LIQUID ROCKET BOOSTER INTEGRATION STUDY

VOLUME V OF V APPENDICES
PART 1
SECTIONS 1-7

KENNEDY SPACE CENTER
NAS10-11475

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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.
# LIST OF ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>ADP</td>
<td>Automatic Data Processing</td>
</tr>
<tr>
<td>A&amp;E</td>
<td>Architectural and Engineering</td>
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<td>AF</td>
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<td>AI</td>
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<td>Aluminum Lithium Alloy</td>
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<td>Advanced Launch Systems</td>
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<td>Alternate</td>
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<td>AOA</td>
<td>Abort Once Around</td>
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<td>AOPL</td>
<td>Advanced Order Parts List</td>
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<td>Auxiliary Platform</td>
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<td>ARF</td>
<td>Assembly and Refurbishment Facility</td>
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<td>ARTEMIS</td>
<td>Accounting, Reporting, Tracking, &amp; Evaluation Management - Information System</td>
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<td>ASSY</td>
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<td>Generator</td>
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<td>Ground Umbilical Carrier Plate</td>
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<td>Hardware Interface Module</td>
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<td>IBM</td>
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<td>Interface Control Document</td>
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<td>Interface</td>
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<td>ILC</td>
<td>Initial Launch Capability</td>
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<td>Integration</td>
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<td>Initial Operational Capability</td>
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<td>IPR</td>
<td>Interim Problem Report</td>
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<td>IRD</td>
<td>Interface Requirements Document</td>
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<td>IUS</td>
<td>Internal Upper Stage</td>
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<td>Johnson Space Center</td>
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K  Thousands
   Kelvin
KLB  Thousands of Pounds
KSC  Kennedy Space Center
KW  Kilowatt

LAC  Launch Accessories Contractor
LC-39  Launch Complex 39
LCC  Life Cycle Cost
       Launch Control Center
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
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<td>MIN</td>
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<td>MLP</td>
<td>Mobile Launch Platform</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>MP</td>
<td>Manpower</td>
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<td>MPS</td>
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<td>MSBLS</td>
<td>Microwave Scanning Beam Landing System</td>
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<td>MTI</td>
<td>Morton-Thiokol, Inc.</td>
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<td>Nitrogen</td>
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<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<td>Orbiter Access Arm</td>
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<td>On-the-job Training</td>
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<td>OMD</td>
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OMI Operations and Maintenance Instruction
OMRF Orbiter Maintenance and Refurbishment Facility
OMRSD Operational Maintenance Requirements and Specifications Document
OMS Orbital Maneuvering System
OPF Orbiter Processing Facility
OPS Operations
OMBUU Orbiter Mid Body Umbilical Unit
ORB Orbiter
ORD Operational Readiness Date
ORI Operational Readiness Inspection
OSHA Occupational Safety & Health Administration
OTV Operational Television

PA Public Affairs
PAWS Pan Am World Services, Inc.
P/A Propulsion/Avionics Module
Pc Engine Combustion Chamber Pressure
PC Personal Computer
PCM Pulse Code Modulator
PCR Payload Changeout Room
PDR Preliminary Design Review
PER Preliminary Engineering Report
PGHM Payload Ground Handling Mechanism
PIC Pyro Initiator Controller
PIF Payload Integration Facility
P/L Payload
PMM Program Model Number
PMS Permanent Measuring System
PO Purchase Order
POP Programs Operations Plan
PR Problem Report
PRACA Problem Reporting and Corrective Action
PRCBD Program Review Control Board Directive
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<td>Planning Research Corporation</td>
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<td>Program Requirements Document</td>
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<td>PRESS</td>
<td>Pressure, pressurization</td>
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<td>Preliminary Requirements Review</td>
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<td>PSI</td>
<td>Pounds Per Square Inch</td>
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<td>Quick Disconnect</td>
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<td>Rotation, Processing &amp; Surge Facility</td>
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<td>Return to Launch Site</td>
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VOLUME V

SECTION 1

LRB GROUND OPERATIONS PLAN
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1.1 SCENARIO  
1.2 FACILITY REQUIREMENTS  
1.3 GSE/LSE  
1.4 OPERATIONAL TIMELINES  
1.5 MANPOWER  
1.6 COSTS
During the flight hardware downselection process, both MSFC Phase-A study contractors considered reusable booster configurations. As a result of independent mid-term trade studies, both MMC and GDSS subsequently eliminated the reusable booster configurations from further study. Prior to this downselection, a cursory evaluation of the launch site requirements for LRB retrieval, disassembly and refurbishment was performed. The study methodology utilized is typical to the techniques described in Volume III of this report.

1.1 SCENARIO

The following recovery scenario has been employed for the station set impact analysis.

• Fully recoverable LRB

• Downrange wet recovery with parachutes

• LRB secured to the deck of the recovery barge (no tow back)

• Partial safing and initial washdown occurring on the recovery barge

• Recovery barge tug to CCAFS

• LRB barge removal by travel lift to ground transporter

• Final safing and washdown

• Disassembly as required

• Parachutes to the KSC parachute facility (by truck)
- Engines to the LRB engine manufacturer for refurbishment (by plane)

- LRB to the manufacturer for refurbishment (by barge)

This scenario was selected for study primarily because it most closely resembled the current SRB recovery scenario, in comparison to the proposed alternate LRB recovery options of down-range wet or dry recovery of the propulsion/avionics module only; or the RTLS LRB toss-back and tow-back options. The downrange wet full recovery is feasible, practical, and reliable. It has the lowest technical risk and the launch site operations are established.

1.2 FACILITY REQUIREMENTS

The station set configuration must provide capability to support the following:

- Recovery barge operations and maintenance

- LRB safing and washdown

- LRB disassembly

- LRU handling, storage and transportation to the refurbishment sites

Our current facility concept envisions a new facility for LRB safing and washdown, sized to accommodate one LRB; a new facility for LRB disassembly including office and logistics areas, sized to accommodate one LRB flight set; and a new barge dockage/slip area, sized to accommodate two recovery barges.

The decision to proceed with new facilities in lieu of modifying the existing SRB Hangar AF facilities is based on technical and schedule issues. The increased LRB diameters and lengths cannot be accommodated by the Hangar AF facilities. Modification activity will disrupt SRB/STS recovery and disassembly operations, impact SRB refurbishment schedules and potentially have a ripple effect to the STS flight rate.

The preferred facility siting plan is south and adjacent to the CCAFS Hangar AF facilities. This site eliminates extensive dredging in the Banana River, required to support the recovery barge traffic from the Port Canaveral locks to the Hangar AF area.
This station set requires approximately 85,000 square feet of facility under roof, and approximately 90,000 square feet of combined apron/dockage area, with at least 200 feet fronting the Banana River.

End-to-end implementation can be accomplished in approximately 24 months utilizing a design/build concept or 36 months utilizing conventional implementation techniques. These conceptual durations exclude the time required to prepare and process the environmental impact statements.

1.3 GSE/LSE

It must be recognized that the ground support equipment and launch support equipment for LRB retrieval and disassembly is in the early conceptual stage. The following is a preliminary list of unique systems and equipment expected to be required at this station set.

- **GSE**
  - High pressure de-ionized water spray system - robot controlled
  - Hazardous waste containment system
  - Engine handling equipment

- **LSE**
  - Recovery barge (2)
  - Commercial Tug (2)
  - Travel lift - 150 ton (1)

1.4 OPERATIONAL TIMELINES

The LRB operational timelines are not expected to differ radically from the projected 1996 timelines for SRB retrieval and disassembly. The following is a synopsis of the projected LRB operational timelines for one LRB flight set.
• Pre-launch OPS 7 days
• At sea recovery OPS 2 days
• Safing and washdown 3 days
• Disassembly 7 days

These timelines are not expected to be schedule critical at the launch site.

1.5 MANPOWER

The LRB processing manpower requirements are expected to be similar to the current SRB headcount, in support to retrieval and disassembly. LRB headcount will peak at 160 SPC type personnel and 60 civil servant and BOC type personnel in FY 1998 and remain constant through the program duration. Initial staffing must start in FY 1995, for training and certification, and initial headcount is projected at 50% of the peak staffing level.

All personnel will be stationized. This is consistent with the staffing philosophy presented in Volume III Section 6 of this report. As LRB/STS flight rate ramps up and SRB/STS flights are phased out, the opportunity exists to transition SRB retrieval and disassembly personnel to the LRB program. This could occur as early as FY 1997.

1.6 COSTS

The total Life Cycle Cost (LCC) for LRB retrieval and disassembly is currently projected at approximately $185.0 million. This includes the non-recurring costs conceptualized at $50.0 million (includes 40% NASA wrap factor) and the recurring costs estimated at $135.0 million. The recurring costs are based upon a projected total manpower requirement of 2420 man years, at a burdened cost of $50,000 per man year, and commercial tug leasing for 122 LRB/STS flights at $100,000 per flight. The Life Cycle Costs are in FY 1987 dollars, and are rough-order of magnitude.
The LCC specifically excludes costs for the following:

- LRB refurbishment
- LRB engine refurbishment
- Recurring spares
- Hazardous waste handling
- SRB de-activation
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SECTION 2

LRB PROCESSING TIMELINES
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**Until:** 31-OCT-94

**Barchart Drawing by:**

**FOR INFORMATION CONTACT:** L5OC J. BOLAND 867-6993

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**30-AUG-93**

**ASSESSMENT:**

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**PROJECT: SRB000**

**FROM 4-SEP-95 UNTIL 31-OCT-96**

**LSOC - KSC PROJECT SUPPORT**

**FOR INFORMATION CONTACT: LSOC J. BOLAND 867-6693**

**FILE: SRB95 - ID: 121 DATED: 9/34 94**

**30-AUG-95**

**Barchart Drawing System**
Figure 2.1-5. FY 1996 ET/SRB Facility Utilization.
Figure 2.1-6. FY 1997 ET/SRB Facility Utilization.
Figure 2.1-7. FY 1998 ET/SRB Facility Utilization.
ITY UTILIZATION

YEAR - 1999

Figure 2.1-8. FY 1999 ET/SRB Facility Utilization.
Figure 2.1-9. FY 2000 ET/SRB Facility Utilization.
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**PROJECT: SRB000**

**LSOC - KSC PROJECT SUPPORT**

**FOR INFORMATION CONTACT: LSOC J. BOLAND 967-6693**

**FILE: SRB001 - TD:121 DATED: 9:30 AM 30-AUG-98**

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FROM 2-SEP-2002 UNTIL 31-OCT-2003
LSOC - KSC PROJECT SUPPORT
FOR INFORMATION CONTACT: LSOC J. BOLAND 867-6693
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**PROJECT: SRB0000**

FROM 1-SEP-2003 UNTIL 31-OCT-2004

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Figure 2.1-14. FY 2005 ET/SRB Facility Utilization.

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*Figure based on preliminary study - SRB baseline.*

*Assignment manifest.*

*Planning purposes only.*

*Note: Times and dates are approximate.*

Submitted 8:53 am 30-AUG-88
Figure 2.1-15. FY 2006 ET/SRB Facility Utilization.
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**PROJECT: SRB0000**

FROM 4-SEP-2006 UNTIL 31-OCT-2007

**FILE: SRB107 - ID: 121 DATED: 30-AUG-98**

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**81022-01-AN**

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**METEOR/ARTEMIS**

Barchart Drawing 81022-01-AN
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**Project:** SR000  
From 2-Sep-91 until 31-Oct-92  
Assessment based on preliminary LRR study - SRB baseline  
For information contact: LSOC J. Zartman 857-8833  
File: 810552A - ID: 121  
Dated: 7:23 am 31-Aug-98  

Barchart Drawing System
## FY OPEN PERIODS

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Figure 2.2-1. FY1992 ET/SRB Facility Open Periods.

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**PROJECT:** SRB000  **FROM 30-AUG-93 UNTIL 31-OCT-94**

**LSOC - KSC PROJECT SUPPORT**

**FOR INFORMATION CONTACT:** LSOC J. ZARTMAN 867-6693

**FILE:** SRB1994 - ID: 121  **DATED:** 7:32 am 31-AUG-88

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**FY OPEN PERIODS**

**EAR - 1994**

Figure 2.2-3. FY1994 ET/SRB Facility Open Periods.
Figure 2.2-4. FY1995 ET/SRB Facility Open Periods.
Figure 2.2-5. FY1996 ET/SRB Facility Open Periods.
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**ET/SRB FACILITY**

**FISCAL YEAR**

**PROJECT: SRB000 FROM 25-AUG-97 UNTIL 31-OCT-98**

**LSOC - KSC PROJECT SUPPORT**

**FOR INFORMATION CONTACT: LSOC J. ZARTMAN 867-6693**

**FILE: SRB1998 - ID: 121 DATED: 7:55 am 31-AUG-88**

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**ET CELL 2**

**ET CELL 4**

**RPSF (BOOSTER BLD-UP)**

**RPSF-1**

**LRB CHECKOUT**

**LRB VAB 2**

**LRB VAB 4**

**MLP**

**MLP-1**

**MLP-2**

**MLP-3**

**VAB HI-BAY**

**VAB-1**

**VAB-3**

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PROJECT: SRB000 FROM 24-AUG-98 UNTIL 31-OCT-99

LSOC - KSC PROJECT SUPPORT

FOR INFORMATION CONTACT: LSOC J. ZARTMAN 867-6693

FILE: SRB1999 - ID: 121 DATED: 8-01 ma31-AUG-98

Barchart Drawing S...
TY OPEN PERIODS
YEAR - 1999

Figure 2.2-8. FY1999 ET/SRB Facility Open Periods.
TY OPEN PERIODS
YEARN - 2000

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Figure 2.2-9. FY2000 ET/SRB Facility Open Periods.
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**PROJECT:** SRB000  FROM 21-AUG-2000 UNTIL 31-OCT-2001

**FILE:** SRB2001 - ID 121  DATED: 8.15  #31-AUG-98

**FOR INFORMATION CONTACT:** LSOC J. ZARTMAN 857-6693

**ASSESSMENT BASED ON:** PRELIMINARY

**FILE:** SRB2001 - ID 121  DATED: 8.15  #31-AUG-98

**FOR INFORMATION CONTACT:** LSOC J. ZARTMAN 857-6693

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**PROJECT: SRB000 FROM 20-AUG-2001 UNTIL 31-OCT-2002**

ASSESSMENT BASED ON PRELIMINARY LRB STUDY - SRB Baseline

FOR INFORMATION CONTACT: LSOG J. ZARTMAN 867-6683

FILE SRB2002 ID 121 DATED 8.22 a231-AUG-88

Barchart Drawing System
**Figure 2.2-11. FY2002 ET/SRB Facility Open Periods.**

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**FY OPEN PERIODS**

EAR - 2002

8:22 am 31-Aug-88
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**PROJECT:** SRBO00 FROM 16-AUG-2004 UNTIL 31-OCT-2005

LSOC - KSC PROJECT SUPPORT

FOR INFORMATION CONTACT: LSOC J. ZARTMAN 867-6693

FILE: SRB2005 - ID: 121 DATED: 8:45 am 31-AUG-06

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PROJECT: SRB000 FROM 15-AUG-2005 UNTIL 31-OCT-2006

ASSESSMENT BASED ON PRELIMINARY LRB STUDY - SRB BASELINE
FOR INFORMATION CONTACT: LSCC J. ZARTMAN 867-5693
FILE: SRB2006 - ID: 121 DATED: 8.54 on 31-AUG-99

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Figure 2.2-16. FY2007 ET/SRB Facility Open Periods.
### ORBITER/SSV FACILITY UTILIZATION

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**Figure 2.3-1 FY1990 Orbiter/SSV Facility Utilization**
Figure 2.3-2 FY1991 Orbiter/SSV Facility Utilization
Figure 2.3-3 FY1992 Orbiter/SSV Facility Utilization
Figure 2.3-5 FY1994 Orbiter/SSV Facility Utilization
**ORBITER/SSV FACILITY UTILIZATION**

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**Figure 2.3-6 FY1995 Orbiter/SSV Facility Utilization**

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PROJECT: SRB000
FROM: KSC PROJECT SUPPORT
LSOC - KSC PROJECT SUPPORT
FOR INFORMATION CONTACT: LSGC J. BOLAND 967
FILE: 81028-01G DATED 12/28/98

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For more information, contact: L. J. Boland W/748

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**Figure 2.3-13** FY2002 Orbiter/SSV Facility Utilization
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PROJECT: SR8000 - FROM 2
L50C - KSC PROJECT SUPPORT
FOR INFORMATION DETAIL: L50C J. RYLAND 887-6900
STYLE: 808/1000 - TD 101 DATED 15 JUL 84 1-1984

81028-01N
Figure 2.3-14 FY2003 Orbiter/SSV Facility Utilization
Figure 2.3-15 FY2004 Orbiter/SSV Facility Utilization
ORBITER/SSV FACILITY UTILIZATION

FISCAL YEAR - 2005

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Figure 2.3-16 FY2005 Orbiter/SSV Facility Utilization
Figure 2.3-17 FY2006 Orbiter/SSV Facility Utilization
## ORBITER/SSV FACILITY UTILIZATION
### FISCAL YEAR - 2007

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**Figure 2.3-18 FY2007 Orbiter/SSV Facility Utilization**
TABLE OF CONTENTS

2.1 ET/SRB BASELINE FACILITY UTILIZATION (FY 1992 THRU FY 2007)

2.2 ET/SRB FACILITY OPEN PERIODS (FY 1992 THRU 2007)

2.3 ORBITER/SSV FACILITY UTILIZATION (FY 1990 THRU FY 2007)
VOLUME V

SECTION 3

LRB FACILITY REQUIREMENTS AND CONCEPTS FOR NEW FACILITIES
3.1 Flame Trench Modification

The appendix section describes the present construction of the flame trench at Pad 34A and B and the geometry with respect to the Crawler Transporter tracks.

3.1.1 Flame Trench Description

The flame trench is 58 feet wide and 40 feet deep. It is lined with 6" refractory concrete brick on a 3 foot thick single pour monolithic steel reinforced walls and base. Figure 3.1.1 shows the detail design. To widen the trench would require removal of the brick and concrete in the area of the booster.

3.1.2 Crawler Transporter Width

As seen in Figure 3.1.1 the inside width of the crawler transporter is 66 feet. The present clearance of the concrete wall and the transporter track is 6 inches. To maintain a 3 foot thick trench wall would require the wall to be under a crawler transporter track. If the trench wall thickness can be reduced to 6 inches at the top of the trench 5 feet can be gained. However, since the wall is a single pour a clear angled surface for installation of the refractory concrete brick will be time consuming.

3.1.4 Conclusion

The feasibility of modifying the flame trench is limited by the existing crawler and existing construction. Providing a new crawler with a wider track will impact the MLP pedestal (on the pad and in the VAB) and the crawlerway. Further detailed design analysis is required in a Phase-B study.

3.1.4 Reference

Core of Engineers Drawings 203-102
Figure 3.1.1. Typical Flame Trench

REF DWG: 203-102 SH 3080
Figure 3.1.2. Typical Cross Section Of Crawlerway

CLASS 'A' SUB-BASE, COMPACTED IN 6" LAYERS TO 100% OF MAX DRY DENSITY, CBR=25 (LIMIT OF CBR 15-25)

NOTE: 1 BITUMINOUS PRIME COAT

REF. DWG: CORPS OF ENGR DWG# 203-102
VOLUME V

SECTION 4

LRB LAUNCH SUPPORT EQUIPMENT DEFINITION

(All supporting data for this Study Product is included in Volume III.)
VOLUME V

SECTION 6

LRB MANPOWER
VOLUME V SECTION 6
LRB MANPOWER APPENDICES
TABLE OF CONTENTS

6.1 Liquid Rocket Booster Integration Study Dr. W. F. Huseonica
6.2 WBS Data On STS Processing
6.3 Morton Thiokol Technician Head Count
6.4 SRB Technician Count By Location
6.5 LRB Skill Mix Counts
6.6 Manloading By Location Data
6.7 NASA Support Team Headcount Data
6.1 LRB Integration Study - Dr. W. F. Huseonica

6.1.1 This study was developed using data for the year 1985 from the WBS/PWO reporting system. SRB manhours were used as a baseline and were modulated with SRB/LRB technical differences to arrive at LRB estimates. The ratios of support technician for the Orbiter were used rather than the SRB because of the multiple liquid engines and associated control mechanisms. These ratios were further modulated to reflect the differences in complexity between the LRB and the Orbiter.
### LRB Processing Manhours and Cost

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<th>Skill Mix</th>
<th>Ratio</th>
<th>Manhours</th>
<th>Rate</th>
<th>Cost</th>
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<th>Cost % of Total</th>
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<td>11%</td>
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<tr>
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<td>$393,258</td>
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<td>1%</td>
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<tr>
<td>PP &amp; C</td>
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<td>2%</td>
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<td>$3,339,599</td>
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**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 assumptions as the EG&G base support assumptions as the EG&G base support assumption in item #4.
6. A non-recoverable LRB is assumed in the above table.

Reviewed 6/17/88
S. Burns
A. Withers
K. Humphries
B. Huseonica
G. Artley
**QUID ROCKET BOOSTER INTEGRATION STUDY**  
**DR. W.F. HUSEONICA, PAWS, INC.**

**LRB PROCESSING MANLOADING**  

<table>
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**SUBTOTAL**  
254

| BASE SUPPT-EG&G   | 1.60  | 32,090   | 76       |
| NASA/KSC-CS       | 1.92  | 38,508   | 91       |

**SUBTOTAL**  
167

**TOTAL**  
421

**COMMENTS AND ASSUMPTIONS:**

1. MANPOWER BASED ON A 53 DAY GENERIC LRB FLOW
2. MANPOWER IS CALCULATED 8 HRS A DAY TIMES 53 DAYS AND DIVIDED INTO MANHOURS
## CURRENT SRB PROCESSING MHRS AND COST

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<th>AVE COST</th>
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<td>SRB PROCESSING</td>
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<td>$847,165</td>
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COMMENTS AND ASSUMPTION:

1. MORTON THIOKOL PROCESSING MHRS AND COST BASED ON THE PAST 14 MISSIONS
2. SPC (LSOC) DATA BASED ON THE PAST THREE (3) MISSIONS
3. ALL SPC MHR AND COST DATA IS PWG AND AND WBS DATA
4. EG&G AND NASA/KSC CS MHR AND COST DATA ASSUMES 80% OF MHRS & COST SUPPORTS SHUTTLE ELEMENT PROCESSING AND 20% SUPPORTS CARGO OPS AT KSC
5. ALL LSOC SUPPORT IS ENGINEERING MHRS EXCEPT 1/2 OF PAD PROCESSING AND THE OTHER HALF IS TECHS AND ALL OPS SUPPORT IS QUALITY PEOPLE
6. IT IS ASSUMED THE USBI-KSC OPS IS STAFF APPROX IS SAME AS MORTON THIOKOL AT 400 PEOPLE
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CONCLUSIONS

0 OVERALL SUPPORT RATIOS TO TECHNICANS

- SHUTTLE - 4.37 : 1
- SHUTTLE II - 1.00 : 1
- NABP - 1.00 : 1
- ELV - 1.60 : 1

0 SHUTTLE SCRUB/RECYCLE PER DAY

- TECHNICANS - 5,000 MHRS
- SUPPORT - 21,850 MHRS
- TOTAL MHRS - 26,850
- TOTAL COST - $483,300 (1986$)

0 SCHEDULED TO UNSCHEDULED MAINTENANCE

RATIO - 2.42 : 1

ORIGINAL PAGE IS OF POOR QUALITY
6.2 WBS Data On STS Processing

6.2.1 Work breakdown structure data for the year 1985 was chosen as a baseline for use in developing LRB data. This period was used because it represented the highest launch rate and busiest work activity of any year in STS history. Ten launches occurred during this era which is the closest approximation to 14 launches per year that could be found.
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## FACILITY AND OVERHEAD WBS DATA

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#### PROCESS AND STORAGE FACILITY

1.1.2.9 PSF OGS MANHOURS 696 807 918 242 5 118
COSTS ($) 14581 16900 19219 5079 118

1.3.28.1 PSF MAINT MANHOURS 99 114 130 34 6
COSTS ($) 2903 3364 3826 1899 236

1.3.28.4 PSF BE MODS MANHOURS 1072 1243 1413 373 87
COSTS ($) 18415 21343 24271 6403 1494

1.3.28.5 PSF OGS SUPP MANHOURS 271 314 357 94 23
COSTS ($) 5442 6307 7172 1892 443

#### VAB

1.3.4.1 VAB FAC MAINT MANHOURS 1344 1557 1771 467 109
COSTS ($) 24436 28321 32207 8496 1903

1.3.4.3 VAB RESERVED MANHOURS 1781 2064 2348 619 145
COSTS ($) 34832 40371 45910 12111 2826

1.3.4.5 VAB OGS SUPP MANHOURS 394 457 520 137 32
COSTS ($) 9164 10621 12079 3186 743

#### MLP

1.3.6.1 MLP MAINT MANHOURS 80 93 106 28 7
COSTS ($) 1473 1707 1941 512 120

1.3.6.2 MLP MODS MANHOURS 123 143 162 43 10
COSTS ($) 2749 3186 3623 956 223

#### PAD A

1.3.8.1 PAD A MAINT MANHOURS 6 7 8 2 1
COSTS ($) 74 86 97 26 6

*ORIGINAL PAGE IS OF POOR QUALITY*
### Facility and Overhead WBS Data
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| CDSTB  | 254158| 299000 |     | 343842 | 85604 | 22879 |
**6.3 Morton Thiokol Technical Head Count**

6.3.1 In order to develop the LRB/SRB comparisons it was necessary to establish the number of MTI technicians and their support ratios. They are as follows:

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6.4 SRB Technician Count By Location

6.4.1 In order to establish a direct correlation between the LRB and SRB technician work force, the manhours at each location was devided by the number of days spent in the facility times 8 hours. This data was used for determining the LRB technician head count. A similar exercise was performed for the SRB as well and is included as a part of the database in this appendix.
SRB STAFFING

TECHNICIANS

SRB Processing
SRB Skirts 17 days

**Inspection/SEG off load**

17 days - (11 day overlap with SRB skirts)

Booster Stacking
ET Mate & C/O
SYS INT C/O

21 days
11 days
5 days

RPSF 5 days / 3 shifts

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6.5 LRB Skill Mix Counts

6.5.1 Each of the tasks in the ARTEMIS CPM charts was examined to determine what technician skill was examined to determine what technician skill would be required. Basic skill types of mechanical, electrical, engine and TPS were established. Totals were compiled and the skill mix comparison charts evolved from the data.
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6.6 Manpower Loading By Location Data

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6.7 NASA SUPPORT TEAM HEAD COUNT DATA

6.7.1 NASA Operations Interface Team

NASA Operations and O&M contractors operational support to all areas of activation functions:

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Ops Engineering types
Yount/Lamberth types
Webb types
Carpenter types
Bobic types

140 Total personnel

* Finance and contracts not included in any team

5 Person required for an LRB project office
145 total team count

NOTE:
Ops and System Engineering OMD’s
Ops and System Engineering Software
Ops and System Engineering Certification
Ops and System Engineering ORI
Ops and System Engineering Pathfinder
Ops and System Engineering ORD Turnover/Acceptance
Ops and System Engineering Training
Ops and System Engineering Certification
6.7.1.1 Schedule of Manpower Utilization (by %)

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Work control, scheduling, outrages/permits, security – covered in activation support

6.7.2 NASA Engineering Interface Team

NASA &/or Contractor To Support Activation Management Team

A. DE/TM-TV-TE Engineering &/or Contractors

4 X 5 TV = 20 - Provide Engineering direction/documents from
2 X 5 TE = 10 - Level II & III
1 X 10 DE = 10 - Provide change and approval loop
1 X 5 RTQ = 5 - Provide Site (field Engineers)
1 X 5 RTQ = 5 - Review & Approval Interium OMIs & TPS Loop
1 X 5 SI = 10 - Walk downs, test surveillance system acceptance.

B. TM Operations &/or Contractor

5 X 1 = Site - All above and schedule
4 X 5 = Site - Plus work control
Functional Interface - Schedule approvals
2 X 5 TE = 10 - Site control for staging
1 X 2 TP = 2 - Outage loop
3 X 5 TL = 15 - Permit loop
1 X 4 TL = 4 - Security loop
2 X 5 RT/RQ = 10 - Area control
1 X 5 RS = 5
15 SI = 15

61
C. NASA and KSC Project Planning Office

1 LRB/EB
1 Engineering/GSE
1 Ground Systems
1 Finance
1 Scheduling

- Change Control
- ICD Approvals
Test data and approvals from/to
Level II & I $
Schedule level III

D. RQ/Safety and Contractors Environmental

30 people Impact Assessment

Schedule

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<td>80%</td>
<td>50%</td>
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6.7.3 Activation Management Team

Responsible for coordination of design construction and activation of facilities. Interface between the LRB activation and the operational SRB program. Migrate to LRB team as core group for operational phase.

Manning Schedule

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# TABLE OF CONTENTS

7.1 ET/LRB Horizontal Processing Facility (Section A)
7.2 VAB (Section B)
7.3 LRB Mobile Launch Platform #4 (Section C)
7.4 LRB Mobile Launch Platform #5 (Section D)
7.5 MLP Parksite #2 (Section E)
7.6 LC-39 PAD A or B (Section F)
7.7 LCC/LPS (Section G)
7.8 Launch Equipment Test Facility (Section H)
7.9 High Voltage Power Distribution (Section I)
This appendix contains the detailed engineering estimates for the launch site non-recurring costs for each station set impacted by LRB STS integration.

It is the intent of this section to display the derivation of costs for the bottoms-up pricing approach. In general, detailed estimates have been prepared for the facility requirements, Launch Support Equipment (LSE) and Ground Support Equipment (GSE) for each station set. The derivation of station set costs associated with design, TTV, initial spares and activation management is consistent with the cost estimating approach described in Volume III, Sections 7.1.3, 7.1.4, 7.1.5 and 7.1.6 respectively. LRB MLP #4 and #5 are the only station set detailed estimates which display this technique for all cost elements.

The station set non-recurring cost estimates have been summarized and presented in matrix format, for each LRB configuration, in Volume III, Section 7 of this report.
<table>
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<tr>
<th>ITEM NO.</th>
<th>DESCRIPTION</th>
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<th>UNIT</th>
<th>UNIT PRICE MATERIAL &amp; LABOR</th>
<th>ESTIMATED AMOUNT</th>
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Subtotal: 26,020,000

- Sub Overhead: 15% $3,903,000
- Sub Profit: 10% $2,993,000
- Prime Markup: 10% $3,291,000
- Bond: 1% $362,000
- Escalation (2 years): 10.25% $3,748,000
- Contingency: 15% $6,048,000

Total: $48,355,000
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ORIGINAL PAGE IS OF POOR QUALITY.
# KSC PRELIMINARY COST ESTIMATE WORK SHEET

||| |
|---|---|---|---|
| **PROJECT** | L.R.B INTEGRATION STUDY. | | |
| **LOCATION** | E.T. AND L.R.B GROUND SUPPORT EQUIPMENT | CODE | (GSE), LC-39, KSC |
| **ARCHITECT/ENGINEER** | | | |
| **ESTIMATOR** | | | K. H. Wassum |
| **DRAWING NO.** | | | |
| **CHECKED BY** | | | |
| **APPROVED BY** | | | |

## Item No.

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<th>Description</th>
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<th>Estimated Amount</th>
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**KSC FORM 21-324 (REV. 4/77)**

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**ORIGINAL PAGE IS OF POOR QUALITY.**
# KSC Preliminary Cost Estimate Work Sheet

**Project:** LRB Integration Study  
**Location:** ET and LRB Ground Support Equipment (GSE), LC-39, KSC  
**Estimator:** P.H. Wassum  
**Date Prepared:** 10-10-89

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**KSC Form 21-324 (REV. 4/77)  5 of 76**
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**KSC PRELIMINARY COST ESTIMATE WORK SHEET**

- **PROJECT:** LRB INTEGRATION STUDY
- **LOCATION:** LRB & ET PROCESSING FACILITY
- **ARCHITECT/ENGINEER:**
- **ESTIMATOR:** E.H. Wassum
- **O. NO.:**
- **PCN:**
- **DATE PREPARED:** 10-2-88

### Item No. | Description | Estimated Quantity | Unit | Unit Price Material & Labor | Estimated Amount
--- | --- | --- | --- | --- | ---
8A | FROM SHEET 8A | | | | $3,771,000
15% | SUB OVERHEAD | 15% | | 565,650 |
10% | SUB PROFIT | 10% | | 433,665 |
10% | PRIME MARKUP | 10% | | 477,032 |
1% | BOND | 1% | | 52,473 |
5% | ESCALATION (1YR.) | 5% | | 264,991 |
15% | CONTINGENCY | 15% | | 834,722 |

**TOTAL CONTROL ROOM**

SAY $6,400,000

**GSE**
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**SUB-TOTAL**

<p>|              |                                                |                  |      |                             | $2,771,000       |</p>
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**UNIT PRICE**

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**ESTIMATED QUANTITY**

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<td>600 EA</td>
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<td>700 EA</td>
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**REMARKS**

- Item 21: Primary Gasgun Panel is required for the integration and test activities.
- Item 24: Thermal Protection is necessary for protecting the engine during testing.
- Item 25: Engine Flush and Panel is essential for cleaning and maintenance.

**APPROVED BY**

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<thead>
<tr>
<th>ITEM NO.</th>
<th>DESCRIPTION</th>
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KSC PRELIMINARY COST ESTIMATE WORK SHEET

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TOTAL FACILITY: SAY $20,000,000

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<tbody>
<tr>
<td>1.</td>
<td>LRB FUEL &amp; OXIDIZER VENT VALVE ACTUATION PANEL</td>
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<tr>
<td></td>
<td>SIMILAR TO ST2-0680-01</td>
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<tr>
<td>2.</td>
<td>STAINLESS STEEL TUBING</td>
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<tr>
<td>3.</td>
<td>NEW 9099 ELECTRICAL INTERFACE</td>
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<tr>
<td>4.</td>
<td>TERMINAL DISTRIBUTORS</td>
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<tr>
<td>8.</td>
<td>MODIFY EXISTING HIM</td>
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<td></td>
<td>(SAME AS ITEM 1)</td>
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<td>SUB OVERHEAD</td>
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<td>CONTINGENCY</td>
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<td>SPECIAL CONDITION</td>
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TOTAL GSE: $1,610,000
## LRB Integration Study

### Facility Modification, VAB, High Bay 4, LC-39, KSC

**Project:**

**Architect/Engineer:**

**Estimator:**

**Drawing No.**

**Checked By:**

**Approved By:**

### KSC Preliminary Cost Estimate Work Sheet

#### Construction Equipment

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
<th>Estimated Quantity</th>
<th>Unit</th>
<th>Unit Price Material &amp; Labor</th>
<th>Estimated Amount</th>
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<tbody>
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<td>Extensible Platforms</td>
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<td>5.</td>
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**Sub Overhead**

15%  
201,789

**Sub Profit**

10%  
154,725

**Prime Markup**

10%  
170,175

**Bond**

1%  
18,719

**Escalation (1% per year)**

5%  
94,332

**Contingency**

15%  
297,777

**Special Conditions**

10%  
228,296

**Total**  
2,511,254
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<th>ITEM NO.</th>
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<tr>
<td>sub overhead</td>
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<td>15%</td>
<td></td>
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<td>3,840,010</td>
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<td>sub profit</td>
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<td>10%</td>
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<td>prime markup</td>
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<td>bond</td>
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<td>special conditions</td>
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<td>TOTAL FACILITY</td>
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<tr>
<th>ITEM NO.</th>
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<tr>
<td>1</td>
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<td></td>
<td>ES CALATED LABOR 25000</td>
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<tr>
<td></td>
<td>MH- MATERIAL $265,810</td>
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<td>3</td>
<td>AUX. ALUMINUM PLATFORMS (SRB-AB @ 1000 LB)</td>
<td>16 EA</td>
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<td>AUX. AL PLATFORMS (LRB @ 2000 LB)</td>
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<td>MODIFY EXISTING AUX. ALUMINUM PLATFORM</td>
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<td>MODIFY SUPERSTRUCTURE</td>
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<tr>
<td>7</td>
<td>ECS STATIONS</td>
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<td>ELECTRICAL CABLES</td>
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SUB-TOTAL: 3,840,010
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<td>FROM SHEET BB</td>
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<td>SUB OVERHEAD</td>
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<td>ESCALATION (1yr)</td>
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<td>CONTINGENCY</td>
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<td><strong>TOTAL GSE</strong></td>
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**KSC PRELIMINARY COST ESTIMATE WORK SHEET**

**PROJECT**
LRB INTEGRATION STUDY

**LOCATION**
GSE, HIGH BAY 3, VAB, KSC

---

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<tr>
<th>ITEM NO.</th>
<th>DESCRIPTION</th>
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<th>UNIT</th>
<th>UNIT PRICE</th>
<th>MATERIAL &amp; LABOR</th>
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<tr>
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<td>EA</td>
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<td>17,000</td>
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<tr>
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<td>LOT</td>
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<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
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<td>MODIFICATIONS TO 9099 ELECTRICAL INTERFACE</td>
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<td>50,000</td>
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<td>9,000</td>
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<td>12,000</td>
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<tr>
<td>7</td>
<td>MOD TO PYRO TEST DISTR</td>
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<td>EA</td>
<td>15,000</td>
<td>15,000</td>
<td>15,000</td>
</tr>
<tr>
<td>8</td>
<td>MOD TO LPS SIGNAL ADAPTER</td>
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<td>EA</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>9</td>
<td>MOD TO HIM</td>
<td>1</td>
<td>EA</td>
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<td>50,000</td>
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**SUB- TOTAL**
$582,000

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<th>MATERIAL &amp; LABOR</th>
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<tr>
<td>1.</td>
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<tr>
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<td>#8 REINFORCING BAR</td>
<td>410</td>
<td>TONS</td>
<td>520</td>
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<td>#6 REINFORCING BAR</td>
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<td>TONS</td>
<td>520</td>
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<td>DEWATERING</td>
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<td>LF</td>
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<td>48,000 SF</td>
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<td>900</td>
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<td>12&quot; POTABLE WATER LINE</td>
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<td>LF</td>
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<td>8&quot; SANITARY SEWER LINE</td>
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<td>LF</td>
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<td>2000</td>
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<td>POWER MANHOLE</td>
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<td>6.</td>
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<td>RAILROAD ENDING</td>
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## KSC Preliminary Cost Estimate Work Sheet

**Project:** LRB Integration Study  
**Location:** VAB Crawlerway, LC-39, KSC

### Equipment

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
<th>Estimated Quantity</th>
<th>Unit</th>
<th>Unit Price Material &amp; Labor</th>
<th>Estimated Amount</th>
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<tr>
<td>11</td>
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<td>Power Manhole</td>
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**Sub Overhead** 15%  
**Sub Profit** 10%  
**Prime Markup** 10%  
**Bond** 1%  
**Escalation (1% / yr.)** 5%  
**Contingency** 15%  
**Total**  

Sub Overhead: $379,911  
Sub Profit: $291,265  
Prime Markup: $820,391  
Bond: $35,243  
Escalation (1% / yr.): $177,977  
Contingency: $50,629  
**Total:** $4,398,153

**Total:** $4,300,000

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## KSC Preliminary Cost Estimate Work Sheet

### Project
LBB Integration Study

### Location
LBB MLP 1H - All LPs / RP-1

### Architect/Engineer

### Estimator
J. Burns

### Drawing No.

### Checked By

### Approved By

## Facility Requirements Summary

### Structural

### Architectural

### Electrical

### Mechanical

### Sub-Total

### Sub Overhead

### Sub Profit

### Prime 0/1/4 Profit

### Bond

### Escalation

### Contingency

### Total

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**ORIGINAL PAGE IS OF POOR QUALITY**
## GROUND SUPPORT EQUIPMENT
### KSC PRELIMINARY COST ESTIMATE WORK SHEET

**PROJECT**: LFRB INTEGRATION STUDY

**LOCATION**: LFRB, MLP #4 - ALL LOC / RP-1

**ARCHITECT/ENGINEER**: S. Burns

---

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**SUB-TOTAL**

**TO SHEET 2**

11,260,000

### ARCHITECTURAL -

| Paint        | 185000 SF 3 00 | 550,000 |
| FLOORING     | 20000 SF 11 00 | 220,000 |
| INSULATION   | 20000 SF 9 00 | 180,000 |
| DOORS/ HATCHES| 60 EA 3700 | 222,000 |

**SUB-TOTAL**

**TO SHEET 2**

1,172,000

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TOTAL

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*ADD TO LO2/RO-1 BASELINE

ORIGINAL PAGE IS OF POOR QUALITY
## GROUND SUPPORT EQUIPMENT

### KSC PRELIMINARY COST ESTIMATE WORK SHEET

**O. NO.** | **PCN** | **DATE PREPARED** | **SHEET** | **15C OF 15C**
--- | --- | --- | --- | ---

### CONSTRUCTION

**PROJECT**

*LRB INTEGRATION STUDY*

**LOCATION**

*GSE LO₂/LH₂, LC-39, NLP-4 OR 5, KSC*

**ARCHITECT/ENGINEER**

*R. H. Wassum*

**DRAWING NO.**

*CHECKED BY**

*APPROVED BY*

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KSC FORM 21-224 (REV. 4/77)
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## KSC Preliminary Cost Estimate Worksheet

**Project:** LRB Integration Study  
**Location:** MLP Parksite #2  
**Architect/Engineer:**  
**Estimator:** S. Burns

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<td>Wire / Connections</td>
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<tr>
<td></td>
<td>Comm. Duct Bank</td>
<td>450</td>
<td>LF</td>
<td>60 %</td>
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<tr>
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<td>Comm. Cable</td>
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<td>LF</td>
<td>25 %</td>
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<td><strong>Sub-Contract O/H</strong></td>
<td>15</td>
<td>%</td>
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<td><strong>Sub-Contract Profit</strong></td>
<td>10</td>
<td>%</td>
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<tr>
<td></td>
<td><strong>Prime Mark-up</strong></td>
<td>10</td>
<td>%</td>
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<td>x 1.10</td>
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<tr>
<td></td>
<td>Bond</td>
<td>1</td>
<td>%</td>
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<td>x 1.01</td>
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<tr>
<td></td>
<td><strong>Escalation (12 months)</strong></td>
<td>2.5</td>
<td>%</td>
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<td>x 1.025</td>
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<td><strong>Contingency</strong></td>
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<td>%</td>
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<td>x 1.15</td>
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<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>2,150,000</strong></td>
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*Based on MLP Parksite #3  
C-100 Estimate
# KSC Preliminary Cost Estimate Work Sheet

## Project: LRB Integration Study

### Location: LOX System Tank Pads A02B, LC-39, KSC

### Estimator: P.H. Wassum

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
<th>Estimated Quantity</th>
<th>Unit</th>
<th>Unit Price Material &amp; Labor</th>
<th>Estimated Amount</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>18&quot; Steel Pipe, 41' Long</td>
<td>96 EA</td>
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<td>921,600</td>
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<tr>
<td>2</td>
<td>Pile Caps 10' x 10' x 3' The</td>
<td>16 EA</td>
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<td>4</td>
<td>Preaugering</td>
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<td>960</td>
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<tr>
<td>5</td>
<td>Testing, Pile</td>
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**From Sheet 2E**

**Subtotal**

**Sub Overhead**

**Sub Profit**

**Prime Markup**

**Bond**

**Education (1yr)**

**Contingency**

**Special Conditions**

**Total Cost for One (1) Pile Cap**

---

KSC FORM 21-224 (REV. 4/77)
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**SUB. TOTAL**

**ORIGINAL PAGE IS OF POOR QUALITY**

C FORM 21-324 (REV. 4/77)

49 of 76
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<th>DESCRIPTION</th>
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<th>COMMERCIAL MATERIAL &amp; LABOR</th>
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TOTAL SAY $25,900,000
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**SUB-TOTAL:** 12,122,170

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## LRB Integration Study

**Location:** Flame Deflectors, Pads A or B

**Code:** LC-39, KSC

### ARCHITECT/ENGINEER

**Estimator:** R.H. Wassum

#### DRAWING NO.

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**Sub Overhead:** 15%
**Sub Profit:** 10%
**Prime Markup:** 10%
**Gond:** 1%
**Escalation (1 yr):** 5%
**Contingency:** 15%
**Special Conditions:** 25%

**Total:** Say $14,000,000
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PCN 16535
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SUB-TOTAL

$1,472,383

ORIGINAL PAGE IS OF POOR QUALITY
## KSC Preliminary Cost Estimate Work Sheet

### Project:
LRB INTEGRATION STUDY

### Location:
LC-39 PAD A or B - ACCESS (408/38-P-1-HNC 1/

### Architect/Engineer:

### Drawing No.:

### Checked By:

### Approved By:

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**NOTE:**
- Original page is of poor quality.
## KSC Preliminary Cost Estimate Work Sheet

### Project:
LRB Integration Study

### Location:
LC-49 Pad A or B - Access (102/102 and 102/103)

### Code:

### Architect/Engineer:
J. Burns

### Drawing No.

### Checked By

### Approved By

### Item No. | Description | Estimated Quantity | Unit | Unit Price Material & Labor | Estimated Amount |
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**Total**

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**KSC FORM 21-224 (REV. 4/77)**

62 of 76
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**Signal Hard Wiring**

- To 48 Signal Pickup Point (1-2B, T.S. #22AWG) 29,400 LF 0.10 25,560
- SUB OVERHEAD 15% 146,940
- SUB PROFIT 10% 112,660
- PRIME MARKUP 10% 123,926
- BOND 1% 15,974
- ESCALATION 5% 67,000
- CONTINGENCY 15% 77,000

**Total of Poor Quality**

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**TOTAL** | 7,600,000 |

- **Ground Support Equipment**
- **KSC Preliminary Cost Estimate Work Sheet**
- **Date Prepared:** 9-30-88
- **Sheet 2 of 6H**

**Code**
- **Estimator:** S. Burns

**Certification Testing -**
- **Date Prepared:** 9-30-88
- **Sheet 2 of 6H**

**Subtotal:** 2,760,000

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<th>ESTIMATED QUANTITY</th>
<th>UNIT</th>
<th>UNIT PRICE</th>
<th>ESTIMATED AMOUNT</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>ALL LO3 / RP-1</td>
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<td>CONFIGURATIONS</td>
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<tr>
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<td>DELTA COSTS MUST BE</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>ADDED TO SUMMARY/ TOTAL</td>
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<td>SHOWN ON SHEET 1</td>
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<tr>
<td></td>
<td>KG-1 UMBILICAL</td>
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<tr>
<td></td>
<td>2 EA</td>
<td></td>
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<td>40'</td>
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<tr>
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<td>CERTIFICATION TESTING / KG-1</td>
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<td>KG-1 UMBILICAL</td>
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<td></td>
<td>60'</td>
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<td>RECURB / MAINTENANCE / KG-1</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>RE-LOAD / SHIP / KG-1</td>
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<tr>
<td></td>
<td>KG-1 UMBILICAL</td>
<td></td>
<td></td>
<td>15'</td>
<td>30,000</td>
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<tr>
<td></td>
<td>INTEGRATION / FACILITY</td>
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<td></td>
<td>60%</td>
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<td>MAINT / DOCUMENTATION</td>
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<td>SUB-TOTAL</td>
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<td>FORMATION (G sq. yd.)</td>
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<td>12.5%</td>
<td>692.40</td>
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<tr>
<td></td>
<td>ACTIVATION MIN.</td>
<td></td>
<td></td>
<td>15%</td>
<td>115.15</td>
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<tr>
<td></td>
<td><strong>TOTAL</strong></td>
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<td>-----------------------------</td>
<td>------------------</td>
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<tr>
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<td>LO\textsubscript{2} / L\textsubscript{2} PUMP FED CONFIGURATION — DELTA COSTS MUST BE ADDED TO SUMMARY TOTAL SHOWN ON SHEET</td>
<td>1</td>
<td></td>
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<tr>
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<td><strong>INSTALLATION &amp; LETF —</strong></td>
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</tr>
<tr>
<td></td>
<td>ET GOX VENT ARM</td>
<td>2</td>
<td>230\textsuperscript{k}</td>
<td>460,000</td>
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<td></td>
<td>L\textsubscript{2} T-O UMBILICAL</td>
<td>4</td>
<td>220\textsuperscript{k}</td>
<td>880,000</td>
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<td><strong>CERTIFICATION TESTING —</strong></td>
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<td></td>
<td>ET GOX VENT ARM</td>
<td>2</td>
<td>240\textsuperscript{k}</td>
<td>480,000</td>
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<td></td>
<td>L\textsubscript{2} T-O UMBILICAL</td>
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<td>180\textsuperscript{k}</td>
<td>1,920,000</td>
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<tr>
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<tr>
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<td>REMOVE / SHIP —</td>
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<tr>
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<td>ET GOX VENT ARM</td>
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<td>190\textsuperscript{k}</td>
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<td>L\textsubscript{2} T-O UMBILICAL</td>
<td>4</td>
<td>135\textsuperscript{k}</td>
<td>540,000</td>
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**KSC Preliminary Cost Estimate Work Sheet**

**Project:** LTB Integration Study  
**Location:** LETF - Additional LSE LO2/LH2 Goss  
**Architect/Engineer:**  
**Estimator:**  
**Drawing No.:**  
**Checked by:**  
**Approved by:**

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
<th>Estimated Quantity</th>
<th>Unit</th>
<th>Unit Price Material &amp; Labor</th>
<th>Estimated Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>LO2/LH2 Sub-total</strong></td>
<td></td>
<td></td>
<td></td>
<td>4,660,000</td>
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<tr>
<td></td>
<td>Integration/Facility</td>
<td>60%</td>
<td></td>
<td></td>
<td>2,796,000</td>
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<td>MAINT./DOCUMENTATION</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td><strong>Sub-total</strong></td>
<td></td>
<td></td>
<td></td>
<td>7,456,000</td>
</tr>
<tr>
<td></td>
<td><strong>Escalation (2 years)</strong></td>
<td>10.25%</td>
<td></td>
<td>x 1.1025</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Contingency</strong></td>
<td>15%</td>
<td></td>
<td>x 1.15</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Activation Maint.</strong></td>
<td>15%</td>
<td></td>
<td>x 1.15</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>LO2/LH2 Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>10,872,000</td>
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</tbody>
</table>
## Project
- **Project:** LRB Integration Study
- **Location:** High Voltage Distribution

## Estimator
- **Estimator:** R. H. Wassum

---

### Item No. | Description | Estimated Quantity | Unit | Unit Price Material & Labor | Estimated Amount
--- | --- | --- | --- | --- | ---
1 | LRB & ET Processing Facility Substation | 2 | EA | 510,436 | $1,020,872 |
2 | Pad A LOX Substation | 1 | EA | 510,436 | 510,436 |
3 | Pad A Fuel Substation | 1 | EA | 510,436 | 510,436 |
4 | Feeders L-39 Area | 1 | EA | 108,460 | 40,046,045 |
5 | LRB & ET UPS | 1 | EA | 424,260 | 424,260 |
6 | LRB & ET Emergency Power | 1 | EA | 220,372 | 220,372 |
7 | Pad B LOX Substation | 1 | EA | 510,436 | 510,436 |
8 | Pad B Fuel Substation | 1 | EA | 510,436 | 510,436 |
9 | New MLP Substations | 2 | EA | **-** | **-** |
10 | Pad A LOX Emergency Power | 1 | EA | 220,372 | 220,372 |
11 | Pad A Fuel Emergency Power | 1 | EA | 220,372 | 220,372 |
12 | Pad B LOX Emergency Power | 1 | EA | 220,372 | 220,372 |
13 | Pad B Fuel Emergency Power | 1 | EA | 220,372 | 220,372 |

### Total
- **Estimated Amount:** $15,500,000
## KSC Preliminary Cost Estimate Worksheet

### Project
- **Location:** High Voltage Distribution, LC-39, KSC Feeders

### Equipment

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Estimated Quantity</th>
<th>Unit</th>
<th>Unit Price Material &amp; Labor</th>
<th>Estimated Amount</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Subtotal from Sheet 35</td>
<td></td>
<td></td>
<td></td>
<td>$639,120</td>
</tr>
<tr>
<td></td>
<td>Sub Overhead</td>
<td>15</td>
<td>%</td>
<td></td>
<td>958,674</td>
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<tr>
<td></td>
<td>Sub Profit</td>
<td>10</td>
<td>%</td>
<td></td>
<td>734,983</td>
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<tr>
<td></td>
<td>Prime Markup</td>
<td>10</td>
<td>%</td>
<td></td>
<td>808,482</td>
</tr>
<tr>
<td></td>
<td>Bond</td>
<td>1</td>
<td>%</td>
<td></td>
<td>88,932</td>
</tr>
<tr>
<td></td>
<td>Escalation (1yr)</td>
<td>5</td>
<td>%</td>
<td></td>
<td>447,112</td>
</tr>
<tr>
<td></td>
<td>Contingency</td>
<td>15</td>
<td>%</td>
<td></td>
<td>444,702</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>$12,046,035</strong></td>
</tr>
</tbody>
</table>

### Notes
- Estimated amounts are calculated based on the provided data.
- The total cost includes subtotals for various components such as sub-overhead, sub-profit, prime markup, bond, and escalation.
- Contingency is included to cover unforeseen expenses.
<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>DESCRIPTION</th>
<th>ESTIMATED QUANTITY</th>
<th>UNIT</th>
<th>UNIT PRICE MATERIAL &amp; LABOR</th>
<th>ESTIMATED AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LRB FEET PROCESSING,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13.8KV @ 200 A (4 EA)</td>
<td>55,200</td>
<td>LF</td>
<td>5.00</td>
<td>276,000</td>
</tr>
<tr>
<td>2</td>
<td>480V @ 400A (1 EA)</td>
<td>12,400</td>
<td>LF</td>
<td>4.00</td>
<td>73,600</td>
</tr>
<tr>
<td>3</td>
<td>DUCT BANK (4-4&quot;)</td>
<td>4,600</td>
<td>LF</td>
<td>11.00</td>
<td>50,600</td>
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<tr>
<td>4</td>
<td>MLP PARK SITE #2 (4000')</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>13.8KV @ 200A (2 EA)</td>
<td>24,000</td>
<td>LF</td>
<td>5.00</td>
<td>120,000</td>
</tr>
<tr>
<td>6</td>
<td>480V @ 400A (1 EA)</td>
<td>16,000</td>
<td>LF</td>
<td>4.00</td>
<td>64,000</td>
</tr>
<tr>
<td>7</td>
<td>DUCT BANK (4-4&quot;)</td>
<td>4,000</td>
<td>LF</td>
<td>7.00</td>
<td>28,000</td>
</tr>
<tr>
<td>8</td>
<td>PAD LOX (52000')</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>13.8KV @ 200A (2 EA)</td>
<td>312,300</td>
<td>LF</td>
<td>5.00</td>
<td>1,561,500</td>
</tr>
<tr>
<td>10</td>
<td>400A EMERGENCY (1 EA)</td>
<td>208,800</td>
<td>LF</td>
<td>4.00</td>
<td>832,800</td>
</tr>
<tr>
<td>11</td>
<td>DUCT BANK (4-4&quot;)</td>
<td>52,000</td>
<td>LF</td>
<td>8.00</td>
<td>416,000</td>
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<tr>
<td>12</td>
<td>PAD FUEL (52,000')</td>
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<td></td>
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<tr>
<td>13</td>
<td>13.8KV @ 200A (2 EA)</td>
<td>312,300</td>
<td>LF</td>
<td>5.00</td>
<td>1,561,500</td>
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<tr>
<td>14</td>
<td>400A EMERGENCY (1 EA)</td>
<td>208,800</td>
<td>LF</td>
<td>4.00</td>
<td>832,800</td>
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<tr>
<td>15</td>
<td>DUCT BANK (4-4&quot;)</td>
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<td>LF</td>
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</table>

**TOTAL**  

73,600
**KSC PRELIMINARY COST ESTIMATE WORK SHEET**

**PROJECT:** RB INTEGRATION STUDY  
**INFORMATION:** HIGH VOLTAGE DISTRIBUTION, LC-39, KSC  
**CODE:**  
**H/T: ENGINEER:**  
**ESTIMATOR:** R.H. Wassum  
**FILING NO.:**  
**CHECKED BY:**  
**APPROVED BY:**  

<table>
<thead>
<tr>
<th>NO.</th>
<th>DESCRIPTION</th>
<th>ESTIMATED QUANTITY</th>
<th>UNIT</th>
<th>UNIT PRICE MATERIAL &amp; LABOR</th>
<th>ESTIMATED AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UNINTERRUPTED POWER SYSTEM (UPS), 3 PHASE 208/120VAC, 600KVA WITH BATTERY RANK</td>
<td>1 EA</td>
<td></td>
<td></td>
<td>259,000</td>
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<tr>
<td></td>
<td>SUB OVERHEAD</td>
<td>15 %</td>
<td></td>
<td></td>
<td>37,500</td>
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<td></td>
<td>SUB PROFIT</td>
<td>10 %</td>
<td></td>
<td></td>
<td>28,750</td>
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<tr>
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<td>PRIME MARKUP</td>
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<td>31,625</td>
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<td>BOND</td>
<td>1 %</td>
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<td>ESCALATION (1YR)</td>
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<td>CONTINGENCY</td>
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**INCLUDES VENDOR QUOTE ON SYSTEM OF $1,716,832**
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<td>PANELBOARD 480/277V, 3PH, 4W, 1/00A</td>
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<td>1,900</td>
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<tr>
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<td>480V-208/120V, 3PH, 4W, 12.5KVA</td>
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<td>24,000</td>
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<td>480V-208/120V, 3PH, 4W, 75.0KVA</td>
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<td>9,400</td>
<td>18,800</td>
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<td>480V-208/120V, 3PH, 4W, 7.5KVA</td>
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<td>4,000</td>
<td>8,000</td>
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<td>42 CKT, 3PH, 225A, 208/120V</td>
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<tr>
<td>8</td>
<td>42 CKT, 3PH, 4W, 100A, 208/120V</td>
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<td>1P CIRCUIT BREAKERS 20AF</td>
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<td>5,000</td>
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<td>3P CIRCUIT BREAKERS 225AF</td>
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<td>540</td>
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<td>SUB OVERHEAD</td>
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<td>SUB PROFIT</td>
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<td></td>
<td>10 %</td>
<td>13,714</td>
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<tr>
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<td>PRIME MARK UP</td>
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<td></td>
<td>10 %</td>
<td>15,085</td>
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<td>RAND</td>
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<td>CONTINGENCY</td>
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<tr>
<td>ITEM NO.</td>
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<td>UNIT PRICE MATERIAL &amp; LABOR</td>
<td>ESTIMATED AMOUNT</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>---------------------</td>
<td>------</td>
<td>-----------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>1.</td>
<td>PRIMARY SWITCH 13.8 KV, 30, 4W TWO POSITIONS WITH 600A CIRCUIT BREAKER</td>
<td>2</td>
<td>EA</td>
<td>12,000</td>
<td>24,000</td>
</tr>
<tr>
<td>2.</td>
<td>TRANSFORMER, DRY TYPE, 2500 KVA A-Y, 13.8 KV-480/277V DISTRIBUTION RACKS</td>
<td>2</td>
<td>EA</td>
<td>42,000</td>
<td>84,000</td>
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<tr>
<td>3.</td>
<td>21&quot; X 60&quot; WITH 4 SPACES</td>
<td>7</td>
<td>EA</td>
<td>8,500</td>
<td>59,500</td>
</tr>
<tr>
<td>4.</td>
<td>34&quot; X 72&quot; WITH 3 SPACES</td>
<td>2</td>
<td>EA</td>
<td>6,000</td>
<td>12,000</td>
</tr>
<tr>
<td>5.</td>
<td>12&quot; X 72&quot; TRANSITION RACK</td>
<td>2</td>
<td>EA</td>
<td>2,000</td>
<td>4,000</td>
</tr>
<tr>
<td>6.</td>
<td>20&quot; X 55½&quot; TRANSITION RACK</td>
<td>2</td>
<td>EA</td>
<td>2,500</td>
<td>5,000</td>
</tr>
<tr>
<td>7.</td>
<td>33&quot; X 55½&quot; PRIMARY SWITCH RACK</td>
<td>2</td>
<td>EA</td>
<td>4,000</td>
<td>8,000</td>
</tr>
<tr>
<td>8.</td>
<td>LOAD CENTERS DS 206 800A ADJ. C.B. PANEL</td>
<td>16</td>
<td>EA</td>
<td>2,930</td>
<td>46,880</td>
</tr>
<tr>
<td>9.</td>
<td>DS 416 1400A ADJ. C.B. PANEL</td>
<td>5</td>
<td>EA</td>
<td>6,800</td>
<td>34,000</td>
</tr>
<tr>
<td>10.</td>
<td>DS 840 4000A ADJ. MAIN C.B.</td>
<td>2</td>
<td>EA</td>
<td>2,200</td>
<td>4,400</td>
</tr>
<tr>
<td>11.</td>
<td>INSTRUMENT/REMOTE SENSE PANEL</td>
<td>2</td>
<td>EA</td>
<td>3,500</td>
<td>7,000</td>
</tr>
</tbody>
</table>

Sub Overhead: 15% = 45117
Sub Profit: 10% = 34590
Prime Markup: 10% = 38049
Panel: 1% = 4185

ESCALATION (11/25): 5

Total: 300780