

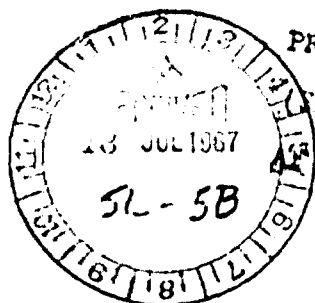
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Report No. TOR-0158(3107-20)-2

STATUS REPORT  
MOL FIRE SAFETY ACTIVITIES  
(BRIEFING)

Prepared by

MOL Systems Engineering Office

El Segundo Technical Operations  
AEROSPACE CORPORATION  
El Segundo, California

Contract No. F04695-67-C-0158

July 1967

Prepared for

DEPUTY DIRECTOR  
MANNED ORBITING LABORATORY PROGRAM  
MOL SYSTEM PROGRAM OFFICE, OSAF  
Headquarters, Space Systems Division  
Air Force Unit Post Office  
Los Angeles, California 90045

[REDACTED]

[REDACTED]

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Prepared by

MOL Systems Engineering Office

Reviewed by

  
J. L. Morgan  
Management Systems  
and Administration  
MOL Systems Engineering Office

Approved by

  
J. R. Henry, Director  
Safety Office  
Engineering Directorate  
MOL Systems Engineering Office

The information in a Technical Operating Report is developed for a particular program and is therefore not necessarily of broader technical applicability.

## FOREWORD

This briefing compares MOL Program design baseline, procedures, plans, etc. to the Apollo 204 Review Board findings and recommendations. (The briefing was presented on 7 July 1967 to Maj. Gen. Stewart, Maj. Gen. Bleymaier and members of their staff.

MOL

STATUS REPORT  
MOL FIRE SAFETY ACTIVITIES  
JULY 7, 1967

MOL

CONTENT OF BRIEFING

- o GENERAL BACKGROUND ON MOL SAFETY ACTIVITIES  
/ SUMMARY OF POST-APOLLO FIRE ACTIVITIES
- o COMPARISON OF MOL ACTIVITIES TO APOLLO 204 REVIEW  
BOARD RECOMMENDATIONS
- o BROOKS AFB INCIDENT
- o SUMMARY

GENERAL BACKGROUND - MOL SAFETY ACTIVITIES

- o MOL SAFETY DID NOT START WITH THE APOLLO 204 INCIDENT
  - / CONSIDERABLE ANALYSES AND PLANNING HAD BEEN PERFORMED
  - / PHASE II CONTRACTS INCLUDED MANY SAFETY REQUIREMENTS AND TASKS
  - / BASELINE DESIGN INCLUDED MANY SAFETY FEATURES
- o APOLLO 204 INCIDENT CAUSED:
  - / ACCELERATION OF MANY BASELINE ACTIVITIES
  - / INITIATION OF SOME NEW TASKS
  - / INCREASED SAFETY AWARENESS AND STRONGER SAFETY ORGANIZATION
- o MAJOR IMPACT OF INVESTIGATION
  - / GEMINI B ATMOSPHERE ON PAD
  - / ORBITING VEHICLE MATERIALS SELECTION AND CONTROL

MOL ACTIVITIES - POST APOLLO FIRE

- MOL SPO AND AEROSPACE SUPPORTED/FOLLOWED APOLLO REVIEW BOARD ACTIVITIES
- REVIEW OF MATERIALS SELECTION AND CONTROL REQUIREMENTS
- RE-EVALUATION OF GEMINI B AND LABORATORY VEHICLE ATMOSPHERE COMPOSITION AND PRESSURE HISTORY
- REVIEW OF EGRESS CAPABILITY
- REVIEW OF STATE OF THE ART IN FIRE DETECTION AND SUPPRESSION FOR USE IN:
  - / AIRBORNE VEHICLE
  - / FACILITIES
- RE-EVALUATION OF EQUIPMENT, PLANS, PROCEDURES, ETC. FOR:
  - / SPACE CHAMBER TESTS
  - / LAUNCH PAD TESTS
- ESTABLISHED A MORE POSITIVE SAFETY ORGANIZATION
  - / WITHIN SPO AND AEROSPACE
  - / WITHIN ASSOCIATE CONTRACTORS
- REVIEWING APOLLO BLOCK II CCB ACTION FOR APPLICABILITY TO MOL

MOL

COMPARISON OF APOLLO BOARD RECOMMENDATIONS  
AND MOL ACTIVITIES



MOL

APOLLO BOARD FINDING 2

- o BOARD RECOMMENDATION
  - / THE AMOUNT AND LOCATION OF COMBUSTIBLE MATERIALS IN THE COMMAND MODULE MUST BE SEVERELY RESTRICTED AND CONTROLLED
- o MOL ACTIVITIES
  - / REVISED SAFSL EXHIBIT IN PREPARATION
    - o BASED ON INCORPORATING PERTINENT ASPECTS OF APOLLO SPECIFICATION ASPO-RQTD-D67-5A
    - o INCLUDES MATERIAL CRITERIA, TEST REQUIREMENTS AND CONTROL
    - o REVISION WILL BE ADDED TO ALL ASSOCIATES' CONTRACTS
  - / STATUS
    - o DRAFT CIRCULATED FOR CONTRACTOR COMMENTS
    - o REVIEW WITH CONTRACTORS WEEK OF 10 JULY 1967
    - o INTEND TO PUBLISH FINAL DOCUMENT AND APPLY CONTRACTUALLY AS SOON AS POSSIBLE

BASIC MATERIALS CRITERIA

- o MATERIALS CATEGORIZED PRIMARILY BY FUNCTIONAL APPLICATION AND LOCATION IN ORBITING VEHICLE
- o MATERIALS QUALIFIED IN MOST SEVERE O<sub>2</sub> ENVIRONMENT RELATIVE TO END USE
- o GEMINI B AND LABORATORY MODULE
  - / PRESSURIZED AREAS: 6 PSIA 100% OXYGEN
  - / UNPRESSURIZED AREAS: AIR
- o MISSION MODULE: AIR
- o CREW EQUIPMENT
  - / PRESSURE SUIT ASSEMBLY
  - / SUIT LOOP: 19.0 PSIA 100% OXYGEN
  - / HIGH PRESSURE OXYGEN SYSTEM: 100 PSIA 100% OXYGEN
- o TEST RESULTS AT HIGHER PRESSURE MAY BE USED TO QUALIFY MATERIALS FOR LOWER PRESSURE USE



APOLLO REVIEW BOARD FINDING 4

- o BOARD RECOMMENDATION
  - / THE TIME REQUIRED FOR EGRESS OF THE CREW BE REDUCED AND THE OPERATIONS NECESSARY FOR EGRESS BE SIMPLIFIED
- o MOL ACTIVITIES
  - / CURRENT GEMINI EGRESS CAPABILITY
    - o HATCH OPEN (~9 SEC) AND BOTH CREWMEN ON PLATFORM IN 15 TO 21 SECONDS
  - / POSSIBLE CHANGES FOR RAPID OPENING HATCH (~.5 SEC) EVALUATED
  - / IMPROVEMENTS IN ENVIRONMENTAL SHELTER HAVE BEEN DEVELOPED
    - o TO ELIMINATE PERIOD REQUIRING EGRESS THROUGH ONLY ONE HATCH (3 MIN)
    - o TO ELIMINATE PERIOD WITH NO EGRESS CAPABILITY (2 MIN)
  - / STATUS
    - o DIRECTION IN COORDINATION TO MAC TO CONDUCT:
      - / ADDITIONAL EGRESS TESTING ON EXISTING SYSTEM
      - / PRELIMINARY DESIGN OF AUTOMATIC HATCH UNLOCKING DEVICE
    - o DIRECTION IN PREPARATION TO A&E TO:
      - / EVALUATE PROPOSED ENVIRONMENTAL SHELTER AND UMBILICAL TOWER MODIFICATIONS
      - / PROPOSE OTHER ALTERNATIVES

CURRENT GEMINI B HATCH EGRESS CAPABILITY

- o PRIOR TO MES BREAKUP (T-120 TO T-90)
  - / WITHOUT OUTSIDE AID
    - o 9 SECONDS TO OPEN HATCHES (WITH UNTRAINED PERSONNEL)
    - o 21 SECONDS (TOTAL) TO STEP ON PLATFORM
  - / WITH OUTSIDE AID
    - o 5 SECONDS TO OPEN HATCHES
    - o 15 SECONDS (TOTAL) TO STEP ON PLATFORM
- o DURING MES BREAKUP
  - / 3 MINUTE PERIOD FOR EGRESS THROUGH SAME HATCH
    - o 35 SECONDS TO STEP ON PLATFORM
  - / 2 MINUTE PERIOD WITH NO EGRESS
- o AFTER MST REMOVAL
  - / RETRACTABLE AND AUXILIARY PLATFORMS
    - o 63 SECONDS TO EXTEND OR RETRACT
    - o UP TO T-3 MINUTES
  - / SALVO FIRE OF RETROS FOLLOWED BY SEAT EJECTION (PAD ABORT)
    - o 1-5 SECONDS CREWMEN CLEAR OF SPACECRAFT

APOLLO REVIEW BOARD FINDING 5

MOL

- o BOARD RECOMMENDATION
  - / MANAGEMENT CONTINUALLY MONITOR THE SAFETY OF ALL TEST OPERATIONS AND ASSURE THE ADEQUACY OF EMERGENCY PROCEDURES
  - / ALL EMERGENCY EQUIPMENT (BREATHING APPARATUS, PROTECTIVE CLOTHING, DELUGE SYSTEMS, ACCESS ARM, ETC.) BE REVIEWED FOR ADEQUACY
  - / PERSONNEL TRAINING AND PRACTICE FOR EMERGENCY PROCEDURES BE GIVEN ON A REGULAR BASIS AND REVIEWED PRIOR TO THE CONDUCT OF A HAZARDOUS OPERATION
  - / SERVICE STRUCTURES AND UMBILICAL TOWERS BE MODIFIED TO FACILITATE EMERGENCY OPERATIONS
- o MOL ACTIVITIES
  - / LAUNCH SITE SAFETY
    - o LAUNCH SUPPORT CONTRACTS ARE NOT YET NEGOTIATED
    - o CONTRACTOR SAFETY POLICIES, CONSTRAINTS AND CRITERIA ARE SET FOR TH IN A SEGMENT GROUND SAFETY PLAN
  - / PRESENTS DETAILED GROUND SAFETY PLANNING FROM ARRIVAL OF FLIGHT HARDWARE THROUGH LIFTOFF
  - / DOCUMENT DUE NINE (9) MONTHS BEFORE FIRST LAUNCH



APOLLO REVIEW BOARD FINDING 5 (CONT'D)

- / LAUNCH SITE SAFETY (CONT'D)
  - o THE LAUNCH OPERATIONS WORKING GROUP INTEGRATES THE SEGMENT REQUIREMENTS INTO A MOL SYSTEM SAFETY PLAN
  - o CONTRACTOR CHECKOUT REQUIREMENTS PLANS TO INCLUDE THE DETAILED SAFETY (EMERGENCY) REQUIREMENTS FOR EACH TEST PROCEDURE AND ACTIVITY
- / SPACE CHAMBER SAFETY
  - o DAC AND MAC SPACE CHAMBERS HAVE BEEN REVIEWED FOR DESIGN AND PROCEDURES SAFETY FEATURES
  - o INTERNAL EVALUATION CURRENTLY IN PROGRESS TO IDENTIFY ITEMS REQUIRING CHANGE
- / ENVIRONMENTAL SHELTER AND SERVICE TOWERS
  - o MOL SERVICE STRUCTURES SAFETY FEATURES WERE REVIEWED AND FOUND TO BE ACCEPTABLE WITH TWO MAJOR EXCEPTIONS
    - / CREW EGRESS
    - / FIRE EXTINGUISHING WITHIN THE ENVIRONMENTAL SHELTER
- / MOL WILL INSTITUTE SENIOR MANAGEMENT REVIEW OF DESIGN, PLANS AND PROCEDURES PRIOR TO TEST

APOLLO BOARD FINDING 6

MOL

- o BOARD RECOMMENDATION
  - / THE GROUND COMMUNICATION SYSTEM BE IMPROVED TO ASSURE RELIABLE COMMUNICATIONS BETWEEN ALL TEST ELEMENTS AS SOON AS POSSIBLE AND BEFORE THE NEXT MANNED FLIGHT.
  - / A DETAILED DESIGN REVIEW BE CONDUCTED ON THE ENTIRE SPACECRAFT COMMUNICATION SYSTEM.
- o MOL ACTIVITIES
  - / MOL GROUND COMMUNICATION IS BASICALLY SOUND
    - o WILL INSTITUTE DISCIPLINE IN ITS USE
  - / SPACECRAFT COMMUNICATION SYSTEM - BASICALLY SAME AS NASA GEMINI
    - o RECENTLY CONDUCTED PDR (SPACECRAFT AND AGE)
  - / THE VCC IN GEMINI B HAS CAPABILITY FOR VOICE OPERATED MICROPHONE (VOX)

APOLLO BOARD FINDING 7

MOL

- o BOARD RECOMMENDATION
  - / TEST PROCEDURES AND PILOT'S CHECKLISTS THAT REPRESENT THE ACTUAL COMMAND MODULE CONFIGURATION BE PUBLISHED IN FINAL FORM AND REVIEWED EARLY ENOUGH TO PERMIT ADEQUATE PREPARATION AND PARTICIPATION OF ALL TEST ORGANIZATION
  - / TIMELY DISTRIBUTION OF TEST PROCEDURES AND MAJOR CHANGES BE MADE A CONSTRAINT TO THE BEGINNING OF ANY TEST
- o MOL ACTIVITIES
  - / SEGMENT AND INTEGRATED CHECKOUT REQUIREMENT PLANS TO BE AVAILABLE NO LATER THAN 12 MONTHS BEFORE LAUNCH
  - / DETAILED SEGMENT AND INTEGRATED TEST PROCEDURES AVAILABLE NO LATER THAN 30 DAYS PRIOR TO SCHEDULED USE
    - o MAJOR REVISIONS TO ANY TEST PROCEDURE WILL BE APPROVED ONLY AFTER EXAMINING THE IMPACT ON CREW PREPARATION AND FAMILIARITY
    - o ONLY THOSE PROCEDURE CHANGES WHICH ARE ABSOLUTELY NECESSARY FOR ATTAINMENT OF TEST OBJECTIVES OR ARE OF A "MAKE PLAY" NATURE WILL BE APPROVED
    - o DOCUMENTS WILL INCLUDE BOTH NORMAL AND EMERGENCY PROCEDURES

APOLLO BOARD FINDING 8

MOL

- o BOARD RECOMMENDATION
  - / FULL-SCALE MOCKUPS IN FLIGHT CONFIGURATION BE TESTED TO DETERMINE THE RISK OF FIRE
- o MOL ACTIVITIES
  - / MOL IS STILL EVALUATING VALUE OF FULL SCALE MOCKUP TESTS AS A QUALIFICATION TEST
  - / FULL SCALE (BOILERPLATE) TESTS HAVE DEFINITE VALUE TO EVALUATE HAZARD DUE TO RESTRICTED USAGE MATERIAL
  - o ALSO FOR EVALUATION OF FIRE DETECTION AND EXTINGUISHING SYSTEMS
  - o USE IS HEAVILY DEPENDENT ON RESULTS OF MATERIALS PROGRAM

APOLLO BOARD FINDING 9

o BOARD RECOMMENDATION

/ THE FIRE SAFETY OF THE RECONFIGURED COMMAND MODULE  
BE ESTABLISHED BY FULL-SCALE MOCKUP TESTS

/ STUDIES OF THE USE OF A DILUENT GAS BE CONTINUED WITH  
PARTICULAR REFERENCE TO ASSESSING THE PROBLEMS OF GAS  
DETECTION AND CONTROL AND THE RISK OF ADDITIONAL OPERATIONS  
THAT WOULD BE REQUIRED IN THE USE OF A TWO-GAS ATMOSPHERE

o MOL ACTIVITIES

/ BASIC CRITERION - NO MANNED HIGH PRESSURE OXYGEN (>6 PSI) TESTING  
/ GEMINI B

o BASELINE GEMINI B ATMOSPHERE 100% OXYGEN WITH  
PRESSURE HISTORY ESSENTIALLY SAME AS APOLLO 204

o STUDIED ALTERNATIVE TWO-GAS SYSTEMS

o HAVE SELECTED GROUND BASED TWO-GAS SYSTEM

/ DIRECTION TO MAC IN COORDINATION



GEMINI B ATMOSPHERE TRADEOFFS

|                                      | BASELINE<br>ATMOSPHERE    | TWO GAS<br>ON BOARD               | TWO GAS<br>GROUND BASED              | AIR                   |
|--------------------------------------|---------------------------|-----------------------------------|--------------------------------------|-----------------------|
| LAUNCH ATMOSPHERE                    | 15psi-100% O <sub>2</sub> | 4psi O <sub>2</sub> / 11psi He    | 4psi O <sub>2</sub> / 11psi He       | 15psi<br>AIR          |
| ON ORBIT ATMOSPHERE                  | 5psi O <sub>2</sub>       | 3.5psi O <sub>2</sub> / 1.5psi He | 3.5psi O <sub>2</sub> / 1.5psi<br>He | 5psi O <sub>2</sub>   |
| HAZARD OF LAUNCH<br>ATMOSPHERE       | GREATEST                  | MINIMAL                           | MINIMAL                              | LEAST                 |
| APPROXIMATE<br>WEIGHT PENALTY, LBS   | 0                         | <sup>19</sup><br>(Use Lab He)     | 12                                   | 14                    |
| COMPLEXITY OF PAD<br>PROCEDURES      | LEAST                     | INCREASED                         | INCREASED                            | SLIGHTLY<br>INCREASED |
| COMPLEXITY OF ON ORBIT<br>PROCEDURES | LEAST                     | MINIMAL                           | MINIMAL                              | GREATEST              |
| EFFECT ON VEHICLE<br>EQUIPMENT       | LEAST                     | SIGNIFICANT                       | MINIMAL                              | MINIMAL               |

ALL VERSIONS USE 100%  
OXYGEN SUIT LOOP

APOLLO BOARD FINDING 9 (CONT'D)

- / LABORATORY VEHICLE
- o BASELINE ATMOSPHERE IS TWO-GAS
  - / LAUNCH HAD PURE OXYGEN PURGE AND HIGH (10.5 PSI) OXYGEN LEVEL
  - / ON-ORBIT - 5 PSI (3.5 PSI OXYGEN-1.5 PSI HELIUM)
  - o EVALUATED ALTERNATIVE LAUNCH ATMOSPHERES
  - / SELECTED 80% HELIUM, 19% OXYGEN, 1% H<sub>2</sub>O
  - / DIRECTION IN COORDINATION
  - o EVALUATED INCREASED LEVELS OF DILUENT ON ORBIT
  - / HAVE DECIDED TO RETAIN BASELINE FOR NOW
  - / REQUEST MAC AND DAC TO EVALUATE IMPACT OF 7 PSI (3.5 PSI OXYGEN, 3.5 PSI HELIUM)
  - / GEMINI B - LABORATORY VEHICLE INTERFACE
  - o DELETING 100% OXYGEN REPRESSURIZATION OF GEMINI
  - / REPRESSURIZING WITH LABORATORY TWO-GAS
  - o DECREASING TIME REQUIRED TO REPRESSURIZE GEMINI B

| LABORATORY PAD TESTING AND LAUNCH<br>ATMOSPHERE ALTERNATIVES                                                                |                                          |                                                                                                                                                           |                            |                                                   |  |
|-----------------------------------------------------------------------------------------------------------------------------|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---------------------------------------------------|--|
|                                                                                                                             | BASELINE<br>70% O <sub>2</sub><br>30% He | 100%<br>HELIUM                                                                                                                                            | CLEAN<br>AIR               | 80% He<br>19% O <sub>2</sub><br>1% H <sub>2</sub> |  |
| HAZARD OF ATMOSPHERE                                                                                                        | GREATEST                                 | LEAST                                                                                                                                                     | MINIMAL                    | MINIMAL                                           |  |
| WEIGHT PENALTY, LBS (1)<br>EQUIVALENT PAYLOAD                                                                               | 0                                        | ~0                                                                                                                                                        | +23                        | +3                                                |  |
| PERMITS MONITORING<br>PO <sub>2</sub> SENSOR                                                                                | YES                                      | NO                                                                                                                                                        | YES                        | YES                                               |  |
| PROVIDES HABITABLE ATMOSPHERE<br>FOR UNSCHEDULED CORRECTIVE<br>MAINTENANCE                                                  | YES                                      | NO                                                                                                                                                        | YES                        | YES                                               |  |
| COMPLEXITY OF PAD PROCEDURES                                                                                                | REQUIRES<br>PURGE                        | REQUIRES<br>PURGE                                                                                                                                         | SIMPLEST<br>NO PURGE REQ'D | REQUIRES<br>PURGE                                 |  |
| COMPLEXITY OF ON ORBIT<br>PROCEDURES                                                                                        | SIMPLEST                                 | Requires depressurization and<br>re-pressurization from Gemini B prior<br>to crew transfer - these differ only in<br>pressure levels for LM decompression |                            |                                                   |  |
| (1) ASSUMES ASCENT VENT TO 5 PSI AND LATER<br>CHANGE TO ON ORBIT ATMOSPHERE (BASED ON<br>5% PENALTY DURING ZERO STAGE BURN) |                                          |                                                                                                                                                           |                            |                                                   |  |

APOLLO BOARD FINDING 10

MOL

- o BOARD RECOMMENDATION
  - / AN IN-DEPTH REVIEW OF ALL ELEMENTS, COMPONENTS AND ASSEMBLIES OF THE ENVIRONMENTAL CONTROL SYSTEM BE CONDUCTED TO ASSURE ITS FUNCTIONAL AND STRUCTURAL INTEGRITY AND TO MINIMIZE ITS CONTRIBUTION TO FIRE RISK
  - / PRESENT DESIGN OF SOLDERED JOINTS IN PLUMBING BE MODIFIED TO INCREASE INTEGRITY OF THE JOINTS BE REPLACED WITH A MORE STRUCTURALLY RELIABLE CONFIGURATION
  - / DELETERIOUS EFFECTS OF COOLANT LEAKAGE AND SPILLAGE BE ELIMINATED
  - o MOL ACTIVITIES
    - / GEMINI B
      - o ECS HARDWARE PDR HELD OCTOBER 1966
      - o ALL JOINTS EITHER MECHANICAL OR BRAZED
      - o PROBLEM - ALUMINUM COOLANT LINES IN CABIN WITH FLAMMABLE COOLANT
    - / LABORATORY VEHICLE
      - o EC/LS HARDWARE PDR HELD APRIL 1967
      - o ALL JOINTS EITHER MECHANICAL OR BRAZED
      - o WATER IS USED AS COOLANT IN CABIN, FREON OUTSIDE

GEMINI B ECS COOLANT CONSIDERATIONS

- o COOLANT ENTERS CABIN FOR SUIT HEAT EXCHANGER
  - / LOWER AFT PORTION ONLY
  - / OXYGEN/COOLANT LINES ENTER CABIN 2 INCHES APART
- o SYSTEM CONTAINS 30 POUNDS OF COOLANT
  - / TWO SEPARATE LOOPS
- o COOLANT FLUID
  - / NASA GEMINI AND CURRENT GEMINI B USE MONSANTO MCS - 198 (SILICONE ESTER)
    - o FLASH POINT OF 175°F
- o HAZARD IS SERIOUS - IF THERE IS A LEAK

GEMINI B COOLANT FLUID STATUS

- o ALTERNATIVES
  - / REMOVE SUIT HEAT EXCHANGER FROM PRESSURIZED AREA
  - / CHANGE COOLANT FLUID
    - o POSSIBLE NEW FLUIDS
      - / MONSANTO OS-139
      - o ORIGINAL NASA FLUID
      - / FREON (FC-75)
      - o NO FLASH POINT
      - / WATER
  - o DIRECTION TO MAC IN COORDINATION

APOLLO BOARD FINDING 10 (CONT'D)

o BOARD RECOMMENDATIONS (CONT'D)

/ REVIEW OF SPECIFICATIONS BE CONDUCTED, 3-DIMENSIONAL JIGS BE USED IN MANUFACTURE OF WIRE BUNDLES AND RIGID INSPECTION OF ALL STAGES OF WIRING DESIGN, MANUFACTURE AND INSTALLATION BE ENFORCED

/ VIBRATION TESTS BE CONDUCTED OF A FLIGHT-CONFIGURED SPACECRAFT

o MOL ACTIVITIES

/ REVIEWING ALL APPLICABLE WIRING DOCUMENTS, INCLUDING CONTRACTOR MANUFACTURING, INSPECTION, TRAINING, HANDLING, STORAGE, SHIPPING, AND QUALITY CONTROLS SPECIFICATIONS

- o PURPOSE - TO INTEGRATE CONSISTENT SET OF REQUIREMENTS FOR ALL ASSOCIATE CONTRACTORS

/ VIBRATION TESTS OF FLIGHT-CONFIGURED SPACECRAFT IS BASELINE

- o FLIGHT 1 (GEMINI B) IS TESTED TO 75% QUAL. LEVELS
- o LABORATORY QUALIFICATION VEHICLE IS ACOUSTICALLY TESTED TO:
  - / QUALIFICATION LEVELS - STRUCTURES
  - / FLIGHT LEVELS - WITH EQUIPMENT
  - o FLIGHT LABORATORY MODULES
  - / LOW LEVEL ACCEPTANCE TEST

APOLLO BOARD FINDING 10 (CONT'D)

MOL

- o BOARD RECOMMENDATIONS (CONT'D)
  - / THE NECESSITY FOR ELECTRICAL CONNECTIONS OR DISCONNECTIONS WITH POWER ON WITHIN THE CREW COMPARTMENT BE ELIMINATED.
  - / INVESTIGATION BE MADE OF THE MOST EFFECTIVE MEANS OF CONTROLLING AND EXTINGUISHING A SPACECRAFT FIRE. AUXILIARY BREATHING OXYGEN AND CREW PROTECTION FROM SMOKE AND TOXIC FUMES BE PROVIDED.
- o MOL ACTIVITIES
  - / THERE ARE COMMUNICATIONS/CREW TRANSFER RELATED CONNECTIONS/DISCONNECTIONS
    - o DIRECTION IN PREPARATION TO ELIMINATE FIRE DETECTION AND EXTINGUISHING
    - o REVIEWING EFFORT UNDER WAY AT OTHER AGENCIES
    - o DERIVING REQUIREMENTS FOR MOL
  - / OXYGEN MASKS ARE BASELINE FOR MOL
    - o TWO IN LABORATORY
    - o TWO IN TRANSFER TUNNEL

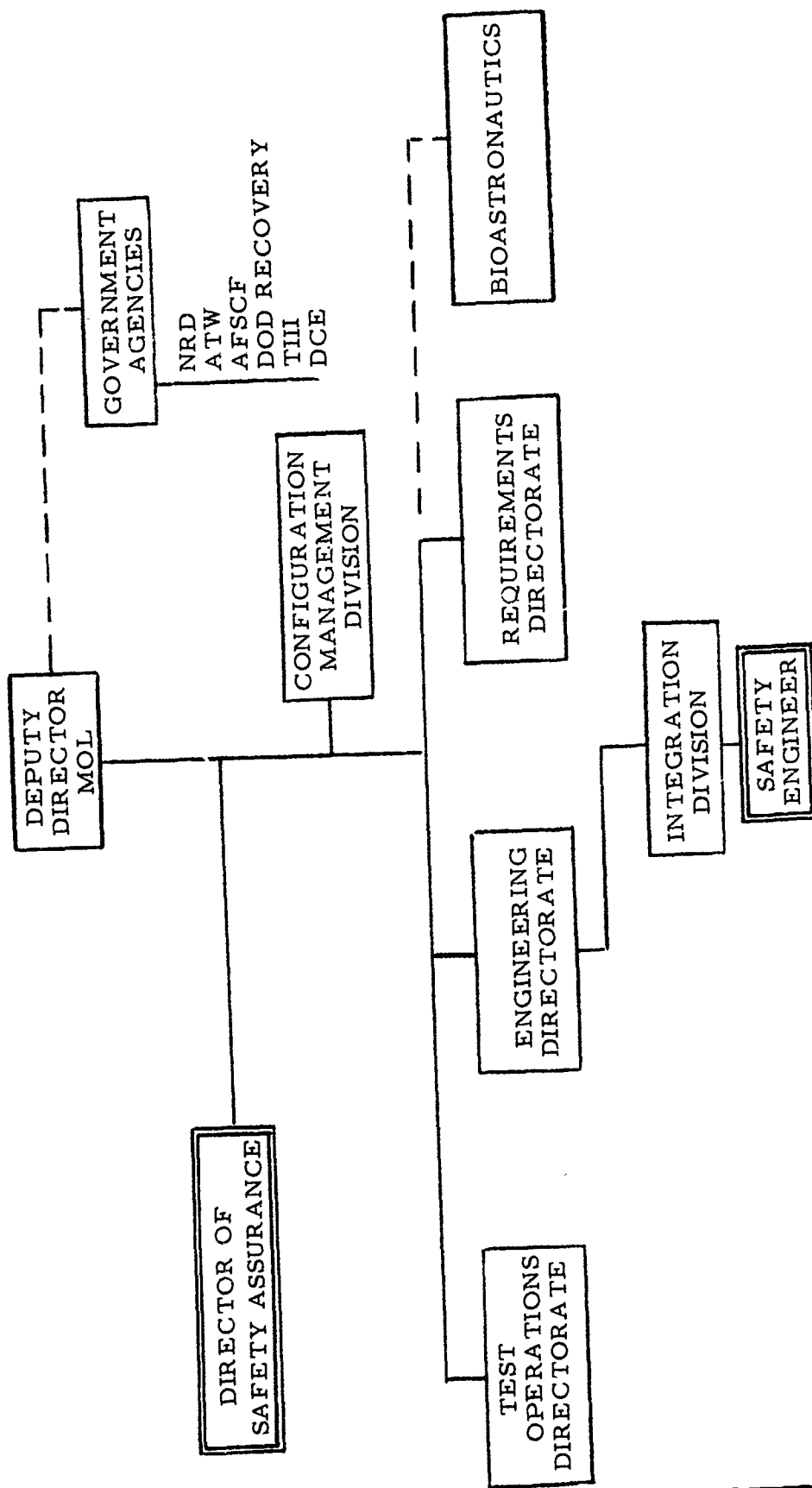
APOLLO BOARD FINDING 11

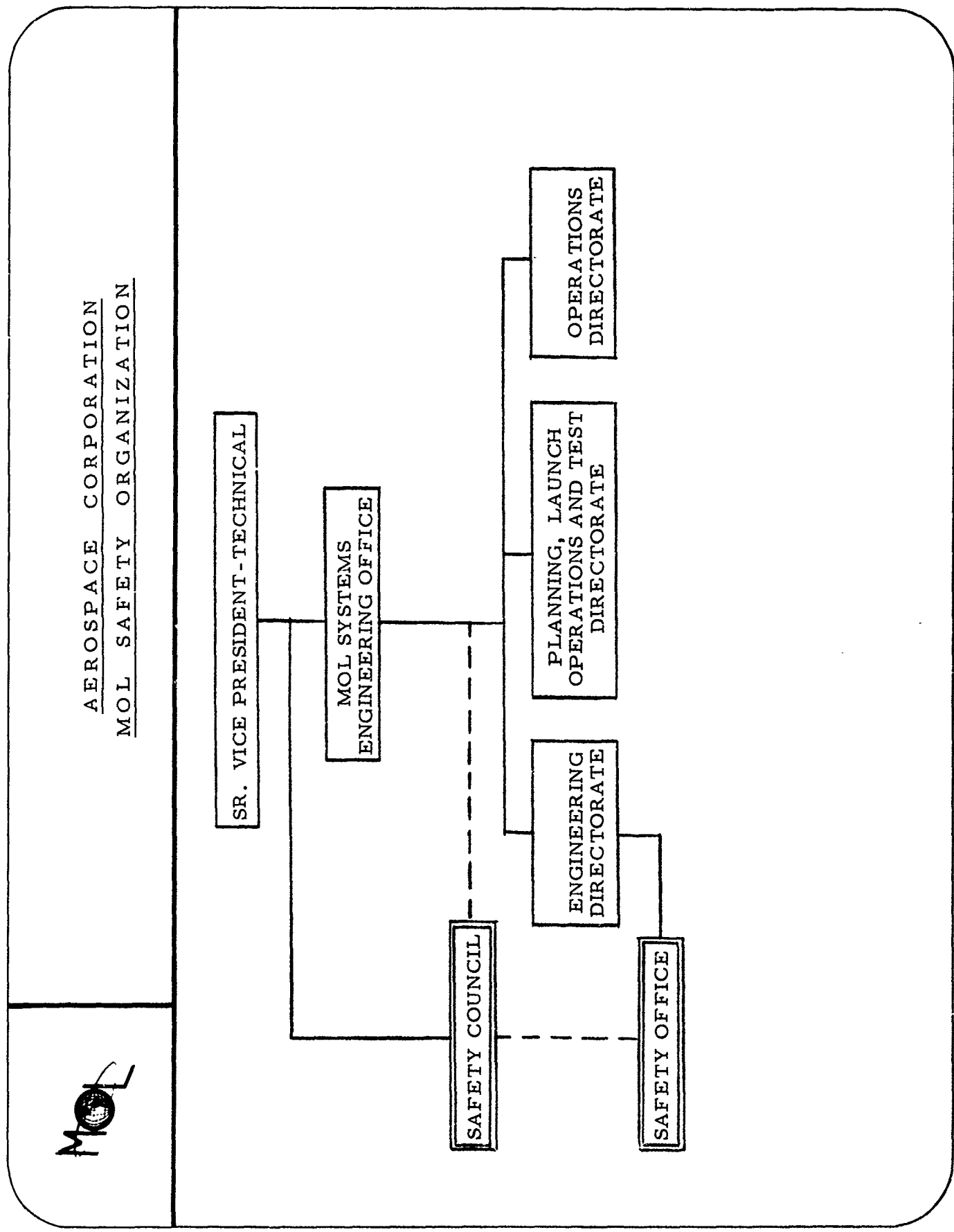
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- o BOARD RECOMMENDATION
  - / EVERY EFFORT MUST BE MADE TO INSURE THE MAXIMUM CLARIFICATION AND UNDERSTANDING OF THE RESPONSIBILITIES OF ALL THE ORGANIZATIONS INVOLVED, THE OBJECTIVE BEING A FULLY COORDINATED AND EFFICIENT PROGRAM.
  
- o MOL ACTIVITIES
  - / MOL SAFETY PLAN IN PREPARATION
    - o OVERALL MANAGEMENT LEVEL DOCUMENT
    - o PURPOSE TO:
      - / SET REQUIREMENTS FOR INTEGRATED TOTAL PROGRAM
      - / IDENTIFY ORGANIZATION RESPONSIBILITY FOR VARIOUS ACTIVITIES
      - / IDENTIFY CONSISTENT SET OF LOWER TIER SAFETY DOCUMENTS

# MOL SPO SAFETY ORGANIZATION

**MOL**





SYSTEM SAFETY GROUP

MOL

- EXECUTIVE COUNCIL
  - / MEMBERSHIP
    - MOL SPO
    - TITAN III SPO
    - AEROSPACE CORPORATION
  - / RESPONSIBILITY
    - SAFETY PROGRAM POLICY AND DIRECTION
- WORKING COUNCIL
  - / MEMBERSHIP
    - MOL SPO
    - TITAN III SPO
    - 6595 ATW
    - HQ. USAF DIRECTORATE OF AEROSPACE SAFETY (AFIAS)
    - AEROSPACE CORPORATION
    - ASSOCIATE CONTRACTORS
  - / RESPONSIBILITY
    - SAFETY PROGRAM AND REQUIREMENTS PLANNING
    - SAFETY PROGRAM SURVEILLANCE
    - PARTICIPATE IN ACCIDENT/INCIDENT INVESTIGATION



EVALUATION OF BROOKS AFB ACCIDENT

MOL

BROOKS AFB ACCIDENT

- o FATAL ACCIDENT OCCURRED IN EXPERIMENTAL LOW PRESSURE CHAMBER ON 31 JANUARY 1967
  - / EXPERIMENT - INFLUENCE OF NEAR PURE OXYGEN AT ONE-HALF ATMOSPHERE ON BLOOD FORMING ORGANS OF MAMMALS
  - / CHAMBER WAS AT 7.5 PSIA PURE OXYGEN
  - / TWO AIRMEN ENTERED CHAMBER TO FEED AND WATER THE RABBITS, REMOVE WASTE AND REPLACE PAPER LINING IN TRAYS
- o SIGNIFICANT EVENTS
  - / 0837 - AIRMEN WERE AT CORRECT PRESSURE WITH ACCESS TO TEST CELL
  - / 0846 - CREW CHIEF SAW FIRE
  - / 0847 - START CHAMBER DUMP ( 15 SECS)
    - o DOOR WAS OPEN IN 31-33 SECS FROM START OF FIRE
  - / 0851 - BOTH AIRMEN REMOVED

CONCLUSIONS OF INVESTIGATING BOARD

MOL

- o PROCEDURES DID NOT EXCLUDE EXCESSIVE FLAMMABLE SOLID MATERIALS FROM BEING USED ROUTINELY
  - / MOL POSITION - NEW MATERIALS SPECIFICATION WILL CONTROL
- o PROCEDURES DID NOT DEMAND EXCLUSION OF ALL POSSIBLE IGNITION SOURCES
  - / MOL POSITION - ACTIVELY REVIEWING AND CONTROLLING ALL POTENTIAL IGNITION SOURCES: PARTICULAR ATTENTION TO ELECTRICAL SYSTEM
- o TRAINING PRACTICES NOT SUFFICIENTLY FORMALIZED TO ASSURE STANDARDIZATION IN ACCOMPLISHMENT OF MAINTENANCE AND OPERATIONS
  - / MOL POSITION - ALL TESTING WILL BE COVERED BY FORMAL WRITTEN PROCEDURES
- o INADEQUATE TIME FOR SENIOR SCIENTIFIC SUPERVISORS TO PARTICIPATE DAILY IN THE PROGRAMS
  - / MOL POSITION - PROPER SENIOR LEVEL SUPERVISION WILL BE GIVEN TO ALL HAZARDOUS TESTING. IN GENERAL, MOL TESTS ARE NOT ROUTINE.

MOL

CONCLUSIONS OF INVESTIGATING BOARD (CONT'D)

- o GROUND SAFETY PROGRAM NOT AS HIGHLY DEVELOPED AS IT COULD BE  
/ MOL POSITION - MOL IS CURRENTLY STRENGTHENING GROUND  
SAFETY PROGRAM
- o EMERGENCY RESPONSE OF FIRE AND MEDICAL SERVICES WAS EXTREMELY  
FAST  
/ MOL POSITION - FIRE AND MEDICAL SERVICES REACTION TIMES  
AT BROOKS DEMONSTRATED THAT QUICK REACTION  
IS POSSIBLE AND SET PRACTICAL STANDARDS  
FOR MOL
- o FIRE PROBABLY RESULTED FROM A SPARK CAUSED BY STEPPING  
ON A TEFLON INSULATED ELECTRICAL LAMP CORD WHICH WAS ON  
A METAL FLOOR

Q

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S U M M A R Y

MOL

SUMMARY

- o IN GENERAL, MOL PROGRAM INCLUDED THE ELEMENTS  
REQUIRED FOR SAFETY
  - / DESIGN FEATURES
  - / PLANNING
- o HOWEVER, THE ACCELERATED REVIEW HAS IDENTIFIED  
SOME AREAS FOR IMPROVEMENT
  - / CORRECTING THESE WILL HAVE COST AND  
WEIGHT IMPACT
  - / WILL BE LATE SUMMER BEFORE ALL STUDIES  
ARE COMPLETE AND IMPACT IS KNOWN
- o THE SAFETY PROCEDURES, PLANS, ANALYSES AND STUDY ACTIVITIES  
WILL RESULT IN IDENTIFYING OTHER POTENTIAL HAZARDS
  - / DUE TO INCREASED EMPHASIS ON SAFETY
  - / DUE TO STRONGER SAFETY ORGANIZATIONS

## 1. MATERIALS SELECTION, TEST AND CONTROL

## 2. ATMOSPHERE/ECS CHANGES

#### 4. HAZARD DETECTION / EMERGENCY CREW PROCEDURES

## TOXIC DETECTION SYSTEM

**MOI ENVIRONMENTAL SHEETER**

## OTHER CHANGES

BACKUP CHARTS

GENERAL BACKGROUND - MOL SAFETY ACTIVITIES

- o SAFETY ACTIVITIES REQUIRED BY NEGOTIATED PHASE II CONTRACTS
  - / MIL-S-38130 REQUIREMENT ON ALL CONTRACTS
  - / ESTABLISHMENT OF SAFETY ORGANIZATIONS
  - / PREPARATION OF SAFETY PLANS
  - / PARTICIPATION IN SAFETY WORKING GROUPS
  - / CONDUCT OF SAFETY ANALYSIS AND CORRECTIVE ACTION
  - / SAFETY SUPPORT OF DESIGN ACTIVITIES
  - / SAFETY REVIEW OF TEST PLANS AND PROCEDURES
  - / SAFETY INSPECTIONS
  - / SAFETY NUMERICS AS PART OF EFFECTIVENESS ANALYSIS
  - / EFFECTIVENESS ACTIVITIES
    - o RELIABILITY
    - o QUALITY ASSURANCE

CREW SAFETY REQUIREMENTS

|                            | ASCENT |        | ON-ORBIT |        | RE-ENTRY |       |
|----------------------------|--------|--------|----------|--------|----------|-------|
|                            | REQ.   | EST.   | REQ.     | EST.   | REQ.     | EST.  |
| o FAILURE ALLOCATION (PPM) |        |        |          |        |          |       |
| TITAN IIM                  | 30,000 | 21,280 | N.A.     | N.A.   | N.A.     | N.A.  |
| LABORATORY VEHICLE         | 600    | —      | 19,000   | —      | N.A.     | N.A.  |
| MISSION PAYLOAD            | 300    | —      | 1,000    | —      | N.A.     | N.A.  |
| GEMINI B                   | 100    | —      | 20,000   | 19,910 | 5,000    | 3,980 |
| TOTAL                      | 31,000 |        | 40,000   |        | 5,000    | 3,980 |

o CREW FATALITY ALLOCATION

|          | REQUIREMENT | CURRENT ESTIMATE |
|----------|-------------|------------------|
| LAUNCH   | .0005       | —                |
| ASCENT   | .0030       | .0024            |
| ON-ORBIT | .0010       | —                |
| RE-ENTRY | .0010       | .0003            |
| TOTAL    | .0055       |                  |

MOL

CREW SAFETY COMPARISON

|   |                                                     |      |
|---|-----------------------------------------------------|------|
| o | APOLLO REQUIREMENTS (LUNAR LANDING MISSION-198 HRS) |      |
| / | MISSION RISK (AT IGNITION)                          | .37  |
| o | AT INSERTION ON LUNAR ORBIT                         | .25  |
| o | ABORT FORCING FAILURE RATE DURING ASCENT            | .120 |
| / | CREW RISK (AT IGNITION)                             | .020 |
| o | AT INSERTION ON LUNAR ORBIT                         | .018 |
| o | CREW FATALITY RATE DURING ASCENT                    | .002 |

|   |                  |                     |                      |
|---|------------------|---------------------|----------------------|
| o | MOL REQUIREMENTS |                     |                      |
| / | ALLOCATIONS      | <u>FAILURE RATE</u> | <u>FATALITY RATE</u> |
| o | ASCENT           | .031                | .003                 |
| o | ON-ORBIT         | .040                | .001                 |
| o | RE-ENTRY         | <u>.005</u>         | <u>.001</u>          |
|   | TOTAL            | .076                | .005                 |

PRE-IGNITION ALLOCATION (120 MIN) IS .0005

ANALYSIS AND TRADEOFF STUDIES

- o PLANNED FOR ALL MISSION PHASES
- o TO DATE HEAVY ACTIVITY ON ASCENT PHASE
- o PROCEDURE
  - / ESTABLISH FORMAL WORKING GROUPE TO DIRECT ASSOCIATE CONTRACTOR AND IN-HOUSE SAFETY TRADEOFF STUDIES AND ANALYSES
  - / PERMITS SPO/AEROSPACE TO INTEGRATE MULTI-SEGMENT ACTIVITIES
  - o RETAIN BALANCE IN SAFETY, WEIGHT, COST, COMPLEXITY, ETC.

ANALYSIS AND TRADEOFF STUDIES

(CONT'D)

- o ASCENT CREW SAFETY GROUP - FUNCTIONING FOR OVER TWO YEARS
  - / ESTABLISHED DESIGN CRITERIA AND GROUND RULES FOR ANALYTICAL EFFORT
  - / PERFORMED GROSS SUB-SYSTEM TRADEOFF STUDIES
    - o REDUNDANCY REQUIREMENTS
    - o ESCAPE SYSTEMS
    - o ESCAPE PROCEDURES
  - / PERFORMED DETAIL FAILURE MODE AND EFFECTS ANALYSIS
  - / FUTURE EFFORT
    - o ANALYSIS WILL CONTINUE IN PRESENT MODE UNTIL MDS HARDWARE FROZEN
    - o EFFORT WILL THEN BE CONCENTRATED ON:
      - / CREW PROCEDURES
      - / DETAIL REVIEW OF EQUIPMENT TESTING FAILURES, ETC.
      - / INCLUSION OF MORE REFINED ANALYSES

MOD

LAUNCH SITE SAFETY ACTIVITIES

- o CONTRACTOR LAUNCH SITE ACTIVITIES ARE DEFERRED  
/ STATEMENTS OF WORK, DOCUMENTATION  
REQUIREMENTS, ETC. ARE NOW IN PREPARATION  
/ WILL INCLUDE PROPER SAFETY CONSIDERATIONS
- o BASIC PLANNING TO DATE INCLUDES BENEFIT OF  
MERCURY AND GEMINI LAUNCH SITE EXPERIENCE

MOL SAFSL EXHIBIT SCOPE

MOL

- SPECIFIES THE CONDITIONS AND REQUIREMENTS FOR USE  
OF MATERIALS IN THE MOL ORBITING VEHICLE  
/ REQUIREMENTS ARE SPECIFIED IN TERMS OF THE  
MOST SEVERE ENVIRONMENT
- TEST METHODS AND CONTROLS DESCRIBED  
/ FLAMMABILITY AND TOXICITY HAZARDS ONLY
- REQUIREMENTS FOR CONTROL OF MATERIALS

MATERIALS CATEGORIES

MOL

- o PRIMARILY BY FUNCTIONAL APPLICATION AND LOCATION IN ORBITING VEHICLE
- o CATEGORIES
  - / CATEGORY A - UNRESTRICTED - USAGE MATERIALS
  - / CATEGORY B- MATERIALS IN THE GEMINI B, TUNNEL AREA AND LABORATORY-MODULE PRESSURIZED COMPARTMENT
  - / CATEGORY C- ELECTRICAL WIRING, ELECTRICAL CONNECTOR MATERIALS, AND OTHER MATERIALS IN PROXIMITY THERETO
  - / CATEGORY D- MATERIALS IN UNMANNED AREAS
  - / CATEGORY E- SUIT-LOOP MATERIALS
  - / CATEGORY F- MATERIALS IN HIGH PRESSURE OXYGEN SYSTEMS
  - / CATEGORY G- MATERIALS IN HERMETICALLY SEALED CONTAINERS
  - / CATEGORY H- MATERIALS IN VENTED CONTAINERS
  - / CATEGORY I- NON-FLIGHT MATERIALS

0

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MOL

SCREENING TEST REQUIREMENTS

TEST ENVIRONMENTS

|     |                       |                        |
|-----|-----------------------|------------------------|
| AIR | 6 PSIA O <sub>2</sub> | 19 PSIA O <sub>2</sub> |
|-----|-----------------------|------------------------|

|                          |              |                |              |
|--------------------------|--------------|----------------|--------------|
| COMBUSTION RATE, IN/SEC* | S.E., UPWARD | <0.3, DOWNWARD | S.E., UPWARD |
|--------------------------|--------------|----------------|--------------|

|                       |        |        |        |
|-----------------------|--------|--------|--------|
| FLASH AND FIRE POINTS | >500°F | >500°F | >500°F |
|-----------------------|--------|--------|--------|

OUTGASSING

|                 |      |                          |
|-----------------|------|--------------------------|
| (a) ODOR RATING | N.R. | 2.0 MAX. (AVERAGE SCORE) |
|-----------------|------|--------------------------|

|                         |      |          |
|-------------------------|------|----------|
| (b) CO, μ g/g of sample | N.R. | 5.0 MAX. |
|-------------------------|------|----------|

|                        |      |                      |
|------------------------|------|----------------------|
| (c) TOTAL ORGANICS, ** | N.R. | 111 AS METHANE, MAX. |
| μ g/g of sample        |      | 102 AS PROPANE, MAX. |
|                        |      | 100 AS PENTANE, MAX. |

\* THERE SHALL BE NO SPARK, SPUTTER, DRIP OR TRANSFER OF SOLID MASS DURING IGNITION OR BURNING.

\*\* ANY OUTGASSING PRODUCED AT A CONCENTRATION OF MORE THAN 20 μ g/g SHALL BE FURTHER IDENTIFIED, AND APPROVAL MUST BE RECEIVED FROM THE MOL SPO BEFORE USING THE CANDIDATE MATERIAL.

S.E. - SELF EXTINGUISHING

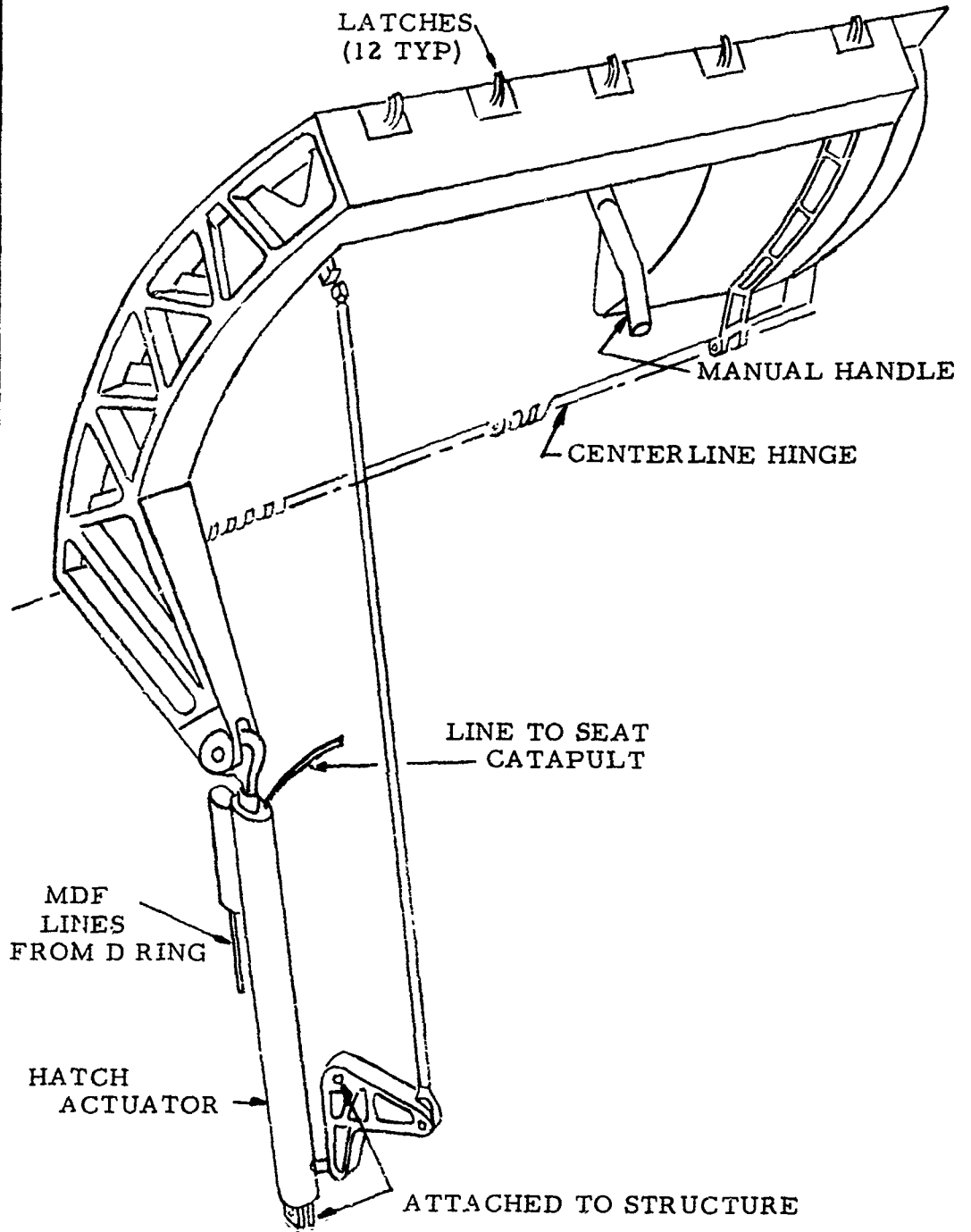
MAC STUDY OF EGRESS CAPABILITY

MOL

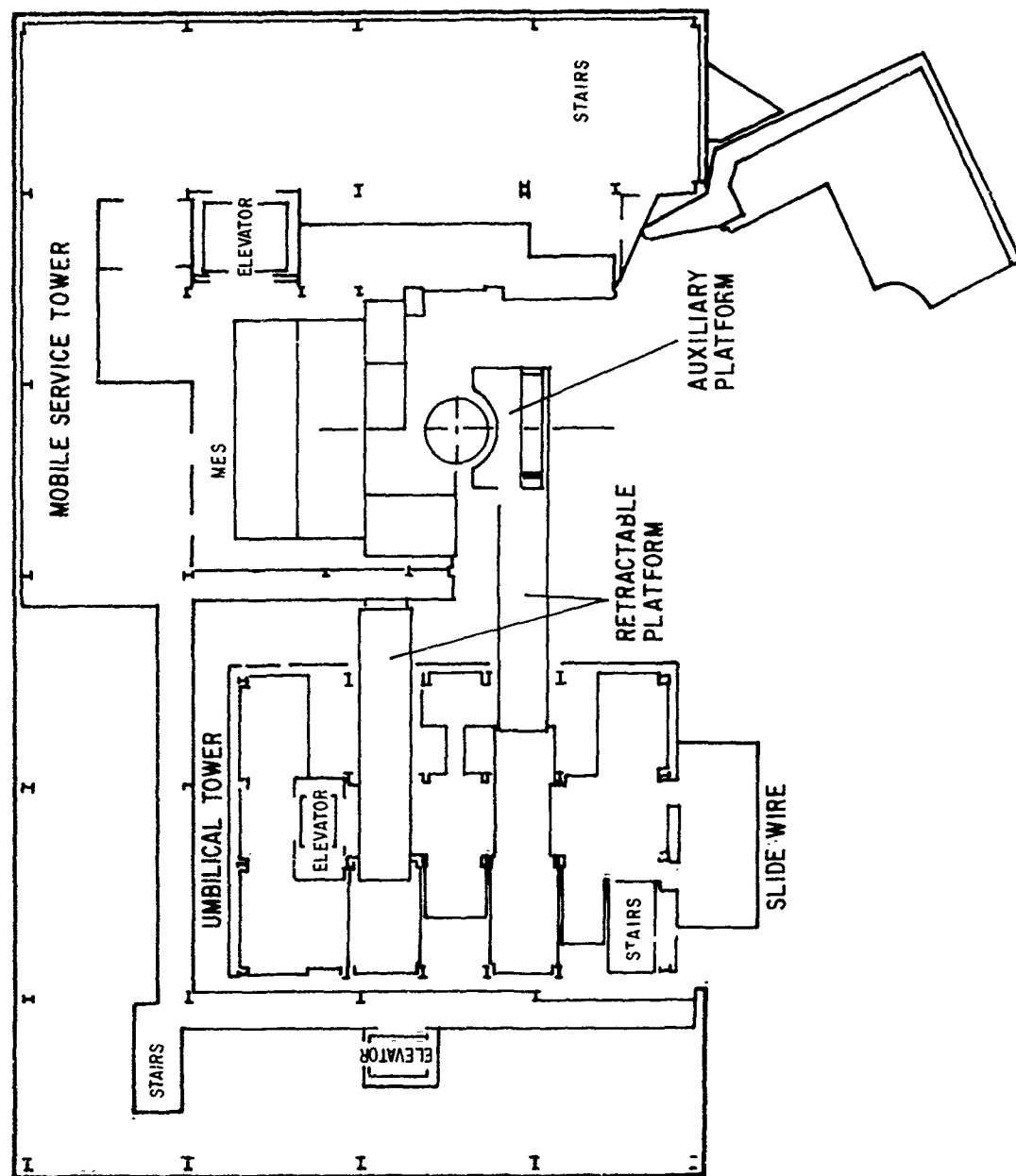
- CURRENT EGRESS HATCH SYSTEM
  - / MANUAL CRANK OPERATION
  - / HATCH ACTUATOR FIRING FOLLOWED BY SEAT EJECTION
    - BY EITHER CREWMAN PULLING "D" RING
- POSSIBLE CHANGES FOR RAPID OPENING HATCH
  - / REDUCES OPENING TIME FROM 9 SECONDS TO 0.5 SECONDS
  - / STUDYING THREE ALTERNATIVE METHODS
    - MANUAL SHUT-OFF VALVE BETWEEN HATCH ACTUATOR AND SEAT CATAPULT
    - SEPARATE PYROTECHNIC SYSTEM WITH MANUAL INITIATION FOR HATCH OPENING ONLY
    - SEPARATE PYROTECHNIC DEVICES TO UNLOCK BOTH HATCHES INDEPENDENT OF ACTUATORS
      - / MANUAL OPENING BY CREWMAN
  - CREW SEVERANCE FROM SPACECRAFT AND EQUIPMENT ATTACHMENTS
    - / CURRENT PROCEDURE IS MANUAL
    - / POSSIBLE IMPROVEMENT
      - MECHANICAL ACTUATOR ON BACKBOARD JETTISON SYSTEM
      - STILL REQUIRES MANUAL RELEASE OF CHUTE RISERS AND SURVIVAL KIT LANYARD

GEMINI B EGRESS HATCH

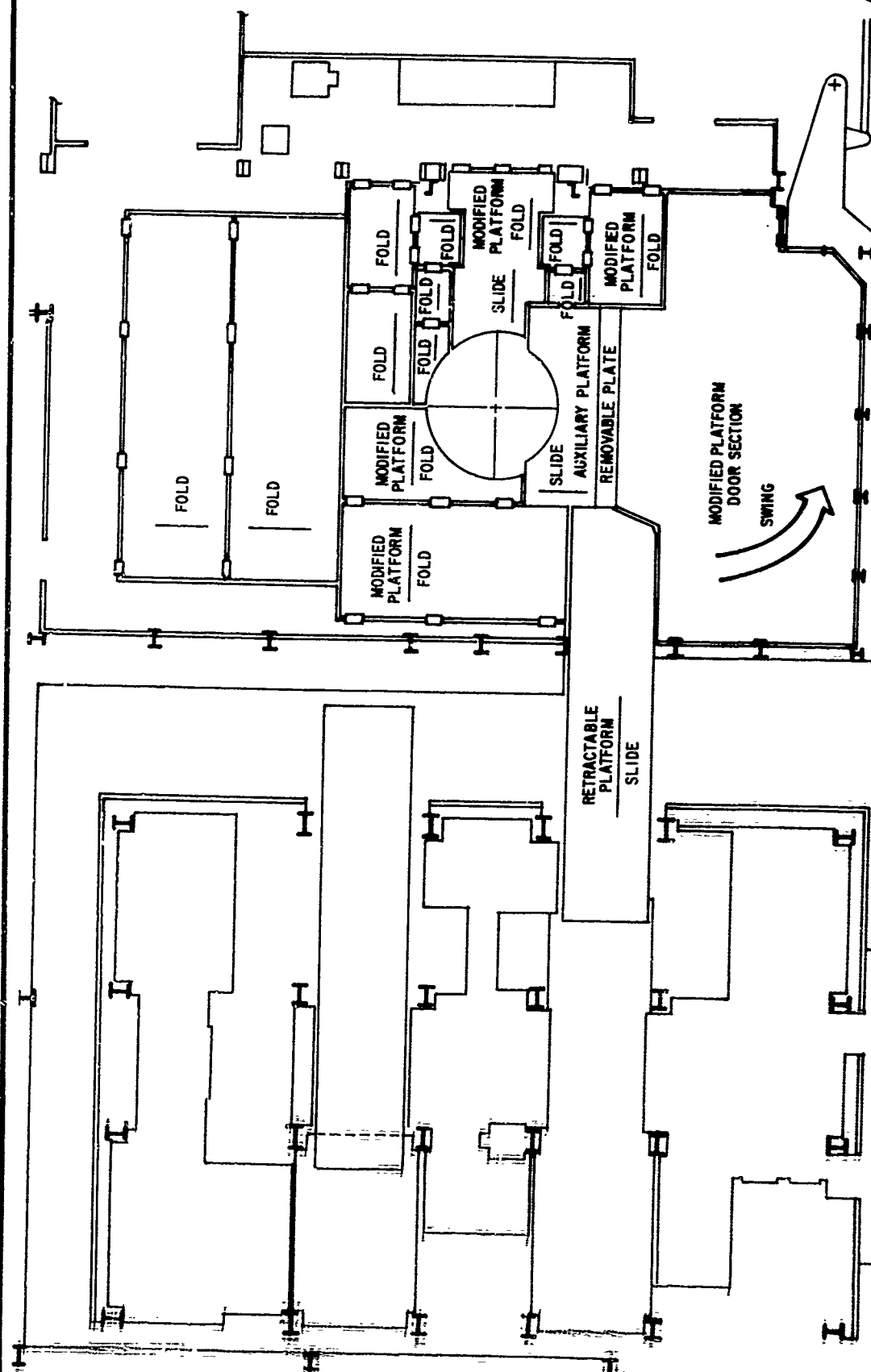
MOL



# PRESENT CONFIGURATION RETRACTABLE AND AUXILIARY PLATFORM



# *PROPOSED CONFIGURATION - RETRACTABLE AND AUXILIARY PLATFORM*



PAD EGRESS CAPABILITY

- o GOAL: PROVIDE CONTINUOUS EGRESS CAPABILITY
- o PRESENT PREFERRED APPROACH
  - / REDESIGN MES LEVEL SUCH THAT THE RETRACTABLE AND AUXILIARY PLATFORMS ARE PART OF THE MES FLOOR
  - / DOES IMPACT ON A & E BASELINE
    - o DESIGN PROBLEMS
    - o OPERATION PROBLEMS
- o PLAN FOR SOLUTION
  - / A & E TO STUDY THIS APPROACH AND/OR DEVELOP ALTERNATE
  - / IMPLEMENT RECOMMENDED SOLUTION LATE SUMMER

**MOL**

MOL ENVIRONMENTAL SHELTER

| TYPE       | PLANNED                                                                                                                                                                                                               | POTENTIAL                                                                                                          |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| PREVENTION | <p>ELECTRICAL INSTALLATIONS PER NATIONAL ELECTRIC CODE STANDARDS</p> <p>PROPELLANT COMPATIBLE SCUFF GUARDS AND BOOTS</p> <p>VENTILATION 20 CHANGES/HR</p>                                                             |                                                                                                                    |
| DETECTION  | <p>FIXED H<sub>2</sub> DETECTORS</p> <p>CLOSED CIRCUIT TV</p> <p>H<sub>2</sub> AND O<sub>2</sub> PIPING LEAK DETECTION INSTRUMENTATION</p> <p>FIXED EXPLOSIVE ATMOSPHERE DETECTORS</p> <p>TOXIC SENSORS, PORTABLE</p> | H <sub>2</sub> FLAME DETECTORS AND ALARMS                                                                          |
| ISOLATION  | <p>REMOTE O<sub>2</sub>, He, N<sub>2</sub>, O<sub>2</sub>, AND MMH TANK FARM</p> <p>SOLID PLATE DECKS</p> <p>EO<sub>2</sub> DUMP AND LH<sub>2</sub> WENT STACKS</p> <p>HYPERGOLIC VENT SYSTEM</p>                     | <p>REMOTE STORAGE OF FUEL CELL GO<sub>2</sub> AND GH<sub>2</sub></p> <p>FLAME RETARDING SCUFF GUARDS AND BOOTS</p> |

# MOL ENVIRONMENTAL SHELTER

## SAFETY PROVISIONS

| TYPE        | PLANNED                                                                                                                           | POTENTIAL                   |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| SUPPRESSION | MST AND T-III DELUGE BELOW MES<br>PORTABLE FIRE EXTINGUISHERS<br>HOSE REELS<br>VAFB FIRE DEPARTMENT                               | OV DELUGE WITHIN THE<br>MES |
| EVACUATION  | SLIDE WIRE FROM LEVEL 15<br>PAD SAFETY CONTROL<br>(LIMITED ACCESS)<br>RESCUE TEAM<br>STAIRS AND ELEVATORS ON BOTH<br>SIDES OF MST |                             |
| SURVIVAL    | SAFETY SHOWERS AND EYE WASHES<br>BREATHING APPARATUS<br>FIRE BLANKETS<br>FIRE/PROPELLANT PROOF SUITS<br>FIRST AID EQUIPMENT       |                             |

CREW VOICE COMMUNICATION ON PAD

o VOICE CIRCUITS AVAILABLE FROM CREW TO LCC

// EITHER HEARD WIRE THROUGH UMBILICAL

/ OR VHF RADIO, OPEN LOOP -

o TRANSCIEVERS REDUNDANT IN GEMINI  
AND ON GROUND

/ CIRCUIT SELECTABLE BY CREW AT VOICE CONTROL  
CENTER

o IN LCC EITHER CIRCUIT CAN BE PATCHED INTO OPERATING  
NETWORKS THROUGHOUT THE LAUNCH COMPLEX

GEMINI B ATMOSPHERE HISTORY - PRE-APOLLO FIRE

- FACTORY TESTING
  - / SYSTEMS TESTS - CLEAN AIR
  - / SPACE CHAMBER
    - PURE OXYGEN (15 PSI TO 5 PSI)
- PRE-LAUNCH TESTING AND OPERATIONS
  - / LAUNCH DRESS REHEARSAL
    - 2 WEEKS PRIOR TO LAUNCH
    - 100% OXYGEN AT 15 PSIA FROM T-115 TO T+30 MINUTES
  - / LAUNCH COUNTDOWN
    - HATCHES CLOSED AT T-100 MINUTES
    - CABIN PURGE AT 17 PSIA
    - CABIN LEAK TEST AT 18 PSIA
    - ~ 15 PSIA DURING FINAL COUNT
- ASCENT, ON-ORBIT AND RE-ENTRY OPERATIONS (100% OXYGEN)
  - / VENT TO 5 PSI DURING ASCENT AND WHEN OCCUPIED
  - / MAINTAINED AT 0.1 PSI (MINIMUM) ON-ORBIT STORAGE
  - / AMBIENT AIR ADMITTED AT 27,000 FEET DURING RE-ENTRY

GEMINI B ATMOSPHERE ALTERNATIVES

MOL

- o BASELINE ATMOSPHERE  
/ 100% OXYGEN SUIT LOOP AND CABIN
- o TWO GAS - ON BOARD  
/ TWO GAS CABIN
  - o CONTROLLED BY PARTIAL PRESSURE SENSOR
- / 100% OXYGEN SUIT LOOP AT LAUNCH
- / TWO GAS SUIT LOOP ON-ORBIT
- o TWO GAS - GROUND BASED  
/ TWO GAS CABIN
  - o CONTROLLED BY FLOW RATES FROM GROUND SOURCE
  - o MONITORED BY PARTIAL PRESSURE SENSOR
- / 100% OXYGEN SUIT LOOP AT LAUNCH
- / TWO GAS SUIT LOOP ON-ORBIT
  - o DECAYS TO HIGHER OXYGEN LEVELS
- o AIR  
/ BASICALLY SAME AS TWO GAS - GROUND BASED

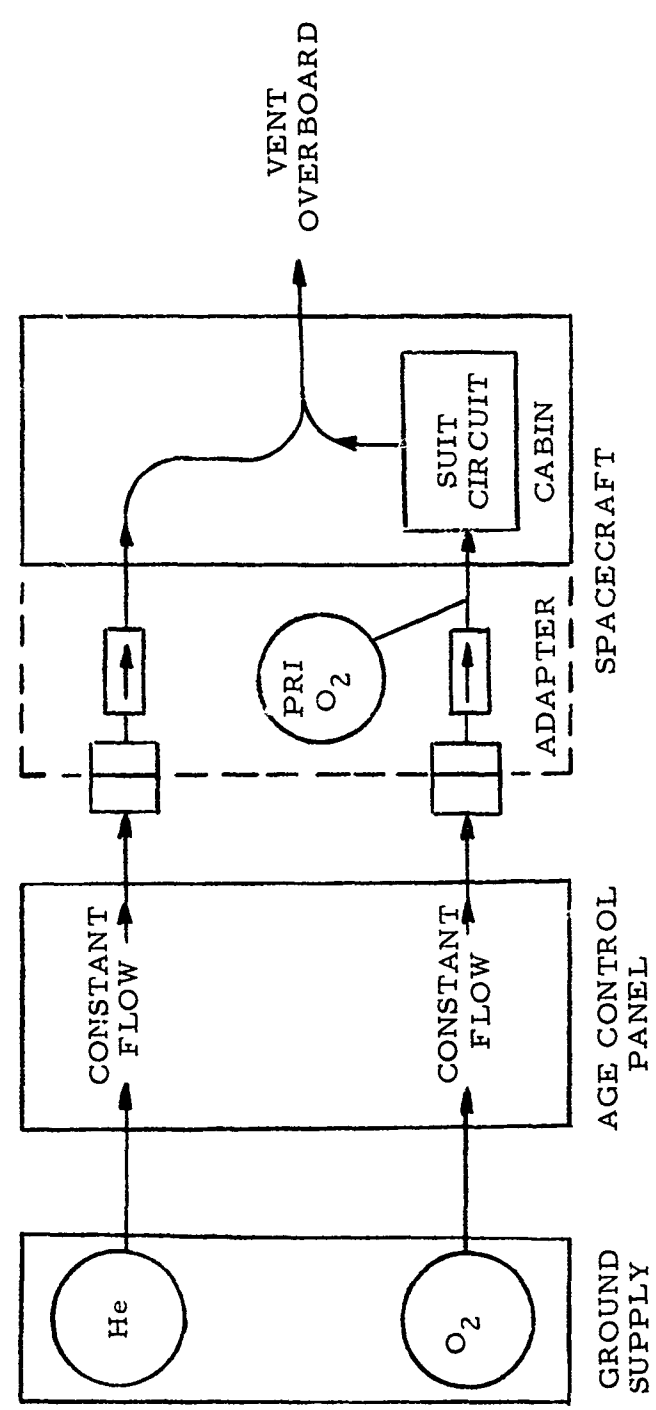
GEMINI B HARDWARE CHANGES FOR ALTERNATE ATMOSPHERES

- TWO GAS/AIR GROUND BASED
  - / ADDITION OF HELIUM AND OXYGEN OR AIR AND OXYGEN INLETS TO COOLANT UMBILICAL
  - / HELIUM/AIR AND OXYGEN LINES AND CHECK VALVES
  - / ADDITION OF A HELIUM/AIR FILTER
  - / ADDITION OF PYRO OPERATED GUILLOTINES
  - / ADDITION OF OXYGEN PARTIAL PRESSURE SENSOR
  - / ADDITION OF He/O<sub>2</sub> OR AIR/O<sub>2</sub> FLOW CONTROL PANEL ADDED TO GROUND CHECKOUT CONSOLE
- TWO GAS ON-BOARD SYSTEM
  - / SAME AS ABOVE PLUS
  - / TWO MANUAL SHUTOFF VALVES
  - / TWO CONTROL VALVES PLUS A DUAL GAS CONTROLLER
  - / REQUIRES NEW STORAGE TANK OR LARGER LABORATORY HELIUM TANK
- TECHNOLOGY INVOLVED
  - / BOTH OF ABOVE SYSTEMS REQUIRE PARTIAL PRESSURE SENSORS WHICH ARE UNDER DEVELOPMENT FOR THE LAB VEHICLE
  - / THE ON-BOARD TWO GAS SYSTEM WOULD REQUIRE A MORE ELABORATE DEVELOPMENT PROGRAM

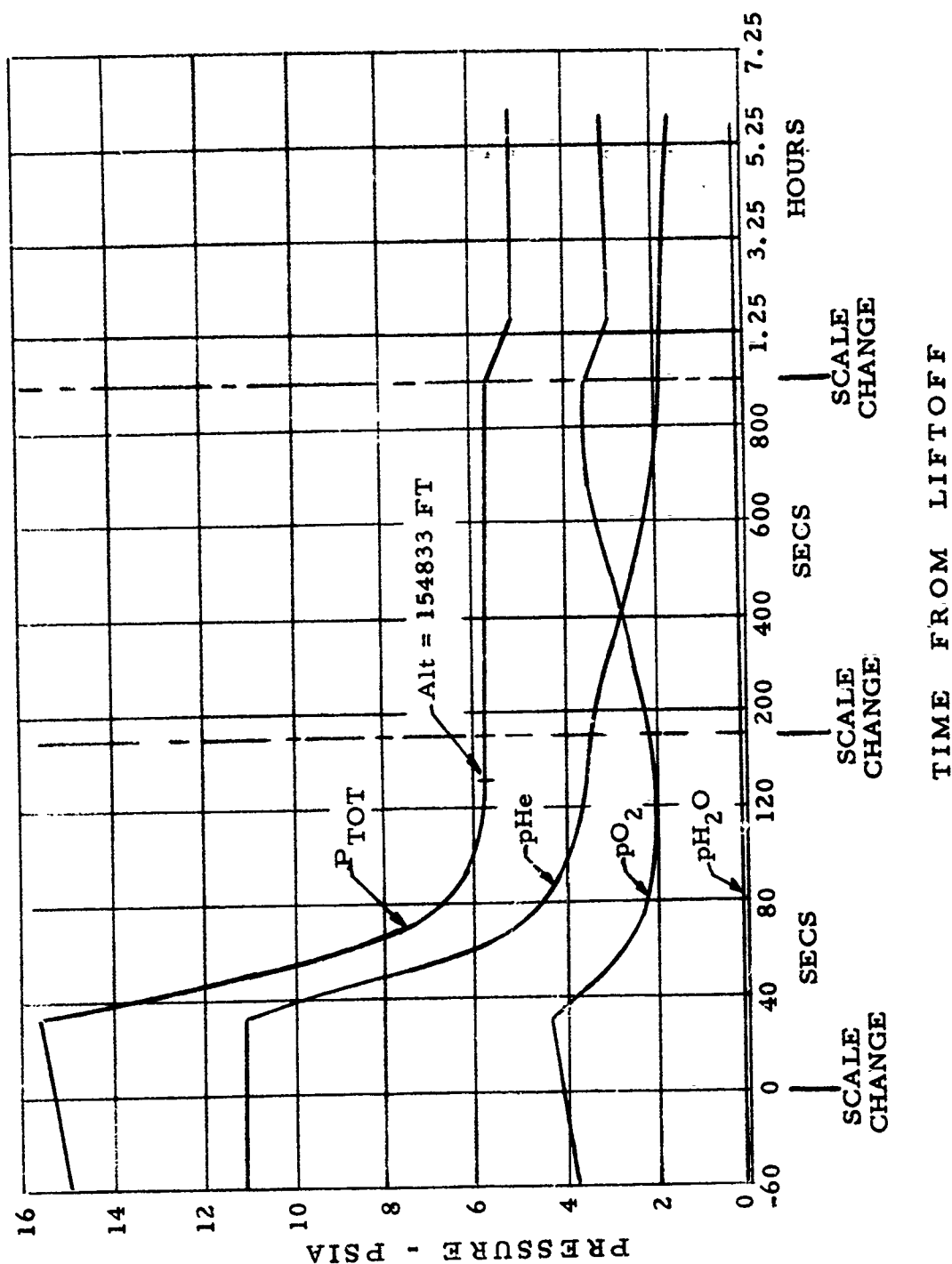
GEMINI B SIMPLIFIED TWO-GAS SYSTEM  
UNDER STUDY

- o GROUND OPERATION
  - / MAINTAIN 3:1 HELIUM TO OXYGEN RATIO IN CABIN (~ 4 PSI PO<sub>2</sub>)
  - o HELIUM DIRECTLY TO CABIN THROUGH GROUND UMBILICAL
  - o 100% OXYGEN TO SUIT LOOP THROUGH GROUND UMBILICAL
  - / EXCESS SUIT LOOP OXYGEN VENTED TO CABIN
  - o EXCESS MIXED GAS VENTED OVERBOARD
  - / GROUND SUPPLIED OXYGEN AND HELIUM CUT OFF AT T-60 SECONDS
  - o MIXED GAS TRAPPED IN CABIN
  - o ON BOARD OXYGEN TO SUIT LOOP AT HIGH RATE
- o ASCENT
  - / CABIN VENTED THROUGH PRESSURE RELIEF VALVE
  - / MINIMUM OXYGEN PARTIAL PRESSURE OF 2 PSI DURING ASCENT
- o ON-ORBIT INCLUDING INTERMEDIATE RETURNS
  - / MIXED GAS SUPPLIED BY LABORATORY PRIOR TO TRANSFER
  - o OXYGEN PARTIAL PRESSURE OF 3.5 PSI
  - / ALTERNATELY PURE OXYGEN
- o RE-ENTRY
  - / MIXED GAS OR 100% OXYGEN
  - o PURE OXYGEN SUIT LOOP

SIMPLIFIED TWO-GAS ATMOSPHERE ON PAD OPERATION



GEMINI B CABIN PRESSURE DURING ASCENT AND EARLY ORBIT  
SIMPLIFIED TWO GAS SYSTEM



LABORATORY ATMOSPHERE HISTORY - PRE-APOLLO FIRE

- o FACTORY TESTING
  - / SYSTEMS TEST - CLEAN AIR
  - / SPACE CHAMBER
    - o PURE OXYGEN PURGE
    - o OXYGEN/HELIUM (70%/30%) FOR BOTH LAUNCH AND ON-ORBIT ATMOSPHERES
- o PRE-LAUNCH TESTING AND OPERATIONS
  - / LAUNCH DRESS REHEARSAL
    - o 2 WEEKS PRIOR TO LAUNCH
    - o 70% OXYGEN AND 30% HELIUM AT 15 PSIA
  - / LAUNCH COUNTDOWN
    - o HATCH CLOSED
    - o CABIN PURGE AT 16 PSIA, 100% OXYGEN (UNMANNED)
    - o DILUTE WITH HELIUM (15 TO 20 PSIA) UNTIL 70-30 RATIO ACHIEVED
    - o CABIN LEAK TEST AT 20 PSIA
    - o ~15 PSIA DURING FINAL COUNT
- o ASCENT AND ON-ORBIT OPERATIONS (70% OXYGEN AND 30% HELIUM)
  - / VENT TO 5 PSI DURING ASCENT AND PRIOR TO CREW TRANSFER
  - / MAINTAINED AT 5.0 PSIA (NOMINAL) ON-ORBIT
  - / DEPRESSURIZE FOR EXTRAVEHICULAR ACTIVITY ONLY IF REQUIRED

6/14/67

MOL

LM ON-ORBIT ATMOSPHERE ALTERNATIVES

CONSIDERED (PHASE IB)

| COMPOSITION<br>TOTAL<br>PRESSURE | PURE<br>OXYGEN       | OXYGEN/<br>HELIUM              | OXYGEN/<br>NITROGEN                        |
|----------------------------------|----------------------|--------------------------------|--------------------------------------------|
| 5.0 PSIA                         | 100 % O <sub>2</sub> | 70 % O <sub>2</sub><br>30 % He | 70 % O <sub>2</sub><br>30 % N <sub>2</sub> |
| 7.0 PSIA                         | -                    | 50 % O <sub>2</sub><br>50 % He | 50 % O <sub>2</sub><br>50 % N <sub>2</sub> |
| 10.0 PSIA                        | -                    | 35 % O <sub>2</sub><br>65 % He | 35 % O <sub>2</sub><br>65 % N <sub>2</sub> |

# LM ON-ORBIT ATMOSPHERE ALTERNATIVES CONSIDERED (CONT)

## 5 PSIA (100% O<sub>2</sub>)

### PRO

- o SIMPLEST CONTROL
- o ACCEPTABLE FOR FAIL SAFE MODE
- o TOTAL PRESSURE COMPATIBLE WITH GEMINI B

### CON

- o HEAVIER EQUIVALENT WEIGHT THAN OTHER ALTERNATIVES
- o FIRE HAZARD HIGHER THAN OTHER ALTERNATIVES

## 5 PSIA (70% O<sub>2</sub> - 30 % He)

### PRO

- o LIGHTEST EQUIVALENT WEIGHT OF ALL
- o TOTAL PRESSURE COMPATIBLE WITH GEMINI B
- o LESS HAZARDOUS THAN PURE O<sub>2</sub>

### CON

- o CONTROL SLIGHTLY MORE COMPLEX

## 7 PSIA (50% O<sub>2</sub> - 50 %He)

### PRO

- o REDUCES IGNITION POTENTIAL AND FLAME PROPAGATION RELATIVE TO THE 5 PSIA TWO-GAS ATMOSPHERE

### CON

- o HEAVIER BY 74 POUNDS THAN 5 PSIA TWO-GAS ATMOSPHERE ABOVE (21 POUNDS IF CRYO HELIUM)\*
- o NOT COMPATIBLE WITH GEMINI B TOTAL PRESSURE
- o REDUCES USAGE OF OFF-THE-SHELF LEM COMPONENTS

## 10 PSIA (35% O<sub>2</sub> - 65% He)

- o SAME AS 7 PSIA ABOVE WITH STILL HEAVIER EQUIVALENT WEIGHT
- o EXCEEDS PHYSIOLOGICAL DECOMPRESSION LIMIT

\* CRYOGENIC HELIUM WAS DELETED FOR APPROX. COST SAVINGS OF \$3 5 MILLION

GEMINI B-LABORATORY INTERFACE ALTERNATIVES

| <u>ALTERNATIVES</u>                                         | <u>ADVANTAGES</u>                                                                                                 | <u>DISADVANTAGES</u>                                                                                         | <u>HARDWARE IMPACT</u>                                                                                                               |
|-------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| MAINTAIN LAB ATMOSPHERE IN GEMINI B                         | <ul style="list-style-type: none"> <li>NO 15 SECOND RE-PRESSURIZATION REQUIRED</li> </ul>                         | <ul style="list-style-type: none"> <li>ADDS WEIGHT INCREASED FIRE HAZARD</li> </ul>                          | <ul style="list-style-type: none"> <li>CRYO TANKS MUST HAVE INCREASED CAPABILITY</li> </ul>                                          |
| MAINTAIN He IN GEMINI B                                     | <ul style="list-style-type: none"> <li>NO 15 SECOND RE-PRESSURIZATION REQUIRED</li> <li>NO FIRE HAZARD</li> </ul> | <ul style="list-style-type: none"> <li>ADDS WEIGHT</li> <li>NONHABITABLE CABIN ENVIRONMENT</li> </ul>        | <ul style="list-style-type: none"> <li>SELECTED COMPONENT TESTING REQUIRED</li> <li>He TANKS MUST HAVE INCREASED CAPACITY</li> </ul> |
| LAB TO HAVE CAPABILITY TO REPRESSURIZE GEMINI B WITH HELIUM | <ul style="list-style-type: none"> <li>PROVIDES EMERGENCY FIRE CONTROL</li> </ul>                                 | <ul style="list-style-type: none"> <li>WEIGHT INCREASE</li> <li>NONHABITABLE</li> </ul>                      | <ul style="list-style-type: none"> <li>REQUIRES CHANGE TO LAB TO GEMINI REPRESSURIZATION SYSTEM</li> </ul>                           |
| LAB TO REPRESSURIZE GEMINI B TO LAB ATMOSPHERE              | <ul style="list-style-type: none"> <li>REDUCED FIRE HAZARD</li> </ul>                                             | <ul style="list-style-type: none"> <li>ADDS CONTROL COMPLEXITY</li> <li>SLIGHT INCREASE IN WEIGHT</li> </ul> | <ul style="list-style-type: none"> <li>REQUIRES CHANGE TO LAB TO GEMINI REPRESSURIZATION SYSTEM</li> </ul>                           |
| LAB TO IMMEDIATELY DEPRESSURIZE G/B TO .1 PSI               | <ul style="list-style-type: none"> <li>NO FIRE HAZARD</li> </ul>                                                  | <ul style="list-style-type: none"> <li>SYSTEM DOES NOT HAVE THIS CAPABILITY</li> </ul>                       | <ul style="list-style-type: none"> <li>VENT VALVE HAS TO BE ADDED AND CONTROLLED FROM LABORATORY</li> </ul>                          |
| LAB TO REPRESSURIZE G/B IN 5-7 SEC.                         | <ul style="list-style-type: none"> <li>INCREASED CREW SAFETY DURING EMERGENCY</li> </ul>                          | <ul style="list-style-type: none"> <li>SYSTEM DOES NOT HAVE THIS CAPABILITY</li> </ul>                       | <ul style="list-style-type: none"> <li>VALVE REDESIGN REQUIRED</li> </ul>                                                            |

WIRE MATERIAL SELECTION

MOL

o MOL IS REVIEWING AVAILABLE WIRE MATERIALS

o SELECTION CRITERIA

/ FLAMMABILITY AND TOXICITY

/ PERFORMANCE

/ RELIABILITY

/ WEIGHT

o PRIME CANDIDATES (INSULATION MATERIALS)

/ EXTRUDED TE LON

/ RAYCHEM 44

/ KAPTON (H FILM AND TEFLON)

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MOL

ELECTRICAL HARNESS REVIEW PROGRAM  
(MANAGEMENT CONTROL)

- o REVIEW PROGRAM OF THE CONTRACTOR'S DOCUMENTATION FOR COMPLIANCE TO MOL REQUIREMENTS.
- o REVIEWS TO INCLUDE
  - / CONTRACTOR ELECTRICAL/ELECTRONIC DESIGN MANUALS
  - / CONTRACTOR APPROVED PARTS LISTS
  - / SPECIAL DESIGN MEMORANDUMS SUPPLEMENTING DESIGN MANUALS
  - / TECHNICAL REQUIREMENTS SPECIFICATION
  - / SPECIAL MOL DESIGN AND DEVELOPMENT CRITERIA
- o PURPOSE
  - / TO INTEGRATE CONSISTENT SET OF REQUIREMENTS FOR ALL ASSOCIATE CONTRACTORS
  - / TO GIVE IN DEPTH VISIBILITY AND EFFECT CORRECTIVE MEASURES MUCH EARLIER IN THE PROGRAM
  - / ABOVE FUNCTIONS ARE CONDUCTED AS PART OF NORMAL PROGRAM ACTIVITIES AND HIGHLIGHTED AT CDR AND FACI

ELECTRICAL EQUIPMENT REVIEW  
(MANAGEMENT CONTROL)

MOL

- o REVIEW CONTRACTOR DESIGNS TO BE ASSURED THAT SUCH  
ARE COMPLETE AND FULFILL THE MOL REQUIREMENTS
  - / HERMETICALLY SEALED
  - / NON IGNITION SOURCE
  - / EXPLOSION PROOFING
  - / DOES NOT PRODUCE TOXIC AND CORROSIVE FUMES
- o REVIEW CONTRACTOR TESTS FOR COMPLETENESS

GEMINI B SPACECRAFT VIBRATION TESTS

BASELINE

- o SPACECRAFT VIBRATION RESPONSE TEST
  - / TEST ARTICLE
    - o REM WITH SIMULATED AND/OR ACTUAL EQUIPMENT
    - o STATIC ADAPTER AND REM SIMULATOR
  - / PURPOSE
    - o OBTAIN RESPONSE CHARACTERISTICS AND TRANSFER FUNCTIONS
  - / TYPE TESTING
    - o LOW LEVEL RANDOM AND SINUSOIDAL
- o SPACECRAFT SYSTEM VIBRATION TEST
  - / TEST ARTICLE
    - o GBQ SPACECRAFT
  - / PURPOSE
    - o DEMONSTRATE FUNCTIONAL INTEGRITY OF OPERATIONAL SPACECRAFT EQUIPMENT
  - / TYPE TESTING
    - o LOW LEVEL SINUSOIDAL SWEEP AND RANDOM TEST LEVEL

LABORATORY VEHICLE DYNAMIC TESTING

BASELINE

- o LABORATORY VEHICLE  
/ DEVELOPMENT
  - o MODE SURVEY OF STRUCTURAL TEST VEHICLE IN SIMULATED FLIGHT VEHICLE CONFIGURATION
  - o MODE SURVEY OF STRUCTURAL TEST VEHICLE IN SIMULATED ORBITING VEHICLE CONFIGURATION
- / ACCEPTANCE
  - o LOW LEVEL VIBRATION OF PRODUCTION VEHICLES IN LABORATORY VEHICLE CONFIGURATION
- o LABORATORY MODULE  
/ DEVELOPMENT
  - o QUALIFICATION LEVEL ACOUSTICS - USING STRUCTURAL TEST VEHICLE LABORATORY MODULE
- / CUALIFICATION
  - o FLIGHT LEVEL ACOUSTICS - USING LABORATORY MODULE QUALIFICATION TEST VEHICLE (3DB DOWN FROM QUALIFICATION LEVEL)
  - o ACOUSTIC AND VIBRATION SURVEY - USING LABORATORY MODULE QUALIFICATION TEST VEHICLE

ELECTRICAL CONNECTIONS IN CREW COMPARTMENT

- o THERE ARE CONNECTIONS/DISCONNECTIONS WITHIN CREW COMPARTMENTS WITH POWER ON
  - / MOSTLY COMMUNICATION RELATED
    - o DURING CREW TRANSFER
    - o DURING LABORATORY OPERATIONS
- o ACTIVITIES
  - / REVIEWING NUMBER AND TYPES OF CONNECTIONS/DISCONNECTIONS
    - o VERIFYING NEED
    - o ELIMINATE IF POSSIBLE
  - / IDENTIFY HAZARD FOR THOSE THAT CANNOT BE ELIMINATED
    - o REDESIGN WHERE HAZARD IS UNACCEPTABLE
  - / INITIAL REVIEW AND ASSESSMENT COMPLETE BY 1 JULY 1967

HAZARD DETECTION

- o HAZARDS CONSIDERED
  - / COMBUSTION
  - / TOXIC PRODUCTS
- o INTIMATELY RELATED TO EMERGENCY CREW PROCEDURES
- o CURRENT ACTIVITIES
  - / IDENTIFYING VARIOUS TYPE EMERGENCIES
  - / IDENTIFYING CREW CUE REQUIRED TO COPE WITH EMERGENCY
  - / ESTABLISHING CREW PROCEDURES
  - / THIS ANALYSIS THEN ESTABLISHES:
    - o REQUIREMENTS FOR DETECTION/ALARM SYSTEM
    - o REQUIREMENTS FOR HARDWARE DESIGN

MOL

COMBUSTION DETECTION SYSTEMS

- o CURRENT ACTIVITIES
  - / REVIEWING EFFORT UNDERWAY AT:
    - o NASA
    - o BROOKS AFB
    - o WPAFB
    - o OTHER AGENCIES
  - / DETERMINE REQUIREMENTS FOR DETECTION SYSTEMS
    - o CANDIDATE SYSTEMS
      - / CONDENSATION NUCLEI COUNTER
      - / IR RADIATION DETECTOR
      - / UV RADIATION DETECTOR
      - / EUTECTIC SALTS
- o FUTURE ACTIVITIES
  - / INITIATE STUDY (TESTS) TO ASSIST IN SYSTEM SELECTION OR TO DETERMINE FEASIBILITY
  - / INITIATE DEVELOPMENT AND/OR PROCUREMENT OF APPROPRIATE SYSTEMS

SPACECRAFT FIRE SUPPRESSION

- o MOST PROMISING AGENTS
  - / WATER
    - o ADVANTAGES
      - / NON TOXIC
      - / AVAILABLE FROM FUEL CELLS
      - / VERY EFFECTIVE AGENT
    - o DISADVANTAGES
      - / DIFFICULT POST FIRE RECOVERY
  - / FREON 1301
    - o ADVANTAGES
      - / VERY EFFECTIVE AGENT
      - / NO DAMAGE TO HARDWARE BY SUPPRESSANT
      - / NO HARDWARE DAMAGE OR TOXIC EFFECT IN EVENT OF UNNECESSARY USE
    - o DISADVANTAGES
      - / SIGNIFICANT TOXIC PRODUCTS IF USED ON LARGE HOT FIRE
      - / POSSIBLE OVERPRESSURIZATION OF CABIN
  - o CURRENT INVESTIGATION NOT LIMITED TO THE ABOVE

ATMOSPHERIC CONTAMINANT DETECTION AND CONTROL

- CURRENT LABORATORY VEHICLE SPECIFICATION BASELINE REQUIRES
  - / MEASURING PARTIAL PRESSURE CO<sub>2</sub>
  - / MEASURING WATER VAPOR (DEW POINT)
  - / TRACE GAS MEASUREMENT BY GAS CHROMATOGRAPH
  - / MATERIAL SCREENING TO MINIMIZE OUTGASSING
- ACTIVITIES UNDERWAY
  - / FEASIBILITY OF GAS CHROMATOGRAPH UNDER RE-EXAMINATION
    - REQUIRES LENGTHY GROUND ANALYSIS OF T/M DATA (~16 HOURS TO CORRECTIVE ACTION)
    - SOME DEVELOPMENT RISK
  - / OTHER RAPID SINGLE-GAS DETECTIONS UNDER EVALUATION
    - CO (COMBUSTION PRODUCT), METHANE, AND TOTAL HYDROCARBONS
  - / STUDYING USE OF CATALYTIC BURNER

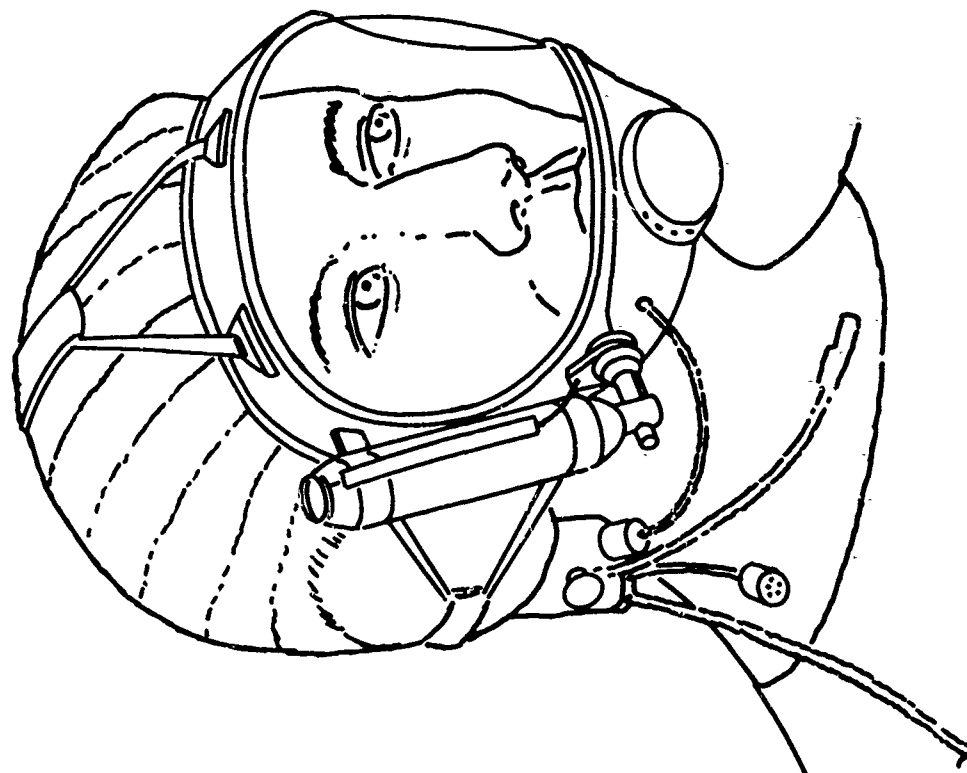
MOL

BASELINE EMERGENCY OXYGEN MASK ASSEMBLY

- o LOCATION:
  - / 2 IN TRANSFER TUNNEL
  - / 2 IN LABORATORY MODULE
- o PURPOSE:
  - / PROVIDE SHIRT SLEEVE CREW WITH SAFE ATMOSPHERE AND EYE PROTECTION IN EVENT CONTAMINATION OR PARTIAL LOSS OF ATMOSPHERE
- o OPERATING CHARACTERISTICS:
  - / 100 PERCENT O<sub>2</sub> FOR TEN MINUTES - SELF CONTAINED
  - / CAPABLE OF USING LM 100 PSI O<sub>2</sub> SUPPLY FOR LONGER PERIODS
  - / DEMAND REGULATOR HAS MANUAL OVERRIDE FOR FLUSH FLOW



## MOL EMERGENCY OXYGEN MASK



1. 10 MINUTES SELF CONTAINED OXYGEN SUPPLY
2. CAPABILITY TO USE VEHICLE OXYGEN SUPPLY FOR LONGER DURATION
3. WEIGHT - 5.1 POUNDS EACH



MOL FLIGHT VEHICLE TECHNICAL  
READINESS PROGRAM

- FORMULATION UNDER WAY
- ADAPTATION OF MERCURY AND GEMINI PILOT SAFETY TECHNIQUES AND EXPERIENCE
- RIGID ACCEPTANCE AND TECHNICAL REVIEW DISCIPLINES
- SUPPORTING CONTROLS AND REQUIREMENTS
- TOP MANAGEMENT SUPPORT
- BOARD REVIEW AND LAUNCH DECISION
- A MEASURE OF SAFETY THROUGH PRODUCT INTEGRITY

**MOL**

SAFETY WORKING GROUP RELATIONSHIP

