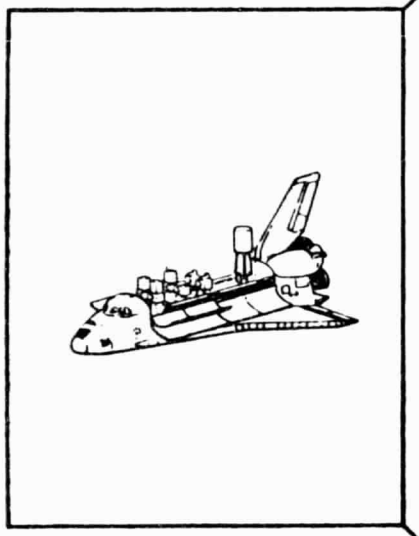
LOCKHEED

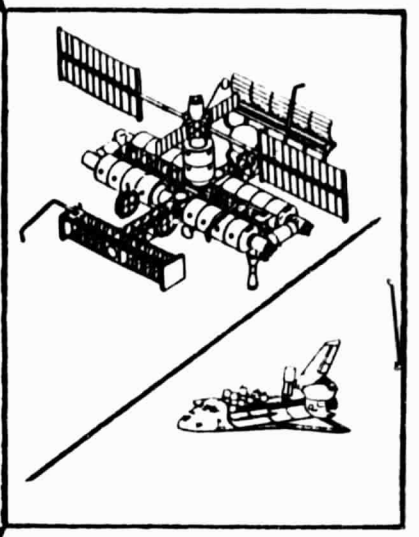
LMSC D-931673

27 January 1984

SERVICING



ON-ORBIT SPACECRAFT/STAGE SERVICING DURING STS LIFE CYCLE



EVOLUTION

NASA JOHNSON SPACECRAFT CENTER

CONTENTS

FOREWORD

THIS DOCUMENT CONTAINS STUDY RESULTS OF AN EVALUTION OF SPACECRAFT/STAGE SERVICING DURING THE SPACE TRANSPORTATION SYSTEM LIFE CYCLE. AIRBORNE SUPPORT EQUIPMENT (ASE) INCLUDING SHUTTLE CREW AIDS, DEVICES, TOOLS, AND SUPPORT EQUIPMENT AS DEFINED IN THE NASA JSC-19211 SATELLITE SERVICES CATALOG, (TOOLS AND EQUIPMENT) ARE IDENTIFIED TO SUPPORT A VARIETY OF SPACECRAFT/STAGES DURING THE STS LIFE CYCLE.

THE APPLICABILITY OF THE SHUTTLE ERA SERVICING EQUIPMENT TO TRANSITION AND SUPPORT A SPACECRAFT/STAGE SERVICING PROGRAM FOR THE SPACE STATION ERA 1990-2000+ IS EVALUATED. ADDITIONAL ASE IS IDENTIFIED TO ENHANCE UNIQUE SPACE STATION CAPABILITIES.

THIS DOCUMENT IS THE RESULT OF A STUDY PERFORMED UNDER NASA CONTRACT NAS 9-15800

ALL QUESTIONS AND COMMENTS REGARDING THE SUPPORT HARDWARE IDENTIFIED SHOULD BE SENT TO THE NASA TECHNICAL MONITOR AS IDENTIFIED BELOW.

Gordon Rysavy
Program Development Office/EB
Lyndon B. Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas 77058

STUDY OBJECTIVES

THE MAJOR OBJECTIVE OF THIS STUDY WAS TO REVIEW SPACECRAFT/STAGE SERVICING USING BOTH THE SHUTTLE AND A STRAWMAN SPACE STATION AS SERVICING BASES AND TO RELATE THE APPLICABILITY OF SERVICING HARDWARE DESIGNED FOR SHUTTLE USE FOR POTENTIAL USE BY THE SPACE STATION.

STUDY OBJECTIVES

A. DEFINE A CANDIDATE SET OF ADVANCED SHUTTLE PAYLOADS REQUIRING SERVICING AND THE ASSOCIATED SERVICING HARDWARE WHICH IS REPRESENTATIVE OF SERVICING MISSIONS IN THE 1984 - 1990 TIME PERIOD

B. RELATE APPLICABILITY OF SERVICING HARDWARE (A ABOVE) TO SPACE STATION SERVICING EQUIPMENT NEEDS TO INDICATE POTENTIAL APPLICATION AND/OR EVOLUTION TO THE STATION

STUDY TASKS

THE STUDY WAS STRUCTURED IN SIX TASKS IDENTIFIED ON THIS FACING PAGE. INITIALLY, A COMPREHENSIVE AND REPRESENTATIVE SET OF SHUTTLE PAYLOADS WERE IDENTIFIED FOR SHUTTLE AND SPACE STATION SERVICING MISSIONS. THE CLASSES OF SERVICING FUNCTIONS WERE IDENTIFIED AND AN ALLOCATION WAS MADE OF THE GENERAL SERVICING SUPPORT REQUIRED FOR THE SET OF REFERENCED SPACECRAFT. A CANDIDATE STRAWMAN SPACE STATION WAS DEPICTED FROM A SYNTHESIS OF SPACE STATION CONCEPTS DERIVED FROM THE NASA SPACE STATION ARCHITECTURE STUDIES BY EIGHT CONTRACTORS IN MAY 1983. THE SHUTTLE SERVICING HARDWARE AND KITS WERE IDENTIFIED AND AN EVALUATION WAS MADE OF THE APPLICABILITY IN TRANSITIONING SERVICING CAPABILITY TO THE SPACE STATION.

STUDY TASKS

A. IDENTIFY A REPRESENTATIVE SET OF ADVANCED SHUTTLE PAYLOADS (SATELLITES) REQUIRING ON-ORBIT SERVICING

B. IDENTIFY CLASSES OF SERVICING FUNCTIONS:
   - SHUTTLE ERA
   - SHUTTLE AND STATION ERA

C. DEVELOP SERVICING VS SPACECRAFT MATRICES

D. PORTRAY A CANDIDATE SPACE STATION SERVICING MODEL/CAPABILITY

E. IDENTIFY SERVICING HARDWARE AND KITS FOR 1984 - 1990 TIMEFRAME

F. INDICATE SHUTTLE ERA (1984 - 1990) SERVICING HARDWARE APPLICABILITY TO STATION UTILIZATION

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CANDIDATE ADVANCED SHUTTLE CARRIED SPACECRAFT AND STATION SERVICED ELEMENTS

SATELLITE SERVICING IN SHUTTLE/SPACE STATION ERA

IN THE PRECEDING SATELLITE SERVICES SYSTEM ANALYSIS STUDY (LOCKHEED LMSC-D792242, CONTRACT NAS 9-16121, VARIOUS DATES), A COMPOSITE OF MISSION CLASSES WAS IDENTIFIED AS THE CANDIDATE TYPES OF SHUTTLE ERA (1985 - 1990+) SPACECRAFT UPON WHICH THE SERVICING STUDIES WOULD BE BASED. THIS LIST IS DUPLICATED ON THE FACING PAGE WITH ONE ADDITIONAL SPACECRAFT; THE GENERIC ASTRONOMICAL PLATFORM (GAP) WHICH IS A COMPOSITE OF SEVERAL OF THE SERVICING FUNCTIONS PREVIOUSLY IDENTIFIED. THE SPACECRAFT CLASSES WERE EACH EXAMINED RELATIVE TO THE VARIOUS SERVICING FUNCTIONS TO ASSURE CONSIDERATION OF NEARLY ALL THE DEFINED FUNCTIONS. IT SHOULD BE NOTED THAT REPAIR IS A SERVICING FUNCTION THAT, TO DATE, HAS RECEIVED LITTLE IF ANY SERIOUS STUDY SIMPLY DUE TO THE COMPLEXITY OF REPAIR TASKS AND THE UNKNOWNS WHICH ARE ASSOCIATED WITH THE REASONS WHEREIN REPAIR MIGHT BE NEEDED. FINALLY, THE HYPOTHETICAL (HYPOT) SATELLITE IS A NAME ASSIGNED TO A CONTRIVED SET OF CLUSTERED SPACECRAFT WHICH COULD BE REPRESENTATIVE OF DoD SPACE VEHICLES ORBITING AT THE SAME INCLINATION AND EQUALLY SPACED AROUND EARTH. THESE SPACECRAFT CLASSES HAVE, THEREFORE, PROVIDED THE BASIS FOR THE CONDUCT OF THE STUDY WHICH FOLLOWS.

SATELLITE SERVICING IN SHUTTLE/SPACE STATION ERA

CANDIDATE SATELLITES (SPACECRAFT) / SERVICING FUNCTION CATEGORIES	INSPECT/EXAMINE AND ASSESS	SAFEING	ORU CHANGEOUT: FAILED OR DEGRADED ITEM	ORU CHANGEOUT: NEW OR UPDATED ITEM	ORU CHANGEOUT: PREVENTATIVE MAINT ITEM	ORU CHANGEOUT: CONSUMABLES REPLENISHMENT	RECONFIGURE	REPAIR	GEN SERVICE ENHANCEMENT	DEBRIS CAPTURE CONTAINMT & PREPARE ITEM FOR DE-ORBIT	CHECKOUT & VERIFY	HANDLE POSITION/ TRANSFER
1. COSMIC BACKGROUND EXPLORER (COBE)	•	•				•					•	•
2. SPACE TELESCOPE (ST)	•		•	•	•	?			?		•	•
3. SOLAR MAXIMUM MISSION (SMM)	•	•	•	•	•						•	•
4. GALILEO	•	•									•	•
5. ORBITING ASTRONOMICAL OBSERVATORY (OAO)	•									?		•
6. NATIONAL OCEANIC SATELLITE SYSTEM (NOSS)	•										•	•
7. HYPOTHETICAL (HYPOT) SAT	•					•					•	•
8. GAMMA-RAY OBSERVATORY (GRO)	•	•	•	•	•						•	•
9. UPPER ATMOSPHERIC RESEARCH SATELLITE (UARS)	•	•				?					•	•
10. ADVANCED X-RAY ASTRO-PHYSICS FACILITY (AXAF)	•		•	•	•	•					•	•
11. GENERIC ASTRONOMICAL PLATFORM (GAP)	•	•	•	•	•	•	?				•	•

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ADVANCED STATION ERA SATELLITE/ELEMENT SERVICING

CANDIDATE SATELLITES (SPACECRAFT) / SERVICING FUNCTION CATEGORIES	INSPECT/EXAMINE AND ASSESS	SAFEING	ORU CHANGEOUT: FAILED OR DEGRADED ITEM	ORU CHANGEOUT: NEW OR UPDATED ITEM	ORU CHANGEOUT: PREVENTATIVE MAINT ITEM	ORU CHANGEOUT: CONSUMABLES REPLENISHMENT	RECONFIGURE	REPAIR	GEN SERVICE ENHANCEMENT	DEBRIS CAPTURE-CONTAINMT & TRANSFER	PREPARE ITEM FOR DE-ORBIT	CHECKOUT & VERIFY	HANDLE/POSITION &/OR TRANSFER	ATTACHED OR FREE FLY
1. ORBITING NATIONAL CMD POST	•	•	•	•	•	•	•	?	?	(•)	•	•	•	FF
2. OCEANOGRAPHIC LABORATORY	•		•	•	•							•	•	ATT
3. SPACE OBSER DEV LAB	•		•	•	•							•	•	ATT
4. EARTH HAB OBSER LAB	•	•	•	•	•							•	•	EITHER
5. CELESTIAL OBSERVATORY	•		•	•	•	•						•	•	ATT
6. SPACE ENVIRON FACILITY	•		•	•	•	•	•					•	•	ATT
7. EARTH OBSER FACILITY	•		•	•	•		•					•	•	EITHER
8. MATERIAL PROCESS REC LAB	•		•	•	•		•					•	•	ATT
9. MATERIAL PROCESS FACILITY	•		•	•	•	•	•	?		?		•	•	EITHER
10. METEOROLOGICAL FACILITY	•	•	•	•	•		•		?			•	•	FF
11. SPACE OBJECTS IDENT SYS	•	•	•	•	•				?			•	•	FF
12. LEO SERVICED SATELLITE	•	•	•	•	•	•			?			•	•	FF
13. MID-HEO SERVICED SAT	•	•	•	•	•	•			?			•	•	FF
14. ASTRONOMY PLTFM SERVICING	•	•	•	•	•	•			?			•	•	FF
15. LARGE SPACECRAFT ASSY	•	•	•	•	•				?			•	•	FF

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SERVICING FUNCTION DEFINITIONS

SERVICING CLASS FUNCTION DEFINITION

TO SET THE STAGE FOR IDENTIFYING SERVICING SUPPORT TO SATELLITES, TEN CLASSES OF SERVICING FUNCTIONS WERE DEFINED AS SHOWN ON THIS FACING PAGE. THESE CLASSES OF SERVICING FUNCTIONS COVERED THE SPECTRUM FROM SELECTIVELY SIMPLE TASKS SUCH AS VISUAL INSPECTION, EXAMINATION TO THE MORE COMPLEX TASKS OF TEST AND CHECKOUT OF SATELLITE OR REPLACEMENT UNITS.

ALSO INCLUDED AS A SERVICE FUNCTION IS THE TASK OF SPACE DEBRIS COLLECTION, INCLUDING CAPTURE, CONTAINMENT AND TRANSFER/STOWAGE.

SERVICING CLASS FUNCTION DEFINITIONS (SYNOPSIS)

A. INSPECTION, EXAMINATION AND ASSESSMENT

B. SAFEING OF THE SYSTEM TO ASSURE SAFETY OF CREW INTERACTION/INTERFACE

C. REPLENSIHMENT OF CONSUMABLES SUCH AS PROPELLANT, RESUPPLY OF INSTRUMENT CRYOGENS OR REPLENISHMENT OF PRESSURANTS

D. CHANGEOUT OF ORBITAL REPLACEMENT UNITS (ORUs)
   - FAILED OR DEGRADED ITEM
   - NEW OR UPGRADED ITEM
   - PREVENTATIVE MAINTENANCE CHANGEOUT OF AN ITEM, E.G., ITEM HAS NOT YET FAILED OR DEGRADED BUT CAN BE EXPECTED TO DO SO PRIOR TO NEXT SCHEDULED SERVICING EVENT

E. RECONFIGURE OF THE SATELLITE, E.G., ADD OR REMOVE AN ITEM (CAPABILITY CHANGE)

F. REPAIR OF AN ITEM WHICH REQUIRES ON-SITE MODIFICATION (UNPLANNED FOR) SUCH AS WELD, SPLICE, SEAL, STRAIGHTEN, TRIM/SMOOTH, DRILL HOLE, 'SAW', STRIKE/PUNCH, CUT, BEND, SHAPE, SCRAPE, BOND, RIVET, ETC.

G. GENERAL SERVICE AND ENHANCEMENT OPERATIONS MIGHT INCLUDE OPTICAL CLEANING, CONTAMINATION CLEAN-UP, ETC.

H. DEBRIS CAPTURE, CONTAINMENT AND TRANSFER TO A STOWAGE CAPABILITY FOR ULTIMATE RESTRAINT OR TIE-DOWN

I. PREPARE ITEM FOR DE-ORBIT BY INSERTING IN CARGO BAY FOR EARTH RETURN OR PLACE A RE-ENTRY KIT ON THE ITEM FOR RETURN AND BURN-UP THROUGH THE ATMSPHR

J. CHECKOUT & VERIF OF THE SAT, SERV ELEMENT, &/OR REPLACEMT ITEM (ORU)

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SERVICING VS SPACECRAFT MATRIX

ADVANCED SHUTTLE ERA SATELLITES AND

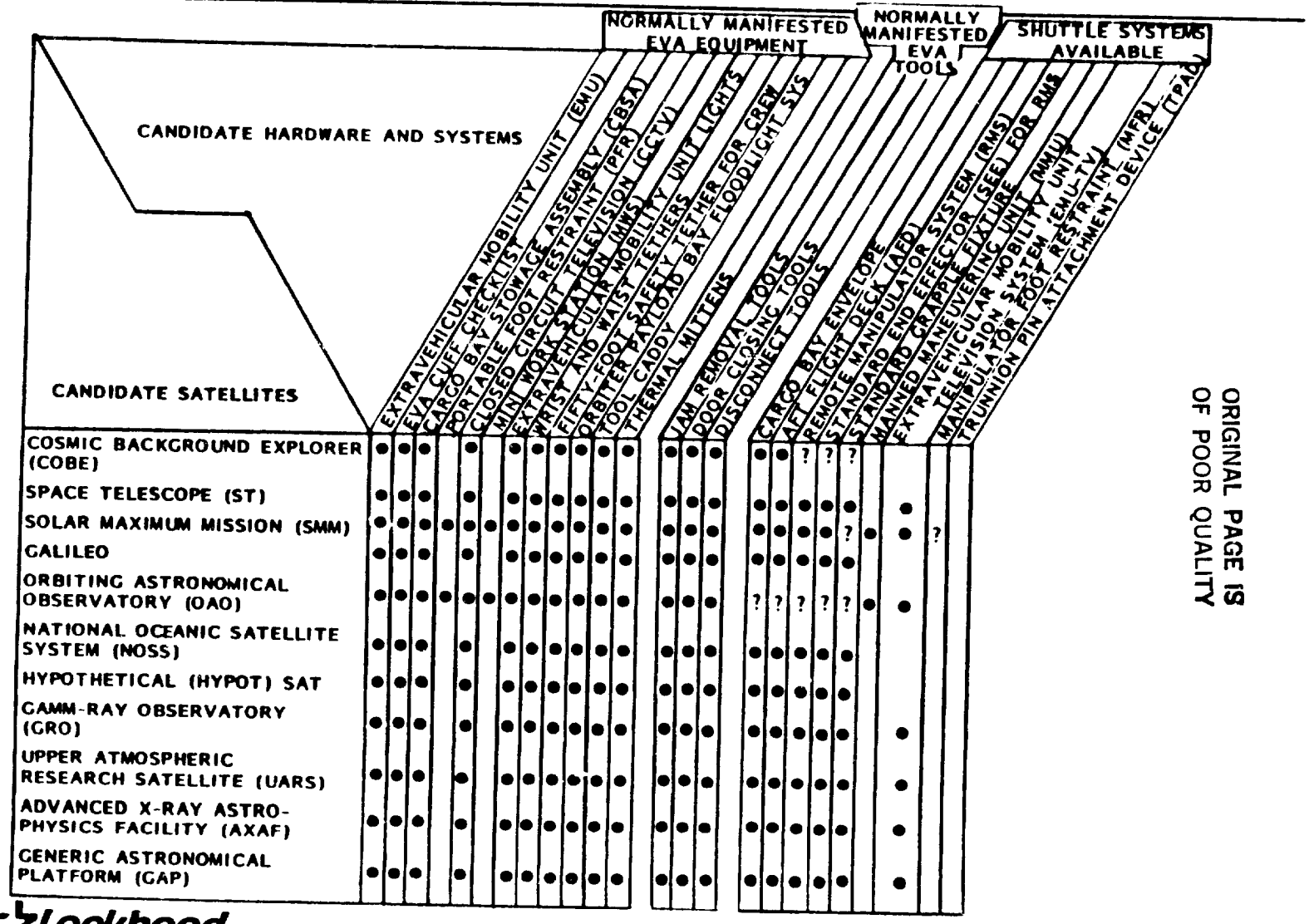
SERVICING EQUIPMENT MANIFESTED AND AVAILABLE

THE FOLLOWING THREE PAGES PRESENT LISTS OF SERVICING EQUIPMENT, AIDS, SYSTEMS, TOOLS, ETC. THAT ARE EXPECTED TO BE ASSOCIATED WITH THE SHUTTLE ERA SPACECRAFT. RATIONALE FOR SELECTION OF THE SPACECRAFT WAS PREVIOUSLY INDICATED. THE SERVICING EQUIPMENT LISTS WERE DERIVED FROM THE RECENT LOCKHEED STUDY FOR NASA ENTITLED SATELLITE SERVICES CATALOG, TOOLS AND EQUIPMENT, JSC-19211, SEPTEMBER 1983. FROM THIS DOCUMENT, SIX BASIC SERVICING EQUIPMENT CATEGORIES WERE USED AS FOLLOWS:

- EXTRAVEHICULAR ACTIVITY SUPPORT EQUIPMENT NORMALLY MANIFESTED (ON THE ORBITER)
- EXTRAVEHICULAR ACTIVITY TOOLS NORMALLY MANIFESTED (ON THE ORBITER)
- SHUTTLE SYSTEMS - AUXILIARY SERVICES AVAILABLE
- TOOLS AND TOOL STORAGE
- PAYLOAD-RELATED SYSTEMS AND CARRIERS
- PROJECTED SATELLITE SERVICING CAPABILITIES

ITEMS FROM EACH OF THE ABOVE CATEGORIES WERE INCLUDED IN THE FOLLOWING THREE PAGES, AND, ADDITIONALLY, A FEW ITEMS ADDED TO THE LIST OF PROJECTED SATELLITE SERVICING CATEGORIES AS PRESENTLY ENVISIONED. EACH OF THE CANDIDATE SPACECRAFT WAS EXAMINED AND AN ASSESSMENT MADE AS TO WHICH SERVICING EQUIPMENT ITEMS WOULD BE REQUIRED. THE FACING PAGE (AND THE TWO FOLLOWING PAGES) INDICATE THE ASSOCIATIONS IDENTIFIED.

ADVANCED SHUTTLE ERA SATELLITES AND SERVICING EQUIPMENT MANIFESTED AND AVAILABLE



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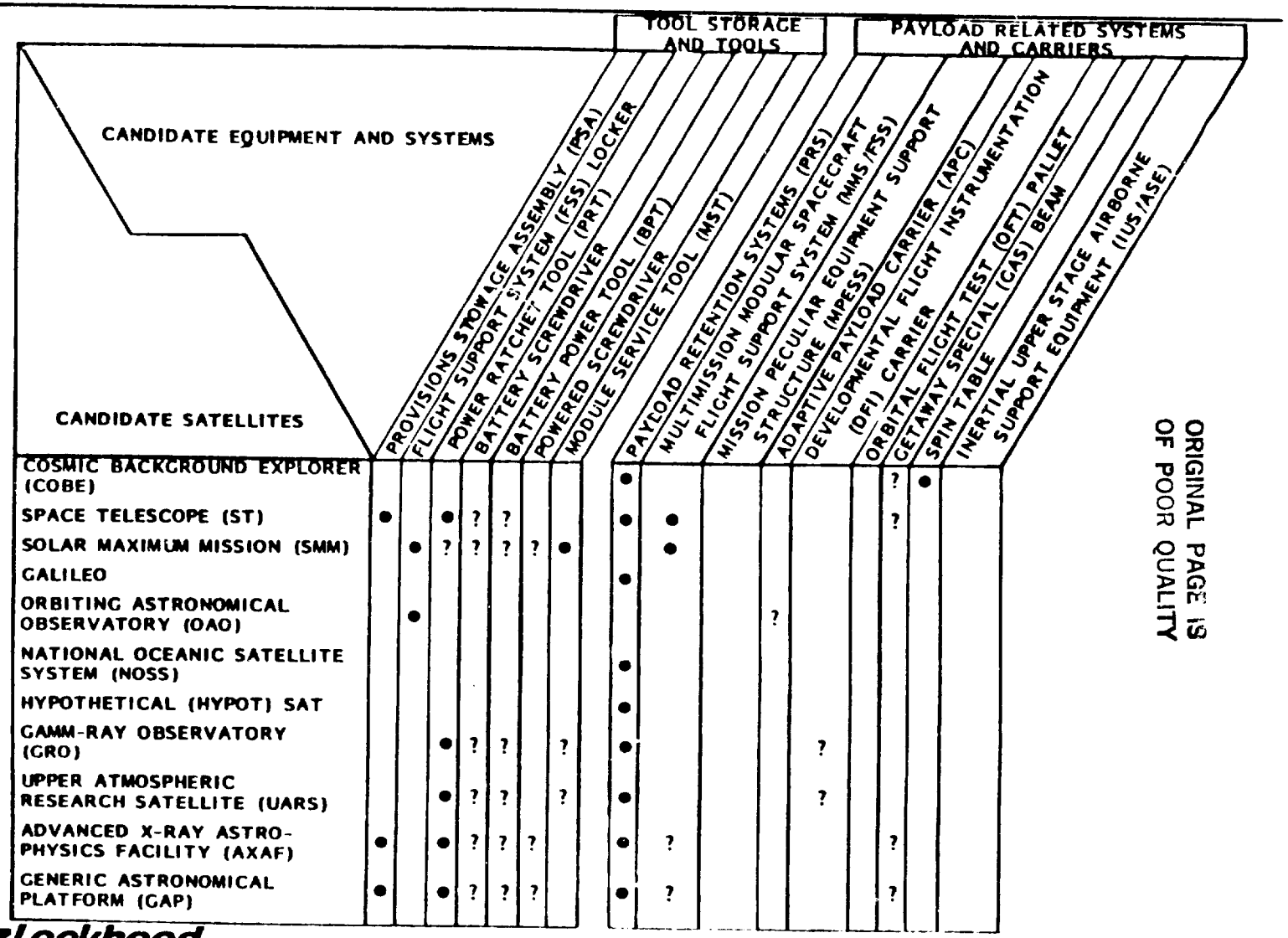
ADVANCED SHUTTLE ERA SATELLITES AND SERVICING EQUIPMENT TOOL STOWAGE/TOOLS AND P/L RELATED SYSTEMS



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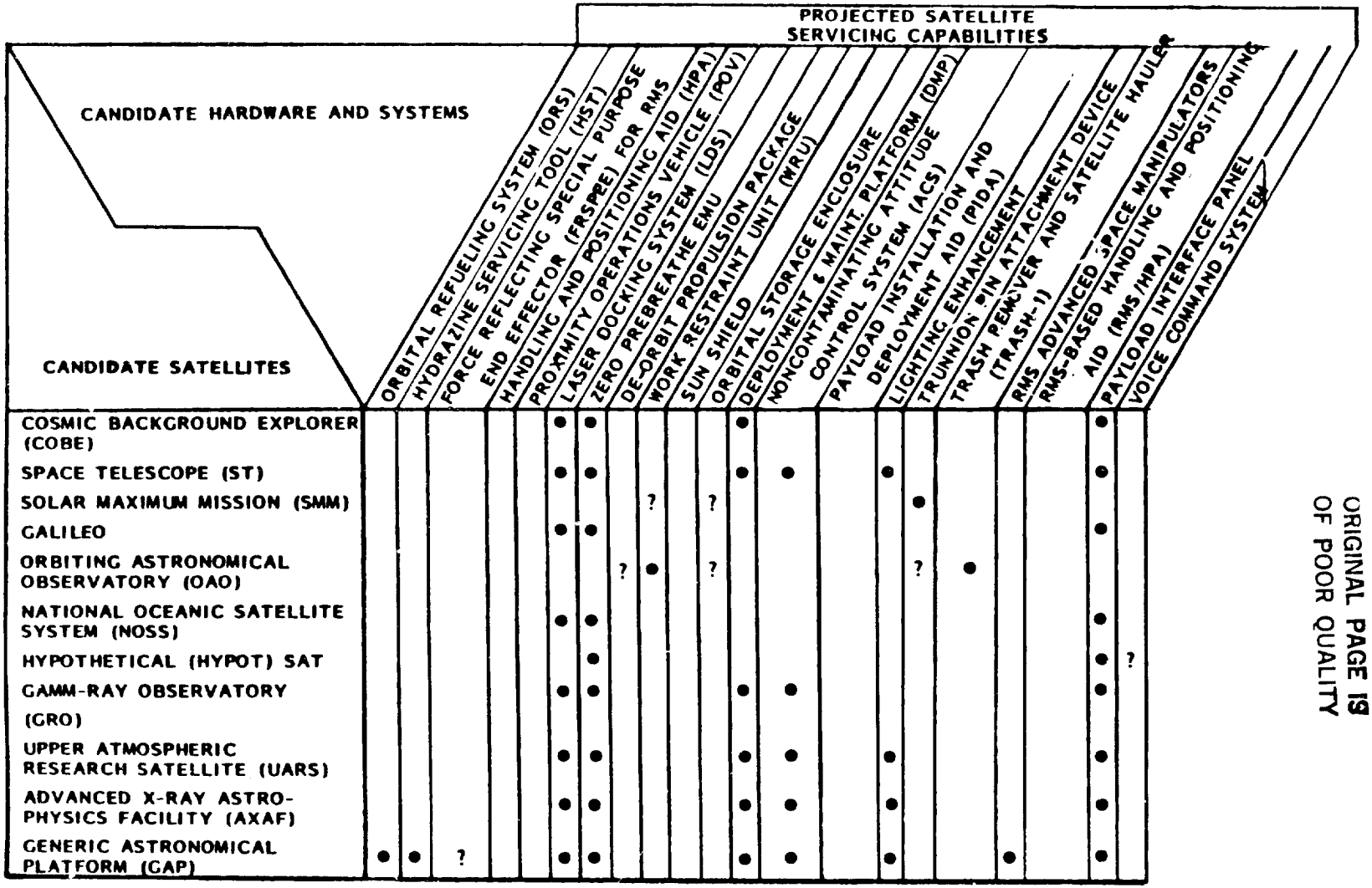
ADVANCED SHUTTLE ERA SATELLITES AND SERVICING EQUIPMENT PROJECTED CAPABILITIES



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CANDIDATE STATION SERVICED SYSTEMS

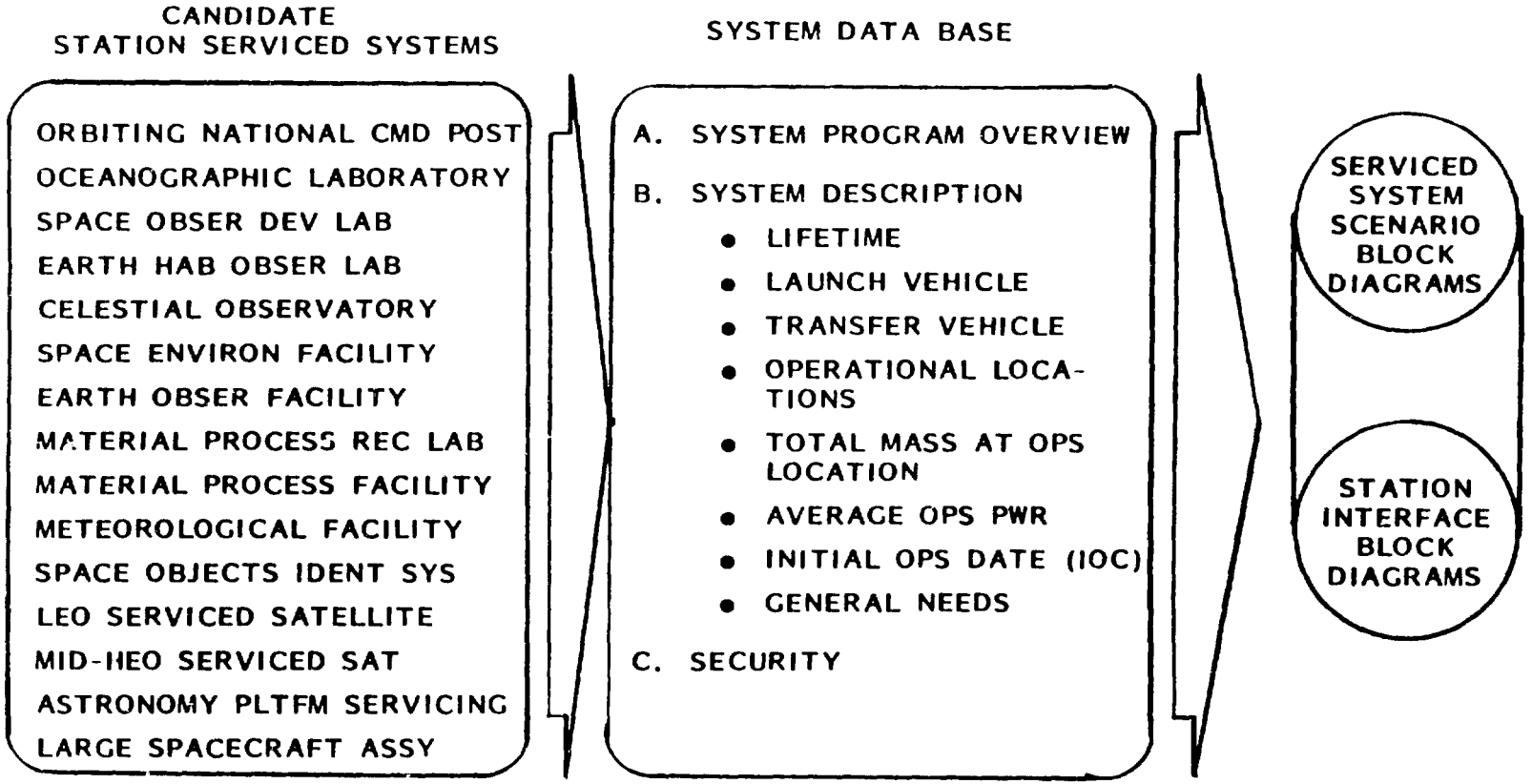
DATA BASE

THE NEXT EFFORT WAS TO EXAMINE SPACE STATION ERA SPACECRAFT (OR ASSEMBLIES) RELATIVE TO SERVICING NEEDS. THE FACING PAGE INDICATES THE LIST OF SPACECRAFT CLASSES AND THE ASSOCIATED SYSTEM DATA BASE DEVELOPED FOR EACH. THREE TYPES OF DATA WERE DEFINED FOR EACH SPACECRAFT;

- SPACECRAFT PROGRAM OVERVIEW
- DESCRIPTION OF THE SPACECRAFT (AS INDICATED)
- BASIC SECURITY FACTORS (IF APPLICABLE)

FROM THIS COMPOSITE OF DATA, TWO SETS OF BLOCK DIAGRAMS WERE PREPARED. THE FIRST WAS THE BASIC SERVICING SYSTEM SCENARIO WHEREIN SERVICING NEEDS AND INTERFACES WERE DEFINED. THE SECOND BLOCK DIAGRAM PROVIDED THE NECESSARY INFORMATION RELATIVE TO SPACE STATION INTERFACES INCLUDING THE ORBITER, GROUND, AND ANY ASSOCIATED ORBITING ELEMENTS SUCH AS TDRSS. THIS INFORMATION PROVIDED THE OVERALL DATA BASE FOR THE STATION ERA SPACECRAFT AND WAS USED AS THE BASIS FOR SUBSEQUENT EVALUATION ON THIS STUDY .

CANDIDATE STATION SERVICED SYSTEMS DATA BASE



ADVANCED SPACE BASED-RADAR

(225 METER ANTENNA)

THE NEAR-TERM, LARGE ANTENNA SYSTEMS USE DEPLOYABLE SYSTEMS WHICH CAN BE CONTAINED IN A SINGLE SPACE SHUTTLE LAUNCH. EXPERIMENTS DESIGNED TO STUDY THE DYNAMICS OF SUCH SYSTEMS ARE PLANNED AS PART OF THE SPACE SHUTTLE EXPERIMENT PROGRAM. THE LIMITS OF THESE SYSTEMS ARE YET TO BE ACCURATELY DETERMINED, BUT THEY ARE PRESENTLY ASSUMED TO BE ON THE ORDER OF 100 TO 150 m. DEVELOPMENT HARDWARE HAS BEEN FABRICATED FOR DEPLOYABLE SYSTEMS WITH A DIAMETER OF 110 m.

ADVANCED SYSTEM STUDIES HAVE DEFINED (SEE FACING PAGE) A NEED FOR LARGER ANTENNA (225 m) FOR USE IN SPACE-BASED RADAR OPERATING AT GEOSYNCHRONOUS ALTITUDES. STRUCTURES OF THIS SIZE CANNOT BE CONSTRUCTED USING UNFURLABLE SYSTEMS AND PRESENT DESIGNS ASSUME IT WILL REQUIRE ON-ORBIT CONSTRUCTION. THE SPACE SHUTTLE CAN PROVIDE A PLATFORM FOR SUPPORT OF CONSTRUCTION ACTIVITIES, BUT THE LIMITED TIME ON ORBIT IMPOSES CONSTRAINTS ON THE SYSTEM THAT MAY BE EXCESSIVELY RESTRICTIVE. THE SPACE STATION OFFERS AN IDEAL PLATFORM FOR LARGE SPACE CONSTRUCTION SINCE IT CAN PROVIDE ALL NECESSARY SUPPORT SERVICES REQUIRED DURING FABRICATION AND CHECKOUT. IT ALSO WILL SUPPLY THE TRANSFER VEHICLE BASE FOR LAUNCH OF THE SYSTEM INTO ITS OPERATING ORBIT.

THE USERS FOR THIS SYSTEM ARE NOT SPECIFICALLY DEFINED SINCE THE CONCEPT IS A PRODUCT OF THE AIR FORCE/AIAA TECHNOLOGY MISSION MODEL. THIS CONFIGURATION IS AN OUTGROWTH AND AN EXTENSTION OF NEAR-TERM CONCEPTS SUCH AS THE INTEGRATED TACTICAL SURVEILLANCE SYSTEM (ITSS) SPACE-BASED RADAR (DISCUSSED ON THE FOLLOWING PAGE).

ADVANCED SPACE-BASED RADAR
(225 METER ANTENNA)

SYSTEM DESCRIPTION:

1. PURPOSE: TO VIEW IN A SURVEILLANCE MODE SPECIFIC EARTH GEOGRAPHICAL LOCATIONS FOR INFORMATION GATHERING, EXAMINATION AND VERIFICATION
2. LIFETIME: 5 TO 10 YEARS (INCLUDING SERVICING)
3. LAUNCH AND TRANSFER VEHICLE: SHUTTLE TO STATION, PROPULSION MODULE (LEO TO GEO XFER) AND POSSIBLE TELEOPERATOR
4. OPERATIONAL LOCATION: PRIMARY-GEO
5. TOTAL MASS AT OPERATIONAL LOCATION: APPROXIMATELY 150,000 KG
6. AVERAGE OPERATIONAL POWER: APPROXIMATELY 15,000 WATTS
7. DESIRED INITIAL OPERATIONAL DATE: 1988 (SHUTTLE BASED EXPERIMENT: 60 KM REFLECTR)
   1993 (STA CONSTRUCTED WITH SBR LAUNCH TO GEO)
8. GENERAL NEEDS:
   - CONSTRUCTION AT STATION: BOTH IVA AND EVA CREW SUPPORT PLUS CONST EQUIP
   - SBR PLATFORM STABILITY ~1/10 OF ANTENNA BANDWIDTH
   - DATA RATE OF ~50 M/BITS/SEC
   - PROPULSION MODULES FOR TRANSPORT FROM LEO TO HEO
   - POTENTIAL USE OF TELEOPERATOR
   - PHYSICAL CHARACTERISTICS: 225 M ANTENNA (REFLECTOR SIZE)
   - ON-ORBIT SERVICING
   - STATION C/O OF SBR PRE/POST LAUNCH TO GEO
   - COMM/DATA LINKS STA TO GROUND AND TO MILSTAR AND TDRSS

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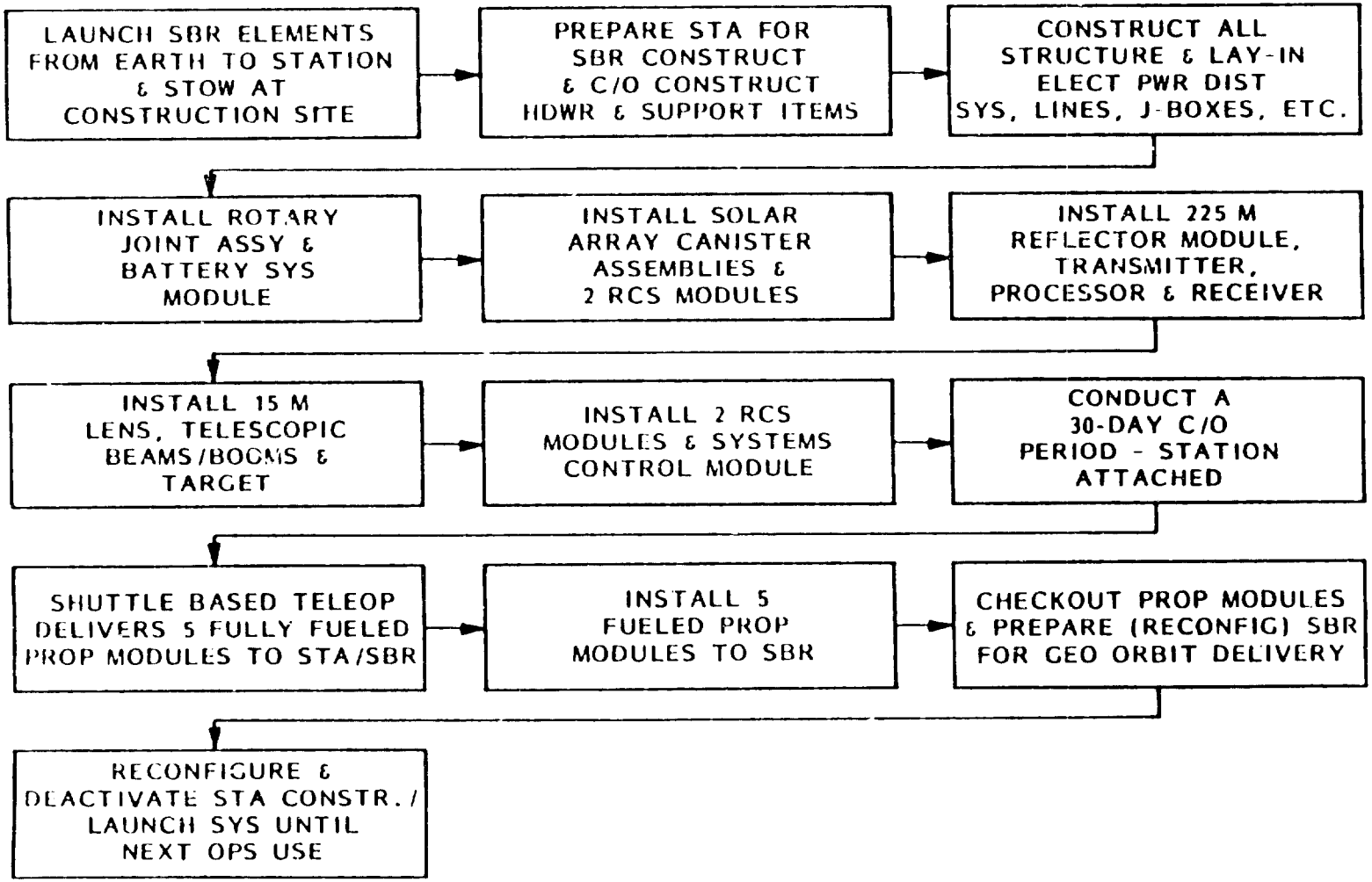
LARGE SATELLITE STRUCTURAL ASSEMBLY IN LEO MISSION OPERATIONAL SEQUENCE (SPACE-BASED RADAR SATELLITE)

THE OBJECTIVE OF THIS MISSION IS TO ASSEMBLE A LARGE SATELLITE STRUCTURE SUCH AS A SPACE-BASED RADAR SATELLITE IN LEO BEFORE THE SATELLITE TRANSFERS TO A HIGHER ORBIT POSITION. ELEMENTS OF THE SATELLITE STRUCTURE ARE TRANSPORTED TO THE SPACE STATION FROM THE EARTH LAUNCH SITE AND PREPARED FOR ASSEMBLY IN ORBIT. USING MANIPULATOR ASSEMBLIES, EVA CREW PERSONNEL, AND TELEOPERATOR MANEUVERING SYSTEM (TMS) VEHICLES STRUCTURAL ELEMENTS ARE ASSEMBLED. THE SATELITE IS CHECKED OUT AS AN OPERATING SYSTEM AND PREPARED FOR LAUNCH AND TRANSPORT TO A HIGHER ORBIT POSITION. SATELLITE PROPELLANT TANKS ARE FILLED AND ATTACHED FOR THE TRANSFER ORBIT. THE FUNCTIONAL SEQUENCE OF EVENTS TO ASSEMBLE AND PREPARE THE SATELLITE FOR LAUNCH FROM THE SPACE STATION IS SHOWN ON THE OPPOSITE PAGE.

LARGE SATELLITE STRUCTURAL ASSEMBLY IN LEO MISSION OPERATIONAL SEQUENCE (SPACE-BASED RADAR SATELLITE)



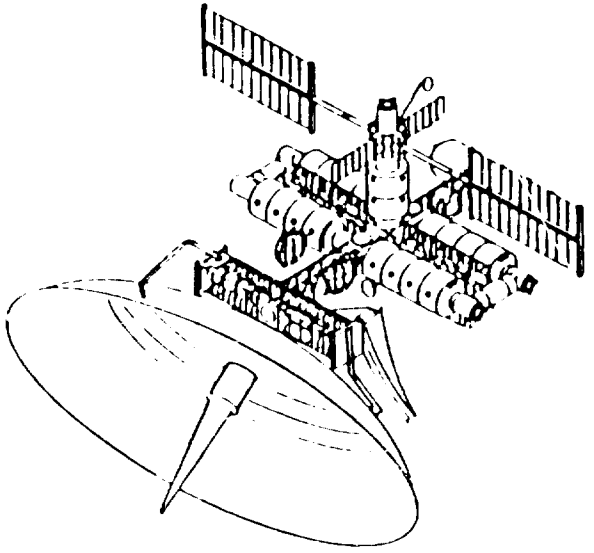
LARGE SATELLITE STRUCTURAL ASSEMBLY IN LEO ARCHITECTURAL CONCEPT

THE SYSTEM ARCHITECTURE FOR PERFORMING LARGE SATELLITE STRUCTURAL ASSEMBLY IN LEO IS SHOWN ON THE FACING PAGE. A PROPELLANT AND GAS STORAGE MODULE (TANKS) IS ADDED TO A BASIC LOGISTICS MODULE (WAREHOUSE) TO PROVIDE PROPELLANT/GAS FOR TRANSFER VEHICLES AND SATELLITES. AN ASSEMBLY OPERATION CONTROL MODULE ACTS AS AN OPERATION CONTROL CENTER FOR COORDINATING ALL ASSEMBLY, SERVICE, AND CHECKOUT OPERATIONS. AN ASSEMBLY AND CONSTRUCTIIN PLATFORM WITH STATIONARY/TRACKED MANIPULATOR ASSEMBLERS PROVIDES A SURFACE WORK AREA FOR ASSEMBLY TASKS. A TELEOPERATOR MANEUVERING SYSTEM (TMS) DOCKING AND SUPPORT MODULE PROVIDES DOCKING, AND SUPPORT MODULE PROVIDES DOCKING, MAINTENANCE, AND SERVICING FOR THE TMS-TYPE VEHICLE. THE TMS VEHICLE IS BASED AT THE STATION.

THE STS PROVIDES DIRECT SUPPORT TO TRANSPORT MODULES, EQUIPMENT, AND PROPELLANTS INITIALLY TO THE STATION AND TO CONTINUE LOGISTICS SUPPORT FOR CONSUMABLES, CREW ROTATION, AND FLIGHT HARDWARE DURING STATION LIFETIME. DATA EVALUATION IS CONDUCTED ONBOARD THE SPACE STATION, AND DATA ARE TRANSMITTED TO THE GROUND DATA SYSTEMS VIA THE SPACE STATION TO GROUND COMMUNICATION LINK. FUNCTIONS OF THE SYSTEM ARCHITECTURE ARE AS FOLLOWS:

	MODUEL/ELEMENT	FUNCTION
1.	HABITATION	LIVING AND MAINTENANCE CREW
2.	POWER AND CONTROL	EPS AND ACS
3.	COMMUNICATION AND DATA SYSTEM	VOICE AND DATA LINK, DATA EVALUATION
4.	DOCKING/BERTHING	DOCKING/BERTHING FOR SHUTTLE, TRANSFER PERSONNEL, EQUIPMENT, SUPPLIES
5.	LOGISTICS	STORAGE FOR FACILITY AND P/L SUPPLIES
6.	GROUND COMMUNICATION AND DATA	TRACKING, VOICE/DATA COMMUNICATION
7.	STS	SHUTTLE GROUND TO SPACE TRANSPORT, LOGISTICS
8.	PROPELLANT/GAS STORAGE	STORE PROPELLANTS AND GASES
9.	ASSEMBLY OPERATIONS CONTROL	EVA MONITOR, DISPLAY AND ASSY OPS
10.	ASSEMBLY AND CONSTRUCTION PLATFORM	WORKING AREA/SPACE FOR EVA ASSIST
11.	TMS DOCKING AND SUPPORT	DOCKING, C/O, PROPELLANT/GAS LOADING
12.	MANIPULATOR ASSEMBLERS	HANDLING, POSITIONING, AND JOINING
13.	TMS	HANDLING, TRANSPORT, ROBOTIC ASSEMBLY

LARGE SATELLITE STRUCTURAL ASSEMBLY IN LOW EARTH ORBIT ARCHITECTURAL CONCEPT (SPACE-BASED RADAR SATELLITE)



HABITATION MODULE

POWER & CONTROL MODULE

COMMUNICATIONS & DATA SYSTEM

ASSEMBLY OPERATIONS CONTROL MODULE

LOGISTICS MODULE

TMS DOCKING & SUPPORT MODULE

ASSEMBLY AND CONSTRUCTION PLATFORM

PROPELLANT & GAS STORAGE MODULE

TMS

MANIPULATOR ASSEMBLERS

DOCKING/ BERTHING

GROUND COMMUNICATIONS & DATA SYSTEM

STS

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ROLE OF SPACE STATION TO SUPPORT LARGE SATELLITE

STRUCTURAL ASSEMBLY IN LEO

THE SPACE STATION PROVIDES DIRECT AND CONTINUOUS SUPPORT TO THE ON-ORBIT SERVICING MISSION. THE STATION PROVIDES ONLINE DIRECT ELECTRICAL POWER AND ENVIRONMENTAL INTERFACES TO THE ASSEMBLY SUPPORT MODULES. IT SUPPORTS ONBOARD DATA ANALYSIS AND COMMUNICATIONS AND DATA TRANSFER TO THE GROUND. DIRECT EVA-TYPE SUPPORT IS PROVIDED BY CREWMEMBERS TO ASSEMBLE, SERVICE, AND CHECK OUT AND PREPARF THE SATELLITE FOR SPACE LAUNCH. MAINTENANCE OF SERVICING SUPPORT EQUIPMENTS AND CONSUMABLE REPLENISHMENT ARE CONDUCTED CONTINUOUSLY. THE SPACE STATION ATTRIBUTES TO SUPPORT THE MISSION ARE SHOWN IN THE FACING CHART.

ROLL OF SPACE STATION TO SUPPORT LARGE SATELLITE ASSEMBLY IN LEO

ATTRIBUTES

- PROVIDE LONG-DURATION HABITATION FOR PERSONNEL
- PROVIDE ELECTRICAL POWER AND DATA/COMMUNICATIONS INTERFACE
- PROVIDE VOICE AND DATA LINK TO GROUND
- PROVIDE ALTITUDE AND ATTITUDE ORIENTATION
- PROVIDE PERIODIC REPLENISHMENT OF EXPENDABLES AND PERSONNEL
- PROVIDE SCHEDULED AND UNSCHEDULED MAINTENANCE
- PROVIDE PROPELLANT AND GAS HANDLING, STORAGE, TRANSFER
- PROVIDE WORK PLATFORM FOR ASSEMBLY AND CONSTRUCTION
- PROVIDE OPERATIONS CONTROL CENTER FOR ASSEMBLY OPERATIONS
- PROVIDE TMS DOCKING AND SUPPORT
- PROVIDE DOCKING AND OPERATIONAL INTERFACE WITH STS

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CANDIDATE SPACE STATION "MODEL"

SPACE STATION ARCHITECTURE FOR SERVICING

SPACE STATION ARCHITECTURE FOR THE 1995-2000 YEAR TIME PERIOD HAS BEEN IDENTIFIED IN NASA STUDIES PERFORMED BY EIGHT MAJOR CONTRACTORS DURING AUGUST 1982 - APRIL 1983. HIGHLIGHTS FROM THE EXECUTIVE SUMMERIES OF THE FINAL STUDY REPORTS ARE SHOWN ON THE FACING PAGE.

THE SPACE STATION CONCEPTS ACCOMODATED SOME DEGREE OF SERVICING FROM INITIAL PLACEMENT. SERVICING CAPABILITY WAS PROGRESSIVELY PHASED FROM INITIAL STATION BASED TO A REMOTE SERVICING CAPABILITY FOR THE ALL-UP STATION.

SERVICING ELEMENTS PROVIDE A MAJOR DRIVER TO THE STATION ARCHITECTURE AND INCLUDE SUCH ITEMS AS FIXED AND TRACKED REMOTE MANIPULATORS, FACILITIES FOR PROPELLANT SERVICING, AND PLATFORM/HANGAR TYPE FACILITIES FOR MAINTENANCE, REPAIR, AND CHECKOUT.

MAJOR LOGISTICS FOR PERFORMING SERVICING IS ACCOMODATED BY SHUTTLE RELATED DOCKING AND STORAGE AREAS.

SPACE STATION ARCHITECTURE FOR SERVICING

HIGHLIGHTS FROM SPACE STATION STUDIES*

- PHASED INCREASING CAPABILITY 1990 - 2000
- CAPABILITY TO PERFORM SERVICING ON/AT BASIC SPACE STATION FACILITY FOR PAYLOAD/EXPERIMENTS SPACECRAFT AND STAGE VEHICLES AND ALSO ON DETACHED PAYLOADS/SPACECRAFT
- DESIGN AND OPERATIONS FOR STATION BASED SERVICING INITIALLY PROGRESSING TO REMOTE SERVICING CAPABILITY AS ORBIT TRANSFER VEHICLES AND ROBOTIC OPERATORS BECAME OPERATIONAL
- FACILITIES FOR PROPELLANT STORAGE, SPACECRAFT AND STAGE STORAGE, PARTS, EQUIPMENT, STORAGE-CONSUMABLE STORAGE VIA DEDICATED LOGISTICS MODULE
- SHUTTLE PROVIDES THE MAJOR LOGISTICS INTERFACE TO SUPPORT SERVICING BETWEEN STATION AND EARTH
- REMOTE MANIPULATOR SYSTEMS USED EXTENSIVELY TO SUPPORT ON STATION SERVICING

* FINAL BRIEFING SUMMARY REPORTS OF ALL CONTRACTORS

SPACE STATION ARCHITECTURAL ELEMENTS FOR SERVICING

SERVICING WILL PLAY A SIGNIFICANT ROLE IN THE SPACE STATION MISSION OPERATIONS. ALL EIGHT CONTRACTORS PERFORMING THE NASA SPACE STATION ARCHITECTURAL STUDIES COMPLETED IN APRIL 1983 IDENTIFIED MAJOR SERVICING ELEMENTS AS INDICATED ON THIS FACING PAGE. USE OF THESE ELEMENTS PROVIDES CAPABILITY TO SUPPORT THE PROJECTED SERVICING NEEDS FOR THE SATELLITE/SPACECRAFT MISSIONS 1990 - 2000.

ALL CONTRACTORS PROPOSED THE USE OF MANIPULATORS FOR REMOTE HANDLING, A STATION ATTACHED SERVICE BASE FOR OPERATIONS OF A TMS-OTV TRANSFER VEHICLE, FUEL STORAGE FACILITIES FOR CRYO PROPELLANT STORAGE, AND THE CONCEPT OF A LOGISTICS MODULE FOR EXPANDABLES RESUPPLY AND HARDWARE TRANSPORT TO FROM EARTH.

HALF OF THE CONTRACTORS IDENTIFIED THE USE OF A DEDICATED SERVICE HANGAR AND HALF IDENTIFIED AN ASSEMBLY SERVICE AREA FOR PERFORMING MAINTENANCE, ASSEMBLY AND CHECKOUT OF SPACECRAFT/TRANSFER STAGES.

SPACE STATION ARCHITECTURAL ELEMENTS FOR SERVICING

SURVEY OF SPACE STATION STUDY CONTRACTOR REPORTS*

SERVICING ELEMENTS	BOEING	GD	GAC	LMSC	MMC	MAC DAC	RI	TRW
MANIPULATOR(S) TRACKED SYSTEM	•	•	•	•	•	•	•	•
SERVICE HANGAR	•			•	•			•
TMS-OTV BASE	•	•	•	•	•	•	•	•
FUEL STORAGE	•	•	•	•	•	•	•	•
MAINTENANCE MODULE	•	•						
LOGISTICS MODULE	•	•	•	•	•		•	•
ASSEMBLY SERVICE AREA		•	•			•	•	•
SURROGATE SHUTTLE BAY			•				•	

* FINAL BRIEFING SUMMARY REPORTS OF ALL CONTRACTORS

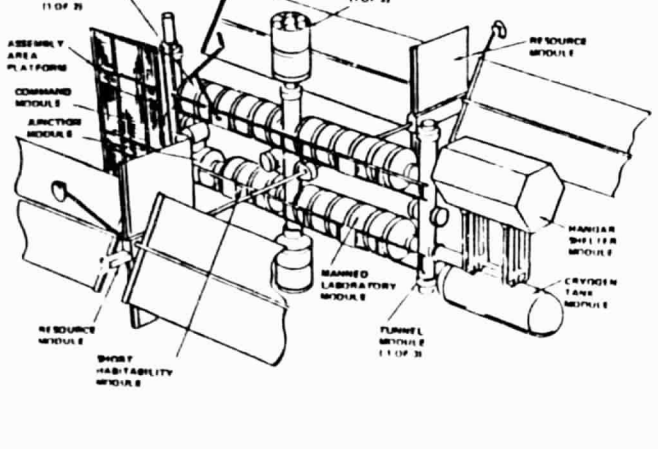
CONTRACTOR STATION CONFIGURATIONS FOR SERVICING

AN EXAMINATION OF A NUMBER OF SPACE STATION CONCEPTS WAS UNDERTAKEN TO DEVELOP A 'TYPICAL' MODEL FOR THIS STUDY. ACCORDINGLY LOCKHEED EXAMINED THE EIGHT CONTRACTOR CONFIGURATIONS IDENTIFIED IN THE NASA HDQ STUDY ENTITLED SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. THE INTENT OF THIS EFFORT WAS TO PREPARE A 'COMPOSITE MODEL' WHICH WAS FAIRLY REPRESENTATIVE OF THE VARIOUS CONTRACTORS. HOWEVER, IT WAS DETERMINED THAT NOT ALL FEATURES OF ALL THE CONTRACTORS COULD BE INCORPORATED IN A SINGLE 'MODEL', THEREFORE, A COMPROMISE WAS MADE AFTER EVALUATION OF EACH CONTRACTORS CONFIGURATION.

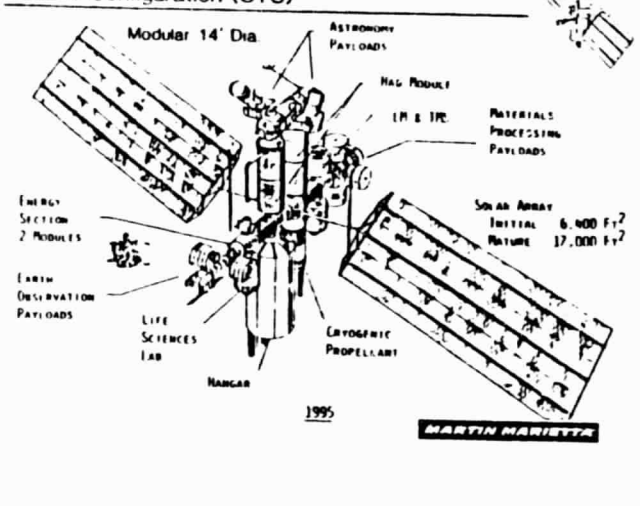
THE FACING PAGE INDICATES THE CONFIGURATION FOR TRW AND MARTIN MARIETTA STUDIES COMPLETED UNDER THE AFOREMENTIONED CONTRACTS COMPLETED IN LATE APRIL 1983.

CONTRACTOR STATION CONFIGURATIONS FOR SERVICING

Flight-11 Configuration (10 Crew) TRW



Mature Configuration (STS)



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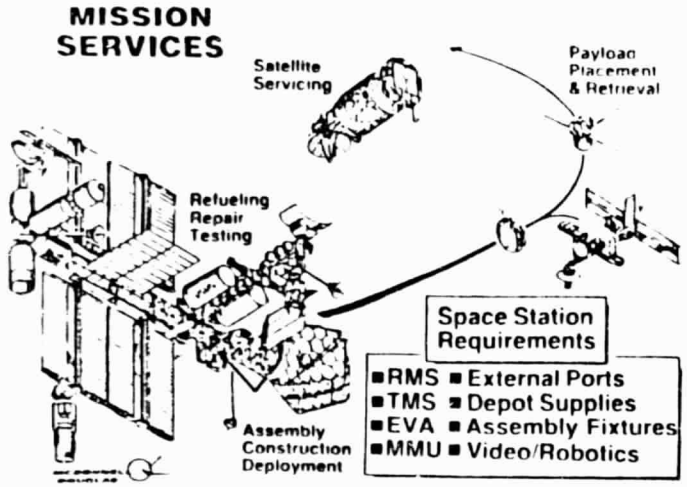
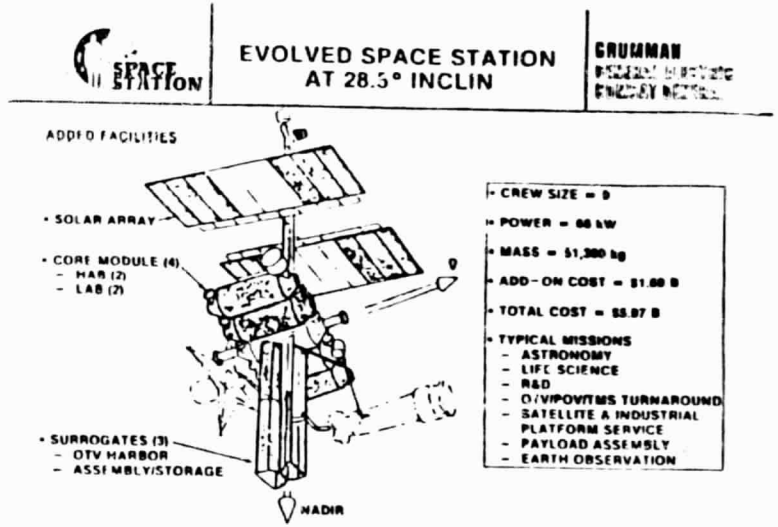
CONTRACTOR STATION CONFIGURATIONS FOR SERVICING

THE McDONNEL DOUGLAS AND GRUMMAN SPACE STATION CONFIGURATIONS ARE SHOWN ON THE FACING PAGE.

CONTRACTOR STATION CONFIGURATIONS FOR SERVICING



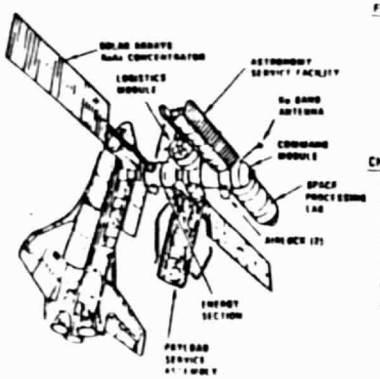


CONTRACTOR STATION CONFIGURATION FOR SERVICING

THE ROCKWELL INTERNATIONAL (LEFT) AND BOEING SPACE STATION CONFIGURATIONS ARE ILLUSTRATED ON THE FACING PAGE.

CONTRACTOR STATION CONFIGURATIONS FOR SERVICING

INITIAL SPACE STATION ARCHITECTURE...



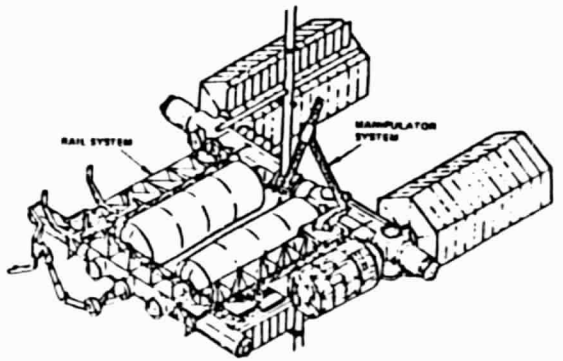
FUNCTIONS

- ACCOMMODATE SPACE OPERATIONS
  - SCIENCE EXPERIMENT MODULES / PALLETS & INTERNAL VOLUME
  - SERVICE OTV & TMS & SPACECRAFT
  - R&D
  - SPACE CONSTRUCTION AND ASSEMBLY
  - SPACE PROCESSING RESEARCH & FACTORY
- PROVIDE ELECT POWER COMMUNICATIONS CREW ACCOMMODATIONS

CHARACTERISTICS

- 4 DOCKING PORTS TO ACCEPT EXPT MODULES
- PALLET MOUNTING ACCOMMODATIONS ON P/A
- 75 KW POWER AT DUS
- ACCOMMODATIONS FOR 4 CREW
- REPLACEABLE SOLAR ARRAYS & RADIATOR
- DUAL VOLUMES FOR CREW SAFETY
- EVA ACCOMMODATIONS

RAIL BASED SYSTEM (BASED ON BOEING MATERIAL)



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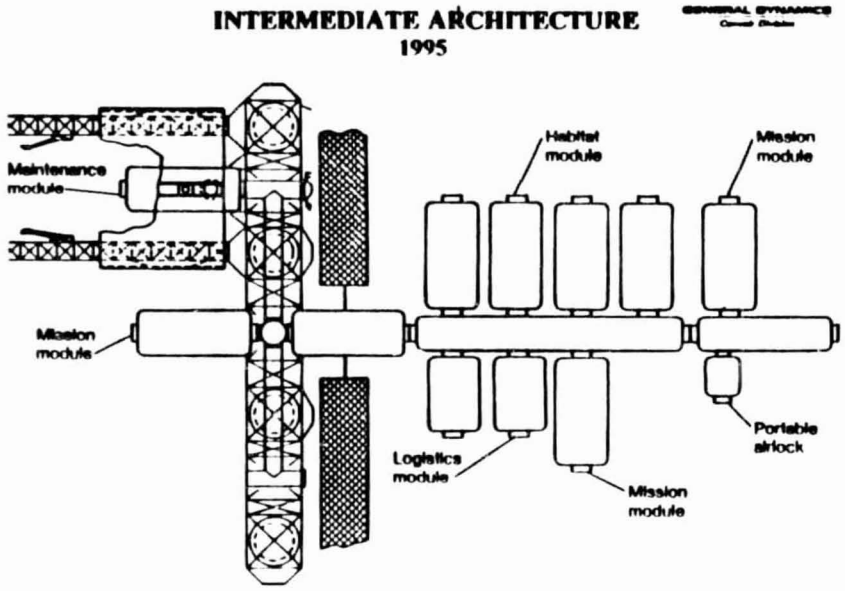
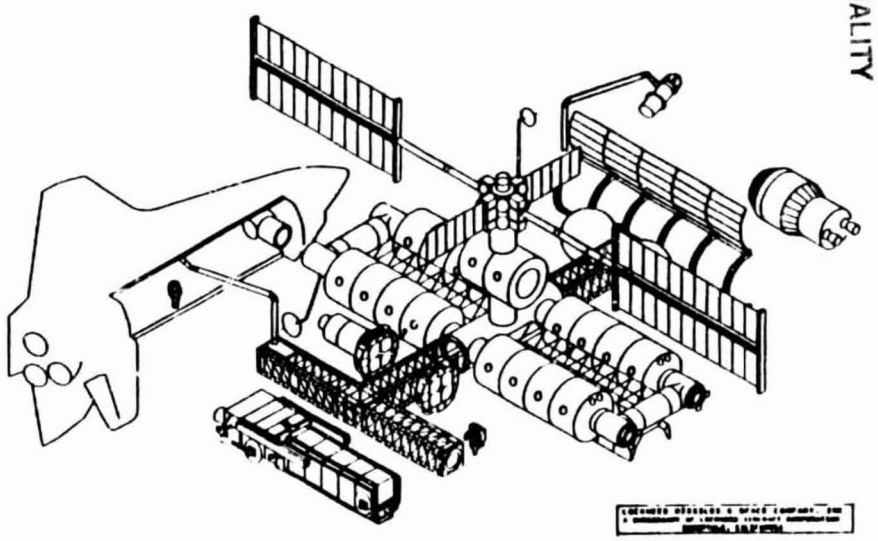
CONTRACTOR STATION CONFIGURATION FOR SERVICING

THE GENERAL DYNAMICS AND LOCKHEED SPACE STATIONS CONFIGURATIONS ARE ILLUSTRATED ON THE FACING PAGE.

CONTRACTOR STATION CONFIGURATIONS FOR SERVICING





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STATION SPECIFIC (UNIQUE) SERVICING EQUIPMENT CANDIDATES

A MORE SIMPLIFIED SERVICING FUNCTION LIST WAS PREPARED FOR THE SPACE STATION'S ANTICIPATED ROLE RELATIVE TO SERVICING. THE FACING PAGE INCLUDES THIS SIMPLIFIED LIST. INCLUDED ON THIS AND THE NEXT PAGE IS A LISTING OF HARDWARE CONSIDERED UNIQUE TO THE SPACE STATION FOR THE CONDUCT OF SERVICING. THESE ARE ITEMS WHICH MAY EVOLVE FROM SHUTTLE ERA SERVICING EQUIPMENT BUT, AT PRESENT, ARE NOT IN THE DEVELOPMENT PHASE. FURTHER, SOME OF THESE 26 ITEMS ARE NOT EVEN UNDER SERIOUS STUDY BY NASA AT THIS TIME. THE MAJORITY ARE ONLY IN THE EARLY CONCEPTUAL STAGE OF IDENTIFICATION AND REQUIREMENTS ALLOCATION. THE PURPOSE OF THE MATRIX ON THIS AND THE FOLLOWING PAGE IS TO IDENTIFY THE EXPECTED STATION SERVICING FUNCTIONS WITH THE VARIOUS UNIQUE SERVICING HARDWARE ITEMS CURRENTLY IDENTIFIED FOR THE MISSION SUPPORT ACTIVITIES. IT SHOULD ALSO BE NOTED THAT A NUMBER OF THESE UNIQUE EQUIPMENT ITEMS ARE ALSO DIRECTLY APPLICABLE TO LARGE STRUCTURE CONSTRUCTION AND ASSEMBLY. THIS LATER TASK HAS BEEN CONSIDERED BY MANY TO BE WITHIN THE DOMAIN OF SERVICING AND THERE IS CONSIDERABLE MERIT FOR THIS CONTENTION.

STATION SPECIFIC (UNIQUE) SERVICING EQUIPMENT CANDIDATES

STATION SERVICING SYSTEMS AND HARDWARE / SERVICING FUNCTIONS	SPACECRAFT BERTHING, HOLDING AND POSITIONING	SPACECRAFT TRANSPORT AND STAGE ASSEMBLY	SERVICE AREA AND ENVIRONMENTAL PROTECTION	ITEM/ORU TRANSFER	CONSUMABLES REPLENISHMENT	REPAIR	NON-NOMINAL SUPPORT-OVERRIDE	PREPARE ITEM FOR DE-ORBIT	RECONFIGURE	SPARES HANDLING, PROTECTION AND TRANSPORT	CHANGEOUT
1. SERVICING HANGAR (NONPRESSURIZED)			●	X	X	X		X	X	X	X
2. SURROGATE CARGO BAY			●	X							
3. TRACKED (MOBILE) RMS	X	●		●			X			X	
4. CAB FOR TRACKED RMS	X	●		●						X	
5. INTERNAL (PRESSURIZED) MAINTENANCE WORK AREA			X			●			X		
6. TRANSPORT BOOM/CRANE	X	●		●			X			X	
7. LOGISTICS (SPARES) CARRIER MODULE			X		X					●	
8. SUNSHADE			●								
9. LARGE MASS ROTATE/TILT DEVICE	●			X					X		
10. CREW AIDS/TOOLS STOWAGE UNITS		X			X	X	X	X	X	X	●
11. CONSUMABLES REPLENISHMENT SYSTEM					●						
12. TANKAGE AND LINES - STATION ATTACHED					●						
13. STATION-BASED OMV/OTV		●			X			X			
14. DECONTAMINATION SYSTEM			●			X	X				

● = PRIMARY X = SECONDARY

STATION SPECIFIC (UNIQUE) SERVICING EQUIPMENT CANDIDATES (CONT)

STATION SERVICING SYSTEMS AND HARDWARE \ SERVICING FUNCTIONS	SPACECRAFT BERTHING, HOLDING AND POSITIONING	SPACECRAFT TRANSPORT AND STAGE ASSEMBLY	SERVICE AREA AND ENVIRONMENTAL PROTECTION	ITEM/ORU TRANSFER	CONSUMABLES REPLENISHMENT	REPAIR	NON-NOMINAL SUPPORT-OVERRIDE	PREPARE ITEM FOR DE-ORBIT	RECONFIGURE	SPARES HANDLING, PROTECTION AND TRANSPORT	CHANGEOUT
15. SERVICING CHECKOUT UNIT (UNPRESSURIZED)			X			X			X	X	●
16. SERVICING CHECKOUT UNIT (PRESSURIZED)			X			X			X	X	●
17. SPACECRAFT PARKING FIXTURE	●	X									
18. SERVICING PASS THROUGH AIRLOCK			X	●		X				X	
19. SHORT-ARM IV CREW OPERATION MANIPULATORS				●		●		●		X	
20. POWER CONDITIONING UNIT			●	X	X	X			X		X
21. SIGNAL/POWER CABLE/UMBILICAL INTERFACE UNIT	●	X	X	X	X	X	X	X	X		X
22. VENT UNIT			X		●		X				
23. STAGE ASSEMBLY KIT/JIG/BEAM OR PIER	●	●					X			X	
24. BERTHING DEVICE	●	X									
25. CONSOLE (IV) FOR REMOTE SYSTEM OPERATION		●		●	●		X	X			X
26. TELEOP/SMART END SERVICER					●	●			●		●

● = PRIMARY X = SECONDARY

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TRANSITION-ORBITER TO STATION

SHUTTLE ERA SERVICING SYSTEM/HARDWARE

APPLICABILITY TO STATION

IN DEVELOPING THE PRECEEDING LIST OF STATION UNIQUE SERVICING HARDWARE, A NUMBER OF INVESTIGATIONS WERE MADE INTO WHAT EQUIPMENT/SERVICES CURRENTLY EXIST FOR SUBSEQUENT EVOLUTION TO THE STATION. THE OPPOSITE PAGE LISTS 5 MAJOR CATEGORIES OF SHUTTLE ERA SERVICING SYSTEMS AND HARDWARE WHICH APPEAR AS POTENTIALLY APPLICABLE TO THE STATION. HOWEVER, A NUMBER OF THE ITEMS (PREVIOUSLY IDENTIFIED HEREIN) ARE NOT YET FULLY OPERATIONAL AND, THEREFORE, ARE IN VARYING STAGES OF PROCUREMENT AS INDICATED. ADDITIONALLY, ALTHOUGH THE FLIGHT HARDWARE EXISTS AT PRESENT (SEE ITEM C OPPOSITE PAGE) DUPLICATES WOULD HAVE TO BE DEVELOPED SINCE THE MAIN LINE ORBITER FUNCTIONS CAN NOT BE JEOPARDIZED THROUGH THE TRANSFER OF THIS HARDWARE TO THE STATION.

SHUTTLE ERA SERVICING SYSTEM/HARDWARE APPLICABILITY TO STATION

A. FIVE MAJOR CATEGORIES OF SHUTTLE SERVICING SYSTEMS AND HARDWARE APPEAR SUBSTANTIALLY APPLICABLE TO STATION SERVICING:

1. EVA SUPPORT EQUIPMENT NORMALLY MANIFESTED ON ORBITER
2. SHUTTLE SYSTEMS
3. TOOLS AND TOOL STORAGE
4. PAYLOAD-RELATED SYSTEMS AND CARRIERS
5. PROJECTED SATELLITE SERVICING EQUIPMENT

B. SEVERAL ITEMS ARE NOT YET FUNDED OR FULLY DEVELOPED (e.g., STATUS):

1. CONCEPT ONLY
2. PRE-PHASE A
3. PHASE A OR B
4. "ON-HOLD" PENDING FUNDING
5. PHASE C/D

C. MANY ORBITER MTD ELEMENTS AND/OR ASE ARE APPLICABLE

1. DUPLICATES WOULD HAVE TO BE FABRICATED IN MANY INSTANCES, e.g.:

- RMS
- END EFFECTOR
- AFT FLIGHT DECK PANELS
- CONTINGENCY TOOLS
- CCTV UNITS AND RECORDERS
- OTHERS

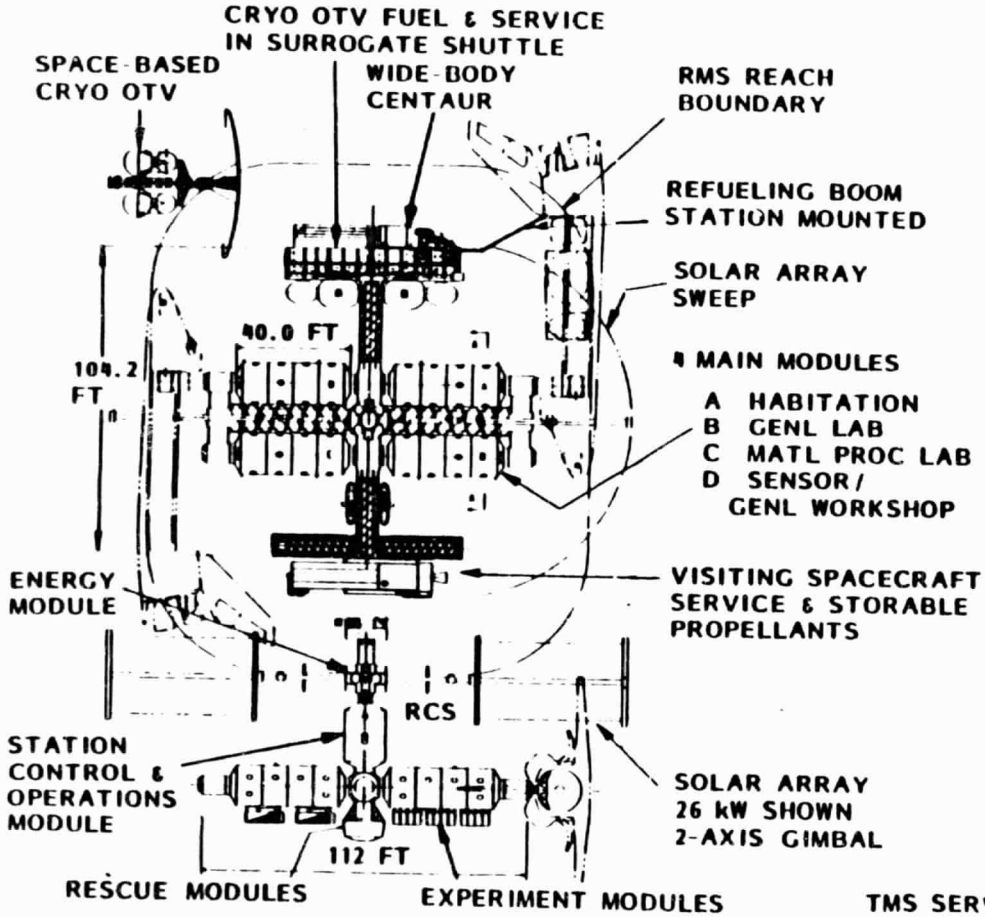
SPACE STATION MODEL-GENERAL SERVICING CONFIGURATION LAYOUT

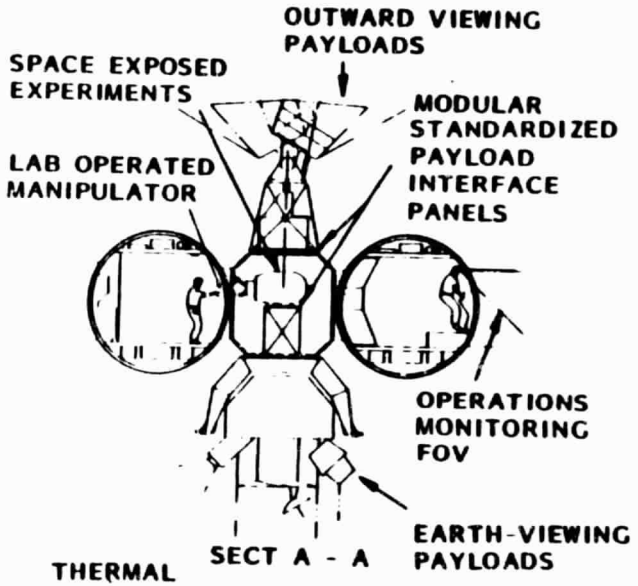
PRIMARILY FOR THE PURPOSES OF THIS EFFORT, A REFERENCE SPACE STATION WAS CONFIGURED AS SHOWN ON THE OPPOSITE PAGE. THE PRINCIPAL CONSIDERATIONS IN DETERMINING THE CONCEPT WERE BASED ON THE FOLLOWING ARBITRARY ASSUMPTIONS:

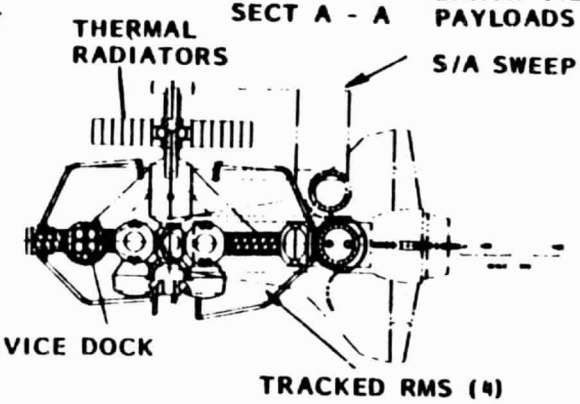
MODULAR APPROACH	EARLY INITIAL CAPABILITY; GROWTH PROVISIONS
EXPERIMENT INTEGRATION	PROVIDE WORK AREAS AND PLATFORMS, INTERNAL AND EXTERNAL
CREW SIZE	3 INITIALLY, GROWING TO 6
POWER	SOLAR ARRAY 13 kW GROWING TO 26 kW
SAFETY	2 INDEPENDENT LIVING CELLS AND RESUCE CAPABILITY
TYPE OF CONTROL	EARTH ORIENTED, ACTIVE RCS THRUSTERS
HABITATION & LAB MODULE SIZE	14 FT DIA x 40 FT LONG
SERVICING	PROVIDE FOR OTV, VISITING SPACECRAFT, OMV, ETC.
COMMUNICATIONS	PRIMARILY PROVIDE FOV FOR DISH TO GROUND AND TDRSS (THERE WILL BE MANY OTHER ANTENNAE).
RESUPPLY	CREW AND CONSUMABLES EVERY 90 DAYS
EVA	PROVIDE VOLUME AND EQUIPMENT TO SUPPORT EVA

A DETERMINED EFFORT WAS MADE TO MAKE THE STATION AS MODULAR AS POSSIBLE, NOT ONLY TO PROVIDE GOOD FOV FOR SOLAR ARRAYS, RADIATORS, PAYLOADS AND ANTENNAE BUT TO SIMPLIFY ATTITUDE CONTROL + CG + MOI EXCURSIONS, AND ALSO TO PROVIDE MAXIMUM VISIBILITY FOR CREW MEMBERS DURING EXTERNAL SERVICING OPERATIONS.

SPACE STATION MODEL-GENERAL SERVICING CONFIGURATION LAYOUT







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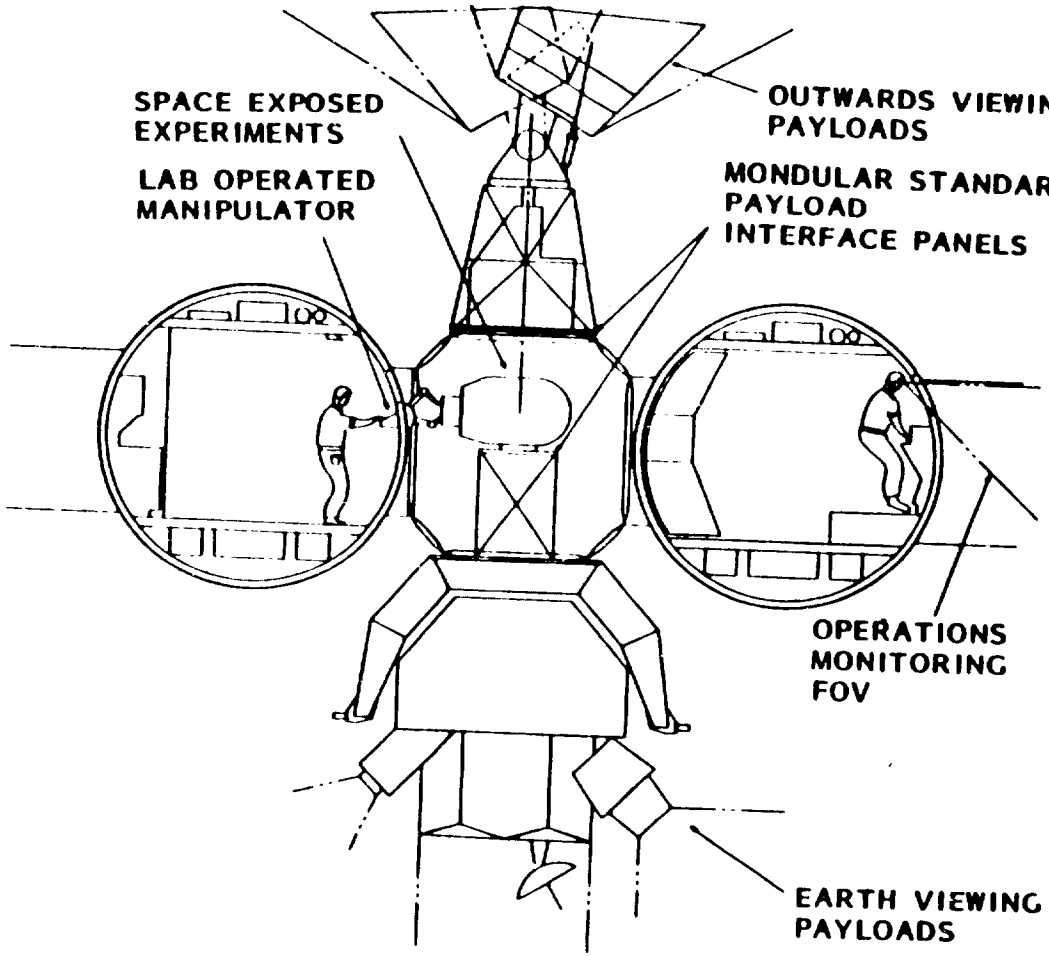
SPACE STATION MODEL-GENERAL CONFIGURATION IVA SERVICING POTENTIAL

IN THE EXAMPLE ILLUSTRATED ON THE FACING PAGE, EFFORT HAS BEEN UNDERTAKEN TO PORTRAY A CONCEPT WHICH PERMITS INTERNAL (IVA) SERVICING OF EXPERIMENTS/SPACECRAFT/PALLETS. THIS IVA SERVICING POTENTIAL LEADS TO THE IDENTIFICATION OF HARDWARE NOT CURRENTLY IN THE SHUTTLE INVENTORY, THEREBY, INDICATING THE NEED FOR CONSIDERATION OF ADVANCED SHORT ARM MANIPULATORS AND ROBOTIC ELEMENTS. ADDITIONALLY, WORK STATIONS DEDICATED TO SERVICING (OR AT LEAST AVAILABLE VIA SOFTWARE RE-CONFIGURING) ARE IDENTIFIED AS ELEMENTAL TO THE SERVICING NEEDS. THIS IS PARTICULARLY TRUE FOR MONITORING AND CHECKOUT OF THE SPACECRAFT OR ITEM PRIOR TO DEPLOYMENT AND/OR OPERATION. FURTHER, THE REMOTE SERVICING OF PAYLOADS (AWAY FROM THE STATION) WILL ALSO ENTAIL THE NEED FOR WORK STATIONS SUCH AS THOSE ASSOCIATED WITH ROBOTIC OPERATIONS OF SMART FRONT ENDS ON OMV'S AND OTV'S.

SPACE STATION MODEL-GENERAL CONFIGURATION IVA SERVICING POTENTIAL



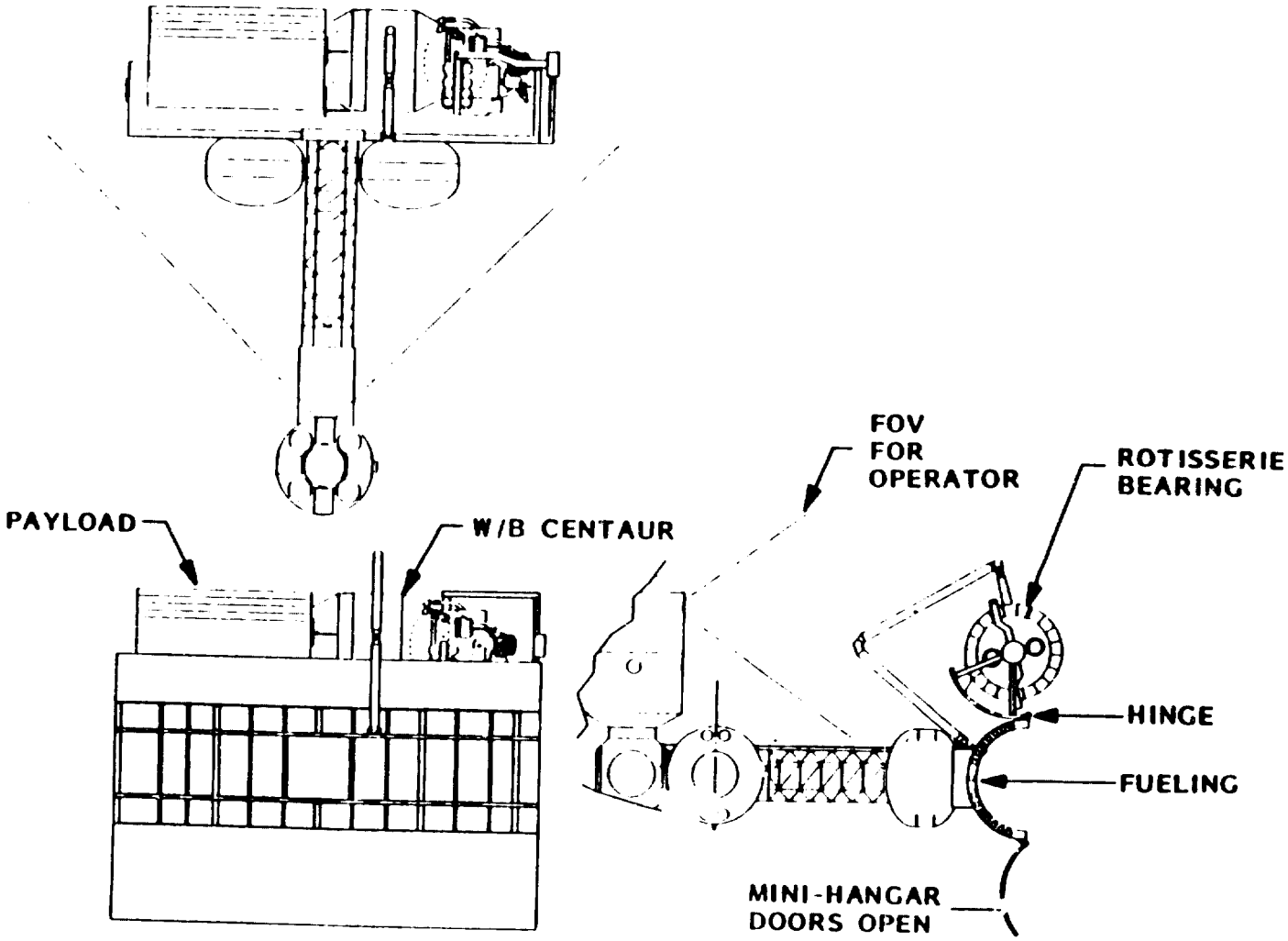
SPACE STATION STAGE ASSEMBLY

THIS CONCEPT FOR STAGE ASSEMBLY AND SERVICING IS A MINIMUM TYPE PROTECTIVE STRUCTURE BASED ON THE GEOMETRY OF THE WIDE BODY CENTAUR. THE BACKBONE IS ESSENTIALLY A SURROGATE SHUTTLE BAY CONTAINING ALL OF THE CRYOGENIC PLUMBING, UMBILICALS, FLOW CONTROL EQUIPMENT AND SAFETY FEATURES DEVELOPED FOR THE INSTALLATION AND FUELING OF THE W/B CENTAUR IN THE REAL SHUTTLE.

THE OUTER PORTION ARE HINGED DOORS, THE UPPER ONE CONTAINING A ROTATION SYSTEM SUCH THAT THE OTV AND IT'S PAYLOAD MAY BE INSPECTED AND SERVICED REMOTELY WITHIN FULL VIEW OF THE STATION COMMAND CENTER. THE UPPER DOOR WOULD ALSO CONTAIN THE DEPLOYMENT MECHANISM.

PROPELLANT TANKS AND FEED SYSTEM ARE ADJACENT ON THE INNER FACE OF THE OTV PIER. RMS TRACKS ARE LOCATED ON THE UPPER AND LOWER FACES OF THE PIER.

SPACE STATION STAGE ASSEMBLY



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SHUTTLE ERA SERVICING EQUIPMENT

THE FOLLOWING FIVE CHARTS ARE ASSOCIATED WITH SHUTTLE ERA EQUIPMENT WHICH CAN BE USED FOR SERVICING. IN THIS PARTICULAR CASE THE EQUIPMENT SHOWN ON THE FACING PAGE IS EVA SUPPORT EQUIPMENT WHICH IS NORMALLY MANIFESTED ON THE ORBITER. THE MATRIX ATTEMPTS TO ILLUSTRATE HOW EACH OF THESE EQUIPMENT ITEMS WOULD BE RELATED TO THE TYPICAL SERVICING FUNCTIONS PREVIOUSLY IDENTIFIED AND DEFINED. THE LIST OF EQUIPMENT IS FROM THE RECENTLY COMPLETED LOCKHEED STUDY FOR NASA-JSC ENTITLED SATELLITE SERVICES, TOOLS AND EQUIPMENT (DATED SEPTEMBER 1983). THE FOLLOWING FOUR PAGES PROVIDE ILLUSTRATIONS OF THE MAJORITY OF THESE ITEMS.

SHUTTLE ERA SERVICING EQUIPMENT

EVA SUPPORT EQUIPMENT NORMALLY MANIFESTED ON ORBITER / SERVICING FUNCTIONS	INSPECT/EXAMINE AND ASSESS	SAFING	ORU CHANGEOUT			CONSUMABLES REPLENISHMENT	RECONFIGURE	REPAIR	GENERAL SERVICE ENHANCEMENT	DEBRIS CAPTURE-CONTAINMENT AND TRANSFER	PREPARE ITEM FOR DE-ORBIT	CHECKOUT AND VERIFY	HANDLE/POSITION AND/OR TRANSFER	ORBITER PECULIAR
			FAILED OR DEGRADED ITEM	NEW OR UPDATED ITEM	PREVENTIVE MAINT ITEM									
1. EXTRAVEHICULAR MOBILITY UNIT (EMU)	●	●	●	●	●	●	●	●	●	●	●	●	●	
2. EVA CUFF CHECKLIST	●	●	●	●	●	●	●	●	●	●	●	●	●	
3. CARGO BAY STOWAGE ASSEMBLY (CBSA)		X	●	●	●	●	X	●	X	X	X	X		
4. PROVISIONS STOWAGE ASSEMBLY (PSA)		X	●	●	●	●	X	●	X	X	X	X		
5. PORTABLE FOOT RESTRAINT (PFR)	●	●	●	●	●	●	●	●	●	●	●	●	●	
6. CLOSED CIRCUIT TELEVISION (CCTV)	●	●	●	●	●	●	X	X	X	●	X	●	●	
7. VIDEO TAPE RECORDER (VTR)							●					●		
8. MINI-WORKSTATION (MWS)			●	●	●	●	X	?	X	X	X	X	X	
9. EMU LIGHTS	●	●	●	●	●	●	●	?	●	X	X	●	●	
10. WRIST AND WAIST TETHERS			●	●	●	●	●	?	X	●	X		●	
11. FIFTY-FOOT SAFETY TETHER FOR CREWMEMBER	●									●			●	
12. ORBITER CARGO BAY FLOODLIGHT SYSTEM	●	●	●	●	●	●	●	?	●	●	X	●	●	●*
13. TOOL CADDY			●	●	●	●	●	?	●	X	X	X		
14. THERMAL MITTENS	●	●	X	X	X	X	X	?	X	●	X	●	●	
15. EVA TOOLS (MISCELLANEOUS)								●						

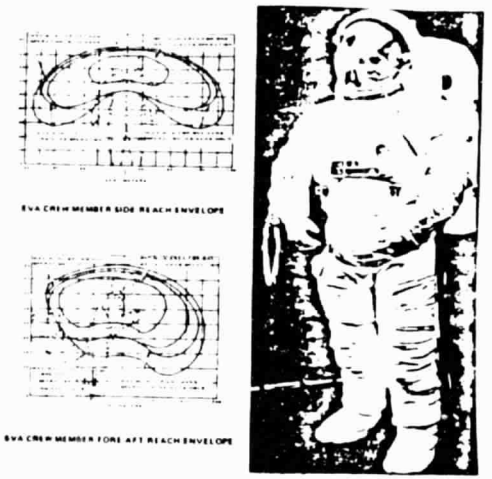
*FLOODLIGHT UNIT

● = PRIMARY

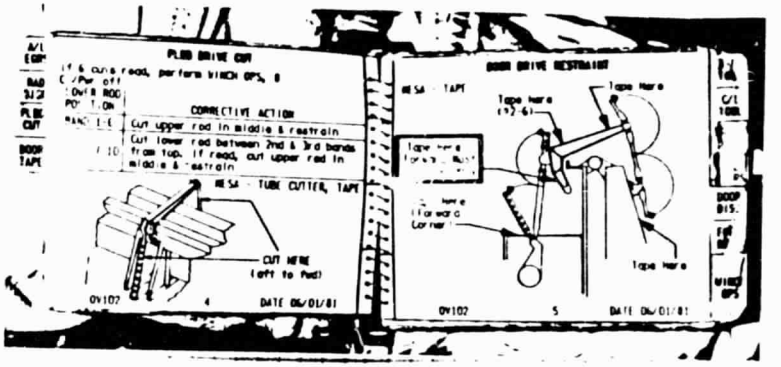
X = SECONDARY

STANDARD SERVICES
EVA SUPPORT EQUIPMENT

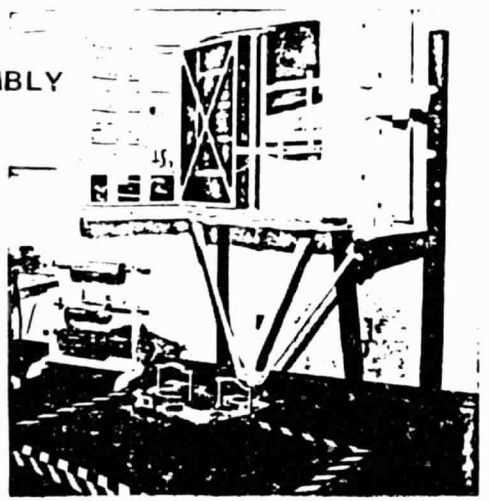
EMU



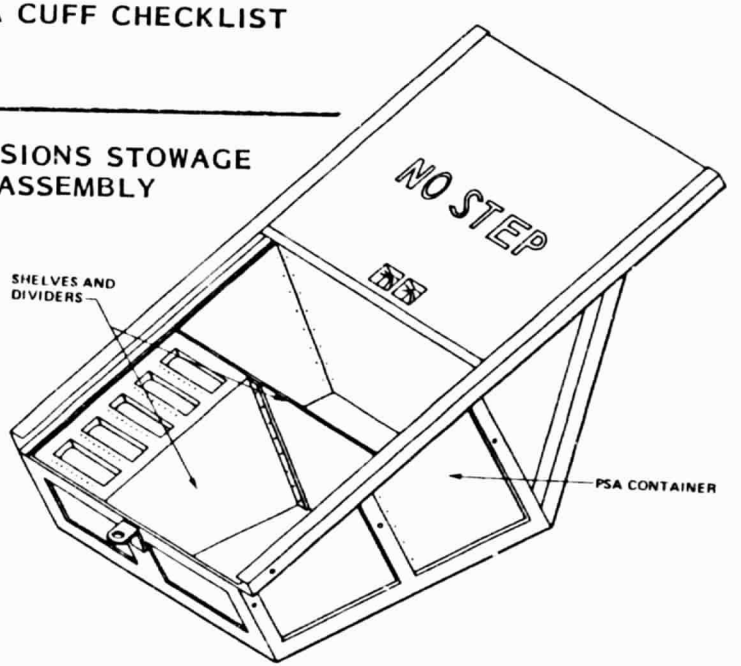
EVA CUFF CHECKLIST



CARGO BAY
STOWAGE ASSEMBLY



PROVISIONS STOWAGE
ASSEMBLY



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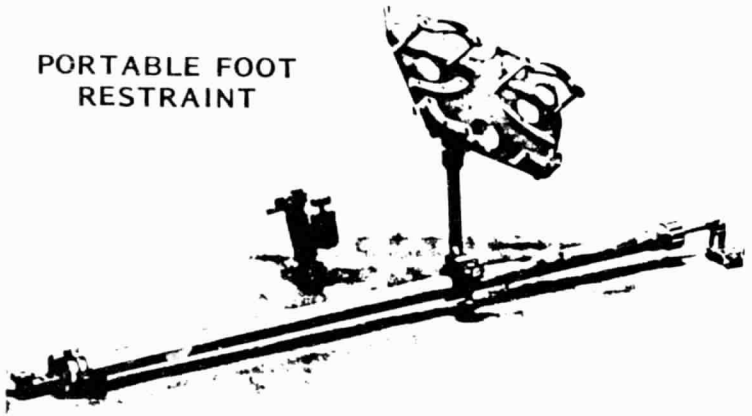
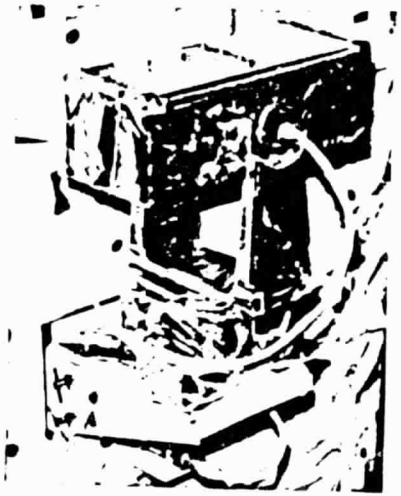
Lockheed

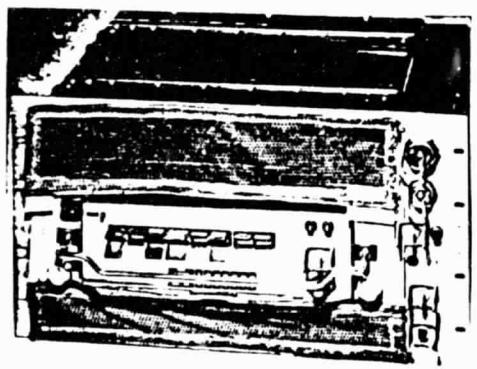
STANDARD SERVICES EVA SUPPORT EQUIPMENT

PORTABLE FOOT RESTRAINT

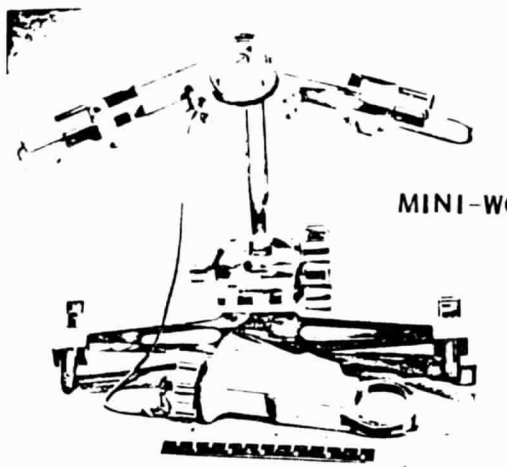




CLOSED CIRCUIT TELEVISION

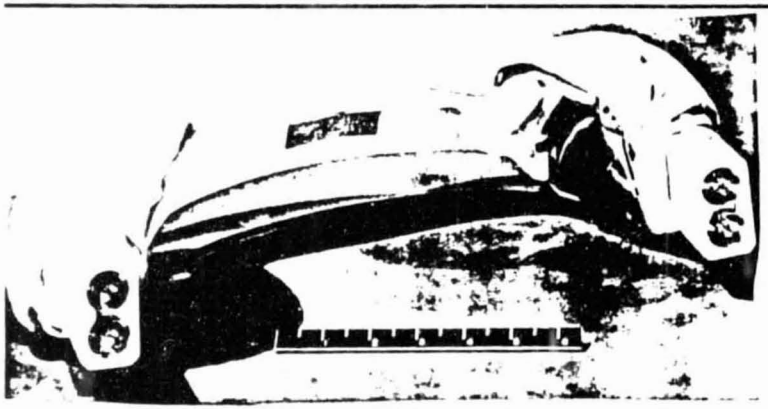


VIDEO TAPE RECORDER

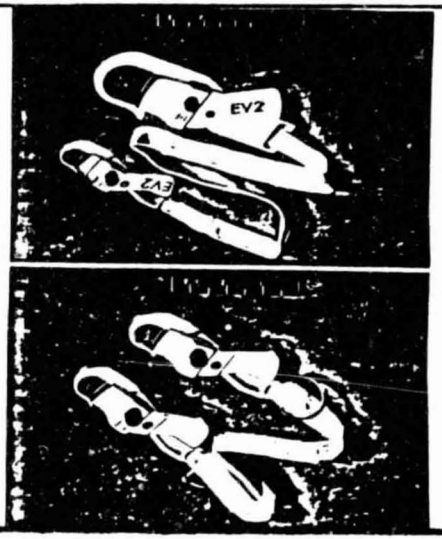


MINI-WORKSTATION

STANDARD SERVICES
EVA SUPPORT EQUIPMENT

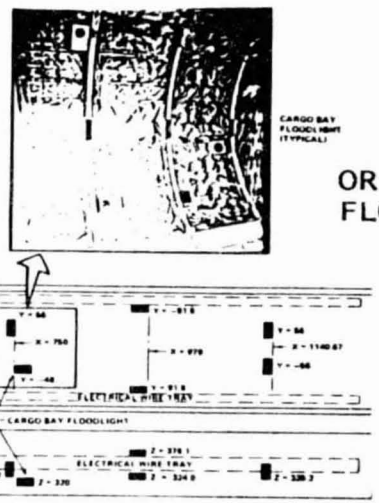


EXTRAVEHICULAR MOBILITY UNIT LIGHTS



WRIST AND WAIST TETHERS

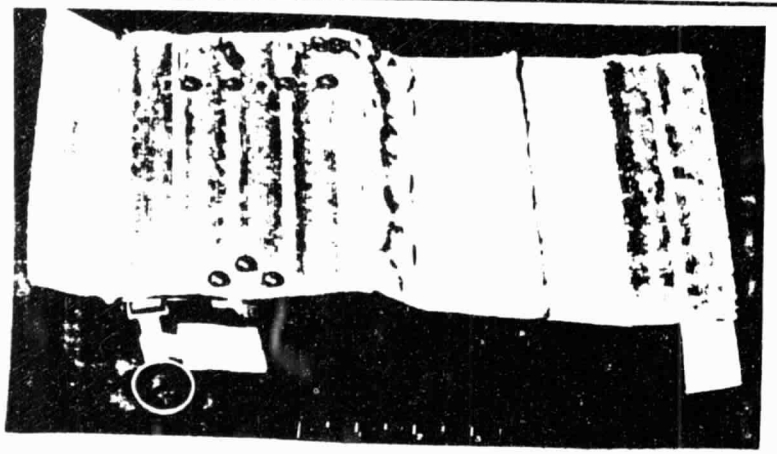
FIFTY-FOOT SAFETY TETHER FOR CREWMEMBER



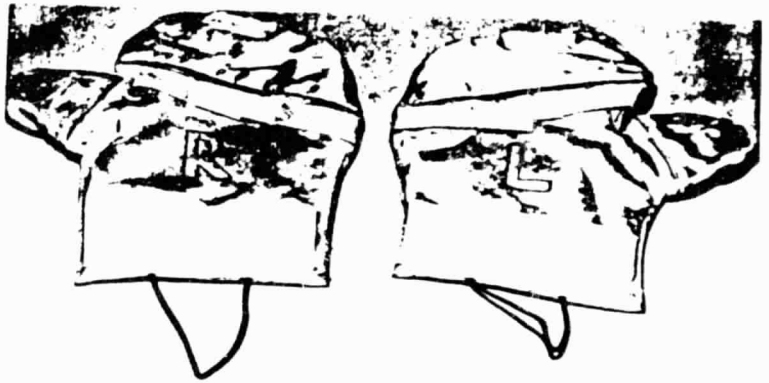
ORBITER CARGO BAY FLOODLIGHT SYSTEM

Lockheed

STANDARD SERVICES
EVA SUPPORT EQUIPMENT



TOOL CADDY



THERMAL MITTENS

SHUTTLE ERA SERVICING EQUIPMENT (CONT)

AS INDICATED PREVIOUSLY, THE SERVICING FUNCTIONS ARE LISTED ACROSS THE MATRIX IN THE OPPOSITE PAGE. THE EQUIPMENT IDENTIFIED ON THE LEFT IS THAT SET OF HARDWARE DEFINED AS THE CURRENT SHUTTLE AUXILIARY ITEMS AND STOWAGE CAPABILITY. EACH OF THESE ITEMS HAS BEEN EXAMINED RELATIVE TO THE SERVICING FUNCTIONS AND AN INDICATION GIVEN AS TO THE PRIMARY OR SECONDARY USE OF THIS EQUIPMENT FOR SERVICING. AGAIN, THE LIST WAS OBTAINED FROM THE SATELLITE SERVICES CATALOG, TOOLS AND EQUIPMENT. THE FOLLOWING FOUR PAGES PRESENT ILLUSTRATIONS OF MANY OF THESE ITEMS FOR REFERENCE PURPOSES.

SHUTTLE ERA SERVICING EQUIPMENT (CONT)

CURRENTLY SHUTTLE AUXILIARY ITEMS AND STOWAGE CAPABILITY / SERVICING FUNCTIONS	INSPECT/EXAMINE AND ASSESS	SAFEING	ORU CHANGEOUT: FAILED OR DEGRADED ITEM	ORU CHANGEOUT: NEW OR UPDATED ITEM	ORU CHANGEOUT: PREVENTIVE MAINTENANCE ITEM	CONSUMABLES REPLENISHMENT	RECONFIGURE	REPAIR	GENERAL SERVICE ENHANCEMENT	DEBRIS CAPTURE-CONTAINMENT AND TRANSFER	PREPARE ITEM FOR DE-ORBIT	CHECKOUT AND VERIFY	HANDLE/POSITION AND/OR TRANSFER	ORBITER PECULIAR
1. SHUTTLE SYSTEMS														
A. CARGO BAY ENVELOPE	X	X	X	X	X	X	X		X		X		X	•
B. AFT FLIGHT DECK (AFD)	X	X				X			X			•		•
C. REMOTE MANIPULATOR SYSTEMS (RMS)	X									X			•	
D. STANDARD END EFFECTOR (SEE) FOR RMS													•	
E. MANNED MANEUVERING UNIT (MMU)	•	•	•	•	•	•	X		X	•	•		•	
F. EMU TV SYSTEM (EMU-TV)	•											X		
G. MANIPULATOR FOOT RESTRAINT (MFR)	•	X	•	•	•	•	•		X	X	X	X	•	
H. TRUNNION PIN ATTACHMENT DEVICE (TPAD)													•	
I. STANDARD GRAPPLE FIXTURE	•												•	
J. EVA SLIDE WIRE SUBSYSTEM	X												•	•
2. TOOLS AND TOOL STORAGE														
A. FLIGHT SUPPORT SYSTEM (FSS) LOCKER		X	•	•	•	•	X		X	X	X	X		
B. POWER RATCHET TOOL (PRT)			•	•	•	•	X	?	X	X	•		X	
C. BATTERY SCREWDRIVER			•	•	•			?	X	X	X			
D. BATTERY POWER TOOL (BPT)			•	•	•	•		?	X	X	X			
E. POWERED SCREWDRIVER			•	•	•			?	X	X	X			
F. MODULE SERVICE TOOL (MST)			•	•	•		X		X				•	
G. PROVISIONS STOWAGE ASSEMBLY (PSA)		X	•	•	•	•	X	•	X	X	X	X		•

• = PRIMARY

X = SECONDARY

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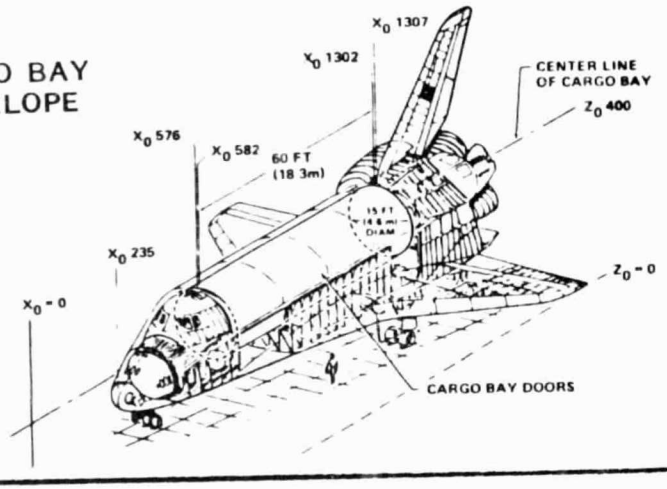
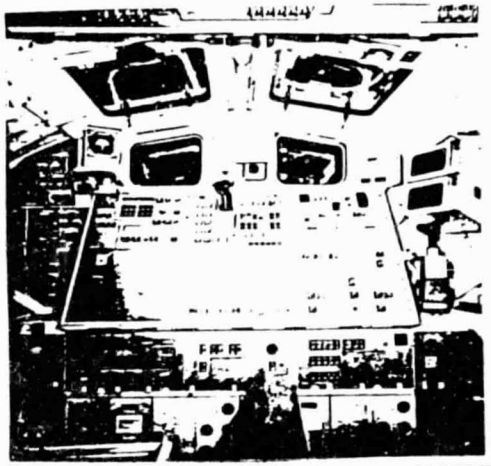
AUXILIARY SERVICES
SHUTTLE SYSTEMS

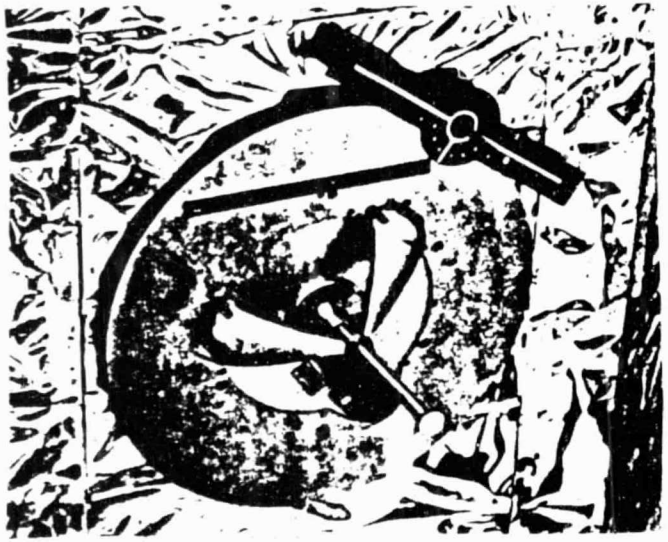
CARGO BAY ENVELOPE





AFT FLIGHT DECK

STANDARD GRAPPLE FIXTURE



MANNED MANEUVERING UNIT

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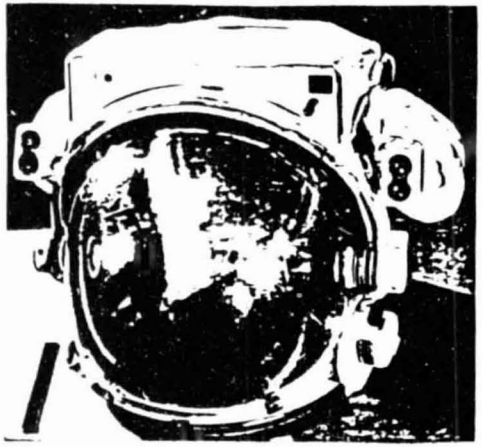
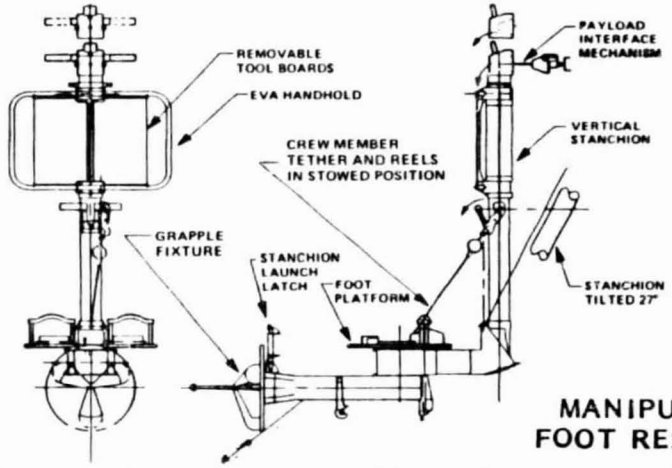
AUXILIARY SERVICES
SHUTTLE SYSTEMS

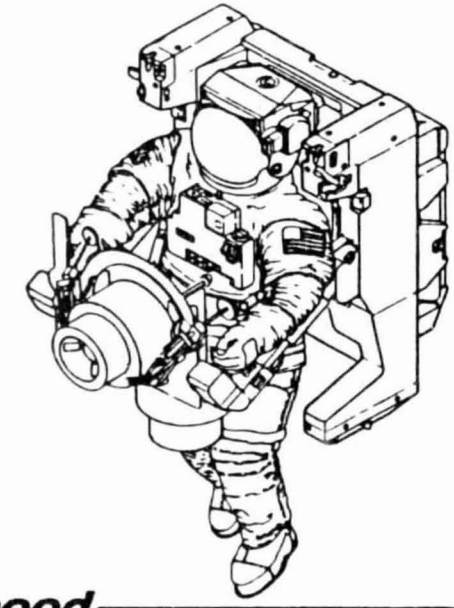
EMU
TELEVISION
SYSTEM

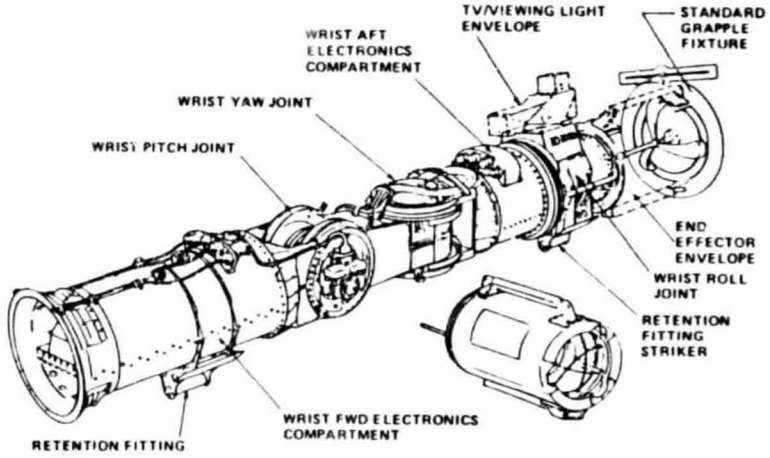




MANIPULATOR
FOOT RESTRAINT

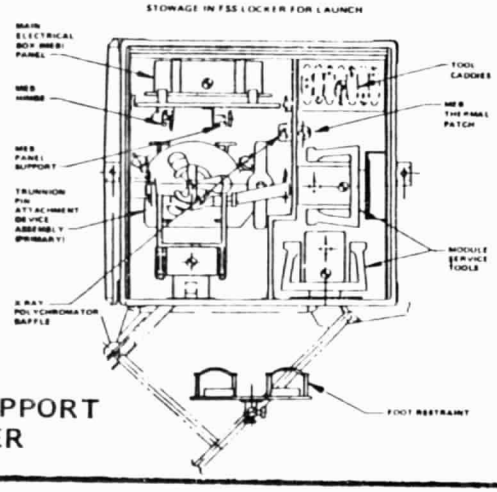
TRUNNION PIN
ATTACHMENT DEVICE



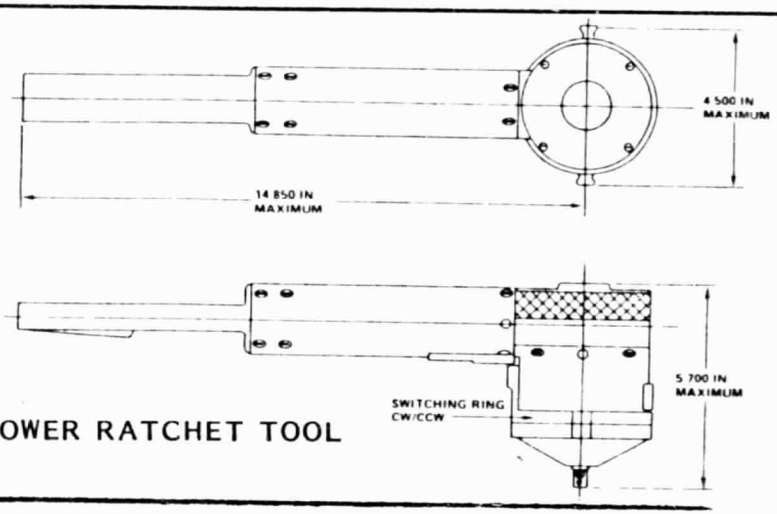


STANDARD END EFFECTOR
FOR RMS

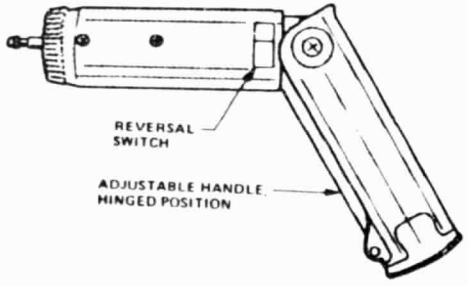
AUXILIARY SERVICES
TOOLS AND TOOL STOWAGE



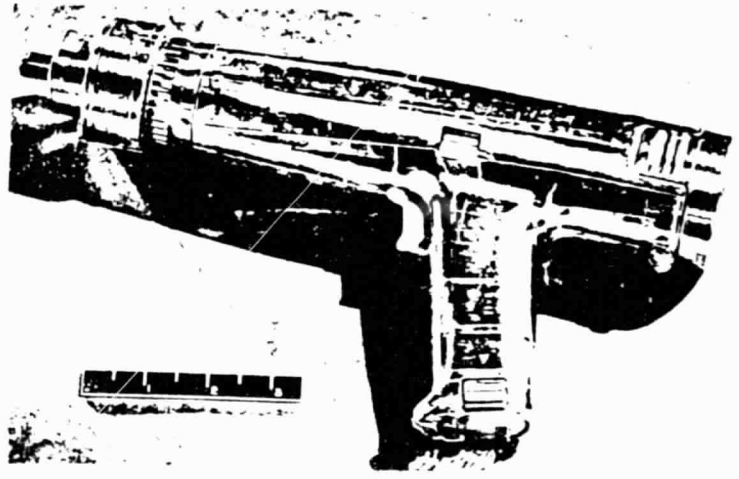
FLIGHT SUPPORT LOCKER



POWER RATCHET TOOL



BATTERY SCREWDRIVER



BATTERY POWER TOOL

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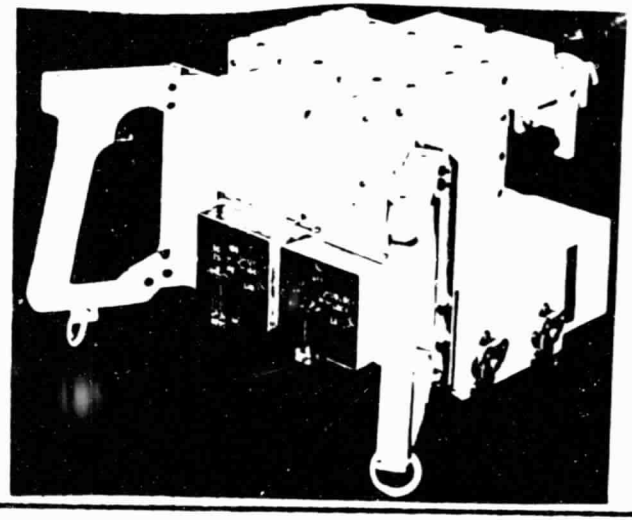
AUXILIARY SERVICES
TOOLS AND TOOL STOWAGE

POWERED SCREWDRIVER



MODULE SERVICE TOOL

SHUTTLE ERA SERVICING EQUIPMENT (CON'T)

THE FACING PAGE INDICATES (AS PREVIOUSLY STATED) THE IDENTIFIED SERVICING FUNCTIONS. THE LEFT HAND SIDE OF THE PAGE LISTS THOSE ITEMS WHICH ARE IDENTIFIED AS PAYLOAD RELATED SYSTEMS AND CARRIERS. AGAIN, THIS LIST COMES FROM THE SATELLITE SERVICES CATALOG, TOOLS AND EQUIPMENT. EACH EQUIPMENT OR SYSTEM WAS EXAMINED AND AN INDICATION GIVEN AS TO ITS APPLICABILITY (PRIMARY OR SECONDARY) FOR SERVICING. THE FOLLOWING THREE PAGES DEPICT SEVERAL OF THESE ITEMS FOR REFERENCE PURPOSES. IT SHOULD BE NOTED THAT SEVERAL ITEMS HAVE BEEN ADDED TO THE CATALOG LIST AS A MEANS OF EXPANDING THE POTENTIALLY AVAILABLE CONCEPTS/HARDWARE.

SHUTTLE ERA SERVICING EQUIPMENT (CONT)

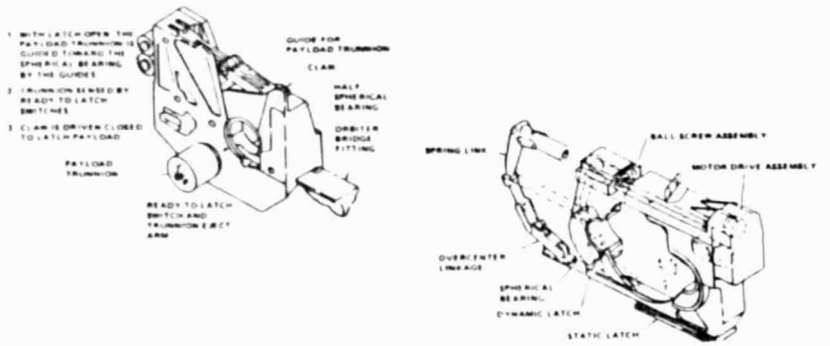
PAYLOAD RELATED SYSTEMS AND CARRIERS / SERVICING FUNCTIONS	INSPECT/EXAMINE AND ASSESS	SAFING	ORU CHANGEOUT: FAILED OR DEGRADED ITEM	ORU CHANGEOUT: NEW OR UPDATED ITEM	ORU CHANGEOUT: PREVENTIVE MAINT ITEM	CONSUMABLES REPLENISHMENT	RECONFIGURE	REPAIR	GENERAL SERVICE ENHANCEMENT	DEBRIS CAPTURE-CONTAINMENT AND TRANSFER	PREPARE ITEM FOR DE-ORBIT	CHECKOUT AND VERIFY	HANDLE/POSITION AND/OR TRANSFER	ORBITER PECULIAR
1. PAYLOAD RETENTION SYSTEMS (PRS)										•			•	•*
2. MULTIMISSION MODULAR SPACECRAFT FLIGHT SUPPORT SYSTEM (MMS/FSS)	X	X	X	X	X	X	X	?	X			X	•	
3. MISSION-PECULIAR EQUIPMENT SUPPORT STRUCTURE (MPESS)										•			•	
4. ADAPTIVE PAYLOAD CARRIER (APC)	•	•							•	X		•		•*
5. DEVELOPMENTAL FLIGHT INSTRUMENTATION (DFI) CARRIER										•			•	
6. ORBITAL FLIGHT TEST (OFT) PALLET										•			•	
7. GETAWAY SPECIAL (GAS) BEAM										X			•	•*
8. SPIN TABLE (PAM-A AND PAM-D)											•		•	
9. IUS AIRBORNE SUPPORT EQUIPMENT (IUS/ASE)											•		•	
10. ESA FULL PALLET										•			•	
11. ESA HALF PALLET										•			•	
12. LMSC ESS-2 PALLET										•			•	
13. ESA/SPAS MODULAR STRUCTURE										•			•	

*POTENTIAL OTHER 'ORBITAL BASE' APPLICATION, e.g., SURROGATE ORBITER CARGO BAY

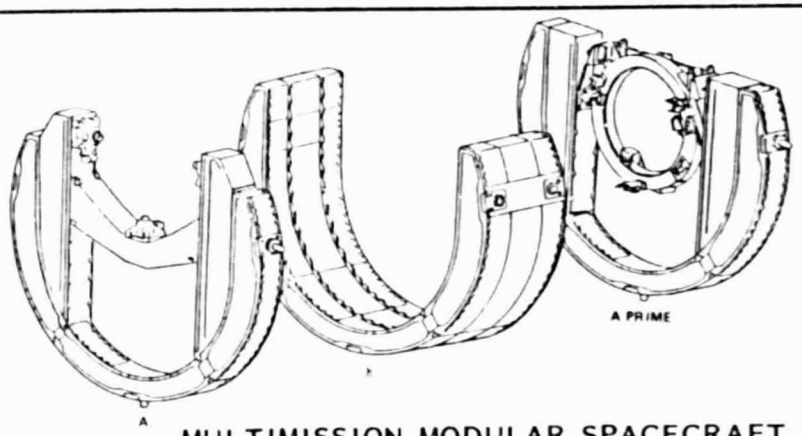
• = PRIMARY

X = SECONDARY

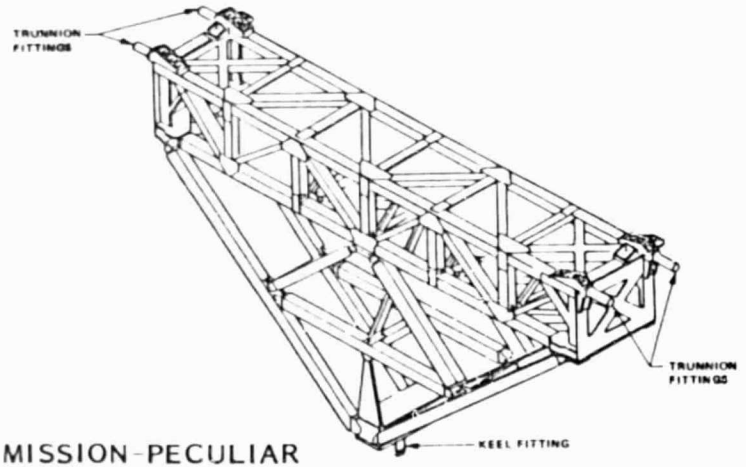
AUXILIARY SERVICES
PAYLOAD-RELATED SYSTEMS AND CARRIERS



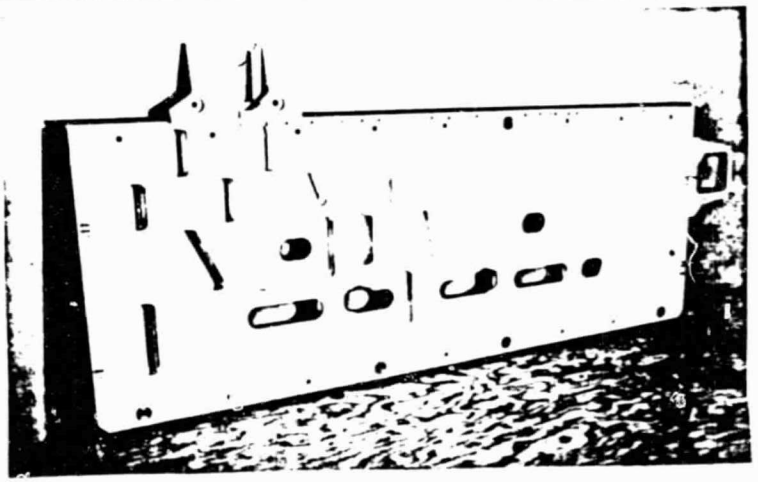
PAYLOAD RETENTION SYSTEMS



MULTIMISSION MODULAR SPACECRAFT FLIGHT SUPPORT SYSTEM



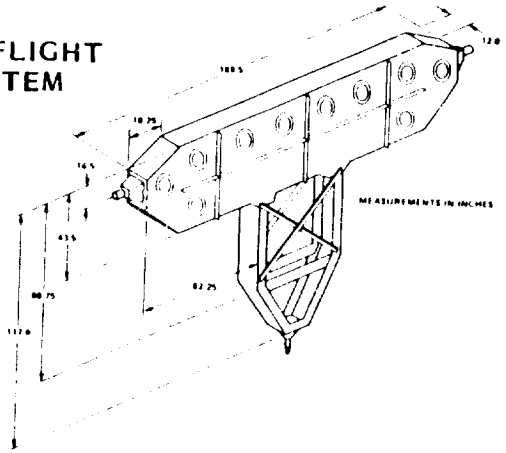
MISSION-PECULIAR EQUIPMENT SUPPORT STRUCTURE

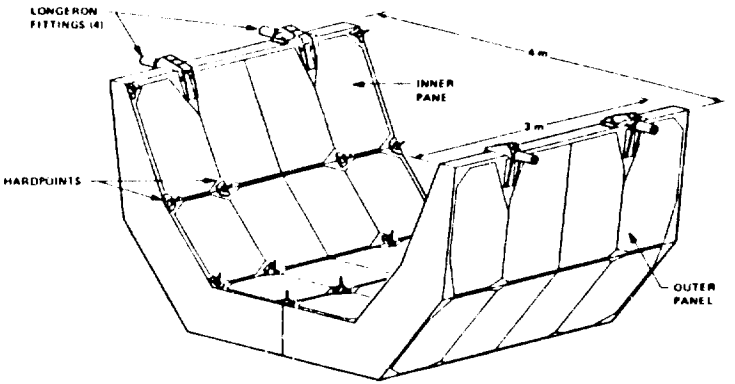


ADAPTIVE PAYLOAD CARRIER

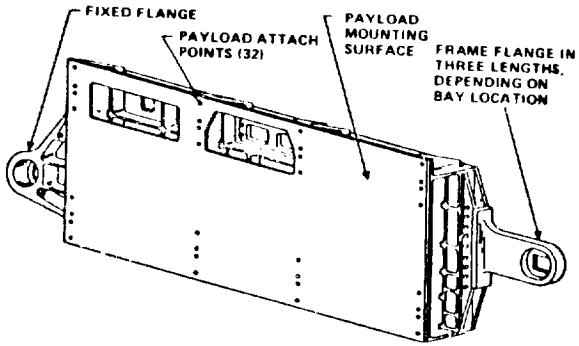
AUXILIARY SERVICES PAYLOAD RELATED SYSTEMS AND CARRIERS

DEVELOPMENT FLIGHT CARRIER SYSTEM

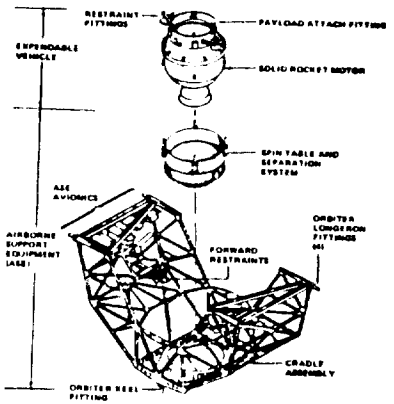




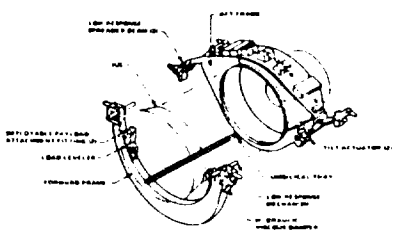
ORBITAL FLIGHT TEST PALLET



GETAWAY SPECIAL BEAM



SPIN TABLE



(IUS/ASE)

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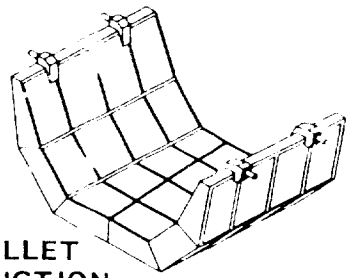
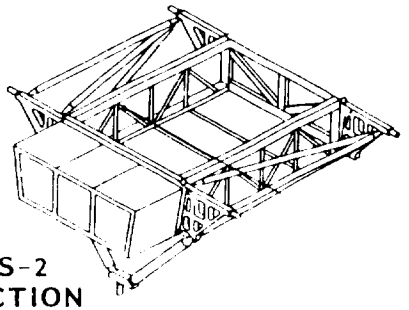
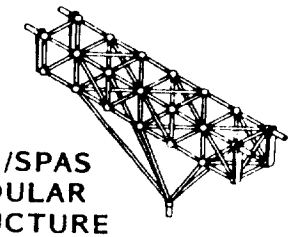
ALTERNATE MINIMUM CARRIERS



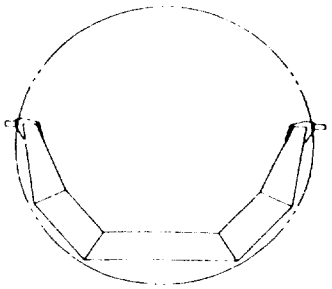
ESA PALLET
IN PRODUCTION

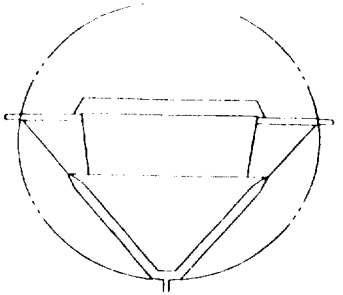


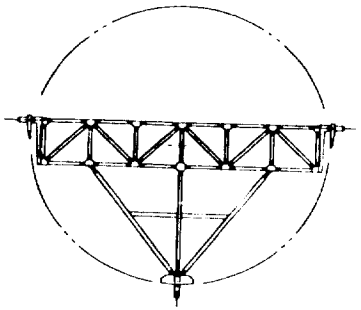
LMSC ESS-2
IN PRODUCTION

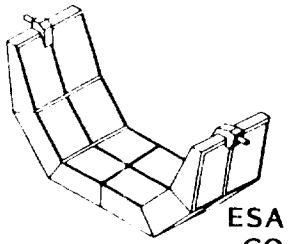


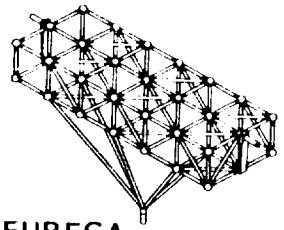
ESA/SPAS
MODULAR
STRUCTURE
IN PRODUCTION







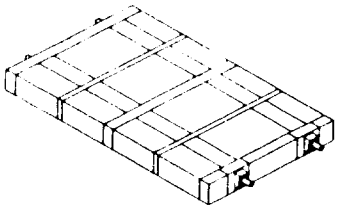




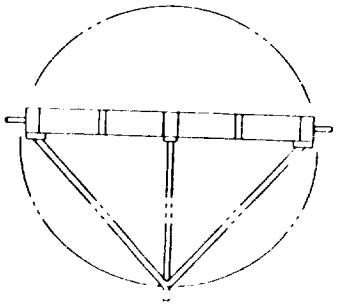
ESA EURECA
CONCEPTS

BAE 1/2 PALLET

MBB TWO-BAY TRUSS



LMSC FLATBED
CONCEPT



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SHUTTLE ERA SERVICING EQUIPMENT (CONT)

AS IN THE CASE OF THE PRECEEDING CHARTS, THE BASIC SERVICING FUNCTIONS ARE LISTED IN THE MATRIX (FACING PAGE) ACROSS THE TOP. ON THE LEFT ARE THOSE PROJECTED SATELLITE SERVICING EQUIPMENT ITEMS CURRENTLY IDENTIFIED AS SHUTTLE ERA SERVICING HARDWARE. IT SHOULD BE NOTED THAT MANY OF THESE ITEMS ARE NOT YET FUNDED OR ARE ONLY IN THE VERY EARLY STAGES OF STUDY OR BREADBOARD DEVELOPMENT. BOTH PRIMARY AND SECONDARY USES OF THESE ITEMS IS INDICATED. THE FOLLOWING FIVE PAGES ARE INCLUDED TO PROVIDE ILLUSTRATIONS OF MANY OF THESE CONCEPTS.

SHUTTLE ERA SERVICING EQUIPMENT (CONT)

PROJECTED SATELLITE SERVICING EQUIPMENT \ SERVICING FUNCTIONS	INSPECT/EXAMINE AND ASSESS	SAFING	ORU CHANGEOUT: FAILED OR DEGRADED ITEM	ORU CHANGEOUT: NEW OR UPDATED ITEM	ORU CHANGEOUT: PREVENTIVE MAINT ITEM	CONSUMABLES REPLENISHMENT	RECONFIGURE	REPAIR	GENERAL SERVICE ENHANCEMENT	DEBRIS CAPTURE-CONTAINMENT AND TRANSFER	PREPARE ITEM FOR DE-ORBIT	CHECKOUT AND VERIFY	HANDLE/POSITION AND/OR TRANSFER	ORBITER PECULIAR
1. ORBITAL REFUELING SYSTEM (ORS)						●					X			
2. HYDRAZINE SERVICING TOOL (HST) SET						●					X			
3. LIGHTING ENHANCEMENT KIT	●	●	●	●	●	●	●	●	●	●	●		●	
4. HANDLING AND POSITIONING AID (HPA) RMS BASED	X		●	●	●	●	●	?	●	X	X		●	
5. PAYLOAD INSTALLATION AND DEPLOYMENT AID (PIDA)										X			●	
6. PAYLOAD INTERFACE PANEL	●	●	X	X	X	●	X	?	X			●		
7. LASER DOCKING SYSTEM (LDS)										X			●	
8. VOICE COMMAND SYSTEM	●											●		
9. ZERO PREBREATHE EMU	●	●	●	●	●	●	●	●	●	●	●	●	●	
10. WORK RESTRAINT UNIT (WRU)	●	●	●	●	●		X	?	X	●	X		●	
11. PROXIMITY OPERATIONS VEHICLE (POV) – MANNED	●										X	●	●	
12. FORCE REFLECTING SPECIAL PURPOSE END EFFECTOR (FRSPEE) FOR ARMS							X		X	●			●	
13. ADVANCED SPACE MANIPULATORS FOR RMS							X		X	●			●	
14. SUN SHIELD	X	X	●	●	●	●	X	?	X		X			
15. NONCONTAMINATING ATTITUDE CONTROL SYSTEM (ACS)										●			●	
16. ORBITAL STORAGE ENCLOSURE	X	X	X	X	X	●	X	?	X	●	X	X	●	
17. DE-ORBIT PROPULSION PACKAGE											●			
18. TRASH REMOVER AND SATELLITE HAULER (TRASH 1)										●			●	
19. FLATBED PALLET						X				●			●	
20. DEPLOYMENT MAINTENANCE PLATFORM (DMP)	X		●	●	●	●	X		X	X			●	
21. REPLENISHMENT SERVICING UNIT (RSU)						●					●			
22. RECHARGE STATION FOR EMU		X				●						●		
23. RECHARGE STATION FOR MMU		X				●						●	●	

● = PRIMARY

X = SECONDARY

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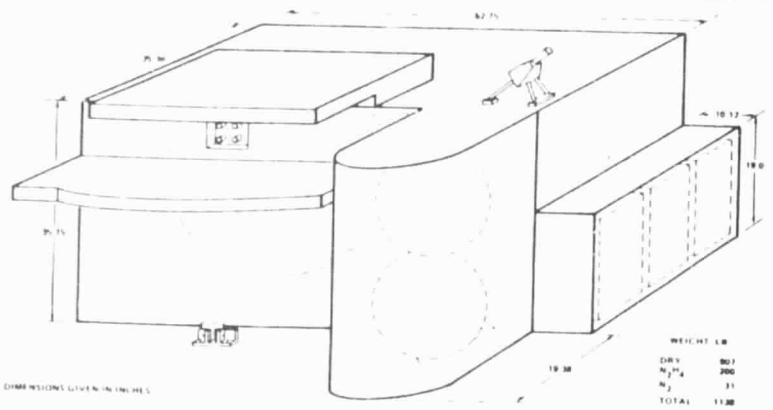
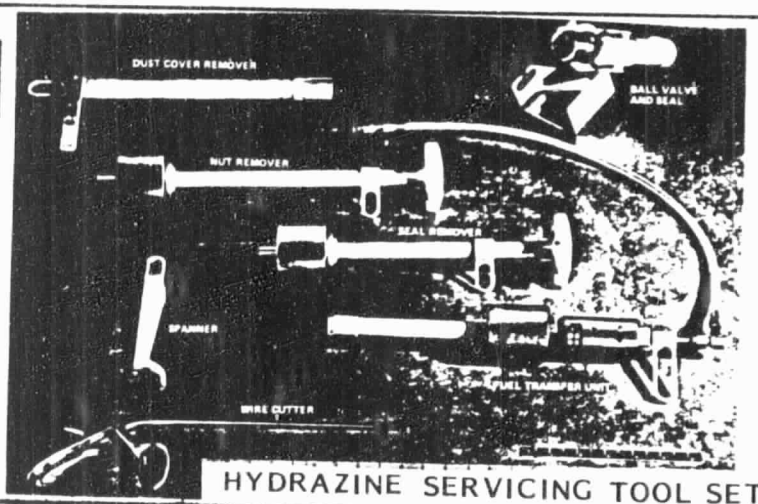
PROJECTED SATELLITE SERVICING CAPABILITIES



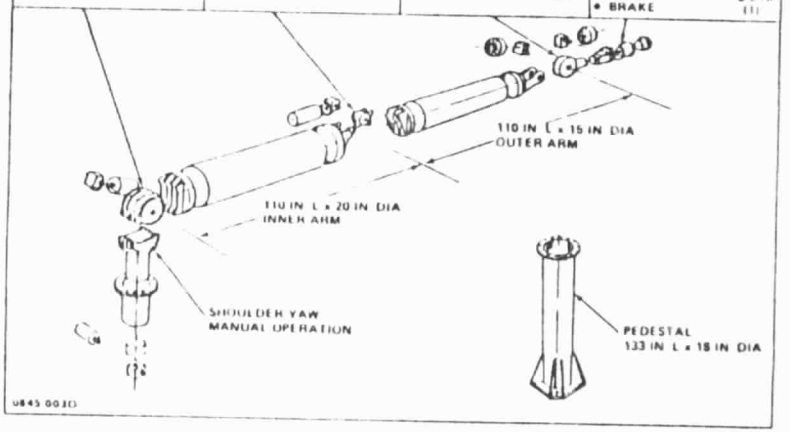
ORBITAL REFUELING SYSTEM



HYDRAZINE SERVICING TOOL SET

LIGHTING ENHANCEMENT

SHOULDER PITCH		ELBOW PITCH		WRIST PITCH		WRIST ROLL	
• MAIN GEAR (CW)	2534 1	• MAIN GEAR (NASA)	162 1	• MAIN GEAR (NASA)	768 1	• MAIN GEAR (CW)	102 1
• SECOND GEAR	5 1	• SECOND GEAR	50 1	• SECOND GEAR	15 1	• SECOND GEAR	10 1
• MOTOR	1 9 HP	• MOTOR	1 9 HP	• MOTOR	0 2 HP	• THIRD GEAR	10 1
• BRAKES	(2)	• BRAKE	(1)	• BRAKES	(2)	• MOTOR	0 2 HP
						• BRAKE	(1)



HANDLING AND POSITIONING AID

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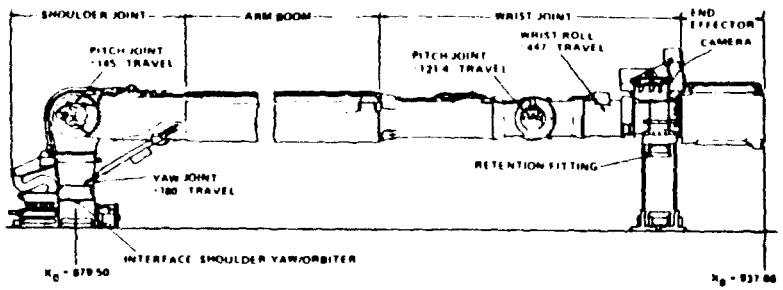
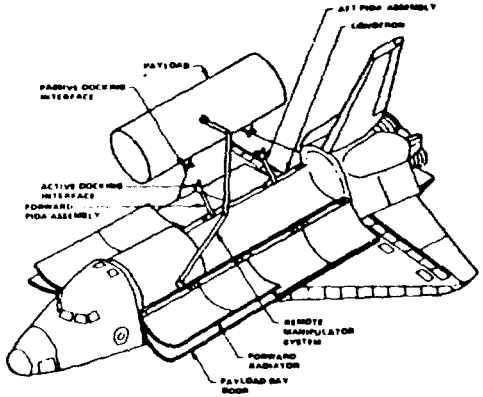
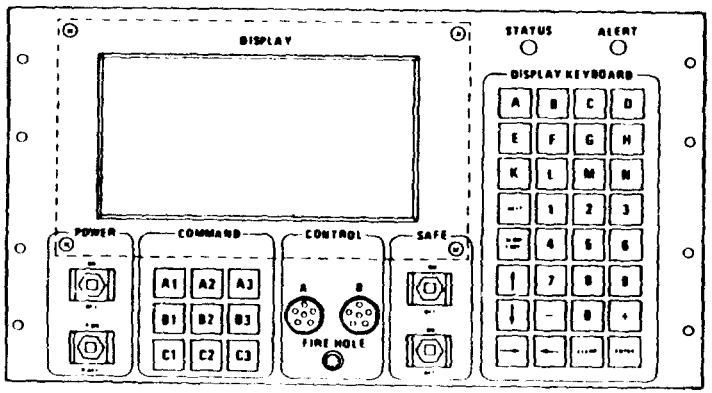
PROJECTED SATELLITE SERVICING CAPABILITIES



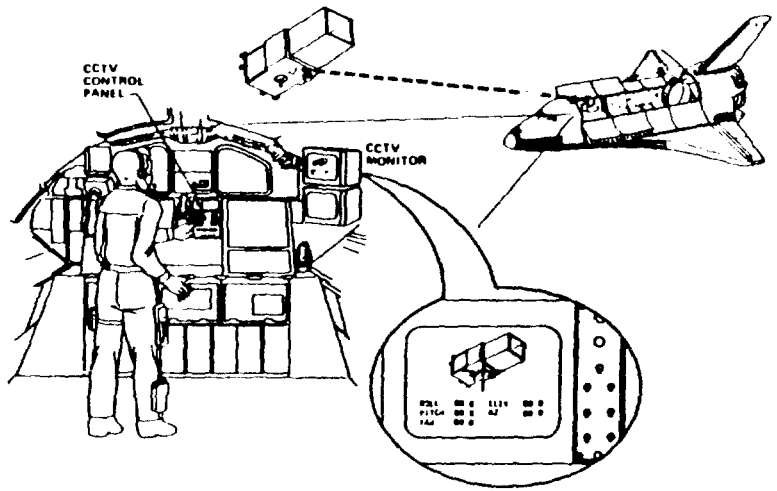
RMS-BASED HANDLING AND POSITIONING AID



PAYLOAD INSTALLATION AND DEPLOYMENT AID



PAYLOAD INTERFACE PANEL



LASER DOCKING SYSTEM

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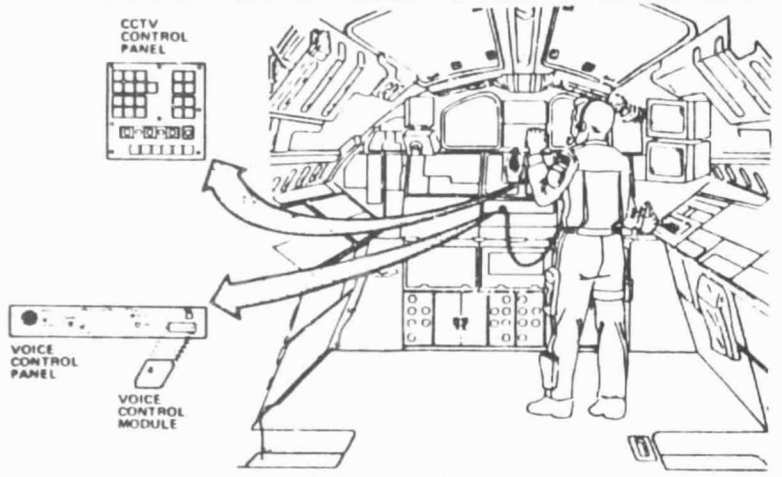
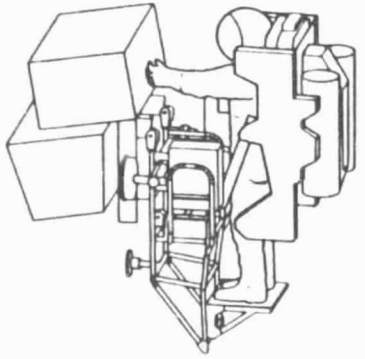
PROJECTED SATELLITE SERVICING CAPABILITIES

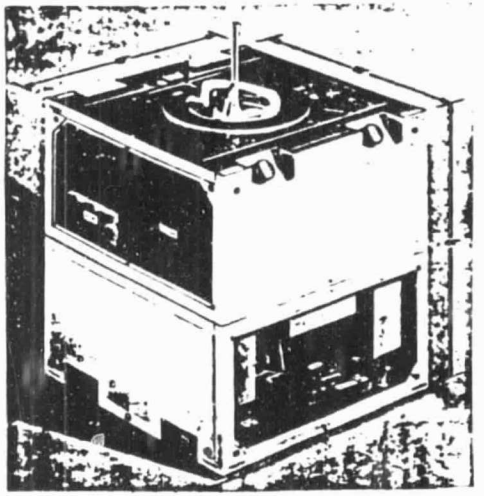


VOICE COMMAND SYSTEM

ZERO PREBREATHE EMU



WORK RESTRAINT UNIT



PROXIMITY OPERATIONS VEHICLE

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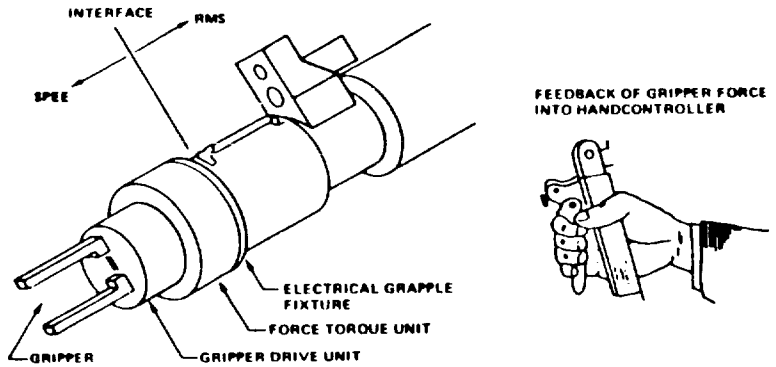
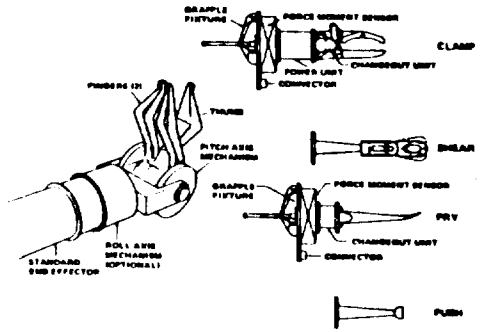
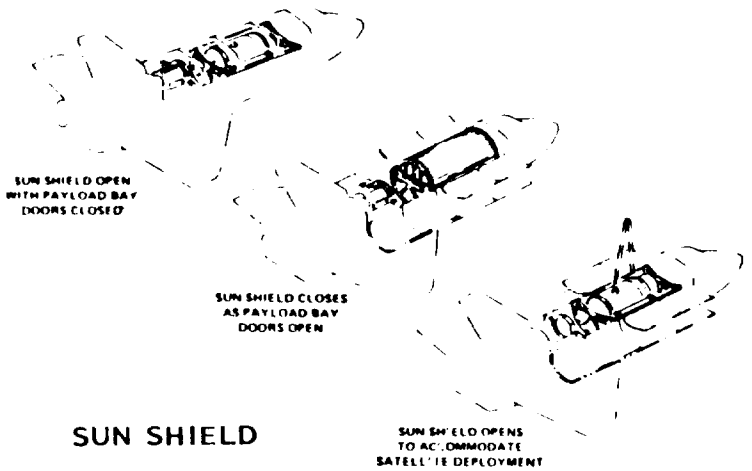
PROJECTED SATELLITE SERVICING CAPABILITIES



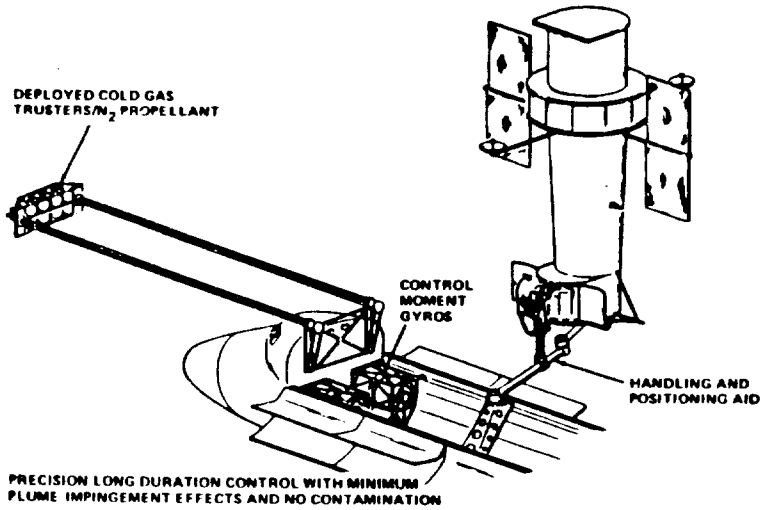
FORCE REFLECTING SPECIAL PURPOSE END EFFECTOR FOR RMS



ADVANCED SPACE MANIPULATORS FOR RMS

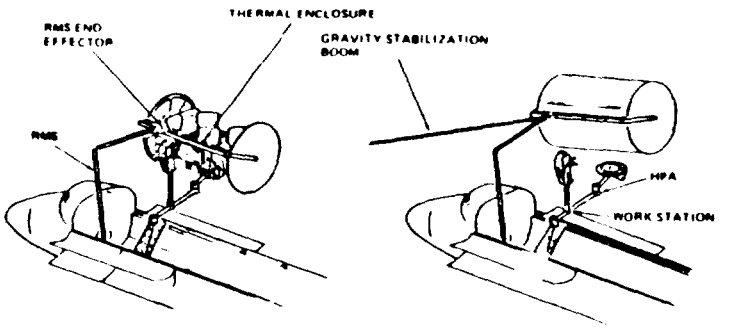


SUN SHIELD

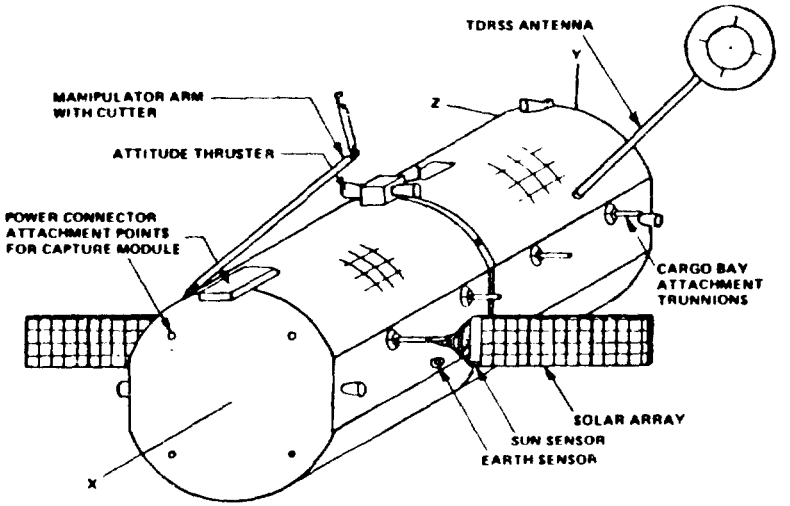


NONCONTAMINATING ATTITUDE CONTROL SYSTEM

PROJECTED SATELLITE SERVICING CAPABILITIES



ORBITAL STORAGE ENCLOSURE



TRASH REMOVER AND SATELLITE HAULER

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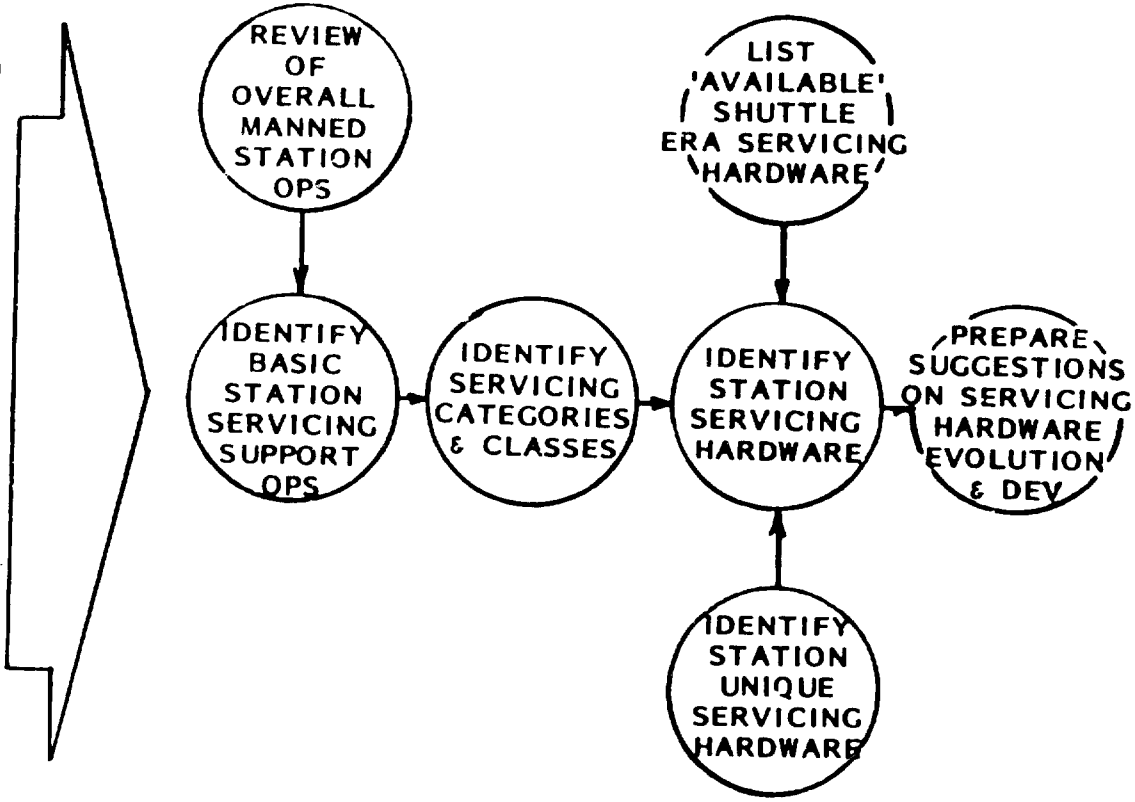
STATION SERVICED ELEMENTS-
DATA BASE

MISSION HARDWARE MODEL AND STATION SERVICING HARDWARE

AS IDENTIFIED EARLIER, A NUMBER OF STATION ERA SPACECRAFT, PLATFORMS, ASSEMBLIES, ETC. ARE POSTULATED AND/OR WILL EVOLVE FROM CURRENT PROGRAMS, E.G., SPACELAB TYPE LABORATORIES. ACCORDINGLY, THIS LIST OF TYPICAL CLASSES OF SPACECRAFT WAS USED AS THE BASIS FOR THE MISSION SERVICING HARDWARE MODEL AND FROM THIS MODEL THE SERVICING HARDWARE ASSOCIATED WITH THE STATION HAS BEEN IDENTIFIED. THE FACING PAGE ILLUSTRATES THE PROCESS USED IN THE FURTHER IDENTIFICATION AND CATEGORIZATION OF THIS SERVICING HARDWARE FOR THE STATION.

MISSION HARDWARE MODEL AND STATION SERVICING HARDWARE

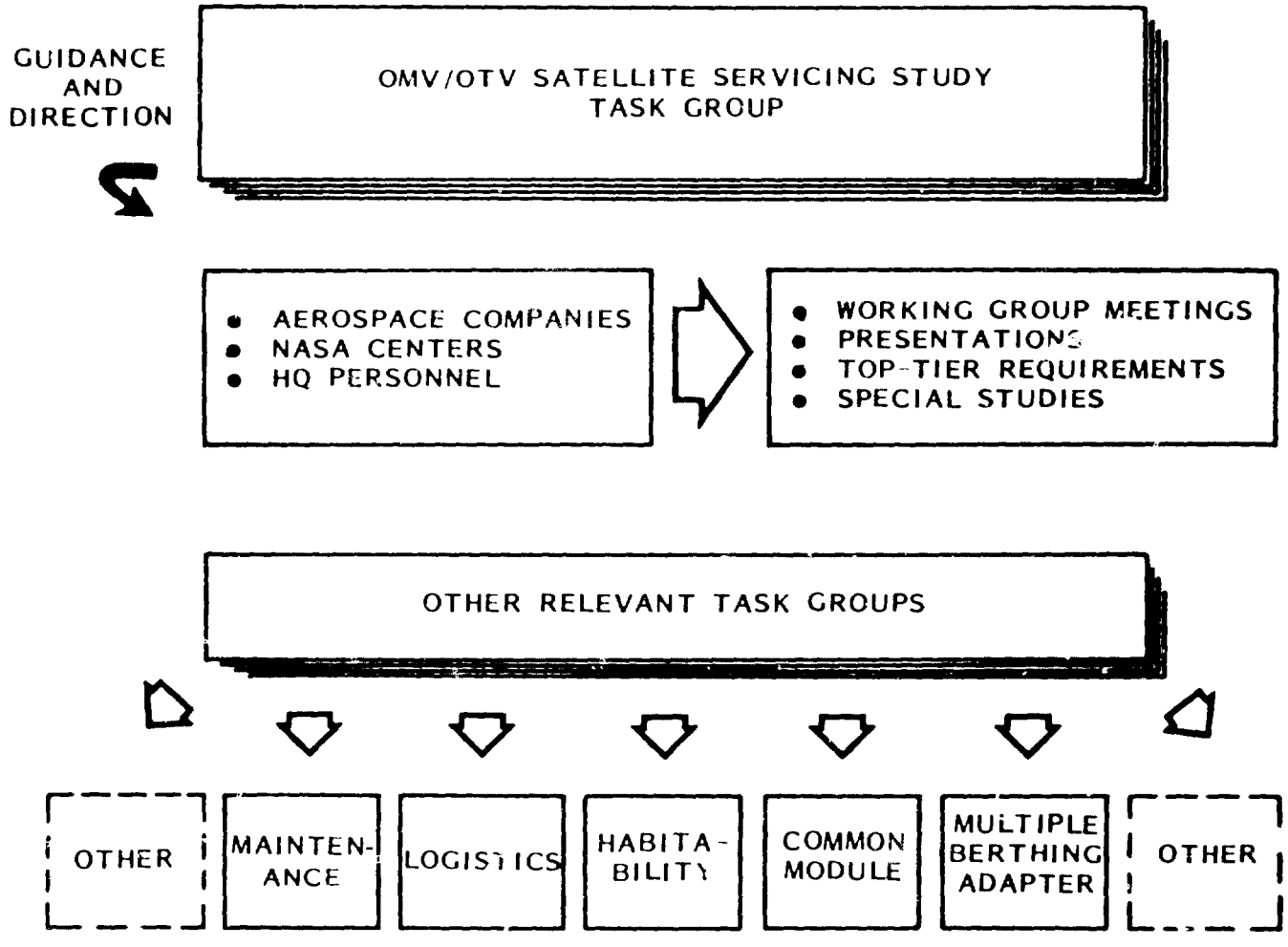
- ORBITING NATIONAL CMD POST
- OCEANOGRAPHIC LABORATORY
- SPACE OBSER DEV LAB
- EARTH HAB OBSER LAB
- CELESTIAL OBSERVATORY
- SPACE ENVIRON FACILITY
- EARTH OBSER FACILITY
- MATERIAL PROCESS REC LAB
- MATERIAL PROCESS FACILITY
- METEOROLOGICAL FACILITY
- SPACE OBJECTS IDENT SYS
- LEO SERVICED SATELLITE
- MID-HEO SERVICED SAT
- ASTRONOMY PLTFM SERVICING
- LARGE SPACECRAFT ASSY



STUDY RELEVANT NASA HQ CDG ACTIVITIES

PERTINENT TO THIS STUDY WAS THE PRESENT 1983 LATTER YEAR SPACE STATION ACTIVITY ON-GOING AT NASA-HDQ RELATIVE TO THE CONCEPT DEFINITION GROUP. IN PARTICULAR, THE OMV/OTV SATELLITE SERVICING STUDY TASK GROUP HAS BEEN WORKING AS A NASA AND INDUSTRY TEAM TO FURTHER IDENTIFY AND DEFINE THE CANDIDATE SERVICING NEEDS MADE AVAILABLE BY THE STATION FOR THE VARIETY OF CANDIDATE SERVICING MISSIONS. THE OPPOSITE PAGE ATTEMPTS TO PORTRAY THE ACTIVITIES OF THIS GROUP AND THE INTERRELATIONSHIP OF THIS GROUP WITH OTHER STATION CDG TASK GROUPS. ATTENDANCE BY LOCKHEED EMPLOYEES AT THESE TASK GROUP MEETINGS PERMITTED SALIENT FEATURES OF THE TEAMS ACTIVITIES TO BE FOCUSED ON THE STUDY REPORTED HEREIN.

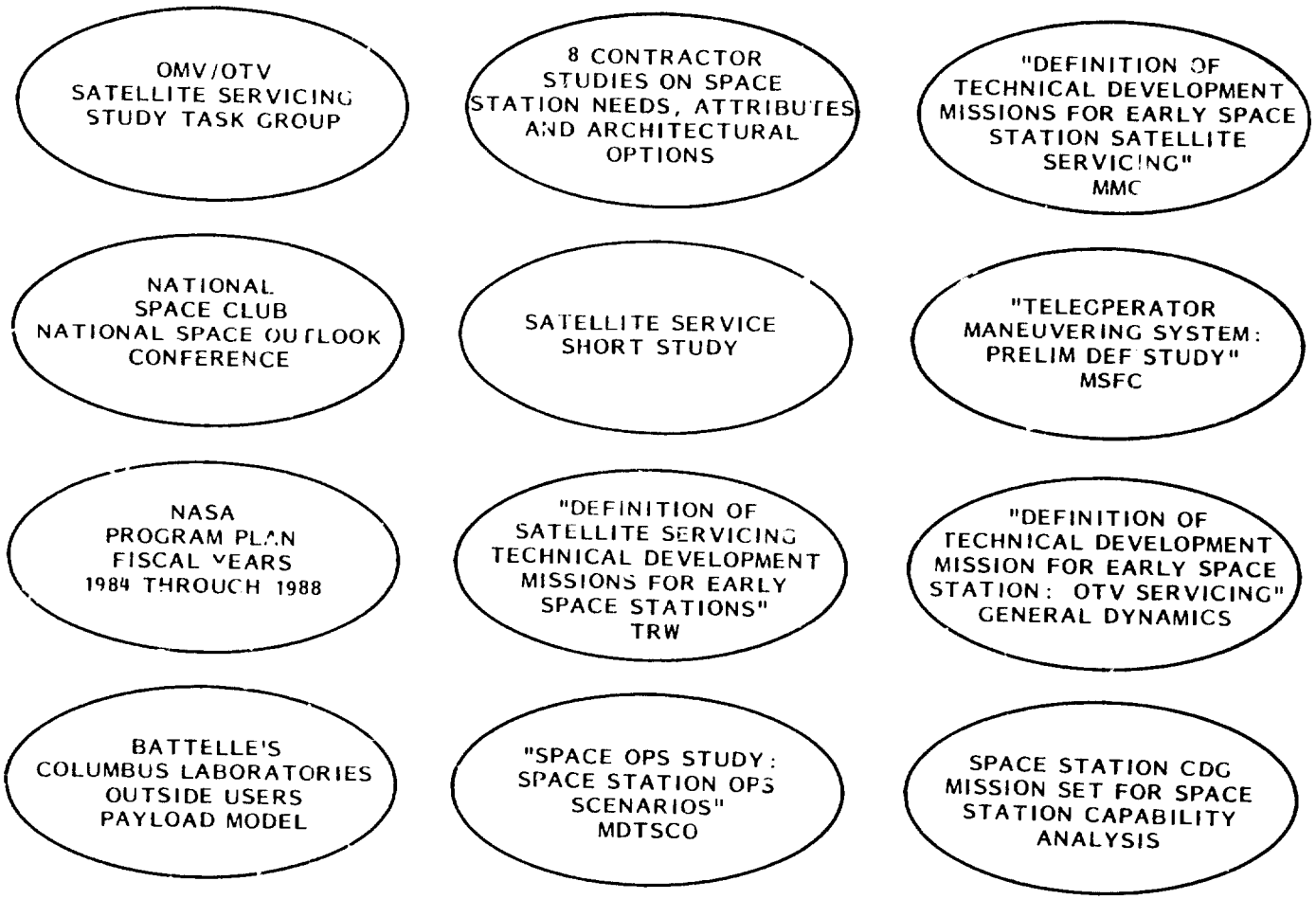
STUDY RELEVANT NASA HQ CDG ACTIVITIES



MISSION MODEL SPACECRAFT SOURCES (REPRESENTATIVE)

ELEMENTAL TO THIS STUDY WAS THE NEED TO EXAMIN 'THE MISSION MODEL' AS DEVELOPED TO DETERMINE THE VARIOUS SPACECRAFT OR ASSEMBLIES/PLATFORMS WHICH WOULD BE PLANNED FOR IN THE STATION ERA. HOWEVER, AS INDICATED ON THE FACING PAGE, THERE WAS NO ONE SINGLE MISSION MODEL WHICH CONTAINED A COMPLETE LIST - NOR FOR THAT MATTER IS THERE A LIST WHICH IS CONSIDERED 'APPROVED'. THUS, A NUMBER OF SOURCES WERE EXAMINED AND ARE INDICATED AS SOURCE DOCUMENTATION FOR THIS STUDY. THE RESULTANT CONCLUSION REACHED AFTER REVIEWING THE MANY SOURCES WAS THAT A LIST WOULD HAVE TO BE GENERATED FOR THIS STUDY. IT IS RECOGNIZED THAT THIS IS A COMPOSITE SET OF SPACECRAFT OR ASSEMBLIES/PLATFORMS, AND AS SUCH NO BETTER THAN ANY OTHER LIST. HOWEVER, IT WAS DEEMED NECESSARY TO PREPARE SUCH A LIST IF FOR NO OTHER REASON THAT SIMPLE TRACEABILITY. THIS LIST WILL BE PRESENTED IN SUBSEQUENT CHARTS.

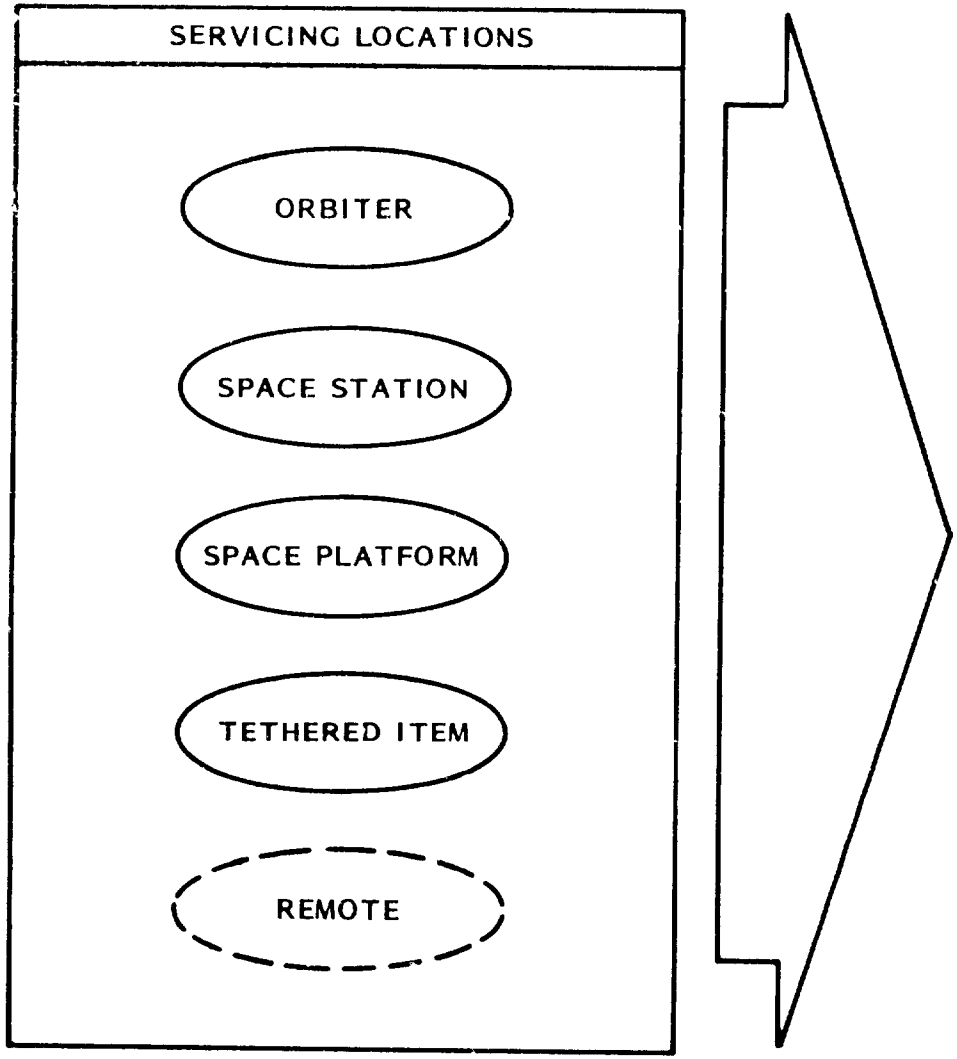
MISSION MODEL SPACECRAFT SOURCES (REPRESENTATIVE)



SERVICING LOCATIONS AND FUNCTIONS

ONCE THE MISSION MODELS HAD BEEN REVIEWED THE NEXT STEP WAS TO DETERMINE THE SERVICING LOCATIONS AND ASSOCIATED FUNCTIONS. THE FACING PAGE CHART INDICATES THE FIVE BASIC SERVICING LOCATIONS AND THE STANDARD SERVICE FUNCTIONS (IDENTIFIED HEREIN) FOR THOSE SERVICING 'BASES'. IT MUST BE CAREFULLY NOTED THAT THE SERVICING LOCATIONS MAY NOT ALL BE IN THE SAME ORBIT (INCLINATION AND/OR ALTITUDE), THUS, SERVICING HARDWARE/SYSTEMS WILL VARY ACCORDINGLY. SPACE LAUNCH AND ASSEMBLY/CONSTRUCTION WERE NOT CONSIDERED IN THIS PARTICULARLY STUDY ONLY DUE TO TIME AND RESOURCE LIMITATIONS.

SERVICING LOCATIONS AND FUNCTIONS



SERVICE FUNCTIONS

- INSPECT, EXAMINE, AND ASSESS
- SAFING
- ORU CHANGEOUT
- RECONFIGURE
- REPAIR
- GENERAL SERVICE ENHANCEMENT
- DEBRIS CAPTURE, CONTAINMENT, AND TRANSFER
- PREPARE ITEM FOR DE-ORBIT
- CHECKOUT AND TRANSFER
- HANDLE/POSITION AND/OR TRANSFER
- CONSUMABLES REPLENISHMENT

- DEDICATED SERVICING
- ENVIRONMENTAL PROTECTION
- STAGE ASSEMBLY

NOT CONSIDERED IN STUDY

- SPACE LAUNCH
- ASSEMBLY AND CONSTRUCTION

SERVICING CANDIDATES- STATION ERA

CANDIDATE SPACECRAFT, SATELLITES, PLATFORMS, WERE DERIVED FROM THE MISSION MODEL DATA BASE. THE NEXT TWO PAGES PRESENTS AN ALPHABETICAL LISTING OF THESE ELEMENTS.

SERVICING CANDIDATES - STATION ERA

ADVANCED COMMUNICATION SATELLITE III
ADVANCED SOLAR OBSERVATORY
ADVANCED TIROS
ADVANCED X-RAY ASTROPHYSICS FACILITY
ASTRONOMY/SOLAR PHYSICS PLATFORM
CELESTIAL OBSERVATORY
CENTAUR CLASS COMMUNICATION SATELLITE
CLOSED ENVIRONMENTAL/LIFE SUPPORT PALLET
COMET HMP RENDEZVOUS
COMMUNICATIONS TEST LABORATORY
CORONAL DIAGNOSTIC MISSION
COSMIC BACKGROUND EXPLORER
DEPLOYABLE ANTENNA III
ERBS
EARTH OBSERVATION FACILITY
EXPERIMENTAL GEO PLATFORM
EXPLORER A
FAR UV SPECTROSCOPY EXPLORER
GOES
GOES FOLLOW-ON
GALILEO
GAMMA RAY OBSERVATORY
GEOPOTENTIAL RESEARCH MISSION
IUS CLASS COMMUNICATION SATELLITE
INTERNATIONAL SOLAR POLAR MISSION
ISTO/ASO PLATFORM
LANDSAT D
LARGE DEPLOYABLE REFLECTOR
LIDAR FACILITY
LARGE SOLAR OBSERVATORY
LUNAR GEOSCIENCE ORBITER
MAPSAT
MAIN-BELT ASTEROID RENDEZVOUS
MARS GEOSCIENCE CLIMATOLOGICAL ORBITER
MARS SAMPLE RETURN MISSION
MATERIALS PROCESSING PLATFORM
MULTILINEAR ARRAY STEREO PLATFORM
NOAA F/O
NATIONAL OCEANIC SATELLITE SYSTEM
NEAR-EARTH ASTEROID RENDEZVOUS
OOXA
ORBITAL TRANSFER VEHICLE – UNMANNED
ORBITAL TRANSFER VEHICLE – MANNED
ORBITING ASTRONOMICAL OBSERVATORY

SERVICING CANDIDATES - STATION ERA (CONT)

ORBITING NATIONAL COMMAND POST
PAM-A CLASS COMMUNICATION SATELLITE
PAM-D CLASS COMMUNICATION SATELLITE
PINHOLE OCCULTER FACILITY
PLASMA TURBULENCE EXPLORER
POLAR ASTRO PLATFORM
POLAR EARTH OBSERVATION PLATFORM
ROSAT
RADAR RESEARCH MISSION
SATURN ORBITER
SATURN PROBE
SOLAR CORONA EXPLORER
SOLAR CORONAL SOUNDER
SOLAR DYNAMICS OBSERVATORY
SOLAR INTERNAL DYNAMICS OBSERVATORY
SOLAR OPTICAL TELESCOPE
SPACE ENVIRONMENT FACILITY
SPACE OBJECTS IDENTIFICATION SYSTEM
SPACE TELESCOPE
STAR PROBE
STARLAB
SUN SYNCHRONOUS SIRTF
TITAN PROBE
UPPER ATMOSPHERIC RESEARCH SATELLITE
VENUS ATMOSPHERE PROBE
X-RAY TIMING EXPLORER

STATION ERA SERVICING CANDIDATES

THE FACING PAGE PORTRAYS THE POTENTIAL SERVICING FUNCTIONS FOR EACH OF THE AFOREMENTIONED SPACECRAFT IDENTIFIED ON THE PRECEDING PAGES. ACROSS THE TOP IS A SIMPLIFIED LIST OF SERVICING FUNCTIONS DERIVED FROM THE STANDARD LIST USED THROUGHOUT THIS STUDY. EACH OF THE CANDIDATE STATION ERA (AND OR LATE 1980' SYSTEMS) IS IDENTIFIED TO THE LEFT. A VERY PRELIMINARY INDICATION AS TO THE POTENTIAL SERVICING FUNCTIONS FOR EACH SPACECRAFT OR ASSEMBLY/PLATFORM MISSION MODEL ITEM HAS BEEN TENTATIVELY NOTED. IN SOME INSTANCES, NO DEFINITION OF THE SPACECRAFT OR ASSEMBLY/PLATFORM COULD BE FOUND (THAT IS NOT TO SAY IT DID NOT EXIST SOMEWHERE!). THUS, EXTREME CAUTION MUST BE EXERCISED IN THE INTERPRETATION AND USE OF THE VERY PRELIMINARY IDENTIFICATION EVALUATION. THE NEXT TWO PAGES PROVIDE THE BASIC LISTING OF SPACECRAFT AND ASSEMBLIES/PLATFORMS FOR WHICH THIS IDENTIFICATION EFFORT WAS CONDUCTED.

STATION ERA SERVICING CANDIDATES

TENTATIVE

SERVICE FUNCTIONS (SELECTED) / CANDIDATE ITEMS TO BE SERVICED	CHECKOUT LAUNCH AND CONTROL	CONSUMABLE REPLENISH-MENT	ORU CHANGEOUT	RETRIEVE	SAFE FOR EARTH RETURN	RECONFIGURE	REPAIR
ADVANCED COMMUNICATION SATELLITE III	•						
ADVANCED SOLAR OBSERVATORY	•	•	o				
ADVANCED TIROS	•						
ADVANCED X-RAY ASTROPHYSICS FACILITY	•	•	•	•			•
ASTRONOMY/SOLAR PHYSICS PLATFORM	•	•	•	•			
CELESTIAL OBSERVATORY	•	•	•	•			•
CENTAUR CLASS COMMUNICATION SATELLITE	•						
CLOSED ENVIRONMENTAL/LIFE SUPPORT PALLET		•	•				
COMET HMP RENDEZVOUS	•						
COMMUNICATIONS TEST LABORATORY			•	•			•
CORONAL DIAGNOSTIC MISSION	•						
COSMIC BACKGROUND EXPLORER	•						•
DEPLOYABLE ANTENNA III	•	•	•				•
ERBS	•		•	•		•	•
EARTH OBSERVATION FACILITY	•	•	•				
EXPERIMENTAL GEO PLATFORM	•	•	•				
EXPLORER A	•						
FAR UV SPECTROSCOPY EXPLORER	•		•	•			•
GOES	•						
GOES FOLLOW-ON	•						
GALILEO	•						
GAMMA RAY OBSERVATORY	•	•		•		•	•
GEOPOTENTIAL RESEARCH MISSION	•						

STATION ERA SERVICING CANDIDATES (CONT)

TENTATIVE

SERVICE FUNCTIONS (SELECTED) / CANDIDATE ITEMS TO BE SERVICED	CHECKOUT LAUNCH AND CONTROL	CONSUMABLE REPLENISHMENT	ORU CHANGEOUT	RETRIEVE	SAFE FOR EARTH RETURN	RECONFIGURE	REPAIR
IUS CLASS COMMUNICATION SATELLITE	•						
INTERNATIONAL SOLAR POLAR MISSION	•						
ISTO/ASO PLATFORM	•						
LANDSAT D	•						
LARGE DEPLOYABLE REFLECTOR	•						
LIDAR FACILITY	•						
LARGE SOLAR OBSERVATORY	•					•	•
LUNAR GEOSCIENCE ORBITER	•						
MAPSAT	•						
MAIN-BELT ASTEROID RENDEZVOUS	•						
MARS GEOSCIENCE CLIMATOLOGICAL ORBITER	•						
MARS SAMPLE RETURN MISSION	•				•		
MATERIALS PROCESSING PLATFORM	•	•	•				•
MULTILINEAR ARRAY STEREO PLATFORM	•						
NOAA F/O	•						
NATIONAL OCEANIC SATELLITE SYSTEM	•						
NEAR-EARTH ASTEROID RENDEZVOUS	•						
OOXA	•						
BITAL TRANSFER VEHICLE – UNMANNED	•	•	•	•	•	•	•
ORBITAL TRANSFER VEHICLE – MANNED	•	•	•	•	•	•	•
ORBITING ASTRONOMICAL OBSERVATORY	•	•	•			•	•
ORBITING NATIONAL COMMAND POST	•	•	•			•	•
PAM-A CLASS COMMUNICATION SATELLITE	•						

STATION ERA SERVICING CANDIDATES (CONT)

TENTATIVE

SERVICE FUNCTIONS (SELECTED) / CANDIDATE ITEMS TO BE SERVICED	CHECKOUT LAUNCH AND CONTROL	CONSUMABLE REPLENISHMENT	ORU CHANGEOUT	RETRIEVE	SAFE FOR EARTH RETURN	RECONFIGURE	REPAIR
PAM D CLASS COMMUNICATION SATELLITE	•						
PINHOLE OCCULTER FACILITY	•					•	
PLASMA TURBULENCE EXPLORER	•						
POLAR ASTRO PLATFORM	•						
POLAR EARTH OBSERVATION PLATFORM	•						
ROSAT	•						
RADAR RESEARCH MISSION	•						
SATURN ORBITER	•						
SATURN PROBE	•						
SOLAR CORONA EXPLORER	•						
SOLAR CORONAL SOUNDER	•						
SOLAR DYNAMICS OBSERVATORY	•						
SOLAR INTERNAL DYNAMICS OBSERVATORY	•						
SOLAR OPTICAL TELESCOPE	•	•		•		•	
SPACE ENVIRONMENT FACILITY	•	•	•			•	
SPACE OBJECTS IDENTIFICATION SYSTEM	•	•	•	•	•		
SPACE TELESCOPE	•	•	•	•	•	•	
STAR PROBE	•						
STARLAB	•	•	•				
SUN SYNCHRONOUS SIRTF	•	•	•	•			•
TITAN PROBE	•						
UPPER ATMOSPHERIC RESEARCH SATELLITE	•	•	•	•	•		
VENUS ATMOSPHERE PROBE	•						
X RAY TIMING EXPLORER	•						

SERVICING MISSION CLASSES

IT WAS DEEMED APPROPRIATE TO IDENTIFY THE SERVICING LOCATION FOR EACH OF THE PREVIOUSLY IDENTIFIED SPACECRAFT OR ASSEMBLIES/PLATFORMS. THUS, ON THE FACING AND FOLLOWING TWO PAGES, SERVICING LOCATION ESTIMATES ARE MADE FOR THE VARIETY OF SPACECRAFT. AGAIN, CAUTION MUST BE EXERCISED IN THE INTERPRETATION OF THE SERVICING LOCATION ALLOCATIONS SINCE IN MANY CASES THERE WAS LITTLE TO NO DATA AVAILABLE ON SEVERAL SPACECRAFT AS TO IDENTIFY IT'S ORBIT OR EVEN IF IT WERE A PLANETARY MISSION. ALSO, TIME FRAME ESTIMATES AS TO WHEN EACH MAY BE ACHIEVING AN IOC HAS BEEN ATTEMPTED RECOGNIZING THE SAME CAUTIONS MUST BE OBSERVED.

SERVICING MISSION CLASSES

CANDIDATE SPACECRAFT/ITEMS TO BE SERVICED / SERVICING LOCATION	FREE FLYERS			STATION ATTACHED		PLATFORM ATTACHED	STATION LAUNCHED (NO SERVICE)	INITIAL FLIGHT TIME FRAME
	LEO	GEO OR HEO	POLAR	EV MTD	IV LOCATED			
ADVANCED COMMUNICATION SATELLITE III		•						
ADVANCED SOLAR OBSERVATORY	•							1999
ADVANCED TIROS		•						
ADVANCED X RAY ASTROPHYSICS FACILITY	•							1991
ASTRONOMY/SOLAR PHYSICS PLATFORM	•							1995
CELESTIAL OBSERVATORY	•							1992
CENTAUR CLASS COMMUNICATION SATELLITE		•					•	1994
CLOSED ENVIRONMENTAL/LIFE SUPPORT PALLET					•			1993
COMET HMP RENDEZVOUS							•	1990
COMMUNICATIONS TEST LABORATORY					•			1993
CORONAL DIAGNOSTIC MISSION					•			1999
COSMIC BACKGROUND EXPLORER	•							1993
DEPLOYABLE ANTENNA III	•							?
ERBS	•							
EARTH OBSERVATION FACILITY					•			1996
EXPERIMENTAL GEO PLATFORM		•						1994
EXPLORER A							•	?
FAR UV SPECTROSCOPY EXPLORER	•							1993
GOES		•						?
GOES FOLLOW ON		•						1996
GALILEO							•	1990's
GAMMA RAY OBSERVATORY	•							1988
GEOPOTENTIAL RESEARCH MISSION			•					1991

SERVICING MISSION CLASSES (CONT)

SERVICING LOCATION / CANDIDATE SPACECRAFT/ITEMS TO BE SERVICED	FREE FLYERS			STATION ATTACHED		PLATFORM ATTACHED	STATION LAUNCHED (NO SERVICE)	INITIAL FLIGHT TIME FRAME
	LEO	GEO OR HEO	POLAR	MTD	IV LOCATED			
IUS CLASS COMMUNICATION SATELLITE		•					•	1994
INTERNATIONAL SOLAR POLAR MISSION			•					1985
ISTO/ASO PLATFORM	•							1994
LANDSAT D	•							1988
LARGE DEPLOYABLE REFLECTOR	•			?		?		1998
LIDAR FACILITY	•			?		?		1991
LARGE SOLAR OBSERVATORY	•							1990
LUNAR GEOSCIENCE ORBITER							•	1993
MAPSAT			•					
MAIN-BELT ASTEROID RENDEZVOUS							•	1997
MARS GEOSCIENCE CLIMATOLOGICAL ORBITER							•	1990
MARS SAMPLE RETURN MISSION							•	1999
MATERIALS PROCESSING PLATFORM	•							1996
MULTILINEAR ARRAY STEREO PLATFORM			•					1991
NOAA F/O			•					
NATIONAL OCEANIC SATELLITE SYSTEM	•							1989
NEAR EARTH ASTEROID RENDEZVOUS							•	1997
OOXA	•							
ORBITAL TRANSFER VEHICLE - UNMANNED				•				1991
ORBITAL TRANSFER VEHICLE - MANNED				•				1991
ORBITING ASTRONOMICAL OBSERVATORY	•							
ORBITING NATIONAL COMMAND POST	•							1995
PAM A CLASS COMMUNICATION SATELLITE		•					•	1994

SERVICING MISSION CLASSES (CONT)

CANDIDATE SPACECRAFT/ITEMS TO BE SERVICED \ SERVICING LOCATION	FREE FLYERS			STATION ATTACHED		PLATFORM ATTACHED	STATION LAUNCHED (NO SERVICE)	INITIAL FLIGHT TIME FRAME
	LEO	GEO OR HEO	POLAR	EV MTD	IV LOCATED			
PAM D CLASS COMMUNICATION SATELLITE		•						1994
PINHOLE OCCULTER FACILITY	•			?	?			1997
PLASMA TURBULENCE EXPLORER		•						
POLAR ASTRO PLATFORM			•					2002
POLAR EARTH OBSERVATION PLATFORM			•					1998
ROSAT			•					
RADAR RESEARCH MISSION	•							
SATURN ORBITER							•	1998
SATURN PROBE							•	1998
SOLAR CORONA EXPLORER	•							1992
SOLAR CORONAL SOUNDER							•	1995
SOLAR DYNAMICS OBSERVATORY			•					1991
SOLAR INTERNAL DYNAMICS OBSERVATORY			•					1986
SOLAR OPTICAL TELESCOPE	•			?	?	?		1993
SPACE ENVIRONMENT FACILITY	•			•				1993
SPACE OBJECTS IDENTIFICATION SYSTEM	•							1995
SPACE TELESCOPE	•							1996
STAR PROBE		•					•	1987
STARLAB	•			?		?		1991
SUN SYNCHRONOUS SIRTF			•					1997
TITAN PROBE							•	1994
UPPER ATMOSPHERIC RESEARCH SATELLITE	•							1989
VENUS ATMOSPHERE PROBE							•	1994
X RAY TIMING EXPLORER	•							1990

SPACE STATION SERVICING - REPLENISHMENT

TYPICAL SPACECRAFT

AS PART OF THE NASA HDQ. CONCEPT DEFINITION GROUP ACTIVITIES RELATIVE TO THE OMV/OTV/SATELLITE SERVICING TASK GROUP, INITIAL ESTIMATES AS TO ON-ORBIT REPLENISHMENT OF SPACECRAFT CONSUMABLES WERE MADE BY BOTH NASA AND CONTRACTOR PERSONNEL. THE FACING PAGE ILLUSTRATES THE CURRENT PRELIMINARY ESTIMATES OF THE REPLENISHMENT CONSUMABLES, THE TIMEFRAME WHEN REQUIRED, AND WHERE PRACTICAL, AN INDICATION OF QUANTITY, PRESSURE AND UTILIZATION. CERTAIN OF THESE SPACECRAFT WILL BE LAUNCHED PRIOR TO THE STATION IOC BUT MAY BE CANDIDATES FOR SERVICING AT THE STATION. FURTHER, THESE EARLIER DEVELOPED SPACECRAFT HAVE MORE AVAILABLE INFORMATION AND THUS, MORE DEFINITIVE DATA IS AVAILABLE AS OPPOSED TO THE DOWNSTREAM MISSION MODEL IDENTIFIED SYSTEMS. THIS INFORMATION IS LISTED FOR SOME 12 SPACECRAFT ON THE FACING AND FOLLOWING PAGE.

SPACE STATION SERVICING - REPLENISHMENT
TYPICAL SPACECRAFT

MISSION	TYPE	SERVICING LOCATION	FLUIDS	WHEN REQUIRED	FREQUENCY	QUANTITY	PRESSURE	FLUID USE
SPACE TELESCOPE	FF (28.5°, 600 km)	OP ORBIT	GN2 SURFUR HEXAFLUORIDE	1985-2000	720 DAYS			PURGE GASES
GAMMA RAY OBSERVATORY	FF (28.5°, 400 km)	OP ORBIT OR STATION	HYDRAZINE	1988-93	720 DAYS	2270 kg		FUEL
XTE-XRAY TIMING EXPLORER	FF (28.5°, 400 km)		HYDRAZINE	1990-92	720 DAYS	75 kg	300 psi	FUEL
SPECTRA OF COSMIC RAY	A (28.5°, 400 km)	STATION	Ne, CO2 FREON	1991	180 DAYS	5001	1 atm 1 atm	DETECTOR GASES COOLANT
LIDAR FACILITY	P (28.5°, 400 km)	PLATFORM OR STATION	ETHYLENE GLYCOL DYES LN2	1991-93	90 DAYS 3 DAYS	19-381 51	40 psi 10 psi	WASTE HEAT REJECTION LASER EXPS DETECTOR COOLANT

FF = FREE FLYER
A = ATTACHED (SPACE STATION OR PLATFORM)
P = PRESSURIZED VOLUME

SPACE STATION SERVICING - REPLENISHMENT
TYPICAL SPACECRAFT (CONT)

MISSION	TYPE	SERVICING LOCATION	FLUIDS	WHEN REQUIRED	FREQUENCY	QUANTITY	PRESSURE	FLUID USE
EARTH OBSERVATION INSTRUMENT TECH	P/A	STATION	CRYOGENS	1996 99	90 DAYS	100 kg		COOLANT
TRANSITION RADIATION AND ION CALORIMETER	A (28.5°, 400 km)	STATION	He, Xe, METHANE Ne, CO_2 GN_2	1994 95	180 DAYS	10001 5001	1 atm 1 atm 1 atm	DETECTOR GASES PRESSURIZATION
LARGE DEPLOYABLE REFLECTOR	FF (28.5°, 700 km)	OP ORBIT OR STATION	He LN_2	1998 99	360 DAYS	50 1001 50 1001	10 psi 10 psi	COOLANT
ADVANCED X RAY ASTROPHYSICS	FF (28.5°, 500 km)	OP ORBIT OR STATION	METHANE, AMMONIA Xe, METHANE	1991 2000	3 YR	36 kg 34 kg	16 TORR 0.1 TORR	(CRYOGENICS) DETECTOR GASES
CORONA DIAGNOSTIC MISSION	FF (28.5°, 400 km)	OP ORBIT OR STATION	HYDRAZINE	1999 2000	180 DAYS	500 kg		FUEL
HIGH ENERGY ISOTOPES	A (28.5°, 400 km) OR FF (57°, 400 km)	STATION OR OP ORBIT	Ar, CO_2, METHANE GN_2	1997 99	180 days	10001	1 atm 1 atm	DETECTOR GASES PRESSURIZATION
EARTH SCIENCE RESEARCH	PP (97°, 500 km)	OP ORBIT	CRYOGENS	1991 2000	180 DAYS			COOLANT

FF = FREE FLYER
P = PRESSURIZED VOLUME
PP = POLAR PLATFORM
A = ATTACHED (SPACE STATION OR PLATFORM)

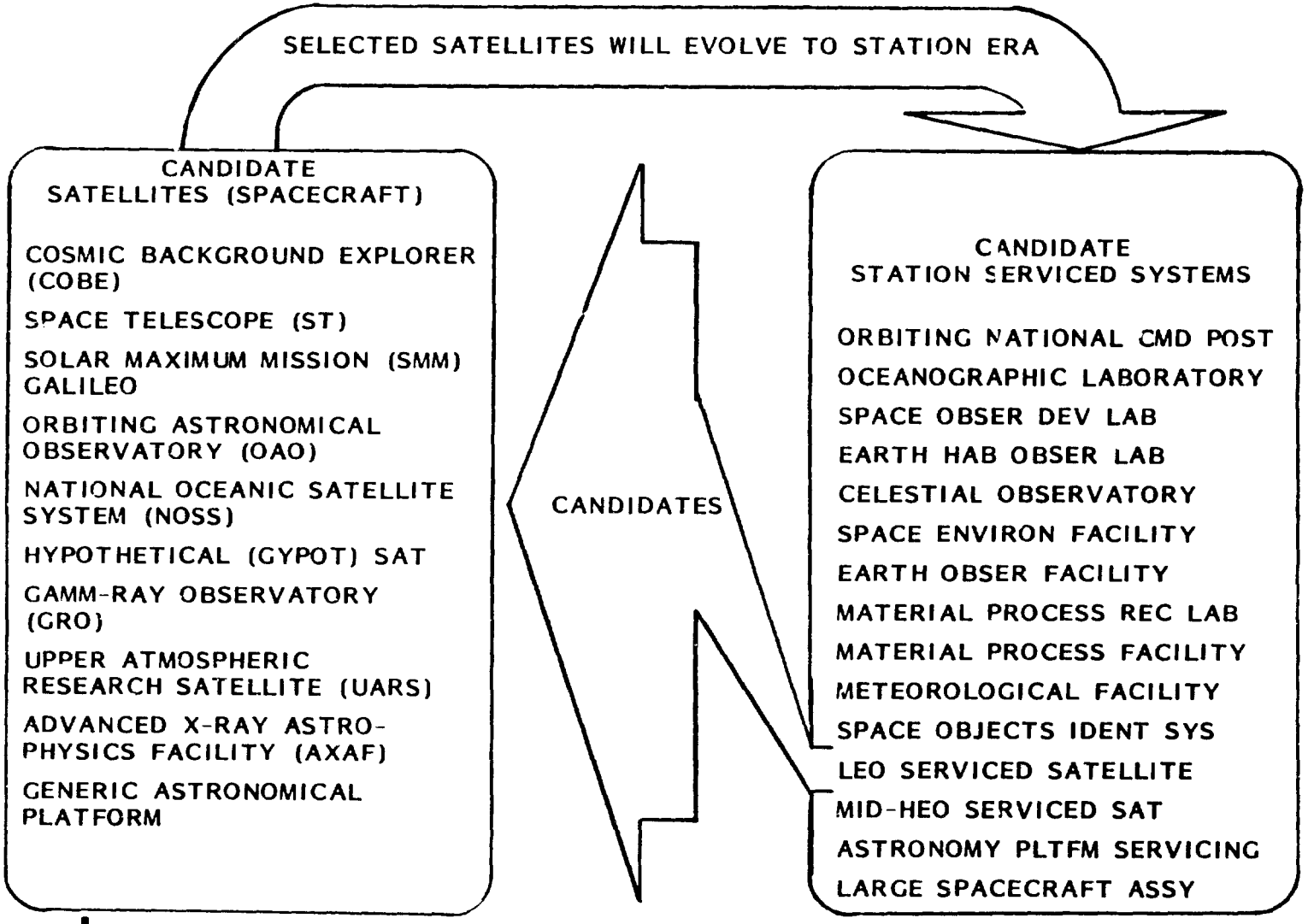
Lockheed

SERVICING HARDWARE ANALYSES

SATELLITE SERVICING EVOLUTION

THE EARLY SHUTTLE ERA SPACECRAFT CLASSES ARE ILLUSTRATED ON THE LEFT ON THE FACING PAGE. THE SUBSEQUENT STATION ERA SPACECRAFT ARE PRESENTED ON THE RIGHT. THE PURPOSE OF THIS CHART IS TO INDICATE THAT THE LEO SERVICED SATELLITES PORTRAYED IN THE STATION ERA MAY INCLUDE A NUMBER OF 1985 TO 1990 SATELLITES POTENTIALLY SERVICED BY THE SHUTTLE PRIOR TO STATION IOC. THUS, THERE MAY BE SOME TRANSITION TO THE STATION OF PREVIOUSLY SHUTTLE SERVICED SATELLITES AS A NATURAL AND PROGRESSIVE STEP IN THE SPACE OPERATIONS ARENA.

SATELLITE SERVICING EVOLUTION



Lockheed

SPACE STATION SERVICING POTENTIAL

THE FACING PAGE SIMPLY ATTEMPTS TO IDENTIFY THE STATION SERVICING POTENTIAL. EACH OF THE LISTED ELEMENTS COULD BE EXPANDED MEASURABLY INTO FURTHER SUB-CATEGORIES, HOWEVER, THE IMPORTANCE OF THIS CHART IS TO RECOGNIZE THE VARIOUS CLASSES AND TO ASSURE CONSIDERATION OF EACH IN THE SERVICING ANALYSES. NOTE, THE IDENTIFICATION OF DEBRIS AS A MAJOR CLASS OF SERVICING POTENTIAL. AS THE NUMBER OF SPACECRAFT INCREASE AND ITEMS DECAY FROM HIGHER ORBITS, MORE AND MORE DEBRIS CAN BE ANTICIPATED. THUS, A MAJOR SERVICING CATEGORY EMERGES AND WILL STRONGLY RELATE TO ORBITAL SAFETY PARTICULARLY AS MORE FLIGHTS ARE UNDERTAKEN.

SPACE STATION SERVICING POTENTIAL

A. SERVICING CANDIDATES

1. FREE FLYING SPACECRAFT (WITH PROPULSION)
2. FREE FLYING SPACECRAFT (WITHOUT PROPULSION)
3. AFIXED PAYLOADS AND PALLETS
4. TETHERED PAYLOADS
5. CONSTRAINED 'FLOATING' PAYLOADS
6. STAGES
7. TRANSPORT SPACECRAFT
8. ASSEMBLED SPACECRAFT/STRUCTURES
9. SERVICING HARDWARE
   - MAJOR EQUIPMENT
   - TRANSPORT SPACECRAFT (OMVs AND OTVs)
10. DEBRIS
11. CREW 'MANEUVERING' TRANSPORTERS
12. EMERGENCY RESCUE VEHICLES/ELEMENTS
13. LOGISTIC SPACECRAFT/ELEMENTS

PRINCIPAL STATION SERVICING DIFFERENCES FROM SHUTTLE

A NUMBER OF FUNDAMENTAL SERVICING DIFFERENCES BETWEEN THE SHUTTLE AND STATION CAN BE EXPECTED. THE FACING PAGE INDICATES BUT A FEW OF THE MORE IMPORTANT ITEMS. AS THE DEFINITION OF THE STATION BECOMES MORE FIRM, PARTICULARLY WITH RESPECT TO SYSTEM REQUIREMENTS, ONE CAN ANTICIPATE THAT THESE DIFFERENCES WILL BE SUBSTANTIAL. NONETHELESS, THE SHUTTLE WILL CONTINUE TO PLAY A VITAL SERVICING ROLE EVEN DURING THE CO-EXISTANCE WITH THE SPACE STATION.

PRINCIPAL STATION SERVICING DIFFERENCES FROM SHUTTLE

A. CONSTANT 24 HOUR AVAILABILITY

B. GREATER SERVICING AREA

C. OMVs AND OTVs - BASED AVAILABILITY
   - AVAILABLE
     - PLANNED SERVICING
     - UNPLANNED SERVICING
   - FUEL AVAILABLE

D. FAST REACTION EVA

E. INTERMEDIATE ORBITAL STAGING FACILITY

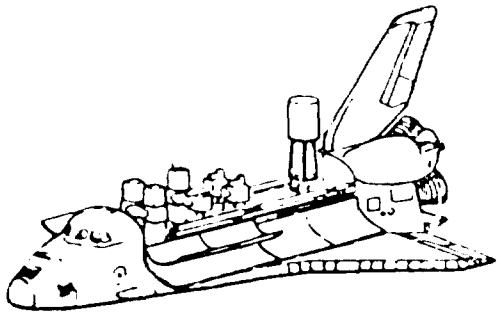
F. MORE 'RELAXED' SERVICING TIMELINE

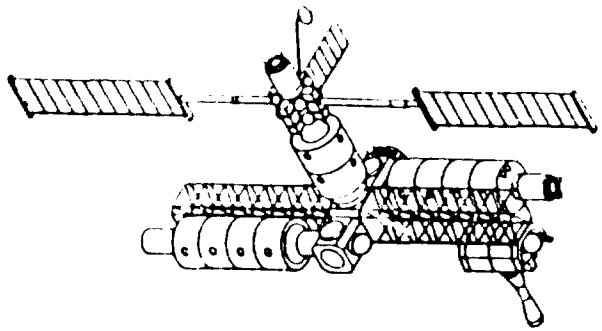
G. ULTIMATE HANGER/DEPOT SERVICING/MAINTENANCE

SERVICING-ORBITER AND STATION

THE OPPOSITE PAGE IS A VERY SIMPLIFIED ATTEMPT TO INDICATE CERTAIN OF THE BASIC SERVICING DIFFERENCES BETWEEN THE ORBITER AND THE STATION. ALTHOUGH THE LIST INDICATES A COMPARATIVE ASSESSMENT, IT IS NOT INTENDED TO BE EXHAUSTIVE, BUT RATHER ONLY AN INDICATION OF THE TYPES OF DIFFERENCES FORSEEN. NOTE ALSO THAT THERE WILL BE A SUBSTANTIAL GREATER NUMBER OF AND ENHANCED SERVICING FUNCTIONS AVAILABLE AT THE STATION AS IT EVOLVES FROM ITS INITIAL ORBITAL CONFIGURATION INTO THE MATURE FACILITY.

SERVICING-ORBITER AND STATION





- A. CREW PRE-BREATH
- B. ORBITER 7 - 28 DAY LIMIT
- C. ORBITER ACCESS (TO S/C) LIMITS
- D. GENERALLY ONE 2-MAN EVA SORTIE EVERY 24 HOURS
- E. VARIED WK STATIONS & BAY LOCATIONS
- F. POTENTIAL JETTISON OF 'USED' ORUs & ASE
- G. ONE RMS ACTIVE AT A TIME
- H. BAY SHARING WITH SPACE CRAFT
- I. TOTALLY 'OPEN' SERVICING AREA
- J. MODEST ON-BOARD S/C C/O CAPABILITY

- A. 8 PSI SUIT
- B. 'OPEN-ENDED' S/C STAY TIME
- C. OTV PROVIDE BROAD S/C ACCESS RANGE
- D. MULTI-EVA/DAY
- E. ONE SERVICING AREA-STD
- F. FULL CONTAINMENT OF ORUs & ASE
- G. POTENTIAL MULTI/SIMUL RMSs
- H. STANDARDIZED SERVICING AREA
- I. POTENTIAL ENCL/PROTECTED SERVICING AREA
- J. EXTENSIVE ON-BOARD C/C CAPABILITY

K. ETC

NUMEROUS OTHER ENHANCED & /OR ADDED FEATURES AND CAPAB

Z.

STATION UNIQUE SERVICING CAPABILITY

IT IS ENVISIONED THAT THERE WILL BE A CERTAIN SET OF UNIQUE SERVICING CAPABILITIES AVAILABLE AT THE STATION WHICH CURRENTLY MAY NOT BE PLANNED FOR THE SHUTTLE. THE OPPOSITE PAGE PRESENTS A COMPOSITE OF SUGGESTED UNIQUE SERVICING CANDIDATES RELATING TO THE STATION. AS THE STATION BECOMES MORE WELL DEFINED, IT IS ANTICIPATED THAT THIS GENERIC LIST WILL EXPAND AND OTHER ITEMS WILL BE ADDED.

STATION UNIQUE SERVICING CAPABILITY

A. SERVICING HARDWARE
   - MAJOR EQUIPMENT
   - TRANSPORT SPACECRAFT (OMVs AND OTVs)

B. NUCLEAR SOURCE HANDLING

C. TELEOPERATOR OPERATIONS - ROUTINE

D. MAJOR PROPELLANT RESUPPLY (BI-PROP AND CRYOGEN)

E. TETHERED ITEMS

F. INTERNAL (IV) 'HABITAT' SERVICE/REPAIR

G. EXTERNAL (EV) MAJOR REPAIR

H. EXTENDED (TIME) SERVICING/REPAIR

I. COMPLEX (LEVEL) SERVICING/REPAIR

SERVICING HARDWARE GROWTH/EVOLUTION CANDIDATES

TYPICAL

CONSIDERABLE CAPABILITY EXISTS FOR SERVICING FROM THE SHUTTLE. THIS CAPABILITY WILL (IT IS EXPECTED) EVOLVE, BE ENHANCED, AND ADDED EQUIPMENT BE PROVIDED IN THE NEXT FIVE TO SIX YEARS. THEREFORE, IT APPEARS HIGHLY PRUDENT TO BUILD ON THE EVOLVING TECHNOLOGY FOR THE STATION. THE OPPOSITE PAGE INDICATES A VERY PRELIMINARY LISTING OF CANDIDATE ITEMS WHICH CAN BE EVOLVED AND/OR ENHANCED TO SUPPORT STATION ERA SERVICING. FURTHERMORE, SOME OF THESE ITEMS CAN BE DEVELOPED IN THE NEXT FEW YEARS THROUGH R&D EFFORTS AND BREADBOARD FLIGHT SYSTEMS. THUS, THE ORBITER FLIGHTS OFFER A MARVELOUS OPPORTUNITY TO BEGIN THE INITIATION OF STATION SERVICING TECHNOLOGY WHICH CAN ACTUALLY BE USED FOR SERVICING OF SPACECRAFT PRIOR TO STATION IOC.

SERVICING HARDWARE GROWTH/EVOLUTION CANDIDATES (TYPICAL)

A. BERTHING/DOCKING SYSTEMS
- SPACECRAFT
- LOGISTICS VEHICLES
- RESCUE SPACECRAFT
- SAFE HAVEN I/F
- SHORT-TERM P/Ls
- SUPPORT MODULES
- SERVICING HABITATS

B. MANIPULATOR SYSTEMS
- LARGER/GREATER-ARTICULATED RMS
- CLOSED CAB RMS
- TRAVELING TRACKED RMS AND CRANE
- MORE EXTENSIVE END EFFECTOR SELECTION
- MULTI-PURPOSE SEMI-ROBTIC UNITS

C. EQUIPMENT 'TRANSPORT AND POSITIONING'AIDS

D. SERVICING WORK STATIONS

E. LOGISTIC (SPARES) CONDITIONING/HANDLING/TRANSPORTING

F. PRE/POST SPACECRAFT C/O STATIONS/SOFTWARE/AUTONOMY

G. REMOTE TELEPRESENCE OPERATIONAL HARDWARE

H. OTHER

SERVICING HARDWARE CATEGORIES

(REPRESENTATIVE)

THE FACING PAGE PRESENTS AN INITIAL CATEGORIZATION OF SERVICING HARDWARE/SYSTEMS. IT IS IN NO WAY TO BE CONSIDERED FINAL, NONETHELESS IT IS CONSIDERED REASONABLY REPRESENTATIVE OF THE HARDWARE/SYSTEM CATEGORIES FOR THE SHUTTLE TO STATION EVOLUTION AND SUBSEQUENT STATION SERVICING SUPPORT. SEVERAL MAJOR ITEMS ARE INCLUDED ON THIS LIST SUCH AS TRANSPORT SPACECRAFT, CRANES, HANGERS, LOGISTIC ELEMENTS, AND DEBRIS HANDLING/CONTAINMENT/DISPOSITION SYSTEMS. A NUMBER OF THESE ITEMS WITHIN CERTAIN OF THE CATEGORIES ARE PRESENTLY AVAILABLE AND/OR ARE CURRENTLY UNDER DEVELOPMENT, THUS, INDICATING THE FORESIGHT THAT HAS BEEN GIVEN TO THE DEVELOPMENT OF MANY OF THESE SYSTEMS RELATIVE TO THEIR POTENTIAL STATION APPLICABILITY.

SERVICING HARDWARE CATEGORIES (REPRESENTATIVE)

A. CAPTURE AIDS

B. BERTHING EQUIPMENT

C. UMBILICALS/CABLES/LINES

D. INT MTD CONSOLES

E. EXT MTD D&C PANELS

F. BASIC ASE

G. PROP XFER SYSTEM

H. RMS AND CRANES

I. POSITIONING AIDS

J. MMU AUGMENTATION

K. TRANSPORT SPACECRAFT

L. IVA/EVA WORKSTATIONS

M. STAGE ASSEMBLY AREAS

N. ASSEMBLY/CONSTRUCTION 'ZONES'

O. SERVICE HANGERS

P. SERVICE PORTS/CHAMBERS

Q. TOOLS/AIDS/LIGHTING

R. CREW 'TRANSPORT UNITS'

S. TRANSPORTABLE 'SERVICING UNITS'

T. STOWAGE AND ILS SUPPORT ELEMENTS

U. EMERGENCY CREW SUPPORT HARDWARE

V. LOGISTIC AND SPARES TRANSPORT PODS

W. DEBRIS HANDLING/CONTAINMENT/DISPOSITION

X. OTHER

SERVICING HARDWARE TRANSITION CONSIDERATIONS

TYPICAL

AS THE SHUTTLE ERA (1984 TO 1990) SERVICING EQUIPMENT IS DEVELOPED AND BECOMES OPERATIONAL, GREATER ON-ORBIT EXPERIENCE WILL BE OBTAINED FROM THE FUNCTIONAL UTILIZATION OF THESE ITEMS. IMPORTANT TO THE REALIZATION OF THAT EXPERIENCE BASE, WILL BE THE NEED TO TRANSITION MANY OF THOSE ITEMS TO THE STATION. THUS, A NUMBER OF TRANSITIONING FACTORS MUST BE CONSIDERED AS PRESENTED IN TYPICAL FORM ON THE FACING PAGE. IMPORTANT TO THIS TRANSITIONING WILL BE THE REALIZATION THAT IF CONSIDERED EARLY ENOUGH IN THE DEVELOPMENT CYCLE, CERTAIN OF THE TRANSITIONING POTENTIAL CAN BE 'BUILT-IN' AND, THUS, SHOULD BE CONSIDERED ON FUTURE PROCUREMENT ACTIVITIES. THIS THEN, WOULD GREATLY ENHANCE THE SERVICING EQUIPMENT TRANSITION PROCESS PARTICULARLY WHERE STANDARDIZATION CAN BE IMPLEMENTED.

SERVICING HARDWARE TRANSITION CONSIDERATIONS (TYPICAL)

A. MOUNTING INTERFACES

B. SIGNAL/POWER INTERFACE
   - UMBILICALS/CABLES
   - POWER LEVEL/PHASE/TOLERANCES

C. SOFTWARE

D. CONSOLES/WORK STATIONS

E. SIZES

F. GROWTH/SCALING

G. RELIABILITY (TIME TO FUNCTION ON-ORBIT

H. SAFETY

I. ARTICULATION ENVELOPES

J. LOADS AND DYNAMICS

K. 'WEAR-OUT' FACTORS

L. AUTONOMY

M. FREQUENCY OF USE

N. QUANTITIES

O. FLEXIBILITY (GENERAL)

P. COMPLEXITY VS 'AUTOMATION'

Q. OVERRIDE

R. DISABLE AND REMOVE/STOW

S. REFURBISHMENT

T. OVERALL UTILITY

U. AGE (FMEA/REL)

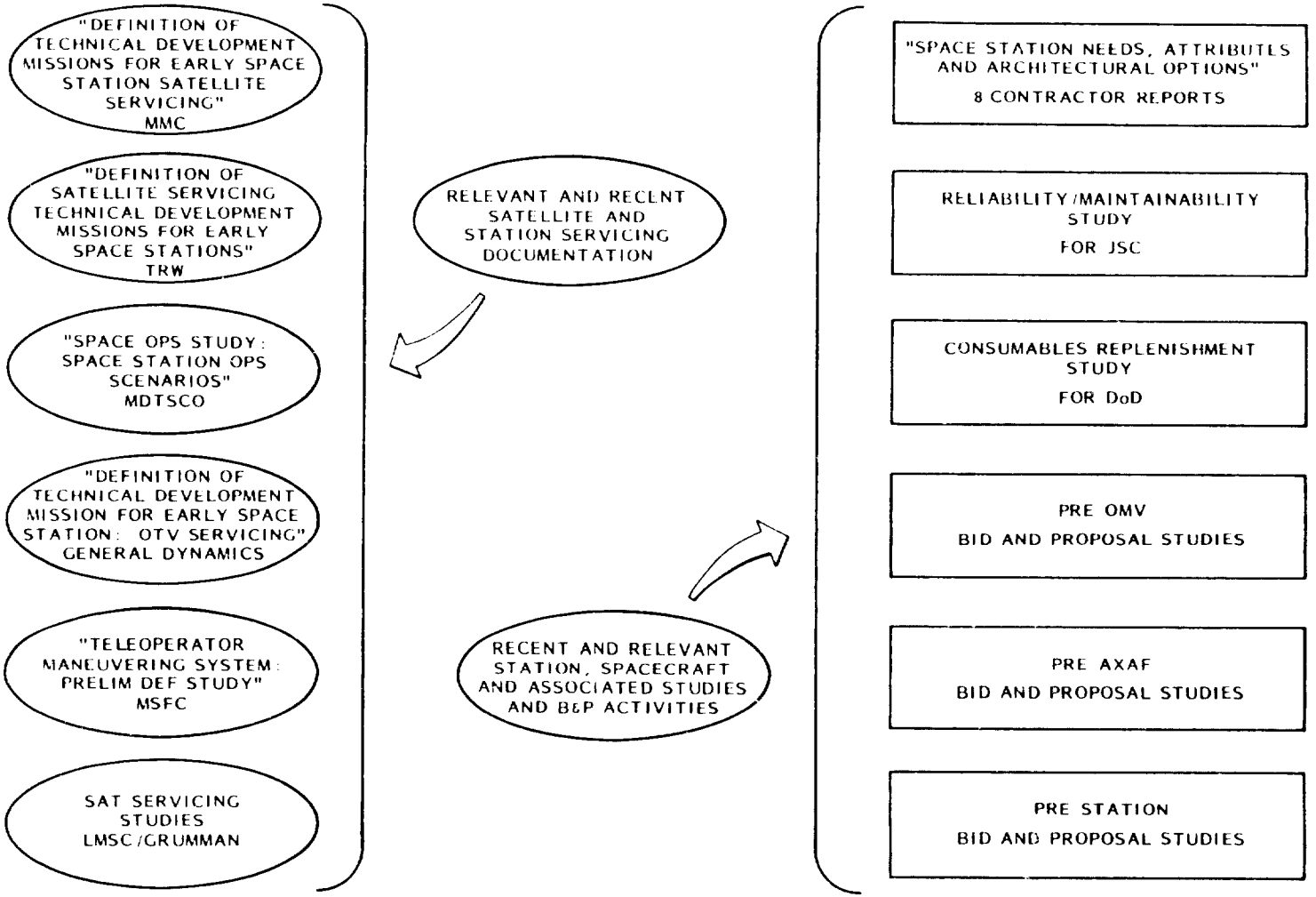
V. UPDATEABILITY

W. AVAIL - ORB/STA OR BOTH

STUDY DATA BASE

PIVOTAL TO THIS STUDY WAS THE NEED TO IDENTIFY CANDIDATE SERVICING EQUIPMENT WHICH WOULD BE NEEDED FOR SERVICING EITHER AT/NEAR THE STATION AND/OR REMOTELY FROM THE STATION. A NUMBER OF STUDIES HAVE BEEN COMPLETED OR ARE STILL UNDERWAY RELATIVE TO THE EXAMINATION OF SERVICING BOTH FROM THE SHUTTLE AND/OR STATION. THESE STUDIES ARE INDICATED ON THE FACING PAGE. IT MUST ALSO BE RECOGNIZED THAT A NUMBER OF CLASSIFIED (DoD) STUDIES ARE ON-GOING WHICH CAN NOT BE REFERENCED. HOWEVER, THE STUDIES INDICATED PROVIDED THE BASIC DATA BASE FOR SERVICING HARDWARE FROM WHICH THE CURRENT STUDY ANALYSES WERE BASED.

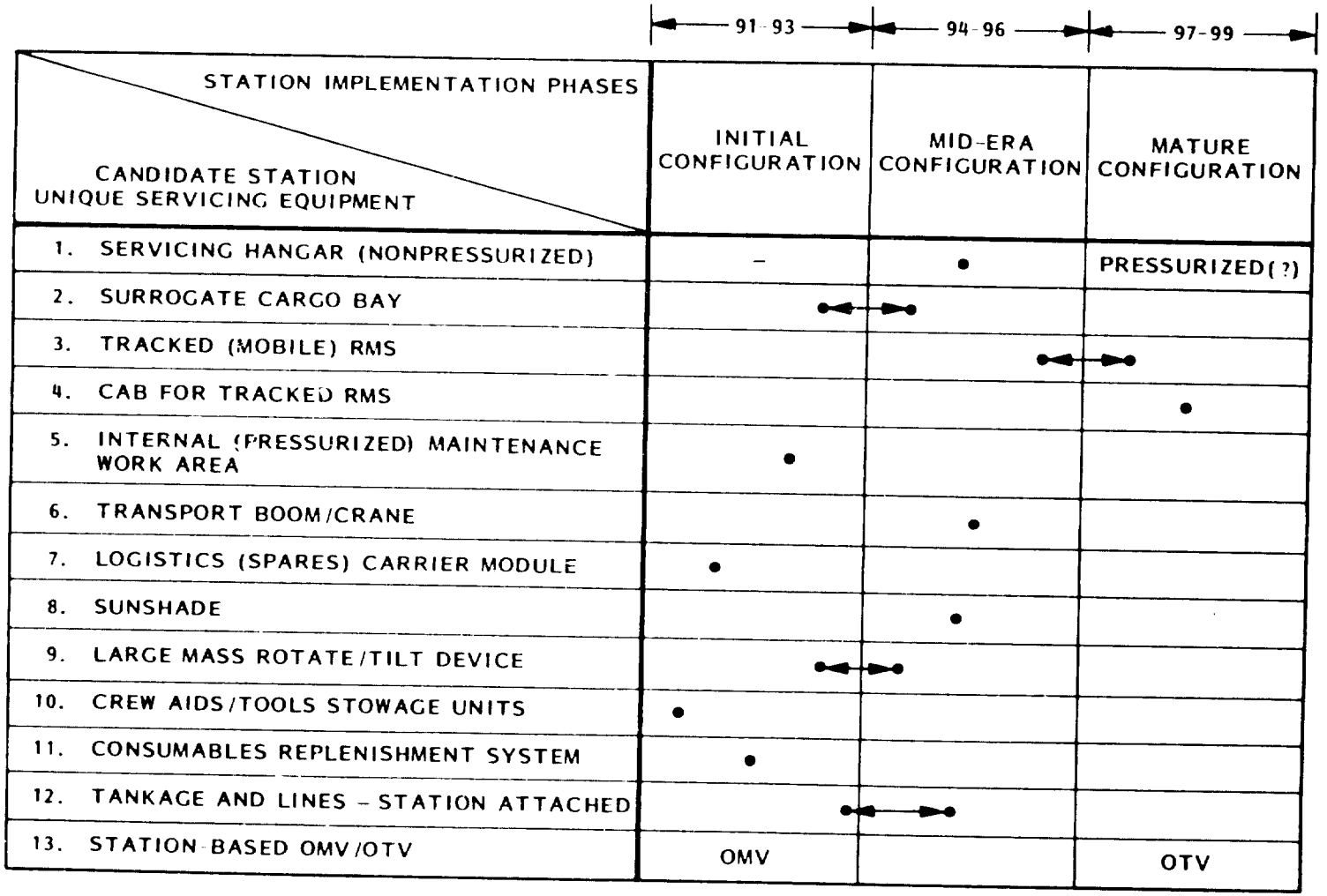
STUDY DATA BASE



STATION SERVICING HARDWARE IMPLEMENTATION (A TRIAL ALLOCATION) (CONT)

SOME 26 STATION UNIQUE SERVICING EQUIPMENTS/SYSTEMS WERE IDENTIFIED AS A RESULT OF THE ANALYSES CONDUCTED FOR THIS STUDY. THE FACING PAGE (AND FOLLOWING PAGE) LIST THESE EQUIPMENTS/SYSTEMS AND AN ATTEMPT HAS BEEN MADE TO INDICATE WHEN EACH MAY BE NEEDED AS THE STATION EVOLVES FROM ITS INITIAL IOC CONFIGURATION TO THE MORE MATURE CONCEPT PLANNED FOR THE MID-TO LATE 1990'S. THESE EQUIPMENT ITEMS REPRESENT A SYNTHESIS OF THE STUDIES CONDUCTED BOTH WITHIN THE NASA AND BY AEROSPACE CONTRACTORS. SINCE THIS IS A SYNTHESIS, CERTAIN SPECIFIC EQUIPMENT ITEMS MAY HAVE BEEN LEFT OUT BASED ON ASSESSMENT WITH THE MISSION SERVICING NEEDS PREVIOUSLY IDENTIFIED HEREIN. THEREFORE, IT SHOULD BE UNDERSTOOD THAT THESE 26 ITEMS ARE NOT THE 'FINAL' IDENTIFIED ITEMS, BUT RATHER SERVE AS A FOCUS AS TO THE BASIC GENERIC NEEDS FORESEEN RELATIVE TO STATION SERVICING UNIQUE HARDWARE/SYSTEMS.

STATION SERVICING HARDWARE IMPLEMENTATION (A TRIAL ALLOCATION)



STATION SERVICING HARDWARE IMPLEMENTATION (A TRIAL ALLOCATION)(CONT)

STATION IMPLEMENTATION PHASES / CANDIDATE STATION UNIQUE SERVICING EQUIPMENT	91-93 INITIAL CONFIGURATION	94-96 MID-ERA CONFIGURATION	97-99 MATURE CONFIGURATION
14. DECONTAMINATION SYSTEM		●	
15. SERVICING CHECKOUT UNIT (UNPRESSURIZED)		●	
16. SERVICING CHECKOUT UNIT (PRESSURIZED)	●		
17. SPACECRAFT PARKING FIXTURE	●		
18. SERVICING PASS-THROUGH AIRLOCK	●		
19. SHORT ARM IV CREW OPERATION MANIPULATORS		●	
20. POWER CONDITIONING UNIT	●		
21. SIGNAL/POWER CABLE/UMBILICAL INTERFACE UNIT	●		
22. VENT UNIT		●	
23. STAGE ASSEMBLY KIT/JIG/BEAM OR PIER		●	
24. BERTHING DEVICE	●		
25. CONSOLE (IV) FOR REMOTE SYSTEM OPERATIONS	●		
26. TELEOP/SMART END SERVICER		●	

UNIQUE STATION SERVICING SYSTEM/HARDWARE EVOLUTION BASE

IN THE COURSE OF THE IDENTIFICATION OF THE 26 UNIQUE STATION ERA SERVICING HARDWARE/SYSTEM ITEMS, IT WAS DETERMINED APPROPRIATE TO INDICATE IN THE MOST GENERAL TERMS WHEREIN THE EVOLUTION BASE MIGHT BE FOR THESE ITEMS. THE FACING PAGE LISTS A MOST PRELIMINARY ASSESSMENT OF THE POTENTIAL EVOLUTIONARY ORIGIN FOR THESE ITEMS. QUITE CANDIDLY, THERE ARE MANY OTHER TECHNOLOGY BASES FROM WHICH MANY OF THESE ITEMS CAN EVOLVE AND, THEREFORE, SHOULD BE CONSIDERED. THE EARLY RECOGNITION OF THESE SOURCES MAY AID IN THE EARLY BREADBOARD DEVELOPMENT OF THESE ITEMS AND PERMIT EARLIER R&D FLIGHT OF THESE ITEMS IN THE LATE 1980'S ABOARD THE SHUTTLE.

UNIQUE STATION SERVICING SYSTEM/ HARDWARE EVOLUTION BASE

UNIQUE STATION SYSTEM/HARDWARE	POTENTIAL EVOLUTION BASIS - EXAMPLES ONLY
1. SERVICING HANGAR (UNPRESSURIZED)	1. ORBITER BAY CONCEPT AND AIRCRAFT INDUSTRY
2. SURROGATE CARGO BAY	2. ORBITER BAY STRUCTURAL LAYOUT
3. TRACKED (MOBILE) RMS	3. RMS AND CONSTRUCTION INDUSTRY
4. CAB FOR TRACKED RMS	4. ORBITER AFD AND CONSTRUCTION, OCEAN AND NUCLEAR INDUSTRIES
5. INTERNAL (PRESSURIZED) MAINTENANCE WORK AREA	5. SHIPBOARD/SUBMARINE
6. TRANSPORT BOOM/CRANE	6. ORBITER RMS AND CONSTRUCTION INDUSTRY
7. LOGISTICS (SPARES) CARRIER MODULE	7. TRANSPORT. INDUSTRY CARRIERS - PODS, PALLETS, CANISTERS
8. SUNSHADE	8. CONSTRUCTION INDUSTRY
9. LARGE MASS ROTATE/TILT DEVICE	9. SPACECRAFT ASE - MMS (FSS), IUS, PAM, ST (DMP)
10. CREW AIDS/TOOLS STOWAGE UNITS	10. ORBITER, SKYLAB, LUNAR MODULE
11. CONSUMABLES REPLENISHMENT SYSTEM	11. ORBITER EXP, FFs, AIRCRAFT, SHIPS, GROUND SYSTEM
12. TANKAGE AND LINES - STATION ATTACHED	12. ORBITER, FFs, AIRCRAFT-TANKERS, SHIPS, GROUND SYSTEM
13. STATION BASED OMV/OTV	13. TELEOP, CENTAUR, OTHER "TUGS"
14. DECONTAMINATION SYSTEM	14. MEDICAL, INDUSTRIAL, NUCLEAR, CHEMICAL INDUSTRIES
15. SERVICING UNIT (PRESSURIZED)	15. ORBITER AFD PS STATION, INDUSTRY, AEROSPACE, SKYLAB
16. SERVICING UNIT (UNPRESSURIZED)	16. ORBITER (FUTURE), OCEAN SYSTEMS (UNDERWATER), SKYLAB
17. SPACECRAFT PARKING FIXTURE	17. ORBITER MTD ASE
18. SERVICING PASS-THROUGH AIRLOCK	18. ORBITER, SKYLAB, OCEAN LABS/VEHICLES
19. SHORT ARM IV CREW OPERATION MANIPULATOR	19. ORBITER, NUCLEAR INDUSTRY, AUTO INDUSTRY, OCEAN DEEP SEA VEHICLE
20. POWER CONDITIONING UNIT	20. ORBITER, SKYLAB, FFs, ASE, OCEAN SYSTEM
21. SIGNAL/POWER CABLE/UMBILICAL INTERFACE UNIT	21. ORBITER, ASE, SKYLAB, FFs, OCEAN SYSTEM, INDUSTRY
22. VENT UNIT	22. ORBITER (ECLSS/PROP), ASE, FFs, CHEM/FUEL INDUSTRY, OCEAN VEHICLE
23. STAGE ASSEMBLY KIT/JIG/BEAM OR PIER	23. CONSTRUCTION INDUSTRY
24. BERTHING DEVICE	24. ORBITER, SKYLAB, ASTP, RESCUE VEHICLE (OCEAN), FFs
25. CONSOLE (IV) FOR REMOTE SYSTEM OPERATIONS	25. ORBITER, SKYLAB, OCEAN DEEP SEA VEHICLES AND SHIPS, ROBOTICS, NUCLEAR INDUSTRY
26. TELEOP/SMART END SERVICER	26. BASIC ROBOTICS INDUSTRY

APPLICABILITY ASSUMPTIONS

IN ORDER FOR THE PREVIOUSLY IDENTIFIED 26 UNIQUE ITEMS TO BE INTEGRATED WITH THE STATION CERTAIN BASIC INCORPORATION PROVISIONS MUST BE PROVIDED AT THE STATION. THE FACING PAGE IDENTIFIES AT A VERY TOP-TIER LEVEL SEVERAL OF THOSE GENERIC PROVISIONS. THUS, IT IS IMPORTANT FOR THE SATELLITE SERVICING COMMUNITY TO INDICATE THESE PROVISION NEEDS IN THE EARLY PHASES OF SYSTEMS DEFINITION OF THE STATION. IT IS RECOGNIZED, HOWEVER, THAT MANY OF THESE PROVISIONS ARE CURRENTLY BEING STUDIED BY THE NASA HDQ. CONCEPT DEFINITION GROUP AND ARE BEGINING TO BE IDENTIFIED IN THE SYSTEMS REQUIREMENTS DOCUMENTATION.

APPLICABILITY ASSUMPTIONS

STATION INCORPORATES PROVISIONS FOR:

1. MTG PALLETS/CARRIERS/RACKS
2. ATTACHING MECHANISMS/BEAMS
3. ATTACHING STOWAGE ITEMS
4. EVA ACCOMMODATIONS
5. SIGNAL/POWER INTERFACE
6. ATTACHING/USING LARGE ITEM TRANSFER/MANIPULATION
7. "ATTACHING" TANKS
8. ACCOMMODATING SERVICE AREA AND SWEPT VOLUME

PRESSURIZED SERVICE FACILITY - STATION ATTACHED

AT THE RECENT NASA HDQ CONCEPT DEFINITION GROUP MEETINGS (LATE OCTOBER 1983) QUESTIONS AROSE AS TO THE NEED FOR A PRESSURIZED SERVICE FACILITY ATTACHED TO THE STATION. LOCKHEED PARTICIPATED IN THAT INQUIRY AND CONDUCTED A STUDY AS INDICATED ON THE FACING PAGE AND IN THE FOLLOWING PAGES.

PRESSURIZED SERVICE FACILITY - STATION ATTACHED

A. NASA HQ CDG OMV/OTV SATELLITE SERVICING STUDY TASK GROUP REQUESTED* LMSC TO PREPARE A POSITION ON THE NEED FOR A PRESSURIZED SERVICING FACILITY

B. LMSC CONDUCTED A TOP-TIER TRADE STUDY OF THE NEED FOR SUCH A FACILITY:

- FUNCTIONAL REQUIREMENTS
- ACCOMMODATIONS
- SAFETY
- LOGISTICS
- CONFIGURATIONS AND GROWTH
- IMPLEMENTATION DATA

C. SUMMARY CONCLUSIONS WERE PREPARED AND SUBMITTED TO STUDY TASK GROUP

*NONFUNDED

Lockheed

NEED FOR A LARGE PRESSURIZED SERVICING FACILITY

A SUMMARY OF THE RESULTS OF THE STUDY CONDUCTED ON THE NEED FOR A PRESSURIZED SERVICING FACILITY, E.G., A HANGAR, IS PROVIDED ON THE OPPOSITE PAGE. IT IS EXTREMELY IMPORTANT TO NOTE, HOWEVER, THAT AN INTERNAL 'SMALL' SERVICING VOLUME BE PROVIDED WITHIN THE STATION. THIS INTERNAL SERVICING PRESSURIZED VOLUME COULD SUPPORT THE FOLLOWING FUNCTIONS:

- SATELLITE SERVICING - ITEMS BROUGHT INTO THE STATION FOR POTENTIAL REPAIR AND CHECKOUT
- REPAIR OF STATION EQUIPMENT
- STOWAGE OF NEARBY NEEDED SPARES/LOGISTIC ITEMS

THUS, A CAREFUL DISTINCTION MUST BE MADE BETWEEN A PRESSURIZED 'HANGAR' AND A PRESSURIZED VOLUME FOR SERVICING AND REPAIR. THE LATER AREA COULD BE ON THE ORDER OF SOME 250 CUBIC FEET FOR THE SERVICING FUNCTION. THE OTHER VOLUMES NEEDED FOR STATION EQUIPMENT REPAIR AND SPARES/LOGISTICS STOWAGE ARE YET TO BE DETERMINED.

NEED FOR A LARGE PRESSURIZED SERVICING FACILITY

GENERAL CONCLUSIONS

A. MAJOR PROGRAM INVESTMENT (RDT&E)

B. ADDED LAUNCHES – DEDICATED

C. NO MISSION MODEL REQUIREMENT YET IDENTIFIED

D. CURRENT AND 5-6 YEAR NEAR-TERM SERVICING TO BE CONDUCTED IN EVA MODE

E. SAFETY IMPLICATIONS ARE SUBSTANTIAL

F. BENEFIT MOST DIFFICULT TO QUANTIFY IN OUT-YEAR DOLLARS

G. SUBSTANTIAL SUPPORT CAN BE PROVIDED BY NONPRESSURIZED SERVICE 'HANGAR'

H. SIGNIFICANT AMOUNT OF SERVICING TO BE ACCOMPLISHED REMOTE FROM STATION

I. HIGHLY FEASIBLE TO CONSIDER PRESSURIZED SERVICING FACILITY (HANGAR) AS A SUBSTANTIAL DOWNSTREAM GROWTH ITEM IF:

- STATION DESIGN AND EVOLUTION INCORPORATES POTENTIAL INCLUSION
- ADDED MISSION REQUIREMENTS EMERGE
- MORE INTRICATE SERVICING IS DESIRED
- STATION GROWTH BUDGET BECOMES AVAILABLE
- DoD MAKES A COMMITMENT

J. A SMALLER INTERNALLY LOCATED (COMMON MODULE OR SERVICE MODULE) MAINTENANCE AREA APPEARS SIGNIFICANTLY BENEFICIAL FOR EARLY STATION

SPACE STATION MODEL-HANGAR CONCEPT

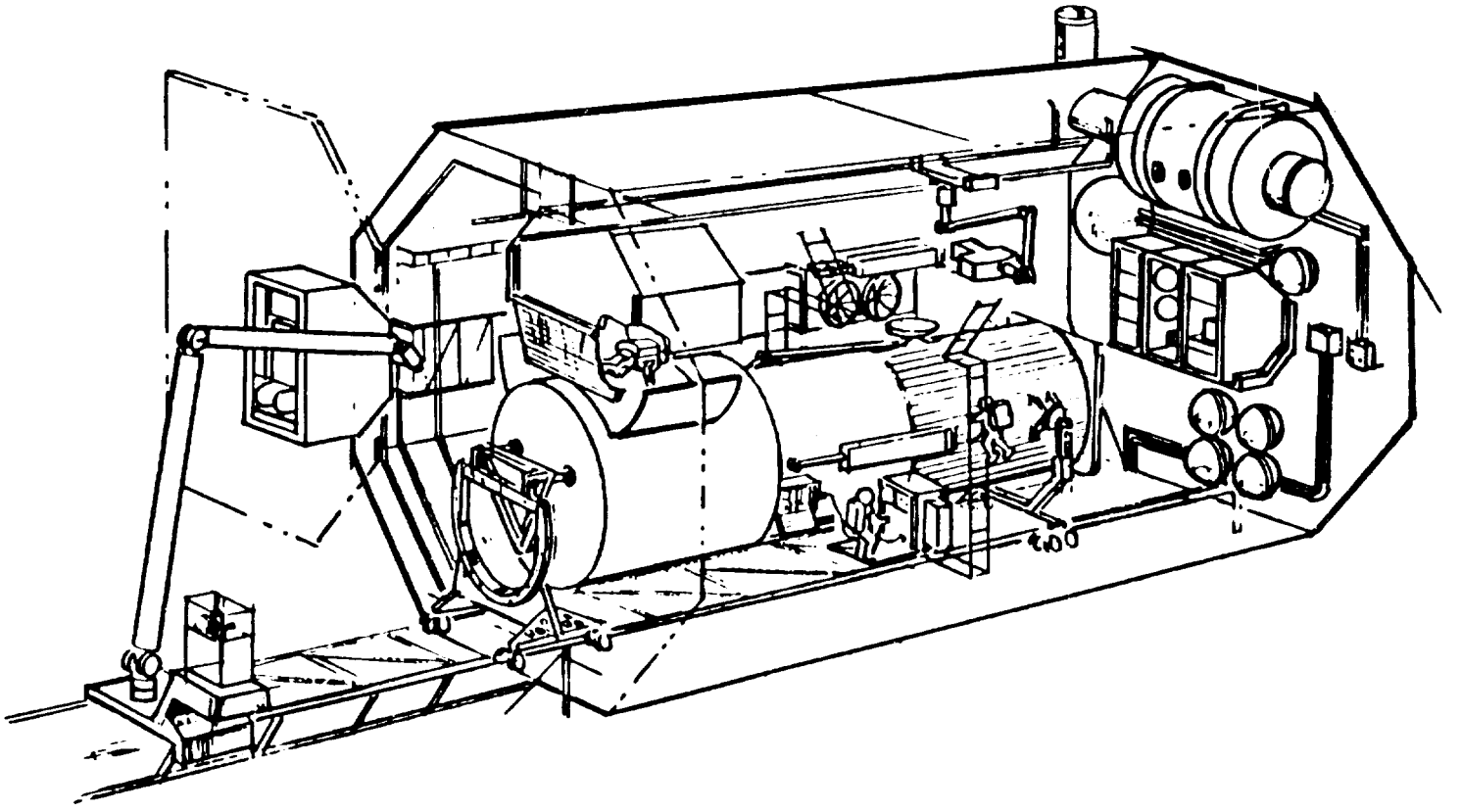
AS PART OF THIS STUDY, A LARGE SERVICING HANGAR FACILITY HAS BEEN INCLUDED FOR REFERENCE. THE FACILITY SHOWN OPPOSITE IS A BASIC FRAME STRUCTURE WITH THE OPTION OF PROVIDING A 'SCREEN-LIKE' MATERIAL AROUND THE ENTIRE ASSEMBLY TO ASSIST IN 0-g 'CONTAINMENT' OPERATIONS. AN OPTION WOULD BE TO ADDITIONALLY COVER THE STRUCTURE WITH MULTI-LAYER INSULATION (MLI) TO CONTROL BOTH THERMAL AND ILLUMINATION ENVIRONMENTS. A HANGAR 'DOOR' MIGHT ALSO BE PROVIDED TO FACILITATE 'ENCLOSURE' OF BASIC INTERNAL CONDUCTED FUNCTIONS. THE FACILITY WOULD BE ATTACHED TO THE MAIN STATION VIA A 'PIER' STRUCTURAL INTERFACE WHICH ALSO DOUBLES AS A TRACK MOUNTING PLATFORM FOR A MOBIL RMS AND/OR CRANE USED FOR SPACECRAFT CAPTURE.

FEATURES ASSOCIATED WITH THIS HANGAR CONCEPT ARE AS FOLLOWS:

- o LOGISTICS RESUPPLY RECEIVING
- o LOGISTICS FLUIDS/PRESSURANT RECEIVING
- o OPERATIONS
- o SPACECRAFT/STAGE HANDLING EQUIPMENT
- o TRANSPORT & POSITIONING RAILS
- o FIXED & TRACKED RMS/CRANE
- o SPARES (ORU'S) HANDLING AIDS
- o CREW TRANSLATION AIDS/RESTRAINTS
- o ILLUMINATION & CCTV AIDS
- o UTILITIES SERVICES
- o CHECKOUT CONSOLES (EV USED)
- o ROTATION/TILT FIXTURE

THIS CONCEPT CAN BE ADDED TO OR SIMPLIFIED AS FUNCTIONAL STATION NEEDS ARE MORE FIRMLY DEFINED PARTICULARLY WITH RESPECT TO AMALGAMATION OF FUNCTIONS (E.G., SERVICING AND STAGE ASSEMBLY) VS INDEPENDENT ALLOCATION OF FUNCTIONS AND ASSOCIATED SUPPORT FACILITIES. CONSIDERABLE MORE EFFORT MUST BE ALLOCATED TO THIS AREA OF ARCHITECTURAL DEFINITION AND LAYOUT PRIOR TO FULLY UNDERSTANDING THE STATION IMPACT (ARCHITECTURAL) INVOLVED IN THE INCORPORATION OF THIS STATION SUB-ELEMENT.

SPACE STATION MODEL-HANGAR CONCEPT



SHUTTLE ERA SERVICING SYSTEMS AND HARDWARE STATUS

(REPRESENTATIVE)

THE RESULTS OF THIS STUDY INDICATE THAT THERE ARE SOME 69 ITEMS OF SERVICING EQUIPMENT PRESENTLY IDENTIFIED FOR THE SHUTTLE ERA. THIS DOES NOT INCLUDE THE 26 ITEMS IDENTIFIED AS UNIQUE TO THE STATION AND REQUIRED IN THE PLUS 1991 - 1995 TIME FRAME. THE OPPOSITE PAGE INDICATES THE CATEGORIES OF EQUIPMENT FOR THE SHUTTLE ERA AND THE STATUS OF EACH. OF THE 69 TOTAL ITEMS, 63 (OR 91%) APPEAR DIRECTLY APPLICABLE TO SPACE STATION SERVICING EQUIPMENT NEEDS. THE LAST COLUMN IN THE FACING CHART IDENTIFIES BY CATEGORY THE APPLICABILITY OF THESE ITEMS TO THE SPACE STATION. IT SHOULD BE FURTHER NOTED THAT SOME 36 OF THE 69 ITEMS ARE CURRENTLY IN A FLIGHT HARDWARE STATUS LEVEL OF DEVELOPMENT. THUS, OVER HALF OF THE TOTAL ITEMS IDENTIFIED FOR USE BY THE STATION ARE ALREADY DEVELOPED. OF THE PROJECTED SATELLITE SERVICING EQUIPMENT (ITEMS NOT YET FUNDED OR ONLY IN THE CONCEPTUAL STAGE), ALL 23 APPEAR TO BE 100% STATION APPLICABLE.

SHUTTLE ERA SERVICING SYSTEMS AND HARDWARE STATUS (REPRESENTATIVE)

SERVICING SYSTEMS AND/OR HARDWARE \ QUANTITY AND STATUS	QUANTITY OF ITEMS	CONCEPT ONLY	PRE PHASE A	PHASE A OR B	ON-HOLD	PHASE C/D	FLIGHT HARDWARE STATUS	STATION APPLICABLE	PERCENT
1. EVA SUPPORT EQUIPMENT NORMALLY MANIFESTED ON ORBITER	15	–	–	–	–	1	14	13	87
2. SHUTTLE SYSTEMS	10				1		9	7	70
3. TOOLS* AND TOOL STORAGE	8			2	1	3	2	7	88
4. PAYLOAD RELATED SYSTEMS AND CARRIERS	13					2	11	13	100
5. PROJECTED SATELLITE SERVICING EQUIPMENT	23	7	5	4	4	3	–	23	100
TOTAL	69	7	5	6	6	9	36	63	91

*EVA CONTINGENCY TOOLS COUNTED AS ONE SET

ITEMS NOT CONSIDERED FULLY COMPATIBLE WITH STATION

FOUR ITEMS IN THE CURRENT NASA SHUTTLE SERVICING EQUIPMENT COMPLIMENT COULD BE STATION APPLIED BUT ARE NOT CONSIDERED FULLY COMPATIBLE. THE FACING PAGE INDICATES WHICH ITEMS AND THE RATIONAL FOR NON-COMPATIBILITY. THUS, WITH MODIFICATIONS, EVEN THESE FOUR ITEMS MIGHT BE MADE STATION APPLICABLE.

ITEMS NOT CONSIDERED FULLY COMPATIBLE WITH STATION

A. PAYLOAD INSTALLATION AND POSITIONING AID

- REMOVAL (FROM ORBITER CARGO BAY) PROVISIONS NOT BUILT-IN FOR EASE OF TRANSFER TO STATION

B. FLIGHT SUPPORT SYSTEM (FSS) LOCKER

- MOUNTING PROVISIONS NOT MODULAR

C. ORBITER CARGO BAY FLOODLIGHTS

- HOUSING MOUNTINGS NOT UNIVERSAL

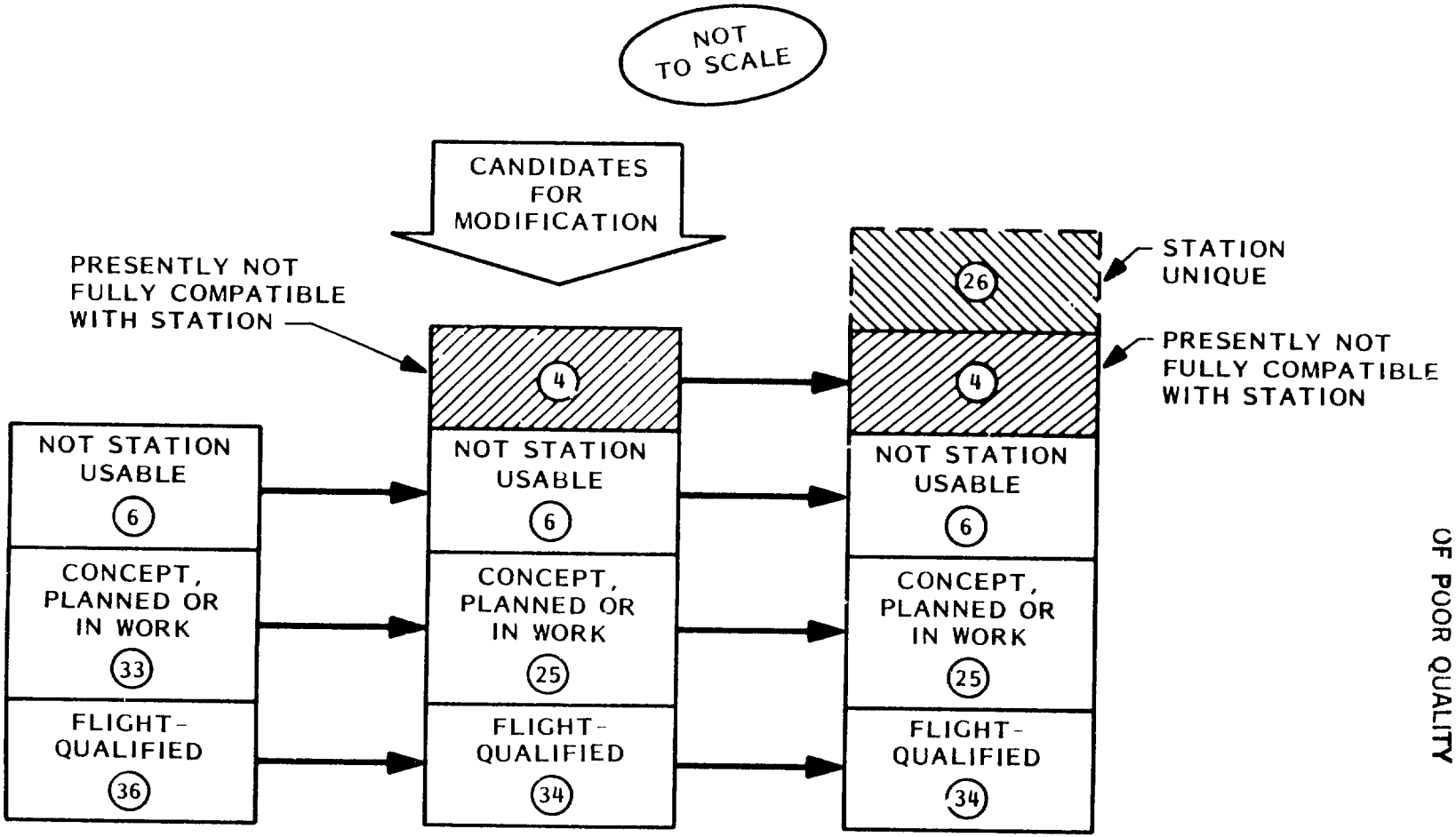
D. PORTABLE FOOT RESTRAINT (PFR)

- MOUNTING PROVISIONS NOT UNIVERSAL
- POSITION (REPOSITIONING) ARTICULATION NOT ADEQUATE

SHUTTLE SERVICING HARDWARE EVOLUTION TO STATION

THE PREVIOUS PAGES HAVE INDICATED THE NUMBER OF ITEMS CURRENTLY IDENTIFIED AS SHUTTLE AVAILABLE, IN WORK, OR POSTULATED AS STATION UNIQUE. THE OPPOSITE PAGE INDICATES IN GRAPHIC FORM THE EVOLUTION OF THE CURRENTLY PLANNED OR CONCEIVED SERVICING APPLICABLE EQUIPMENT, THOSE THAT ARE CANDIDATES FOR MODIFICATION, THOSE NOT STATION USEABLE AND THE FINAL STATION APPLICATION POTENTIAL.

SHUTTLE SERVICING HARDWARE EVOLUTION TO STATION



CONCLUSIONS/SUMMARY

THE GENERAL STUDY CONCLUSIONS ARE PRESENTED ON THE OPPOSITE CHART.

CONCLUSIONS/SUMMARY

A. SUBSTANTIAL NUMBER OF SPACECRAFT/FACILITIES/ELEMENTS TO BE SERVICED:
   - SHUTTLE LAUNCHED/SERVICED
   - STATION LAUNCHED/SERVICED
   - POTENTIAL TRANSITION FROM SHUTTLE TO STATION

B. SHUTTLE ERA (1984-1190) SERVICING HARDWARE/SYSTEM (69 TOTAL ITEMS):
   - 36 FLIGHT-QUALIFIED ITEMS (52 PERCENT)
   - 38 ITEMS IN CONCEPT FORMATION OR SOME STAGE OF DEVELOPMENT (48 PERCENT)

C. DURING THE SPACE STATION ERA, THE SHUTTLE WILL CONTINUE TO PLAY A KEY ROLE IN SATELLITE SERVICING BASED ON THE ORBITER's CAPABILITY TO ACCOMMODATE VARYING ALTITUDE AND INCLINATION REQUIREMENTS

D. SHUTTLE ERA SERVICING HARDWARE/SYSTEM APPLICABILITY TO STATION (1990+):
   - 6 ITEMS NOT STATION USABLE (9 PERCENT)
   - 4 ITEMS PRESENTLY NOT FULLY COMPATIBLE WITH STATION (6 PERCENT)
   - 59 ITEMS POTENTIALLY APPLICABLE (85 PERCENT)

E. STATION NEW AND/OR UNIQUE SERVICING HARDWARE/SYSTEM:
   - 26 SIGNIFICANT ITEMS IDENTIFIED

F. LARGER THAN ANTICIPATED NUMBER (85 PERCENT) OF SHUTTLE-ERA FLIGHT-QUALIFIED OR PLANNED HARDWARE/SYSTEM APPLICABLE TO STATION SERVICING NEEDS

G. NEARLY ALL SHUTTLE SATELLITE SERVICING EQUIPMENT IS APPLICABLE TO SATELLITE SERVICING FROM/AT THE SPACE STATION