</td>
<td>292,916</td>
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Residuals Gases And Liquids

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<tr>
<td>Propellant - Pressure System</td>
<td>8,640</td>
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<tr>
<td>Glow</td>
<td>1,300,860</td>
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LRB PROPOSED ENGINE POSITIONS

0 All GD configurations (except pressure-fed) have engines positioned at 45-degrees to the major vehicle axes ("X" pattern). This facilitates gimbal actuators along the prime pitch and yaw vehicle axes, but requires a bridge across the booster flame hole to support the North holddowns.

0 All MMC configurations have engines positioned along or parallel to the major vehicle axes ("+" pattern). This feature permits the use of the same haunch/holddown locations currently in use along the sides of the flame holes, but moves outermost engine closer to edge of flame trench - complicating flame deflector design.

0 GD pressure-fed LOX/RP-1 has engines positioned in the "+" pattern (same as MMC configuration).
LRB CONFIGURATION UPDATE

GENERAL DYNAMICS

PUMP-FED AND PRESSURE-FED LOX/RP1 CONFIGURATIONS REMAIN VIABLE OPTIONS. PUMP-FED SIZING IS CLOSEST TO SRB DIMENSIONS. PRESSURE-FED IS THE LARGEST AND USES CENTERED LOX FEED LINE THROUGH LOWER FUEL TANK. ET INTERFACE POINTS ARE NOTED ON THE CHART.

STUDIES ASSOCIATED WITH LOX/CH4 SPLIT EXPANDER HAVE SHOWN NO SIGNIFICANT ADVANTAGES AND THIS CONFIGURATION HAS BEEN DELETED. HOWEVER, AS SHOWN ON A SUBSEQUENT CHART THE ENGINE DESIGN IS BEING EVALUATED AS AN OPTION FOR THE LOX/LH2 CONFIGURATION.
LO₂/LH₂ PUMP FED LRB (LENGTH VS DIAMETER)

0 THE LO₂/LH₂ CONFIGURATION HAS BEEN RETAINED AND IS THE TARGET OF SOME RESIZING STUDIES. SHORTENED LENGTH ALLOWS CLEARANCE FOR ET GOX VENT ARM AT PAD WHILE RESULTING DIAMETER GROWS TO NEAR 18 FT.

0 THIS ALSO RESULTS IN FORWARD ET ATTACH POINT IN A MID-TANK AREA (NOT CONSIDERED A GOOD POINT FOR TRANSFERRING 3 M POUNDS OF THRUST).
LO2/LH2 PUMP FED LRB
LENGTH VS DIAMETER

ET ATTACH
169.5 FT
18 FT
18.3 FT

ET ATTACH
16.3 FT
191 FT
17.7 FT

FATBIRD
STRUCTURE WEIGHT=52,886
DRY WEIGHT=103,339
LIFT OFF WEIGHT=763,367

LO2/LH2
STRUCTURE WEIGHT=58,237
DRY WEIGHT=108,822
LIFT OFF WEIGHT=751,037
LRB CONFIGURATION UPDATE

GENERAL DYNAMICS

0 GD'S DOWNSELECT RESULTS INDICATE THE ATTENTION GIVEN TO KSC LAUNCH SITE INTEGRATION AS A PROMINENT CRITERIA (NOTE THE HIGHLIGHTED AREAS).

0 WE THINK THEY ARE LISTENING - NOW IF WE CAN GET DOWN TO THE BEST TWO CONFIGURATIONS . . .

Lockheed
Space Operations Company
<table>
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<th>ITEM</th>
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<td>A. GUIDELINES GOALS, ASSUMPTIONS</td>
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<td>C. LEVEL II REQUIREMENTS (SPACE SHUTTLE VEHICLE)</td>
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<td>D. LEVEL III REQUIREMENTS (LIQUID ROCKET BOOSTER)</td>
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<td>E. LEVEL IV REQUIREMENTS (AVIONICS / FLT CONTROLS / SEPARATION SYSTEMS)</td>
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<td><strong>TOTALS</strong></td>
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LRB CONFIGURATION UPDATE

JSC

RENEGADE LRB OPTIONS SUCH AS THIS SIX-ENGINED "LAB RAT" CONFIGURATION STILL STRUGGLE FOR RESPECTABILITY AT OUR PERIODIC TECHNICAL WORKING GROUP MEETINGS.

HIDDEN ADVANTAGES OF THIS APPROACH INCLUDE FIXED ENGINES (NO GIMBALING) AND THRUST VECTOR CONTROL VIA DIFFERENTIAL THROTTLING. ADDITIONAL ENGINE-OUT CAPABILITY IS ALSO ACHIEVED.

IDEAS SUCH AS THESE WILL CARRY OVER INTO THE PHASE B ACTIVITIES - SO WE MUST STAY FLEXIBLE.
SIX-ENGINE PRESS-FED LRB "LAB RAT"
LRB PROCESSING SUMMARY

THE LRB PROCESSING SCENARIO BEGINS AT KSC WITH BARGE DELIVERY, AND HORIZONTAL TRANSPORTER TOW TO THE NEW LRB PROCESSING FACILITY. HERE ALL STANDALONE BOOSTER CHECKOUT AND TESTING IS CONDUCTED. THE ADJACENT ET HORIZONTAL PROCESSING FACILITY RELOCATES THE ET CHECKOUT AND STORAGE ACTIVITY SO THAT HB4 CAN BE USED.

THE CONVERSION OF VAB/HB4 TO A FULL INTEGRATION CELL PERMITS LRB TRANSITION WITHOUT IMPACT TO ON-GOING SHUTTLE LAUNCHES. A NEW MLP CUSTOM-BUILT FOR LRB WILL BE CONSTRUCTED TO SUPPORT THE LRB IOC, AND A SECOND NEW MLP IS NOW SCHEDULED TO SUPPORT THE LRB TRANSITION LAUNCH RATE BUILD-UP. THIS APPROACH REPLACES THE EARLIER PLANNED MODIFICATION OF EXISTING MLP's.

THE LAUNCH CONTROL CENTER FIRING ROOMS WILL BE MODIFIED TO SUPPORT ANY NEW CONSOLES AND GROUND SOFTWARE REQUIRED FOR LRB PROCESSING AND LAUNCH OPERATIONS.

CHANGES SINCE LAST REVIEW:

- SECOND NEW MLP DUE TO: 1) DIFFICULTY OF MOD AND 2) IMPACT TO SRB LAUNCHES

- NEW MORE EXTENSIVE PAD MODS:
  1) DEFLECTOR REDESIGN IN FLAME TRENCH
  2) SIDE DEFLECTOR (PROXIMITY REQUIREMENTS)
  3) POSSIBLE FLAME TRENCH MODS
Task 3 - Preliminary LRB Scenarios

LRB Processing Summary

- New ET/LRB Horizontal Processing Facility
- VAB Mods
- Pad Mods
- LCC Mods
- LETF Support

Barge Delivery

New MLP (2)

New Integ. Cell

OPF/Orbiter Processing Unchanged
LRB INTEGRATION - A PHASED APPROACH

0 LAUNCH SITE ACTIVATION BEGINS IN FY 91 TO SUPPORT INITIAL LRB LAUNCH CAPABILITY IN 1995. FIRST LINE NEW FACILITIES, REQUIRED FACILITY MODS AND NEW GSE/LSE ARE DESIGNED, CONSTRUCTED AND VALIDATED DURING THIS INITIAL FIVE YEAR PERIOD. THESE ACTIVATION SCHEDULES ARE LAID OUT IN AN ARTEMIS MODEL AND PLANNED ON A NON-INTERFERENCE BASIS.

0 THE TRANSITION PHASE BEGINS WITH 3 LAUNCHES OF LRB IN 1996 AND BUILDS TO THE FULL 14 ANNUAL LAUNCH MANIFEST BY THE YEAR 2000. DURING THIS PERIOD SRB-BOOSTED LAUNCHES ARE PHASED DOWN BY SIMILAR INCREMENTS. AS YOU CAN SEE, ADDITIONAL FACILITY (AND GSE) ACTIVATIONS ARE SCHEDULED OVER THIS TRANSITION - MAJOR ONES ARE NOTED HERE.

0 TOTAL LIFE CYCLE EVALUATIONS ARE DIMENSIONED OVER AN APPROXIMATE 10-YEAR LAUNCH PERIOD. THE LAST 5 YEARS ARE AT THE FULL 14/15 FLIGHTS PER YEAR RATE. A TOTAL LRB LIFE OF 122 MISSIONS IS CURRENTLY PROJECTED.
# Phased Approach

## Milestones

<table>
<thead>
<tr>
<th>CY</th>
<th>CY</th>
<th>CY</th>
<th>CY</th>
<th>CY</th>
<th>CY</th>
<th>CY</th>
<th>CY</th>
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</tr>
</thead>
<tbody>
<tr>
<td>91</td>
<td>92</td>
<td>93</td>
<td>94</td>
<td>95</td>
<td>96</td>
<td>97</td>
<td>98</td>
<td>99</td>
<td>00</td>
<td>01</td>
</tr>
</tbody>
</table>

### I. Initial Activation
- NEW MLP
- HB4 / HPF
- 1ST PAD MOD
- LETF/LCC

### II. Transition Phase
- LAUNCH RAMP
- CONT'D ACTIVATIONS
  - 2ND MLP
  - 2ND HB
  - 2ND PAD

### III. Operations Phase
- FULL RATE
- OPTIMIZATION

### Notes
- ILC
- LRB LAUNCH RATE BUILD-UP
- OPERATIONAL CAPABILITY
- MIXED FLEET OPS

---

**Lockheed Space Operations Company**
GENERIC LRB PROCESS FLOW

After a detailed analysis and update of the 130-task LRB processing flow, it was found that the planned MLP mate and closeouts (prior to ET mate) could be reduced from 6 days to 4 days. This results in a total LRB flow of 51 days from receipt of hardware to launch. This summary of the 130-task flow illustrates major functional flow time in work days.

Other refinements added to this model include updated engine processing tasks and manpower model updates to all LRB task areas. The processing model is networked and man-loaded in Artemis and is currently in use for evaluations of both manpower and GSE requirements for each station set.

Major LRB activities are highlighted here in this top level summary chart.
GENERIC LRB PROCESS FLOW

△ LRB BARGE ON DOCK KSC

11

LRB STANDALONE CHECKOUT (5/3)

△ LRB MOVE TO VAB

4 MLP MATE & CLOSEOUTS (7/3)

LRB FLOW = 51 DAYS

△ ET MATE

11 ET/LRB CLOSEOUTS (7/3)

△ 5 ORB MATE/INTEG SYS TEST (7/3)

SSV PREPS/TRANSFER TO PAD ▲

20

• SSV STD OPS
• PAYLOAD OPS
• CDDT
• LRB ENG SYS READINESS
• LRB FUEL (RP) TANKING
• ORB HYPER LOAD/CLOSEOUT
• LAUNCH COUNTDOWN (INCLUDING CRYO LOAD)

LAUNCH (6/3)
STS BASELINE MODEL

0 MULTI-FLOW PROCESSING TIMELINES ARE COMPLETE FOR STS LAUNCHES 1991 THRU 2006 (ARTEMIS MODEL)

0 THIS SCHEDULE REPRESENTS THE STS TRANSITION FROM NEAR TERM MANIFEST (MAR 88) TO LONG RANGE LAUNCH RATE OF 14/15 PER YEAR

0 FACILITY UTILIZATION DIAGRAMS PRESENT WINDOWS FOR SCHEDULING LRB FACILITY MODS/ACTIVATION

0 PLANNING LAYOUTS FOR ACTIVATION/TRANSITION/OPERATIONS PHASES CAN NOW BE PREPARED/UPDATED

0 MINIMUM IMPACTS TO ON-GOING LAUNCH OPERATIONS CAN BE ASSURED
LRB/SRB FACILITY PLANNING COMPARISON

0 Graphically noted here are the flow time differences for LRB (shown solid black) on the backdrop of planned SRB flow processing timelines in the mid-to-late 90's.

0 All in-line ground processing to support an example flow is presented. Note major facilities and elements. The LRB changes are shown in the boxes for the four affected facilities.

0 The Artemis Multiflow processing model contains 224 missions of this detail over the period FY 91 thru FY 06. Insertion of the 122 LRB life cycle mission profile into this model will facilitate effective planning for KSC integration.
SRB/LRB FLOW COMPARISON

SUMMARIZED HERE ARE THE PROJECTED IMPROVEMENTS IN FLOW TIME FOR LRB VERSUS THE "PLANNED" SRB PROCESSING TIMES FORECAST FOR THE LATE 90's.

THESE IMPROVEMENTS REPRESENT A SIGNIFICANT REDUCTION IN DEMAND ON LAUNCH SITE RESOURCES REQUIRED TO SUPPORT A 14 TO 15 ANNUAL LAUNCH RATE - AND THEY PROVIDE THE FLEXIBILITY TO ACCOMMODATE ALTERNATE SHUTTLE "C" OR ALS LAUNCH CAPABILITIES.
## SRB/LRB Flow Comparison

<table>
<thead>
<tr>
<th>Description</th>
<th>SRB</th>
<th>LRB</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAB HB (INTEG CELL)</td>
<td>21</td>
<td>4</td>
<td>81%</td>
</tr>
<tr>
<td>MLP USE PER FLOW</td>
<td>55</td>
<td>40</td>
<td>27%</td>
</tr>
<tr>
<td>INTEG CRITICAL PATH (BOOSTER STACK TO ORB MATE)</td>
<td>32</td>
<td>15</td>
<td>53%</td>
</tr>
<tr>
<td>PAD FLOW</td>
<td>18</td>
<td>20</td>
<td>-11%</td>
</tr>
<tr>
<td>BOOSTER FLOW (PRE-LAUNCH)</td>
<td>78</td>
<td>51</td>
<td>35%</td>
</tr>
</tbody>
</table>
OVERVIEW OF LAUNCH SITE PLAN

THE OVERALL LAUNCH SITE PLAN SPANS A PERIOD OF 15 + YEARS AND CONTAINS THE MAJOR PHASES SHOWN HERE.

OUR FINAL REPORT WILL DOCUMENT THESE PHASES IN THE FORM OF STUDY PRODUCTS SUCH AS:

- GROUND OPERATIONS PLAN - COVERS ALL ASPECTS OF LRB FACILITY ACTIVATIONS/MODS AND GSE/LSE DESIGN/INSTALLATION FOR ALL STATION SETS.

- PRELIMINARY TRANSITION PLAN - COVERS ALL ASPECTS OF THE FIVE-YEAR CHANGE FROM SRB TO LRB OPERATIONS.
OVERVIEW OF LAUNCH SITE PLAN

FACILITIES ACTIVATION PHASE
(GROUND OPS)

STS TRANSITION PHASE
(PRELIMINARY TRANSITION PLAN)

FULL OPERATIONAL PHASE
(SRB CAPABILITY RETAINED)

LRB
LAUNCH SITE PLAN*

* TIME LINE BASED ON ACCOMPLISHING A MINIMUM OF 122 LRB BOOSTER MISSIONS IN THE PROGRAM LIFE CYCLE
LRB PRELIMINARY TRANSITION PLAN

IN ORDER TO PROJECT NEW FACILITY "NEED" DATES AND TO OPTIMIZE EXISTING FACILITY "DOWN-TIME" FOR CONVERSION IT IS NECESSARY TO:


- PROVIDE FOR PARALLEL PROCESSING OF BOTH LRB AND SRB CONFIGURATIONS (A DUAL CAPABILITY IS TO BE RETAINED THROUGHOUT THE TRANSITION PERIOD)

- ANTICIPATE LAUNCH PROCESSING MANPOWER REQUIREMENTS (JOB ASSIGNMENT, NUMBERS, SKILLS AND LOCATION)

- CALCULATE THE BUDGETARY EXPENDITURES EXPECTED DURING THIS PERIOD (SOURCE OF FUNDS, YEARLY ACCOUNTING, RELATION TO TOTAL PROGRAM COSTS)

- ARRANGE THE AVAILABILITY OF DOCUMENTATION TO SUPPORT BOTH KSC FLIGHT HARDWARE PROCESSING AND GSE/LSE READINESS.
LRB PRELIMINARY TRANSITION PLAN

PROGRESS MADE DURING THE LAST QUARTER

- DIVISION OF PROGRAM INTO

  0 1ST AND 2ND LINES OF FACILITY ACTIVATION
  0 3 PHASE APPROACH: ACTIVATION, TRANSITION AND OPERATIONS

- CORRELATION OF FACILITY ACTIVATION AND CONVERSION SCHEDULES WITH INCREMENTAL TRANSITION LAUNCH GOALS

- SELECTION OF THE FIRST LRB MISSION
  (STS 111 - FEB 20, 1996) AND PROVIDE FOR A LENGTHY FIRST FLOW.

  0 BASED ON PROJECTED 1991 PROGRAM START
  0 LATEST FLIGHT HARDWARE DELIVERY AND FACILITY COMPLETION DATES

LRB PRELIMINARY TRANSITION PLAN

FLOW CHART OF THE FIRST FOUR LRB MISSION PROCESSING CYCLES LEADING TO IOC

0  LENGTH OF PROCESSING TIME EXPECTED FOR AN OPERATIONAL MISSION MULTIPLIED BY A FACTOR OF 2.5 FOR FIRST FLOW THEN 2.0 AND 1.5 RESPECTIVELY FOR SECOND AND THIRD FLOWS

0  FOURTH FLOW IS EXPECTED TO DEMONSTRATE OPERATIONAL PROCESSING TIMELINES
LRB PRELIMINARY TRANSITION PLAN

- "MAJOR ISSUES" REMAINING TO BE ACCOMPLISHED
  - COMPLETE INTEGRATION OF LRB GENERIC FLOWS AND
    FACILITY ACTIVATIONS INTO THE MULTI-MISSION MODEL
  - IDENTIFY AND DOCUMENT ALL DESIGN AND SCHEDULE IMPACTS
  - COMPLETE ESTIMATES OF KSC TRANSITION REQUIREMENTS
    FOR LRB AND THE ASSOCIATED MANPOWER AND SKILLS
    NEEDED
  - SCOPE CHANGES REQUIRED IN GROUND SOFTWARE AND
    LAUNCH CONTROL CENTER FOR LRB
  - DEFINE AND DOCUMENT ALL "DELTAS" BETWEEN SELECTED
    DESIGN CONFIGURATIONS AND PROPOSED VENDOR APPROACHES
2. TECHNICAL WORKING GROUP ACTIVITIES

- LRB ASCENT PERFORMANCE / ABORT ANALYSIS
- TOWER CLEARANCE STUDIES
- BASELINE VEHICLE EXCURSIONS AT PAD
- COORDINATION OF PHASE A COST ESTIMATES
LRB/STS INTEGRATION / ANALYSIS BY LESC/JSC

- STS/LRB ASCENT FLIGHT DESIGN
  - GD AND MMC CONFIGURATIONS (5)
  - ASCENT PERFORMANCE
  - INTACT ABORT PERFORMANCE
- CONTINGENCY ABORT ASSESSMENT
- LRB CONTROLLABILITY ANALYSIS
- LRB FMEA/CIL ANALYSIS
- JSC MISSION OPERATION DIRECTORATE (MOD) IMPACTS
LRB/STS TOWER CLEARANCE STUDIES

0 DRIFT CURVES/ENGINE OUT CONDITIONS
0 LRB ENGINE OUT/SSME ENGINE OUT (NO. 2)
0 THRUST/WEIGHT DESIGN GOALS (1.6 OR 1.2)
0 PRE-LAUNCH VEHICLE EXCURSIONS AT PAD (LRB VS SRB)
BASELINE VEHICLE EXCURSIONS AT PAD

CURRENT SRB/SSV EXCURSIONS AT THREE SELECTED INTERFACE LOCATIONS ARE PRESENTED HERE IN THE VEHICLE COORDINATE SYSTEM. DISPLACEMENTS ARE FOR STEEL CASE SRB’S AND INCLUDE VEHICLE TOLERANCES, PAYLOAD WEIGHTS (ZERO AND 65K LB), WIND LOADS, ET TANKING, SRB JOINT FREEPLAY AND SSME IGNITION AND SHUTDOWN. THESE DATA ARE TAKEN FROM "DYNAMIC WORST-CASE EXCURSIONS" DEVELOPED BY ROCKWELL IN STRUCTURAL DESIGN LOADS DATA BOOK, VOL. 7, JULY 1988 (STS 85-0169).

OTHER INTERFACE LOCATIONS WHERE DISPLACEMENTS ARE DEFINED ARE INDICATED ON THE ILLUSTRATION IN THE NEXT CHART. THESE COMPUTED EXCURSIONS CORRESPOND TO THE SSV WITH FIRST MODE FREQUENCY OF 0.29 HZ AND SECOND MODE OF 0.44 HZ. IF LRB CHARACTERISTICS DROP BELOW THESE LEVELS MOST DYNAMIC EXCURSIONS WILL BE SIGNIFICANTLY HIGHER. THIS COMPOUNDS THE DIFFICULTY OF GROUND INTERFACE REDESIGN.
### Baseline Vehicle Excursions at Pad

<table>
<thead>
<tr>
<th>Function</th>
<th>Timing</th>
<th>Location</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOX Vent</td>
<td>T-2 MIN</td>
<td>ET TIP</td>
<td>+4.6</td>
<td>+1.4</td>
<td>+16.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+0.2</td>
<td>-1.9</td>
<td>-3.8</td>
</tr>
<tr>
<td>GH2 Vent</td>
<td>T-0</td>
<td>ET FWD INTERTANK</td>
<td>+3.6</td>
<td>+1.8</td>
<td>+17.5</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>-0.6</td>
<td>-2.9</td>
<td>-22.7</td>
</tr>
<tr>
<td>TSM</td>
<td>T-0</td>
<td>ORB AFT</td>
<td>+7.1</td>
<td>+2.4</td>
<td>+2.0</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>-11.1</td>
<td>-3.1</td>
<td>-1.5</td>
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</table>

* Maximum positive and negative motion in vehicle coordinate system (see illustration)
COORDINATION OF PHASE A COST ESTIMATES

- MMC AND GDSS COST SUMMARIES

- KSC COST ASSESSMENT STATUS
  - 10 MAY 88 EXERCISE
  - DETAILED BOTTOMS-UP (IN WORK)

- GROUND OPERATIONS COST MODEL (GOCM)
COMPARISON OF KSC LAUNCH SITE LCC COST ESTIMATES

These ROM data represent best current estimates of both recurring and non-recurring
LRB launch site costs for the 122-mission model.

0 "LCC LAUNCH OPERATIONS" covers recurring manpower costs of all direct and
supporting contractors plus booster-supporting civil service personnel at the
launch site.
0 "FACILITIES, GSE/LSE" cost cover all launch site equipment and facilities
required to support the full LRB flight rate of 14 per year.
0 MMC is concurring with LSOC launch operations cost.
0 Total LCC shown here does not include 40% NASA load factor.
0 All costs shown here are based on May 88 estimates
0 LSOC facility cost element estimates include:

1) FIRST LINE FACILITIES ($293M)
0 MLP (121M), HPF (59M), VAB/HB 4 (19M), PAD (60M), LETF/LCC (14M),
GRD S/W (20M)

2) SECOND LINE FACILITIES ($183M)
0 MLP (109M), VAB/HB3 (6M), PAD (60M), LETF/LCC (8M)
## COMPARISON OF KSC LAUNCH SITE LCC COST ESTIMATES

<table>
<thead>
<tr>
<th>TEAM</th>
<th>FACILITIES, GSE/LSE $ (M)</th>
<th>LCC LAUNCH OPERATIONS $ (M)</th>
<th>TOTAL LCC COST $ (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GD</td>
<td>337</td>
<td>758</td>
<td>1095</td>
</tr>
<tr>
<td>MMC</td>
<td>324</td>
<td>501*</td>
<td>825</td>
</tr>
<tr>
<td>LSOC</td>
<td>476</td>
<td>501</td>
<td>977</td>
</tr>
</tbody>
</table>

**NOTE:** COSTS DO NOT INCLUDE 40% NASA LOAD FACTOR  
* MMC IS CONCURRENCE WITH LSOC LAUNCH OPS COST ESTIMATE
3. ALTERNATE LRB APPLICATIONS

- GDSS AND MMC ACTIVITIES
- LAUNCH SITE REQUIREMENTS FOR ALS
- MIXED FLEET OPERATIONS
- CANDIDATE PAD "C" CONCEPTS
### TOP LEVEL REQUIREMENTS FOR

**ALTERNATE LRB APPLICATIONS (2.0)**

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>STS LRB</th>
<th>ALS</th>
<th>SHUTTLE &quot;C&quot;</th>
<th>STANDALONE</th>
<th>SHUTTLE &quot;II&quot;</th>
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<td>REQUIREMENT</td>
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<td></td>
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<tr>
<td>PAYLOAD (LBS)</td>
<td>70.5 K</td>
<td>160 K</td>
<td>102 K</td>
<td>&lt; 60 K</td>
<td>20 K</td>
</tr>
<tr>
<td></td>
<td>(160nm, 28.5°)</td>
<td>(80x150nm, 90°)</td>
<td>(220nm, 28.5°)</td>
<td>(150nm, 28.5°)</td>
<td>(262nm, 28.5°)</td>
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<tr>
<td>PERFORMANCE (TOTAL BOOSTER IMPULSE)</td>
<td>500 M LBSEC</td>
<td>640 M LBSEC</td>
<td>500 M LBSEC</td>
<td>250+ M LBSEC</td>
<td>730 M LBSEC</td>
</tr>
<tr>
<td>MAN - RATED</td>
<td>YES</td>
<td>NO*</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>FLIGHT RATE/YEAR</td>
<td>14</td>
<td>20-30</td>
<td>2-3</td>
<td>(TBD)</td>
<td>~25</td>
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<tr>
<td>ENGINE - OUT</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>(TBD)</td>
<td>YES</td>
</tr>
<tr>
<td>BOOSTER REUSABILITY</td>
<td>NO</td>
<td>(TBD)</td>
<td>(TBD)</td>
<td>NO</td>
<td>YES</td>
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* WILL EXAMINE MAN-RATED DERIVATIVE
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<tr>
<th>Upper Stage Gross Weight</th>
<th>Thrust T/W After Sep</th>
<th>Booster Thrust T/W At Liftoff</th>
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<tr>
<td>359,965 Lbs</td>
<td>469,923 Lbs</td>
<td>1,370,725 Lbs</td>
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<tr>
<td>469,923 Lbs</td>
<td>1,326 Lbs</td>
<td>1,933,911 Lbs</td>
</tr>
<tr>
<td>1,326 Lbs</td>
<td>40 K Lbs</td>
<td>1,411 Lbs</td>
</tr>
</tbody>
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**STANDALONE LRB (4B)**

15 ft, Dia. 60 fl
Payload Cylindrical
LAUNCH SITE REQUIREMENTS FOR ALS

- REQUIREMENTS DEFINITION
  - PROCESSING
  - LAUNCH OPERATIONS
  - RECOVERY OPS

- CANDIDATE SCENARIOS FOR EFFICIENT GROUND OPS CONCEPTS
  - PAYLOAD CANNISTER/SHTROUD FLOW
  - CORE VEHICLE FLOW
  - BOOSTER OPTIONS/PROCESSING APPROACHES
  - VEHICLE INTEGRATION PLAN

- FACILITIES PLAN
  - HORIZONTAL VS VERTICAL PROCESSING
  - MLP (YES/NO)
  - VAFB LAUNCH SITE OPTIONS
  - PAD "C" CONCEPTS AT KSC
  - ALS GSE/LSE
  - SHARED STS FACILITIES

- LAUNCH SITE INTEGRATION MUST BE MERGED WITH ALS SYSTEM DESIGN TO ENSURE CONTROL OF LIFE CYCLE COST ELEMENTS
SHUTTLE "C" FLOW SUMMARY

0 THE SHUTTLE "C" LAUNCH SITE PROCESSING SCENARIO CONTAINS SIGNIFICANT NEW FACILITY ACTIVATION REQUIREMENTS

0 SHOWN HERE IS THE FAVORED "SIDEMOUNT" PROCESSING FLOW ILLUSTRATING THE MAJOR NEW AND MODIFIED FACILITIES:

- CARGO CARRIER/PAYLOAD PROCESSING BLDG.
- NEW SRB BUILD-UP AND STACKING FACILITY (REMOTE STACKING)
- EXPANDED OR NEW RPSF/SURGE FACILITY

0 ESTIMATED SHUTTLE "C" LAUNCH SITE FACILITY CHANGES TOTALLED $320 M IN A FEB 1988 NASA ASSESSMENT. A PRELIMINARY COMPARISON USING LRB IS IN WORK.

0 SIGNIFICANT REDUCTION IN THIS LAUNCH SITE IMPACT COULD BE REALIZED THRU THE APPLICATION OF LRB TO THE SHUTTLE "C" SYSTEM.

0 THE MAJOR FACTORS ARE: 1) THE ELIMINATION OF THE REQUIREMENT FOR THE REMOTE STACKING FACILITY, 2) NO NEW OR EXPANDED RPSF/SURGE, AND 3) LOWER RISK OF IMPACT TO ON-GOING STS LAUNCH OPERATIONS.

Lockheed
Space Operations Company
A-32A
AGENDA

I. INTRODUCTION

II. STUDY PROGRESS
   A. ACHIEVEMENT SUMMARY
   B. ENGINE PROCESSING STUDY Pat Scott
   C. LRB/ET PROCESSING EVALUATION Glen Waldrop
   D. SAFETY & ENVIRONMENTAL IMPLICATIONS Greg DeBlasio
   E. GOCM STATUS Roger Lee

III. SUMMARY
     Gordon Artley
• LRB ENGINE PROCESSING CONSIDERATIONS

- ENGINE CHARACTERISTICS
- OPERATIONS
- FACILITIES / EQUIPMENT
- PROCESSING FLOW
LRB ENGINE CHARACTERISTICS

• PROPELLANTS
  - LOX/RP-1 -- PRESSURE & PUMP FED
  - LOX/LH2 -- PUMP FED

• GAS REQUIREMENTS
  - NITROGEN
  - HELIUM

• ELECTRIC ACTUATORS
• SUPERVISORY CONTROLLER
• PHYSICALS / ENGINE WEIGHT
  - LOX/RP-1 -- PRESSURE -- 5700LB
  - LOX/RP-1 -- PUMP -- 8100LB
  - LOX/LH2 -- PUMP -- 6700LB
  - SIMILAR TO SSME IN SIZE
  - SSME: HT = 168", EXIT DIA = 90"

• EXPENDABLE
LRB LOX/RP-1 Pump-Fed Engine

Top View
LOX Turbopump

RP-1 Turbopump

119.26 in.

178.88 in.

119.26 in.

42.10 in.

43.10 in.

108.00 in.

163.23 in.

LOX φ12.0

RP-1 φ8.0
# LRB Pressure Fed Engine

**LO2/RP1**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NPL</th>
<th>FPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrust, S.L. klbs</td>
<td>562</td>
<td>750</td>
</tr>
<tr>
<td>Thrust, Vac klbs</td>
<td>700</td>
<td>887</td>
</tr>
<tr>
<td>ISP, S.L. sec</td>
<td>257</td>
<td>271</td>
</tr>
<tr>
<td>ISP, Vac, sec</td>
<td>321</td>
<td>321</td>
</tr>
<tr>
<td>Mixture Ratio</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Total Flow Rate, lb/sec</td>
<td>2185</td>
<td>2766</td>
</tr>
<tr>
<td>Chamber Pressure, Psia</td>
<td>630</td>
<td>800</td>
</tr>
<tr>
<td>Exit Pressure, Psia</td>
<td>5.5</td>
<td>6.9</td>
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<tr>
<td>Expansion Ratio</td>
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<tr>
<td>Chamber Type</td>
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<td>Ablative</td>
</tr>
<tr>
<td>Nozzle Type</td>
<td></td>
<td>Ablative</td>
</tr>
<tr>
<td>Weight, Dry, lbs</td>
<td></td>
<td>4500</td>
</tr>
<tr>
<td>Propellants</td>
<td></td>
<td>LO2/RP1</td>
</tr>
<tr>
<td>Gimbal Angle</td>
<td></td>
<td>±6°</td>
</tr>
<tr>
<td>Gimbal Type</td>
<td></td>
<td>Head End</td>
</tr>
<tr>
<td>Throttle Range</td>
<td></td>
<td>Flex Seal (Optional)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>65 - 100%</td>
</tr>
</tbody>
</table>

- **Flex Seal**: Optional

---

- **Figure**: Diagram of the LRB Pressure Fed Engine showing key components such as Oxidizer Valve, Fuel Valve, Combustion Chamber, and Nozzle.

---

- **Dimensions**: Total length 170", Diameter 109.2".
NO FACING PAGE TEXT
LRB PUMP FED ENGINE
LO2/RP1

<table>
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<tr>
<th></th>
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<th>EPL</th>
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<tbody>
<tr>
<td>Thrust, S.L. kils</td>
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<td>685</td>
</tr>
<tr>
<td>Thrust, Vac. kbs</td>
<td>623</td>
<td>788</td>
</tr>
<tr>
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<td>277</td>
</tr>
<tr>
<td>ISP, Vac, sec</td>
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<td>318</td>
</tr>
<tr>
<td>Mixture Ratio</td>
<td>2.6</td>
<td>2.5</td>
</tr>
<tr>
<td>Total Flow Rate, lb/sec</td>
<td>1933</td>
<td>2473</td>
</tr>
<tr>
<td>Chamber Pressure, Psia</td>
<td>1033</td>
<td>1300</td>
</tr>
<tr>
<td>Exit Pressure, Psia</td>
<td>5.9</td>
<td>7.7</td>
</tr>
<tr>
<td>Expansion Ratio</td>
<td></td>
<td>21.2</td>
</tr>
<tr>
<td>Nozzle Type</td>
<td></td>
<td>Carbon-Carbon</td>
</tr>
<tr>
<td>Weight, Dry, lbs</td>
<td></td>
<td>6807</td>
</tr>
<tr>
<td>Engine Cycle</td>
<td></td>
<td>Gas Gen</td>
</tr>
<tr>
<td>Propellants</td>
<td></td>
<td>LO2/RP1</td>
</tr>
<tr>
<td>Gimbal Type</td>
<td></td>
<td>Head End</td>
</tr>
<tr>
<td>Gimbal Angle</td>
<td></td>
<td>±6°</td>
</tr>
<tr>
<td>Throttle Range</td>
<td></td>
<td>65 - 100%</td>
</tr>
</tbody>
</table>
LRB ENGINE PROCESSING OPERATIONS

THE LRB ENGINE PROCESSING OPERATIONS HAVE BEEN BROKEN DOWN INTO FOUR BASIC CATEGORIES: HARDWARE HANDLING, HARDWARE REPLACEMENT (FROM ENTIRE ENGINE DOWN TO THE COMPONENT LEVEL), VERIFICATION OF ENGINE FUNCTIONAL INTEGRITY, AND, THE FINAL CLOSEOUT ITEMS REQUIRED FOR THE LAUNCH PHASE OF THE OPERATION.

LIQUID ROCKET BOOSTER INTEGRATION
SECOND PROGRESS REVIEW

- HANDLING
- CHANGEOUT / LRU LEVEL
- CHECKOUT
- SERVICING FOR LAUNCH
# Liquid Rocket Booster Integration

Second Progress Review

**LRB Engine Processing Equipment**

## Facility Support

<table>
<thead>
<tr>
<th>Item</th>
<th>Similar Current Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Platforms Vehicle Vertical</td>
<td>A70 - 0643</td>
<td>Used to remove/install engines</td>
</tr>
<tr>
<td>Access Platforms Vehicle Horizontal</td>
<td>OPF AFT Plate</td>
<td></td>
</tr>
<tr>
<td>Access Platforms Engine Shop</td>
<td>A70 - A70</td>
<td></td>
</tr>
<tr>
<td>Chamber Entry Manlift</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Mass Spectrometer Station (Fixed)</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

## Service / Checkout

<table>
<thead>
<tr>
<th>Item</th>
<th>Similar Current Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Protection Set</td>
<td>S70 - 0902</td>
<td>Seal engine openings for environmental control</td>
</tr>
<tr>
<td>Internal Inspection Equipment</td>
<td>C70 -</td>
<td></td>
</tr>
<tr>
<td>Test Adapter Set</td>
<td>C70 -</td>
<td></td>
</tr>
<tr>
<td>Flow Tester</td>
<td>C76 - C78 - C79 - C80-</td>
<td></td>
</tr>
<tr>
<td>Regulator Panels</td>
<td>C70 -</td>
<td></td>
</tr>
<tr>
<td>Regulator Panels</td>
<td>S78 - S79 - S80 -</td>
<td></td>
</tr>
<tr>
<td>Engine Flush &amp; Drying Unit Chamber Servicing</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Thermal Protection System Welder</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Engine Command and Data Simulator</td>
<td>N/A</td>
<td></td>
</tr>
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</table>

## Engine Handling

<table>
<thead>
<tr>
<th>Item</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Hyster Lift Truck</td>
<td>H70 - 0764</td>
<td>Install/remove engine - horizontal</td>
</tr>
<tr>
<td>Horizontal Installer</td>
<td>H70 - 0558</td>
<td>Install/remove engine - horizontal</td>
</tr>
<tr>
<td>Engine Handler</td>
<td>H70 - 0001</td>
<td>ISP/store and horizontal processing</td>
</tr>
<tr>
<td>Engine Handler Bling</td>
<td>H70 - 0902</td>
<td>Load/unload engine handler</td>
</tr>
<tr>
<td>Engine Support with Handler and Rotating Bling</td>
<td>H70 - 0911</td>
<td></td>
</tr>
<tr>
<td>Rotating Bling</td>
<td>H70 - 0903</td>
<td>Rotate engine to vertical</td>
</tr>
<tr>
<td>Vertical Installer</td>
<td>H70 - 0774</td>
<td>Install/remove engine - vertical</td>
</tr>
<tr>
<td>Proofload Fixture Set</td>
<td>S70 - 0911</td>
<td>Proofload/critical lift of handling equipment</td>
</tr>
<tr>
<td>Engine Mover Set</td>
<td>H70 - 0800</td>
<td>Move engine without TVC actuators</td>
</tr>
<tr>
<td>Engine Alignment Set</td>
<td>A70 - 0546</td>
<td>Setting of TVC actuators</td>
</tr>
<tr>
<td>Component Handler Set</td>
<td>H70 - 0905</td>
<td>Used when lifting LRU's</td>
</tr>
<tr>
<td>Engine LRU Install/Removal Set</td>
<td>H70 - 0528</td>
<td>Install/remove LRU with vehicle in either horizontal or vertical</td>
</tr>
<tr>
<td>Engine/Handler Mover</td>
<td>N/A</td>
<td>Move engine/handler in shop areas</td>
</tr>
<tr>
<td>Engine Dolly (Vertical)</td>
<td>N/A</td>
<td>Used to process engine in vertical</td>
</tr>
<tr>
<td>TVC Actuator Locks</td>
<td>A70 - 0551</td>
<td>Used to maintain engine in desired fixed position when engine installed in vehicle</td>
</tr>
<tr>
<td>TVC Actuator Supports</td>
<td>H70 - 0828</td>
<td></td>
</tr>
<tr>
<td>TVC Actuator Extend/Retract Locks</td>
<td>A70 - 0883</td>
<td></td>
</tr>
</tbody>
</table>
LRB ENGINE HANDLING
LRB ENGINE/LRU CHANGEOUT

THE GROUND SUPPORT EQUIPMENT (GSE), REALIZED AT THIS TIME TO SUPPORT THE LIQUID ROCKET BOOSTER ENGINE OPERATIONS HAS BEEN ARBITRARILY GROUPED INTO THREE (3) OPERATIONAL CATEGORIES. THESE OPERATIONAL CATEGORIES WOULD INCLUDE: A) ENGINE HANDLING, B) CHECKOUT/SERVICING, AND C) FACILITY SUPPORT.

THE ENGINE HANDLING CATEGORY WOULD INCLUDE ALL ENGINE, AND ENGINE COMPONENT, MOVEMENT AND SUPPORT. SUCH ACTIVITIES AS RECEIVING/SHIPPING AN ENGINE, ENGINE PREPARATION FOR VEHICLE INSTALLATION AND REMOVAL, ENGINE INSTALLATION AND REMOVAL, AND, COMPONENT HANDLING/INSTALLATION/REMOVAL WOULD BE INCLUDED IN THIS CATEGORY.
LRB ENGINE/LRU CHANGEOUT

VERTICAL INSTALLER

COMPONENT
LRU GSE

HORIZONTAL INSTALLER
LRB ENGINE CHECKOUT/SERVICING

ENGINE CHECKOUT AND SERVICING WOULD INCLUDE SUCH ITEMS AS ENGINE PROTECTION, INSPECTION, ALL MECHANICAL/FLUID/ELECTRICAL CHECKOUTS, AND THE SERVICING AND "CLOSEOUT" REQUIREMENTS FOR LAUNCH.
LRB ENGINE CHECKOUT/SERVICING

LEAK & FUNCTIONALS

FLOW

ELECTRONIC

TEST & PROTECTIVE COVERS

LAUNCH PREPARATION
LRB ENGINE ACCESS REQUIREMENTS

TOTAL AND EASE OF ACCESS TO THE ENGINES IS A MUST FOR EFFICIENT AND EFFECTIVE PROCESSING OPERATIONS. "LESSONS LEARNED" EVOLVING FROM THE SSME PROCESSING AT ALL AREAS OF LC-39 HAS BEEN USED TO PROMOTE CONCEPTS FOR THE LRB ENGINE ACCESS THAT SHOULD ENHANCE THE SAFETY FOR PERSONNEL AND FLIGHT HARDWARE, AND PROVE TO BE COST EFFECTIVE.

FACILITY SUPPORT DENOTES THE "FACILITIES" TYPE GSE REQUIRED TO INSURE THE PERFORMANCE OF THE FIRST TWO OPERATIONAL CATEGORIES MENTIONED ABOVE.
LRB ENGINE PROCESSING FACILITIES

LRB ENGINE PROCESSING FACILITIES

- ENGINE SHOP
  - COMPONENT CHANGEOUT
  - SERVICING
  - CHECKOUT
  - GSE STAGING AREA
  - CENTRALIZED PERSONNEL

- VEHICLE AREA
  - ENGINE CHANGEOUT
  - SERVICING
  - TOTAL ACCESS
LRB HORIZONTAL PROCESSING FACILITY
LRB ENGINE SHOP

THE LRB ENGINE SHOP AREA WILL BE THE NUCLEUS FOR THE ENGINE RELATED PROCESSING OPERATIONS. THIS FACILITY SHOULD PROVIDE FOR THE RECEIPT, STORAGE, INSTALLATION/REMOVAL, MODIFICATION, CHECKOUT, AND MAINTENANCE OF THE ENGINES, AND, ANY RELATED OPERATIONS ASSOCIATED WITH THE GROUND SUPPORT EQUIPMENT NEEDED FOR ENGINE PROCESSING. USING THESE BASELINES, A GENERAL DESCRIPTION OF THE FACILITY CAN BE DEVELOPED TO SUPPORT ALL PHASES OF ENGINE PROCESSING AS DEFINED BY THE CONCEPTUAL DESIGN OF THE LRB PROPULSION SYSTEM.
LRB ENGINE PROCESSING FACILITIES

VEHICLE AREA

IN ORDER TO EFFECTIVELY SUPPORT THE PROCESSING FLOW, "SATELLITE" AREAS AT THE INTEGRATION AND PAD LOCATIONS WILL BE NEEDED FOR THE LRB ENGINE OPERATIONS. THESE AREAS WILL BE USED AS STAGING AREAS FOR PERSONNEL, TOOLS, MINOR EQUIPMENT, AND MINOR FLIGHT HARDWARE.

OTHER AREA(S)

SOME PRESENT LRB ENGINE OPERATION CONCEPTS INDICATE THE USE OF PACKAGE IGNITION SYSTEM AND PYRO CARTRIDGES FOR INITIAL GAS GENERATOR OPERATION. SPECIAL AREAS WILL HAVE TO BE CONSIDERED FOR THESE DEVICES AND SHOULD BE EASILY ACCESSIBLE TO SUPPORT COST EFFECTIVE LAUNCH "CLOSEOUT" OPERATIONS.
LRB ENGINE PROCESSING FACILITIES

• VEHICLE AREA

  - INTEGRATION CELL
  - LAUNCHER PLATFORM
  - LAUNCH AREA

• OTHER AREA(S)

  - IGNITION PACKAGE STORAGE
  - GAS GENERATOR CARTRIDGE STORAGE
**LRB ENGINE PROCESSING FLOW**

<table>
<thead>
<tr>
<th>Area</th>
<th>Shifts</th>
<th>Technicians</th>
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</thead>
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<tr>
<td><strong>ENGINE SHOP</strong></td>
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</tr>
<tr>
<td>Receiving</td>
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<td>5</td>
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<tr>
<td>De-Package</td>
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<tr>
<td>Inspection</td>
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<tr>
<td>Preps for Installation</td>
<td>3</td>
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</tr>
<tr>
<td><strong>HORIZONTAL PROCESSING FACILITY</strong></td>
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</tr>
<tr>
<td>Installation</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Interface Verification</td>
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</tr>
<tr>
<td>Engine Alignment Verification</td>
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<tr>
<td>Gimbal Profile Verification</td>
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<tr>
<td>External Leak Checks</td>
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<td></td>
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<tr>
<td>Internal Leak Checks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Checks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Checkout</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated Checkout</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Protection System Installation**</td>
<td>1</td>
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<tr>
<td><strong>INTEGRATED CONFIGURATION</strong></td>
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<td></td>
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<tr>
<td>Integrated Testing/FRT</td>
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<td>2</td>
</tr>
<tr>
<td>Thermal Protection System Installation**</td>
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</tr>
<tr>
<td>Launch Preparation</td>
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<td></td>
</tr>
<tr>
<td>• Ignition System Installation</td>
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<td></td>
</tr>
<tr>
<td>• Gas Generator Cartridge Installation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Flush/Dry Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Prepare Fuel System (Anti-Freeze)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Final TPS Installation</td>
<td>1</td>
<td>14</td>
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</tbody>
</table>

* PER ENGINE

18 SHIFT TOTAL - 10 TECHS
AGENDA

I. INTRODUCTION

II. STUDY PROGRESS
   A. ACHIEVEMENT SUMMARY
   B. ENGINE PROCESSING STUDY
   C. LRB/ET PROCESSING EVALUATION
   D. SAFETY & ENVIRONMENTAL IMPLICATIONS
   E. GOCM STATUS

III. SUMMARY

Gordon Artley
Pat Scott
Glen Waldrop
Greg DeBlasio
Roger Lee
Stephen Schneider

Gordon Artley
REVIEW OF ACTIVITIES

THE FIRST PROGRESS REVIEW (JULY 1988) PRESENTED IMPACT ANALYSIS FOR EXISTING AND NEW FACILITIES BY STATION SET. THIS ANALYSIS AND REQUIREMENT DEFINITION IS CONTINUING, SINCE SCHEDULED COMPLETION OF THE ANALYSIS IS CLOSE TO THE FINAL PROGRESS REVIEW THE STATION SET REPORT WILL BE PRESENTED AT THAT TIME.

THIS PROGRESS REVIEW WILL CONCENTRATE ON THE SELECTED TOPIC OF THE EVALUATION OF USING THE VAB FOR PROCESSING AND STORAGE OF THE LRB.
REVIEW OF ACTIVITIES

- 1st PROGRESS REVIEW (JULY 1988) PRESENTED A NEW ET/LRB FACILITY CONCEPT

- DUE TO THE CONCERNS WITH THE RECOMMENDATION OF AN OFF-LINE LRB FACILITY AND RELOCATION OF ET PROCESSING TO AN OFF-LINE FACILITY THE SECOND PROGRESS REVIEW WILL PRESENT THE EVALUATION
REVIEW OF ACTIVITIES (CONT)

DRIVERS FOR NEW FACILITIES

INTRODUCTION OF LRB WITHOUT IMPACT TO EXISTING FACILITIES AND OPERATIONS

ACTIVATION OF LRB FACILITIES WITHOUT IMPACT TO LAUNCH SCHEDULE OF 12 TO 14 STS/YEAR

ACTIVATION OF LRB FACILITIES IMPACTS DUE TO SRB OPERATIONS IN VAB AND FLIGHT RATE REQUIREMENTS

NEW FACILITY REQUIREMENTS

NEED FOR A THIRD INTEGRATION CELL SO NOT TO IMPACT SRB FLIGHTS

NEED TO MOVE ETs OUT OF HB4 SO IT CAN BE USED AS THIRD CELL
ET/LRB PROCESSING EVALUATION

1. HB2/4 SPACE UTILIZATION
2. FLIGHT ELEMENT FLOW PATHS THROUGH VAB
3. CRANE/LIFT OPERATION REQUIREMENTS
4. ACTIVATION SCHEDULE
5. NEW ET/LRB HORIZONTAL PROCESSING SITE LOCATION
6. ET/LRB PROCESSING CONSTRAINTS IN VAB HB2/4
   (CONCEPT EVALUATION)
7. ET/LRB REQUIREMENTS FOR STORAGE & PROCESSING
8. CONCLUSIONS
THE FOLLOWING AREAS ARE AVAILABLE FOR LRB PROCESSING AND STORAGE CELLS:

AREA 1: ATTACHED TO TOWER "A" ABOVE LEVEL 10 (112') 10'-FEET BY 76'-FEET (BETWEEN COLUMN LINES Q, U, 12, 16).

AREA 2: IN FRONT OF HIGH BAY DOOR ABOVE LEVEL 10 (112') 76'-FEET BY 76'-FEET (BETWEEN COLUMN LINES U, X, 12, 14).

THE FLOOR SPACE BELOW LEVEL 10 ON EITHER SIDE OF THE DOOR IS 76'-FEET BY 38'-FEET (BETWEEN COLUMN LINES U, X, 14, 16 AND U, X, 10, 12).
CONCEPT FOR HI-BAY 2 SPACE UTILIZATION FOR TWO LRB CELLS

THE FOLLOWING TWO LOCATIONS ARE AVAILABLE:

- PROCESSING - AREA BETWEEN COLUMN LINES Q, U, 14, 15, ABOVE LEVEL 10 (ATTACHED TO TOWER "A")

- STORAGE - AREA BETWEEN COLUMN LINES U, X, 13, 14 ABOVE LEVEL 10 (IN FRONT OF HIGH BAY DOOR)

THIS ARRANGEMENT OF CELLS WILL PERMIT STORAGE OF A LRB FLIGHT PAIR AND PROCESSING OF A FLIGHT PAIR

HAVING THE CELLS ABOVE THE LEVEL 10 ELEVATION WILL ALLOW FOR VERTICAL ENGINE REMOVAL/INSTALLATION AND ACCESS TO THE HIGH BAY DOOR AND TOWER "A".

 Lockheed
Space Operations Company
C-5A
PRESENT HB-4 SPACE AVAILABLE

THE FOLLOWING AREAS ARE AVAILABLE FOR LRB PROCESSING AND STORAGE CELLS:

AREA 1: BETWEEN THE ET CELLS AND SRB WORK STANDS 66-FEET BY 76-FEET (BETWEEN COLUMN LINES Q, U, 5, 7)

AREA 2: IN FRONT OF HIGH BAY DOOR ABOVE LEVEL 10 (112') 76-FEET BY 76-FEET (BETWEEN COLUMN LINES U, X, 5, 7)

THE FLOOR SPACE BELOW LEVEL 10 ON EITHER SIDE OF THE DOOR IS 76-FEET BY 38-FEET (BETWEEN COLUMN LINES U, X, 3, 5 AND U, X, 7, 9)

THE SRB WORK STAND MUST REMAIN TO PROVIDE BACK-UP FOR RPSF.
CONCEPT FOR HI-BAY 4 SPACE UTILIZATION WITH TWO LRB CELLS

THE FOLLOWING LOCATION IS AVAILABLE:

0 AREAS BETWEEN COLUMN LINES U, X, 5, 6 AND U, X, 6, 7 (IN FRONT OF HIGH BAY DOOR) ABOVE LEVEL 10.

THIS ARRANGEMENT OF CELLS WILL PERMIT STORAGE OF A LRB FLIGHT PAIR AND PROCESSING OF A FLIGHT PAIR.

HAVING THE CELLS ABOVE LEVEL 10 ELEVATION WILL ALLOW FOR VERTICAL ENGINE REMOVAL/INSTALLATION AND ACCESS TO THE HIGH BAY DOOR.

THE CAPABILITY TO PROVIDE BACK-UP TO THE RPSF REQUIRES MAINTAINING THE SRB WORK STANDS IN THE HB.
TWO CONCEPTS FOR FLIGHT ELEMENT FLOW IN VAB

• CONCEPT 1- USING HB 2 & 4 FOR ET & LRB PROCESSING

• CONCEPT 2- USING NEW ET/LRB PROCESSING FACILITY
CONCEPT 1
FLIGHT ELEMENT FLOW PATH
VAB HB 1, 3 AS INTEGRATION CELLS
VAB HB 2, 4 AS ET/LRB C/O CELLS

THE FLOW PATH CONSISTS AS FOLLOWS:
0 SRB ARRIVE FROM RPSF AND LIFT OPERATION TO HB 1 OR 3
0 ORBITER ARRIVE FROM OPF AND LIFT OPERATIONS TO HB 1 OR 3
0 LRB RECEIVED FROM BARGE AND LIFTED TO HB 2 OR 4 FOR PROCESSING
  - FOR STACKING: LIFTING OPERATION FROM HB 2 TO 1 OR 4 TO 3.
  - IN HB 2 AND 4, THESE WILL BE LIFT OPERATIONS TO MOVE LRB FROM C/O TO
    STORAGE CELLS
0 ET RECEIVED FROM BARGE AND LIFTED TO HB 2 OR 4 FOR PROCESSING
  - FOR STACKING: LIFTING OPERATION FROM HB 2 TO 1 OR 4 TO 3
  - IN HB 2 AND 4, THESE WILL BE LIFT OPERATIONS TO MOVE ET FROM C/O TO
    STORAGE CELLS

THE SIGNIFICANT CONCERN AS THE NUMBER OF LIFT OPERATIONS, THE TIMELY ACTIVATION OF HB
3 AND 1 TO SUPPORT LRB AND SRB, AND ACTIVATION OF HB 4 AND 2 TO SUPPORT LRB
PROCESSING.

THE ACTIVATION REQUIREMENTS FOR THIS PROCESS INCLUDES
0 ACTIVATION/MODIFICATION OF HB 1 AND 3 AS INTEGRATION CELLS TO SUPPORT LRB AND
  SRB
0 ACTIVATION/MODIFICATION OF HB 2 AND 4 AS LRB PROCESSING FACILITIES.
CONCEPT 2
FLIGHT ELEMENT FLOW PATH
VAB HB 1, 3, 4 AS INTEGRATION CELLS
ET PROCESSING AT HORIZONTAL FACILITY

THE FLOW PATH CONSISTS AS FOLLOWS:

- SRB ARRIVES FROM RPSF AND LIFT OPERATION TO HB 1 OR 3
- ORBITER ARRIVES FROM OPF AND LIFT OPERATION TO HB 1, 3 OR 4
- LRB ARRIVES FROM LRB FACILITY AND LIFT OPERATION TO HB 3 OR 4
- ET ARRIVES FROM HORIZONTAL FACILITY AND LIFT OPERATION TO HB 1, 3 OR 4

THIS FLOW PATH PROVIDES THE MINIMUM CRANE/LIFT OPERATIONS

THE ACTIVATION REQUIREMENTS FOR THIS PROCESS INCLUDES:

- ACTIVATION OF AN OFF LINE LRB FACILITY
- ACTIVATION OF OFF LINE ET FACILITY
- ACTIVATION OF VAB HB 4 AS AN INTEGRATION CELL
- MODIFICATION/ACTIVATION OF VAB HB 3 AS AN INTEGRATION CELL SUPPORTING LRB AND SRB
- RELOCATION OF SRB STANDS FROM HB 4 TO HB 2
VAB LIFT OPERATION SUMMARY

EXCLUDING THE ORBITER AND SRB LIFT REQUIREMENTS, THERE IS SIGNIFICANT REDUCTION IN THE NUMBER OF FLIGHT ELEMENT LIFTS WHEN ET'S AND LRB'S ARE PROCESSED HORIZONTALLY.

IF THE PLANNED USE OF THE VAB REMAINS AS IT IS TODAY UTILIZING HB 2 & 4 FOR ET AND LRB PROCESSING 10 LIFT OPERATIONS WOULD BE REQUIRED TO STACK AN LRB/STS. SRB/STS WOULD REMAIN UNCHANGED.

IF LRB/STS INTEGRATION OCCURRED IN HB 3 OR 4 AND ET'S AND LRB'S WHEN PROCESSED HORIZONTALLY ELSEWHERE 4 LIFT OPERATIONS WOULD BE REQUIRED TO STACK. SRB/STS LIFT OPERATIONS FOR HB 1 & 3 WOULD DECREASE BY 2.

SINCE LIFTING FLIGHT HARDWARE IS A HAZARDOUS OPERATION REDUCING THE LIFT OPERATIONS REPRESENTS A SIGNIFICANT ENHANCEMENT TO GROUND OPERATIONS SAFETY.
<table>
<thead>
<tr>
<th></th>
<th>CURRENT SRB/STS</th>
<th>CONCEPT 1 LRB/STS</th>
<th>CONCEPT 2 LRB/STS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOOSTER ET ORB</td>
<td>10</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>14</td>
<td>10</td>
<td>4</td>
</tr>
</tbody>
</table>
THE SIGNIFICANT IMPACT OF PROCESSING LRB's IN THE VAB TO MEET A 1/96 LAUNCH DATE WILL
BY THE NEED TO CONVERT VAB HB 3 FROM SRB ONLY TO LRB AND SRB CAPABILITY. OPEN WORK
TIMES TO MAKE THE CONVERSION WILL NOT ALLOW THE TIMELY COMPLETION. THE ESTIMATE
CONVERSION TIME IS 13 MONTHS WITHOUT INTERRUPTION. THERE ARE APPROX. 151 WORKDAYS
BETWEEN OCT. 1991 TO OCT 1994 AVAILABLE.

THE USE OF HB 4 AS AN INTEGRATION CELL PREVENTS THE LOSS OF FLIGHTS SINCE CONVERSION
OF HB 3 CAN BE DELAYED UNTIL LRB FLIGHTS HAVE COMMENCED AND SRB FLIGHTS ARE REDUCED.
THIS HOWEVER WILL REQUIRE HB 2 TO SUPPORT TWICE AS MANY ET's WITH LITTLE ROOM FOR
LRB.

THE OPTIMUM ACTIVATION SCHEDULE IS ALLOWED BY MOVING ET's TO A NEW FACILITY.
### VAB HIGH BAY FACILITY OPEN PERIODS
#### FISCAL YEAR - 1993

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<th>SEP</th>
<th>OCT</th>
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<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
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<tr>
<td><strong>VAB-1</strong></td>
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#### FISCAL YEAR - 1994

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*Lockheed Space Operations Company*
ACTIVATION OF FIRST LINE FACILITIES

USING HB 3 FOR FIRST LRB STACKING AND HB 4 FOR FIRST LRB PROCESSING (CONCEPT 1) WILL REQUIRE SUSPENSION OF 5 - 7 SRB/SSV FLIGHTS DURING THE HB 3 MODIFICATION PERIOD. THE MODIFICATION IS ESTIMATED TO BE 13 MONTHS OF UNINTERRUPTED TIME BETWEEN THE CONCEPTUAL TIME FRAME OF OCTOBER 1993 TO OCTOBER 1994. THE AREA CONTROLS IN THE VAB DURING THE MODIFICATION OF HB 3 & HB 4 WILL BE EXTENSIVE DUE TO CONSTRUCTION AND SSV INTEGRATION (LIFTING, SRB STACKING) OCCURRING IN PARALLEL.

(USING THE HB 4 FOR FIRST LRB STACKING AND A NEW HPF FOR ET & LRB (CONCEPT 2) WILL NOT REQUIRE SUSPENSION OF SRB/SSV FLIGHTS. THE NEW HPF FOR ET CAN BE ACTIVATED PRIOR TO HB 4 MODIFICATION AND STACKING. MODIFICATION OF HB 3 AS A DUAL INTEGRATION FACILITY FOR SRB/SSV A LRB/SSV CAN OCCUR AFTER THE SRB FLIGHT RATE IS DOWN TO 7 PER YEAR.)
ACTIVATION OF FIRST LINE FACILITIES

CONCEPT 1

• SUSPENSION OF 5 - 7 SRB / SSV FLIGHTS
• EXTENSION AREA CONTROL DURING MODIFICATION PERIOD

CONCEPT 2

• NO IMPACT TO SRB / SSV FLIGHTS
• ACTIVATE HB-3 WHEN SRB / SSV FLIGHT DOWN TO 7 PER YEAR
• MINIMIZE AREA CONTROLS DURING MODIFICATION PERIOD
ET/LRB HORIZONTAL PROCESSING FACILITY SITE LOCATION

THIS PROPOSED SITE PROVIDES AN EXCELLENT POTENTIAL LOCATION. THE EXISTING PRESS SITE MAY BE RELOCATED WHICH WILL PROVIDE ADDITIONAL AREA. IT IS IN CLOSE PROXIMITY TO THE BARGE TERMINAL & TOW ROUTE. SAFETY CONCERNS ARE ELIMINATED SINCE THIS SITE IS BEYOND THE VAB QUANTITY-DISTANCE (QD) ENVIRONMENTAL CONCERNS ARE MINIMIZE SINCE AN EXISTING LOCATION IS BEING UTILIZED.

THIS SITE WAS ONE OF THE TWO PRIME CANDIDATE SITES PRESENTED AT THE FIRST PROGRESS REVIEW.
ET/LRB DESIGN REQUIREMENTS FOR STORAGE AND PROCESSING OPERATIONS WITH SRB STANDS IN VAB

**COMPARISON**

<table>
<thead>
<tr>
<th>LRB</th>
<th>CONCEPT 1</th>
<th>CONCEPT 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIFT/ROTATION STORAGE/PROCESSING ENGINE CHANGEOUT ENVELOPE</td>
<td>YES VERTICAL ON HOLDDOWN VERTICAL 36' X 76'</td>
<td>NO HORIZ (ON TRANSPORTER) HORIZ (ON TRANSPORTER) UNLIMITED</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<tr>
<td>LIFTING/ROTATION STORAGE/PROCESSING ENVELOPE</td>
<td>YES VERTICAL EXISTING</td>
<td>NO HORIZ (ON TRANSPORTER) UNLIMITED</td>
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</table>
CONCEPT 1 EVALUATION

USING THE VAB HB 2 & 4 FOR LRB/ET PROCESSING/STORAGE, HAS CONSTRAINTS TO ACTIVATION AND PROCESSING.

ACTIVATION OF HB 1 & 3 TO SUPPORT LRB AS WELL AS SRB WILL REQUIRE AN UNINTERRUPTED OUTAGE OF 13 MONTHS. THIS WILL RESULT IN A SUSPENSION OF FLIGHTS. ACTIVATION OF HB 2 & 4 FOR LRB PROCESSING/STORAGE WILL IMPACT ET PROCESSING OR ET PROCESSING AND SRB STACKING WILL INTERRUPT ACTIVATION. ACTIVATION WILL BE REQUIRED TO BE COVERED BY THE INTEGRATED AREA CONTROL SCHEDULE.

PROCESSING CONSTRAINTS INCLUDE THE NEED TO PROCESS THE LRB VERTICALLY AND WILL INCREASE THE NUMBER OF CRANE LIFT OPERATIONS IN THE VAB. PROCESSING IN THE VAB WILL BE COMPLICATED BY THE NUMEROUS CRANE OPERATIONS AND AREA CONTROL SCHEDULES FOR SRB, LRB, ET AND ORBITER PROCESSING AND HAZARDOUS OPERATIONS. THE SURGE/STORAGE CAPACITY WILL BE LIMITED. CONTINGENCY USE OF THE SRB WORK STANDS FURTHER COMPLICATE THE JOINT OCCUPANCY OF VAB HB 4. FUTURE USE OF THE VAB FOR ELEMENT STORAGE (ORBITER, PAYLOAD CANISTER) OR FUTURE PROGRAMS (ALS, SHUTTLE C) WILL BE ELIMINATED.
CONCEPT 1 EVALUATION

- **ACTIVATION** IN VAB WILL IMPACT ON-GOINGOPS

- **PROCESSING** IN VAB COMPLICATED BY NUMEROUS LIFTS/AREA CONTROL/SCHEDULE INTERACTION

- **FUTURE USE** OF VAB LIMITED
CONCLUSION

BY THE IMPLEMENTATION OF CONCEPT 2, WHICH INCLUDES A NEW LRB/ET HORIZONTAL PROCESSING/STORAGE FACILITY AND ACTIVATION OF VAB HB 4 AS LRB INTEGRATION FACILITY MANY OF THE CONSTRAINTS ARE ELIMINATED.

ACTIVATION OF HB 4 WILL ELIMINATE THE NEED TO SUSPEND SCHEDULED FLIGHT TO BE INTEGRATED IN HB 3. CONVERSION OF HB 3 AS A LRB/SRB INTEGRATION FACILITY CAN BE DEFERRED UNTIL SRB LAUNCHES ARE BELOW SEVEN AND CAPABLE OF BEING SUPPORTED BY HB 1.

THE NUMBER OF CRANE/LIFT OPERATIONS TO PROCESS ET/LRB ELEMENTS IS REDUCED. LOCATING THE LRB PROCESSING IN A SEPARATE FACILITY PLACES THE PERSONNEL AND FLIGHT ELEMENTS OUTSIDE THE QUANTITY/DISTANCE INHABITED SAFETY ZONE OF THE VAB.

A NEW PROCESSING FACILITY FOR LRB & ET MINIMIZES AREA CONTROL SCHEDULE IMPACTS FOR THE VAB.
CONCLUSION

IMPLEMENTATION OF CONCEPT 2 WILL:

- MINIMIZE LIFT OPS
- ELIMINATE THE REQUIREMENT OF SUSPEND LAUNCHES
- PROVIDES REMOTE ET/LRB PROCESSING/STORAGE
- MINIMIZE AREA CONTROL, SCHEDULING INTERACTIONS
AGENDA

I. INTRODUCTION

II. STUDY PROGRESS
   A. ACHIEVEMENT SUMMARY
   B. ENGINE PROCESSING STUDY
   C. LRB/ET PROCESSING EVALUATION
   D. SAFETY & ENVIRONMENTAL IMPLICATIONS
   E. GOCM STATUS

III. SUMMARY

Gordon Artley
Pat Scott
Glen Waldrop
Greg DeBlasio
Roger Lee
Stephen Schneider
Gordon Artley
SAFETY/ENVIRONMENTAL IMPLICATIONS

STUDY OBJECTIVES:

- IDENTIFY SAFETY AND ENVIRONMENTAL IMPLICATIONS FOR LRB INTEGRATION INTO CURRENT BASELINE

- ANALYZE SAFETY/ENVIRONMENTAL IMPLICATIONS - GENERIC AND STATION SET UNIQUE

- EVALUATE LRB VS SRB PROCESSING AND IDENTIFY ENHANCEMENTS

- DEVELOP CONCLUSIONS AND RECOMMENDATIONS BASED ON STUDY FINDINGS

- DOCUMENT FINDINGS IN FINAL REPORT
SAFETY/ENVIRONMENTAL IMPLICATIONS

INITIAL PITCH PRESENTED IN JANUARY 1988 ADDRESSED SAFETY/ENVIRONMENTAL IMPLICATIONS OF HYPERGOLS (MMH/N2O4). SUBSEQUENTLY HYPERGOLS WERE DROPPED FROM CONSIDERATION AS PROPELLANTS FOR THE LRB.

SAFETY/ENVIRONMENTAL IMPLICATIONS BEING ADDRESSED IN THE STUDY WERE PRESENTED AT THE FIRST PROGRESS REVIEW PRESENTED IN JULY 1988; UPDATE PRESENTED IN AUGUST 1988 REVIEW.


THIS PRESENTATION WILL ADDRESS THE MAJOR SAFETY AND ENVIRONMENTAL IMPLICATIONS IDENTIFIED IN THE STUDY TO DATE.
SAFETY AND ENVIRONMENTAL IMPLICATIONS

MAJOR ISSUES/STATUS

• EVALUATION OF HYPERGOLS AS PRIMARY LRB PROPELLANTS

• SUMMARY OF PROPELLANT AND SAFETY ISSUES BEING ADDRESSED IN THE BOOSTER STUDY

• DRAFT REPORT SUBMITTED AUG. 1988 FOR INTERNAL LSOC REVIEW

• UPDATES ARE IN PROGRESS. RESUBMISSION OF REPORT FOR FINAL REVIEW DRAFT MID OCT 1988 AND SUBMISSION OF FINAL REPORT MID NOV 1988

• MAJOR SAFETY AND ENVIRONMENTAL IMPLICATIONS ARE SUMMARIZED IN THIS PRESENTATION
OPERATIONAL SAFETY ADVANTAGES OF LRB

1. NO HANDLING OF LIVE PROPELLANTS DURING PROCESSING OPERATIONS
2. DECREASE IN HAZARDOUS CONTROL ZONES IN THE VAB
3. QUANTITY - DISTANCE REQUIREMENTS IN VAB AND RPSF DRASTICALLY REDUCED OR ELIMINATED
4. SRB STACKING OPERATIONS ELIMINATED - REDUCING LIFTING HAZARDS
5. REDUCES OR ELIMINATES WORKING UNDER SUSPENDED LOADS
6. NO LOWERING OF PERSONNEL INTO LIVE SEGMENTS
7. NO APU / HYPER BOOSTER OPERATIONS
MAJOR SAFETY IMPLICATIONS

QUANTITY DISTANCE REQUIREMENTS PREVIOUSLY ESTABLISHED FOR THE VAB, RPSF AND OPF (INTRALINE AND INHABITED BUILDING DISTANCES) DURING SRB AND ORBITER PROCESSING WERE TAKEN INTO CONSIDERATION WHEN SITING LOCATIONS FOR THE LRB/ET PROCESSING FACILITY.

THREE PROPOSED SITES WERE SELECTED AS SHOWN IN THE LRB/ET PROCESSING FACILITY SITING PLAN. SITE #1 (PRIMARY) IS IN THE GENERAL AREA OF THE EXISTING PRESS SITE. SITE #2 IS SOUTH OF THE LOGISTICS FACILITY. BOTH SITES ARE OUTSIDE THE QUANTITY DISTANCE REQUIREMENTS CURRENTLY ESTABLISHED. EVEN THOUGH THESE REQUIREMENTS ARE NOT BEING STRICTLY ENFORCED, WE DECIDED NOT TO INFRINGE ON THESE ZONES BY LOCATING THE FACILITY WITHIN IT. OTHER FACTORS WERE CONSIDERED IN THE SITE SELECTION WHICH WILL BE DISCUSSED IN THE ENVIRONMENTAL IMPLICATIONS.

QUANTITY DISTANCE REQUIREMENTS FOR SITING STORAGE FACILITIES AT THE PAD ARE BASED ON REQUIREMENTS CALLED OUT IN AFR 127-100, EXPLOSIVE SAFETY STANDARD. THE DISTANCES SHOWN ON THE SITE PLAN ARE FOR THE PROJECTED MAXIMUM STORAGE CAPABILITIES FOR SUPPORT OF THE LRB. THE DISTANCES WERE ESTABLISHED FOR LO2 (17,100,000 LBS), RP-1 (1,734,000 LBS), AND LH2 (1,062,000 LBS). SITING CAN BE ACCOMPLISHED WITHOUT IMPLICATING EXISTING FACILITIES.
MAJOR SAFETY IMPLICATIONS

- QUANTITY DISTANCE REQUIREMENTS
  - SITING OF ET/LRB PROCESSING FACILITY
    - PRESS SITE (PRIMARY SITE)
    - N.E. OF VAB
    - SOUTH OF LOGISTICS FACILITY
  - SITING OF STORAGE FACILITIES AT THE PADS
MAJOR SAFETY IMPLICATIONS (CONTINUED)

QUANTITY DISTANCE REQUIREMENTS FOR THE VAB AS SHOWN ON THE ET/LRB PROCESSING FACILITY SITING PLAN AS FOLLOWS:

INTRALINE DISTANCE = 820 FT.

THIS IS THE MINIMUM DISTANCE REQUIRED FOR SEPARATION OF STRUCTURES HOUSING NONEXPLOSIVE OPERATIONS FROM EXPLOSIVE OPERATING BUILDING.

INHABITED BUILDING DISTANCE = 1,320 FT

THIS IS THE MINIMUM ALLOWABLE DISTANCE BETWEEN INHABITED BUILDINGS (STRUCTURES NOT DIRECTLY RELATED TO EXPLOSIVE OPERATIONS WHERE PEOPLE USUALLY ASSEMBLE TO WORK) AND AN EXPLOSIVE LOCATION.

MAJOR SAFETY IMPLICATIONS (CONTINUED)

THE QUANTITY DISTANCES SHOWN ON THE PAD A SITE PLAN FOR LRB PROPELLANTS REPRESENT MAXIMUM STORAGE CAPACITY. THE SMALLER INNER CIRCLE REPRESENTS THE INTRAGROUP/INTRALINE QUANTITY DISTANCE REQUIREMENT AND THE LARGER OUTER CIRCLE REPRESENTS EITHER THE INHABITED BUILDING QUANTITY DISTANCE REQUIREMENT FOR THE LO2 SITE OR THE PROTECTED DISTANCE REQUIREMENT FOR LH2. THE INHABITED BUILDING QUANTITY DISTANCE REQUIREMENT FOR RP-1 FALLS WITHIN THE PROTECTED DISTANCE REQUIREMENT FOR LH2 AND SINCE THEY ARE IN THE SAME COMPATIBILITY GROUP (LIQ-C) IT DOES NOT APPLY. LISTED BELOW ARE THE QUANTITY DISTANCE REQUIREMENTS FOR EXISTING, AS WELL AS, THOSE PROJECTED FOR LRB PROPELLANT REQUIREMENTS, PER AFR 127-100, EXPLOSION SAFETY STANDARD.

<table>
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<tr>
<th></th>
<th>UNPROTECTED DISTANCE</th>
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<tr>
<td>EXISTING LH2 TANK</td>
<td>* 1,800 Ft</td>
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<tr>
<td>ADDITIONAL LH2 TANK</td>
<td>* 1,800 Ft</td>
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<td></td>
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<td>500 Ft</td>
<td>185 Ft</td>
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<tr>
<td></td>
<td></td>
<td>630 Ft</td>
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* NOT SHOWN ON SITE PLAN

NOTE: LH2 IS CLASSIFIED AS A HAZARD GROUP III LIQUID PROPELLANT AND COMPATIBILITY STORAGE GROUP LIQUID C BY AFR 127-100. PROTECTED AND UNPROTECTED DISTANCES APPLY ONLY TO THIS GROUP.

<table>
<thead>
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<th>INTRAGROUP/INTRALINE DISTANCE</th>
<th>INHABITED BUILDING STRUCTURE</th>
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<tr>
<td>RP-1 EXISTING AND PROJECTED</td>
<td>175 Ft</td>
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<tr>
<td>EXISTING LO2 TANK</td>
<td>305 Ft</td>
<td>235 Ft</td>
</tr>
<tr>
<td>ADDITIONAL LO2 TANK</td>
<td>* 350 Ft</td>
<td>* 700 Ft</td>
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* DISTANCES DETERMINED BY COMBINING TOTAL QUANTITIES FOR EXISTING AND ADDITIONAL LO2 AND EXTRAPOLATING FROM DATA IN AFR 127-100.
MAJOR SAFETY IMPLICATIONS (CONTINUED)

RP-1 IS CLASSED AS A COMBUSTIBLE LIQUID BY NFPA FLAMMABLE AND COMBUSTIBLE LIQUIDS CODES, CHAPTER 30, AND THE STORAGE/SERVICING FACILITY MUST MEET DESIGN, CONSTRUCTION, OPERATION AND MONITORING REQUIREMENTS SPECIFICATIONS AS CALLED OUT IN NFPA CODES, UNDERWRITERS LABORATORIES, INC. STANDARDS, AMERICAN PETROLEUM INSTITUTE STANDARDS AND SPECIFICATIONS, AND THE AMERICAN SOCIETY FOR TESTING AND MATERIALS STANDARDS.

RP-1 STORAGE FACILITY EXISTING AT PAD A USED DURING APOLLO PROGRAM. CONDITION OF STORAGE CONTAINERS AND PIPING UNKNOWN. NDE SHOULD BE PERFORMED TO DETERMINE CONDITION OF SYSTEM AND IF IT MEETS CURRENT REQUIREMENTS AS LISTED ABOVE, OTHERWISE NEW FACILITY WILL BE REQUIRED.

RP-1 STORAGE FACILITY WAS REMOVED FROM PAD B AND THEREFORE WILL REQUIRE NEW FACILITY.

A SUGGESTION HAS BEEN MADE TO CONSIDER A CENTRALIZED STORAGE FACILITY TO SERVICE BOTH PADS.

REGARDLESS OF THE SELECTED OPTION, THE REQUIREMENTS FOR CONSTRUCTION MATERIAL, VENTING, LEAK DETECTION, FIRE PROTECTION, VAPOR DETECTION, AND SAFETY HANDLING PRACTICES MUST BE MET.
MAJOR SAFETY IMPLICATIONS (CONT)

- RP-1 STORAGE FACILITY
  - REFURBISHMENT OF PAD A FACILITY OR TOTALLY NEW FACILITY
  - TOTALLY NEW FACILITY REQUIRED AT PAD B
  - SUGGESTION TO CONSIDER NEW CENTRALIZED FACILITY
  - FACILITY OR FACILITIES MUST COMPLY WITH CURRENT SAFETY REQUIREMENTS
MAJOR SAFETY IMPLICATIONS (CONTINUED)

ACCORDING TO GP-1098, THE KSC STS GROUND SAFETY PLAN, THERE ARE 65 CONTROL ZONES ESTABLISHED FOR CURRENT HAZARDOUS OPERATIONS IN THE VAB, 21 OF WHICH COULD IMPACT CONSTRUCTION ACTIVITIES REQUIRED TO MODIFY HIGH BAY 4 FOR LRB PROCESSING.

THOSE SAME CONTROL ZONES WOULD AFFECT LRB PROCESSING IN THE VAB DURING PHASE-IN WHEN SIMULTANEOUS LRB AND SRB PROCESSING OCCUR.

ACCORDING TO GP-1098, THERE ARE 61 CONTROL ZONES ESTABLISHED FOR CURRENT HAZARDOUS OPERATIONS AT THE PADS, MANY OF WHICH COULD IMPACT CONSTRUCTION ACTIVITIES REQUIRED TO MODIFY THE PADS FOR LRB SUPPORT. IN ADDITION, MANY OF THESE SAME CONTROL ZONES WILL IMPACT LRB PROCESSING ACTIVITIES DURING PHASE-IN. HOWEVER, THESE CAN BE MINIMIZED BY ADVANCED PLANNING AND SCHEDULING.

OUR FINAL REPORT EVALUATES THE CONTROL ZONES AT THE VAB AND PADS AND THEIR EFFECTS ON LRB PROCESSING TASK.
MAJOR SAFETY IMPLICATIONS

CONTROL ZONES FOR HAZARDOUS OPERATIONS

VAB:
- CONSTRUCTION ACTIVITIES TO MODIFY HIGH BAY 4
- SIMULTANEOUS LRB AND SRB OPERATIONS DURING LRB PHASE-IN

PADS:
- CONSTRUCTION ACTIVITIES TO MODIFY PADS FOR LRB SUPPORT
- LRB PROCESSING ACTIVITIES DURING PHASE-IN
MAJOR SAFETY IMPLICATION (CONTINUED)

THE CONTROL ZONE SHOWN ON THE VAB FLOOR PLAN IS JUST ONE EXAMPLE OF A CONTROL ZONE ESTABLISHED FOR HAZARDOUS OPERATIONS IN THE VAB. THIS CONTROL ZONE IS ESTABLISHED FOR SRM HOISTING AND STACKING OPERATIONS IN HB 3. FOR THESE OPERATIONS THE ENTIRE TRANSFER AISLE BETWEEN TOWERS A/D AND C/F, HIGH BAYS 3 AND 4, AND TOWERS B, C, F, AND E REQUIRE CLEARING OF ALL NON-ESSENTIAL PERSONNEL.
MAJOR SAFETY IMPLICATIONS (CONTINUED)

SINCE THE LRB/ET PROCESSING FACILITY IS A NEW FACILITY THERE ARE NUMEROUS SAFETY REQUIREMENTS TO CONTEND WITH DURING DESIGN, CONSTRUCTION AND OPERATION PHASES, SUCH AS: (1) FIRE DETECTION/PROTECTION SYSTEMS; (2) CONSTRUCTION TO MEET FIRE RATINGS IN HAZARD CLASSIFIED AREAS; (3) O2 AND ENVIRONMENTAL MONITORING FOR HAZARDOUS VAPORS; (4) VENTILATION SYSTEMS TO MEET INDUSTRIAL HYGIENE REQUIREMENTS; (5) HAZARD/EXPLOSION PROOF ELECTRICAL EQUIPMENT IN HAZARD CLASSIFIED AREAS; (6) LIGHTING TO MEET INDUSTRIAL HYGIENE REQUIREMENTS IN DIFFERENT WORK AREAS. WE PLAN TO USE OMRF LESSONS LEARNED:

DELIVERY OF THE QUANTITIES OF RP-1 REQUIRED TO SUPPORT AN LRB LAUNCH POSES SAFETY, AS WELL AS ENVIRONMENTAL CONCERNS (WHICH WILL BE DISCUSSED LATER). FROM A SAFETY STANDPOINT IT IS RECOMMENDED THAT ALL DELIVERY BE MADE BY RAIL CAR RATHER THAN TANKER TRUCK. THIS REDUCES THE POTENTIAL FOR ACCIDENTS BY CUTTING DOWN ON THE DELIVERY TRAFFIC AND PRESENTS LESS IMPlication ON PAD OPERATIONS.
MAJOR SAFETY IMPLICATIONS (CONT)

- LRB/ET PROCESSING FACILITY
  - MANY SAFETY REQUIREMENTS TO CONTEND WITH DURING DESIGN, CONSTRUCTION AND OPERATION PHASES

- RP-1 DELIVERY TO SITE STORAGE FACILITIES
  - RAIL DELIVERY VS TANKER TRUCK DELIVERY
MAJOR ENVIRONMENTAL IMPLICATIONS

ENVIRONMENTAL REGULATIONS ARE BECOMING INCREASINGLY MORE STRINGENT WHEN APPLIED TO STORAGE OF HAZARDOUS MATERIALS (RP-1) IN STORAGE CONTAINERS. THEY IMPOSE STRICT REQUIREMENTS FOR LEAK DETECTION, NOT ONLY FOR THE STORAGE CONTAINER, BUT THE PIPING AS WELL. SPILL CONTAINMENT REQUIRES CAPABILITY TO CONTAIN THE TOTAL CAPACITY OF THE FUEL STORAGE FACILITY, SUCH AS THE METHOD EMPLOYED AT PAD A BY PUTTING TANKS IN CONCRETE VAULTS. DUE TO THE ENVIRONMENT THE TANKS ARE EXPOSED TO AT THE PADS, PROTECTION FROM BLASTS IS NEEDED. THE PROTECTION PROVIDED FOR THE EXISTING RP-1 TANKS AT PAD A (CONCRETE VAULT COVERED WITH DIRT, WITH CONCRETE PAD ON TOP) SHOULD BE SUFFICIENT. A VAPOR RECOVERY SYSTEM MAY BE REQUIRED.

LOCATING THE LRB/ET PROCESSING FACILITY IN THE GENERAL PROXIMITY OF THE PRESS SITE, AS SHOWN PREVIOUSLY IN THE LRB/ET PROCESSING FACILITY SITE PLAN, MINIMIZES THE ENVIRONMENTAL IMPLICATIONS. IT IS CONVENIENT TO THE BARGE DELIVERY SITE, AS WELL AS THE TOW ROUTE TO THE VAB. THIS WILL ELIMINATE THE NEED TO CONSTRUCT AN EXTENSIVE TOW ROUTE AND ALSO REDUCES THE IMPLICATION OF CONSTRUCTION ACTIVITIES IN WET LANDS.

HANDLING LARGE QUANTITIES OF FUEL POSES A GREATER POTENTIAL FOR GROUND WATER CONTAMINATION DURING DELIVERY, TRANSFER AND SERVICING OPERATIONS. A LARGE SPILL IN THE AREA WOULD BE DIFFICULT TO CLEAN UP DUE TO HIGH WATER TABLE AND THE PERMEABILITY OF THE SOIL. FOR THIS REASON THE OPERATIONS SHOULD OCCUR AS MUCH AS POSSIBLE OVER IMPERVIOUS SURFACES WITH SPILL CONTROL MEASURES. IN ADDITION, MONITORING WELLS WILL BE REQUIRED IN THE VICINITY OF THE STORAGE FACILITY, WHICH ARE NOT IN EXISTENCE AT THIS TIME.
MAJOR ENVIRONMENTAL IMPACTS

• RP-1 STORAGE FACILITY
  - LEAK DETECTION REQUIREMENTS
  - SPILL CONTAINMENT REQUIREMENTS
  - CONSTRUCTION REQUIREMENTS

• ET/LRB PROCESSING FACILITY
  - SELECTED LOCATION WILL DETERMINE ENVIRONMENTAL IMPACT

• GROUND WATER CONTAMINATION
  - POTENTIAL FOR GROUND WATER CONTAMINATION
  - MONITORING WELLS REQUIRED
MAJOR ENVIRONMENTAL IMPLICATIONS (CONTINUED)

THE MOST SIGNIFICANT ENVIRONMENTAL IMPLICATION IMPOSED ON ENDANGERED SPECIES IS THAT POSED BY THE INCREASED BARGE TRAFFIC FOR LRB DELIVERY ON THE MANATEE. IT IS ESTIMATED THAT 10% OF THE MANATEE POPULATION LIVE IN THE WATER SURROUNDING KENNEDY SPACE CENTER. THIS IMPLICATION CAN BE MINIMIZED BY PLACING GUARDS AROUNDS THE PROPELLER BLADES ON THE BARGE MOTOR AND POSTING MANATEE OBSERVERS ON BOARD. THE ET BARGE CURRENTLY USES THIS APPROACH.

THE MOST SIGNIFICANT IMPROVEMENT FROM AN ENVIRONMENTAL QUALITY STANDPOINT OF LRB OVER SRB IS IN THE AREA OF AIR QUALITY. DUE TO IGNITION BY-PRODUCTS AIR EMISSIONS WILL BE LESS HAZARDOUS FROM THE LRB THAN THOSE OF THE SRB. IN ADDITION, THE PROBLEM OF THE HCL CLOUD FORMED BY THE SRB IGNITION WILL BE ELIMINATED.
MAJOR ENVIRONMENTAL IMPACTS (CONT)

- ENVIRONMENTAL IMPACTS ON ENDANGERED SPECIES
  - IMPACT ON THE MANATEE

- ADVANTAGES OF LRB OVER SRB
  - IMPROVEMENT IN AIR QUALITY
  - ELIMINATION OF HCL CLOUD
AGENDA

I. INTRODUCTION

Gordon Artley

II. STUDY PROGRESS

A. ACHIEVEMENT SUMMARY
Pat Scott

B. ENGINE PROCESSING STUDY
Glen Waldrop

C. LRB/ET PROCESSING EVALUATION
Greg DeBlasio

D. SAFETY & ENVIRONMENTAL IMPLICATIONS
Roger Lee

E. GOCM STATUS
Stephen Schneider

III. SUMMARY

Gordon Artley
GOCM IS A PARAMETRIC MODEL

THE GROUND OPERATIONS COST MODEL, AS A PARAMETRIC MODEL, USES ONLY VERY BASIC PARAMETERS, SUCH AS HEIGHT, AREA, VOLUME OR TYPE. BASED ON THESE FUNDAMENTAL INPUTS, THE MODEL GENERATES A VARIETY OF COST ESTIMATES. THESE ESTIMATES ARE DESIGNED TO PROVIDE DEPENDABLE AND CONSISTENT ROUGH ORDER OF MAGNITUDE (ROM) DOLLAR FORECASTS. THIS IS AN IDEAL MANAGEMENT TOOL FOR "WHAT IF" OR SENSITIVITY STUDIES.

THE LIQUID ROCKET BOOSTER INTEGRATION STUDY IS IN THE PROCESS OF EVALUATING HISTORICAL COST PERFORMANCE AND CORRELATING THIS DATA WITH THE GROUND OPERATIONS COST MODEL OUTPUTS. THIS ON-GOING ANALYSIS IS VERIFYING THE MODEL'S ORIGINAL CERS AND GENERATING THE INFORMATION NECESSARY TO REFINE THESE RELATIONSHIPS IN THE FUTURE. THIS HEURISTIC PROCESS WILL CONFIRM THE RELIABILITY OF THE MODEL'S FINANCIAL ESTIMATES.
E. GOCM STATUS

1. Flow Chart
2. Enhanced GOCM Software
4. "Actuals" Evaluation
1. Developed by NASA
2. Parametrically generates STS/equivalent
ground processing costs using fundamental
inputs, e.g., booster size, generic type
3. LSOC Task 9
expand and enhance GOCM through the
incorporation of lessons learned
4. Task 9 Study Products
   a. User's manual
   b. Recommendations
   c. Instructions
   d. Software
TASK 9 OVERVIEW

LSOC COST MODEL TASK CONTINUED TO BE ON SCHEDULE. COST ESTIMATING RELATIONSHIP (CER) DATA HAS BEEN COLLECTED AND IS UNDER ACTIVE EVALUATION. THIS HAS ALLOWED THE REALISM AND ACCURACY EVALUATION OF CERS IN THE ORIGINAL MODEL TO BEGIN AS PLANNED. THESE ACCOMPLISHMENTS HAVE ALLOWED US TO INITIATE PRELIMINARY CER/MODEL MODIFICATIONS AND IDENTIFY PRELIMINARY SYSTEM/CER INADEQUACIES.

THE USER'S MANUAL CONTINUED TO MOVE TOWARDS COMPLETION AS ORIGINALLY PLANNED. THE TECHNICAL INSTRUCTIONS MANUAL IS ALSO ON TARGET. THE PRELIMINARY SET OF RECOMMENDATIONS, DISCUSSED LAST PERIOD, ARE BEING REFINED THIS PERIOD.
ENHANCED GOCM SOFTWARE

THE CERS OF THE ORIGINAL MODEL HAVE BEEN RETAINED. ALTHOUGH THE ORIGINAL CONCEPT IS THE SAME, IT HAS BEEN THOROUGHLY "REPACKAGED" WITH A NUMBER OF ENHANCEMENTS.

THESE ENHANCEMENTS HAD TWO GOALS. THE FIRST WAS TO ACHIEVE A HIGHER DEGREE OF USER FRIENDLINESS. THE SECOND WAS TO MAKE THE MODEL "EXPANSION READY." BOTH THESE GOALS SHOULD ALLOW INEXPERIENCED USERS TO UTILIZE GOCM AND IMPLEMENT MINOR MODIFICATIONS. ENHANCING USER FRIENDLINESS MAKES GOCM ACCESSIBLE TO A GREATER USER AUDIENCE, THEREBY EXPANDING ITS GENERAL UTILITY. THIS USER FRIENDLINESS ENCOMPASSES HELP SCREENS, USER PROMPTS AND PROMPTED MENUS.

GOCM WAS MADE EXPANSION READY IN ORDER TO READILY INCORPORATE FUTURE CER MODIFICATIONS AND ADDITIONS. AS ADDITIONAL CERS BECOME AVAILABLE, THEY CAN BE DIRECTLY INSERTED INTO AREAS ALREADY PROGRAMMED INTO THE SPREADSHEET. THIS MEANS THAT ADDITIONAL FORMULAS CAN BE EASILY INCORPORATED INTO THE SPREADSHEET WITHOUT RESTRUCTURING THE MODEL.
ENHANCED VERSION OF GOCM NEAR COMPLETION

1. Preserved original CERs
2. Enhanced user friendliness
3. GOCM is expansion ready

Result: Inexperienced users can now use GOCM effectively
GOCM USER'S MANUAL

THE GOCM USER'S MANUAL FOLLOWS THE MODULAR DESIGN OF THE GOCM PROGRAM. EACH PROGRAM MODULE HAS ITS OWN COUNTERPART IN THE USERS MANUAL. AN OUTLINE STYLE (WITH SCREEN FACSIMILES) ALLOWS EASY ACCESS TO FULL EXPLANATIONS. THIS SUPPLEMENTS THE EXTENSIVE ON-SCREEN USER HELP. THE LESSON LEARNED FROM INEXPERIENCED-USER FEEDBACK, OBTAINED DURING CLINICAL TRIALS OF MANUAL/SOFTWARE, ARE BEING INCORPORATED INTO THE MANUAL ON A CONTINUING BASIS.
DRAFT GOCM USER'S MANUAL NEAR COMPLETION

1. Follows program modular design

2. User friendly
   a. Menus fully documented
   b. Grammatik III evaluation

3. Complete manual testing
   a. Inexperienced subjects used
   b. Lessons learned incorporated
"ACTUALS" EVALUATION

GOCM MODELS KSC AND THE GROUND PROCESSING ACTIVITY IN A REALISTIC MANNER. WE ARE CURRENTLY PERFORMING AN ASSESSMENT OF ACCURACY. THIS ASSESSMENT CONCENTRATES ON TWO COST CATEGORIES: THE PROCESSING SHIFTS/MANPOWER AND COST OF FACILITIES.

THE WORK BREAKDOWN STRUCTURE ACCOUNTING RECORDS FOR JAN 85 - DEC 85 WERE EVALUATED BY FLIGHT ELEMENT AND STATION SET. THIS WILL ALLOW US TO EFFECTIVELY EVALUATE THE GOCM PROCESSING CERS AND FACILITY O&M CERS.

USING HISTORICAL DATA, WE DERIVED A FORM OF LEARNING CURVE FOR THE GROUND PROCESSING ACTIVITY. THIS GROUND PROCESSING CURVE WILL BE USED IN THE GOCM MODEL. FURTHER DETAILS AND BACKUP WILL BE PROVIDED IN THE FINAL REPORT.
"ACTUALS" EVALUATION IN PROGRESS

1. SPC WBS manhours for Jan 85-Dec 85 collected and sorted by:
   a. Flight element
   b. Work station

2. We can now more accurately
   a. assess GOCM processing CERs
   b. verify facility O&M CERs

3. Learning curve assessment with empirical data now in progress
GROUND OPERATIONS COST MODEL
Next Period's Goals

1. Totally complete a thorough evaluation of the original and enhanced GOCM
2. Deliver a commercial quality software product usable by inexperienced personnel
3. Deliver a complete and understandable User's Manual
4. Deliver a technically accurate and detailed set of program instructions
5. Deliver a practical and useable set of future recommendations
6. Present a Final Oral Report
AGENDA

I. INTRODUCTION

II. STUDY PROGRESS
A. ACHIEVEMENT SUMMARY
B. ENGINE PROCESSING STUDY
C. LRB/ET PROCESSING EVALUATION
D. SAFETY & ENVIRONMENTAL IMPLICATIONS
E. GOCM STATUS

III. SUMMARY

Gordon Artley
Pat Scott
Glen Waldrop
Greg DeBlasio
Roger Lee
Stephen Schneider
Gordon Artley
# LIQUID ROCKET BOOSTER INTEGRATION
## SECOND PROGRESS REVIEW

### LRB INTEGRATION SCHEDULE - REVISED SEPT. 6, 1988

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### PROJECT STUDY TASKS
1. BASELINE
2. LRB REQUIREMENTS
3. LRB SCENARIOS
4. IMPACT ANALYSIS
5. DESIGN RECOMMENDATIONS
6. LAUNCH SITE PLANS
7. FOLLOW-ON RECOMMENDATIONS (OPTIONS/PROPOSALS)
8. FINAL REPORT
9. GROUND OPERATIONS COST MODEL

---

**9/6/88** % COMPLETE
PRIME LRB IMPACTS

- LRB INTEGRATION DISRUPTIVE TO ONGOING OPERATIONS

- ACHIEVEMENT OF 1990's BASELINE MANIFEST REQUIRES IMPROVED AUTOMATED MANAGEMENT INFORMATION SYSTEMS AND PROCESS CONTROL

- NEW MOBILE LAUNCHER DESIGN

- ENGINE EXHAUST TRENCH/DEFLECTOR TO ACCOMMODATE BOTH LRB AND SRB

- PAD AND HIBAY 3 DESIGN FOR BOTH LRB AND SRB
LSOC PARTICIPATION IN LRB WORKING GROUP

ISSUES:

- WORK PRIME LRB IMPACTS TO KSC
- REFINEMENT OF THE LRB DESIGN
- DEVELOPMENT OF IGNITION AND LAUNCH SEQUENCE
- APPLICATION OF LRB CONCEPTS TO ALTERNATE VEHICLES
OBJECTIVES FOR FINAL PERIOD

THE FINAL REPORT WILL RESPOND TO ALL THE STUDY OBJECTIVES AND PROVIDE THE FOLLOWING PLANS AND PRODUCTS:

1. LRB GROUND OPERATIONS PLAN
2. LRB PROCESSING TIMELINES
3. LRB FACILITY REQUIREMENTS AND CONCEPTS FOR NEW FACILITIES
4. LRB LAUNCH SUPPORT EQUIPMENT DEFINITION
5. LRB GROUND SUPPORT EQUIPMENT DEFINITION
6. LRB MANPOWER
7. COST ESTIMATES INCLUDING TRANSITION
8. POTENTIAL IMPACTS TO ON-GOING LAUNCH SITE ACTIVITY
9. PRELIMINARY TRANSITION PLAN
10. POTENTIAL ENVIRONMENTAL AND SAFETY IMPLICATIONS
11. PROPELLANT ACQUISITION STORAGE AND HANDLING REQUIREMENTS
12. RECOMMENDED CHANGES TO LRB DESIGN FOR OPERATIONAL EFFICIENCY
13. A DETAILED USERS' MANUAL FOR GOCM OPERATION
14. INSTRUCTIONS FOR UPDATING/MODIFYING THE GOCM PROGRAM
15. ALL SOFTWARE DEVELOPED
16. RECOMMENDATIONS FOR FOLLOW-ON STUDY ACTIVITY
17. VLS ASSESSMENT
18. ENGINE SHOP REQUIREMENTS
19. LRB/ET HORIZONTAL PROCESSING FACILITY
FINAL PERIOD PLANS

- PREPARE THE FINAL LRBI ORAL PRESENTATIONS

- PREPARATION OF THE FINAL REPORT
VOLUME IV

SECTION 7

FINAL PROGRESS REVIEW

November, 1988
LIQUID ROCKET BOOSTER INTEGRATION

AGENDA

I. INTRODUCTION

II. LRBI RESULTS
   BASELINE / LAUNCH SITE SCENARIO
   FACILITIES AND GROUND SYSTEMS
   IMPLEMENTATION
   COST

III. SUMMARY

Gordon Artley
Pat Scott
Greg DeBlasio
Gordon Artley
Jerry Lefebvre
Gordon Artley
PURPOSE: ASSESS THE FEASIBILITY OF REPLACING SOLID ROCKET BOOSTERS WITH LIQUID ROCKET BOOSTERS

APPROACH: DEFINE OPTIMUM PUMP-FED AND PRESSURE-FED BOOSTERS AND THEIR IMPLEMENTATION PLANS

GOALS: INCREASE SAFETY AND RELIABILITY WITH MINIMUM IMPACT TO STS INTEGRATION AND PROVIDE INCREASED PERFORMANCE
# KSC - LRBI Study Objectives

The study methodology used to achieve the LRBI objectives utilized study tasks to create end products.

## Study Products

<table>
<thead>
<tr>
<th>Study Products</th>
<th>Tasks</th>
<th>SRB Baseline</th>
<th>LRBI Requirements</th>
<th>LRBI Scenarios</th>
<th>Impacts / Analysis</th>
<th>LRBI Design Recommendation</th>
<th>Launch Site Plan</th>
<th>Follow-on Recommendation</th>
<th>Final Report</th>
<th>Ground Ops Cost Model</th>
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<td>1. LRBI Ground Ops Plan</td>
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KSC - LRBI STUDY OBJECTIVES

- DEFINE FACILITY IMPACTS
- DEVELOP OPERATIONAL SCENARIOS
- PROVIDE BOOSTER DESIGN RECOMMENDATIONS
- PROMOTE OPERATIONAL EFFICIENT LRB SYSTEMS
- PERFORM COST ASSESSMENT UTILIZING GOCM
- GENERATE PRELIMINARY PROCESSING LSE-GSE REQUIREMENTS
- CREATE LAUNCH SITE SUPPORT PLAN
THE LRB NASA / CONTRACTOR TEAM USED THE INTERCENTER WORKING GROUP AS THE CENTRAL COMMUNICATIONS POINT. THIS ALLOWED THE FULL AND EFFECTIVE EXCHANGE OF LRB REQUIREMENTS / LRBI IMPACTS AND RECOMMENDATIONS.

GORDON ARTLEY
STEVEN BURNS
DEBORAH CANNADAY
GREGORY DEBLASIO
H. GENE ELLIS (PAN AM)
KEITH HUMPHRYES (PAN AM)
DR. WILLIAM HUSEIONICA (PAN AM)
ROBERT KELLAR (PAN AM)
KENNETH LATHROP (PAN AM)
ROGER LEE
GERALD LFEVBRE
JANET MOODY
PEERI PAPPAS, P.E.
STEPHEN SCHNEIDER
LELAND P. SCOTT
JAMES TEFFT
GLEN WALDROP (ROCKETDYNE)

LOCKHEED STUDY MANAGER
GROUND OPERATIONS PLAN/FACILITY ACTIVATION
TECHNICAL EDITOR
FACILITY, PROPPELLANTS, GSE/LSE REQUIREMENTS
MANPOWER ANALYSIS
OPERATIONS ANALYSIS/LAUNCH SITE PLAN
PROCESSING ANALYSIS
IMPLEMENTATION PLAN
TRANSITION PLAN/MANPOWER
SAFETY AND ENVIRONMENTAL IMPLICATIONS
COST MODELING/ANALYSIS
GRAPHICS COMPILATION
GROUND OPERATIONS COST MODEL
GROUND OPERATIONS COST MODEL
LOCKHEED DEPUTY STUDY MANAGER
VLS ASSESSMENTS
ENGINE SERVICING/OPERATIONS
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<td>7. FOLLOW-ON RECOMMENDATIONS (OPTIONS/PROPOSALS)</td>
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<td>8. FINAL REPORT</td>
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**KSC MSFC HQ**
## LRB STUDY FINDINGS

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<tr>
<td><strong>FACILITY IMPACTS</strong></td>
<td>MODIFY VAB HB-3 AND HB-4, PADS A AND B PROVIDE 2 NEW MLPs, AND ET/LRB HPF REACTIVATE MLP #2 PARKSITE</td>
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<tr>
<td><strong>OPERATIONAL SCENARIOS</strong></td>
<td>ACTIVATION PHASE, SRB/LRB PHASE SUSTAINED LRB LAUNCH OPERATIONS PHASE</td>
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<td><strong>BOOSTER RECOMMENDATIONS</strong></td>
<td>60% OF RECOMMENDATIONS INCORPORATED</td>
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<td><strong>EFFICIENT LRB SYSTEMS</strong></td>
<td>ACCOMMODATED THE LRB PROGRAM LIFE CYCLE COST GOALS</td>
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<td><strong>COST ASSESSMENT</strong></td>
<td>ENHANCE GOCM AND BOTTOM-UP ASSESSMENT</td>
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<td>VOLUME III, SECTION 4 AND 5 FINAL REPORT</td>
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<td><strong>LAUNCH SITE PLAN</strong></td>
<td>IMPLEMENTATION PLAN/MANPOWER/IPOP</td>
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LIQUID ROCKET BOOSTER INTEGRATION

AGENDA

I. INTRODUCTION

II. LRBI RESULTS
   BASELINE / LAUNCH SITE SCENARIO

FACILITIES AND GROUND SYSTEMS

IMPLEMENTATION

COST

III. SUMMARY

Gordon Artley

Pat Scott

Greg DeBlasio

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LRBI BASELINE AND LAUNCH SITE SCENARIO

- MSFC PHASE A STUDY RESULTS
- SELECTED LRB CONFIGURATIONS
- MMC
- GDSS
- LIQUID ENGINE DESIGNS
- LAUNCH SITE LRB DESIGN RECOMMENDATIONS
- GROUND SYSTEM DESIGN ISSUES
MSFC PHASE-A STUDY FINDINGS

0 GDSS AND MMC STUDIES HAVE RESULTED IN THESE BASIC FINDINGS.

0 A SELECTION OF PRELIMINARY LRB DESIGNS FOR BOTH PUMP AND PRESSURE-FED SYSTEMS HAS BEEN MADE.

0 THE KSC "MODERATE" IMPACTS ARE ADDRESSED IN THIS PRESENTATION
SUMMARY OF MSFC PHASE-A LRB FINDINGS

MSFC LRB STUDY FINDINGS

- LRB SHOULD BE EXPENDABLE BOOSTER
- ALL CONFIGURATIONS ARE 4-ENGINED
- NEW LOW-COST ENGINE DEVELOPMENT IS REQUIRED
- LOX/RP-1 IS FAVORED PROPELLANT FOR STS
- LOX / LH2 PUMP-FED IS PREFERRED FOR ALTERNATE APPLICATIONS
- BOTH PUMP AND PRESSURE-FED OPTIONS ARE VIABLE (PRESSURE-FED REQUIRES TECHNOLOGY DEVELOPMENTS)
- ALL SELECTED CONFIGURATIONS CAN BE FLOWN WITHIN CURRENT STS CONSTRAINTS
- LRB WILL IMPACT KSC "MODERATELY"
  — BOOSTER DIAMETERS (13.9 TO 18.0 FEET)
  — BOOSTER LENGTHS (147 TO 197 FEET)
  — ET / ORBITER INTERFACES MAINTAINED
  — LIFT-OFF UMBILICALS BASELINED
LRB SELECTED CONFIGURATIONS

(MARTIN MARIETTA)

PUMP-FED CONFIGURATION IS SHOWN HERE. DUAL 17-INCH FEED LINES ROUTE THE LOX AROUND THE RP-TANK. FORWARD THRUST ATTACH POINT IS LOCATED IN LRB FORWARD SKIRT AREA. AFT ATTACH IS IN MID-TANK AREA WHERE LOWER TRANSVERSE LOADS ARE DISTRIBUTED THROUGH A DEEP RING STIFFENER WITHIN THE TANK. DIAMETER AND LENGTH DIMENSIONS ARE CLOSEST TO SRB.
## MMC PUMP-FED LO2/RP-1 CONFIGURATION

### VEHICLE DIMENSIONS
- LENGTH (IN) 1,810.7
- DIAMETER (OD-IN) 183.0
- ENGINE EXIT AREA (IN²) 7,359

### PROPELLANT VOLUMES (FT³)
- LO2 10,769
- RP-1 5,798
- FEEDLINES 245

### WEIGHT (LB) INCLUDES 10% CONTINGENCY
- STRUCTURE 77,840
- PROPULSION SYSTEM 34,820
- OTHER SUBSYSTEMS 11,060

<table>
<thead>
<tr>
<th>DRY WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>123,720</td>
</tr>
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</table>

USABLE IMPULSE PROPELLANT
- LO2 701,302
- RP-1 268,698
- RESIDUALS GASES AND LIQUIDS 5,335

<table>
<thead>
<tr>
<th>PROPELLANTS/GASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>975,335</td>
</tr>
</tbody>
</table>

GLOW (GROSS LIFTOFF WEIGHT) 1,099,055

10% < SRB

Lockheed
Space Operations Company
A-5A
LRB SELECTED CONFIGURATIONS

(MARTIN MARIETTA)

PRESSURE-FED CONFIGURATION IS SIGNIFICANTLY LARGER. TANK WALL THICKNESSES ARE APPROXIMATELY 1-INCH. ENGINE CHAMBER PRESSURES REQUIRE HIGH TANK PRESSURES AND A PRESSURIZATION SYSTEM OF 3000 - 4000 psi. HIGHER PROPELLANT LOADING INCREASES GROSS LIFT OFF WEIGHT TO 1.3 M POUNDS WHICH IS HEAVIER THAN CURRENT SPB. HIGHER ENGINE THRUST IS REQUIRED (APPROXIMATELY 750K EACH.)
MMC PRESSURE-FED LO2/RP-1 CONFIGURATION

VEHICLE DIMENSIONS
- LENGTH (IN) 1,952.0
- DIAMETER (OD-IN) 194.0
- ENGINE EXIT AREA (IN²) 9,365

PROPELLANT VOLUMES (FT³)
- LO2 12,012
- RP-1 6,328
- FEEDLINES 214

WEIGHT (LB) INCLUDES 10% CONTINGENCY
- STRUCTURE 166,760
- PROPULSION SYSTEM 44,030
- OTHER SUBSYSTEMS 10,730

| DRY WEIGHT | 221,520 |

<table>
<thead>
<tr>
<th>USABLE IMPULSE PROPELLANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LO2</td>
</tr>
<tr>
<td>RP-1</td>
</tr>
</tbody>
</table>

| RESIDUALS GASES AND LIQUIDS | 5,910 |
| HELIUM-PRESSURE SYSTEM | 11,790 |
| PROPELLANT-PRESSURE SYSTEM | 22,560 |

| PROPELLANTS/SYSTEMS | 1,115,260 |

GLOW (GROSS LIFTOFF WEIGHT) | 1,336,780

7% SRB

Lockheed
Space Operations Company
LRB SELECTED CONFIGURATIONS

(GENERAL DYNAMICS)

PUMP-FED AND PRESSURE-FED LOX/RP1 CONFIGURATIONS ARE SIZED AS SHOWN. PUMP-FED SIZING IS CLOSEST TO SRB DIMENSIONS. PRESSURE-FED IS THE LARGEST AND USES CENTERED LOX FEED LINE THROUGH LOWER FUEL TANK. LENGTH OF PRESSURE-FED IS EXTREME.

THE LOX/LH₂ CONFIGURATION HAS BEEN SELECTED AND IS THE TARGET OF SOME RESIZING STUDIES. SHORTENED LENGTH ALLOWS CLEARANCE FOR ET GOX VENT ARM AT PAD, WHILE RESULTING DIAMETER GROWS TO NEAR 18 FT.

STUDIES ASSOCIATED WITH LOX/CH₄ SPLIT EXPANDER HAVE SHOWN NO SIGNIFICANT ADVANTAGES AND THIS CONFIGURATION HAS BEEN DELETED. HOWEVER, THE ENGINE DESIGN IS BEING EVALUATED AS AN OPTION FOR THE LOX/LH₂ CONFIGURATION.
# GDSS SELECTED LRB CONFIGURATIONS

**GENERAL DYNAMICS**  
*Space Systems Division*

<table>
<thead>
<tr>
<th>DATA (ONE BOOSTER)</th>
<th>SOLID ROCKET BOOSTER</th>
<th>LO2/RP-1 PUMP-FED</th>
<th>LO2/LH2 PUMP-FED</th>
<th>LO2/RP-1 PRESS-FED</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRY WEIGHT (K lbs)</td>
<td>146</td>
<td>104</td>
<td>131</td>
<td>216</td>
</tr>
<tr>
<td>STRUCTURE (K lbs)</td>
<td>-</td>
<td>46.7</td>
<td>75.6</td>
<td>127</td>
</tr>
<tr>
<td>LRB GLOW (K lbs)</td>
<td>1,250</td>
<td>1,032</td>
<td>775</td>
<td>1,602</td>
</tr>
<tr>
<td>THRUST PER ENGINE (sea level)(K lbs)(nominal)</td>
<td>2,912</td>
<td>546</td>
<td>481</td>
<td>850</td>
</tr>
<tr>
<td>INITIAL T/W</td>
<td>1.5</td>
<td>1.37</td>
<td>1.34</td>
<td>1.54</td>
</tr>
<tr>
<td>BECO (sec)</td>
<td>120</td>
<td>123</td>
<td>126</td>
<td>119</td>
</tr>
</tbody>
</table>

* ALTERNATE: SPLIT EXPANDER CYCLE
DOWNSLCT CRITERIA

(GENERAL DYNAMICS)

GD's DOWNSLCT RESULTS INDICATE THE ATTENTION GIVEN TO KSC LAUNCH SITE INTEGRATION AS A PROMINENT CRITERIA (NOTE THE HIGHLIGHTED AREAS).
DOWNSELECT RESULTS

CRITERIA
SAFETY
ENVIRONMENT
RELIABILITY
SIMPPLICITY
INTEGRATION
KSC
STS
PERFORMANCE
COST
RISK

DISCRIMINATORS
LOWEST IMPACT
TO KSC
LOW
DEVELOPMENT
RISK
NO COMMON FUEL,
ENGINE TO ALS
CONTINUE
TO
REFINE
- SIZE
- COST

ALS
COMMON
- FUEL
- ENGINES
- TEST &
DEVELOPMENT
STS
SHUTTLE
"C"
STAND
ALONE

LO2/LH2
PUMP-FED
LOW DEVELPOMMENT
RISK
POTENTIAL COST
SPLIT WITH ALS

DELETED
LO2/CH4
SPLIT EXPANDER
LESS FAMILIAR
WITH FUEL
SAFETY
CONCERNS
NO SIGNIFICANT
- COST
- PERFORMANCE
BENEFITS
DEVELOPMENT
RISK
SPLIT EXPANDER
FEATURES
- LOW COST
- ALS OPTION

RP-1
PUMP-FED

LO2/LH2
PUMP-FED
ESTABLISHED
SAFETY
PROCEDURES

POTENTIAL LOW
COST
HIGH
DEVELOPMENT
RISK DUE TO
TECHNOLOGY
REQUIREMENTS

CONTINUE
OPTIMIZATION
- SYSTEM
- COST
TEST-BED
ACTIVITY

PRESSURE-FED
LRB SELECTED CONFIGURATIONS

(GENERAL DYNAMICS)

LOX/LH₂ CONFIGURATION Incorporates on-board 4-inch GH₂ vent line to route vented gases through lift-off umbilical, avoiding the need for new pad vent arm.
LRB PROPOSED ENGINE POSITIONS

0 ALL GD CONFIGURATIONS (EXCEPT PRESSURE-FED) HAVE ENGINES POSITIONED AT 45-DEGREES TO THE MAJOR VEHICLE AXES ("X" PATTERN). THIS FACILITATES GIMBAL ACTUATORS ALONG THE PRIME PITCH AND YAW VEHICLE AXES, BUT REQUIRES A BRIDGE ACROSS THE BOOSTER FLAME HOLE TO SUPPORT THE NORTH HOLDDOWN. THIS CONFIGURATION CONCENTRATES COMPLETE PRE-RELEASE TWANG LOADS ON ONLY TWO PAIRS OF HOLDDOWN POSTS.

0 ALL MMC CONFIGURATIONS HAVE ENGINES POSITIONED ALONG OR PARALLEL TO THE MAJOR VEHICLE AXES ("+" PATTERN). THIS FEATURE PERMITS THE USE OF THE SAME HAUNCH/HOLDDOWN LOCATIONS CURRENTLY IN USE ALONG THE SIDES OF THE FLAME HOLES, BUT MOVES OUTERMOST ENGINE OUTSIDE THE EDGE OF FLAME TRENCH - COMPLICATING FLAME SIDE DEFLECTOR DESIGN.

0 GD PRESSURE-FED LOX/RP-1 HAS ENGINES POSITIONED IN THE "+" PATTERN (SAME AS MMC CONFIGURATIONS).

0 ENGINE POSITION TRADE STUDIES SHOULD BE ANALYZED IN MORE DETAIL TO ESTABLISH BEST DESIGN APPROACH.
• PUMP-FED

• PRESSURE-FED

• SPLIT EXPANDER

• LRB ENGINE PROCESSING STUDY
  BY ROCKETDYNE
  - ENGINE SHOP/GSE/HANDLING
  - PRE-LAUNCH AND LAUNCH
    PROCEDURES, MANPOWER
    AND SCHEDULE
# LRB Pump-Fed Engine

**LO2/RP-1**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NPL</th>
<th>EPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrust, S.L. klbs</td>
<td>513</td>
<td>685</td>
</tr>
<tr>
<td>Thrust, Vac. kbs</td>
<td>623</td>
<td>788</td>
</tr>
<tr>
<td>ISP, S.L. sec</td>
<td>265</td>
<td>277</td>
</tr>
<tr>
<td>ISP, Vac. sec</td>
<td>322</td>
<td>318</td>
</tr>
<tr>
<td>Mixture Ratio</td>
<td>2.6</td>
<td>2.5</td>
</tr>
<tr>
<td>Total Flow Rate, lb/sec</td>
<td>1933</td>
<td>2473</td>
</tr>
<tr>
<td>Chamber Pressure, Psia</td>
<td>1033</td>
<td>1300</td>
</tr>
<tr>
<td>Exit Pressure, Psia</td>
<td>5.9</td>
<td>7.7</td>
</tr>
<tr>
<td>Expansion Ratio</td>
<td></td>
<td>21.2</td>
</tr>
<tr>
<td>Nozzle Type</td>
<td></td>
<td>Carbon-Carbon</td>
</tr>
<tr>
<td>Weight, Dry, lbs</td>
<td></td>
<td>6807</td>
</tr>
<tr>
<td>Engine Cycle</td>
<td></td>
<td>Gas Gen</td>
</tr>
<tr>
<td>Propellants</td>
<td></td>
<td>LO2/RP1</td>
</tr>
<tr>
<td>Gimbal Type</td>
<td></td>
<td>Head End</td>
</tr>
<tr>
<td>Gimbal Angle</td>
<td></td>
<td>±6°</td>
</tr>
<tr>
<td>Throttle Range</td>
<td></td>
<td>65 - 100%</td>
</tr>
</tbody>
</table>
# LRB Pressure Fed Engine

**LO2/RP-1**

<table>
<thead>
<tr>
<th></th>
<th>NPL</th>
<th>FPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrust, S.L. kibs</td>
<td>562</td>
<td>750</td>
</tr>
<tr>
<td>Thrust, Vac kibs</td>
<td>700</td>
<td>887</td>
</tr>
<tr>
<td>ISP, S.L. sec</td>
<td>257</td>
<td>271</td>
</tr>
<tr>
<td>ISP, Vac, sec</td>
<td>321</td>
<td>321</td>
</tr>
<tr>
<td>Mixture Ratio</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Total Flow Rate, lb/sec</td>
<td>2185</td>
<td>2766</td>
</tr>
<tr>
<td>Chamber Pressure, Psia</td>
<td>630</td>
<td>800</td>
</tr>
<tr>
<td>Exit Pressure, Psia</td>
<td>5.5</td>
<td>6.9</td>
</tr>
<tr>
<td>Expansion Ratio</td>
<td></td>
<td>15.4</td>
</tr>
<tr>
<td>Chamber Type</td>
<td></td>
<td>Ablative</td>
</tr>
<tr>
<td>Nozzle Type</td>
<td></td>
<td>Ablative</td>
</tr>
<tr>
<td>Weight, Dry, lbs</td>
<td></td>
<td>4500</td>
</tr>
<tr>
<td>Propellants</td>
<td></td>
<td>LO2/RP1</td>
</tr>
<tr>
<td>Gimbal Angle</td>
<td></td>
<td>±6°</td>
</tr>
<tr>
<td>Gimbal Type</td>
<td></td>
<td>Head End</td>
</tr>
<tr>
<td>Throttle Range</td>
<td></td>
<td>Flex Seal (Optional)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>65 - 100%</td>
</tr>
</tbody>
</table>

**Diagram**

- Oxidizer Valve
- Fuel Valve
- Flex Seal
- Combustion Chamber
- Nozzle

**Dimensions**

- 170"
- 109.2"
LO2/LH2 PUMP-FED ENGINES FOR LRB

**BASELINE**
- Engine Cycle
- Thrust, vac: EPL
- Weight
- Isp, s/vac
- Mixture Ratio
- Area Ratio
- Pe, EPL
- Throttling Capability
- Engine Control
- Min Inlet Pressure
- POGO Suppression
- Bleed Systems
- Boost Pumps
- Engine Reliability

<table>
<thead>
<tr>
<th>LO2/LH2 Gas Generator</th>
<th>LO2/LH2 Split Expander</th>
</tr>
</thead>
<tbody>
<tr>
<td>612 kib</td>
<td>629 kib</td>
</tr>
<tr>
<td>6,737 lb</td>
<td>5,089 lb</td>
</tr>
<tr>
<td>374.1/426.3 sec</td>
<td>352.7/418.5 sec</td>
</tr>
<tr>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>40.1</td>
<td>16.2</td>
</tr>
<tr>
<td>2538 psia</td>
<td>840 psia</td>
</tr>
</tbody>
</table>
- Continuous; 110% to 65%
- Closed Loop
- LO2 - 65; LH2 - 25 psia
- He Accumulator Required
- 0.99 @ 90% Confidence
- Low; Cost Verification is needed

**ALTERNATE**
- Engine Cycle
- Thrust, vac: EPL
- Weight
- Isp, s/vac
- Mixture Ratio
- Area Ratio
- Pe, EPL
- Throttling Capability
- Engine Control
- Min Inlet Pressure
- POGO Suppression
- Bleed Systems
- Boost Pumps
- Engine Reliability

<table>
<thead>
<tr>
<th>LO2/LH2 Split Expander</th>
</tr>
</thead>
<tbody>
<tr>
<td>629 kib</td>
</tr>
<tr>
<td>5,089 lb</td>
</tr>
<tr>
<td>16.2</td>
</tr>
<tr>
<td>840 psia</td>
</tr>
</tbody>
</table>
- Continuous; 100% to 65%
- Closed Loop
- LO2 - 47; LH2 - 25 psia
- He Accumulator Required
- None
- 0.99 @ 90% Confidence
- Technology & Low Cost Verification is needed
DESIGN RECOMMENDATIONS

- LAUNCH SITE LRB DESIGN RECOMMENDATIONS
- OPERATIONAL EFFICIENCIES
- LAUNCH SITE CONSTRAINTS
- LRB DESIGN REQUIREMENTS ASSESSMENT
- GROUND SYSTEMS IMPLICATIONS
A REPRESENTATIVE LIST OF RECOMMENDATIONS HAS BEEN PREPARED WHICH REFLECT LAUNCH SITE CONSTRAINTS AND IMPROVE OPERATIONAL EFFICIENCY. MANY, BUT NOT ALL, OF THESE HAVE BEEN INCORPORATED INTO THE PHASE-A LRB DESIGNS.
<table>
<thead>
<tr>
<th>Design Recommendations</th>
<th>Incorporation Design Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make Booster Autonomous with Minimum Orbiter Interfaces</td>
<td>?</td>
</tr>
<tr>
<td>Use Separate Booster Downlink (RF)</td>
<td>?</td>
</tr>
<tr>
<td>Facilitate Separate LRB Standalone Test and Checkout</td>
<td>?</td>
</tr>
<tr>
<td>On Board LOX Vent/NO Beanie Cap</td>
<td>?</td>
</tr>
<tr>
<td>Hard Mounted Engines (Nozzle Gimbals for TVC)</td>
<td>(ALT)</td>
</tr>
<tr>
<td>Minimize ET Mods</td>
<td>?</td>
</tr>
<tr>
<td>Eliminate Engine Purges, Bleeds and Special Preps</td>
<td>N.A.</td>
</tr>
<tr>
<td>Consider External Pod for Avionics and Batteries to Facilitate Access and Ease of Service</td>
<td>N.A.</td>
</tr>
<tr>
<td>Avoid Elephant Trunks (Traps) in Propellant Lines that Require Special Attention</td>
<td>?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design Recommendations</th>
<th>Incorporation Design Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Hydraulics/No Hydrazine</td>
<td>?</td>
</tr>
<tr>
<td>Use Lift-Off Umbilicals-No Swing Arms or LUT</td>
<td>?</td>
</tr>
<tr>
<td>Maximum LRB Diameter Less Than 16 Feet</td>
<td>½</td>
</tr>
<tr>
<td>Locate Avionics LRU's in Aft Skirt Area</td>
<td>?</td>
</tr>
<tr>
<td>Facilitate Engine PIR in Vertical on MLP</td>
<td>?</td>
</tr>
<tr>
<td>Use Expendable Design</td>
<td>?</td>
</tr>
<tr>
<td>LOX/LH2 Propellant Has Minimum Pad Impacts</td>
<td>?</td>
</tr>
<tr>
<td>No Flame Trench (Concrete) Mods at Pad</td>
<td>?</td>
</tr>
<tr>
<td>Facilitate Vertical and Horizontal Checkout</td>
<td>?</td>
</tr>
</tbody>
</table>
LRB DESIGN REQUIREMENTS ASSESSMENT

Our study team reviewed the preliminary LRB design requirements published in GDSS final report. The total range of requirements was represented from top level guidelines to 4th level system requirements.

About 70% (33 out of 48) have ground system design implications.
<table>
<thead>
<tr>
<th>ITEM</th>
<th>A. GUIDELINES GOALS, ASSUMPTIONS</th>
<th>B. LEVEL I REQUIREMENTS (SPACE TRANSPORTATION SYSTEM)</th>
<th>C. LEVEL II REQUIREMENTS (SPACE SHUTTLE VEHICLE)</th>
<th>D. LEVEL III REQUIREMENTS (LIQUID ROCKET BOOSTER)</th>
<th>E. LEVEL IV REQUIREMENTS (AVIONICS / FLT CONTROLS / SEPARATION SYSTEMS)</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER WITH GROUND SYSTEMS IMPLICATIONS</td>
<td>12</td>
<td>8</td>
<td>8</td>
<td>11</td>
<td>9</td>
<td>48</td>
</tr>
<tr>
<td>TOTAL</td>
<td>11</td>
<td>7</td>
<td>4</td>
<td>9</td>
<td>2</td>
<td>33</td>
</tr>
</tbody>
</table>
LRB DESIGN FEATURE → AFFECTED GROUND SYSTEM ← DESIGN ISSUE
# SYSTEMS/DESIGN ISSUES

<table>
<thead>
<tr>
<th>LRB DESIGN FEATURE</th>
<th>AFFECTED GROUND SYSTEM</th>
<th>DESIGN ISSUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DIAMETER</td>
<td>• MLP FLAME HOLES</td>
<td>• SIZE TO ACCOMMODATE (NEW MLP)</td>
</tr>
<tr>
<td>(13.9 TO 18.0 FT)</td>
<td>• VAB PLATFORMS</td>
<td>• VEHICLE CLEARANCES</td>
</tr>
<tr>
<td></td>
<td>• PAD FLAME TRENCH</td>
<td>• CONCRETE MODS &amp; C/T TRACK WIDTH</td>
</tr>
<tr>
<td></td>
<td>• FLAME DEFLECTORS</td>
<td>• DESIGN ANGLES / PLUME IMPINGEMENT</td>
</tr>
<tr>
<td></td>
<td>• ET GH2 VENT</td>
<td>• VEHICLE LIFT-OFF CLEARANCE</td>
</tr>
<tr>
<td>2. LENGTH</td>
<td>• VAB PLATFORMS</td>
<td>• ACCESS AT HIGHER LEVELS</td>
</tr>
<tr>
<td>(147 TO 197 FT)</td>
<td>• GOX VENT ARM</td>
<td>• 170 FT LENGTH LIMIT FOR CLEARANCE</td>
</tr>
<tr>
<td></td>
<td>• TRANSPORTER/BARGE AND PROCESS FACILITY</td>
<td>• SIZE TO ACCOMMODATE</td>
</tr>
<tr>
<td></td>
<td>• VAB DIAPHRAGM</td>
<td>• LIFT OVER HEIGHT LIMITS BOOSTER LENGTH TO 200 FT</td>
</tr>
<tr>
<td></td>
<td>• PAD ACCESS / FWD</td>
<td>• LENGTHS ABOVE 150 FT REQUIRE SIGNIFICANT NEW CONSTRUCTION</td>
</tr>
</tbody>
</table>
## SYSTEMS/DESIGN ISSUES

<table>
<thead>
<tr>
<th>LRB DESIGN FEATURE</th>
<th>AFFECTED GROUND SYSTEM</th>
<th>DESIGN ISSUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. ENGINE POSITIONS (&quot;X&quot; OR &quot;X&quot; PATTERNS)</td>
<td>• MLP HOLDDOWN SYSTEM AND FLAME HOLES &lt;br&gt; • PAD FLAME TRENCH AND DEFLECTORS</td>
<td>• HOLDDOWNS BETWEEN ENGINES FORCE FLAME HOLE BRIDGE FOR &quot;X&quot; PATTERN AND CONCENTRATES TWANG LOADS ON TWO HD POSTS &lt;br&gt; • &quot;X&quot; PATTERN FORCES OUTBOARD ENGINES OUT OF FLAME TRENCH</td>
</tr>
<tr>
<td>4. BOOSTER BENDING STIFFNESS (FIRST MODE FREQUENCY) IGNITION SEQUENCE, LAUNCH LOADS</td>
<td>• ALL GROUND INTERFACES AT PAD &lt;br&gt; • T-0 UMBILICALS</td>
<td>• STATIC / DYNAMIC EXCURSIONS UNDER ALL PRE-LAUNCH AND SHUTDOWN LOAD CONDITIONS / TRACKING REQMTS &lt;br&gt; • TWANG DEFLECTIONS AT T-O, UMBILICAL TRACKING ABILITY, LRB / SSME IGNITION SEQUENCE &lt;br&gt; • MLP STIFFNESS AND HD DESIGN</td>
</tr>
<tr>
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<td>• ON-BOARD NON-ICING GOX VENTS VS NEW SWING ARMS, GH2 VENTS ROUTED TO LIFT-OFF UMBILICALS VS NEW SWING ARMS</td>
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<td>6. LRB ENGINE THRUST BUILDUP, POGO SUPPRESSION AND LAUNCH LOADS</td>
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<th>LRB DESIGN FEATURE</th>
<th>AFFECTED GROUND SYSTEM</th>
<th>DESIGN ISSUE</th>
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</tr>
<tr>
<td>8. LRB INSTRUMENTATION FLIGHT AND LPS SOFTWARE INTERFACES</td>
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</tr>
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<tr>
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</tr>
<tr>
<td>LRB DESIGN FEATURE</td>
<td>AFFECTED GROUND SYSTEM</td>
<td>DESIGN ISSUE</td>
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<td>11. LRB ENGINE TVC DESIGN</td>
<td>• CHECKOUT GSE AND PROCEDURES</td>
<td>• ELECTRO-MECHANICAL CHECKOUT AND GSE VS HYDRAULICS AND HPU HYDRAZINE PROCEDURES / GSE. GROUND ELECTRICAL PROVISIONS FOR TVC CHECKOUT</td>
</tr>
<tr>
<td>12. LRB ENGINE DESIGN APPROACH</td>
<td>• CHECKOUT GSE AND PROCEDURES</td>
<td>• ENGINE PURGES, BLEEDS AND SPECIAL CONDITIONING VS SIMPLIFIED, &quot;ROBUST&quot; ENGINE DESIGN W/AUTOMATED DIAGNOSTICS</td>
</tr>
<tr>
<td>13. ENGINE LRU DESIGN</td>
<td>• GROUND HANDLING GSE AND PROCEDURES</td>
<td>• MODULARIZED ENGINE-LEVEL LRU PLUS SHOP SERVICE VS INVOLVED LRU R/R IN-PLACE ON VEHICLE</td>
</tr>
<tr>
<td>14. LRB DESIGN FOR HORIZONTAL PROCESSING</td>
<td>• GROUND HANDLING, CRANE LIFTING OPERATIONS/ PROCEDURES</td>
<td>• VERTICAL CHECKOUT AND LIFTING OPERATIONS VS HORIZONTAL SERVICING ON TRANSPORTER AND SINGLE ROTATION AND LIFT TO MATE MLP</td>
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<tr>
<td>15. LRB PRESSURIZED TANKS</td>
<td>• GSE FOR PRESSURIZING ON-BOARD SYSTEMS, AND LEAK CHECK PROCEDURES AND GSE FOR CHECKOUT</td>
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</tr>
</tbody>
</table>
LAUNCH SITE SCENARIO

- LRB PROCESSING REQUIREMENTS
- KSC / STS BASELINE MODEL
  - SRB PROCESSING
- LRB SCENARIO
  - PROCESSING TIMELINES
  - STANDALONE / INTEGRATED TASKS
- SRB / LRB COMPARISON
- LRB LAUNCH SITE PLAN
- KEY LRBI STUDY FINDINGS
LRB PROCESSING REQUIREMENTS CHECKLIST

Our study team drafted a "KSC REQUIREMENTS CHECKLIST" early in the study and circulated it to both GDSS and MMC study teams. The checklist was organized into a questionnaire format dealing with these major areas of processing activities and systems.

Responses were received and coordinated with both contractors and are included in our final report.

The requirements checklist promoted discussions and design recommendations for LRB launch site operational efficiencies.
# LRB PROCESSING REQUIREMENTS CHECKLIST

## Properties
- **Booster Properties**
  - Pump-fed
  - Pressure-fed
  - Split expander
- **Propellants**
  - LOX / RP-1
  - LOX / LH2

## General Requirements
- Configuration data
- Equipment descriptions
- Operating criteria
- Interface requirements
- Launch site constraints
- Handling requirements

## System-Specific Requirements
- Receiving / handling
- Assembly / processing
- Integration
- Safety / environmental
- Spares / logistics
- Test / checkout
- Pre-launch
- Ground software
- Launch ops
- Abort / scrub
- Recovery
- Refurbishment
MULTI-FLOW PROCESSING TIMELINES HAVE BEEN DEVELOPED FOR STS LAUNCHES 1991 THRU 2006 (ARTEMIS MODEL)

THIS SCHEDULE REPRESENTS THE STS TRANSITION FROM NEAR TERM MANIFEST (MAR 88) TO LONG RANGE LAUNCH RATE OF 14/15 PER YEAR

FACILITY UTILIZATION DIAGRAMS PRESENT WINDOWS FOR SCHEDULING LRB FACILITY MODS/ACTIVATION ACTIVITIES

FLANNING LAYOUTS FOR ACTIVATION/TRANSITION/OPERATIONS PHASES WERE PREPARED TO ACHIEVE LRB IMPLEMENTATION

MINIMUM IMPACTS TO ON-GOING LAUNCH OPERATIONS CAN BE ACHIEVED USING THIS PLANNING TOOL THROUGHOUT THE INTEGRATION ACTIVITIES, ACCOMMODATING SCHEDULE AND MANIFEST CHANGES AS THEY (MOST ASSUREDLY WILL) OCCUR.
1994 SRB PROCESSING BASELINE SUMMARY

18 JANUARY 1988

97 DAY FLOW

DAYS

△ AFT SKTS AT RPSF

17 Booster Buildup - RPSF

12 6 Inspection/Offload - RPSF

21 Stack - VAB

△ FWD SKT AISLE XFER

11 ET MATE & C/O - VAB

5 Integrated Operations - VAB

15-18 Pad Operations

7 Retrieval Operations

△ Parachutes to PRF

Disassembly Operations

10 FWD SKT XFER TO USBI REFURB△

AFT SKT XFER TO USBI REFURB△

Start Seg XFER △

Spent Seg Onload to Railcars

△ Note: Remanufacturing at Utah Not Shown

△ USBI Refurb ARF and Parachute Repack Not Shown

SRB Pre-Launch Timeline = 78 Days

Lockheed
Space Operations Company
LRB PROCESSING SUMMARY

THE LRB PROCESSING SCENARIO BEGINS AT KSC WITH BARGE DELIVERY, AND HORIZONTAL TRANSPORTER TOW TO THE NEW LRB PROCESSING FACILITY. HERE ALL STANDALONE BOOSTER CHECKOUT AND TESTING IS CONDUCTED. THE ADJACENT ET HORIZONTAL PROCESSING FACILITY RELOCATES THE ET CHECKOUT AND STORAGE ACTIVITY SO THAT HB4 CAN BE USED.

THE CONVERSION OF VAB/HB4 TO A FULL INTEGRATION CELL PERMITS LRB TRANSITION WITHOUT IMPACT TO ON-GOING SHUTTLE LAUNCHES. A NEW MLP CUSTOM-BUILT FOR LRB WILL BE CONSTRUCTED TO SUPPORT THE LRB IOC, AND A SECOND NEW MLP IS NOW SCHEDULED TO SUPPORT THE LRB TRANSITION LAUNCH RATE BUILD-UP. THIS APPROACH REPLACES THE EARLIER PLANNED MODIFICATION OF EXISTING MLP's.

THE LAUNCH CONTROL CENTER FIRING ROOMS WILL BE MODIFIED TO SUPPORT ANY NEW CONSOLES AND GROUND SOFTWARE REQUIRED FOR LRB PROCESSING AND LAUNCH OPERATIONS. LETF SUPPORT FOR THE NEW MLP/FAP LSE QUALIFICATION/CERTIFICATION TESTING IS PLANNED.

- SECOND NEW MLP DUE TO:
  1) DIFFICULTY OF MOD AND 2) IMPACT TO SRB LAUNCHES

- NEW MORE EXTENSIVE PAD MODS:
  1) DEFLECTOR REDESIGN IN FLAME TRENCH
  2) SIDE DEFLECTOR (PROXIMITY REQUIREMENTS)
  3) POSSIBLE FLAME TRENCH MODS
A detailed processing assessment of the LRB requirements was performed which resulted in the development of a 130-task LRB flow schedule. This schedule includes standalone checkout and testing, MLP mate and ET/LRB mate/closeout, orbiter integration/test and pad operations.

A total LRB flow time of 58 days is presented here as the "generic" process flow time. The schedule is anticipated to be achieved on the 4th LRB launch processing flow known as the initial operational capability (IOC).

This model is networked in Artemis where hands-on manpower and shift durations for each task are displayed. Integration with major STS activities and milestones has been achieved.
**GENERIC LRB PROCESS FLOW**

**LRB BARGE ON DOCK KSC**

18

- LRB STANDALONE CHECKOUT (5/3)
- OFFLOAD/TRANS TO HPF
- REC/INSPECTION
- SYS FUNCTION CHECKOUTS
- ENGINE/PROP SYS LEAK & FUNCTIONAL

**LRB MOVE TO VAB**

4 MLP MATE & CLOSEOUTS (7/3)

**ET MATE**

11 ET/LRB CLOSEOUTS (7/3)

5 ORB MATE/INTEGRATION SYS TEST (7/3)

**SSV PREPS/TRANSFER TO PAD**

20 SSV STD OPS
- PAYLOAD OPS
- CDDT
- LRB ENG SYS READINESS
- LRB FUEL (RP) TANKING
- ORB HYPER LOAD/CLOSEOUT
- LAUNCH COUNTDOWN (INCLUDING CRYO LOAD)

**LRB FLOW = 58 DAYS**

**LAUNCH**

(6/3)
LRB/SRB FACILITY PLANNING COMPARISON

GRAPHICALLY NOTED HERE ARE THE FLOW TIME DIFFERENCES FOR LRB (SHOWN SOLID BLACK) ON THE BACKDROP OF PLANNED SRB FLOW PROCESSING TIMELINES IN THE MID-TO-LATE 90's.

ALL IN-LINE GROUND PROCESSING TO SUPPORT AN EXAMPLE FLOW IS PRESENTED. NOTE MAJOR FACILITIES AND ELEMENTS. THE LRB "DELTAS" ARE SHOWN IN THE BOXES FOR THE FOUR MAJOR-AFFECTED FUNCTIONS.

THE ARTEMIS MULTIFLOW PROCESSING MODEL CONTAINS 224 MISSIONS OF THIS DETAIL OVER THE PERIOD FY91 THRU FY06. INSERTION OF THE 122-MISSION LRB LIFE CYCLE PROFILE INTO THIS MODEL WILL FACILITATE EFFECTIVE PLANNING FOR KSC INTEGRATION.
The LRB flow from receipt of hardware to launch is here compared with the late 90's forecasted SRB timeline.

A total of 20 days is saved in the LRB activities due to the lengthy stack time for SRB. This stack time estimate varies from 21 to 24 days. STS-26R stack time was about 65 days.

This improved flow time for LRB results in lower demand on launch site resources for the same sustained STS flight rate.
GENERIC LRB/SRB PROCESS FLOW COMPARISON

**LRB Flow = 58 Days**

1. LRB Barge on Dock KSC
2. Offload/LRB Stand Alone Checkout
3. LRB Move to VAB
   - MLP Mate
4. ET Mate and C-O
5. STS Integ Test
6. STS Move to Pad
7. Pad Ops

**SRB Flow = 78 Days**

1. SRB Aft Skirts at RPSF
2. Aft Booster Buildup
3. Inspection/Segment Offload
4. Booster Stacking
5. ET Mate and C-O
6. STS Integ Test
7. STS Move to Pad
8. Pad Ops

Note: SRB retrieval, disassembly, refurbishment and remanufacturing are not shown.
SRB/LRB FLOW COMPARISON

SUMMARIZED HERE ARE THE PROJECTED IMPROVEMENTS IN FLOW TIME FOR LRB VERSUS THE "PLANNED" SRB PROCESSING TIMES FORECAST FOR THE LATE 90's.

THESE IMPROVEMENTS REPRESENT A SIGNIFICANT REDUCTION IN DEMAND ON LAUNCH SITE RESOURCES REQUIRED TO SUPPORT A 14 TO 15 ANNUAL LAUNCH RATE - AND THEY PROVIDE THE FLEXIBILITY TO ACCOMMODATE ALTERNATE SHUTTLE "C" OR ALS LAUNCH CAPABILITIES.
## SRB / LRB Flow Comparison

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<thead>
<tr>
<th></th>
<th>Work Days</th>
<th>% Reduction</th>
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<tbody>
<tr>
<td><strong>VAB HB (INTEG CELL)</strong></td>
<td>21</td>
<td>4</td>
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<tr>
<td><strong>MLP USE PER FLOW</strong></td>
<td>55</td>
<td>40</td>
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<tr>
<td><strong>INTEG CRITICAL PATH</strong> (Boosters Stack to Orb MATE)</td>
<td>32</td>
<td>15</td>
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<tr>
<td><strong>PAD FLOW</strong></td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td><strong>BOOSTER FLOW (PRE-LAUNCH)</strong></td>
<td>78</td>
<td>58</td>
</tr>
</tbody>
</table>
• KSC
  • PHASED PLANNING
  • TRANSITION ENVIRONMENT
  • DEFINED IMPACTS

• VLS

• SUMMARY SCENARIO
LAUNCH SITE ACTIVATION BEGINS IN FY 91 TO SUPPORT INITIAL LRB LAUNCH CAPABILITY IN 1996. FIRST LINE NEW FACILITIES, REQUIRED FACILITY MODS AND NEW GSE/LSE ARE DESIGNED, CONSTRUCTED AND VALIDATED DURING THIS INITIAL FIVE YEAR PERIOD. THESE ACTIVATION SCHEDULES ARE LAID OUT IN AN ARTEMIS MODEL AND PLANNED ON A NON-INTERFERENCE BASIS.

THE TRANSITION PHASE BEGINS WITH 3 LAUNCHES OF LRB IN 1996 AND BUILDS TO THE FULL 14 ANNUAL LAUNCH MANIFEST BY THE YEAR 2000. DURING THIS PERIOD SRB-BOOSTED LAUNCHES ARE PHASED DOWN BY SIMILAR INCREMENTS. AS YOU CAN SEE, ADDITIONAL FACILITY (AND GSE) ACTIVATIONS ARE SCHEDULED OVER THIS TRANSITION - MAJOR ONES ARE NOTED HERE.

TOTAL LIFE CYCLE EVALUATIONS ARE DIMENSIONED OVER AN APPROXIMATE 10-YEAR LAUNCH PERIOD. THE LAST 5 YEARS ARE AT THE FULL 14/15 FLIGHTS PER YEAR RATE. A TOTAL LRB LIFE OF 122 MISSIONS IS CURRENTLY PROJECTED.
## Phased Approach

### Milestones

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<th>CY</th>
<th>91</th>
<th>92</th>
<th>93</th>
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<tr>
<td>I. INITIAL ACTIVATION</td>
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<td>NEW MLP</td>
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<td>HB4 / HPF</td>
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<td>1ST PAD MOD</td>
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### Transition Phase

- Launch Ramp
- Cont'd Activations
  - 2nd MLP
  - 2nd HB
  - 2nd Pad

### Operations Phase

- Full Rate
- Optimization

### Key Dates

- ILC
- IOC
- LRB Launch Rate Build-Up
- Ops Capability
- Mature Operations
- Mixed Fleet Ops
LAUNCH SITE PLANNING

- The developed study products support the phased planning of LRB launch site integration.
- Activation activities in the first phase are supported by these identified study products dealing with facility design/construction.
- Transition issues are described in the key products of the second phase.
- Operational issues dominate these study products of the third phase.
- The ground operations cost model (GOCM) summarizes cost elements parametrically over all three phases of launch site implementation.
## LRB Launch Site Planning

### Activation
- Ground Operations Plan
- Facility Concepts (GSE / LSE)
- Propellant Storage and Handling
- Environmental / Safety Implications

### Transition
- Preliminary Transition Plan
- Manpower / Costs
- Impacts to Ongoing Activities

### Operations
- LRB Processing Timelines
- Operational Efficiencies
- LRB Engine Processing

---

**Ground Operations Cost Model**

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VLS/LRB PROCESSING SCENARIO

DELIVERY BY BARGE OF A COMPLETELY ASSEMBLED LRB TO THE EXISTING VLS DOCKING FACILITY SIMPLIFIED THE VLS FLOW PROCESSING FROM THE CURRENT RAIL DELIVERY OF SRB PROPELLANT SEGMENTS AND AIR DELIVERY OF ITS OTHER COMPONENTS. LAND TRANSPORTATION FROM THE DOCKING FACILITY WILL BE BY TRANSPORTER TOW, IDENTICAL TO THE KSC CONCEPT. ALL LRB STAND-ALONE CHECKOUT AND TESTING WILL BE CONDUCTED IN THIS FACILITY. EACH LRB WILL THEN BE TOWED ON ITS TRANSPORTER TO THE SLC-6 LAUNCH PAD WHERE IT WILL BE ERECTED BY THE EXISTING MST AND SAB CRANES. THE MST CRANE WILL THEN LIFT AND TRANSLATE EACH LRB IN A VERTICAL ATTITUDE TO ITS RESPECTIVE HOLDDOWN POSTS. THE BALANCE OF THE VLS SHUTTLE VEHICLE INTEGRATION WILL REMAIN UNCHANGED.

INCORPORATION OF EXTENSIVE LAUNCH MOUNT MODIFICATIONS OR REPLACEMENT BY A NEW LAUNCH FIXTURE WILL PROVIDE THE NECESSARY HOLDDOWN MODIFICATIONS AND ENLARGED BOOSTER DUCT ENTRANCE AREA. THIS ARRANGEMENT WILL PROVIDE CONTROL AND GUIDANCE OF THE EXHAUST PLUME INTO THE EXISTING VLS CLOSED DUCTS. THERE MAY BE A REQUIREMENT FOR STEAM INERTING THE BOOSTER CLOSEOUT DUCTS TO PRECLUDE A POTENTIALLY HAZARDOUS OVERPRESSURE.

VEHICLE LAUNCH PROCESSING WILL BE MODIFIED TO PROVIDE FOR EXPANDED LOX AND LH₂ CAPACITY AND LOADING (OR INSTEAD OF LH₂ THE ADDITION OF RP-1 FUEL CAPABILITY, IF IT IS SELECTED).

ADDITIONALLY, THE LAUNCH CONTROL CENTER WILL INCORPORATE THE NEW LRB CONSOLES AND GROUND SOFTWARE, SIMILAR TO KSC.
VLS LRB PROCESSING SCENARIO

EXISTING ORBITER PROCESSING FACILITY

EXISTING ET PROCESSING FACILITY

NEW LRB HORIZONTAL PROCESSING FACILITY

ON-PAD INTEGRATION

LAUNCH & PAD REFURBISHMENT

LRB DELIVERY BY BARGE*

*KSC Common/Mod-Common

REQUIRED NEW FACILITY

LOCKHEED
Space Operations Company
THE SHARED FACILITIES AND MANPOWER DURING TRANSITION CONSTITUTE SIGNIFICANT RISK OF LAUNCH DELAYS, EVEN THOUGH THE PLANNED LRB PROCESSING SCENARIO IS DESIGNED TO MINIMIZE RISKS TO THE SCHEDULE OF ON-GOING LAUNCH ACTIVITIES. SCHEDULE RISK IS, IN GENERAL, INSENSITIVE TO THE SELECTED LRB DESIGN.

INTEGRATION OF LRB AT KSC WILL REQUIRE NEW AND MODIFIED FACILITIES AND GSE.

NEW - MLPs (2)
- HORIZONTAL PROCESSING FACILITY FOR LRB AND ET OFFLINE PROCESSING

MODS - PADS (2)
- VAB (HB-4 AND HB-3)
- LCC (AND LPS)
- LETF (MODS AND TESTING)

PAD MODIFICATION TIMELINES DO NOT FIT THE AVAILABLE OPEN WINDOWS (AT 14 LAUNCHES PER YEAR) FOR THE CONSTRUCTION TO IMPLEMENT LRB CHANGES. DURING LRB PAD MODIFICATION APPROXIMATELY EIGHT MONTHS OF EXCLUSIVE ACCESS MAY BE REQUIRED. DURING THIS PERIOD ALL LAUNCHES ARE FORCED TO THE OTHER PAD. THESE SINGLE PAD LAUNCH OPERATIONS MUST BE COMPRESSED TO ACHIEVE THE PLANNED LAUNCH RATES.

NEW MLP DESIGN AND CONSTRUCTION IS THE CRITICAL PATH ACTIVITY TO MEET FIRST LRB LAUNCH IN FY96. (ASSUMES A FY91 ATP).

KEY LRB CONFIGURATION DESIGN FEATURES WERE IDENTIFIED WHICH RESULT IN ENHANCED LAUNCH SITE OPERATIONS.

LOX/RP-1 AND LOX/LH2 ARE BOTH VIABLE AND ACCEPTABLE PROPELLANTS FOR THE NEW LRB AT KSC. OTHER PROPELLANTS STUDIED WERE LESS ACCEPTABLE. LOX/LH2 IS THE PREFERRED PROPELLANT AT THE LAUNCH SITE.
### OBJECTIVES/FINDINGS

<table>
<thead>
<tr>
<th>STUDY OBJECTIVES</th>
<th>LRBI KEY STUDY FINDINGS/ACCOMPLISHMENTS</th>
</tr>
</thead>
</table>
| 1. IMPACTS (OPS + FAC) | • SHARED FACILITIES/MANPOWER ARE SIGNIFICANT TRANSITION RISK  
• NEW LRB FACILITIES REQUIRED PLUS MODS TO EXISTING  
• MOST SCHEDULE-CRITICAL FAC. MODS ARE PADS A&B  
• MOST SCHEDULE-CRITICAL NEW FAC. IS TWO MLPs |
| 2. SCENARIOS | • LRB PROC. SCENARIO DESIGNED TO AVOID SCHED. RISK  
• DETAILED LRB PROCESSING TASKS DEFINED |
| 3. LRB DESIGN RECOM | • LRB DESIGN FEATURES ID'ED FOR L.S. OPS EFFICIENCY  
• LOX/LH2 IS KSC PREFERRED PROPELLANT  
• L.S. CONSTRAINTS ID'ED TO ACCOMMODATE LRB OPTIONS |
LRB has a significantly shorter integration timeline on the MLP, in the VAB, compared to SRB. This feature provides greater launch site capability to achieve a 14 per year launch rate.

The ground operations cost model (GOCM) has been shown to be a useful parametric tool for phase-A cost analysis. The model has been enhanced, applied to the LRB launch site integration and documented. In its current form it is ready to apply to any emerging new launch vehicle evaluation at KSC.

Launch site costs are approximately $1B non-recurring and $1B recurring for a 10-year (122 mission) life cycle. Cost savings due to SRB phase-out still require further evaluation.

Extent of modifications to existing facilities and costs is highly sensitive to selected LRB design characteristics (propellant, length, diameter, etc.).

Manpower requirements will peak during FY94-FY95 at an additional 800 people to support activation, transition and operational phases of LRB implementation plus approximately 1500 A&E and construction installation contractor personnel.

KSC needs a dedicated activation team for LRB activation and transition planning with follow-thru to implement new booster operations.
### OBJECTIVES/FINDINGS

<table>
<thead>
<tr>
<th>STUDY OBJECTIVES</th>
<th>LRBI KEY STUDY FINDINGS/ACCOMPLISHMENTS</th>
</tr>
</thead>
</table>
| 4. OPER. EFF. LRB | • KEY LRB DES FEATURES ID'ED FOR L.S. OPS EFFICIENCY  
                        • L.S. PROCESSING ADVANTAGES OF LRB DEFINED |
| 5. COST MODEL    | • GOCM IMPROVED AND DOCUMENTED  
                        • LRB LAUNCH SITE PROJECTED COSTS DEFINED |
| 6. LSE - GSE     | • CONCEPT LEVEL GSE - LSE DEFINED TO ACCOM. LRB |
| 7. LAUNCH SITE SUPPORT PLAN | • MANPOWER FOR ACTIVATION, TRANSITION, OPS DEFINED  
                                          • KSC NEEDS DEDICATED ACTIVATION TEAM FOR LRB INTEG. |
AGENDA

I. INTRODUCTION
   Gordon Artley

II. LRBI RESULTS
   BASELINE / LAUNCH SITE SCENARIO
   Pat Scott

   FACILITIES AND GROUND SYSTEMS
   Greg DeBlasio

   IMPLEMENTATION
   Gordon Artley

   COST
   Jerry Lefebvre

III. SUMMARY
     Gordon Artley
STATION SET APPROACH

- FACILITY REQUIREMENTS AND IMPACTS
- IDENTIFY NEW FACILITIES
- DEFINE LRB LAUNCH SUPPORT EQUIPMENT
- DEFINE LRB GROUND SUPPORT EQUIPMENT
- DEFINE LRB PROPELLANT REQUIREMENTS
EVALUATION OF LRB PROCESSING/STORAGE IN THE VAB

THIS STUDY ADDRESSED FACILITY REQUIREMENTS FOR RECEIVING, PROCESSING, AND STORING LRB's IN THE VEHICLE ASSEMBLY BUILDING (VAB). THE LRB PROCESSING FLOW WAS ANALYZED AND ACTIVATION, OPERATIONAL, AND SAFETY IMPACTS WERE IDENTIFIED INCLUDING CRANE LIFT OPERATIONS AND HAZARDOUS CLEAR AREAS. OPERATIONAL COMPARISONS WERE MADE TO EVALUATE USE OF AN EXTERNAL ET AND LRB FACILITY.

CONCEPT 1

THE CONCEPTUAL FLIGHT HARDWARE FLOW PATH USES VAB HIGH BAYS 1 AND 3 AS INTEGRATION CELLS AND VAB HIGH BAYS 2 AND 4 AS LRB/ET PROCESSING AND STORAGE AREAS. THE ET PROCESSING WOULD NOT BE CHANGED. PHASE 1 ACTIVATION WOULD BE IN HIGH BAYS 3 AND 4 TO SUPPORT FIRST LRB FLOW.

CONCEPT 2

THIS CONCEPTUAL FLIGHT HARDWARE FLOW PATH USES VAB HIGH BAY 1 AS AN INTEGRATION CELL FOR SRB/SSV, VAB HIGH BAY 3 AS AN INTEGRATION CELL FOR SRB/SSV OR LRB/SSV, AND HIGH BAY 4 AS AN INTEGRATION CELL FOR LRB/SSV. HIGH BAY 2 WOULD BE USED FOR THE SRB BUILDUP WORKSTAND TO BACKUP THE RPSF. BOTH LRB AND ET PROCESSING AND STOPAGE REQUIREMENTS WOULD BE PERFORMED IN A HORIZONTAL FACILITY. THE FIGURE SHOWS THE FLOW PATH OF ALL THE ELEMENTS.
LIFTING OPERATIONS IMPACTS/EVALUATION

THE CONCEPTS WERE EVALUATED TO ESTABLISH VAB CRANE UTILIZATION AND LIFT REQUIREMENTS.

THE CURRENT NUMBER OF LIFTS REQUIRED TO STACK A SRB/STS IS 14. THE TABLE SHOWS THAT 10 LIFTS ARE REQUIRED TO STACK/MATE THE BOOSTERS. THE PRESENT REQUIREMENT FOR ET's IS THREE (1 OFFLOAD, 1 FROM C-0 TO STORAGE CELL AND 1 TO MATE STACK).

CONCEPT 1 FOR LRB/STS WOULD REQUIRE SIX LIFT OPERATIONS TO STACK/MATE THE BOOSTERS IN HIGH BAY 1 OR 3. THE ET LIFTING REQUIREMENT REMAINS UNCHANGED AT THREE, FOR A TOTAL OF 10 LIFTS FOR STS.

CONCEPT 2 REQUIRES FOUR LIFT OPERATIONS TO STACK/MATE AN LRB/SSV IN HIGH BAY 3 OR 4. THE SRB/SSV STACKING/MATING OPERATIONS WOULD REQUIRE ONLY ONE LIFT OF AN ET USING THIS CONCEPT. THIS IS A TOTAL REDUCTION OF TEN LIFTS FROM THE CURRENT SRB/SSV INTEGRATION REQUIREMENTS.

SINCE LIFTING FLIGHT HARDWARE IS A HAZARDOUS OPERATION REQUIRING AREA CLEARS, MINIMIZING THE NUMBER OF LIFTS REPRESENTS A SIGNIFICANT SAFETY ENHANCEMENT FOR THE ENTIRE STS LAUNCH PROCESSING. AT A RATE OF 14 PER YEAR THERE WILL BE 140 LESS OPPORTUNITIES PER YEAR FOR MAJOR LIFTING INCIDENTS. THIS IS A 70% REDUCTION IN TOTAL REQUIRED LIFTS (AND THE LRB HAS TO LIVE PROPELLANTS ON-BOARD).
<table>
<thead>
<tr>
<th>LIFTS PER FLIGHT SET</th>
<th>CURRENT SRB/STS (ET/LRB PROCESSED IN VAB)</th>
<th>CONCEPT 1 LRB/STS (ET/LRB PROCESSED IN VAB)</th>
<th>CONCEPT 2 LRB/STS (ET/LRB PROCESSED IN HFP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOOSTER</td>
<td>10</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>ET</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>ORB</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>14</td>
<td>10</td>
<td>4</td>
</tr>
</tbody>
</table>
SRB PROCESSING IN THE VAB

Currently, the SRB's are built up and processed in the RPSF. They are then transported to the VAB, lifted, and stacked on the Mobile Launcher Platform (MLP). During the VAB SRB stacking operations, areas of the transfer aisle and high bays 2 and 4 are cleared. The figures show the clear areas for high bay 1 or 3 stacking. This requirement to clear for SRB stacking could impact the LRB processing schedule as well as the activation of any high bay for LRB processing or integration.
• **PROCESSING** IN VAB COMPLICATED BY NUMEROUS LIFTS / AREA CONTROLS / SCHEDULE INTERACTION

• **ACTIVATION** IN VAB WILL IMPACT ON-GOING OPERATIONS

• **FUTURE USE** OF VAB LIMITED
LRB HORIZONTAL PROCESSING REQUIREMENTS

The methodology of this study established a comparison between the LRB pump-fed propellant system and the orbiter/et pump-fed propellant system processing operations since the et and orbiter engines contain similar physical characteristics; e.g., thin wall constructed liquid propellant storage tanks, main engines, intertank access, a nose cone, a ground support equipment (GSE) interface, a tank/engine interface, and an exterior network of shuttle range safety system (SRSS) ordnance and thermal protection system (TPS).

The study team defined the conceptual functional processing and test requirements for LRB by analyzing the present day storage and checkout procedures for the ET and orbiter main engines. The functional requirements for LRB storage and checkout processing were then developed.
FLUID GSE FOR LRB PROCESSING

A SOURCE FOR HIGH PRESSURE GASES AND COMPRESSED AIR TO SUPPLY THE ET/LRB HORIZONTAL PROCESSING FACILITY WILL BE REQUIRED. FABRICATION OF GSE WILL BE BASED ON EXISTING FACILITY GSE DESIGN AT THE ORBITER PROCESSING FACILITY (OPF).

THE OPF PNEUMATIC SYSTEM UTILIZES THREE PERMANENTLY INSTALLED PANELS OUTSIDE THE BUILDING. THESE PANELS MONITOR, CONTROL, AND DISTRIBUTE GASEOUS GN₂, GHe, AND A HAZARDOUS AIR PURGE AT VARIOUS PRESSURES, TEMPERATURES, AND FLOW RATES TO THE HIGH BAYS. THE FACILITY GSE FOR THE NEW HPF WILL CONSIST OF SIMILAR EQUIPMENT.

THE FACILITY WILL HAVE ITS OWN SUPPLY OF HIGH PRESSURE GASES AND COMPRESSED AIR SYSTEM FOR HAZARDOUS PURGE AND SHOP TOOLS. A SEPARATE AREA TO HOUSE THE 6000-psig HIGH PRESSURE GAS STORAGE TANKS FOR GHe AND GH₂ WOULD BE LOCATED AS NEAR TO THE CCF/VAB GHe PIPELINE AS POSSIBLE AND THE BIG THREE GN₂ PIPELINE. THE GHe WILL BE SUPPLIED FROM THE CCF, WHILE THE GN₂ WILL BE SUPPLIED BY A BIG THREE PIPELINE. A UTILITY ANNEX WILL BE REQUIRED AT THE HPF TO HOUSE THE AIR COMPRESSOR AND OTHER UTILITIES.

THE GROUND SUPPORT SYSTEM FOR SERVICING THE LRB TANKS CONSISTS OF A NETWORK OF PNEUMATIC PANELS TO REGULATE AND DISTRIBUTE FACILITY HELIUM AND NITROGEN GASES FOR PRESSURIZATION, MONITORING, AND MAINTENANCE OF TANK PRESSURES, VENT VALVES FUNCTIONAL CHECKS, AND VARIOUS LEAK CHECKS ASSOCIATED WITH LRB PROCESSING.
ET HORIZONTAL PROCESSING REQUIREMENTS

THE ET WILL BE PROCESSED WHILE INSTALLED ON AN ET TRANSPORTER IN THE NEW ET/LRB HORIZONTAL PROCESSING FACILITY.

CONCLUSIONS/RECOMMENDATIONS

THE ET TANK'S PROCESSING OPERATIONS IN A HORIZONTAL CONFIGURATION WOULD REQUIRE GSE AND OPERATIONAL PROCEDURES SIMILAR TO THOSE CURRENTLY IN USE. THE INTERFACING OF THIS EQUIPMENT TO THE ET WOULD REQUIRE ACCESS STANDS, FIXED PLATFORMS, AND PORTABLE PLATFORMS. THE HORIZONTAL INSTALLATION AND CHECKOUT OF THE GUCP IS QUESTIONABLE DUE TO LACK OF WORKSPACE AND CLEARANCES WITH ET IS ON THE TRANSPORTER; MODIFICATION OF THE TRANSPORTER WOULD BE REQUIRED TO ENABLE THE GUCP TO BE INSTALLED IN THE HORIZONTAL POSITION. A NEW CHECKOUT GSE INTERFACE MIGHT BE REQUIRED TO SUPPORT TANK PROCESSING. THE VERIFICATION MEASUREMENTS PERFORMED ON THE ET/ORBITER, LOX, AND HYDROGEN FLAPPER VALVES SHOULD BE PERFORMED VERTICALLY AFTER STACKING ON THE MLP TO PROTECT THE INNER TANK FROM CONTAMINATION.
ET FUNCTIONAL REQUIREMENTS

NOSE CONE REQUIREMENTS
ASCENT AIR DATA SYSTEM (AADS) ALIGNMENT
FAIRINGS REMOVAL/INSTALLATION/INSPECTION
NON-RETRIEVAL SYSTEM CHECKOUT

OXIDIZER TANK REQUIREMENTS
PURGE/PRESSURIZATION/SAMPLING
PRESSURE MAINTAINANCE/MONITORING
LEAK AND FLOW CHECKS
VENT/RELIEF VALVES FUNCTIONAL CHECKOUT

INTERTANK ACCESS REQUIREMENTS
LEAK AND FLOW CHECKS
ELECTRICAL/INSTRUMENTATION INSTALLATION
HAZARDOUS PURGE SYSTEM VALIDATION
SRSS-SHUTTLE RANGE SAFETY SYSTEM INSTALLATION

GSE INTERFACE FUNCTIONAL REQUIREMENTS
LEAK CHECKS
DISCONNECT FUNCTIONAL CHECKS

EXTERIOR REQUIREMENTS
THERMAL PROTECTION SYSTEM (TPS)
CLOSE OUT
FLIGHT ACCESSORIES INSTALLATION/INSPECTION
SUPPORT FIXTURE VERIFICATION
FAIRINGS INSTALLATION/INSPECTION
SRSS-SHUTTLE RANGE SAFETY SYSTEM

FUEL TANK REQUIREMENTS
PRESSURE MAINTAINANCE/MONITORING
PURGE/PRESSURIZATION/SAMPLING
LEAK AND FLOW CHECKS
VENT/RELIEF VALVES FUNCTIONAL CHECKOUT

ORBITER/ET INTERFACE REQUIREMENTS
DISCONNECT VALVE ADJUSTMENTS

GUCP INTERFACE PLATE
REQUIRES GSE AND PROCEDURES FOR HORIZONTAL PROCESSING
FLUID GSE FOR ET PROCESSING

THE GROUND SUPPORT SYSTEM FOR SERVICING THE EXTERNAL TANK (ET) WILL CONSIST OF A NETWORK OF PNEUMATIC PANELS TO REGULATE AND DISTRIBUTE FACILITY HELIUM AND NITROGEN GASES FOR PRESSURIZATION, MONITORING, AND MAINTENANCE OF TANK PRESSURES, VENT VALVES FUNCTIONAL CHECKS AND VARIOUS LEAK CHECKS ASSOCIATED WITH PROCESSING.

THE EXISTING ET PROCESSING GROUND SUPPORT SYSTEM PANELS IN THE VAB CAN BE RELOCATED TO THE NEW ET/LRB PROCESSING FACILITY.
ET/LRB HORIZONTAL PROCESSING FACILITY CONCEPT

THE NEW OFFLINE FACILITY WILL PROVIDE THE CAPABILITY TO PROCESS TWO ET's AND FOUR LRB's HORIZONTALLY. SHOP AREAS ARE PROVIDED FOR ENGINE, BATTERY, TPS, AND ELECTRONICS/AVIONICS ACTIVITIES. THE PROCESSING BAY WILL PROVIDE CRANE SUPPORT AND SPACE FOR GSE; PLATFORMS AND STRUCTURES REQUIRED FOR ACCESS AND INSTALLATION; AND REMOVAL OF ENGINES, LRU's, AND OTHER COMPONENTS AND SUBSYSTEMS. FINAL CHECKOUT OF COMPONENTS AND SUBSYSTEMS OF THE LRB's AND ET's WILL BE CONDUCTED ON THE HPF. AREAS FOR LOGISTICS, GSE AND LRU STORAGE, OFFICE, AND CONTROL ROOM ARE PROVIDED. SPACE IS PROVIDED FOR FACILITY ELECTRICAL AND MECHANICAL EQUIPMENT, AND THERE WILL BE A HIGH PRESSURE GAS STORAGE AREA FOR HELIUM AND NITROGEN. FLOOR TRENCHES IN THE HIGH BAY AREAS ARE PROVIDED FOR CABLE AND GAS PIPING RUNS.
HPF SITING

SELECTION TRADE STUDIES WERE CONDUCTED FOR FOUR POSSIBLE HPF SITES IN THE LC-39 AREA

1. SOUTH OF THE SPC LOGISTICS FACILITY ON CONTRACTORS ROAD
2. SOUTH OF THE TURN BASIN ADJACENT TO THE PRESS SITE
4. NORTH OF THE VAB AND EAST OF THE ORBITER, MAINTENANCE, AND PROCESSING FACILITY (OMRF)

THE SITE NEAR THE PRESS SITE LOCATION IS RECOMMENDED, SINCE IT BEST SATISFIES THE MAJORITY OF THE SELECTION CRITERIA. THE LOCATION WOULD BE IN CLOSE PROXIMITY TO THE VAB, BARGE TERMINAL, EXISTING TOW ROUTE TO THE VAB, AND EXISTING FACILITIES AND SERVICES. THE SITE IS BEYOND THE VAB QUANTITY/DISTANCE AREA AND OUTSIDE THE CURRENTLY DEFINED LAUNCH DANGER AREA. LC-39 TRAFFIC CONGESTION WOULD NOT BE SIGNIFICANTLY INCREASED, TOW ROUTE CONSTRUCTION WOULD BE MINIMUM. SITE PREPARATION COSTS WOULD BE MINIMIZED BECAUSE THIS AREA IS CURRENTLY UTILIZED AND HAS ALREADY HAD ENVIRONMENTAL IMPACT STUDIES PERFORMED. A MINIMUM OF DEMOLITION AND RELOCATION OF FACILITIES IS REQUIRED.

<table>
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<th>PRIMARY TRADE SELECTION CRITERIA</th>
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<th>SITE 3</th>
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<tr>
<td>KEY-APPROPRIATION FACILITY PROXIMITY</td>
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<td>GOOD</td>
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</tr>
<tr>
<td>TURN BASIN PROXIMITY</td>
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<td>ND</td>
<td>ND</td>
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<tr>
<td>LAUNCH DANGER AREA (QUANTITY/DISTANCE)</td>
<td>OUT</td>
<td>OUT</td>
<td>IN</td>
<td>IN</td>
</tr>
<tr>
<td>ENVIRONMENTAL IMPACTS</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>ET &amp; UB TOW ROUTES PROXIMITY</td>
<td>NO</td>
<td>GOOD</td>
<td>GOOD</td>
<td>NO</td>
</tr>
<tr>
<td>LC-39 AREA CONGESTION (INCLUDING TRAFFIC)</td>
<td>GOOD</td>
<td>GOOD</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>AVAILABILITY OF UTILITY SERVICES</td>
<td>NO</td>
<td>GOOD</td>
<td>GOOD</td>
<td>NO</td>
</tr>
<tr>
<td>DEMOLITION AND RELOCATION OF EXISTING FACILITIES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>SITE PREPARATION COSTS</td>
<td>LOW</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
<td>LOW</td>
</tr>
</tbody>
</table>

Legend:
NO = NOT GOOD
GOOD = GOOD
MEDIUM = MEDIUM

Lockheed
Space Operations Company
ET/LRB HORIZONTAL PROCESSING FACILITY - CONTROL ROOM REQUIREMENTS

USE OF THE FIRING ROOMS IN THE LAUNCH CONTROL CENTER (LCC) TO PERFORM TESTING CAN BE RULED OUT. BASED ON THE ESTIMATES OF NEW LRB SYSTEMS THAT ARE EXPECTED TO UNDERGO TESTING PRIOR TO FLIGHT, THE INCREASE IN FIRING ROOM REQUIREMENTS WOULD BE GREATER THAN COULD BE PROVIDED BY THE EXISTING LCC EQUIPMENT WITHOUT IMPACTING ON-GOING SHUTTLE OPERATIONS.

AN INDEPENDENT CONTROL ROOM WILL BE PROVIDED IN THE HPF FOR THE PERFORMANCE OF ALL PRE-MATE CHECKOUT. THE NEW CONTROL ROOM WILL BE A MINT-FIRING ROOM FOR INITIAL TESTING OF LRB's AND ET's SOON AFTER THEIR ARRIVAL AND RETEST AFTER MAINTENANCE, REPAIR, OR MODIFICATIONS. TESTING WILL INCLUDE FUNCTIONAL TESTS OF ENGINE COMPONENTS, THRUST VECTOR CONTROL (TVC) SYSTEMS, AVIONICS, INSTRUMENTATION, AND POWER SYSTEMS ON THE LRBs. SIMILAR TESTING OF ET SYSTEMS CURRENTLY PERFORMED IN THE VAB HIGH BAYS WILL ALSO BE PERFORMED.

THE CONCEPT OF A CONTROL ROOM IN THE HPF SEPARATE FROM THE LCC FIRING ROOM IS RECOMMENDED PRIMARILY BECAUSE IT WOULD SUPPORT PARALLEL SHUTTLE PROCESSING AND LRB IMPLEMENTATION.

IT IS STRONGLY SUGGESTED THAT LPS-2 BE UTILIZED TO SPECIFY AND PROVISION FOR THE HPF CONTROL ROOM LPS EQUIPMENT. THIS IS RECOMMENDED BECAUSE OF INITIAL FABRICATION COST AND RECURRING/REPLACEMENT COST. IF THE LPS EQUIPMENT IS SEPARATELY SPECIFIED AND THEN LATER UPGRADED TO LPS 2, A PROCESSING SCHEDULE IMPACT AND ADDED COST WILL BE EXPERIENCED.
ET / LRB HPF CONCLUSIONS

- **PROCESSING** ET / LRB OFFLINE-INDEPENDENT OF INTEGRATED STS FLOW

- **ACTIVATION** OF FACILITY WILL NOT IMPACT ON-GOING OPERATIONS

- **PROCESSING** OUT OF VAB SAFETY ZONE

- **ET GROUND UMBILICAL CARRIER PLATE** (GUCP) INSTALLATION IN THE HPF WILL REQUIRE NEW GSE, PROCEDURES AND ET TRANSPORTER MOD
VAB HIGH BAY 3 - INTEGRATION


THE LRB WILL BE LIFTED AND STACKED ON THE MLP HOLD DOWN SYSTEM. THE ATTACH STRUT LOCATIONS WILL BE THE SAME AS FOR THE SRB's. THEREFORE, EXISTING SRB ACCESS PLATFORMS CAN BE MODIFIED FOR DUAL CAPABILITY.

ONLY THREE LRB AREAS REQUIRE ACCESS: FORWARD, INTERTANK, AND AFT SKIRT:

THE STRUCTURAL INTEGRITY OF THE EXISTING ENTENSIBLE PLATFORMS WILL BE AFFECTED BY THE MODIFICATIONS REQUIRED TO CLEAR THE ENVELOPE OF THE LRB. EACH FLOOR LEVEL WILL BE ANALYZED ON A CASE-BY-CASE BASIS. THE LRB CONCEPT CHOSEN WILL DETERMINE THE EXTENT OF IMPACT ON THE STRUCTURAL MEMBERS.

ALL EXISTING SRB ACCESS REQUIREMENTS WILL BE REVIEWED TO ENSURE THAT THE NEW MODIFICATIONS FOR LRB WILL NOT ELIMINATE THE ABILITY TO PERFORM THE REQUIRED OPERATIONAL TASKS.

AS STATED IN THE GROUND RULES, THE MODIFICATION OF HIGH BAY 3 TO SUPPORT BOTH LRB's AND SRB's WILL NOT COMMENCE UNTIL HIGH BAY 4 IS OPERATIONAL FOR PROCESSING WITH LRB/SSVs. THIS SCENARIO WILL HAVE THE LEAST IMPACT ON THE ON-GOING FLIGHT SCHEDULE, SINCE SRB FLIGHTS WILL THEN BE BELOW SEVEN PER YEAR AND CAN BE SUPPORTED BY HIGH BAY 1 ONLY.

<table>
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<tr>
<th>LRB Access Requirements</th>
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</thead>
<tbody>
<tr>
<td>HDR1</td>
</tr>
<tr>
<td>10'6&quot;</td>
</tr>
<tr>
<td>14'6&quot;</td>
</tr>
<tr>
<td>18'6&quot;</td>
</tr>
<tr>
<td>22'6&quot;</td>
</tr>
<tr>
<td>23'5-1/2&quot;</td>
</tr>
</tbody>
</table>

* LOCKHEED SPACE OPERATIONS COMPANY*
ACCESS REQUIREMENTS HB-3

2ND FLOOR ACCESS TO NOSE CONE AVIONICS FOR GDSS LO2/LH2

AP 100 REDESIGNED TO ACCESS NOSE CONE AVIONICS FOR MMC LO2/RP-1 AND SRB EL 180'-11"

AP 46 & 47 TO ACCESS GDSS LO2/LH2 INTERTANK AREA AND SRB TOP/FWD ATTACH STRUT EL 171'-6 3/8"

AP 98 (SRB FIELD JOINT ACCESS) REDESIGNED TO CLEAR LRB EL 182'-2"

AP 50 (SRB FIELD JOINT ACCESS) REDESIGNED TO ROLLBACK EL 134'-3 1/4"

AP 93 (SRB FIELD JOINT ACCESS) REDESIGNED TO CLEAR LRB EL 109'-0"

NEW INTERTANK ACCESS PLATFORM FOR MMC LO2/RP-1 APPROX. 5'-0" ABOVE 3RD FLOOR

AP 48 (SRB FIELD JOINT ACCESS) REDESIGNED TO CLEAR LRB EL 80'-2 1/2"

MMC LO2/RP-1 PUMP FED LRB

MLP "O" DECK
EL 47'-0"

8100S-01BB-V/G
VAB HIGH BAY LRB/SSV ROLLOUT CLEARANCES

AN EVALUATION STUDY WAS CONDUCTED ON VAB HIGH BAY 3 PLATFORMS AND VAB HIGH BAY 3 AND 4 DOORS FOR LRB/ET/ORBITER EXIT CLEARANCES FROM THE VAB.

IMPACTS TO HIGH BAY 3 PLATFORMS

PLATFORMS AT LEVELS D, B, E, AND C IN HIGH BAY 3 RETRACT OR FLIP UP TO ALLOW SRB/ET/ORBITER STACK CLEARANCE WHEN EXITING THE HIGH BAY.

PLATFORMS AFFECTED FOR THE MMC LO₂/RP1 PUMP-FED VEHICLE INCLUDE:

A. ROOF AND MAIN PLATFORMS OF LEVEL D
B. MAIN, SECOND, AND ROOF PLATFORMS OF LEVEL B
C. MAIN PLATFORM OF LEVEL E

THE PLATFORMS NOT AFFECTED INCLUDE:

A. SECOND AND THIRD PLATFORMS OF LEVEL D
B. ROOF PLATFORM OF LEVEL E
C. MAIN, SECOND, AND ROOF PLATFORMS OF LEVEL B

VAB DOOR EXIT CLEARANCE

VAB EXIT DOOR WIDTH FOR SRB/ET/ORBITER STACK CLEARANCE IS 71 FT 1 INCH. DOOR CLEARANCES HAVE BEEN EVALUATED FOR SEVEN CASES. ALL SELECTED LRB CONFIGURATIONS WILL PROVIDE ADEQUATE VAB DOOR CLEARANCES.
LRB INTEGRATION FLUID GSE FOR HIGH BAY 3 AND HIGH BAY 4

The integration processing ground support equipment for the liquid rocket boosters will consist of equipment to support tank monitoring, contingency pressurization, vent valve actuation, and LRB engine leak check operations. The baseline requirements for LRB servicing are similar to the ET processing operations performed in High Bay 3 of the VAB. A network of similar pneumatic panels are required in High Bay 4 and on the LRB-dedicated MLP.

The pneumatic system will consist of a network of pneumatic panels that will regulate and distribute facility helium and nitrogen gases for pressurization, monitoring, safing and maintenance of tank pressures, vent valve operations, and various leak checks.

The existing VAB facility helium and nitrogen high pressure regulation and control system can be used to regulate and distribute the facility gas to the pneumatic support system.
VAB HIGH BAY 3 CONCLUSIONS

- Platforms to support LRB will be required

- All LRB configurations infringe on High Bay 3 platforms during exit

- All platforms require modification for LRB diameter

- New GSE for LRB required
VAB HIGH BAY 4 - INTEGRATION

TO MEET A LAUNCH RATE OF THREE LRB's IN 1996 AND STILL MAINTAIN SRB LAUNCH PROCESSING OPERATIONS IN HIGH BAY 1 AND HIGH BAY 3, IT WILL BE NECESSARY TO CONVERT HIGH BAY 4 INTO AN LRB STACKING AND INTEGRATION CELL.

AT PRESENT HIGH BAY 4 IS USED AS A STORAGE AND CHECKOUT CELL FOR THE ET AND HAS A BACKUP CAPABILITY OF PROVIDING BUILDUP STANDS FOR THE SRB AFT SEGMENTS. NO PLATFORMS ARE AVAILABLE TO ACCESS THE ORBITER, LRB, OR ET. NEW PLATFORMS WILL BE BUILT.

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<tbody>
<tr>
<td>BOOMER DIAZMETER</td>
<td>15.2</td>
<td>16'</td>
<td>16'</td>
<td>16'</td>
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</tr>
<tr>
<td>HEIGHT</td>
<td>150'</td>
<td>162 Y</td>
<td>166 Y</td>
<td>166 Y</td>
<td>166 Y</td>
<td>166 Y</td>
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<tr>
<td>ENGIN LEVEL ACCESS</td>
<td>EL 47'</td>
<td>EL 47'</td>
<td>EL 47'</td>
<td>EL 47'</td>
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<tr>
<td>INTEREASESS</td>
<td>PLATFORM 116' 3'</td>
<td>PLATFORM 116' 3'</td>
<td>PLATFORM 147' 4'</td>
<td>PLATFORM 116' 3'</td>
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<tr>
<td>EWD ACCESS</td>
<td>PLATFORM 116' 3'</td>
<td>PLATFORM 116' 3'</td>
<td>PLATFORM 116' 3'</td>
<td>PLATFORM 116' 3'</td>
<td>PLATFORM 147' 4'</td>
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<thead>
<tr>
<th>ACCESS REQUIREMENTS</th>
<th>OPERATOR</th>
<th>CSRF OPERATOR</th>
<th>ACCESS TO PRODUCT</th>
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<tr>
<td>AFT FASCULATING ACCESS DOOR</td>
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<td></td>
<td>INFLOOR PLATFORM LEVEL 3 AP 38</td>
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<tr>
<td>AFT ATTACH POINT</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>SRB FASCULATING AND PRFLENT LINKS</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEREASESS</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>EWD ACCESS ROOM + STAR TRACER DOOR</td>
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<td></td>
<td>INFLOOR PLATFORM LEVEL 3 AP 38</td>
</tr>
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<td>EWD ATTACH POINT</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>EWD SERVICE PLATFORM</td>
<td>✓</td>
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</table>

TO CONVERT HIGH BAY 4 INTO AN STS INTEGRATION FACILITY, THE PRESENT ET CHECKOUT FUNCTION WILL BE RELOCATED TO THE NEW ET/LRB HORIZONTAL PROCESSING FACILITY. THE SRB BUILDUP STANDS WILL BE DISMANTLED AND RELOCATED TO HIGH BAY 2.

THREE OF THE FOUR MLP PEDESTALS IN HB-4 HAVE BEEN DISMANTLED AND STORED IN THE MLP PARKSITE AREA. THESE ARE NOT IN THE BEST SHAPE STRUCTURALLY AFTER BEING IN OPEN STORAGE FOR A NUMBER OF YEARS. NEW PEDESTALS WILL BE REQUIRED.
REACTION OF CRAWLERWAY TO VAB HIGH BAY 4

A LARGE SECTION OF CRAWLERWAY REQUIRE REFURBISHMENT FOR HB-4 USE. IT STARTS NORTHWEST OF THE OMRF WHERE IT JOINS THE EXISTING CRAWLERWAY AND PROCEEDS SOUTH AND EAST TO THE NORTHWEST CORNER OF THE VAB (HIGH BAY 4).

THE OPF MODULAR COMPLEX WILL REQUIRE RELOCATION. A SECTION OF THE ORBITER TOWWAY FROM THE OPF TO THE VAB WILL HAVE TO BE MODIFIED TO BE COMPATIBLE WITH BOTH THE ORBITER AND CRAWLER. CURRENTLY, A PARKING AREA IS LOCATED EAST OF THE OPF MODULAR COMPLEX AND A PORTION OF THIS MUST BE DELETED: A SECTION OF RAILROAD WILL HAVE TO BE REROUTED; AND A SECTION OF FENCE CROSSING THE CRAWLERWAY SITE WILL BE RELOCATED. VARIOUS UNDERGROUND UTILITY LINES AND MANHOLES WILL REQUIRE RELOCATION. THE OMRF ECS DUCT AND CHILL WATER PIPING FROM THE VAB, WHICH RUNS ALONG THE WEST SIDE OF THE PARKING AREA AND UNDER THE TOWWAY MUST BE RELOCATED.

REACTION REQUIREMENTS

THE OLD CRAWLERWAY BED MUST BE PREPARED WITH A NEW COMPACTED BASE COURSE, AS REQUIRED. A BITUMINOUS PRIME COAT SHOULD BE APPLIED AND THE BED RESURFACED WITH GRAVEL, AND CURBS ADDED.

UTILITY AND COMMUNICATIONS LINES BENEATH THE CRAWLERWAY WILL REQUIRE RELOCATION AND ADEQUATE PROTECTION AGAINST CRAWLER LOADS. NEW COMMUNICATION AND ELECTRICAL MANHOLES ARE REQUIRED. THE ECS CROSSCOUNTRY DUCT CAN BE REROUTED ADJACENT TO THE CRAWLERWAY AND NEW GATES INSTALLED WHERE THE FENCE CROSSES THE CRAWLERWAY.
• NEW PLATFORM STRUCTURES FOR ORBITER / ET / LRB REQUIRED

• ET PROCESSING MOVED TO HPF

• SRB WORK STANDS MOVE TO HIGH BAY 2

• CRAWLERWAY MUST BE REACTIVATED

• GSE FOR ORBITER / ET / LRB REQUIRED
MLP EXHAUST HOLES (MMC)

MMC LOX/RP1 PUMP-FED CONFIGURATION IMPACTS. THE IMPACTS OF THIS CONFIGURATION ON THE EXISTING MLP STRUCTURAL DESIGN ARE SHOWN IN THE FIGURE.


COMPARISONS BETWEEN PUMP-FED AND PRESSURE-FED CONCEPTS HAVE BEEN DEVELOPED. EXHAUST HOLE SIZES, GIRDOR LOCATION CLEARANCES, AND IMPACTS HAVE BEEN IDENTIFIED. FOR EXAMPLE: GIRDER G-20 GOES AWAY TOTALLY IN THE PRESSURE-FED CONCEPT.

G-20 IS THE MAIN GIRDER OF MLP STRUCTURAL FRAMINGS. ANY RELOCATION NORTH OF THE PRESENT POSITION WOULD MAKE THE SSME EXHAUST HOLE SMALLER. RELOCATING G-20 TOWARD THE SOUTH FROM ITS PRESENT POSITION WOULD GIVE IT HEAVY EXPOSURE TO LRB ENGINE BLAST. RESOLUTION OF THIS DILEMMA IN THE NEW MLP DESIGN WILL BE A CHALLENGE.

TO MEET THE GROUND RULES, ALL STRUCTURAL DESIGNS REQUIRE A MINIMUM OF THREE ENGINE NOZZLE DIAMETERS CLEARANCE FROM ANY FLAT SURFACE, AS STATED IN PARAGRAPH 3.5 OF "STANDARD FOR FLAME DEFLECTOR DESIGN (KSC-STD-Z-0012)."

RELOCATING GIRDER G-20 WOULD SERIOUSLY AFFECT THE STRUCTURAL INTEGRITY OF THE EXISTING MLP, AND TOTAL OMISSION IS NOT FEASIBLE. DESIGN FEASIBILITY OF PROVIDING A NEW GIRDER IN THE REDESIGN IS QUESTIONABLE.

MODIFICATION OF MLP-1 & 2 FROM THE OLD APOLLO SYSTEM TOOK 5 YEARS EACH. ALL LRB MODIFICATIONS WOULD TAKE ABOUT THE SAME LENGTH OF TIME OR MORE IF PERMITTED BY DESIGN FEASIBILITY.

IT IS THEREFORE RECOMMENDED THAT A NEW MLP BE BUILT TO START THE LRB PROGRAM.
<table>
<thead>
<tr>
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<th>LO2/RP-1 PUMP-FED</th>
<th>LO2/RP-1 PRESS-FED</th>
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<tr>
<td>BOOSTER DIAMETER</td>
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<tr>
<td>SKIRT DIAMETER</td>
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<tr>
<td>Q LRB FROM Q ET</td>
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<td>EXHAUST HOLE SIZE</td>
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<tr>
<td>IMPACT TO G-20 AT 6° ENGINE GIMBAL</td>
<td>APPROX .8&quot; CLEARANCE FROM BLAST SHIELD</td>
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<tr>
<td>Q G-10 TO RELOCATED G-25 AND G-4 TO RELOCATED G-2</td>
<td>6'-3 1/8&quot;</td>
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<td>Q ET TO RELOCATED G-23 AND G-24</td>
<td>6'-1 1/8&quot;</td>
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<tr>
<td>LOCATION OF NEW HOLDDOWN POST HAUNCHES</td>
<td>TBD</td>
<td>TBD</td>
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<tr>
<td>ENGINE LAYOUT</td>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
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</table>
MLP EXHAUST HOLES (GDSS)

GDSS LOX/RP-1 PUMP-FED CONFIGURATION IMPACTS. THE IMPACTS OF THIS CONFIGURATION ON THE EXISTING MLP STRUCTURAL DESIGN ARE SHOWN IN THE FIGURES.


COMPARISONS HAVE BEEN MADE BETWEEN GDSS LOX/RP-1 PUMP-FED, LOX/LH2 AND LOX/CH4 CONCEPTS. THE SIZE OF EXHAUST HOLES, LOCATION OF GIRDERS, AND IMPACT TO EXISTING GIRDER G-20 CAN BE SEEN IN THE FIGURE.

G-20 IS THE MAIN GIRDER OF MLP STRUCTURAL FRAMINGS. ANY RELOCATION NORTH OF THE PRESENT POSITION WOULD MAKE THE SSME EXHAUST HOLE SMALLER. RELOCATING G-20 TOWARD THE SOUTH FROM ITS PRESENT POSITION WOULD GIVE IT HEAVY EXPOSURE TO LRB ENGINE BLAST.

TO MEET THE GROUNDRULES, ALL STRUCTURAL DESIGNS REQUIRE A MINIMUM OF THREE ENGINE NOZZLE DIAMETERS CLEARANCE FROM ANY FLAT SURFACE, AS STATED IN PARAGRAPH 3.5 OF "STANDARD FOR FLAME DEFLECTOR DESIGN (KSC-STD-Z-0012)."

RELOCATING GIRDER G-20 WOULD SERIOUSLY AFFECT THE STRUCTURAL INTEGRITY OF THE MLP, AND TOTAL OMISSION IS NOT FEASIBLE. DESIGN FEASIBILITY OF PROVIDING A NEW GIRDER IN THE LRB EXHAUST HOLES MAY BE QUESTIONABLE.

MODIFICATION OF MLP-1 & 2 FROM THE OLD APOLLO SYSTEM TOOK 5 YEARS EACH. ALL LRB MODIFICATIONS WOULD TAKE ABOUT THE SAME LENGTH OF TIME OR MORE IF PERMITTED BY DESIGN FEASIBILITY.

IT IS THEREFORE RECOMMENDED THAT A NEW MLP BE BUILT TO START THE LRB PROGRAM.

Lockheed
Space Operations Company

KSC FORM 29 43 REV. 4/96
C-27A
MLP EXHAUST HOLE WALL FLAME IMPINGEMENT

GDSS LOX/RP-1 PUMP-FED

SOFT RELEASE HOLDOWN

HOLDOWN HAUNCH

FOLDDOWN MODIFIED SIDE FLAME DEFLECTOR

ENGINE LAYOUT

MLP 'O' DECK

GIMBAL

58'-0'' FLAME TRENCH

20'-4'' 21'-10'' 20'-10''

8'-7 3/4'' 10'-8''

27'-6 1/2''

11'-4 1/2''

3°

73°
MLP COLUMN LINE G-20 FLAME IMPINGEMENT

ENGINE LAYOUT

SOFT RELEASE HOLDDOWN
NEW GIRDER

G-20 GIMBAL

MLB IN LRB CONFIGURATION

EXISTING FLAME DEFLECTOR

LOCKHEED
Space Operations Company
# Comparisons Between GDSS Configurations

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<tbody>
<tr>
<td><strong>Booster Diameter</strong></td>
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<td>15'-0&quot;</td>
<td>16'-2&quot;</td>
<td>15'-0&quot;</td>
</tr>
<tr>
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<td>26''-9 1/2&quot;</td>
<td>22'-3 1/2&quot;</td>
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<tr>
<td>ξ LRB From ξ ET</td>
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<td>22'-3 1/2&quot;</td>
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<td>Q ET To Relocated G-23 And G-24</td>
<td>6'-3&quot;</td>
<td>6'-8 1/2&quot;</td>
<td>8'-3 1/2&quot;</td>
<td>6'-8 1/2&quot;</td>
</tr>
<tr>
<td>Q G-10 To Relocated G-25 and G-4 to Relocated G-22</td>
<td>7'-7&quot;</td>
<td>7'-1 1/2&quot;</td>
<td>5'-6 1/2&quot;</td>
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</tr>
<tr>
<td><strong>Location of New Girder to Support Release Mech From ξ LRB</strong></td>
<td>15'-7&quot;</td>
<td>15'-7&quot;</td>
<td>15'-7&quot;</td>
<td>15'-7&quot;</td>
</tr>
<tr>
<td><strong>Haunch Size &amp; Supports</strong></td>
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<td>TBD</td>
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<tr>
<td><strong>Engine Layout</strong></td>
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<td><img src="image2.png" alt="Layout" /></td>
<td><img src="image3.png" alt="Layout" /></td>
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**Lockheed Space Operations Company**

81005-01AB-V/G

LRF1
• NEW MLPs FOR LRB REQUIRED

• EXTENSIVE DEMOLITION

• FLAME IMPINGEMENT IMPACT

• G-20 STRUCTURAL IMPACT

• G-20 COLUMN LINE FLAME IMPINGEMENT IMPACT

• FOR X PATTERN ENGINES CROSS MEMBER FOR HOLDDOWN SUPPORT

• INFRINGEMENT OF BOOSTER EXHAUST WITH SSME EXHAUST
LRB ENGINE LEVEL ACCESS

ACCESS FOR ENGINE MAINTENANCE CAN BE PROVIDED BY BUILDING PLATFORMS SIMILAR TO THE SSME PLATFORMS. AT PRESENT THE SSME SERVICE PLATFORMS ARE LIFTED INTO THE ORBITER EXHAUST HOLE OF THE MLP UTILIZING WINCHES. SIMILAR SERVICE PLATFORMS ARE USED FOR SRBs.
FRAME TRENCH

THE ANALYSIS OF THE FLAME TRENCH IS BASED ON THE ASSUMPTION THAT MODIFICATIONS TO THE EXISTING FLAME TRENCH MUST BE AVOIDED.


THIS STUDY HAS ANALYZED THE IMPACTS ON MAIN AND SIDE DEFLECTORS. THE BASELINE LRBs FOR THE ANALYSIS WERE THE GDSS AND MMC PUMP-FED CONCEPTS USING LOX/RP-1.

SIDE FLAME DEFLECTOR IMPACTS


MAIN FLAME DEFLECTOR IMPACTS

SIDE FLAME DEFLECTORS

THERE ARE BASICALLY TWO LRB ENGINE CONFIGURATIONS; ONE BY GENERAL DYNAMICS SPACE SYSTEMS DIVISION AND ANOTHER BY MARTIN MARIEETTA SPACE MANNED SYSTEMS. EACH HAS A FOUR-ENGINE CONFIGURATION WITH THE BASIC DIFFERENCE BETWEEN THEM BEING A CLOCKING ANGLE OF 90°.

BOTH CONCEPTS OF THE LRB ENGINES HAVE THE CAPABILITY OF GIMBALLING 6° MAXIMUM FROM THE NEUTRAL POSITION. THIS INTRODUCES HIGHER BLAST PRESSURES ON THE SIDE DEFLECTORS AT MAXIMUM GIMBAL POSITION.

MAXIMUM IMPINGEMENT ANGLE OF THE FLAME DEFLECTORS IS DEPENDENT ON THE POSITION OF THE LRB ENGINES. THE BLAST PRESSURES INTRODUCED ON THE FLAME DEFLECTOR CAN BE EXTREME.

THE FIGURES SHOW BOTH GDSS AND MMC IMPACT CONCEPTS. ALL ENGINES ARE SHOWN IN THE 6° GIMBALED POSITIONS AND THE AREA OF IMPACT ON SIDE DEFLECTOR IS ILLUSTRATED. AT PRESENT SRB BLAST PRESSURE HAS NO DIRECT IMPINGEMENT ON SIDE FLAME DEFLECTORS. THE EXISTING SOUND SUPPRESSION SYSTEM ALSO RECEIVES DIRECT BLAST PRESSURES FROM LRB ENGINES. FURTHER EVALUATION AND STUDY ARE REQUIRED.

A NEW SEALING CONCEPT AND DESIGN WILL BE REQUIRED TO STOP EXHAUST FROM GOING BETWEEN THE MLP AND THE TOP EDGE OF THE SIDE DEFLECTORS.

SIGNIFICANT REDESIGN OF THE SIDE FLAME DEFLECTOR WILL BE REQUIRED. A 6.4 PER CENT SCALE MODEL TEST AND RECERTIFICATION FOR FLIGHT READINESS OF THE NEW DEFLECTORS IS REQUIRED.
MAIN FLAME DEFLECTOR

AN EVALUATION OF THE EXISTING MAIN FLAME DEFLECTOR REVEALED MAJOR PROBLEMS. WITH THE CONFIGURATION OF THE NEW LRB ENGINES, THE BOOSTER BLAST PRESSURES HAVE SHIFTED SOUTH ON THE MAIN DEFLECTOR INTRODUCING A DIRECT HIT TO THE APEX OF THE DUAL ANGLE DEFLECTOR. THIS IS TRUE EVEN WITH THE LRB ENGINES IN THE NULL POSITION. THESE PRESSURES WILL INCREASE AS THE LRB ENGINES GIMBAL TO THEIR MAXIMUM POSITION AND SPILL-OVER INTO THE SSME SIDE IS LIKELY. THE MAIN DEFLECTOR NEEDS TO BE REDESIGNED AND POSITIONED SOUTH OF THE PRESENT LOCATION TO AVOID THIS CONDITION.
MAIN DEFLECTOR FLAME IMPINGEMENT

MMC LOX/RP-1 PUMP-FED

SOFT RELEASE HOLDDOWN
NEW GIRDER
GIMBAL
EXISTING FLAME DEFLECTOR
MLB IN LRB CONFIGURATION
LRB CONFIGURATION

11'-4 1/2''
3°
0-20

C LRB
14'-6''

ENGINE LAYOUT

81005-01E-V/G
VE2
LPB ACCESS REQUIREMENTS


FORWARD (NOSE CONE) AREA ACCESS - THIS AREA IS ABOUT THE SAME LEVEL AS FOR SRB FORWARD AREA ACCESS. WITH DOME MODIFICATIONS TO THE EXISTING PLATFORM, ACCESS TO THE FORWARD AREA FOR LRB CAN BE ACHIEVED. THIS IS GOOD FOR MMC LOX/RP-1 PUMP-FED AND GDSS CONCEPTS. BUT, FOR TALLER BOOSTERS THERE IS NO EXISTING STRUCTURES TO SUPPORT ACCESS. A FURTHER STUDY WILL BE REQUIRED. THIS STUDY WILL EXAMINE THE POSSIBILITY OF ADDING STRUCTURAL MEMBERS FROM FSS/RSS STRUCTURES TO SOLVE THESE ACCESS PROBLEMS. A PROPOSED CONCEPT IS SHOWN. THIS CONCEPT REQUIRES IN-DEPTH ANALYSIS AND DESIGN.
ORBITER/ET UMBILICAL IMPACTS

This section describes the impact to existing LC-39 umbilicals and swing arms that will result from a conversion from SRBs to LRBs in the Space Shuttle program.

Five major umbilicals and three swing arms are required to service the SRB-configured shuttle system at the launch pad. Of these, all but the SRB joint heater umbilicals will still be required for an LRB-equipped shuttle.

Existing orbiter and ET ground interfaces will remain at current position relative to LC-39. Number and size of connections across existing orbiter and ET ground interfaces will not change significantly. Although it is assumed for the purpose of this study that the vehicle excursions will not change, the impact of an increase should be considered. A significant increase in vehicle excursions could affect all the existing systems requiring hardware modifications and require LETF testing. Two systems in particular, the GOX vent and TSM's, currently have very little capability for excursion growth without hardware modification. Also, the ET GH2 vent and OAA have limited capability for excursion increases. Although vehicle launch drifts will change due to a decrease in the thrust-to-weight ratio and blast loads will change they still need to be addressed in greater detail in Phase B.

Based on the assumptions of this study, the primary concern for LRB compatibility is that LRBs have sufficient clearance for all prelaunch conditions. Ground systems must clear LRB's during disconnect and retraction. The LRB's must clear systems for worst case launch drifts.
<table>
<thead>
<tr>
<th>CANDIDATE LSE</th>
<th>LSE MOD / RETEST</th>
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<tr>
<td>ORBITER ACCESS ARM (1 EACH PAD)</td>
<td>MOD / RETEST DEPENDENT ON EXCURSIONS OF LRB / SSV</td>
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<tr>
<td>ET INTERTANK ACCESS ARM (1 EACH PAD)</td>
<td>MOD / RETEST DEPENDENT ON EXCURSIONS OF LRB / SSV</td>
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<tr>
<td>MOD OF ET GH2 VENT LINE / ARM SYS (1 EACH PAD)</td>
<td>MOD / RETEST DUE TO LRB DIAMETER</td>
</tr>
<tr>
<td>MOD OF ET GOX VENT ARM AND SYS (1 EACH PAD)</td>
<td>MOD / RETEST DUE TO LRB LENGTH</td>
</tr>
<tr>
<td>MOD OF LOX / LH2 TSM (2 EACH MLP)</td>
<td>MOD / RETEST DEPENDENT ON EXCURSIONS OF LRB / SSV</td>
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</table>
GOX VENT ARM

This arm will be generally unaffected by the diameter for any of the LRB concepts. However, LRB lengths over 170 ft will have hard interference with the existing structure.

To accommodate the ET GOX venting for the longer LRBs, it will be necessary to place the vent arm alongside the booster rather than over it, as in the existing design. For a GDSS-L02/LH2 LRB to obtain a 2-ft clearance, it would be necessary to place the vent arm at 45 degrees to the booster centerline. The arm could be projected north or south of the vehicle. North was chosen to place the pivot closer to the existing position, thereby simplifying routing of fluid and electrical service lines.

The concept will use as much of the existing arm and associated components as possible, but it would require a new or modified hood assembly, a new aft arm segment, new hinge and hinge actuating mechanism, and structural additions to the FSS. Additionally, a modification of this magnitude would almost certainly require launch equipment test facility (LETF) requalification.
ET H2 VENT

There are two major areas of concern for LRB compatibility with this umbilical. The first and most significant concern deals with vehicle drift clearance to the ET vent support structure. The minimum clearance occurs as the skirt passes the 222-ft 6.5-in level. A plan view is shown of the SRB skirt to structure clearance at the 222-ft 6.5-in level. Note the minimum clearance is 2.7 ft.

Assuming a similar drift for the LRB's vs SRB and applying the larger skirt diameters, the structure-to-vehicle relationship is shown. Note that all the LRB concepts show interference at the 222-ft 6.5-in level. Unless the drifts could be modified to obtain clearance, it will be necessary to relocate the ET vent structure. But relocating the structure would obviously produce some major system impacts. First, since the ET intertank access arm is mounted on the structure, it would have to be lengthened to reach the ET. Also, the distance the structure is moved would require additional umbilical vent lines. And lengthening the vent line would necessitate modifying the lower level of the ET vent structure and deceleration unit, since the vent line would extend to a lower level in the retracted position. (Vent line is vertical when retracted.) Furthermore, lengthening the vent line would aggravate the already marginal safety factor for the pyro-bolt, which holds the umbilical to the vehicle. Maintaining the pyro-bolt load within acceptable limits could prove very difficult and could lead to revision of the basic operating design of the umbilical.

In summary, if relocating the ET vent structure is necessary, an extensive design and modification effort would be required, along with LETF requalification testing.
ET H2 VENT

The second area of concern for the ET vent deals with clearance of the LRB during umbilical disconnect and retract. The figure shows the resulting clearance (or interference) after substituting the larger LRB diameters. As shown, only the GDSS RP-1 pump-fed has any clearance remaining. Assuming a clearance of 12 inches is desired for all cases, some modification would have to be made to the umbilical.

A concept which could alleviate this problem involves using a cam arrangement on the vent line pivot, which would swing the umbilical around the LRB during retract. This concept could conceivably be implemented without major modifications to the system. However, some LETF testing would be required.
ET H2 VENT ARM MOD LOCATION

WILL REQUIRE SHORTENING STRUCTURE 4.3'

WILL HAVE TO MOVE STRUCTURE NORTH 2.5'

TO OBTAIN CLEARANCE FOR GDSS RP-1 PUMP, NEED TO MOVE END OF STRUCTURE APPROXIMATELY 5 FT.*

ASSUME 2' MIN. CLEARANCE

* ALL THE LRB CONCEPTS REQUIRE RELOCATION OF ET VENT STRUCTURE (ASSUMING SRB DRIFTS).
-WORST CASE GDSS LO2/CH4 = 6 FT. RELOCATION
-BEST CASE GDSS LO2/LH2 = 4 FT. RELOCATION
LRB UMBILICALS

NEW CRYOGENIC UMBILICAL REQUIREMENTS

Each of the LRB concepts would require, at the least, an LO2 fill and drain umbilical. The GDSS LO2/LH2 LRB concept would also require LH2 fill/drain and vent umbilicals for each LRB. Likewise, the GDSS LO2/LCH4 LRB concept would require LCH4 fill/drain and vent umbilicals for each LRB in addition to the LO2 umbilicals. All the new umbilical GSE systems would require complete LEFE validation and qualification testing.

CRYOGENIC VENT UMBILICAL REQUIREMENTS

Although an assumption was made that vent interfaces for the cryogenic propellants would be provided in the skirt area and LOX would vent to atmosphere, there is the possibility that umbilicals might be located at upper elevations.

It will be required to capture H2 and CH4 because of their hazardous nature. The LRB configuration using LH2 and LCH4 may have umbilicals which would require swing arms and towers.

CONCLUSIONS/RECOMMENDATIONS

The requirement for new vent umbilical and swing arm systems, associated FSS modifications, and a new support tower structure can be eliminated by requiring the GDSS LO2/LH2 and LO2/LCH4 LRB concepts to have aft skirt vent umbilicals.
## LRB LSE LETF Test Requirements

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<tbody>
<tr>
<td>NEW LO2 UMB FOR EACH LRB (2 EACH MLP)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>NEW LH2 UMB FOR EACH LRB (2 EACH MLP)</td>
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<td>NEW CH4 UMB FOR EACH LRB (2 EACH MLP)</td>
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<td>NEW GH2 VENT LINE &amp; SWING ARM FOR EACH LRB (2 EACH PAD IF REQD)</td>
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<tr>
<td>NEW HOLDDOWN SYSTEM (8 EACH MLP)</td>
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<td>X</td>
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</tr>
<tr>
<td>NEW POWER / INST. FOR EACH LRB (2 EACH MLP)</td>
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<td>X</td>
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<tr>
<td>NEW RP-1 UMB &amp; SERVICE MAST FOR EACH LRB (2 EACH PAD)</td>
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ORBITER WEATHER PROTECTION SYSTEM

THIS SECTION WILL IDENTIFY THE IMPACTS TO SWING PATH OF THE -Y CURTAIN WALL BY THE LRB CONCEPTS.

A DYNAMIC CLEARANCE OF 1 FOOT SIX INCHES MUST BE MAINTAINED FROM FLIGHT HARDWARE TO HARD STEEL.

THE MMC LOX/RP-1 PUMP-FED LRB CONCEPT IN THE FIGURE SHOWS A CLEARANCE OF 8 INCHES FROM THE -Y CURTAIN WALL DURING THE EXTEND/RETRACT OPERATION. ALL OTHER LRB CONCEPTS WITH LARGER DIAMETERS WILL HAVE A GREATER IMPACT.

THIS DIRECT IMPACT ON THE EXISTING ORBITER WEATHER PROTECTION SYSTEM CANNOT BE ADDRESSED THOROUGHLY IN THIS STUDY. THE MODIFICATIONS REQUIRED WOULD BE DETERMINED BY STRUCTURAL ANALYSIS AND FURTHER DESIGN STUDY UPON COMPLETION OF LRB DOWN SELECTION.
PRESSURE-FED LRB PRESSURIZATION GSE

THE LRB PRESSURE-FED SYSTEM WILL BE EQUIPPED WITH ONBOARD PRESSURANT BOTTLES THAT WILL BE PRESSURIZED TO APPROXIMATELY 3,000 psig.

THERE ARE TWO PRESSURANT CANDIDATES BEING PROPOSED FOR LRB USE:

THE GENERAL DYNAMICS CONFIGURATIONS USE TRIDYNE (He, H2, O2.) TRIDYNE WOULD BE SUPPLIED IN TUBE BANK TRAILERS BY GENERAL DYNAMICS. THE TRAILER WILL BE PARKED INSIDE THE PAD HIGH PRESSURE GAS STORAGE FACILITY. SUPPLY GAS FROM THE TUBE BANK IS CONVEYED TO A PRESSURANT REGULATION PANEL WHERE IT WILL BE REGULATED, MONITORED, AND DELIVERED TO THE LRB'S.

THE MARTIN MARIETTA CONFIGURATIONS USE HELIUM 6,000 psig; GHe WOULD BE SUPPLIED TO THE PRESSURANT CONTROL PANEL FROM THE EXISTING PAD HIGH PRESSURE GAS STORAGE FACILITY. THE GHe LINE ALREADY EXISTS IN THE MLP AND WILL BE TAPPED AND ROUTED INTO THE LRB PRESSURANT CONTROL PANEL WHERE IT WILL BE REGULATED, MONITORED, AND DELIVERED TO THE TWO LRBs.

IF THE LRB BOTTLE FILL INTERFACE IS LOCATED ON THE LRB FORWARD SEGMENT, THE PRESSURE REGULATION WILL BE DONE WITH THE PANEL MOUNTED ON THE PCR ROOFTOP.

IF HELIUM IS USED FOR THE LRB PRESSURIZATION SYSTEM, THE HELIUM HIGH PRESSURE STORAGE BATTERY SHOULD BE EXPANDED. ADDITION OF 10 HIGH PRESSURE STORAGE BOTTLES WITH A CAPACITY OF 200 CUBIC FEET IS RECOMMENDED.

IF TRIDYNE IS USED FOR THE LRB PRESSURIZATION SYSTEM, A MINIMUM OF 11 TUBE BANK TRAILERS (ASSUMING EACH TUBE BANK TRAILER CAPACITY OF 200 CUBIC FEET) ARE REQUIRED.

HELIOUM SHOULD BE USED WITH THE LRB PRESSURE-FED SYSTEM. IT IS AN EXISTING AND KNOWN COMMODITY, AND DISTRIBUTION LINES ARE ALREADY IN PLACE.

THE ONBOARD PRESSURANT BOTTLE FILL INTERFACE SHOULD BE LOCATED ON THE AFT SEGMENT OF THE LRB FOR CONVENIENCE AND LESS INTERFERENCE WITH OTHER SHUTTLE SYSTEMS.
PROPELLANT ACQUISITION, STORAGE, AND HANDLING


THE PROPELLANTS REVIEWED INCLUDE LIQUID OXYGEN (LOX), LIQUID HYDROGEN (LH₂), ROCKET GRADE KEROSENE (RP1), AND LIQUID METHANE (LCH₄).

THE BASELINED LRB IS THE LOX/RP1 CONFIGURATIONS AND A REVIEW OF THE SYSTEM REQUIREMENTS ARE PRESENTED.

THE PRESENT PAD PROPELLANT STORAGE AREAS WILL BE UTILIZED.
LIQUID OXYGEN SYSTEM

THE ANALYSIS OF THE LRB LOX REQUIREMENTS IS BASED ON DATA PROVIDED BY GENERAL DYNAMICS AND MARTIN MARIETTA, KNOWN EXTERNAL TANK (ET)/SPACE SHUTTLE MAIN ENGINE (SSME) PROCESSING OPERATIONAL DATA, AND PRESENT SPACE SHUTTLE VEHICLE (SSV) INTERFACE CONTROL REQUIREMENTS. THE SIX LRB CONFIGURATIONS WERE ANALYZED TO DEFINE FILL AND DRAIN REQUIREMENTS, INCLUDING ANTICIPATED BOILOFF LOSSES. SCRUB/TURNAROUND OPTIONS WERE DEFINED. LOX STORAGE AND ACQUISITION REQUIREMENTS WERE EVALUATED. A DESCRIPTION OF A LRB LOX FACILITY WAS DEVELOPED.

CONCEPT: PROVIDE A NEW 5000-GPM VARIABLE PUMP AND 8 INCH TRANSFER LINE FOR THE LRB. THIS CONCEPT DOES NOT CHANGE ANY OF THE EXISTING MPS OPERATIONAL PROCEDURES.

THE CONCEPT WILL REQUIRE A SECOND 900,000-GALLON STORAGE VESSEL TO MEET TURNAROUND REQUIREMENTS WITHOUT STORAGE VESSEL REFILL. ALSO IN THE RECOMMENDED DESIGN IS THE CAPABILITY TO OFFLOAD 10 TANKEPS AT A TIME INSTEAD OF THE PRESENT 5.

CONCLUSION/RECOMMENDATIONS

THE EXISTING LOX FACILITY CANNOT MEET PROGRAM REQUIREMENTS FOR SCRUB/TURNAROUND WITH LRB IN 24 HOURS; THEREFORE, DOUBLING THE FACILITY SIZE IS REQUIRED. ALSO INCLUDED IN THE RECOMMENDATION IS THE DOUBLING OF THE TANKER FLEET SO THAT NUMBER OF SHIFTS REQUIRED TO FILL THE STORAGE VESSEL IS REDUCED.
LRB LOX SYSTEM FLUID GSE REQUIREMENTS FOR PAD/MLP

THE PNEUMATIC SYSTEM WILL INCLUDE NITROGEN AND HELIUM PNEUMATIC DISTRIBUTION SYSTEMS. NITROGEN IS USED FOR REMOTE OPERATION OF VALVES AND IN THE PURGE SYSTEM TO PROTECT FACILITY LINES, COMPONENTS, AND EQUIPMENT FROM MOISTURE AND CONTAMINATION. NITROGEN IS SUPPLIED FOR BLANKET PRESSURE WHEN THE LOX SYSTEM IS IN STANDBY CONFIGURATION, AND FOR LEAK CHECKS OF SYSTEM CONNECTIONS. HELIUM IS USED FOR LRB LOX TANK ANTI-GEYSERING, PREPRESSURIZATION AND VENT VALVE OPENING ACTUATION. IT IS ALSO USED FOR LRB UMBILICAL ANTI-ICING.
RP1 SYSTEM

THE GDSS AND MMC LOX/RP1 DATA YIELDS FOUR CONFIGURATIONS/OPTIONS FOR THE LOX/RP1 SYSTEM. THESE OPTIONS INVOLVE THE USE OF EITHER PUMP- OR PRESSURE-FED LIQUID ROCKET BOOSTERS. ALSO INCLUDED IN THIS STUDY IS AN EVALUATION OF THE TRANSFER METHOD FROM STORAGE TO VEHICLE.

DUE TO THE PHYSICAL PROPERTIES OF RP1, TRANSFER AND STORAGE FACILITIES WILL NOT INVOLVE A MASS LOSS OF RP1 (SUCH AS BOILOFF). THIS SIMPLIFIES A SCRUB/TURNAROUND OPERATION, AND NO ADDITIONAL STORAGE SPACE WOULD BE REQUIRED ABOVE THAT NECESSARY TO SUPPORT THE VEHICLE AND MAINTAIN THE REQUIRED MASS STORAGE CAPABILITY. ONE OF THE ADVANTAGES OF RP1/LOX IS THE EXPERIENCE GAINED DURING THE APOLLO PROGRAM. A NEW BASELINE WOULD BE REQUIRED, AND A REBIRTH OF THE APOLLO DOCUMENTATION AND PROCEDURES SHOULD PROVE SUFFICIENT. THERE ARE STILL SOME EXISTING INSTALLATIONS INVOLVING RP1, SUCH AS STORAGE FACILITIES ON PAD A; HOWEVER, THESE FACILITIES HAVE BEEN ABANDONED IN PLACE AND TO ASSUME THEIR USABILITY WOULD BE UNREALISTICALLY OPTIMISTIC. TO PRESUME THE WORST, THE RP1 SYSTEM WOULD REQUIRE THE INSTALLATION OF AN ENTIRELY NEW STORAGE AND TRANSFER MECHANISM.

DESIGN CONCEPT FOR PUMP TRANSFER

THE USE OF A PUMP-FED RP1 SYSTEM INVOLVES THE INSTALLATION OF A NEW TRANSFER (AND PROBABLY STORAGE) FACILITY AT KSC. THREE 85,000-GALLON STORAGE TANKS WOULD HOLD THE RP1, WHILE A REDUNDANT TWO-PUMP SYSTEM WILL PROVIDE THE MOTIVE FORCE. A NEW EDUCTOR SYSTEM WOULD AID THE HYDRAULIC PRESSURES IN THE EVENT A SCRUB TURNAROUND WAS REQUIRED.终于, THE SECONDARY 1,000 GPM-PUMPING SYSTEM WOULD PROVIDE A PURIFICATION CAPACITY AS REQUIRED.
RP1 SYSTEM FLUID GSE REQUIREMENTS FOR PAD/MLP

This report assumes that the LRB RP1 system will be similar to the Apollo RP1 propellant loading system. The propellant will be stored at the launch pad and be transferred to the vehicle fuel tank using pumps.

The valve complexes will require control panels and consoles consisting of pneumatically operated valves to provide control of the transfer components, operate the LRB RP-1 tank vent valves, pressurize the vehicle RP1 tank in preparation for flight, and provide blanket pressures for the system for moisture protection when the system is not in use.

The block diagram depicting these systems is described here.
COMPARISON OF LH2 VS RP-1 LRB

The LRB's used as a baseline to study the KSC impacts was the LOX/RP-1 configurations from both contractors. This choice of configuration allowed the comparison of apples and apples and was not intended to advocate RP-1 as a fuel. The fuel choice at the launch site for any future propulsion system is liquid hydrogen. Although the GDSS LOX/LH2 configuration has facility impacts which are more extensive than the four LOX/RP-1 configurations (see section 3), from a propellant point of view the LH2 LRB's are preferred.

To compare LH2 with the RP-1 system, a LH2 system would be more expensive to implement but the benefits outweigh the cost. The intangibles include environmental impacts (emission - air quality, pollution - ground water (quality), availability, engine requirements and system maintenance.

From a hazard point of view LH2 vapor is more hazardous than RP-1 vapor but the safety system for H2 currently exists and the environmental impacts are low.

All LRB configurations pose facility impacts (access, umbilical redesigns, flame deflector redesigns) which must be solved with engineering and operational changes. The taller LOX/LH2 LRB will interfere with the GOX vent arm (this problem exists with the LOX/RP-1 GDSS press fed configuration also. This impact to the GOX vent arm can be solved either with a configuration change to the vent arm or a design change to the ET.

Even with the facility impacts the versatility of LH2 is far superior to RP-1 for launch vehicle programs of the future.
# COMPARISON OF LH2 vs RP-1

<table>
<thead>
<tr>
<th>NON-RECURRING COST</th>
<th>RP-1</th>
<th>LH2</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECURRING COSTS Include TECHNOLOGY / SYSTEM</td>
<td>LEAST @ $6.6M</td>
<td>MOST @ $25.9M</td>
</tr>
<tr>
<td>COMMODITY COST / LAUNCH (SUCCESSFUL - NO SCRUB)</td>
<td>- PUMP MAINTENANCE</td>
<td>- VJ EQUIP / VESSEL MAINTENANCE</td>
</tr>
<tr>
<td>ACQUISITION - COST MADE FROM AVAILABILITY TRANSPORTATION</td>
<td>- GROUND WATER MONITORING</td>
<td>- H2 MONITORING</td>
</tr>
<tr>
<td></td>
<td>- AIR QUALITY MONITORING</td>
<td>- MODIFY EXISTING SYSTEM</td>
</tr>
<tr>
<td></td>
<td>- NEW ENGINEERING STAFF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- NEW INSTALLATION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- NEW SUPPORT / SAFETY SYSTEM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WORST LRB $348,000 (1)</td>
<td>$455,000</td>
</tr>
<tr>
<td></td>
<td>BEST LRB $261,000 (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$3.00/GALLON PETROLEUM</td>
<td>$1.00 / GALLON NATURAL GAS, PETROLEUM</td>
</tr>
<tr>
<td></td>
<td>LIMITED NEW FLEET</td>
<td>EXPANDING EXISTING FLEET</td>
</tr>
</tbody>
</table>

**Notes:**
1. GDSS PRESSURE
2. MMC PUMP
3. GDSS LOX / LH2
4. GDSS FATBIRD
5. GDSS PUMP
6. MMC PRESSURE

**Lockheed Space Operations Company**

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# COMPARISON OF LH2 vs RP-1 (CONT)

<table>
<thead>
<tr>
<th></th>
<th>RP-1</th>
<th>LH2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXHAUST</strong></td>
<td>• ENVIRONMENTALLY DIRTY</td>
<td>• ENVIRONMENTALLY CLEAN</td>
</tr>
<tr>
<td></td>
<td>• HOTTER THAN LOX / LH2</td>
<td></td>
</tr>
<tr>
<td><strong>ENGINE SERVICING</strong></td>
<td>• FLUSH / GUSH WITH WATER GLYCOL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• INSTALLATION OF PROPELLANT IGNITION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CARTRIDGES</td>
<td></td>
</tr>
<tr>
<td><strong>HAZARD</strong></td>
<td>LOW VAPOR IGNITION HAZARD</td>
<td>HIGH IGNITION POINT HAZARD</td>
</tr>
<tr>
<td><strong>LRB SITE - SHIRT DIAMETER</strong></td>
<td>WORST 26.8' (1)</td>
<td>WORST 24.4' (1)</td>
</tr>
<tr>
<td></td>
<td>BEST 22.1' (2)</td>
<td>BEST 22.3' (3)</td>
</tr>
<tr>
<td></td>
<td>WORST 195.7' (1)</td>
<td>WORST 191.0' (3)</td>
</tr>
<tr>
<td></td>
<td>BEST 148.8' (5)</td>
<td>BEST 169.5' (4)</td>
</tr>
<tr>
<td></td>
<td>WORST 16.2' (6)</td>
<td>WORST 17.7' (4)</td>
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</tbody>
</table>

**NOTES:**

(1) GDSS PRESSURE
(2) MMC PUMP
(3) GDSS LOX / LH2
(4) GDSS FATBIRD
(5) GDSS PUMP
(6) MMC PRESSURE
LAUNCH AD CONCLUSIONS

- SIDE DEFLECTOR ACTS AS AN EXTENSION OF FLAME TRENCH
  - FLAME IMPINGEMENT

- MULTI-BOOSTER (LRB / SRB) MAIN DEFLECTOR REQUIRED

- NEW ACCESS REQUIRED

- ACCESS ABOVE PCR ROOF NOT AVAILABLE

- EXISTING UMBILICALS / MECHANISMS REQUIRE REDESIGN AND LETF TESTING
  - MAJOR IMPACT TO ET H2 VENT DUE TO DIAMETER
  - GOX VENT IMPACT DUE TO LENGTH

- NEW LRB UMBILICALS REQUIRED

- WEATHER PROTECTION SYSTEM REQUIRES REDESIGN

- NEW PROPELLANT STORAGE REQUIRED

- NEW GSE REQUIRED
FIRING ROOM LPS REQUIREMENT FOR LRB


TO ACCOMMODATE LRBs DURING LAUNCH COUNTDOWN NEW APPLICATION SOFTWARE WILL BE REQUIRED. EACH OF THE FIRING ROOMS WILL REQUIRE ADDITIONAL LPS HARDWARE. EACH OF THE FOUR FIRING ROOMS WILL NEED: THREE NEW LPS TYPE-I CONSOLES, AND EITHER TWO OR FOUR NEW PCM-TYPE FEPs, DEPENDING ON WHETHER OR NOT THE LRB PCM DATA COMES INDEPENDENTLY FROM THE ORBITER 128 KB PCM. REALLOCATION OF THE EXISTING BOOSTER TEST CONDUCTOR PERSONNEL AND SOFTWARE WILL ALSO BE NECESSARY.

TO ACCOMMODATE NEW COMMAND TYPES, DATA STREAMS, AND DATA TYPES REQUIRED BY LRB SYSTEMS, APPROXIMATELY 900,000 LINES OF CCMS SYSTEM SOFTWARE WILL BE REQUIRED. FURTHER STUDY WILL BE REQUIRED TO DETERMINE THE IMPACT OF EXCEEDING THE CURRENT LIMITATION OF FIFTEEN CONSOLES IN A FIRING ROOM.

THE EXISTING CCMS EQUIPMENT IN THE FIRING ROOMS WILL NOT SUPPORT THE EXPANSION NEEDED TO SUPPORT LRBs. NO EQUIPMENT OF THIS TYPE IS AVAILABLE, LPS 2 WILL BE NECESSARY FOR THE UPGRADE OF THE FIRING ROOM CCMS EQUIPMENT. THIS PROPOSED USE OF LPS 2 EQUIPMENT SHOULD BE FEASIBLE BECAUSE THE TIMELINES FOR LPS 2 DEVELOPMENT VERY CLOSELY MATCH THOSE PROJECTED FOR THE LRB.
<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>LINES AFFECTED</th>
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<tr>
<td>SYSTEM BUILD</td>
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<tr>
<td>EXECUTORS</td>
<td>100,000</td>
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<tr>
<td>OPERATING SYSTEM</td>
<td>100,000</td>
</tr>
<tr>
<td>FEP</td>
<td>150,000</td>
</tr>
<tr>
<td>RETRIEVAL</td>
<td>200,000</td>
</tr>
<tr>
<td>CONSOLE</td>
<td>50,000</td>
</tr>
<tr>
<td>SGOS</td>
<td>100,000</td>
</tr>
<tr>
<td>RPS</td>
<td>100,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>950,000</strong></td>
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LPS APPLICATION SOFTWARE REQUIREMENTS FOR LRB

THE LPS APPLICATIONS SOFTWARE ASSESSMENT WAS BASED ON A PERCENTAGE OF EXISTING SOFTWARE EXPECTED TO CHANGE OR BE ADDED AS A RESULT OF SWITCHING TO A LIQUID ROCKET BOOSTER. THE EXISTING FIRING ROOM APPLICATION SOFTWARE WAS REVIEWED BY USING EQUIVALENT SHUTTLE SYSTEMS TO REPRESENT THE LRB ONBOARD SYSTEMS, AS WELL AS KNOWLEDGE OF EXISTING GSE, PROCEDURES, AND OPERATING METHODS. SGOS MODELS USED TO PERFORM SOFTWARE VERIFICATION AND VALIDATION WERE ESTIMATED IN THE SAME MANNER. THE EXPECTED CONFIGURATIONS OF THE VARIOUS SYSTEMS AND SUBSYSTEMS WERE ESTIMATED BY COMPARATIVE ANALYSES TO SIMILAR SYSTEMS ABOARD THE ORBITER. RELATIVE NUMBERS OF CONSOLE DISPLAY USED DURING THE DIFFERENT TESTS PERFORMED ON THE SHUTTLE DURING BOTH PROCESSING AND LAUNCH COUNTDOWN WERE ASSESSED.

THE OPERATIONAL PHILOSOPHY AND CURRENT ASSIGNMENTS OF SYSTEM RESPONSIBILITIES WITHIN THE FIRING ROOM MAKE IT FEASIBLE FOR ALL SYSTEMS TO BE OPERATED AND MONITORED BY PERSONNEL CURRENTLY PERFORMING THESE TASKS ON THE ORBITER, ET, AND SRBs, WITH THE EXCEPTION OF LRB ENGINES AND PROPELLANT SYSTEMS.

THE GROUND LAUNCH SEQUENCER (GLS) IS AN EXCEPTIONALLY TIME CRITICAL SET OF APPLICATION SOFTWARE. THE EFFECTS OF ADDING EIGHT NEW ENGINES AND THEIR IMPACTS ON THE TERMINAL COUNTDOWN, ABORT, AND SAFING PROCEDURES WILL NECESSITATE THE REWRITE OF THE ENTIRE GLS TO INCLUDE LRBS.

APPROXIMATELY 900,000 LINES OF CODE WILL HAVE TO BE WRITTEN OR MODIFIED TO INCORPORATE LRBS INTO FIRING ROOM APPLICATION SOFTWARE. IN ADDITION THERE WILL BE APPROXIMATELY 1,000 NEW OR MODIFIED DISPLAY SKELETONS THAT WILL BE REQUIRED.
## DELTA_LINES OF CODE

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<tr>
<th>SYSTEM</th>
<th>EXISTING</th>
<th>% DELTA</th>
<th>LINES DELTA</th>
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</thead>
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<tr>
<td>EPDC</td>
<td>52,599</td>
<td>95%</td>
<td>49,969</td>
</tr>
<tr>
<td>TAVC</td>
<td>40,540</td>
<td>95%</td>
<td>38,523</td>
</tr>
<tr>
<td>INST</td>
<td>8,288</td>
<td>95%</td>
<td>7,862</td>
</tr>
<tr>
<td>RSS</td>
<td>16,298</td>
<td>95%</td>
<td>15,483</td>
</tr>
<tr>
<td>RP-1</td>
<td>35,076</td>
<td>95%</td>
<td>33,322</td>
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<tr>
<td>LO2</td>
<td>36,448</td>
<td>95%</td>
<td>34,625</td>
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<tr>
<td>ETCO</td>
<td>15,202</td>
<td>95%</td>
<td>14,442</td>
</tr>
<tr>
<td>ENGINES</td>
<td>121,004</td>
<td>95%</td>
<td>114,954</td>
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<tr>
<td>UMBILICALS</td>
<td>10,094</td>
<td>25%</td>
<td>2,523</td>
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<tr>
<td>GNC</td>
<td>275,084</td>
<td>35%</td>
<td>131,280</td>
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<td>DPS</td>
<td>21,888</td>
<td>40%</td>
<td>8,750</td>
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<tr>
<td>INTG</td>
<td>4,638</td>
<td>95%</td>
<td>4,406</td>
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<tr>
<td>COMM</td>
<td>21,320</td>
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<td>5,330</td>
</tr>
<tr>
<td>HAZGAS</td>
<td>16,800</td>
<td>30%</td>
<td>5,040</td>
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<tr>
<td>FSW</td>
<td>20,117</td>
<td>20%</td>
<td>4,024</td>
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<tr>
<td>GLS</td>
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<tr>
<td>CCS</td>
<td>1,500,000</td>
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<td>ESA</td>
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<td>50%</td>
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<tr>
<td>MODELS</td>
<td>200,000</td>
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</tr>
<tr>
<td>TOTAL</td>
<td>2,655,374</td>
<td>34%</td>
<td>900,533</td>
</tr>
</tbody>
</table>
LAUNCH CONTROL CENTER CONCLUSIONS

- 950,000 LINES OF CODE FOR CCMS REQUIRED
- 900,533 ADDITIONAL LINES OF CODE REQUIRED FOR APPLICATION SOFTWARE
C-5 SUBSTATION AND EMERGENCY GENERATOR

THE POWER REQUIREMENTS OF ALL LC-39 FACILITIES WILL RESULT IN THE NEED FOR 12 NEW 13.8 KV FEEDERS FROM THE C-5 SUBSTATIONS. THE C-5 SUBSTATION IS AT OR NEAR CAPACITY AT THIS TIME. ADDITIONAL SWITCHES AND TRANSFORMERS WILL BE REQUIRED IN THE SWITCHYARD TO ACCOMMODATE THIS NEW CAPACITY.

THERE WILL BE FIVE NEW 480 V AC FEEDERS REQUIRED FROM THE C-5 EMERGENCY GENERATORS. SUFFICIENT GENERATOR CAPACITY EXISTS TO SUPPORT THE ADDITIONAL POWER LOADS RESULTING FROM THE ADDITION OF EMERGENCY SUBSTATIONS. TRANSFORMER CAPACITY IN THE EXISTING GENERATOR BUILDING WILL BE EXCEEDED AND THEREFORE TWO NEW TRANSFORMERS WILL BE REQUIRED TO ACCOMMODATE THE NEW EMERGENCY FEEDERS. THE EXISTING CABLE TRENCHES ARE AT CAPACITY.

TO SUPPORT THE ADDITION OF NEW FEEDERS, SOME NEW MANHOLES, CABLE TRENCHES, AND DUCT BANKS WILL BE REQUIRED.
## LC-39 POWER REQUIREMENTS

<table>
<thead>
<tr>
<th>SITE</th>
<th>FACILITY 60 Hz POWER</th>
<th>EMERGENCY GENERATOR 60 Hz POWER</th>
<th>UPS</th>
<th>FIBER DATA LINKS</th>
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<tbody>
<tr>
<td>LRB AT ET PROCESSING FACILITY</td>
<td>4-13.8KV FEEDERS</td>
<td>1-480V @ 400 AMP FEEDER</td>
<td>1-600KVA @ 480V</td>
<td>N/R</td>
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<tr>
<td></td>
<td>2-2000 AMP SUBSTATION (DOUBLE ENDED)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLP PARK SITE</td>
<td>2-13.8KV FEEDERS</td>
<td>1-480V @ 400 AMP FEEDER</td>
<td>N/R</td>
<td>20-LCC</td>
</tr>
<tr>
<td>PAD A LOX</td>
<td>1-13.8KV FEEDER 1-2000 AMP SUBSTATION</td>
<td>N/R</td>
<td>N/R</td>
<td>3-LCC</td>
</tr>
<tr>
<td>PAD A FUEL</td>
<td>1-13.8KV FEEDER 1-2000 AMP SUBSTATION</td>
<td>N/R</td>
<td>N/R</td>
<td>3-LCC</td>
</tr>
<tr>
<td>PAD B LOX</td>
<td>1-13.8KV FEEDER 1-2000 AMP SUBSTATION</td>
<td>N/R</td>
<td>N/R</td>
<td>3-LCC</td>
</tr>
<tr>
<td>PAD B FUEL</td>
<td>1-13.8KV FEEDER 1-2000 AMP SUBSTATION</td>
<td>N/R</td>
<td>N/R</td>
<td>3-LCC</td>
</tr>
<tr>
<td>LCC</td>
<td>N/R</td>
<td>N/R</td>
<td>N/R</td>
<td>54</td>
</tr>
<tr>
<td>VAB HI-BAY 4 (ALL NEW)</td>
<td>2-13.8KV FEEDERS</td>
<td>1-480V @ 400 AMP FEEDER</td>
<td>N/R</td>
<td>20-LCC</td>
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<tr>
<td>C-5 POWER STATION C-5 EMERGENCY GENERATORS</td>
<td>12-200 AMP @13.8KV FEEDERS</td>
<td>3-400V @ 480 AMP FEEDERS</td>
<td>N/R</td>
<td>12-LCC</td>
</tr>
</tbody>
</table>
LIQUID ROCKET BOOSTER INTEGRATION

AGENDA

I. INTRODUCTION

   Gordon Artley

II. LRBI RESULTS

   BASELINE / LAUNCH SITE SCENARIO

      Pat Scott

   FACILITIES AND GROUND SYSTEMS

      Greg DeBlasio

   IMPLEMENTATION

      Gordon Artley

III. SUMMARY

      Jerry Lefebvre

      Gordon Artley
- LAUNCH SITE PLAN
- TRANSITION OVERVIEW
- DOCUMENTATION REQUIREMENTS
- MANPOWER
- PROGRAM OPERATING PLAN
- VLS
LRB LAUNCH SITE PLAN

THE LRB LAUNCH SITE PLAN PRESENTS AN IMPLEMENTATION CONCEPT FOR INTEGRATION OF THE NEW BOOSTER ELEMENT INTO THE STS. THIS PLAN SATISFIES THE PHASE-A STUDY GROUND RULE OF MINIMIZING OR ELIMINATING SRB/STS OPERATIONAL IMPACTS DURING LRB IMPLEMENTATION. IN ADDITION, AT THE CONCLUSION OF THE TRANSITION PHASE, SRB/STS OPERATIONAL CAPABILITY IS RETAINED.

THIS PLAN SPANS A PERIOD OF APPROXIMATELY 15 YEARS, FROM PHASE C/D AUTHORITY TO PROCEED THROUGH LRB MISSION #122 AND CONSISTS OF THREE NON-AUTONOMOUS LAUNCH SITE PHASES; ACTIVATION, TRANSITION AND OPERATIONS. THESE PHASES ARE INTEGRATED WITH THREE DISCRETE PROGRAM ASPECTS: FUNDING, MULTI-CENTER DESIGN DEVELOPMENT, AND THE FLIGHT ELEMENT HARDWARE DELIVERY TO THE LAUNCH SITE.

ACTIVATION INCLUDES THE END-TO-END IMPLEMENTATION OF THE 1ST LINE FACILITIES, REQUIRED TO SUPPORT THE PROPOSED LRB PATHFINDER PROGRAM AND ILC; AND THE 2ND LINE FACILITIES, REQUIRED AS THE LRB FLIGHT RATE RAMPS UP.

TRANSITION IS EFFECTIVELY THE 5 YEAR PERIOD OF MIXED-FLEET PROCESSING ACTIVITY OF SRB AND LRB FLIGHT HARDWARE.

THE OPERATIONAL PHASE EXTENDS OVER THE 15 YEAR PROGRAM DURATION, INITIATING WITH SUPPORT TO THE ACTIVATION DESIGN DEVELOPMENT, PROCEEDING WITH STAFFING AND TRAINING, AND CONCLUDING WITH FULL OPERATIONAL CAPABILITY SUPPORTING A SUSTAINED LRB FLIGHT RATE OF 14 MISSIONS PER YEAR.
LRB LAUNCH SITE PLAN SYNOPSIS

TODAY'S FACILITIES
USE AS IS
- BARGE DOCKS
- OPF

MODIFY
- VAB HIGH BAYS
- CRAWLERWAY
- LETF
- LCC
- LAUNCH PAD FAC
- ELEC. PWR. DIST.

ADDITIONAL FACILITIES
- LRB/ET PROCESSING
- MLPs

SUPPORTING DOCUMENTATION
- OMD
- OMI / PM-OMIs

SOFTWARE CHANGES
- RSL & GLS
- FLIGHT

TRANSITION
△ HARDWARE ON DOCK
△ INITIAL LAUNCH CAPABILITY
GRADUATED LAUNCH RATE
- 3 MISSIONS IN 1996
△ INITIAL OPERATIONAL CAPABILITY
- 6 MISSIONS IN 1997
- 9 MISSIONS IN 1998
- 12 MISSIONS IN 1999
- 14 MISSIONS IN 2000
△ TRANSITION COMPLETE
- 14-LRB 0-SRB MISSIONS/YEAR

OPERATIONS
△ INITIAL GOAL
(MINIMUM SUSTAINED LAUNCH RATE 14/YR)

FUTURE POTENTIAL
- SHUTTLE 'C'
- ALS
- STANDALONE
FACILITY TRANSITION OVERVIEW

THIS GRAPH SHOWS THE TWO LINES OF FACILITIES PLANNED AND THE ASSOCIATED PART OF THE TRANSITION FLIGHT RATE COVERED. THE OPERATIONAL CAPABILITY IS ALSO ILLUSTRATED WITH THE FINAL MIX OF STS MISSIONS SUMMARIZED AT THE BOTTOM.
## Transition Overview

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### Operations 81 Mission Total 1st Line Capability

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### 2nd Line Activation

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### Operations 47 Additional Mission Capability

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**Total LRB Missions Thru MID 2006 = 122**
FIRST LINE FACILITY ACTIVATION

THE FIRST LINE FACILITIES ARE IDENTIFIED IN THIS GRAPHIC, AND THE END-TO-END IMPLEMENTATION DURATIONS FOR EACH STATION SET ARE DISPLAYED. THESE FACILITIES ARE REQUIRED TO SUPPORT THE PROPOSED LRB PATHFINDER PROGRAM AND ILC, AND RESULT IN THE CAPABILITY TO SUPPORT LRB FLIGHT RATES OF 6 TO 9 MISSIONS PER YEAR.

THE CURRENT LAUNCH SITE CRITICAL PATH IS THE DESIGN, CONSTRUCTION, VERIFICATION AND CERTIFICATION OF THE NEW LRB MLP #4.

CONVERSION OF LC-39 PAD B TO LRB /STS CAPABILITY, POSES THE GREATEST TECHNICAL AND PROGRAMMATIC SCHEDULE RISK IN THE SCOPE OF LRB ACTIVATION AT KSC. DESIGN IS CHALLENGED BY THE CONSTRAINT OF MAINTAINING SRB/STS LAUNCH CAPABILITY. SCHEDULE CHALLENGES ARE ASSOCIATED WITH MAINTAINING THE STS PROGRAM FLIGHT RATE WHILE MODIFYING AN OPERATIONAL LAUNCH PAD.
### FIRST LINE FACILITY ACTIVATION

#### ACTIVATION PHASE

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#### LEGEND:
- **Scheduled Work**
- [ ] Float
- (M) Mod
- (N) New Construction
SRB/LRB PROCESSING FACILITY UTILIZATION

THIS GRAPH (ONLY ONE OF TEN YEARS COVERED IN THE FINAL REPORT) SHOWS THE KSC ACTIVATION ACCOMMODATIONS THAT HAD TO BE MADE AS WELL AS THEIR IMPACT ON SRB/LRB FLOW PROCESSING.

0 ALL MISSION PROCESSING FLOWS KEEP THE ORIGINALLY SCHEDULED LAUNCH DATE (LRB FLOWS WERE "BACKED OFF" THIS DATE USING THE NEW FACILITIES AND TIME LINES).

0 ARROWS INDICATE PROCESSING ACTIVITIES DISPLACED TO ALTERNATE FACILITIES.

0 X'S INDICATE FLOW PROCESSING REQUIREMENTS CANCELLED OR SUBSTANTIALLY CHANGED DUE TO CHANGE FROM SRB TO LPB.

Lockheed
Space Operations Company

D-6A
# LRB/STS-111-1ST LAUNCH TABLE

## FY 1996-I.L.C. FIRST LRB POWERED STS MISSION

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<th>KSC LOCATION</th>
<th>PROCESSING FUNCTION</th>
<th>GENERIC WORK DAYS</th>
<th>LOCATION SCHEDULE DAYS/SHIFTS (FACTOR)</th>
<th>CALENDAR START</th>
<th>CALENDAR COMPLETE</th>
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<td>PAD</td>
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<td>VAB</td>
<td>ORB MATE &amp; INTEG TEST</td>
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<td>OPF</td>
<td>ORBITER PROCESSING</td>
<td>55*</td>
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<td>7/3 (1.00)</td>
<td>NOV 16</td>
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<td>DEC 26</td>
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* Function not subject to Learning Curve Factor (LCF), All others multiplied by a LCF of 2.5 for this flow only.
NOTES:
- FLOW TIME SHOWN IN WORK DAYS
- ALL LRB VAB OPS IN HB4
- ALL PAD FLOWS ON PAD B
SECOND LINE FACILITY ACTIVATION

ACTIVATION OF THE SECOND LINE FACILITIES IS REQUIRED TO SUPPORT THE INCREASED LRB FLIGHT RATE, PROJECTED DURING THE THIRD, FOURTH AND FIFTH YEARS OF TRANSITION; CONCLUDING WITH THE CAPABILITY TO SUPPORT 14 LRB MISSIONS PER YEAR DURING THE SUSTAINED OPERATIONAL PHASE.

THE ON-SITE IMPLEMENTATION ACTIVITY FOR THE VAB HIGH BAY 3 AND LC-39 PAD A STATION SETS, ARE SIGNIFICANT SCHEDULING CHALLENGES. MODIFICATION WINDOWS ARE SHORT IN DURATION, FORCING WORK TO PROCEED "AROUND THE CLOCK." CONTINGENCY TIME HAS BEEN ELIMINATED IN THE CONCEPTUAL PROJECT PLANNING.
FACILITY PLANNING CHART


0 HIGHLIGHTED MISSIONS WERE CHOSEN FOR CONVERSION FROM SRB'S TO LRB'S

0 CIRCLED NUMBER INDICATES LRB MISSION SEQUENCE

- MISSION (1) EXERCISES THE INITIAL LAUNCH CAPABILITY
- MISSION (4) ESTABLISHES INITIAL OPERATIONAL CAPABILITY

0 FISCAL YEAR DIVISIONS PORTRAY THE 3/6/9/12/14 LRB RAMP RATE

DOCUMENTATION REQUIREMENTS

- FLIGHT HARDWARE DRAWINGS AND LRU SPECIFICATIONS (NEW)
- GSE AND LSE DRAWINGS, FMEA/CIL ANALYSIS, AND PM OMIs (NEW)
- LOGISTICAL SPARES LISTS, AND SPARES AND PROPELLANT ACQUISITION PLANS (NEW)
- OMRSD AND ASSOCIATED PROCESSING OMIs AND JOB CARDS (REVISION)
  - HORIZONTAL ET PROCESSING (REVISION)
  - STAND ALONE HORIZONTAL LRB PROCESSING (NEW)
  - INTEGRATED MATE, TESTING, AND CLOSE OUT - VAB (REVISED)
  - PAD OPERATIONS (REVISION)
- LAUNCH PROCESSING SYSTEM SOFTWARE (NEW)
  - LAUNCH COMMIT CRITERIA (REVISION)
  - FLIGHT RULES (REVISION)
- STANDARD PRACTICE INSTRUCTIONS AND MANUALS (REVISION)
NASA/CONTRACTOR MANPOWER REQUIREMENTS

These manpower requirements are the cumulative support requirement for the LRB program. Three teams make up the support group.

**Activation Management Team**
- Responsible for coordination of design, construction and activation of facilities.
- Interface between the LRB activation and operation, SRB program migrate to LRB team as core group for operational phase.

**NASA Engineering Interface Team**
- Perform environmental impact studies for new facilities and modifications to existing facilities.
- Engineering document - change and approval loops system walk-downs/test surveillance
- Schedules and approvals
- Site control

**NASA Operations Interface Team**
- Operations and engineering OMD
- Operations and engineering software
- Operations and engineering certifications
- Operations and engineering ORI's
- Operations and engineering Pathfinder
- Operations and engineering turnover/acceptance
- Operations and engineering CDR's
- Operations and engineering training
PROCESSING MANPOWER REQUIREMENTS

The generic ARTEMIS LRB flow model CPM was resource loaded with projected technician headcount for each LRB processing activity. There was not an attempt to level manpower. Peaks were allowed to develop to maintain minimum processing time in each facility. Critical path items are outlined with the dark broad lines. Parallel tasks are accomplished at the earliest start point and completed at the earliest finish time. The technicians are stationized at the facility and do not move with the booster. The graphs are by shift and must be summed to determine peak headcount. The peak headcount by facility are as follows:

HPF. = 260 on the 4th day

VAB = 70 on the 4th day

PAD = 107 on the 16th day

Total = 437
TECHNICAL SKILL MIX

The percentages of skills required for LRB ground processing were determined by an examination of each work task in the Artemis LRB flow model. Because of the requirement for electrical TVC/flight controls, there is a high percentage of electrical skills. Engine skills seem low, but that is based on a "ship and shoot" concept and scheduled task. If the potential for unscheduled work is considered based on SSME and ET processing, the percentage could go much higher. Another factor was the premise that work on the TVC actuators was assigned to electricians and engine plumbing was assigned to mechanical technicians. If these assumptions were reversed the ratio would increase for engine technicians. The percentages for SRB's is shown for comparison. While it is unusual that the percentage for electrical skills is the same, it can be explained. MTI Cross utilizes electricians one way to mechanical work.
MANPOWER REQUIREMENTS - LRB PROCESSING


MANPOWER COUNTS AND RATIOS WERE DEVELOPED FROM THE BASELINE STUDY WHICH COMPARED SRB/ET/ORBITER MANPOWER AND SUPPORT TO LRB PROCESSING TASKS.
MANPOWER REQUIREMENTS - LRB PROCESSING
TIME PHASED LRB INTEGRATION HEADCOUNT

LRB PROCESSING PERSONNEL GRADUALLY REPLACE SRB PROCESSING PERSONNEL. EACH GROUP CONTAINS TECHNICIANS AND THEIR DIRECT SUPPORT FROM ENGINEERING, FACILITY/GROUND SUPPORT, LOGISTICS, QUALITY, SAFETY, OPERATIONS PLANNING AND CONTROL, OVERHEAD AND LPS.

THE NASA/NON SPEC PROCESSING SUPPORT (CS & BOC) PERSONNEL PROVIDE DIRECT SUPPORT TO BOTH SRB AND LRB PROCESSING ACTIVITIES.

THE USBI-KSC REFURBISHMENT/SUPPORT AND SRB RETRIEVAL/DISASSEMBLY PERSONNEL PHASE OUT WITH SRB LAUNCH PHASE OUT.

THE ACTIVATION MANAGEMENT TEAM SUPPORTS THE FACILITY PREPARATIONS.

THE NASA ENGINEERING INTERFACE AND NASA OPERATIONS INTERFACE PERSONNEL SUPPORT THE INTENSIVE ACTIVITIES OF ALL LRB INTERFACE AREAS IN PREPARATION FOR SUSTAINED OPERATIONAL CAPABILITY.
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**Lockheed Space Operations Company**
## LRB PROGRAM OPERATING PLAN

**LO2/RP-1 PUMP-FED BOOSTERS**

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*Numbers are '87$M*
SLC-6 CONVERSION TO LRB

Detailed studies of VLS re-activation from the planned mothball status have not been performed. For the purpose of this assessment the VLS studies for re-activation from minimum facility caretaker status were modified to account for additional staffing time required and increased facility restoration time. The engineering assessment of the VLS modifications required to convert to LRB operation shows that the effort can be completed prior to the initiation of the re-activation GSTS and flow tests. It is anticipated that the LRB conversion schedule will be paced by the procurement and installation of the new cryogenic dewar(s).

As a result of the VLS cursory review, two recommendations have been received from our VLS team, which provide some interesting program opportunities.

1.) Consider using VLS to pathfind the LRB implementation into the Shuttle program

   a. Processing development would be achieved without any impact with KSC SRB Shuttle launches
   b. Integration of a developed system at KSC would be low technical and schedule risk

2.) VLS should be considered as the LRB vehicle development static hot firing test facility

   a. Required modification could be cost effective
   b. Testing would not interfere with other Shuttle facilities
AGENDA

I. INTRODUCTION
Gordon Artley

II. LRBI RESULTS
Pat Scott
BASELINE / LAUNCH SITE
SCENARIO
Greg DeBlasio
FACILITIES AND GROUND
SYSTEMS
Gordon Artley
IMPLEMENTATION
Jerry Lefebvre
COST

III. SUMMARY
Gordon Artley
LRBI CONCLUSIONS


THE CRITICAL PATH FOR THE ACTIVATION TO MEET THE FIRST LAUNCH IS THE COMPLETION OF A NEW LRB MOBILE LAUNCH PLATFORM (MLP). IN ADDITION TO THE MLP CONSTRUCTION AND EQUIPMENT INSTALLATION EFFORT, A COMPLETE SYSTEMS CHECKOUT MUST BE ACCOMPLISHED FOR THE FIRST LAUNCH. THIS WILL INCLUDE FIT CHECKS AT THE VAB AND PAD, CRYO FLOWS AND SUPPORT TO THE PATHFINDER STATIC FIRING. ADDING THESE EFFORTS TO THE PAD TIME FOR THE FIRST 3 LAUNCHES CONSUMES 10-12 MONTHS OF DEDICATED PAD ACCESS. ALTHOUGH SOME PAD ACCESS WINDOWS EXIST FOR SRB Configured launches, there is a substantial element of risk.

THE PROPELLANT OPTIONS AND THE BOOSTER CONFIGURATIONS DO NOT IMPOSE NEW HAZARDS OR TECHNOLOGY TO THE KSC SAFETY AND ENVIRONMENTAL COMMUNITY.

THE TRANSITION OF THE SHUTTLE PROGRAM TO LIQUID ROCKET BOOSTER CONFIGURATION GENERATES A PROGRAM LIFE CYCLE COST IN EXCESS OF $15 BILLION. THE OPERATIONS COST WILL BE LESS THAN 10 PERCENT OF THIS LIFE CYCLE COST.
• WE CAN ACHIEVE THE 1990 - 2006 LRB INTEGRATION SCENARIO

• THE PRINCIPAL RISK IS THAT THE LRBI ACTIVATION AND OPERATIONS IMPLEMENTATION MAY IMPACT THE 14 FLIGHTS/YEAR PROGRAM

• WE CAN ACCOMMODATE THE ENVIRONMENTAL AND SAFETY IMPLICATIONS WITH ESTABLISHED KSC POLICIES

• THE LIFE CYCLE COSTS AT KSC WILL BE LESS THAN 10% OF THE TOTAL LRB PROGRAM COSTS. THE KSC NON-RECURRING COST WILL BE LESS THAN 6%
MAJOR PROGRAM RISKS

CRITICAL GROUND SYSTEMS RISKS

PAD A & B

- ACCESS TO EXISTING FACILITIES FOR LRB ACTIVATIONS

- FLAME TRENCH AND DEFLECTOR DESIGNS

MLP

- SCHEDULE CRITICAL PATH

- FLAME HOLES AND HOLDDOWN STRUCTURAL DESIGN
STATION SET MAXIMUM TIME SCHEDULE

EARLIEST START LATEST FINISH SCHEDULE

FIRST LRB LAUNCH

MLP PARK SITE
MLP-1
LETF
HPF
HIGH BAY 4
VAB CRAWLERWAY 4
PAD CONV
LCC
LPS
LRB MLP-2
LRB FLT
TEST ARTICLE
VAB HIGH BAY 3
2ND LRB PAD
RECOMMENDATIONS FOR FOLLOW-ON STUDY

THE LRBI STUDY HAS IDENTIFIED A NUMBER OF ISSUES THAT WILL REQUIRE FURTHER STUDY AND IN-DEPTH ANALYSIS. WE SHOULD CONTINUE TO SUPPORT THESE CRITICAL ISSUES WITH THE DEVELOPMENT OF MORE RIGOROUS STUDY TOOLS AND MORE COMPLETE DATABASES. ADDITIONAL INFORMATION, AS IT BECOMES AVAILABLE FROM MSFC, WILL REQUIRE KSC LAUNCH OPERATIONS IMPACT ASSESSMENT. FOR INSTANCE, BOOSTER IMPACTS TO THE PAD WILL REQUIRE FURTHER DESIGN ANALYSIS. THE RESOLUTION OF THESE PROBLEMS WILL REQUIRE FURTHER SUPPORT AND COOPERATION WITH THE MSFC WORKING GROUP.

WE ALSO NEED BETTER TECHNIQUES TO PROVIDE IMPROVED ACCURACY IN DEVELOPING MIXED-MISSION SCHEDULES AND COST. THESE TECHNIQUES MIGHT INCLUDE ENHANCED VERSIONS OF THE ARTEMIS-BASED SRB/STS GROUND PROCESSING FLOW MODEL AND AUGMENTED EDITIONS OF THE GROUND OPERATIONS COST MODEL (GOCM). THE EXPANSION OF GOCM WOULD ALLOW MORE REFINED COST PROJECTIONS THAN CURRENTLY AVAILABLE WITH THE PRESENT PARAMETRIC MODEL.

WE SHOULD ALSO ASSESS ALTERNATIVE LAUNCH SITE CONFIGURATIONS AND SCENARIOS. WE CURRENTLY PLAN TO INTEGRATE THE LRBI INTO ON-GOING KSC OPERATIONS. THIS ESTABLISHES A FORMIDABLE CONSTRAINT IN LRBI GROUND OPERATIONS PLANNING. THUS, WE MUST EVALUATE A WIDE VARIETY OF LAUNCH SITE CONFIGURATIONS AND SCENARIOS IN ORDER TO FIND AND SELECT THE BEST ALTERNATIVES. THIS INFORMATION WILL BE VALUABLE NOT ONLY TO THE LRBI EFFORT, BUT ALSO TO THE LRBI-DERIVED PROGRAMS, SUCH AS UNMANNED SHUTTLES OR ALS.
RECOMMENDATIONS FOR FOLLOW-ON STUDY

- CONTINUE TO SUPPORT MSFC WORKING GROUP

- ENHANCE THE LRBI EVALUATION TECHNIQUES FOR MULTI-MISSION ASSESSMENT

- ASSESS ALTERNATIVE LAUNCH SITE CONFIGURATIONS AND SCENARIOS
AGENDA

I. INTRODUCTION
   Gordon Artley

II. LRBI RESULTS
   BASELINE / LAUNCH SITE SCENARIO
   Pat Scott
   FACILITIES AND GROUND SYSTEMS
   Greg DeBlasio
   IMPLEMENTATION
   Gordon Artley
   COST
   Jerry Lefebvre

III. SUMMARY
     Gordon Artley
LRBI CONCLUSIONS

KSC can achieve 10 years of ground system and facility activation for LRBI by 2000. In addition, 122 launches can be accommodated from 1996 to 2006. These milestones include a 5 year, 44 launch transition phase (SRB-to-LRB) for STS operations from 1996 to 2006.

The critical path for the activation to meet the first launch is the completion of a new LRBI mobile launch platform (MLP). In addition to the MLP construction and equipment installation effort, a complete systems checkout must be accomplished for the first launch. This will include fit checks at the VAB and pad, cryo flows and support to the Pathfinder static firing. Adding these efforts to the pad time for the first 3 launches consumes 10-12 months of dedicated pad access. Although some pad access windows exist for SRB configured launches, there is a substantial element of risk.

The propellant options and the booster configurations do not impose new hazards or technology to the KSC safety and environmental community.

The transition of the Shuttle program to liquid rocket booster configuration generates a program life cycle cost in excess of $15 billion. The operations cost will be less than 10 percent of this life cycle cost.
LRBI CONCLUSIONS

- WE CAN ACHIEVE THE 1990 - 2006 LRB INTEGRATION SCENARIO

- THE PRINCIPAL RISK IS THAT THE LRBI ACTIVATION AND OPERATIONS IMPLEMENTATION MAY IMPACT THE 14 FLIGHTS/YEAR PROGRAM

- WE CAN ACCOMMODATE THE ENVIRONMENTAL AND SAFETY IMPLICATIONS WITH ESTABLISHED KSC POLICIES

- THE LIFE CYCLE COSTS AT KSC WILL BE LESS THAN 10% OF THE TOTAL LRB PROGRAM COSTS. THE KSC NON-RECURRING COST WILL BE LESS THAN 6%
MAJOR PROGRAM RISKS

PAD A & B
- ACCESS TO EXISTING FACILITIES FOR LRB ACTIVATIONS
- FLAME TRENCH AND DEFLECTOR DESIGNS

MLP
- SCHEDULE CRITICAL PATH
- FLAME HOLES AND HOLDDOWN STRUCTURAL DESIGN
STATION SET MAXIMUM TIME SCHEDULE

MLP PARK SITE
- MLP-1
- LETF
- HPF
- HIGH BAY 4
- VAB CRAWLERWAY 4
- PAD CONV
- LCC
- LPS
- LRB MLP-2
- LRB FLT TEST ARTICLE
- VAB HIGH BAY 3
- 2ND LRB PAD

△ FIRST LRB LAUNCH

EARLIEST START LATEST FINISH SCHEDULE

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RECOMMENDATIONS FOR FOLLOW-ON STUDY

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RECOMMENDATIONS FOR FOLLOW-ON STUDY

- CONTINUE TO SUPPORT MSFC WORKING GROUP

- ENHANCE THE LRBI EVALUATION TECHNIQUES FOR MULTI-MISSION ASSESSMENT

- ASSESS ALTERNATIVE LAUNCH SITE CONFIGURATIONS AND SCENARIOS
**Title and Subtitle:**
Liquid Rocket Booster Integration Study
Final Report, Phase I

**Authors:**
- Gordon E. Artley, Lockheed Study Manager
- L.P. Scott, Lockheed Deputy Study Manager
- W.J. Dickinson, NASA Study Manager

**Performing Organization Name(s) and Address(es):**
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Advanced Projects Office
1100 Lockheed Way, Titusville, FL 32780

**Sponsoring/monitoring agency name(s) and address(es):**
NASA / Kennedy Space Center
Advanced Projects Technology and Commercialization Office
Future Launch Systems
Kennedy Space Center, FL 32899

**Supplementary Notes:**
This study supplemented the Liquid Rocket Booster Studies performed by Martin Marietta and General Dynamics for NASA/MSFC under Senate contracts. Follow-on activities in Phase II (1989) and Phase III (1990) were performed and separate quarterly reviews were provided as documentation to Kennedy Space Center.

**DISTRIBUTION/AVAILABILITY STATEMENT:**
Document is available for public distribution.
(Unclassified - Unlimited)

**ABSTRACT (Maximum 200 words):**
The impacts of introducing Liquid Rocket Boosters (LRB) into the STS/KSC Launch environment are identified and evaluated. Proposed ground systems configurations are presented along with a launch site requirements summary. Pre-launch processing scenarios are described and the required facility modifications and new facility requirements are analyzed. Flight vehicle design recommendations to enhance launch processing are discussed. Processing approaches to integrate LRB with existing STS launch operations are evaluated. The key features and significance of launch site transition to a new STS configuration in parallel with on-going launch activities are enumerated.

The LRB Integration Study Final Report is presented in five volumes as follows:

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**SUBJECT TERMS:**
- Liquid Rocket Boosters for STS
- Launch Site Operations
- Launch Site Facility Requirements
- Mixed Fleet Operations

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