SESSICN 2

SUMMARY AND KEY ISSUFS IDENTIFICATION

by

Session 2 Chairman: Judith Robey

NASA - Code SU

N91-15936

SPACE STATION TOXIC AND REACTIVE MATERIALS HANDLING WORKSHOP

Judith Robey
Session 2 Chairman

Below is a summary of the workshop objectives. From the presentations and the panel discussions some of the objectives were satisfied and others still need some follow-up work involving more details than the workshop time permitted.

WORKSHOP OBJECTIVES

IDENTIFY SPECIFIC AREAS FOR TECHNOLOGY DEVELOPMENT

From the discussions and presentations on the current space station subsystem designs it was not clear whether new technology is needed to handle a centralized waste system capable of mixing multiple chemicals or whether development of existing technology can do the job. The safe treatment of waste in a centralized system includes identification of incompatible chemicals, purging the waste lines and verifying their cleanliness, separating, filtrating and compressing waste material for storage. How this is to be done with existing technology was not clear. Another area that needs development is the technology for sensors and detectors. Many of the existing ground based detection systems are large resource consumers (volume, power, vacuum, cooling, etc.), and would require considerable modification for use in space. Space station subsystems designers should clearly identify how the current designs will accommodate the users requirements with existing technology and what, if anything, necessitates the development of new technology.

ADDRESS PAYLOAD/FACILITY REQUIREMENTS SUCH AS SAMPLE SIZE RESTRICTIONS, LEVELS OF CONTAINMENT, ETC. BY BRINGING TOGETHER THE SCIENTIFIC INVESTIGATORS AND THE SAFETY EXPERTS

To satisfy this objective much more detailed information is needed than was available at the workshop. Experiment operational scenarios are needed from the users that address how much on board characterization will be performed and how much automation versus crew interaction will be required during this analysis. Further communications between safety experts, space station subsystems designers and the user payload designers will need to take place before any conclusions about restrictions on samples or payload designs can be addressed. User sponsored workshops or studies including crew utilization, on-orbit characterization and operations is needed to fulfill this objective.

INSURE THAT CREW SAFETY IS THE HIGHEST PRIORITY FOR SPACE STATION

Although the focus of every presentation was on safety concerns past, present and future, there was not a clear space station programmatic line of responsibility to address safety issues. The question "How does space station insure that crew safety is the highest priority?" was not answered. Safety representatives from the workpackage centers addressed many safety related questions, however, safety is a program wide responsibility and to satisfy this objective more participation from space station safety organizations is needed.

IDENTIFY PRELIMINARY OPERATIONAL CONSTRAINTS

-IDENTIFICATION OF FACILITIES/EXPERIMENTS REQUIRING SPECIALIZED EQUIPMENT AND/OR PROCEDURES

-CREW LIMITATIONS AND PROTECTIVE GEAR REQUIREMENTS

The equipment or operational procedures required to accommodate some users, such as, a pressurized furnace (to 80 atm), radioisotopes used in life sciences experiments and a high vacuum (10-6 torr) were not identified. It was unclear whether these payload requirements could or would be accommodated in the current space station designs. Preliminary payload or operational constraints were not identified. These examples all have safety and/or PMMS design implications.

It was pointed out by a university participant that the Spacelab crew carrying out experiments on orbit were not required to wear the minimum ground based lab protective gear, such as goggles, lab coats, gloves etc.

ESTABLISH A FRAME OF REFERENCE OR BASELINE OF APPLICABLE WASTE HANDLING EXPERIENCE

Lessons learned from Skylab and Spacelab were presented, as well as how things have changed based on that experience. This information provided a frame of reference for on orbit experience. Industry presented some ground based examples of waste handling, such as, microbial systems, exhaust gas conditioning and reactive bed plasma systems. How much, if any, of this information is being studied for incorporation into space station systems was not clear.

USE THE WORKSHOP AS A BASIS FOR ASSESSING THE CURRENT AND APPLICABLE SPACE STATION REQUIREMENTS

The space station subsystems designs (PMMS, FMS, ECLSS), are currently undergoing revision as a result of the Program Requirements Review (PRR). To satisfy this objective and to establish a greater fidelity in the subsystems capabilities, user payload experiment and facility developers need to provide their best estimate of operational requirements for volumes of fluids needed, volumes of waste expected, pressures, temperatures, flow rates, concentration and purity levels. The workshop has encouraged dialogue in these areas.

PROVIDE AN EDUCATIONAL AND INFORMATIONAL FORUM FOR GOVERNMENT EMPLOYEES, CONTRACTORS, EXPERIMENTAL FACILITY DEVELOPERS, AND POTERNTIAL HARDWARE SUPPLIERS INVOLVED WITH THE SPACE STATION PROGRAM

Presentations were given by 22 government, 16 industry and 2 university participants. These included contractors, experimental facility developers and potential hardware suppliers. There was information exchange during the discussion periods, as well as exchange of business cards and telephone numbers during the coffee and lunch breaks. Communications have been initiated and it is to the benefit of all of us to keep them going.

DOCUMENT THE WORKSHOP RESULTS AND IDENTIFY FOLLOW-ON STUDY ISSUES

The workshop proceedings will be mailed to the participants in January, 1989. This will include the summary report and recommendations from the Discussion Panel as well as summary reports from the Session Chairmen and any written questions submitted from the participants. It will also include Xerox copies of the material presented at the workshop. The Environmental Steering Committee, co-chaired by the Office of Space Station and the Office of Space Science and Applications, will review the workshop results and propose a follow-up plan. This plan should include the involvement of the appropriate space station level II panels and working groups as well as the applicable workpackage representatives. It should also include close cooperation with, and representatives from, the user community.

SPACE STATION TOXIC AND REACTIVE MATERIALS HANDLING WORKSHOP

Judith Robey
Session 2 Chairman

Many questions were asked during the course of the workshop. Some answers may exist in the space station documentation being revised after the Program Requirements Review (PRR) or are currently being worked in studies or working groups and panels. However, since satisfactory answers were not available at the workshop, some of these questions were flagged as issues and concerns and some resulted in recommendations. For the session 2 summary report, rather than try to recommend design solutions for systems that cross many technical discipline borders, I have summarized the essence of the questions that were asked during the course of the workshop.

SUMMARY QUESTIONS

1. It was stated that ECLSS would provide 7 locations for contaminant detection. Is this sufficient given the lack of gravity driven air flows in micro-g?

2. Does PMMS have the sole responsibility for payload leak detection? Does ECLSS have any responsibility? Are there back-up systems for payload contaminant detection? What is the users responsibility?

3. What is the range of contaminants that space station subsystems (PMMS, ECLSS, FMS) provided sensors can detect?

4. Will the warning, caution and alarm displays and systems be common in all pressurized modules?

5. In the event of a toxic or hazardous material spill within the lab module, is the responsibility for the cleanup redundant between ECLSS and PMMS, or do they have specific areas of responsibility? If

so what are they? Who provides the contingency plans and the necessary tools?

6. Which safety office provides overview of the systems design and development, particularly in cases where the subsystems cross workpackage assignments or where their interfaces meet? What safety office will be responsible for developing user payload facility and operational guidelines and regulations? How do shuttle safety regulations get folded into space station?

7. What kinds of user safety guidelines or regulation manuals are, or will be, available to the user facility/payload designers? What safety office, panel or review board will be responsible for verifying compliance of these regulations? Where and when will this information be available?

8. PMMS, FMS and ECLSS design requirements are driven to a large extent by operational scenarios, such as, the amount of on orbit characterization of toxic or reactive materials and vacuum/vent, glovebox, and lab support equipment usage. Strawman operational scenarios are needed by the subsystems designers for greater definition of their requirements. Information is needed in the area of fluid volumes (supply and waste), pressures, temperatures, flow rates, concentration levels and purity specifications.

9. What is meant by triple containment and two-failure-tolerant? (It was unclear as to whether triple containment was the method by which the requirement of two-failure-tolerant is met, or whether they were two separate requirements, both with independent methods for compliance.) Is there consistent agreement across NASA centers? Will vacuum vent be considered one level of containment? Will there be a station wide policy on what triple containment is, or will it be on a case by case bases as it has been on shuttle flights in the past?

10. Will gallium arsenide, mercury cadmium teluride, and mercury iodide samples be processed and characterized on orbit? How will any restrictions, regulations or guidelines be developed for the handling of these toxic materials?

11. How much processing and containment will be required at each level of responsibility: payload, lab level (PMMS for USL) and station wide (FMS)?

12. Will the PMMS be capable of handling biotoxins and biohazardous material?

13. What is the space station plan for handling radioactive waste?

14. Will the emergency shower for crew decontamination provide enough water to meet flushing requirements?

15. Will the waste water reclamation system be capable of processing the waste water (brine) from the cage washer (approximately .75 gallons per cage) and the biotechnology facilities requirement to wash and sterilize between each run?

16. What are the international partners planning for waste management in their modules? What plans does ESA have for handling payload waste in their module? What capability does the JEM waste system have?

17. Does a centralized waste system make sense given the problems of combining multiple chemicals? Ground processing systems do not, in general, operate using a centralized system.

18. Is this centralized waste system used simultaneously by multiple users, or in series? If used one at a time, how will the contaminants from one dump be purged and cleanliness verified?

19. Is there a period when venting to space will be allowed, such as during station reboost or shuttle visits?

20. Is the vacuum vent for purging experiments a separate line from the hard space vacuum provided for isolation purposes?

21. If the vacuum system is provided to 4 quadrants of the USL, does this mean a user (in the USL) will risk cross contamination with another user in the same quadrant?

22. What is the planned disposition of "large" solid waste such as contaminated "Kimwipes" or empty sample containers?

23. What are the resource costs for the PMMS and FMS in terms of volume, power and mass, considering such things as compressors and high pressure storage tanks for the waste material?

24. Is space station (PMMS, FMS, safety, operations, logistics, etc.) looking at how systems are designed and procedures are carried out on the ground? For example:
a. College chemical laboratories are required to store their chemicals in a protected area, such as, behind a "blow out wall".
b. Department of Transportation has categorized chemicals for storage and transport purposes.
c. Some laboratories precipitate and distill their chemicals to reduce their storage volume.
d. Ground laboratory safety regulations require lab workers to wear protective gear, i.e. goggles, gloves, lab coats, shoes etc.

25. Is space station developing a chemical labeling system that is consistent, accurate, common and "user friendly" across all lab modules?

26. What are the trade-offs and safety concerns of having an experiment which processes hazardous or toxic materials and is operated autonomously reducing crew risk, but requires fluid supply and waste management scheduling with the inherent risk of disposal schedule overlap of two incompatible chemical waste products?

27. Is fluid delivery. waste disposal and vacuum/venting a scheduled service? Is the scheduling local to PMMS, or is it a station wide operational schedule?

28. Has space station considered safety implications in USL rack layout? For example:
a. Placing payloads involving hazardous operations in locations such that they do not block the exit route in the event of a leak of a toxic substance?
b. Placing the emergency, decontamination shower in a node?

29. Are the space station leak detection and contaminant control systems looking at the ground based sensors and detectors currently available? Are they doing any research or development in the new technology areas such as fiber optics and laser systems?

30. Are the waste management system designers looking at ground based systems, such as, microbial systems, reactive bed plasma and exhaust gas conditioning systems?

31. In micro-g conditions, stagnant air pockets may reside where toxins could collect, Is the ECLSS air circulation sufficient to flush out these areas?

32. With the build up of perspiration, dust and dirt particles, due to micro-g conditions, is there a regular maintenance plan to "wash" the internal surfaces of space station? Who has this responsibility?

33. Will an individual module be capable of "dumping" its contaminated atmosphere and repressurizing to normal conditions?

All of these questions were asked in some form or another during the course of the workshop. Some had no answers, others had partial answers, still others had definitive answers, but the answers were not acceptable as solutions. Any follow on work the space station or the users agree to sponsor should, as a first step, answer the questions raised at this workshop.

Space Station Freedom

Space Station Freedom Toxic and Reactive Materials Handling Workshop

BOEING

U.S. Laboratory Overview

November 30, 1988

Frank J. Jackson

Boeing Aerospace
P. O. Box 1470
MS JA-94
Huntsville AL 35807-3701

Work phone: 205/461-2473
FAX No.: 205/461-2787

Misc #1/Lancaster/Title/lt/11-29-88

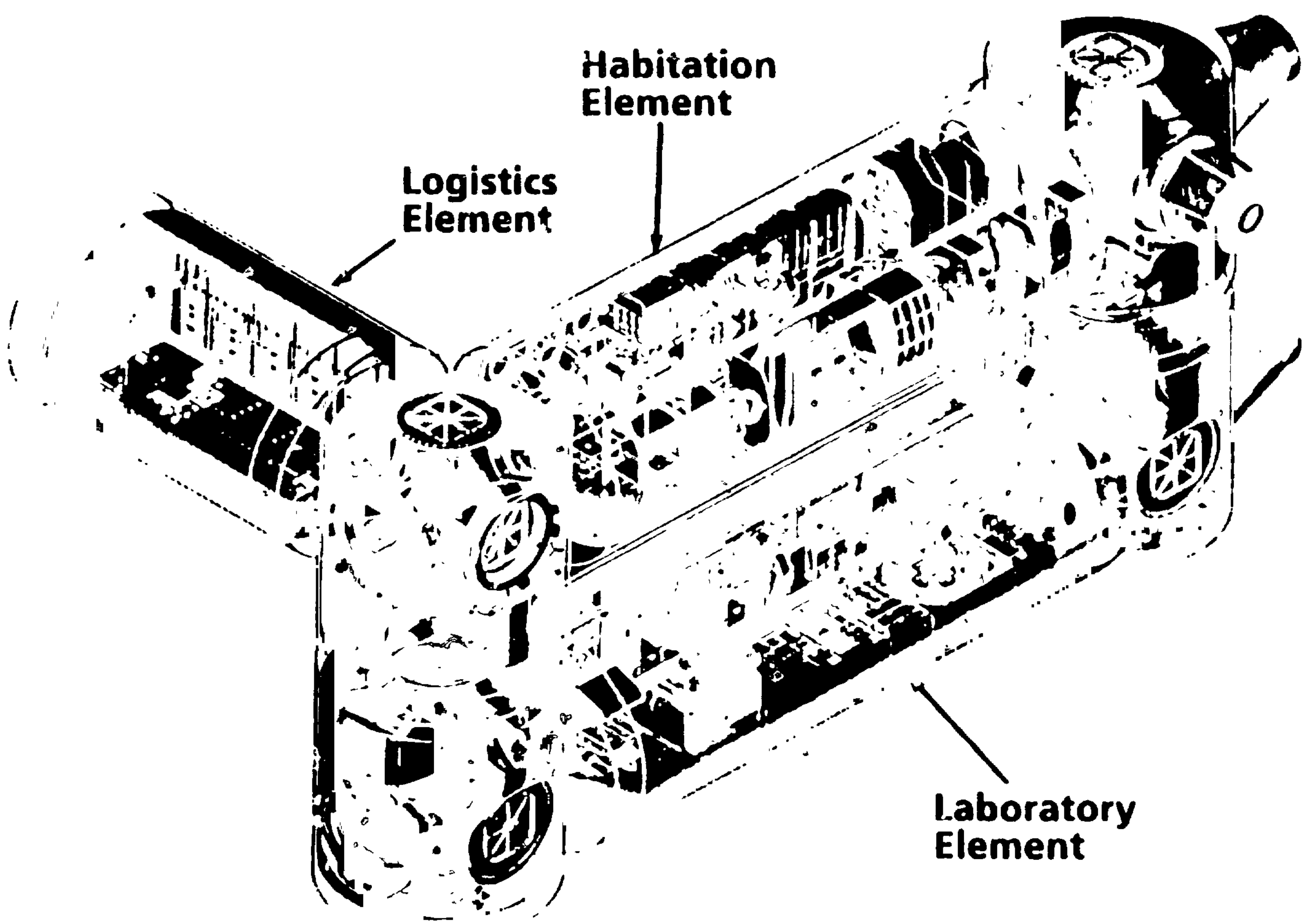
U. S. Laboratory

- Features
- Equipment Summary
- Subsystems

Space Station Freedom

Space Station Freedom
Pressurized Element Arrangement

BOEING



U.S. Lab Module

ORIGINAL PAGE IS
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U.S. Laboratory Features

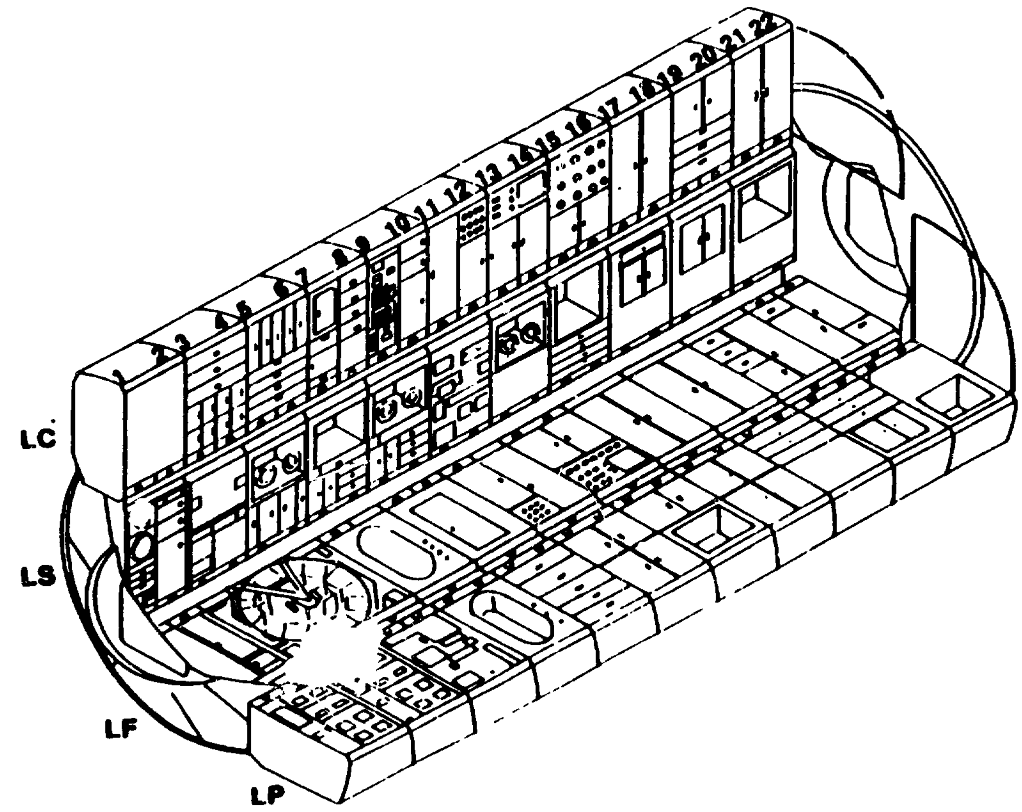
- Accommodate, multidiscipline payloads
- Provide for evolutionary growth
- Process materials management system
- Accelerometer mapping system
- Space vacuum access
- Generic laboratory equipment for multidiscipline activities

U. S. Laboratory

- Features
- Equipment Summary
- Subsystems

U. S. Laboratory Modules Systems

Distributed Systems + Laboratory Unique Systems + Payloads



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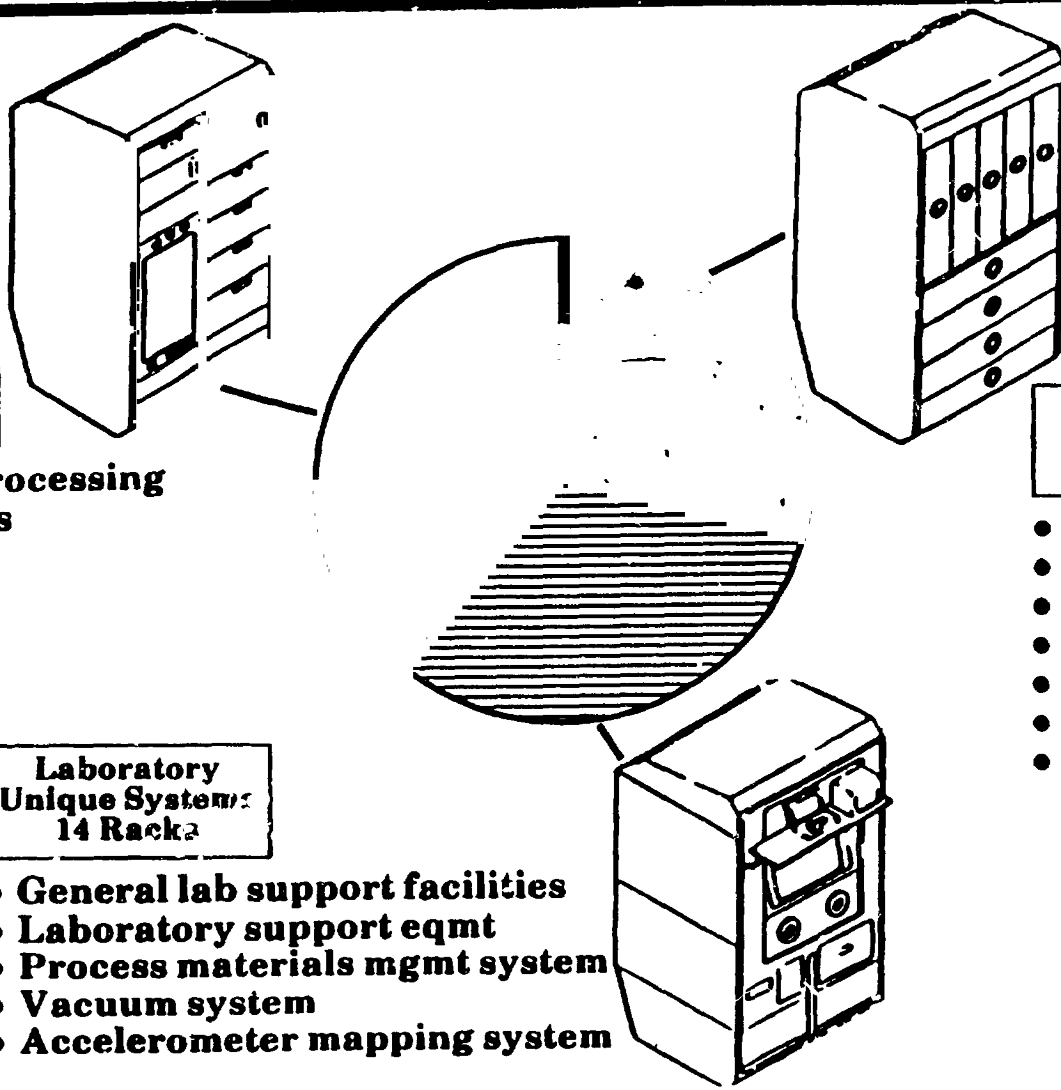
Space Station Freedom

U. S. Laboratory Equipment Summary

BOEING



Payloads
17 Racks

- Materials processing
- Life sciences

Distributed Systems
13 Racks

- ECLSS
- Thermal Control
- Electrical Power
- Data Management
- Software
- Internal Audio/Video
- Man-systems

Laboratory Unique Systems
14 Racks

- General lab support facilities
- Laboratory support eqmt
- Process materials mgmt system
- Vacuum system
- Accelerometer mapping system

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SSP88/0386

U. S. Laboratory

- Features
- Equipment Summary
- Subsystems

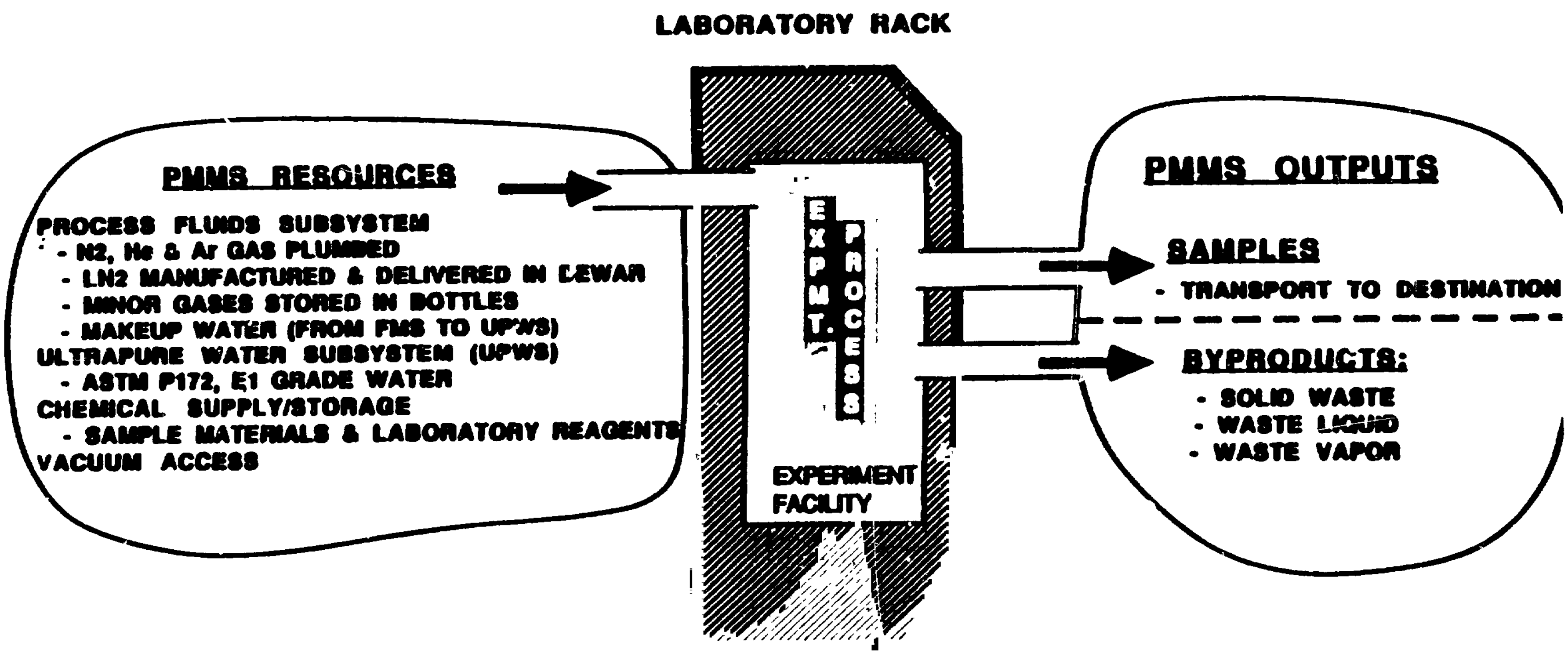
U.S. Laboratory Module Subsystems

Laboratory subsystems
- Vacuum vent system
- Process materials management system
- Accelerometer mapping system

General laboratory support facilities
- Materials processing sciences glovebox
- Life sciences glovebox
- Laboratory sciences work bench

Laboratory support equipment
- 31 items (oscilloscopes to x-rays)

U.S. Laboratory Module
PMMS System



THE PMMS PROVIDES A CLOSED SYSTEM FOR ALL MATERIALS ENTERING OR LEAVING LABORATORY EXPERIMENTS AND FACILITIES

SPACE STATION CONTAMINANT CONTROL AND MONITORING

WILLIAM R. HUMPHRIES
EP62

NOVEMBER 1988

LIFE SUPPORT MANAGEMENT WORKING GPOUP BRIEFING

MSFC SPACE STATIO. ECLSS RESPONSIBILITIES

ECLSS

TEMPERATURE & HUMIDITY CONTROL (THC)
- AIR TEMPERATURE CONTROL
- HUMIDITY CONTROL
- VENTILATION
- EQUIPMENT AIR COOLING
- THERMALLY CONDITIONED STORAGE
- PARTICULATE AND MICROBIAL CONTROL

ATMOSPHERE CONTROL & SUPPLY (ACS)
- O_2/N_2 STORAGE & DISTRIBUTION
- VENT & RELIEF
- O_2/N_2 PRESSURE CONTROL

ATMOSPHERE REVITALIZATION (AR)
- CO_2 REMOVAL
- CO_2 REDUCTION
- O_2 GENERATION
- CONTAMINATION CONTROL & MONITORING

WATER RECOVERY & MANAGEMENT (WRM)
- URINE PROCESSING
- HYGIENE WATER PROCESSING
- POTABLE WATER PROCESSING
- WATER STORAGE & DISTRIBUTION
- WATER THERMAL CONDITIONING
- WATER QUALITY MONITORING

WASTE MANAGEMENT (WM)
- RETURN WASTE STORAGE
- FECAL PROCESSING & STORAGE

FIRE DETECTION AND SUPPRESSION (FDS)

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CONTAINANT SOURCES

SOURCE	CONTAMINANT
• MAN	— METABOLIC PRODUCTS: CO_2, NH_3, CO, H_2S, H_2, CH_4, ORGANIC ACIDS, MERCAPTANS — BACTERIOLOGICAL CONTAMINANTS
• SPACECRAFT SUBSYSTEMS, NON-ISOLATED EXPERIMENT EQUIPMENT AND PAYLOADS	— WIDE VARIETY OF ALCOHOLS, ALDEHYDES, AROMATICS, ESTERS, ETHERS, CHLOROCARBONS, FLUOROCARBONS, HALOCARBONS, HYDROCARBONS, KETONES, ACIDS, etc.
• EMERGENCY SITUATIONS: FIRE, SPILLS, EQUIPMENT FAILURES	— CO, CO_2, HYDROCARBONS AROMATICS, ACID GASES. OXIDES OF N_2, SO_2, NH_3, SMOKE, ALCOHOLS, FORMALDEHYDE, etc.
• NONISOLATED ANIMAL AND PLANT EXPERIMENTS	— METABOLIC, BACTERIOLOGICAL

5-507-9-71

ECLSS DESIGN PREMISES

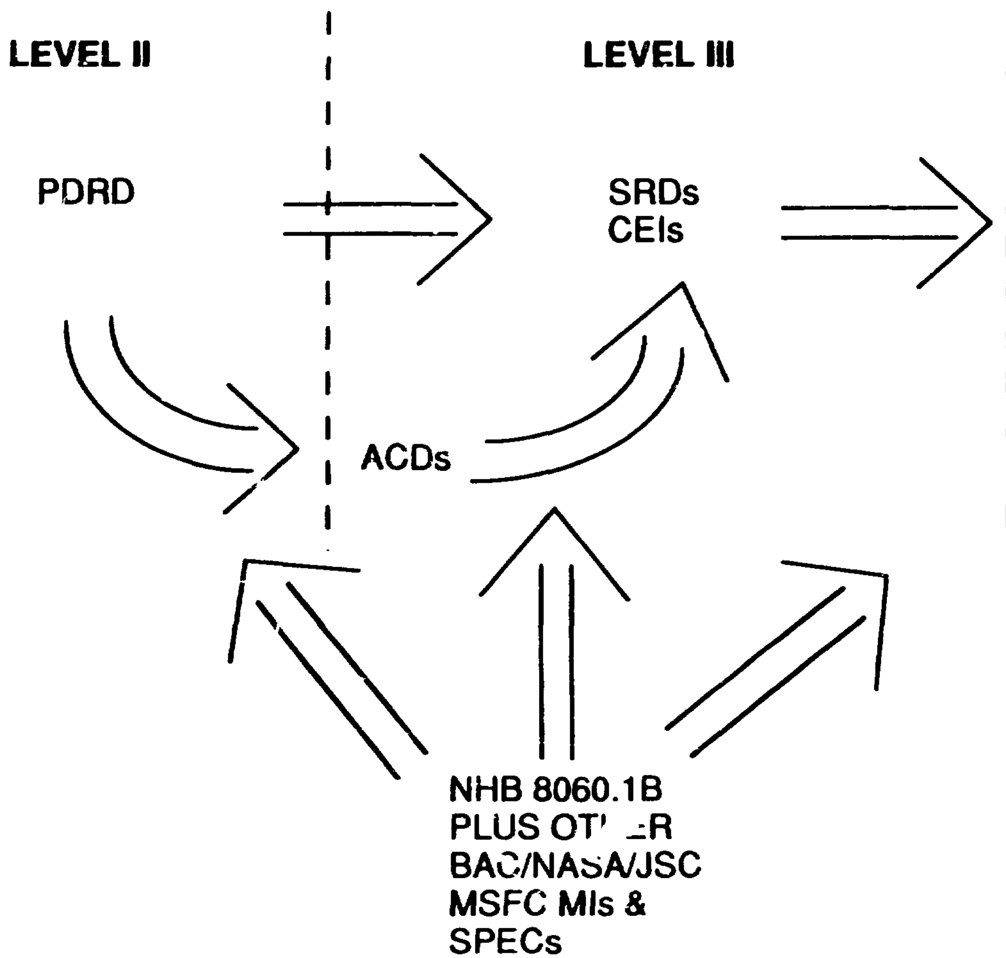
- HAZARDOUS SUBSTANCE USERS WILL BE ISOLATED FROM THE MODULE ENVIRONMENT AND BE TWO FAILURE TOLERANT (i.e., THE PMMS/PAYLOAD SUPPLIER WILL PROVIDE CONTAINMENT AND CONTROL FOR THEIR NON-STANDARD SUBSTANCES - NOT THE ECLSS).

- ANY LIFE SCIENCE OR OTHER PAYLOADS UTILIZING POTENTIALLY HAZARDOUS MICROBIAL MATERIAL IN THEIR OPERATIONS MUST PROVIDE TWO FAILURE TOLERANT MICROBIAL ISOLATION FROM THE MODULE ENVIRONMENT (ANIMALS WILL BE PATHOGEN FREE PER THE HPRRC).

- SUFFICIENT DATA WILL BE MADE AVAILABLE TO THE NASA SO THAT AN INDEPENDENT ASSESSMENT OF CONTAMINANT SAFEGUARDS CAN BE VERIFIED.

5-508-9-71

SPACE STATION PROGRAM
CONTAMINANT CONTROL DOCUMENTATION



PRIME

PLANS AND REPORTS

– SAFETY PLAN	DR SA01
– SAFETY ANALYSIS AND HAZARDS REPORTS	DR SA03
– CONTAMINATION CONTROL & IMPLEMENTATION PLAN	DR SE05
– CONTAMINATION CONTROL AND IMPLEMENTATION REPORT	DR SE06
– SYSTEM & SUBSYS CONTAMINATION ANALYSIS	DR SE27
– CUSTOMER INTEGRATION	DR SE31

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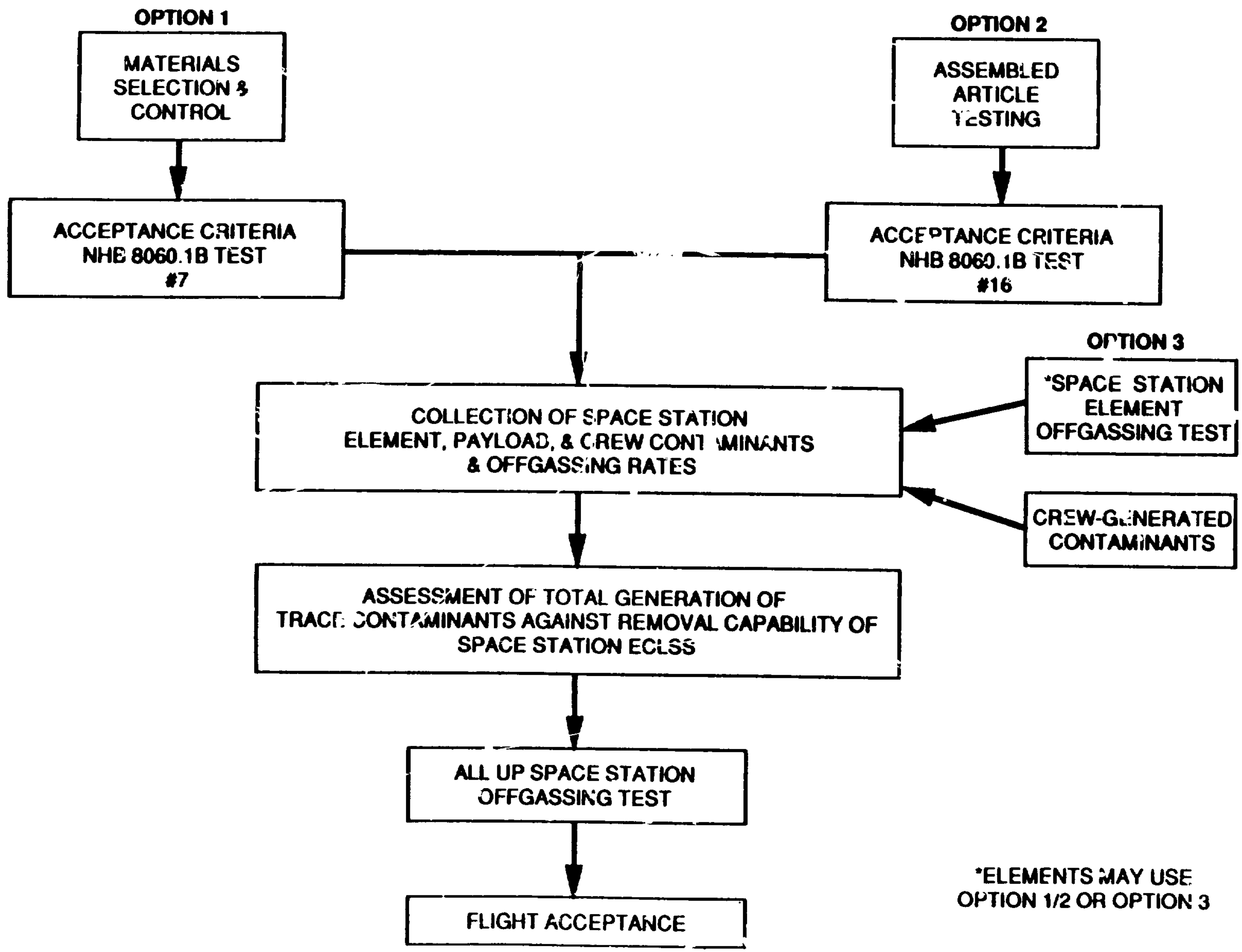
SPACE STATION/PAYLOAD TRACE CONTAMINANT CONTROL PROCEDURE



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SPECIAL CONCERNS

- LIFE OF SAFETY EQUIPMENT
- HIGH TEMPERATURE CATALYTIC REACTION WITH AIR BORNE CONTAMINANTS
- ISOLATION OF HAZARDOUS SUBSTANCES

  IMPLIES: JEOPARDY OF FLIGHT DUE TO HIGH RISK

  RIGOROUS PAYLOAD DESIGN ISOLATION PROOF

  SLOW TRANSITION TO HAZARDOUS SUBSTANCE USE

- ISOLATION OF AVIONICS COOLING LOOP FROM HAZARDOUS USERS

IMPETUS TO UTILIZE BENIGN MEDIA

5-513-9-71

THE ECLSS WILL:

- CONTROL ALL CONTAMINANTS TO CONCENTRATIONS LESS THAN THE SMAC LEVELS
  - ANTICIPATED LOADS ARE BASED ON PREVIOUS FLIGHTS AND ANALYSIS UTILIZING EXISTING SMAC LEVELS IN GUIDING EARLY DESIGN OF THE TRACE CONTAMINANT CONTROL AND MONITORING SUBSYSTEM.
  - AS EQUIPMENT OFF-GASSING DATA AND NEW SPACE STATION SMAC VALUES (DUE TO LONGER EXPOSURE) BECOME AVAILABLE THE DESIGN WILL BE UPDATED.
- INDIVIDUAL EQUIPMENT ITEMS WILL BE OFF GAS TESTED OR MATERIAL EVALUATIONS USED TO DETERMINE THE READINESS TO FLY PER NHB8060.1B FOR EACH EQUIPMENT ITEM BY A JOINT ECLSS/MATERIALS DISCIPLINE TEAM.
- DEVELOP AND UTILIZE AN ANALYTICAL MODEL TO ASSESS TRACE CONTAMINANT LEVELS.
- NEAR REAL-TIME MONITORING WILL BE PROVIDED (INTERACTIVE CONTROLS AND TBD ALARMS).
- SUPPORT ACTIVITIES IN THE PERFORMANCE OF TBD SYSTEM LEVEL OFF-GAS TESTING TO VERIFY THE DESIGN.
- ALERT CREW AND ASSURE CORRECTIVE ACTIONS ARE PLANNED AND IMPLEMENTED IN THE EVENT ANY CONTAMINENT IS APPROACHING AN "OUT-OF-TOLERANCE" CONDITION.
- VERIFY THE PAYLOAD/PMMS CONTAMINANT CONTROL DESIGN.

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MEASURES USED TO CONTROL CONTAMINANTS

TRACE GASES AND ODORS (<SMACs)

- CONTROL OF MATERIALS
- FIXED CHARCOAL (TREATED AND UNTREATED) SORPTION BEDS
- HIGH/LOW TEMPERATURE CATALYTIC CONVERTERS IN CONJUNCTION WITH PRE/POST TREATMENT BEDS
- CONSIDERATION OF CONDENSING HEAT EXCHANGER REMOVAL CAPACITY
- CONSIDERATION OF MOLE SIEVE REMOVAL CAPACITY
- MISCELLANOUS EFFECTS (LEAKAGE MAKEUP, METABOLIC OXYGEN REPLENISHMENT AND LOGISTIC MODULE REVISIT CLEANSING ACTIONS, etc.)

PARTICULATES (< 100k PARTICLES/FT^3)

- CONTROL OF MATERIALS
- FILTERATION WITH CIRCULATION
- HEPAFILTRATION

MICROBES

- CONTROL OF FLIGHT MATERIALS
  - — AIRBORNE (<1000 CFU/M^3)
    - SAME AS PARTICULATES
  - — WATERBORNE
    - BIOCIDE
    - HEAT

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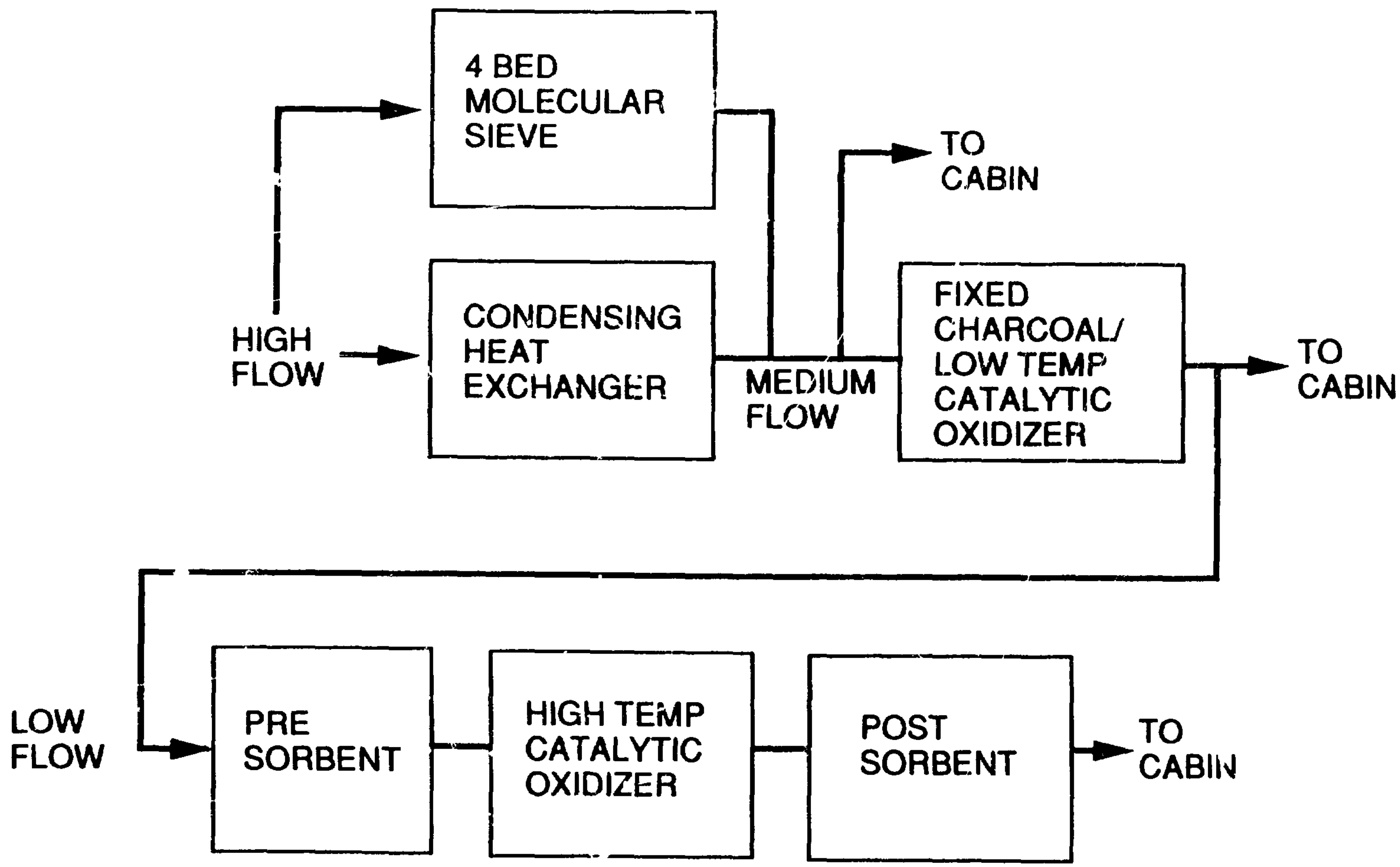
TYPICAL CONTAMINANT CONTROL SYSTEM CONFIGURATION



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TRACE CONTAMINANT MONITORING

5-516-9-71

ECLSS CONTAMINATION MONITORING

- AIRBORN/SURFACE MICROBES
  - — OFF-LINE
- POTABLE/HYGIENE WATER QUALITY
  - — ON-LINE
  - — OFF-LINE
- PARTICULATE MONITOR
  - — .5 TO 100 MICRON RANGE
- MAJOR CONSTITUENT MONITOR
  - — SPECIFIC CONSTITUENTS OF H_2, O_2, N_2, CO, CO_2, H_2O & CH_4
  - — ONE UNIT IN EACH MAJOR ELEMENT
  - — RAPID SAMPLING
- TRACE GAS MONITOR
  - — ONE ATMOSPHERIC CONTAMINANT MONITOR EACH IN THE HAB AND LAB MODULES
  - — GAS CHROMATOGRAPH/MASS SPECTROMETER INSTRUMENT USED
  - — MULTIPLE SAMPLING LOCATION CAPABILITY – HAB, LAB, NODES, COLUMBUS, JEM & LOG MODULE

5-514-9-71

TRACE GAS MONITORING DESIGN GOALS

- FULLY AUTOMATED WITH POSITIVE SPECIFICATION AND QUANTIFICATION OF ALL COMPOUNDS IN AMU RANGE
- $\leq$ 30 MINUTE CYCLE TIME FOR APROXIMATE AMU RANGE OF 24-250
- SPECIFICATION CONTAINS 222 ACTUAL CONTAMINANT SPECIES RANGING FROM METHANOL (AMU = 32) TO HEXADECAMETYL (AMU =593)
- TARGET SENSITIVITY $\leq$ 50% OF MAC LEVEL
- DATA AVAILABLE ON-BOARD AND GROUND

5-515-9-71

ABSTRACT

THE PROCESS MATERIALS MANAGEMENT SYSTEM OF THE FREEDOM SPACE STATION'S U.S. LABORATORY

The space station user community requirements were defined during the phase B study, 1985 thru 1987, and served to identify common use set of required unique subsystems and facilities. These requirements which resulted in the current design are reviewed and updated. Comparisons are drawn between the Skylab, Spacelab and MIR programs, both as to program goals, methods employed and the facilities provided.

Major system design issues identified are related to the unprecedented space hardware life expectancy of 20 to 30 years, such as reliability and safety, and to the broad spectrum of potentially hazardous chemical substances to be used by the science community, such as materials compatibility, contamination, triple containment and safety.

The PMMS is defined in terms of the currently baselined subsystems and current issues, design options and schedules are reviewed.

PMMS

THE

PROCESS MATERIALS MANAGMENT SUBSYSTEM

(PMMS)

THE HEART OF THE
UNITED STATES LABORATORY

SPACE STATION

PMMS

TELEDYNE BROWN ENGINEERING

TOPICS

- LABORATORY OUTFITTING
- PMMS SYSTEM DEFINITION
- USER/DESIGN REQUIREMENTS
- PRIOR PROGRAMS INPUTS
- LABORATORY ENVIRONMENT/INTERFACES
- SUBSYSTEM FUNCTIONS & INTERFACES
- DEVELOPMENT TESTING & SCHEDULES

U.S. LABORATORY OUTFITTING

- Accelerometer Mapping System
- PMMS Subsystem
  - Process Fluids Distribution/Storage
  - Ultrapure Water
  - Waste Fluid Management
  - Crew/Hardware Decontamination
  - Chemical Storage
  - Leak Detection
  - Materials Transport
- Vacuum Subsystem
- Materials Science Glovebox

- Laboratory Support Equipment
  - Cutting/Polishing System
  - Microscope System
  - Autoclave
  - X-Ray System
  - Etching Equipment
  - Fluid Handling Tools
  - Digital Multimeter
  - Digital Recording Oscilloscope
  - pH Meter
  - Ultraviolet Sterilization
  - General-Purpose Hand Tools
  - Camera/Camera Locker
  - Electrical Conductivity Probe
  - Cleaning Equipment
  - Digital Thermometers
  - EM Shielded Storage Locker
  - Film Locker

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SPACE STATION

PMMS SYSTEM DEFINITION

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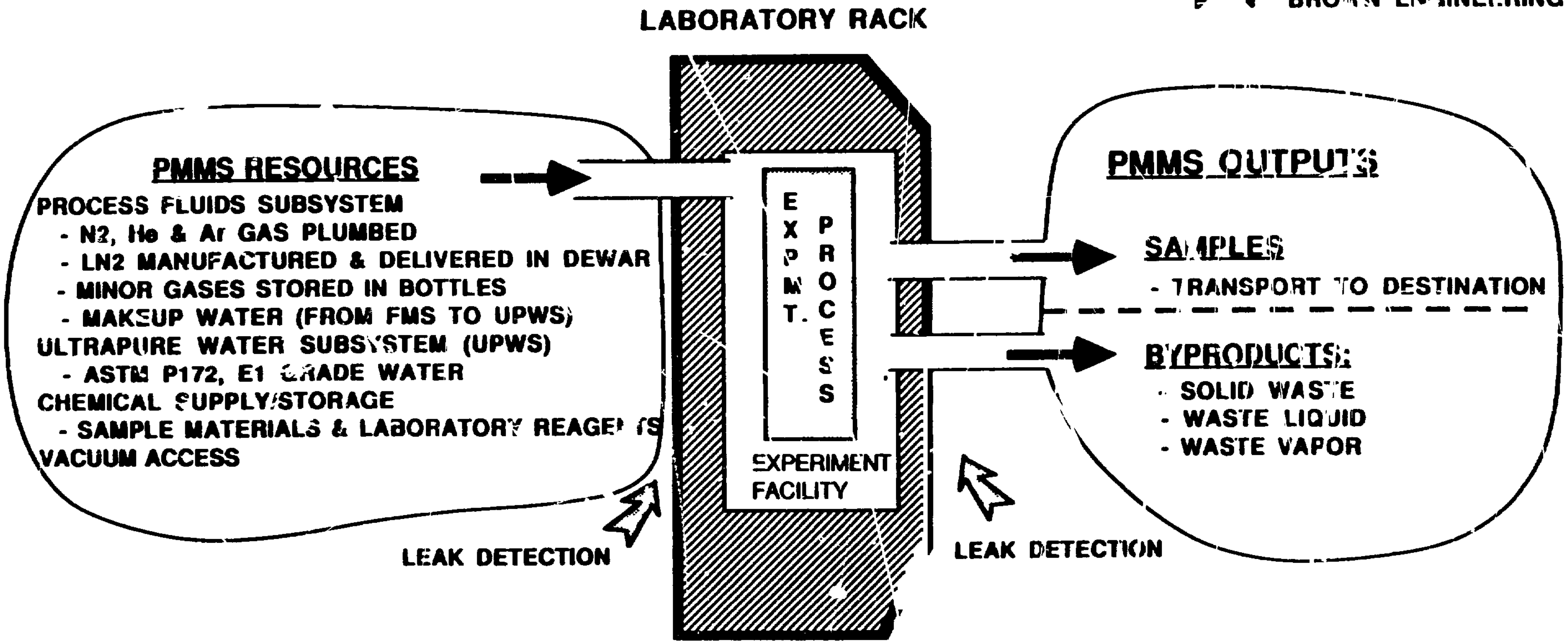

THE PMMS PROVIDES CLOSED SYSTEM FOR ALL MATERIALS ENTERING OR LEAVING LABORATORY EXPERIMENTS AND FACILITIES

GOAL: PROVIDE ON-ORBIT CAPABILITIES AND SAFETY ENVIRONMENT EQUIVALENT TO EARTH BASED LABORATORY

vg 4

PROCESS MATERIALS MANAGEMENT SYSTEM

THE CHALLENGE:

- THE PMMS MUST HANDLE ALL INPUTS AND OUTPUTS OF MATERIALS TO THE US LAB EXPERIMENTS AND SUBSYSTEMS
- SOME MATERIALS MAY BE HAZARDOUS IN ONE OR MORE OF THEIR STATES AND DURING EXPERIMENT OPERATIONS
- PARTS OF THE PMMS MUST BE SERVICEABLE AND MAINTAINABLE OVER THE 30 YEAR LIFE OF THE STATION

THE APPROACH:

- USER DATA BASE ANALYSIS PROVIDES THE MATERIAL HANDLING REQUIREMENTS FOR THE PMMS
- BASED ON CURRENT NASA SAFETY GUIDELINES THE PMMS IS DESIGNED FOR TRIPLE CONTAINMENT
- THE PMMS IS DESIGNED WITH ORU DEFINED MODULES FOR MAINTAINABILITY

PMMS DESIGN RATIONALE

PRIMARY CRITERIA

- MAXIMUM SAFETY
- MAXIMUM USER ACCOMMODATION
- MINIMUM CREW TIME
- MINIMUM WEIGHT & VOLUME
- COST/BENEFIT
- COOPERATIVE FUNCTIONS
- AUTOMATED OPERATION
- MAINTAINABILITY
- RELIABILITY

SPACE STATION

PMMS REQUIREMENTS SUMMARY

TELEDYNE BROWN ENGINEERING

PMMS STATED REQUIREMENTS

REF. SOURCES:		SUBJECT:	REQUIREMENTS
SS-SRD-0001		General	Safety, maintainability, reliability, ground/manual function inhibit, venting limited
SS-IRD-0200		PMMS	Process fluid...distribution...interface. Waste scheduling/identification, customer containment/control at rack level.
JSC-30000	PDRD	FMS	FMS provides storage, transfer, control, conditioning of integrated fluids [nitrogen, water, waste], venting constraints.
JSC-30264	ACD	Integrated: Nitrogen Water Waste	Primary interface: node 1, secondary: node 2. Tank pressurant, ECLSS, PMMS process fluids. Internal storage, separate line to PMMS. Options: fuel, oxidizer, inert, liquid. Waste interfaces are TBD.
SS-SPEC-J002	CEI	PMMS	Physical, functional, PMMS parameters.

DERIVED REQUIREMENTS

REFERENCE MISSION OPERATION ANALYSIS DOCUMENTS (RMOAD)

- RED BOOK
- GREEN BOOK
- BLUE BOOK

MMPF USER STUDY

- MSFC
- TBE
- BAC

SYSTEMS OPERATION IMPERITIVES

- SPACELAB EXPERIENCE
- PHASE B DESIGN DRIVERS

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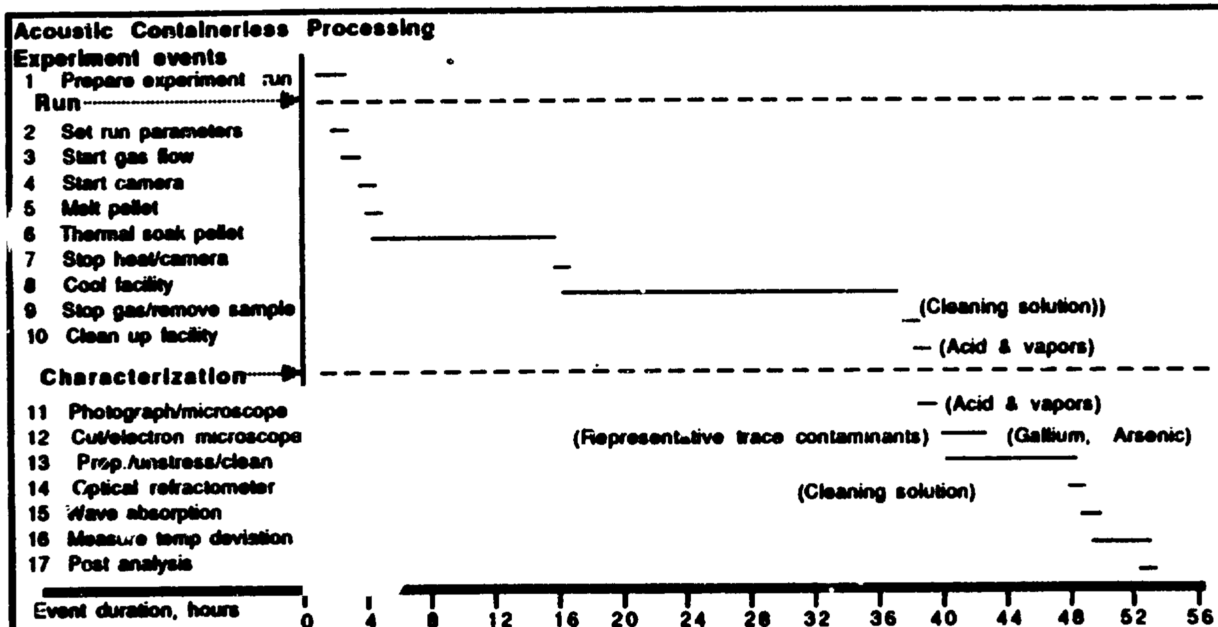
C-4

PMMS WASTE FLUID ANALYSIS (SAMPLE)

TELEDYNE BROWN ENGINEERING



	Run										Characterization				
Event #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Category total
Time (min)	20	1	1	1	1	1	1	20	10	15	15	30	30	30	178 min.
Waste category	Volume (liters)														
Inert gas (Ar, He)	18	52	52	52	52	52	52	320							650.0 liters
Cabin air	64							18	5	16	8	28	10	10	159.0 liters
Water									0.1					1	1.1 liters
Nitrogen												10	28		38.0 liters
Event total	82	52	52	52	52	52	52	338	5.1	16	8	38	38	11	848.1 liters

Analysis Indicates Predominant Waste Constituents Are Inert Gas and Cabin Air

SPACE STATION

PMMS REQUIREMENTS SAMPLE

TELEDYNE BROWN ENGINEERING

USL PROCESS FLUID REQUIREMENTS*
14 EXPERIMENT SET, CHARACTERIZATION
NO RECYCLING

FLUID	10 HRS/DAY CREW TIME		20 HRS/DAY CREW TIME		30 HRS/DAY CREW TIME	
	MASS	VOL (FT^3)	MASS	VOL (FT^3)	MASS	VOL (FT^3)
LIQ. H_2O	904.4	14.5	2152.5	34.5	2720.3	43.6
GAS Ar	25.8	231.9	49.5	444.9	70.2	630.9
GAS N_2	26.9	344.7	64.2	822.7	96.5	1236.7
LIQ. N_2	75.1	1.5	150.5	3.0	262.0	5.2
GAS O_2	10.4	116.7	18.9	212.1	25.7	288.3
GAS He	1.9	170.4	4.1	367.7	6.1	544.5
GAS CO_2	0.4	3.3	1.1	9.0	1.3	10.6
GAS H_2	0.2	35.6	0.2	35.6	0.3	53.4
TOTAL	1045.1	918.6	2441.0	1929.5	3182.4	2813.2

*ALL GAS VOLUMES ARE BASED ON STANDARD ATMOSPHERIC TEMPERATURE AND PRESSURE.

LAB SUPPPORT EQUIPMENT INTERFACES
(Excluding Life Sciences Equipment)

NOMENCLATURE	INTERFACES WITH						
	PMMS/GB	FMS	USERS	ECLSS	DMS/C&W	PWR/THERM	STRUCTURE
AUTOCLAVE	√	√	√	√	√	√	√
BATTERY CHARGER			√		√	√	
CAMERA	√		√				
CAMERA LOCKER							√
CLEANING EQUIPMENT	√	√	√	√	√	√	
CUTTING & POLISHING UNIT		√	√		√	√	√
DIGITAL MULTIMETER	√		√		√	√	
DIG RECORDING O-SCOPE			√		√	√	√
DIGITAL THERMOMETER	√		√		√	√	
DOSMETER, PASSIVE				√		√	
ELECT. CONDUCT. PROBE	√		√		√	√	
EM - STORAGE LOCKER			√				√
ETCHING EQUIPMENT	√	√	√				
FILM LOCKER							√
FLUID HANDLING TOOLS	√	√	√				
GEN PURPOSE HAND TOOLS	√		√				
MAINT WS/LS GB (GLSF)			√	√	√	√	√
MASS MEAS DEVICE - μ	√		√		√	√	
" " " - MACRO	√		√		√	√	
MICROSCOPE SYSTEM			√		√	√	√
MP GB (GLSF)	√	√	√		√	√	√
pH METER	√	√	√		√	√	
REFRIGERATOR	√		√	√	√	√	√
SPECIMEN LABELING	√		√				
ULTRAVIOLET STERILIZER	√		√		√	√	√
X-RAY SYSTEM	√		√		√	√	√

OTHER PROGRAMS

SKYLAB:

NOMINAL 90 DAY MISSIONS
LIMITED SET OF EXPERIMENTS
LIMITED FLEXIBILITY

SHUTTLE/SPACELAB:

NOMINAL 8 DAY MISSIONS
DIVERSE EXPERIMENT SETS
FLEXIBLE WITHIN BOUNDS

SALYUT/MIR:

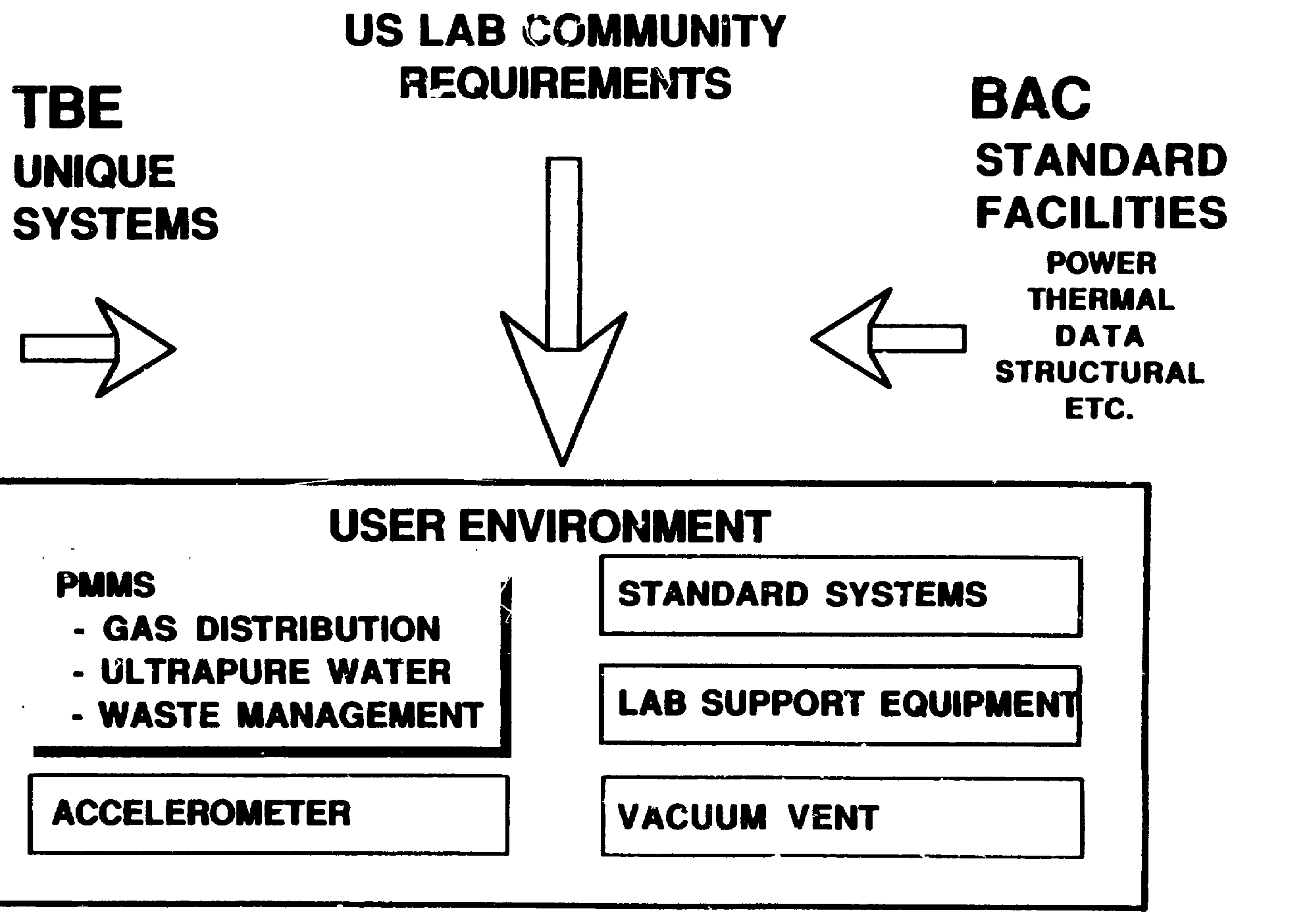
VARIABLE STAY MISSIONS
TEST OF THE MAN
LIMITED EXPERIMENT SET
LIMITED FLEXIBILITY

REMOTE SENSING MODULE
ATMOSPHERIC SCIENCES MODULE
MATERIALS PROCESSING MODULE
ROBOTS ON-ORBIT

SPACE STATION

PMMS LABORATORY SCIENCE ACCOMMODATION

TELEDYNE BROWN ENGINEERING



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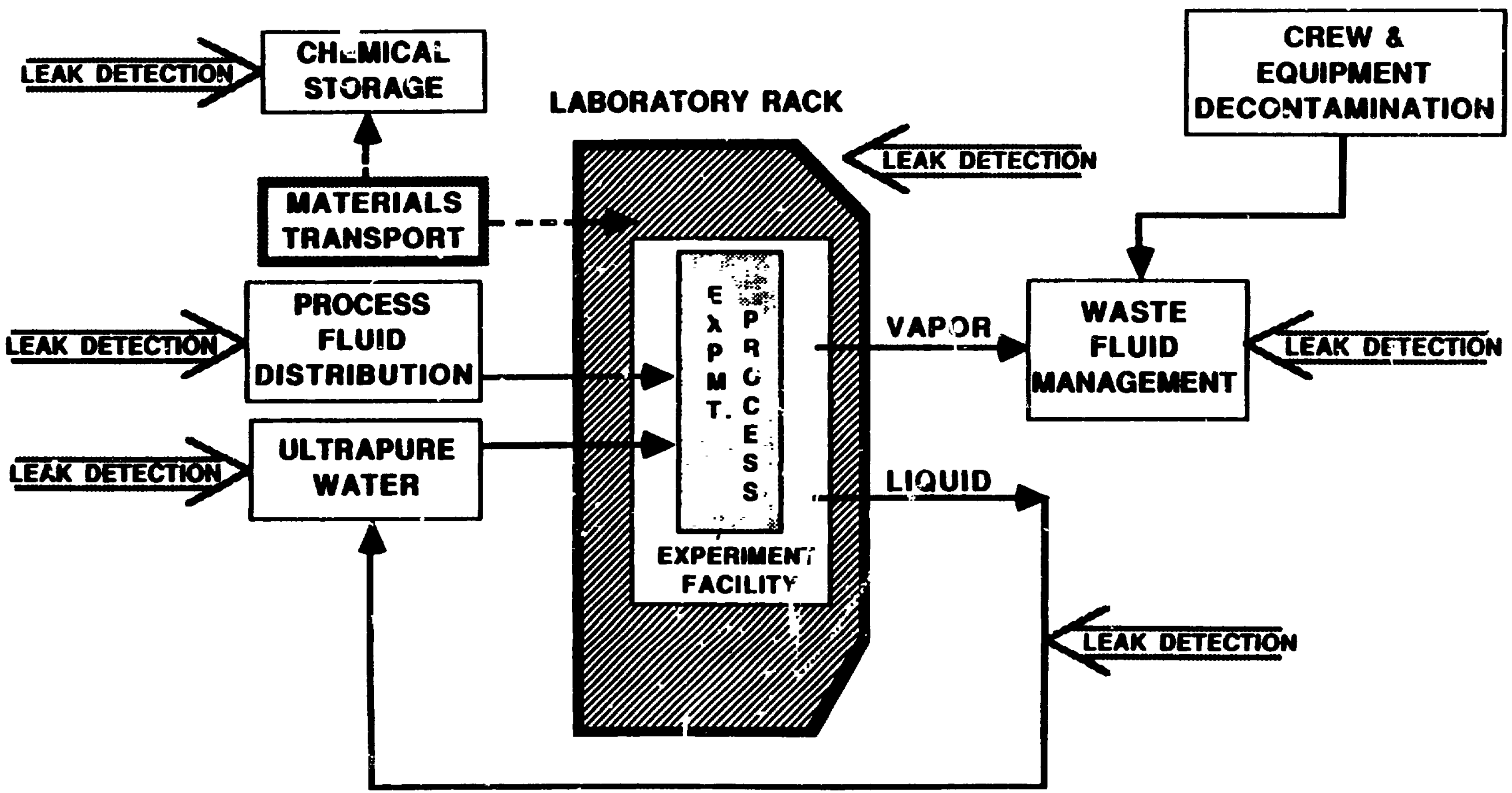
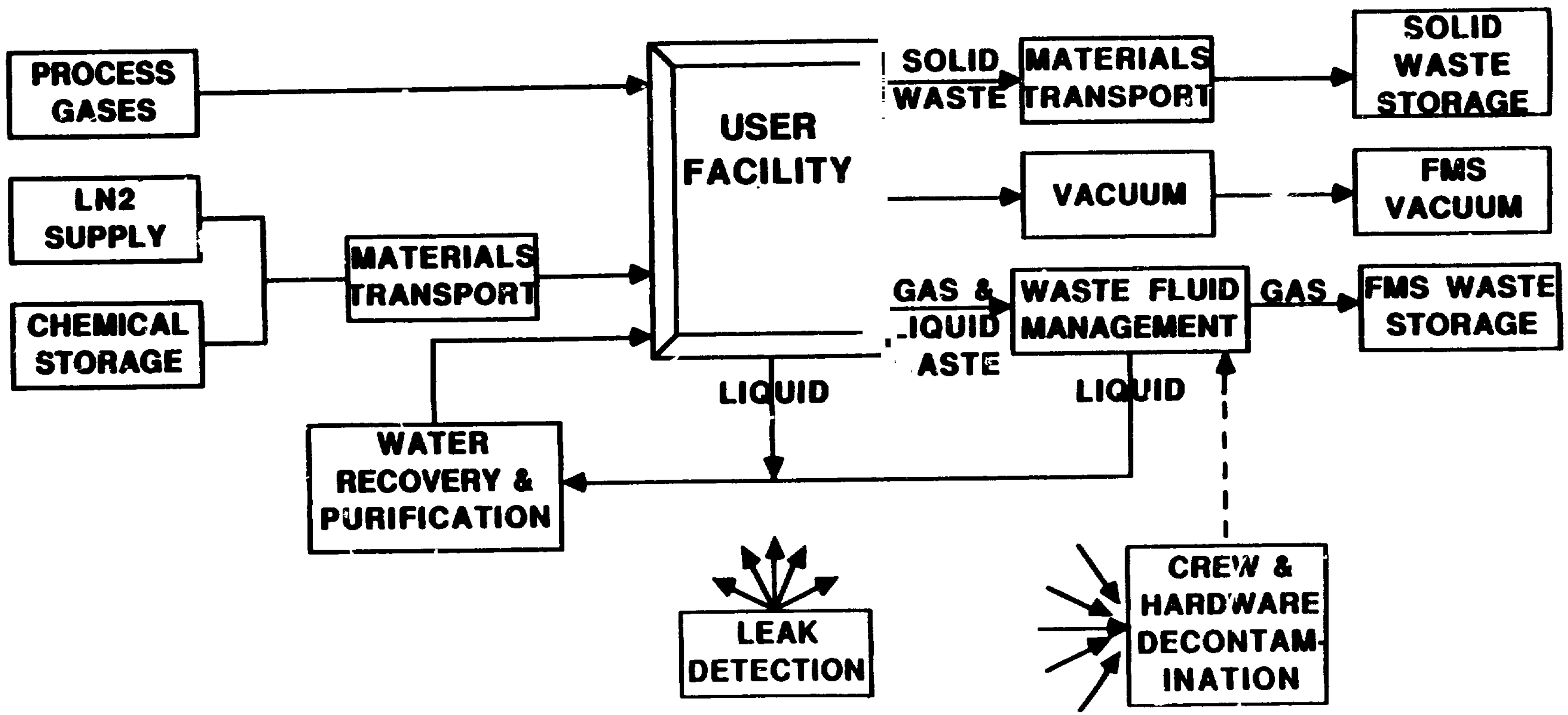
SPACE STATION

PMMS FUNCTIONAL DIAGRAM

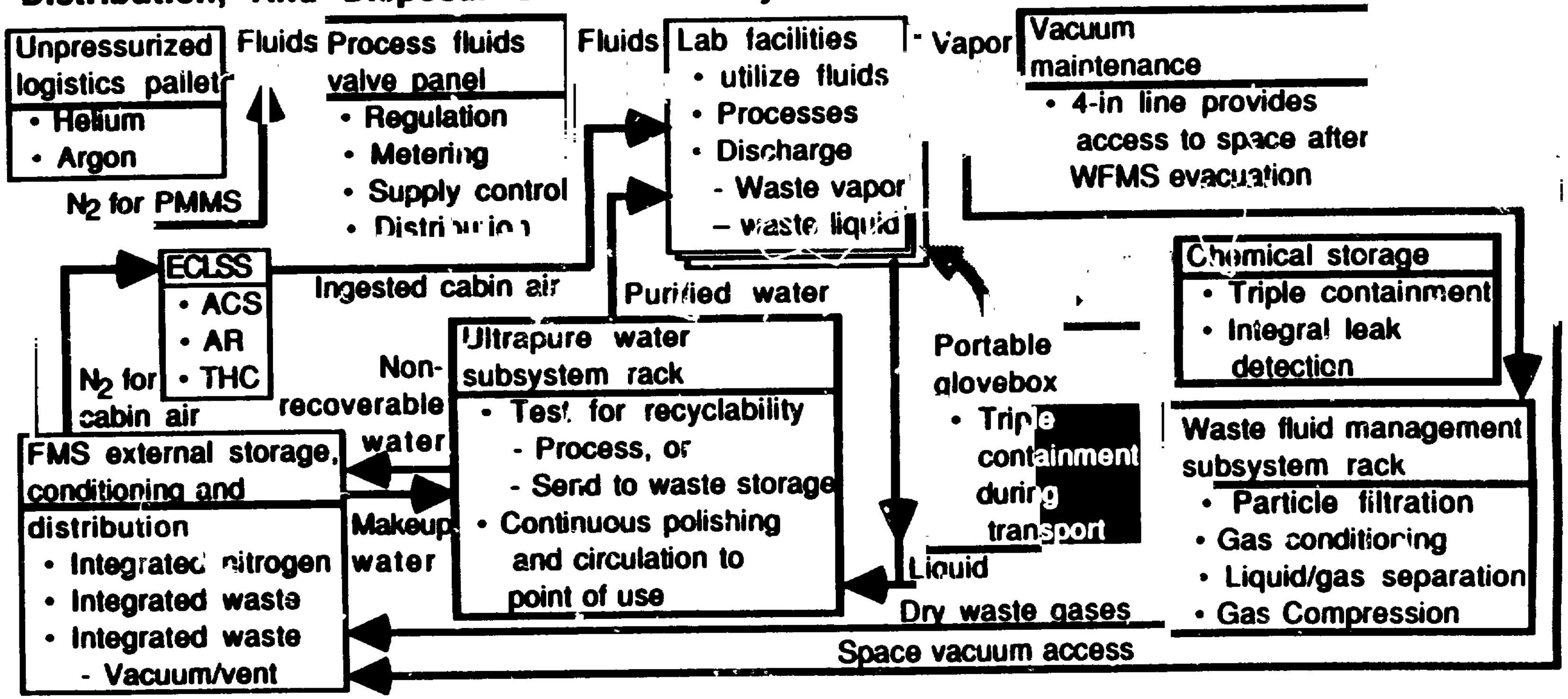
TELEDYNE BROWN ENGINEERING



USER FACILITY INTERFACES
(DIRECT & INDIRECT)



■ b PMMS provides Safe Containment, Centralized Storage, Distribution, And Disposal Of Potentially Hazardous Materials



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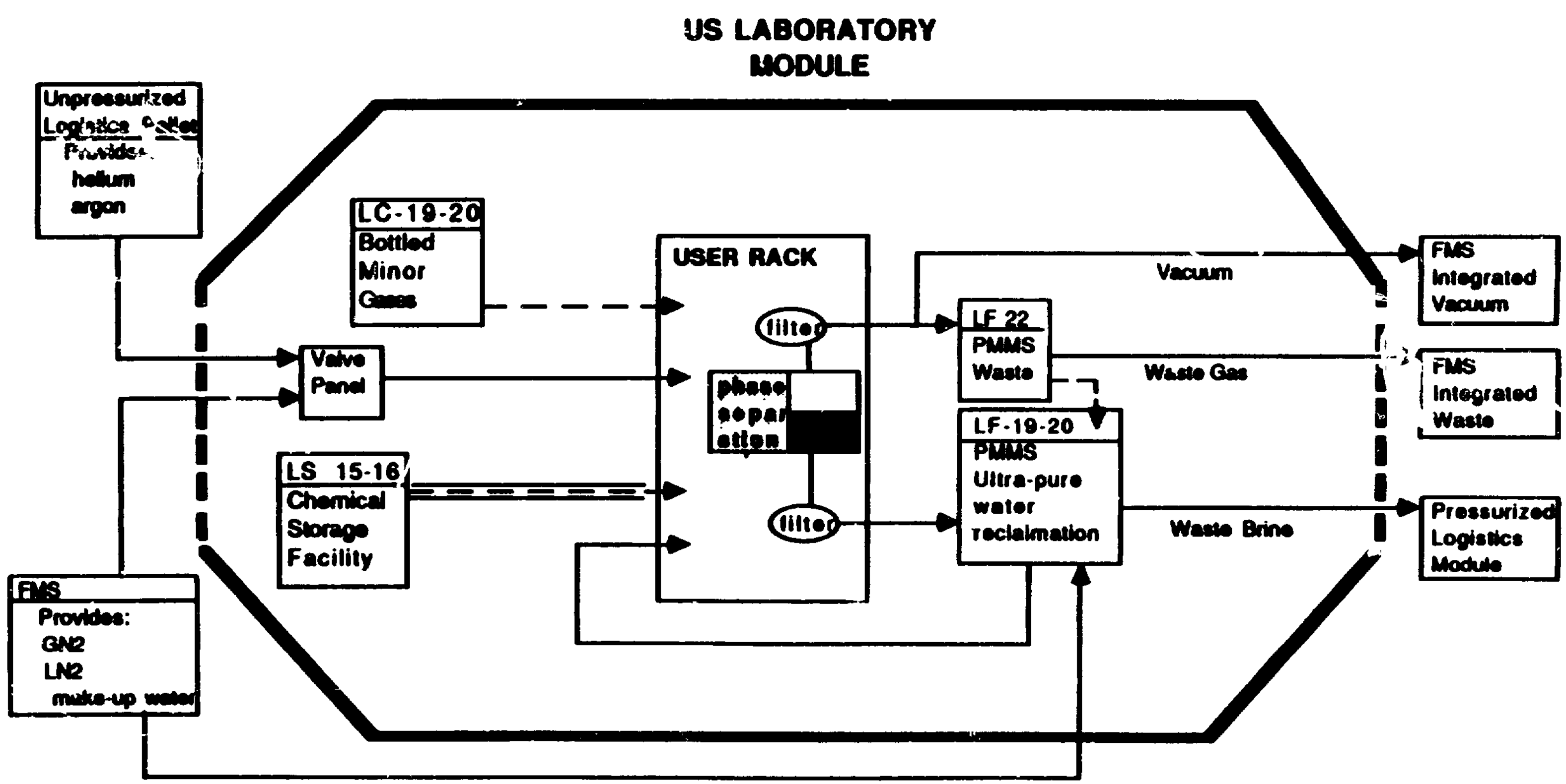
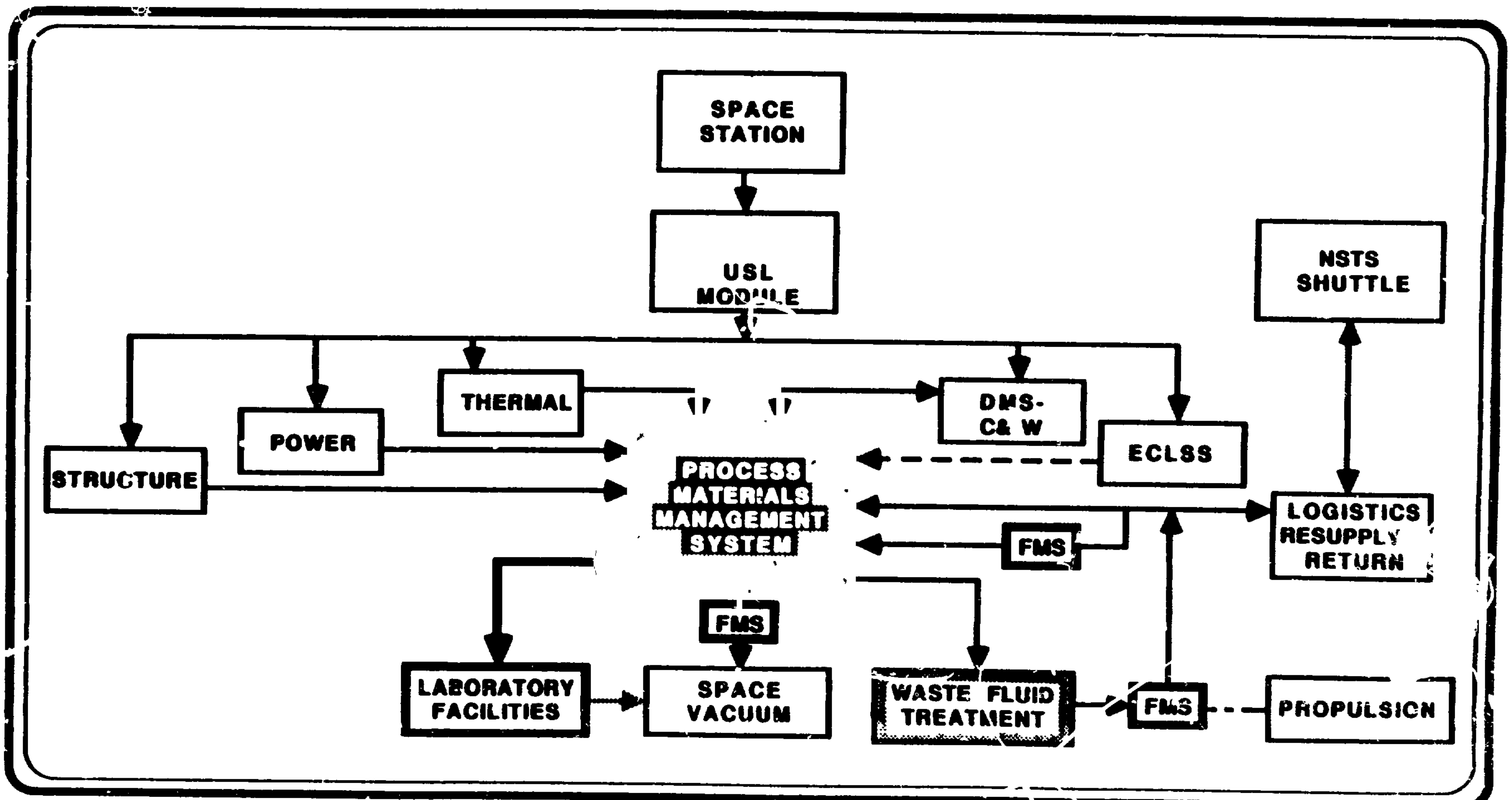
PMMS OPERATION

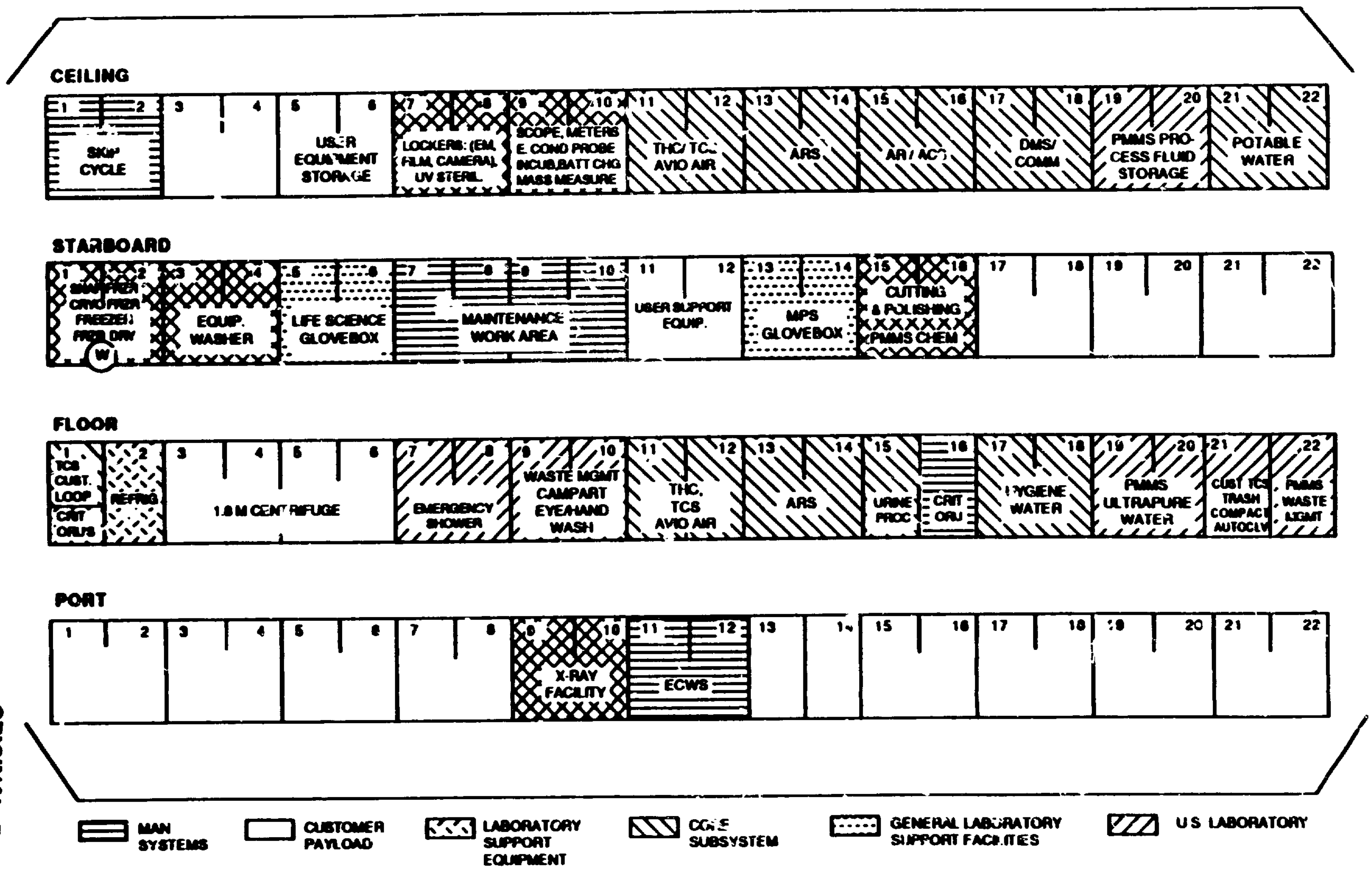
INTERNAL & EXTERNAL PMMS INTERFACES



PMMS INTERFACES



U. S. LABORATORY



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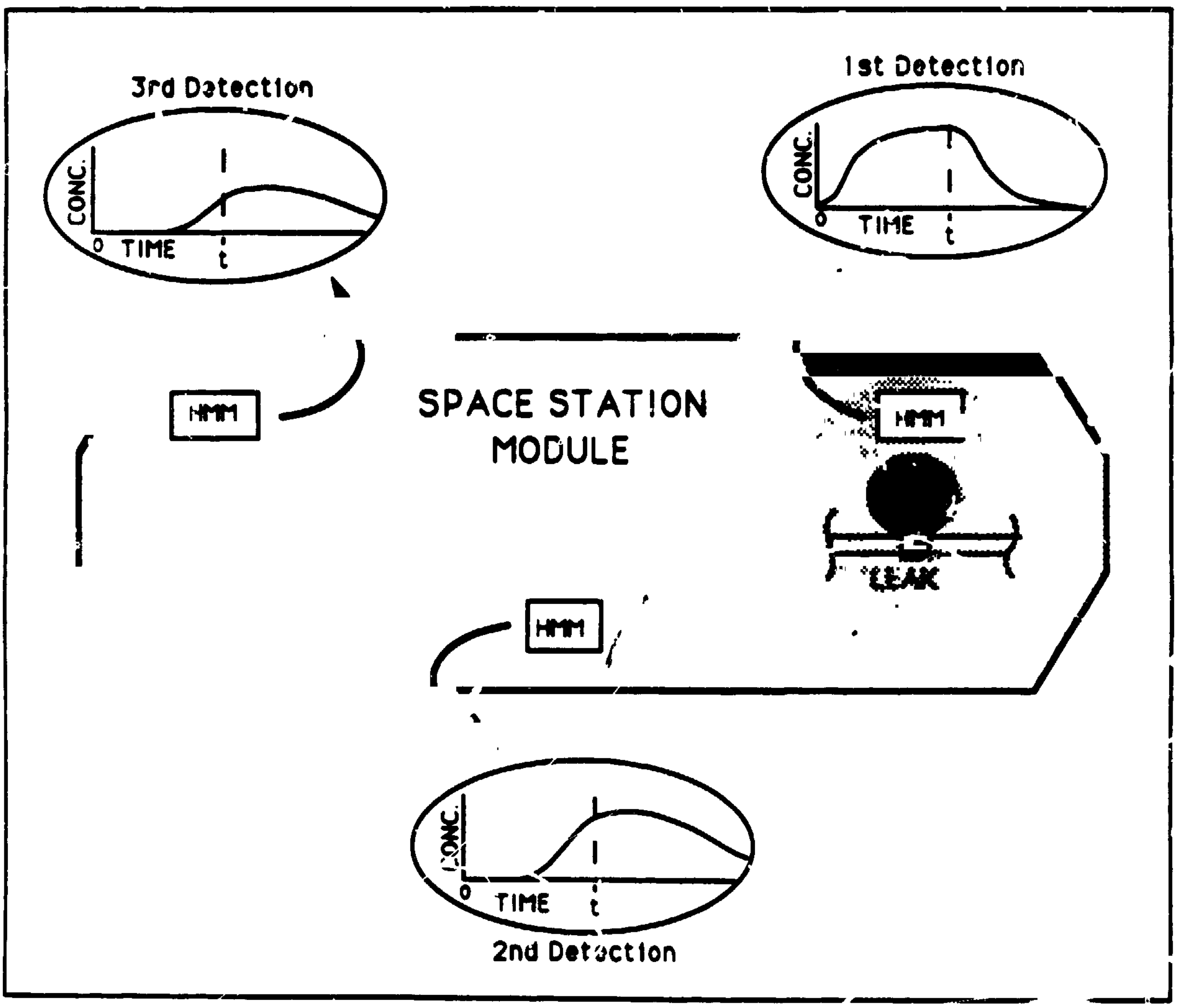
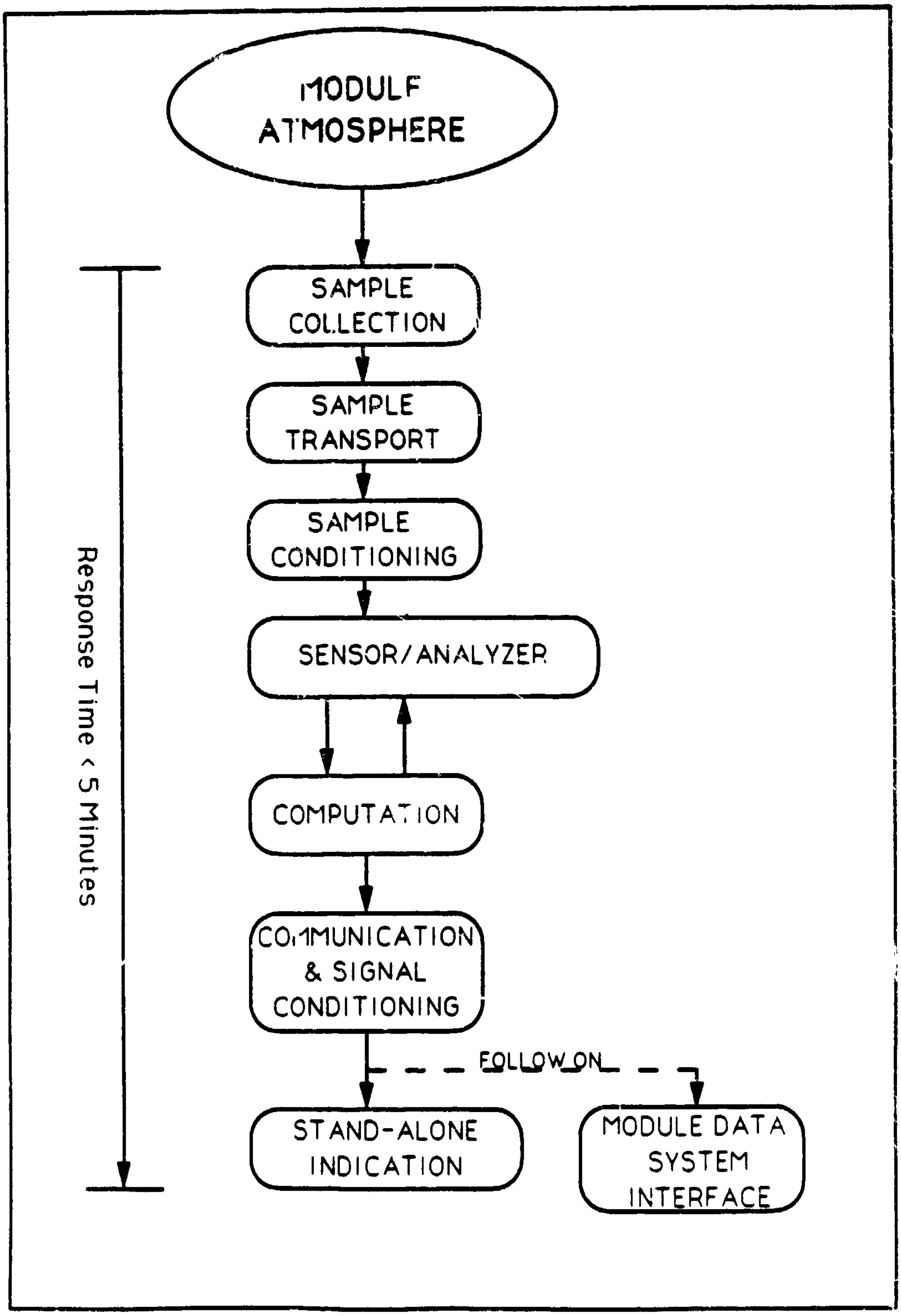
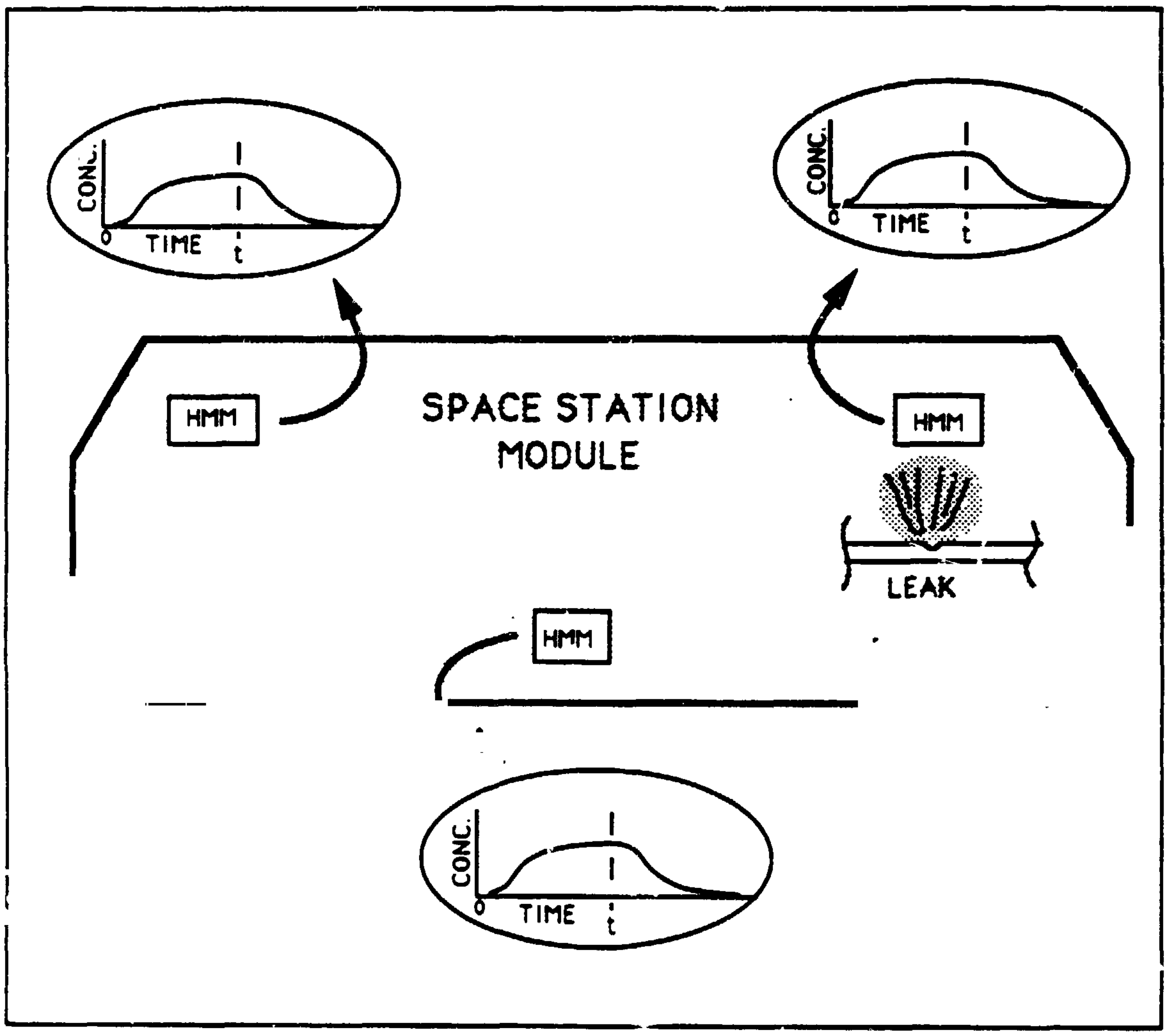
Detection & Quantification Problem (Simplified)



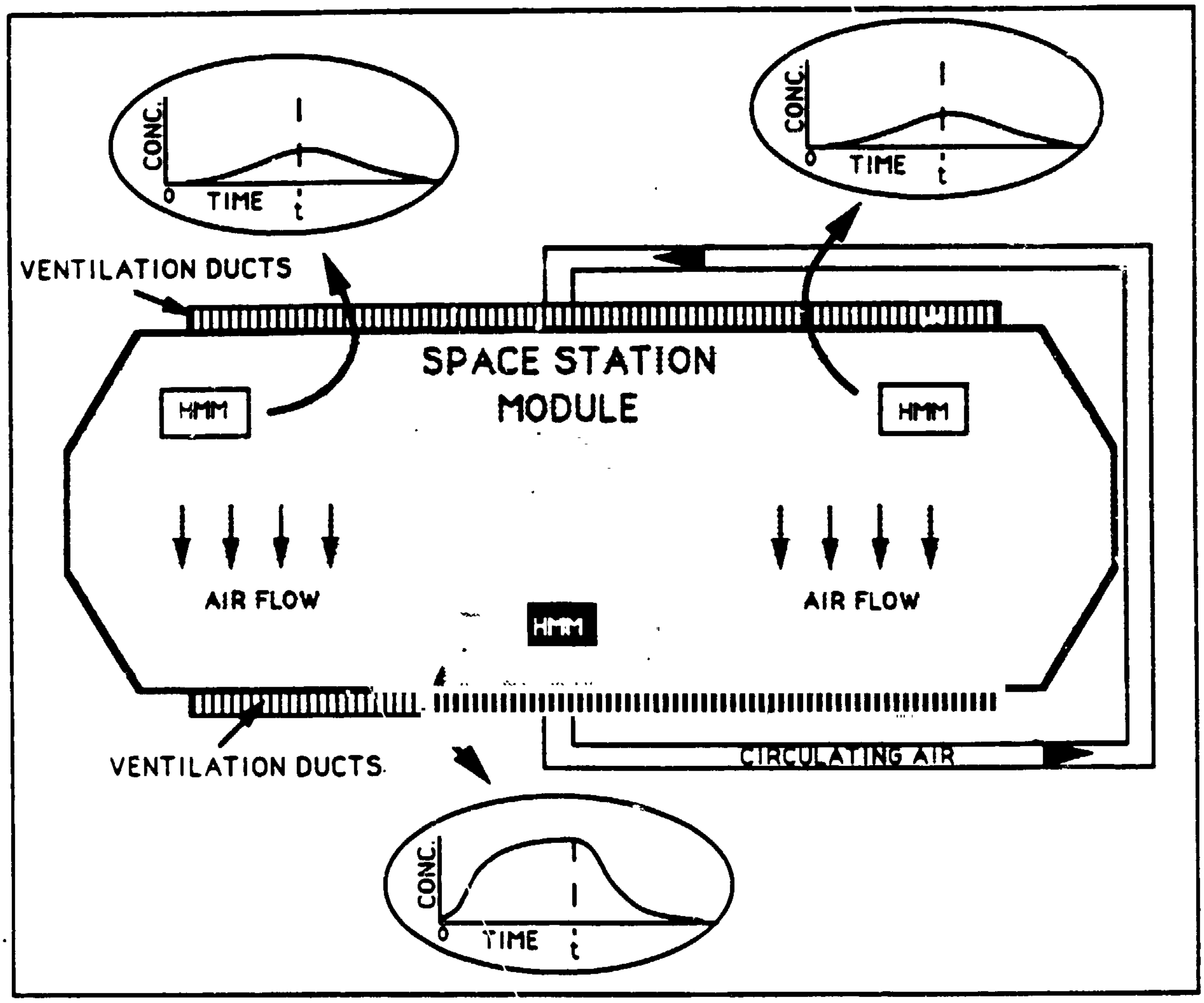
CASE 1: STAGNANT AIR

Response Time Elements



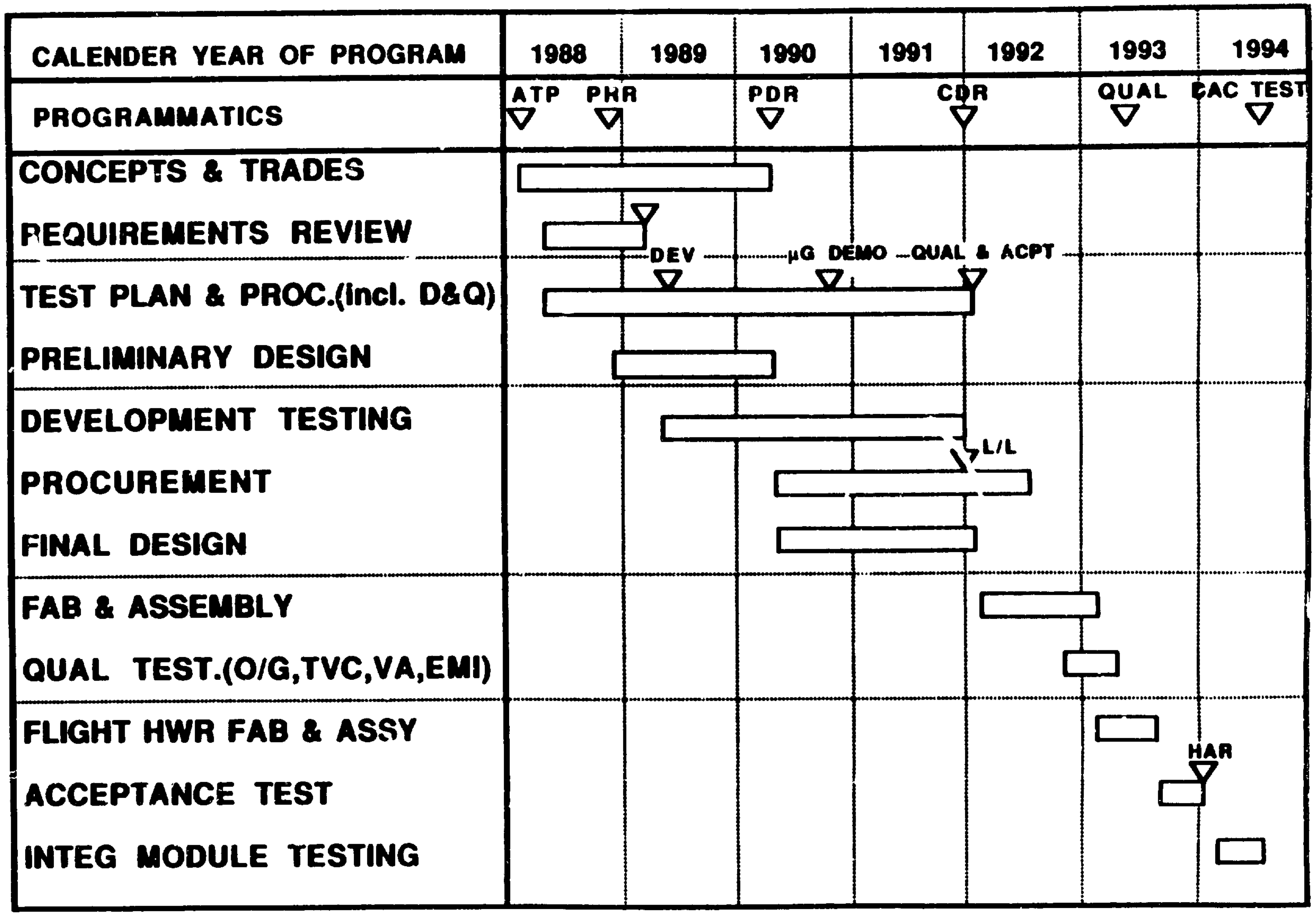


CASE 2: TURBULENT AIR

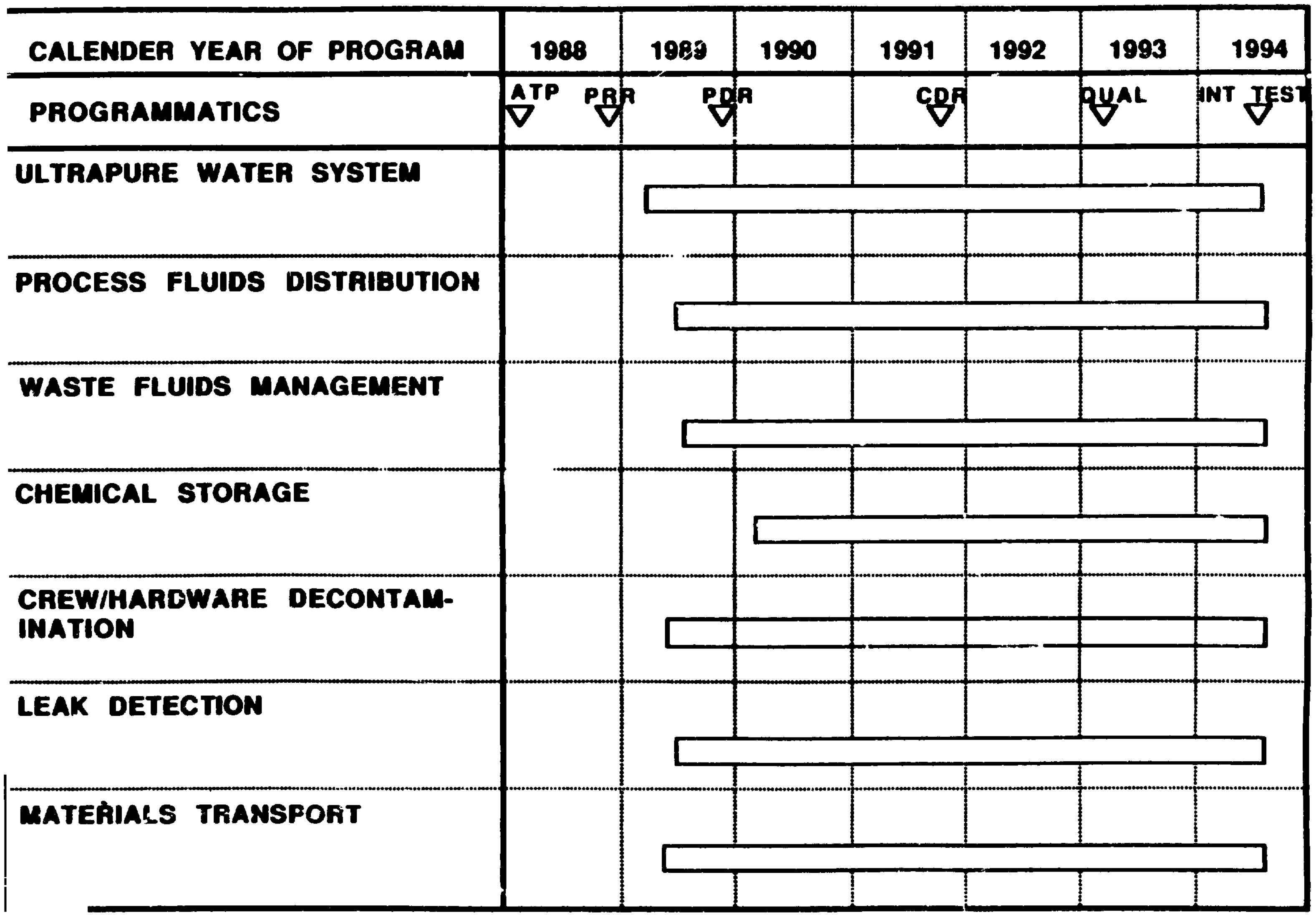


CASE 3: AIR RECYCLE

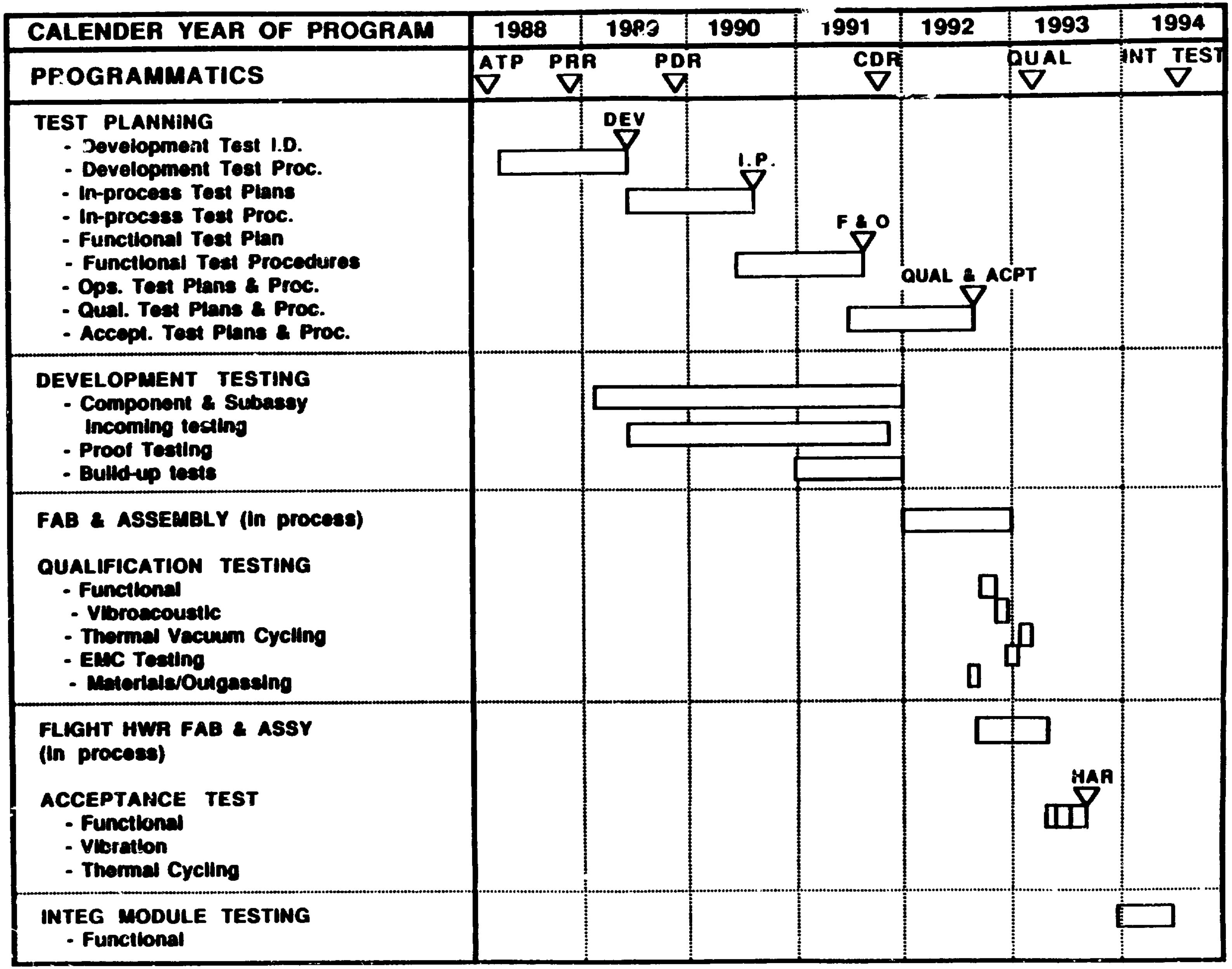
PMMS SCHEDULE
DEVELOPMENT & QUALIFICATION



PMMS DEVELOPMENT TESTING SCHEDULE



ULTRAPURE WATER SYSTEM
TEST ACTIVITIES



TYPES OF TESTING
PRIOR TO PDR

SUPPORT TO GENERIC COMPONENT/SUBASSEMBLY SELECTION
(common PMMS components - Q.D.'s, sensors, tubing...)

SELECTED COMPONENT VERIFICATION TESTS
(performance to specifications for pumps, controls, filters...)

MATERIALS COMPATIBILITY TESTING/EVALUATION
(chemical reactivity tests, samples to MSFC...)

UNIQUE DESIGN PROOF TESTS
(Q.D. & ATMOS bag dual containment, MTS seals, fluid handling tools, etc.)

pH COMPATIBILITY TESTS
(acid treatment & microscopic/SEM evaluation)

WASTE LINE CONTAMINATION AND CLEANING TESTS
(waste materials can be handled & lines cleaned between runs)

ULTRAPURE WATER MONITORING - CONTINUOUS & RELIABLE
(Total Organic Carbon(TOC), Limulus Amebocyte Lysate(LAL)...)

ULTRAPURE WATER PRODUCTION MAINTENANCE
(continuously pure production with maintenance of lines & filters)

LEAK DETECTION CAPABILITIES
(broad spectrum, sensitivity, detection software...)

ACCELEROMETER MEASUREMENTS, CALIBRATION & SOFTWARE
(prove sensitivity, spectrum, ground calibration & mapping S/W concepts)

PMMS POTENTIALLY HAZARDOUS PROOF TESTING

* TBE PROOF TEST: WHERE COMPONENT OR ASSEMBLY FAILURE MIGHT HAVE AN ADVERSE EFFECT ON CREW SAFETY OR MISSION SUCCESS, THESE WILL BE TESTED WITH QUALIFICATION LEVEL TEMPERATURES, PRESSURES AND MATERIAL COMPATABILITY STRESSES, IN ADDITION TO ANY OTHER TEST PROCEDURES.

TYPES OF PROOF TESTING:

1) NO LEAK UNDER QUAL PRESS & TEMP'S

2) HOT/COLD FLUID TRANSFER

3) pH VARIABLE MATERIALS STABILITY

4) INTERNAL OPERATIONS CLEANLINESS

5) COMBUSTABLE SUBTANCES HANDLING

6) COMBINATIONAL STRESS TEST
   - HOT CORROSIVES & CAUSTICS UNDER PRESSURE
   - SERIAL CLEAN RUNS OF HIGHLY REACTIVE SUBSTANCES

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PMMS

SUBSYSTEM	NECESSARY FUNCTIONS
• Process Fluids Distribution	Storage, Conditioning, Distribution, Monitoring and Storage
• Ultrapure Water	Recovery, Processing, Quality Monitoring, Distribution
• Waste Fluid Management	Recovery, Processing (phase separation, filtration, gas compression, mixing, combustion), Quality Monitoring, Transportation
• Crew/Hardware Decontamination	Handle effluent from crew and hardward decontamination
• Chemical Storage	Containment, leak detection
• Leak Detection	Sample from multiple locations, analyze for anomalous conditions, deliver hazard warning, perform high-resolution analysis to identify substance(s)
• Materials Transport	Mobile Containment Unit (with manipulative access)

PMMS CRITICAL DEVELOPMENT AREAS

DUE TO IT'S NATURE AS A CENTRALIZED SYSTEM WITH DISTRIBUTION LINES, THE PHYSICAL AND FUNCTIONAL PARAMETERS OF THE PMMS WILL LEVEY REQUIREMENTS ON THE MODULE & CORE SYSTEMS, LOGISTICS, USER FACILITIES, AND INTEGRATED FMS. IN ADDITION, RISK WILL MANDATE EARLY PMMS DEVELOPMENT TESTING IN THE INDICATED AREAS:

PROCESS FLUIDS DISTRIBUTION:

THE ON ORBIT DELIVERY OF CRYOGENS IS A NEW AND UNTESTED TECHNOLOGY. THE METHOD OF APPLICATION IS NOT WELL DEFINED.

- POWER DEMANDS FOR CRYOGEN PRODUCTION & STORAGE
- TRANSPORT & DELIVERY FOR TEMPERATURE SENSITIVE, TWO PHASE FLUID IN ZERO-G
- STORAGE BOIL-OFF
- CONVERSION EFFICIENCY

CHEMICAL STORAGE:

A NUMBER OF SAFETY RELATED CONCEPTS GENERATE CONTRADICTOR DESIGN REQUIREMENTS. (e.g.)

- CHEMICAL STORAGE CONTINGENCY VENTING NEGATES SPECIES ISOLATION
- ACCESS & USE BREAKS TRIPLE CONTAINMENT AT SOME POINT
- ACTIVE STORAGE & LEAK DETECTION NEGATES TRIPLE CONTAINMENT BY REQUIRING RACK AVIONICS AIR
- HYPOBARIC STORAGE PROMOTES CONTAINER LEAKAGE
- CHEMICAL SPECTRUM COMPLICATE PASSIVE LEAK DETECTION & CONTAINER COMMONALITY

PMMS CRITICAL DEVELOPMENT AREAS (CONTINUED)

MATERIALS TRANSPORT:

THE MULTIPLICITY OF FUNCTIONS TO ACCOMMODATE AND THE NECESSITY TO INTERFACE WITH MANY FACILITIES COMPLICATES CONFIGURATION AND SIZING.

- MECHANICAL INTERFACE DESIGN TO PREVENT LEAKAGE INTO THE CABIN
- MATERIALS SELECTION TO RESIST MULTIPLE THREAT ENVIRONMENTS
- CLEANING TO PRECLUDE CROSS CONTAMINATION

ULTRAPURE WATER:

RECLAMATION OF WASTE WATER AND PROCESSING TO HIGH PURITY ARE TWO DISTINCT PROCESSES

- BOTH ARE COMPLICATED BY THE UNDEFINED QUALITY OF THE FEED WATER.
- USER INTERFACES MUST BE DEFINED PRIOR TO INITIATION OF FACILITY DESIGN.
- INSTRUMENTATION FOR ONLINE QUALITY MONITORING IS A DEVELOPMENT ISSUE
- POWER CONSUMPTION, THROUGHPUT, QUALITY, AND RECOVERY EFFICIENCY MUST BE SIMULTANEOUSLY OPTIMIZED.

PMMS CRITICAL DEVELOPMENT AREAS (CONTINUED)

WASTE MANAGEMENT:

THE UNCONSTRAINED NATURE OF THE CHEMICALLY AGGRESSIVE AND POTENTIALLY HAZARDOUS WASTE STREAM IMPOSES COMPLEX DESIGN/DEVELOPMENT ISSUES.

- PUMP/COMPRESSOR DESIGN FOR CHEMICALLY AGGRESSIVE ENVIRONMENT
- LOW PROFILE VACUUM RATED VALVES AND QD'S FOR CHEMICALLY AGGRESSIVE ENVIRONMENT
- SEALS (DESIGN & MATERIALS) TO WITHSTAND CHEMICALLY AGGRESSIVE ENVIRONMENT
- ANALYSIS TO REDUCE RISK OF MIXING UNCONSTRAINED WASTE STREAMS
- TEST & EVALUATE CANDIDATE COMBUSTION TECHNOLOGIES TO REDUCE REACTIVE POTENTIAL OF MIXED WASTE STORAGE
- ESTABLISH COMPONENT LIFE EXPECTANCIES & ACCEPTABLE DESIGN MARGINS
- DEVELOP ORU CHANGEOUT PROCEDURES WHICH PROVIDE APPROPRIATE CONTAINMENT
- DEVELOP & VERIFY CLEANING METHODS
- MAJOR INTERFACES WITH THE FMS MUST BE RESOLVED IN PARALLEL WITH FMS DEVELOPMENT

PMMS CRITICAL DEVELOPMENT AREAS (CONTINUED)

LEAK DETECTION:

A SAFETY CRITICAL FUNCTION WITH UNCONSTRAINED CHALLENGE. MUST DEFINE ECLSS, PMMS, AND USER RESPONSIBILITIES WITH AN APPROPRIATE DEGREE OF OVERLAP. ESTABLISH ONE OR MORE TECHNOLOGIES WHICH WILL:

- DETECT A NEAR INFINITE RANGE OF CHEMICAL SUBSTANCES AT EXTREMELY LOW LEVELS
- PROVIDE TIMELY ALERT TO PROTECT CREW & INITIATE CONTINGENCY MEASURES
- AID ECONTINGENCY PLANNING WITH MATERIAL IDENTIFICATION, SOURCE LOCATION, AND THREAT EVALUATION
- VERIFY EFFECTIVENESS OF CONTINGENCY MEASURES PRIOR TO RESUMPTION OF NORMAL LAB OPERATIONS

CREW & HARDWARE DECONTAMINATIO

ANOTHER SAFETY CRITICAL FUNCTION. MAY HAVE TO OPERATE IN A DEGRADED RESOURCE ENVIRONMENT.

- ENVELOPE UNDEFINED CHALLENGES WITH MINIMAL HARDWARE
- DEFINE PROCEDURES AND ESTABLISH CAPABILITY LIMITS

PMMS & USL KEY CHALLANGES

- **PMMS DESIGN FOR TRIPLE CONTAINMENT TO INSURE SAFETY DURING POTENTIALLY HAZARDOUS OPERATIONS**

- **NUMEROUS COMPLEX INTERFACES:**
  - LOGISTICS
  - MODULE "CORE" SYSTEMS
  - USER FACILITIES
  - FLUIDS MANAGEMENT SYSTEM

- **ON-ORBIT INTEGRATION OF LINES AND RACKS WITH POTENTIAL FOR LEAKS FROM SYSTEMS HANDLING HAZARDOUS MATERIALS**

- **NEW TECHNOLOGIES OR NEW ON-ORBIT ACTIVITIES:**
  - CRYOGEN MANUFACTURE, DELIVERY AND USE IN μG ENVIRONMENT
  - BROAD SPECTRUM CHEMICAL STORAGE ISOLATION METHODS
  - CHEMICAL/SAMPLE TRANSPORT MECHANISM WITH MULTIPLE INTERFACES
  - CONTINUOSLY ON-LINE WATER QUALITY MONITORING INSTRUMENTATION
  - SERIAL HANDLING TECHNIQUES & ANALYSES FOR CHEMICAL WASTES
  - COMPONENTS NECESSARY TO OPERATE IN HARSH CHEMICAL ENVIRONMENT
  - RAPID, SENSITIVE & BROAD SPECTRUM LEAK DETECTION IN μG
  - TEST & OPERATIONAL PROCEDURE DEVELOPMENT TO INSURE SAFE OPS OF POTENTIALLY HAZARDOUS MATERIALS

FLUID MANAGEMENT SYSTEMS (FMS)
DESCRIPTION AND ISSUES

Presentation to

SPACE STATION FREEDOM
TOXIC AND REACTIVE MATERIALS HANDLING
WORKSHOP

November 30, 1988

G.R. Schmidt
FMS Systems Engineer
Level II/ PSC
Booz•Allen & Hamilton

AGENDA

- **INTRODUCTION**
  - Overview of FMS
  - Rationale for Integration

- **PROCESS FLUID SUPPLY**
  - Integrated Nitrogen System (INS)
  - Integrated Water System (IWS)
  - Other Potential Integrated Process Fluid Systems

- **WASTE HANDLING**
  - Integrated Waste Gas System (IWGS)

- **CONCLUSIONS**
  - Acronym List

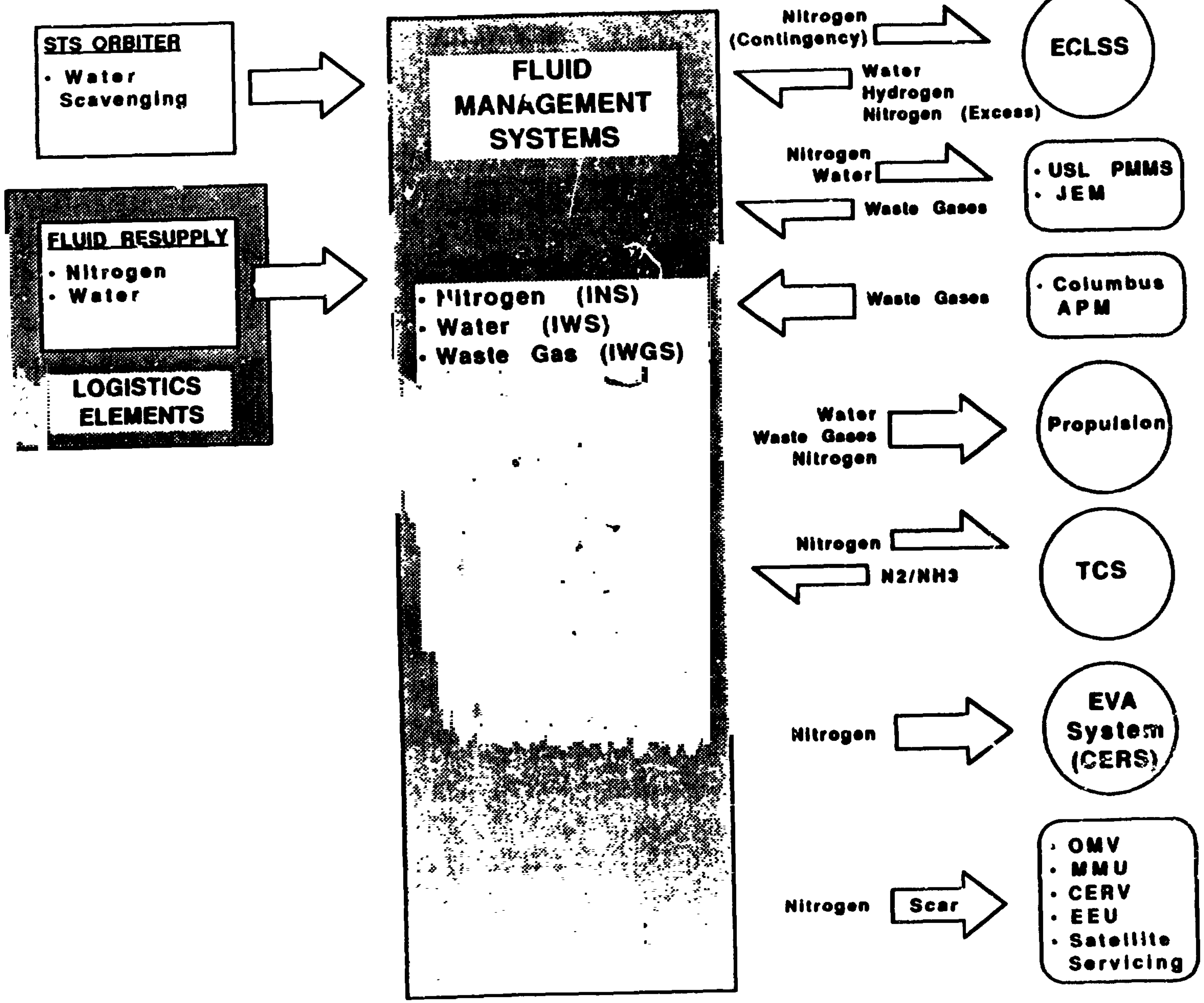
OVERVIEW OF FMS

- FMS PROVIDES INTEGRATED FLUID RESOURCES TO ELEMENTS AND SYSTEMS OF FREEDOM MANNED BASE
  - 1 of 9 Baselined Distributed Systems
  - Responsible for Handling Nitrogen, Water and Waste Gases
  - Potential for Addition of Other Integrated Systems

- FMS DESIGN AND OPERATION SIGNIFICANTLY INFLUENCED BY:
  - Design and Operational Characteristics of Interfacing Elements and Systems
  - Fluid Resupply and Disposal Requirements of Users

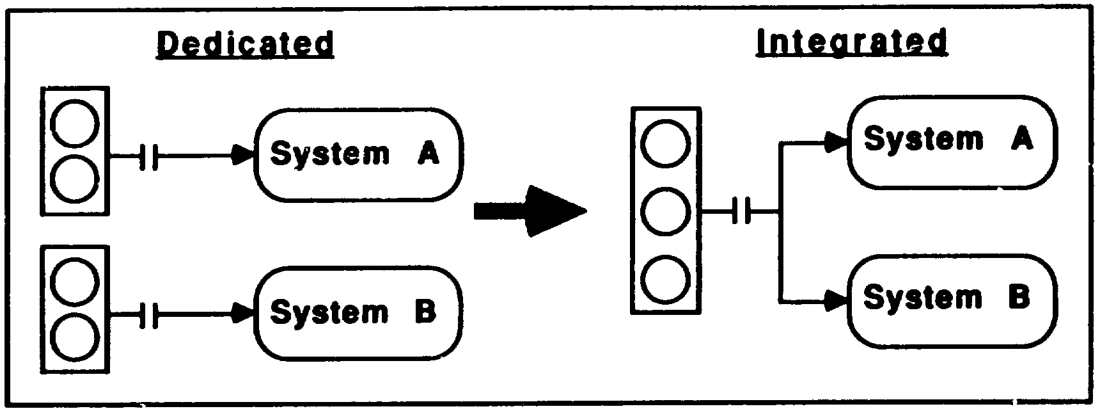
- RECENT FMS WORKING GROUP PROPOSED MANY CHANGES IN ARCHITECTURE
  - Addition of More Functional and Design Detail
  - Resolution of Many Overlap Issues with Other Systems
  - Changes in Partitioning of Responsibilities Between FMS, ECLSS and Labs

PRINCIPAL FMS INTERFACES



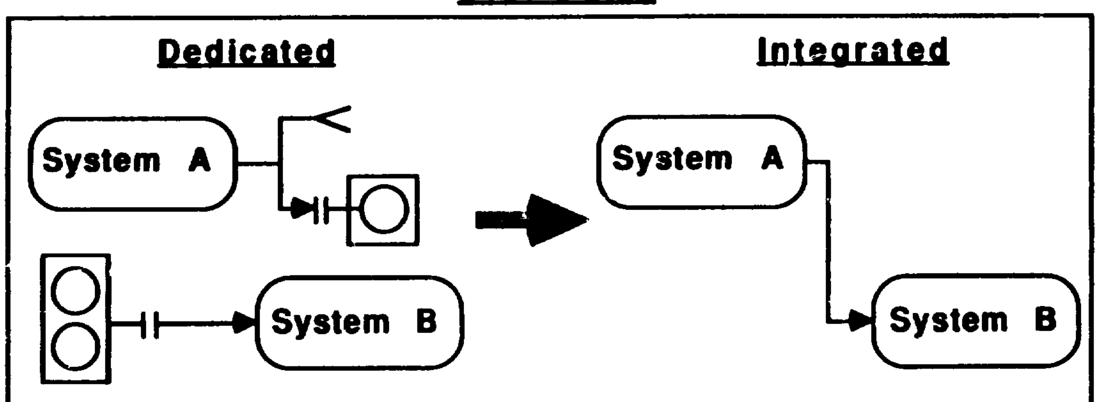
RATIONALE FOR FLUIDS INTEGRATION

RESUPPLY



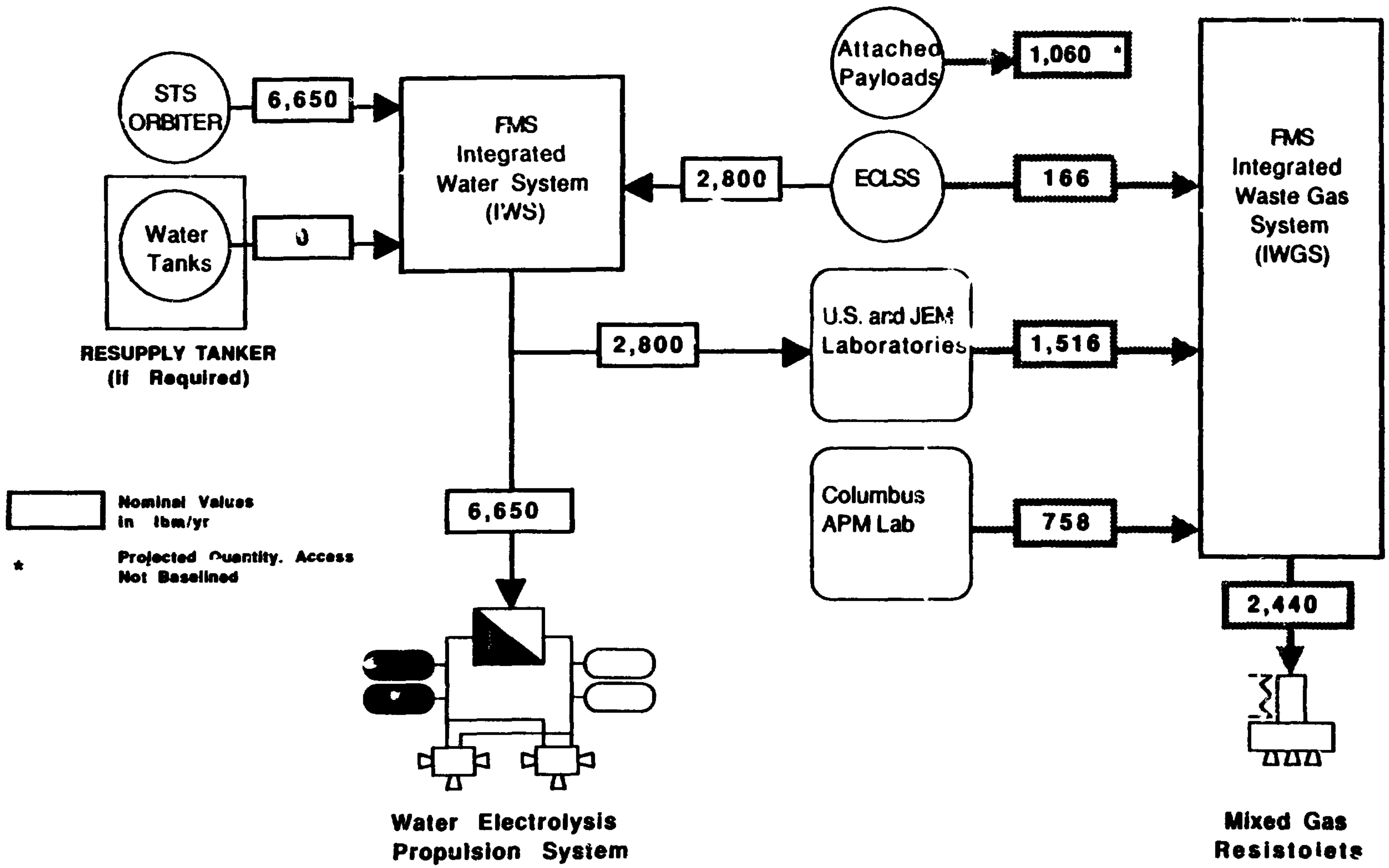
- REDUCTION IN OVERALL DISTRIBUTION HARDWARE
- INCREASE IN RESUPPLY HARDWARE MASS EFFICIENCY
- REDUCTION IN ON-ORBIT TANK CHANGEOUT AND OPERATIONS

DISPOSAL



- REDUCTION IN OVERALL DISTRIBUTION AND DISPOSAL HARDWARE
- REDUCTION IN SYSTEM B RESUPPLY COSTS
- REDUCTION IN ON-ORBIT S/S SUPPORT OPERATIONS AND DOWNSUPPLY DEMAND

EXAMPLE OF INTEGRATED FLUIDS USAGE



INTEGRATION OF WATER AND WASTE GAS HANDLING SIGNIFICANTLY REDUCES RESUPPLY COSTS

AGENDA

- INTRODUCTION
  - Overview of FMS
  - Rationale for Integration

- PROCESS FLUID SUPPLY
  - Integrated Nitrogen System (INS)
  - Integrated Water System (IWS)
  - Other Potential Integrated Process Fluid Systems

- WASTE HANDLING
  - Potential Additional Systems

- CONCLUSIONS
  - Acronym List

INTEGRATED NITROGEN SYSTEM (INS) DESCRIPTION

FUNCTIONAL REQUIREMENTS

- PROVIDES NITROGEN GAS TO THE FOLLOWING:
  - USL and JEM Fluid Systems for Experiments
  - ECLSS for Emergency Storage Makeup and Extra Contingency
  - IWS for Node Water Tank Pressurant Control
  - External TCS for Ammonia Loop Purge
  - EVA System Crew Equipment Retrieval System (CERS) for Propellant
  - Propulsion for Electrolysis Unit Pressurization
  - IWGS for Disposal Access

- PROVIDES SCAR INTERFACES FOR FUTURE HIGH PRESSURE USERS
  - Manned Maneuvering Unit (MMU) Propellant
  - Extravehicular Excursion Unit (EEU) Propellant
  - Crew Emergency Rescue Vehicle (CERV) Propellant
  - Orbital Maneuvering Vehicle (OMV) and Satellite Servicing Pressurant

KEY FEATURES

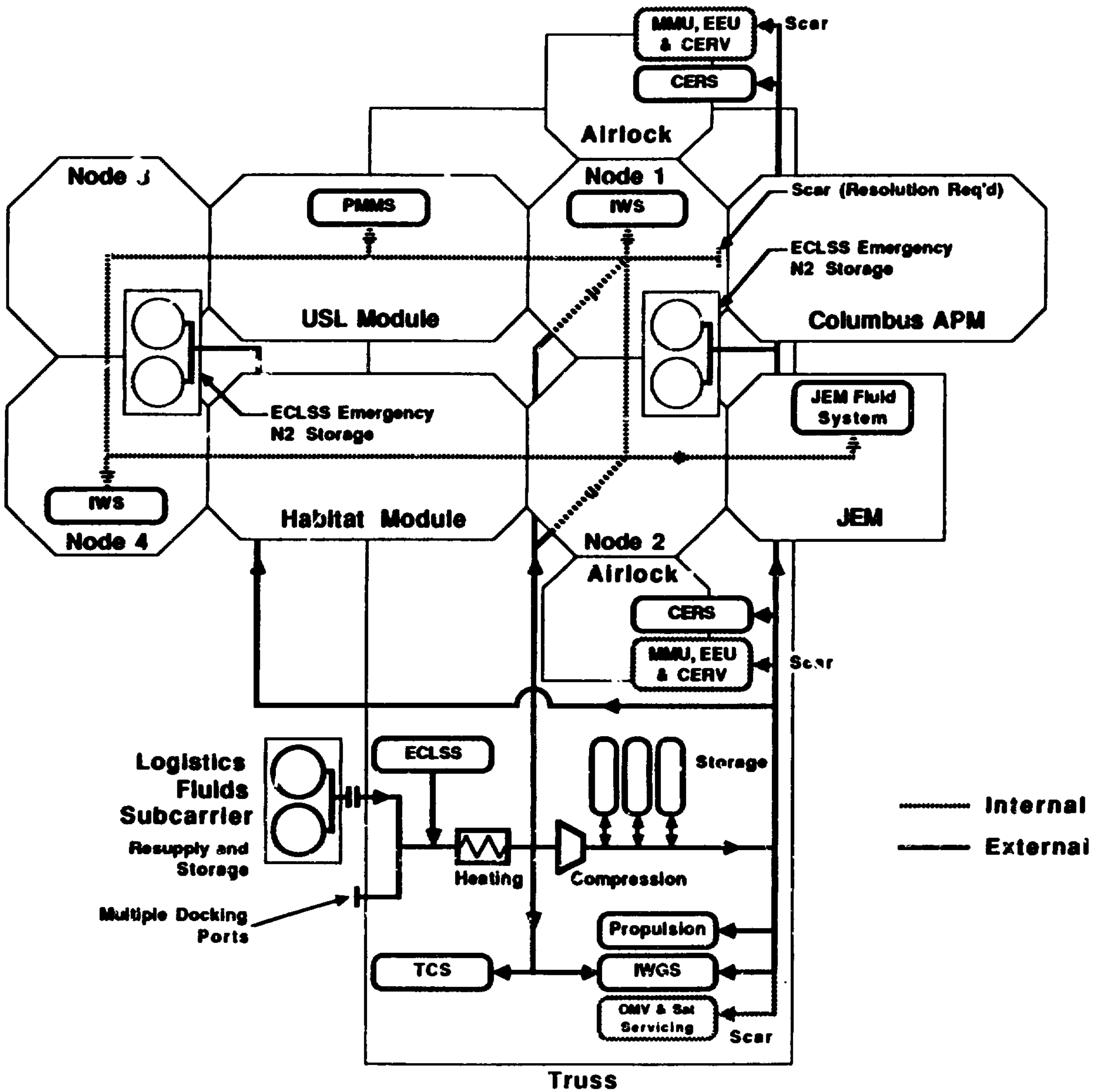
- RESUPPLY OF N_2 VIA SUPERCRITICAL CRYOGENIC STORAGE TANKS IN UNPRESSURIZED LOGISTICS CARRIER (Fluids Subcarrier)

- THERMAL EXPANSION, HEATING AND TRANSFER TO INTERNAL AND LOW PRESSURE USERS

- COMPRESSION AND HIGH PRESSURE STORAGE ON TRUSS FOR HIGH PRESSURE USERS

- INTERNAL AND EXTERNAL DISTRIBUTION LINES

INS ARCHITECTURE



INS SUMMARY

FEATURES THAT MITIGATE SAFETY, CONTAMINATION AND COST IMPACTS

- SEPARATE ECLSS NITROGEN SUPPLY
  - Eliminate Possibility of Lab/ECLSS Cross-Contamination
  - Establish ECLSS End-to-End Control of Nitrogen Supply
  - Add ECLSS Access to INS Nitrogen in Event of Emergency

- HIGH PRESSURE NITROGEN STORAGE ON TRUSS
  - 6,000 psi Required for Baseline and Growth Users
  - External Location to Minimize Impact of Catastrophic Failure

- ALL INS DISPOSAL ROUTED THROUGH WASTE GAS SYSTEM (IWGS)

CURRENT ISSUES

- NO PROVISION FOR TRANSFER OF CRYOGENIC LIQUID OR GAS TO LABORATORIES
  - No Clear Requirement
  - Responsibility of Laboratory Element or User

- GROUND HANDLING OF RESUPPLY SUBSYSTEM SUPERCRITICAL NITROGEN
  - Ground Hold Requirement Major Design Driver on Tanks

- REMOVAL OF NITROGEN SUPPLY TO COLUMBUS APM PAYLOADS
  - No PMMS-type Process Fluid Supply in Columbus APM
  - Raises Issues With Standardization of Payload Interfaces

INTEGRATED WATER SYSTEM (IWS) DESCRIPTION

FUNCTIONAL REQUIREMENTS

- COLLECTS EXCESS WATER PRODUCED BY ON-ORBIT SYSTEMS (ELIMINATES POTENTIAL VENTING, DUMPING OR RETURN)
  - Water Product from NSTS Orbiter Fuel Cells
  - Discarded ECLSS Hygiene Water

- PROVIDES WATER TO ON-ORBIT CONSUMERS
  - USL PMMS and JEM
  - Propulsion Electrolysis Units

- RECEIVES MAKEUP WATER FROM LOGISTICS IN EVENT OF NET WATER DEFICIT
  - Unpressurized Logistics Carrier (ULC) Fluids Subcarrier
  - Pressurized Logistics Carrier

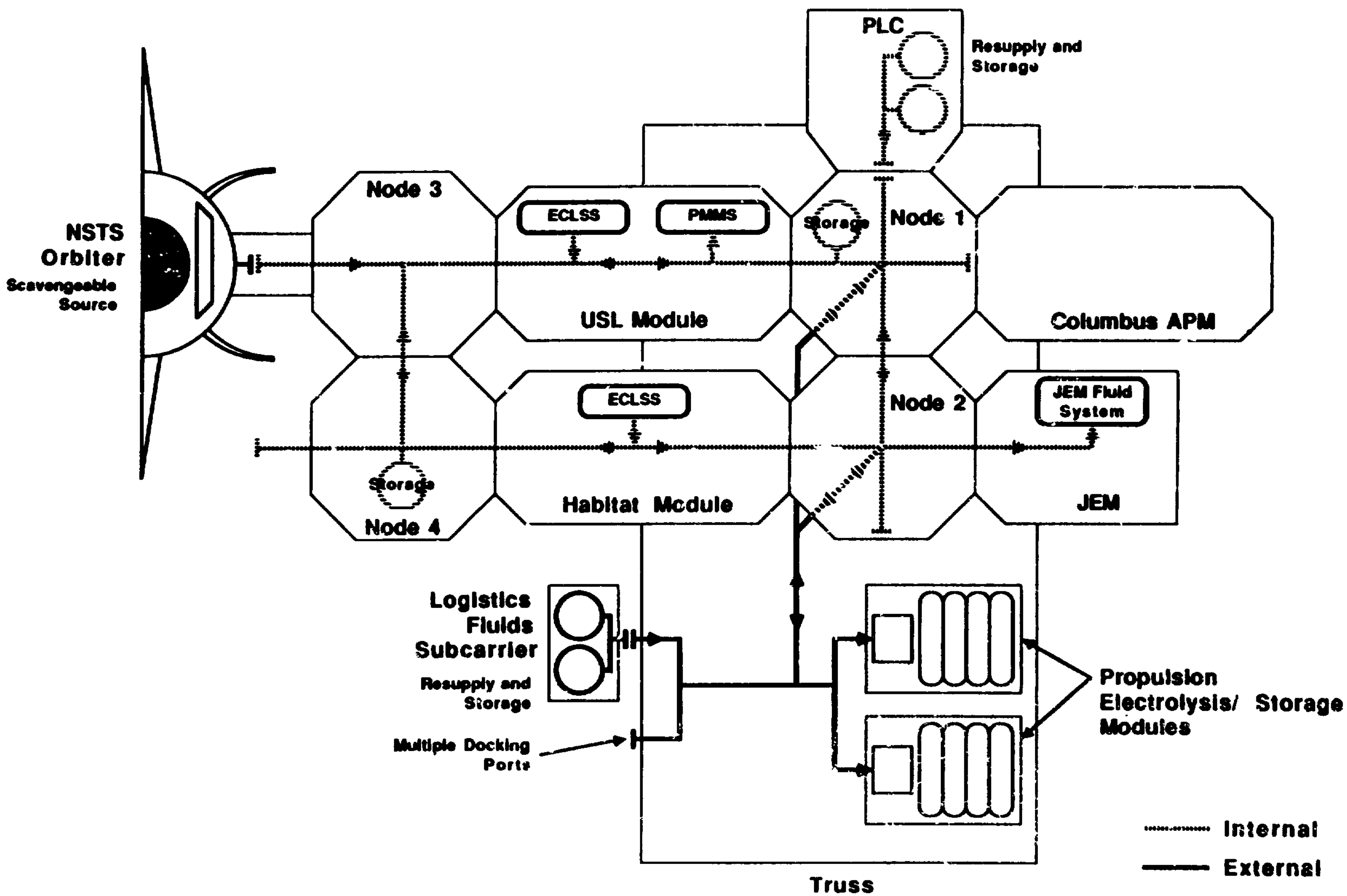
KEY FEATURES

- ORBITER WATER SCAVENGING EQUIPMENT IN NODES 3 AND 4

- INTERNAL WATER LOOP AND EXTERNAL DISTRIBUTION THROUGH NODES 1 AND 2

- WATER STORAGE IN NODES 1 AND 4

IWS ARCHITECTURE



IWS SUMMARY

FEATURES THAT MITIGATE SAFETY, CONTAMINATION AND COST IMPACTS

- SEPARATE FMS AND ECLSS WATER LOOPS
  - Autonomous IWS Storage in Nodes
  - Design Features to Prevent Backflow of Contaminants Across ECLSS/FMS Interface

- DIRECT ACCESS TO ORBITER WATER BY ECLSS
  - Separate ECLSS Scavenging Equipment
  - Allows Flushing of ECLSS Water Loops

CURRENT ISSUES

- REMOVAL OF WATER SUPPLY TO COLUMBUS APM PAYLOADS
  - No PMMS-type Process Fluid Supply in Columbus APM
  - Raises Issues With Standardization of Payload Interfaces

ADDITIONAL POTENTIAL INTEGRATED FLUID SYSTEMS

- INTEGRATED LABORATORY SUPPLY
  - Argon
  - Helium

    } Favorable Reductions in Resupply and On-Orbit Hardware Costs

  - CO_2
  - Krypton
  - Oxygen

    } Small Quantities May Not Justify Integration

- ECLSS BACKUP OXYGEN
  - Implement Access to Propulsion High Pressure Oxygen by ECLSS (Emergency Backup Only)
  - Similar to ECLSS/INS High Pressure Interface

AGENDA

- INTRODUCTION
  - Overview of FMS
  - Rationale for Integration

- PROCESS FLUID SUPPLY
  - Integrated Nitrogen System (INS)
  - Integrated Water System (IWS)
  - Other Potential Integrated Process Fluid Systems

- WASTE HANDLING
  - Potential Additional Systems

- CONCLUSIONS
  - Acronym List

INTEGRATED WASTE GAS SYSTEM (IWGS) DESCRIPTION

FUNCTIONAL REQUIREMENTS

- COLLECTS DISCARDED REDUCING GAS MIXTURES
  - Excess Hydrogen from ECLSS O_2 Generation and Bosch CO_2 Reduction
  - Ammonia/Nitrogen Mixtures from External TCS Purge

- COLLECTS DISCARDED INERT/ OXIDIZING GAS MIXTURES
  - USL PMMS, JEM and Columbus APM
  - IWS Water Tanks
  - INS Dump

- PROVIDES GAS MIXTURES TO RESISTOJETS FOR AUGMENTATION OF REBOOST

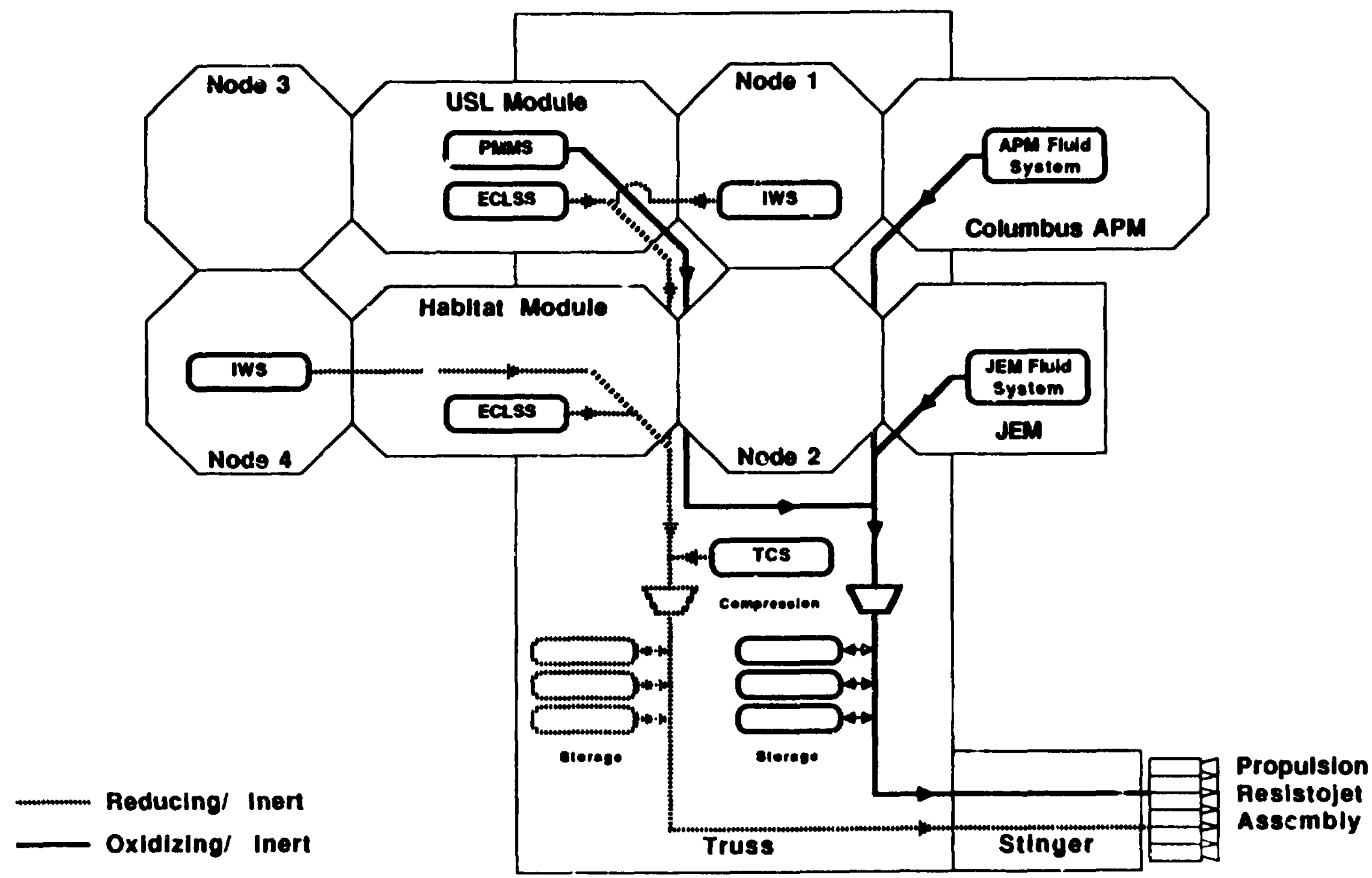
KEY FEATURES

- 2 TYPES OF WASTE GAS COLLECTION AND STORAGE
  - Reducing/Inert Mixtures
  - Oxidizing/ Inert Mixtures

- COMPRESSION AND STORAGE ON TRUSS

- NO PROCESSING OR REACTIVE STABILIZATION
  - All Safing Performed by Labs and/or Users

IWGS ARCHITECTURE



IWGS SUMMARY

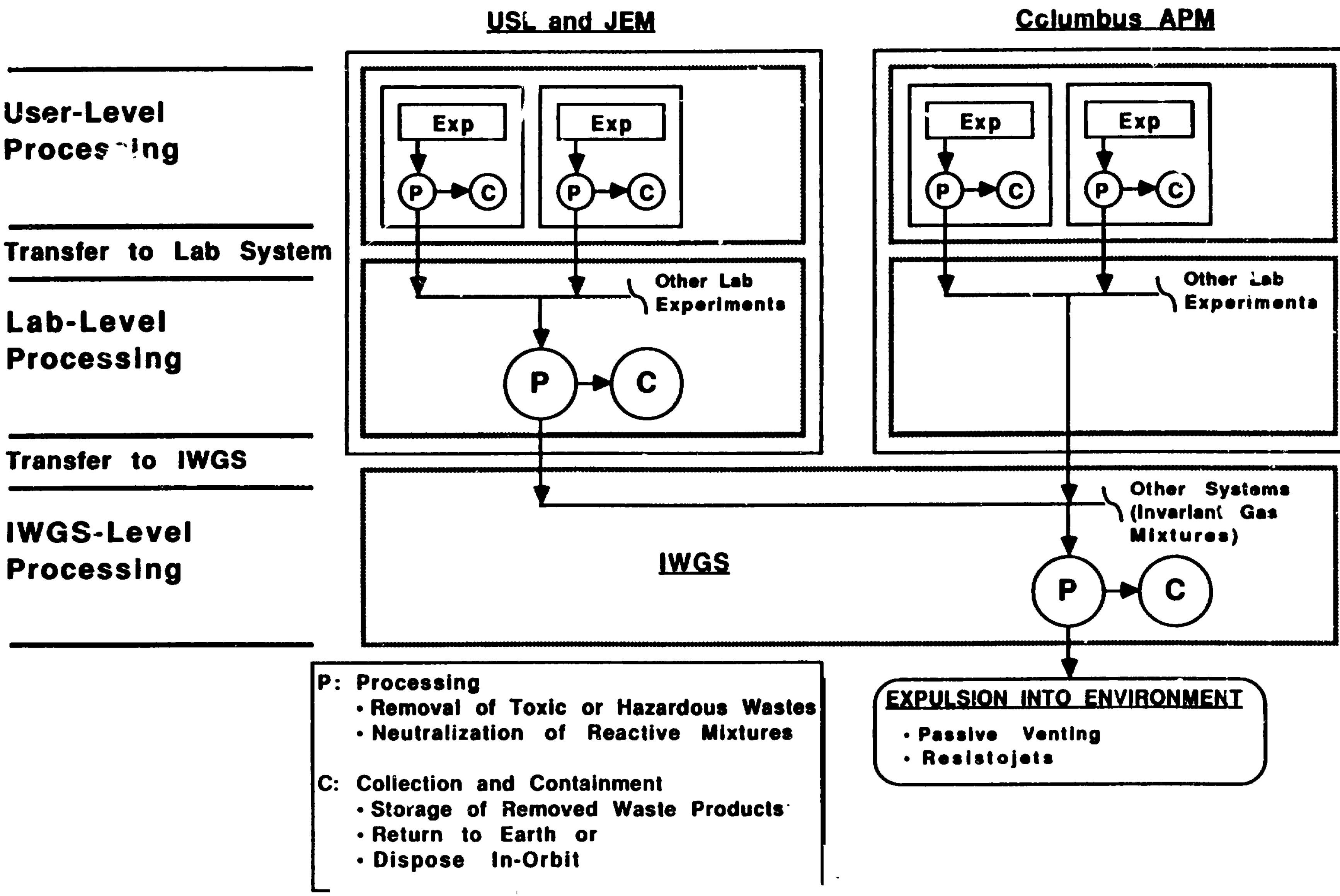
FEATURES THAT MITIGATE SAFETY, CONTAMINATION AND COST IMPACTS

- STORAGE AND HANDLING IN 2 SEPARATE GAS COLLECTION STREAMS
  - Sufficient for Safe Transfer and Storage on Truss
  - Elim ates Complex and Potentially Hazardous Processing Equipment

CURRENT ISSUES

- DELETION OF FMS PROVIDED WASTE GAS PROCESSING
  - Removal or Neutralization of Toxic and Hazardous Compounds Performed by User Payloads and/or Lab System
- ELIMINATION OF INTEGRATED VACUUM VENT SYSTEM
  - Feasibility of Extensive Vacuum Network Questionable
  - Venting of Very Low Pressure Products Performed at Lab/ Element Level
  - Requires Station Provided Integrated Control (e.g., OMA)
- REMOVAL OF FMS PROVIDED WASTE WATER DISPOSAL
  - Lab Reclamation Reduces Amount of Discarded Water
  - Handling Performed by Lab or Users

S.S. FREEDOM WASTE GAS HANDLING HIERARCHY



WASTE PROCESSING REQUIREMENTS BETWEEN EACH LEVEL ARE INFLUENCED BY:

- TYPES AND COMMONALITY OF DISCARDED WASTES
  - Toxicity and Handling Hazards
  - Commonality of Products from Different Sources

- EXTERNAL CONTAMINATION RESTRICTIONS
  - Column Densities of Respective Constituents
  - Deposition Limits
  - Disposal Locations and Viewing Angle Requirements
  - Definition of Quiessence and Non-quiessance

- TRANSFER, STORAGE AND DISPOSAL HARDWARE COMPATIBILITY
  - Resistojet Materials
  - Storage Tank Liners
  - Compressors

- VOLUME AND MASS LIMITATIONS
  - Internal Volume Requirements for Storage
  - Downsupply Demand and Capability

- PARTITIONING BETWEEN USER AND STATION COSTS

LEVEL II STUDY INITIATED TO DETERMINE DEGREE OF PROCESSING FOR USERS, LABS AND IWGS

STUDY SOURCES

- MICROGRAVITY AND MATERIALS PROCESSING FACILITY DATA RELEASE-2/2/87
- WASTE PROCESSING INDUSTRY
  - Technology, Methods and Hardware
- FMS WORKING GROUP

GENERAL GUIDELINES

- SIMPLIFY PROCESSING REQUIREMENTS
  - Isolate Unique Hazardous Products at Source
  - Transfer Common Gases to Integrated System (i.e., PMMS, FMS)
- MINIMIZE OVERALL HARDWARE
- ASSURE THAT EXPERIMENT DESIGNS MINIMIZE POTENTIALLY DANGEROUS FAILURES

WASTE PROCESSING REQUIREMENTS - STUDY RESULTS

- USL PAYLOAD LEVEL
  - Removal of Hazardous and User Unique Products
  - Removal of Particulates

- PMMS LEVEL
  - Removal of Cleaning Fluids and Water Vapors

- COLUMBUS APM AND JEM FLUID SYSTEM LEVEL
  - Removal of Hazardous Gases

- FMS LEVEL
  - None for Gases Collected from Labs (All Oxidizing/Inert Mixtures)
  - Dedicated Collection, Storage and Disposal of ECLSS and TCS Waste Gases

AGENDA

- INTRODUCTION
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- PROCESS FLUID SUPPLY
  - Integrated Nitrogen System (INS)
  - Integrated Water System (IWS)
  - Other Potential Integrated Process Fluid Systems

- WASTE HANDLING
  - Potential Additional Systems

- CONCLUSIONS
  - Acronym List

CONCLUSIONS

- MOST SIGNIFICANT HAZARDOUS MATERIALS HANDLING ISSUES FOR FMS PERTAIN TO WASTE HANDLING
  - Requires End-to-End Consideration from User Production to Final Disposal
  - May Significantly Impact User and Station Costs

- INITIATION OF IWGS AND LAB MODULE PRELIMINARY DESIGN REQUIRES COMMON SET OF REFERENCE REQUIREMENTS
  - Results of Level II Waste Processing Study

- FMS WORKING GROUP SERVES AS FORUM FOR DEFINING END-TO-END ARCHITECTURE FOR WASTE GAS HANDLING ON S.S. FREEDOM
  - User Accomodation Panel
  - External Contamination Working Group
  - Resource Allocation Panel

ACRONYM LIST

ACD	Architectural Control Document
CERS	Crew Equipment Retrieval System
CERV	Crew Emergency Rescue Vehicle
ECLSS	Environmental Control and Life Support System
EEU	Extravehicular Excursion Unit
EVA	Extravehicular Activity
FMS	Fluid Management System
HBC	Hyperbaric Chamber (Airlock)
INS	Integrated Nitrogen System
IWFS	Integrated Waste Fluid System (Current Baseline)
IWGS	Integrated Waste Gas System (Proposed Baseline)
IWS	Integrated Water System
JEM	Japanese Experiment Module
Lab	Laboratory
MMU	Manned Maneuvering Unit
OMV	Orbital Maneuvering Vehicle
NSTS	National Space Transportation System
PLC	Pressurized Logistics Carrier
ULC	Unpressurized Logistics Carrier

Transport of Hazardous Materials

Presented by
A. Winters 11/29/88

Address:
Boeing Company
499 Boeing Boulevard
Huntsville AL 35806
MS JA-84

Work phone: (205/461-2468
FAX No.: (205/461-3070

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Logistics Elements - Transport of Hazardous Materials

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- Outline
  - Logistics Elements Background
    - Requirements
    - Resources
    - Design Drivers
    - Design Goals
    - Baseline Elements
  - Operations
    - Phase (ø) Definitions
    - Cargo Delivery Modes
    - Cargo Handling Methods
    - On Station Parking Positions
  - Hazard Identification
    - Definition
    - Classification
  - Hazardous Cargo Transportation
    - Transportation Method Criteria
    - Hazardous Cargo Identification - PLM
    - Hazardous Cargo Delivery Methods - PLM
    - Hazardous Cargo Identification - FSC, HSC, BSC, ASTS
    - Hazardous Cargo Delivery Methods - FSC, HSC, BSC, ASTS
  - Future Development

Log #6/Haz Materials/Outline/lt/11-23-88

Logistics Elements - Transport of Hazardous Materials

• Background

- Baseline cargo requirements

Category	Type	Annual Quantity (lbs) Resupply	Annual Quantity (lbs) Return
Crew, Station, Customer	Pressurized	80,672	72,800
	Unpressurized	41,140	41,140
	Fluids	6,400	1,532
	Propellants	14,832	0
		143,044	115,472

- Baseline launch and landing resource

  Transportation Vehicle - Orbiter

  Dedicated logistics flights/year - 8

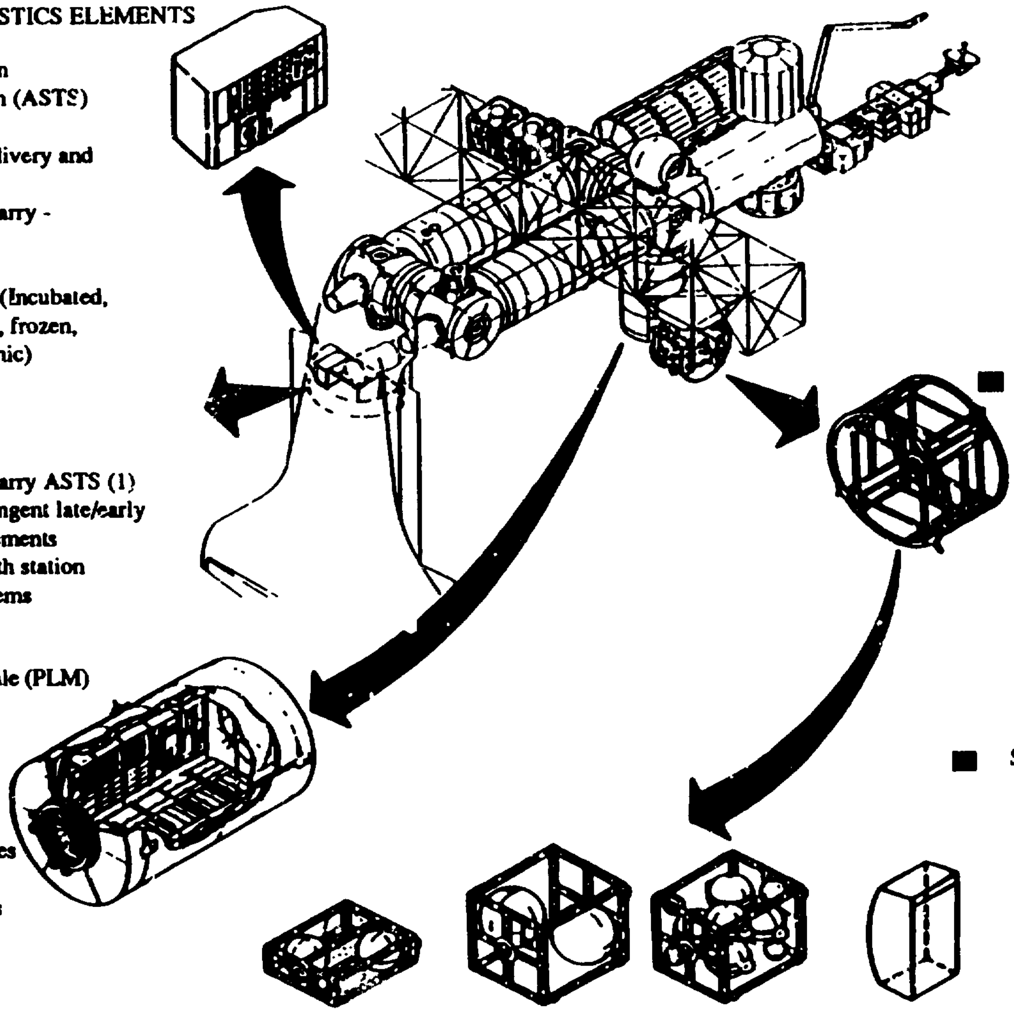
Logistics Elements – Transport of Hazardous Materials

- **Background**
  - **Logistics Transportation System**
    - **—Major design requirements**
      - **Weight**
      - **Power**
      - **Heat rejection**
      - **Safety**
    - **—Major design goals**
      - **Lightweight**
      - **Efficient**
      - **Flexibility**

LOGISTICS ELEMENTS
TRANSPORT OF HAZARDOUS MATERIALS

- **BACKGROUND**

BASELINE LOGISTICS ELEMENTS



■ Animal/Specimen Transport System (ASTS) (2 required)
- Specimen delivery and return.
- Outfitted to carry -
  - Rats
  - Plants
  - Specimens (Incubated, refrigerated, frozen, and cryogenic)

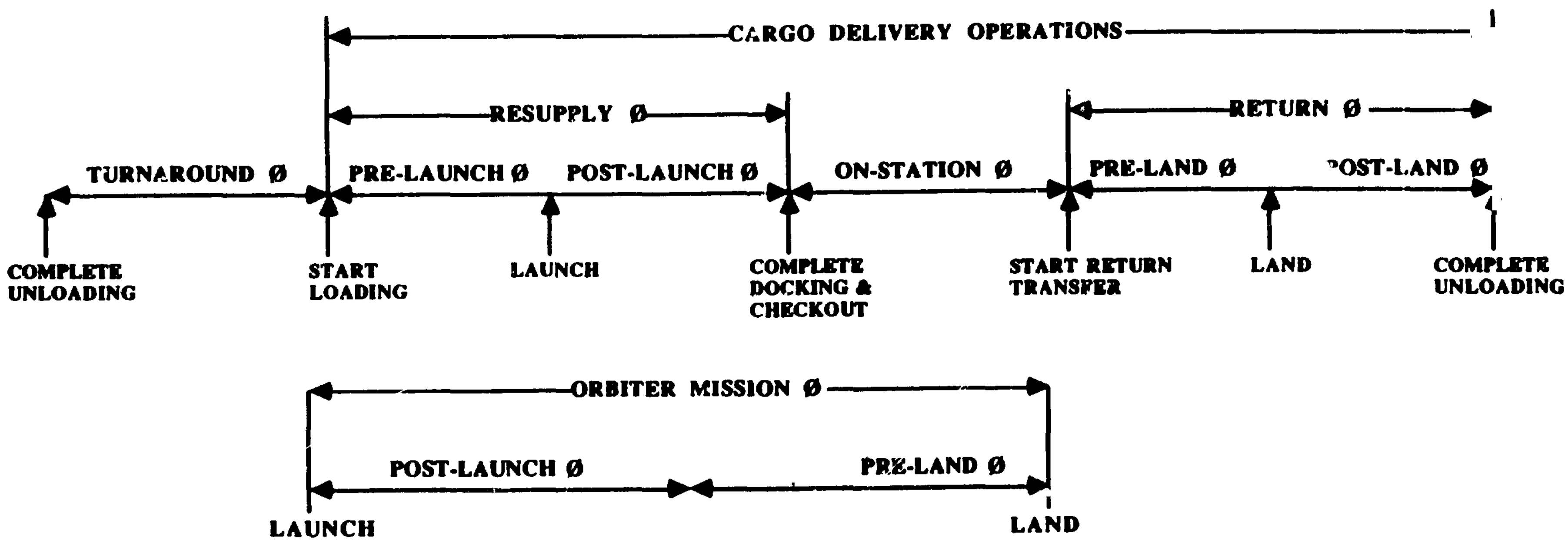
■ Docking module
- Outfitted to carry ASTS (1)
- Satisifies stringent late/early access requirements
- Interfaces with station docking systems

■ Pressurized Logistics Module (PLM) (3 required)
- Cargo:
- Crew Support:
  - Food
  - Personnel supplies
  - Housekeeping supplies
- Station Support
  - Maintenance supplies
  - Spares
  - EVA support
- Customer Support
  - USL Equipment & supplies
  - JEM Equipment & supplies
  - Columbus equipment & supplies
- GSE Roller Floor

■ Unpressurized Logistics Carrier (ULC) (4 required)
- Carriers
  - Station spares
  - Platform and satellite supplies (resupply and ORU's)
  - Attached payloads
- Modular Interchangeable fluid/ propellant subcarriers

■ Subcarriers
- Provides multiple combinations of subcarriers with the ULC
- Efficient manifesting
- Direct mounting to a variety of non-containerized cargo configurations
- Subcarriers are attached by automated attachments and umbilical mechanisms

- **OPERATIONS**
  - **OPERATIONS CYCLE Ø DEFINITIONS**



Logistics Elements – Transport of Hazardous Materials

- **Operations**
  - Cargo delivery modes

Transfer	– Movement of the cargo to and from the Logistics Elements by manual or systems operations
Transport	– Movement of the cargo from origin to destination after it has been emplaced in/on the Logistics Elements
Storage	– Containment of the cargo after it has been emplaced in the Logistics Element Cargo Accommodations

Logistics Elements - Transport of Hazardous Materials

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- **Operations**
  - Cargo handling method

Operations Phase	Cargo Handling Method		
	Transfer Method	Transport Vehicle	Storage Location
Prelaunch	Manual and System	GSE	PLM, ASTS, FSC, DCSC
Postlaunch	Manual	Orbiter	PLM, ASTS, FSC, DCSC
On Station	Manual and System	NA	PLM, FSC, DCSC
Preland	Manual	Orbiter	PLM, ASTS, FSC, DCSC
Postland	Manual	GSE and 747	PLM, ASTS, DCSC
Turnaround	NA	NA	NA

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LOGISTICS ELEMENTS - TRANSPORT OF HAZARDOUS MATERIALS

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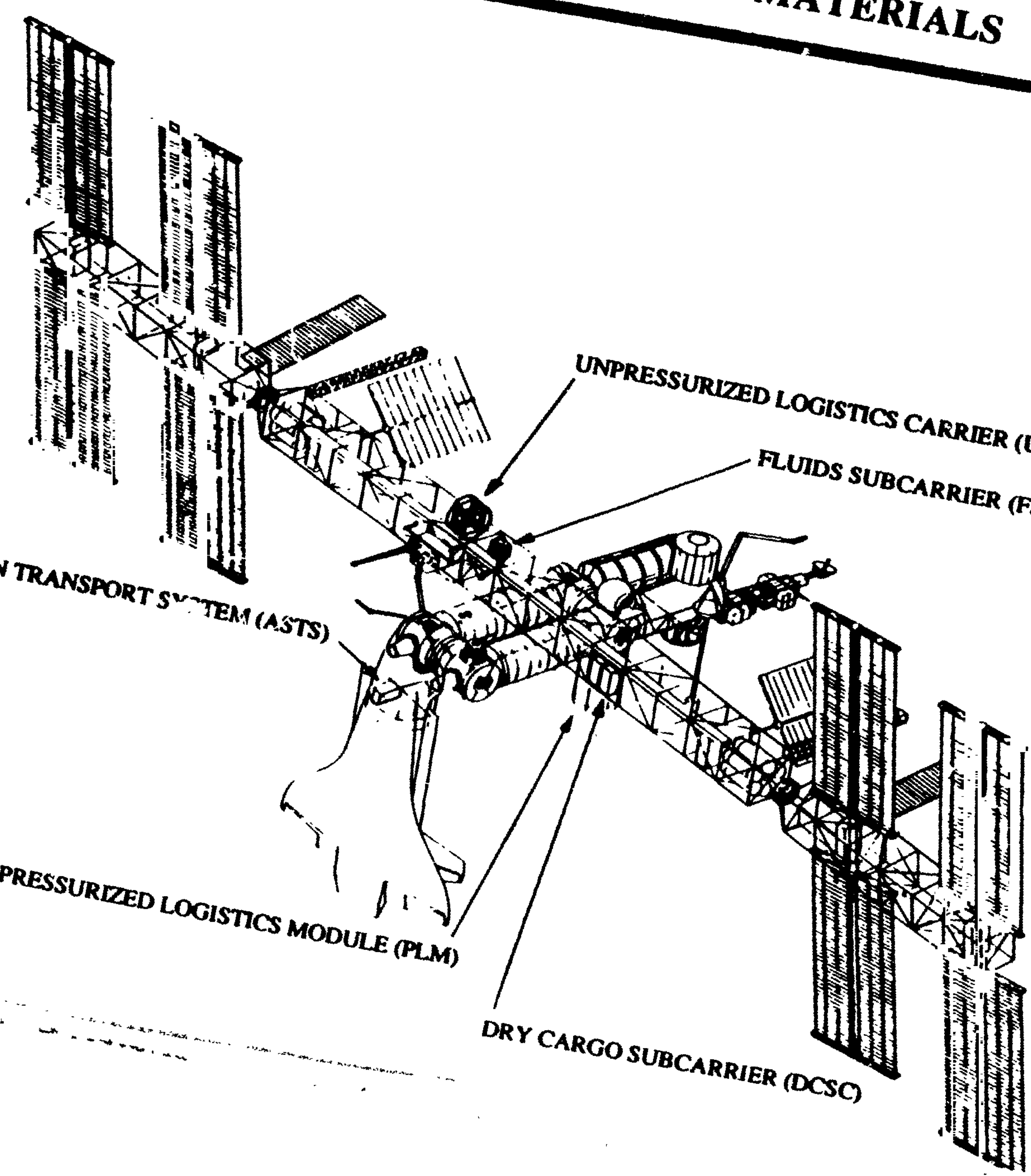
• OPERATIONS



Logistics Elements - Transport of Hazardous Materials

- Hazard Identification

  Definition

  - Hazardous cargo is defined as any cargo that poses a threat to the
    - Personnel
    - Ground facilities
    - Flight systems - Orbiter, Space Station, 747
    - Mission
    - Environment
  - The degree of the threat is measured by the effect on the
    - Personnel's ability to function
    - Operational capabilities of the facilities or flight systems
    - Successful completion of mission plans
    - Level of environmental contaminants

Logistics Elements - Transport of Hazardous Materials

- Hazard Identification

  <u>Classification</u>

  - Cargo is classified as hazardous if -
    - The cargo material has properties which pose a hazard
    - The delivery state of the cargo poses a hazard
  - The three types of hazards are
    1) Explosive release of potential energy
       - Explosion
       - Combustion
    2) Contamination
       - Toxins
       - Harmful Biotic Forms
       - Corrosive
       - Asphyxiants
       - Irritants
    3) Chemical spills
    4) Any combination of 1), 2), and 3)

Logistics Elements - Transport of Hazardous Materials

- Hazardous cargo transportation
  - Criteria will be defined to govern the method of hazardous cargo transportation by establishing standards for
    - Safe distance
    - Energy containment
    - Energy release confinement
    - Contaminant containment
    - Acceptable contaminant levels
    - Operating procedures

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Logistics Elements - Transport of Hazardous Materials

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- Hazardous cargo identification
  - Transported in PLM

Cargo	Transportation Phase	Destination /Orgin	Hazard						
			Explosive	Flammable	Toxic	Biological	Corr	Asphyx	Irritants
AMMONIUM BIFLOUIDE	RESUPPLY	USL					√		
BROMINE	RESUPPLY	USL					√		
CHROMIC ACID	RESUPPLY	USL					√		
HYDROCHLORIC ACID	RESUPPLY	USL					√		
HYDROFLUORIC ACID	RESUPPLY	USL					√		
HYDROGEN PEROXIDE	RESUPPLY	USL					√		
LITHIUM	RESUPPLY	USL					√		
LITHIUM NIOBIUM	RESUPPLY	USL					√		
NITERIC ACID	RESUPPLY	USL					√		
POTASSIUM	RESUPPLY	USL					√		
POTASSIUM HYDROXIDE	RESUPPLY	USL					√		
PERCHLORIC ACID	RESUPPLY	USL					√		
SILVER NITRATE	RESUPPLY	USL					√		
SODIUM ALUMINATE	RESUPPLY	USL					√		
SODIUM HYDROXIDE	RESUPPLY	USL					√		
SODIUM HYPOCHLORITE	RESUPPLY	USL					√		
SULFURIC ACID	RESUPPLY	USL					√		
ACETONE	RESUPPLY	USL		√					
ACETONITRILE	RESUPPLY	USL		√					
BENZENE	RESUPPLY	USL		√					
DIMETHYL SULFIDE	RESUPPLY	USL		√					
ETHANOL	RESUPPLY	USL		√					
FRUAN	RESUPPLY	USL		√					
GLYCEROL	RESUPPLY	USL		√					
ISOPROPYL ALCOHOL	RESUPPLY	USL		√					
KEROSENE	RESUPPLY	USL		√					
LATEX SOLUTION	RESUPPLY	USL		√					
METHANOL	RESUPPLY	USL		√					
METHYL ETHYL KETONE	RESUPPLY	USL		√					
TOLUENE	RESUPPLY	USL		√					
XYLENE	RESUPPLY	USL		√					

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Logistics Elements - Transport of Hazardous Materials

- **Hazardous cargo identification**
  - Transported in PLM

Cargo	Transportation Phase	Destination /Orgin	Hazard						
			Explosive	Flammable	Toxic	Biological	Corr	Asphyx	Irritants
AC[illegible]	RESUPPLY	USL		√					
N-BUTANE	RESUPPLY	USL		√					
HEPTANE	RESUPPLY	USL		√					
HYDROGEN	RESUPPLY	USL		√					
METHANE	RESUPPLY	USL		√					
OXYGEN	RESUPPLY	USL		√					
PROPANE	RESUPPLY	USL		√					
TRICHLOROETHANE	RESUPPLY	USL		√					
LITHIUM	RESUPPLY	USL		√					
POTASSIUM	RESUPPLY	USL		√					
POTASSIUM FERRICYA	RESUPPLY	USL		√					
POTASSIUM HYPOPHOS	RESUPPLY	USL		√					
ACETIC ACID	RESUPPLY	USL							√
ACROLEIN	RESUPPLY	USL							√
ALLYL ALCOHOL	RESUPPLY	USL							√
AMMONIUM HYDROXIDE	RESUPPLY	USL							√
BENZENE	RESUPPLY	USL							√
CARBON TETRACHLORIE	RESUPPLY	USL							√
CHLORINE	RESUPPLY	USL							√
CHLOROBENZENE	RESUPPLY	USL							√
CHLORODIFLOUROMETN	RESUPPLY	USL							√
COPPER CULFATE PENT	RESUPPLY	USL							√
DICHLOROMETHANE	RESUPPLY	USL							√
FLUORINE	RESUPPLY	USL							√
HYDROFLUORIC ACID	RESUPPLY	USL							√
IODINE	RESUPPLY	USL							√
IRON	RESUPPLY	USL							√
ISOPROPYL ALCOHOL	RESUPPLY	USL							√
METNANOL	RESUPPLY	USL							√
METHYL ETHYL KETONE	RESUPPLY	USL							√
OXALIC ACID	RESUPPLY	USL							√

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Logistics Elements - Transport of Hazardous Materials

- Hazardous cargo identification
  - Transported in PLM

Cargo	Transportation Phase	Destination /Orgin	Hazard						
			Explosive	Flammable	Toxic	Biological	Corr	Asphyx	Irritants
PHENOL	RESUPPLY	USL							√
ORTHOPHOSPHORIC ACID	RESUPPLY	USL							√
SODIUM HYPOCHLORITE	RESU"PLY	USL							√
SULFURIC ACID	RESUPPLY	USL							√
TRICHLOROTRIFLUOROE	RESUPPLY	USL							√
TRICGHLOROTTHYLENE	RESUPPLY	USL							√
TRIMETHYLBENZENE	RESUPPLY	USL							√
XYLENE 0-,M-,P-	RESUPPLY	USL							√
ZINC CHLORIDE	RESUPPLY	USL							√
ARGON	RESUPPLY	USL						√	
CARBON DIOXIDE	RESUPPLY	USL						√	
CARBON MONOXIDE	RESUPPLY	USL						√	
NITROGEN	RESUPPLY	USL						√	
XENON	RESUPPLY	USL						√	
ACETONITRILE	RESUPPLY	USL						√	
ACROLEIN	RESUPPLY	USL						√	
ALLYL ALCOHOL	RESUPPLY	USL							
AMMONIA	RESUPPLY	USL			√				
AMMONIUM CHLORIDE	RESUPPLY	USL			√				
ARSENIC	RESUPPLY	USL			√				
ATROPINE	RESUPPLY	USL			√				
BENZALKONIUM CHLO	RESUPPLY	USL			√				
BERYLLIUM	RESUPPLY	USL			√				
BROMINE	RESUPPLY	USL			√				
2-BUTOXYETHANOL	RESUPPLY	USL			√				
N-BUTYL ALCOHOL	RESUPPLY	USL			√				
CADIUM	RESUPPLY	USL			√				
CADIUM IODIDE	RESUPPLY	USL			√				
CADIUM SULFIDE	RESUPPLY	USL			√				
CADIUM SELENIDE	RESUPPLY	USL			√				
CADIUM TELLURIDE	RESUPPLY	USL			√				

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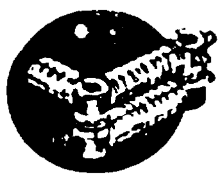

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Logistics Elements - Transport of Hazardous Materials

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Hazardous cargo identification

- Transported in PLM

Cargo	Transportation Phase	Destination /Orgin	Hazard						
			Explosive	Flammable	Toxic	Biological	Corr	Asphyx	Irritants
CARBON MONOXIDE	RESUPPLY	USL							
CARBON TETRACYHLOR	RESUPPLY	USL			✓				
COPPER CHLORDIE	RESUPPLY	USL			✓				
COPPER NITRATE	RESUPPLY	USL			✓				
CYCLOHEXANOL	RESUPPLY	USL			✓				
DIHYDROXYDIETHYL ET	RESUPPLY	USL			✓				
DIISOBUTYL KETONE	RESUPPLY	USL			✓				
2,6-DIMETHYL-4-HEPTAN	RESUPPLY	USL			✓				
FLUORINE	RESUPPLY	USL			✓				
GALLIUM ARSENIDE	RESUPPLY	USL			✓				
GALLIUN PHOSPHIDE	RESUPPLY	USL			✓				
GERMANIUM	RESUPPLY	USL			✓				
GLUTARALDEHYDE	RESUPPLY	USL			✓				
HYDROGEN BROMIDE	RESUPPLY	USL			✓				
HYDROGEN PEROXIDE	RESUPPLY	USL			✓				
HYDROGEN IODIDE	RESUPPLY	USL			✓				
IODINE	RESUPPLY	USL			✓				
INDENE	RESUPPLY	USL			✓				
INDIUM	RESUPPLY	USL			✓				
INDIUM PHOSPHIDE	RESUPPLY	USL							
LEAD	RESUPPLY	USL			✓				
MAGNESIUM CHLORIDE	RESUPPLY	USL			✓				
MAGNESIUM OXIDE	RESUPPLY	USL			✓				
MERCURY	RESUPPLY	USL			✓				
MERCURIC BROMIDE	RESUPPLY	USL			✓				
MERCURIC CHLORIDE	RESUPPLY	USL			✓				
MERCURIC OIODIDE	RESUPPLY	USL			✓				
MERCURY CADMIUM TEL	RESUPPLY	USL			✓				
OZONE	RESUPPLY	USL			✓				
POTASSIUM DICHROMA	RESUPPLY	USL			✓				
POTASSIUM FERRICY	RESUPPLY	USL			✓				

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Logistics Elements - Transport of Hazardous Materials

- Hazardous cargo identification
  - Transported in PLM

Cargo	Transportation Phase	Destination /Orgin	Hazard						
			Explosive	Flammable	Toxic	Biological	Corr	Asphyx	Irritants
POTASSIUM ORTHOHOS	RESUPPLY	USL			√				
POTASSIUM PERMANGA	RESUPPLY	USL			√				
PHENOL	RESUPPLY	USL			√				
STYRENE	RESUPPLY	USL			√				
SODIUM ALUMINATE	RESUPPLY	USL			√				
SODIUM AZIDE	RESUPPLY	USL			√				
SODIUM CHLORATE	RESUPPLY	USL			√				
SODIUM NITRATE	RESUPPLY	USL			√				
SODIUM THICUANATE	RESUPPLY	USL			√				
SILVER NITRATE	RESUPPLY	USL			√				
SULFAMIC ACID	RESUPPLY	USL			√				
TELLURIUM	RESUPPLY	USL			√				
TANTALUM	RESUPPLY	USL			√				
TRICHLOROOETHANE	RESUPPLY	USL			√				
TRICHLORETHYLENE	RESUPPLY	USL			√				
TRINITROPHENOL	RESUPPLY	USL			√				
HEMIMELLITINE	RESUPPLY	USL			√				
PSEUDOCUMENE	RESUPPLY	USL			√				
MESITYLENE	RESUPPLY	USL			√				
MESITYLENE	RESUPPLY	USL			√				
ZINC CHLORIDE	RESUPPLY	USL			√				
ZINC TELLURIDE	RESUPPLY	USL			√				
LAB WASTE	RETURN	USL	√	√	√	√	√	√	√
HUMAN WASTE	RETURN	USL/HAB				√	√		√
TRASH	RETURN	USL/HAB				√			√
ECLSS - HYDROGEN	RESUPPLY	TBD	√	√					

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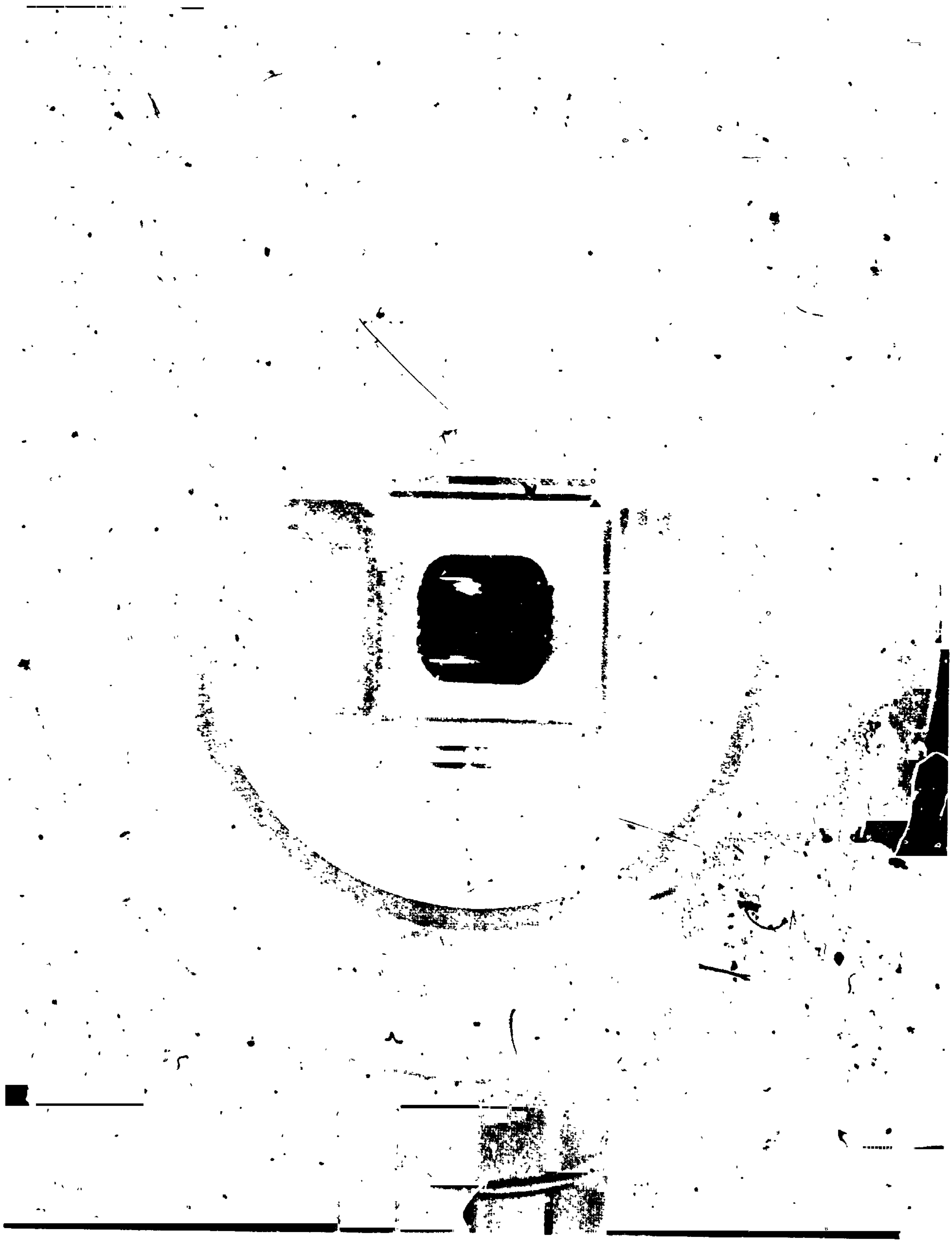
Logistics Elements - Transport of Hazardous Materials

- **Hazardous cargo transportation**
  - **Baseline hazardous cargo delivery methods - PLM**

Cargo	Transfer Method	Cargo Accommodations
Lab supplies	Manual	User supplied containers providing triple containment
Experiment products	Manual	User supplied containers providing triple containment
Lab waste	Manual	User supplied containers providing triple containment
Human waste	Manual	User supplied containers providing triple containment
Trash	Manual	User supplied containers providing triple containment



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Space Station Freedom

Logistics Elements - Transport of Hazardous Materials

BOEING
11/29/88

- **Hazardous cargo identification**
  - Transported in FSC, HSC, BSC, ASTS

Cargo	Transportation Phase	Destination /Orgin	Hazard						
			Explosive	Flammable	Toxic	Biological	Corr	Asphyx	Irritants
FSC									
NITROGEN	RESUPPLY	USL, ECLSS, JEM, OMV						√	
OXYGEN	RESUPPLY	USL	√		√				
HELIUM	RESUPPLY	USL	√					√	
ARGON	RESUPPLY	USL	√					√	
HSC									
HYDRAZINE (N2H2)	RESUPPLY	SATELLITE SERVICE		√	√			√	
BSC									
MONOMETHYL HYDRAZINE (MMH)	RESUPPLY	COP	√	√	√			√	
TETROXIDE (N204)	RESUPPLY	COP	√	√	√			√	
ASTS									
LIVING ANIMALS	RESUPPLY/RETURN	USL				TBD			
SPECIMENS	RESUPPLY/RETURN	USL				TBD			

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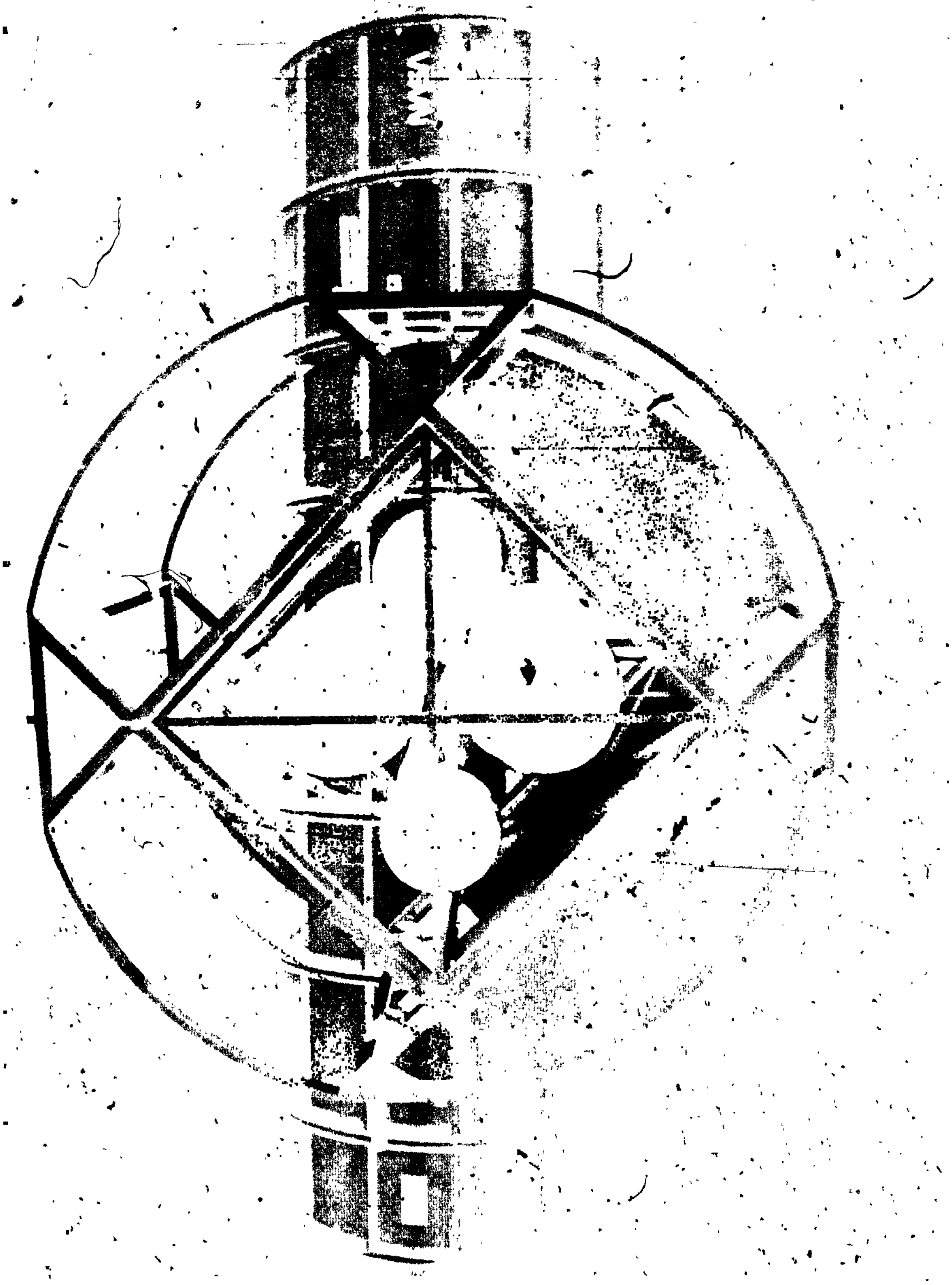
Logistics Elements - Transport of Hazardous Materials

11/29/88

- Hazardous cargo transportation
  - Baseline hazardous cargo delivery methods - FSC, HSC, BSC, ASTS

Cargo	Transfer Method	Logistics Element	Cargo Accommodations
High pressure gas	Plumbing	FSC	Leak before burst tanks
Cryogenic fluid	Plumbing	FSC	Dewar
Propellants	Plumbing	HSC/BSC	Leak before burst tanks
Special access specimens	Manual	ASTS	Cages and conditioned storage satisfying specified bio isolation requirements



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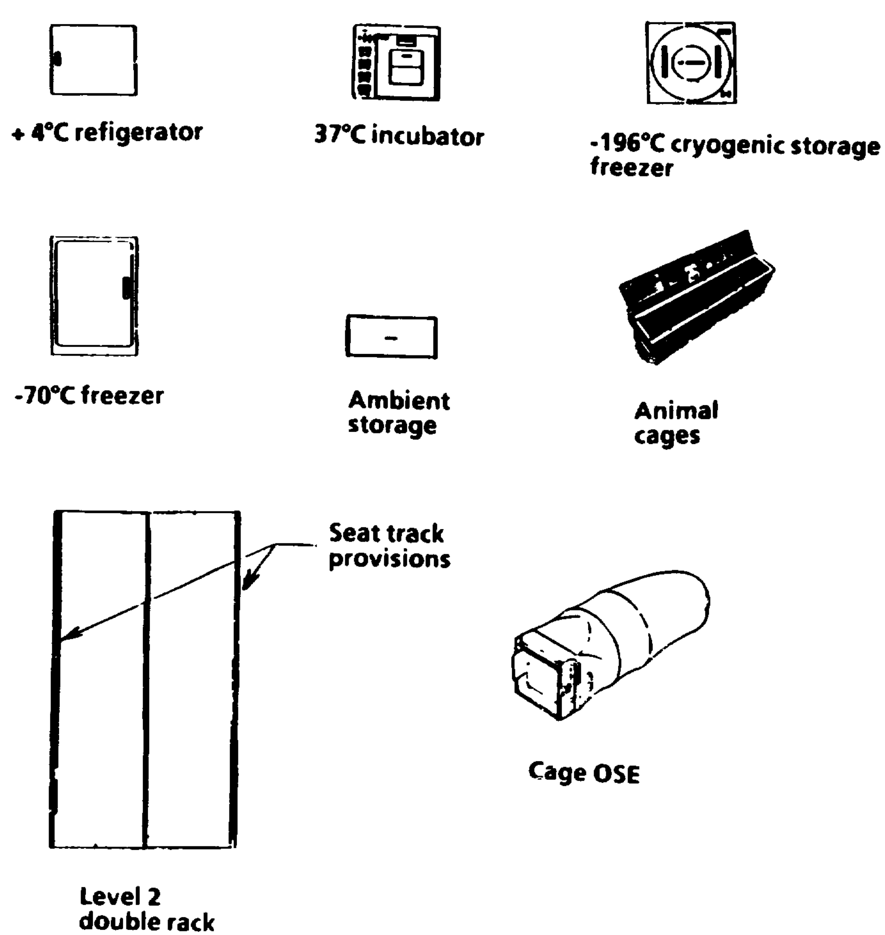
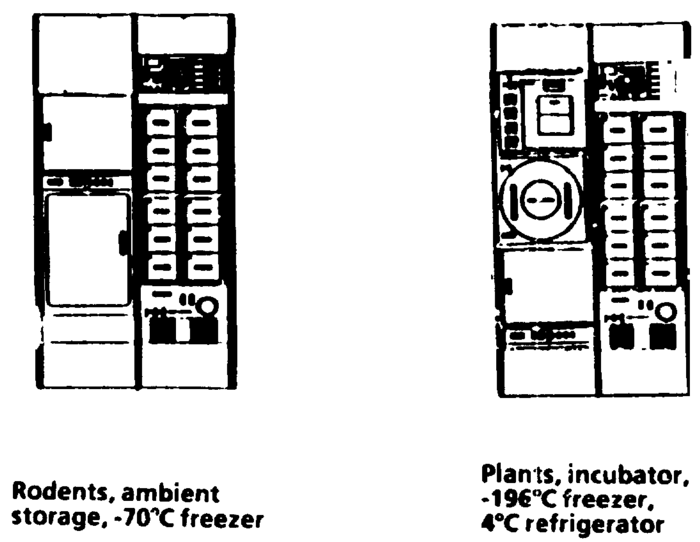
Animal Specimen Transport Facility Description

Components



Flight Configuration



Logistics Elements - Transport of Hazardous Materials

- Future Development
  - Continued hazardous cargo identification
    Evolving cargo requirements
    On going optimum fluids delivery state analyses
  - Finalize transportation method criteria
  - Continued design and de opment of Logistics Elements and cargo accommodations
  - Continued design and development of user supplied hazardous cargo containers

Log #6/Haz Materials/Future Dev./lt/11-22-88

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Space Station Freedom Pressurized Element Arrangement

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