SPACE STATION EVOLUTION LOGISTICS

LUNAR/MARS INITIATIVE CASE

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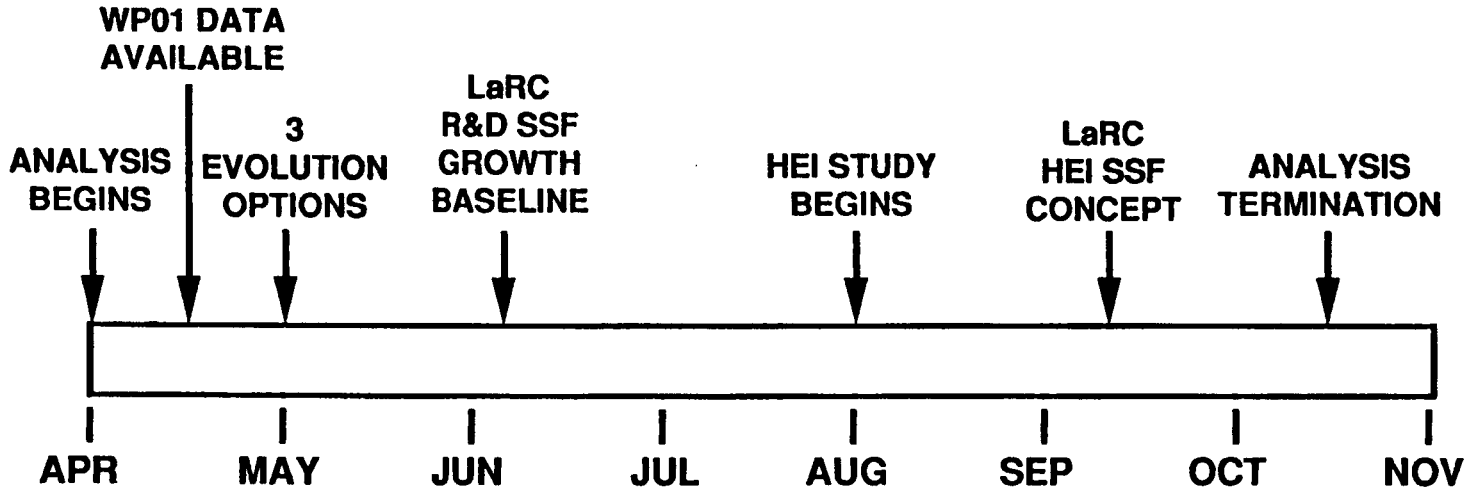
LOGISTICS STUDY FY'89 HISTORY



Objectives

The purpose of this study is to examine the potential logistics requirements for Space Station Freedom growth/evolution, and to provide definition of logistics systems for such growth/evolution as stated in the LS/ME Study Statement of Work, Contract NAS8-50000, Logistics System/Modules Evolution Study, NASA MSFC memorandum KA01, 88-13-071. Logistics requirements and logistics system elements for the initial Space Station were used as a starting point.

In the early part of the study, a small portion of the effort was used to characterize a spectrum of potential SSF growth/evolution possibilities, with the intent of assessing logistics requirements for a few selected SSF concepts. The data characterizing these concepts is included herein. An evolution concept of an R&D SSF & a Lunar/Mars Expedition (data from on-going related studies) began to emerge as a "reference" concept, so the logistics study effort was shifted to focus on this concept.

The ability of the present concepts of the logistics system elements as well as other concepts to accommodate the logistics requirements for the advanced SSF are assessed. The number of required attachment locations on the SSF are identified.

The data provided herein is an initial output from a study that is expected to continue during the next fiscal year. Other studies are in progress which will change the definition of the initial SSF, the growth/evolution SSF, the logistics requirements, and the ETO vehicle concepts. The continuation of this study will assess the implication of such changes.

The implications on the logistics systems of utilizing present and larger (ETO) vehicles than the present space transportation systems is assessed.

"Hooks and Scars" requirements for the initial Space Station, including logistics elements are defined.

OBJECTIVES

- PROVIDE LIMITED CHARACTERIZATION OF A SET OF REPRESENTATIVE GROWTH/EVOLUTION SSF CONCEPTS.
- DEFINE GROSS LOGISTICS REQUIREMENTS FOR SSF GROWTH/ EVOLUTION OPTIONS.
- DEFINE LOGISTICS ELEMENT CONCEPTS & FLIGHT RATES FOR SSF GROWTH/EVOLUTION OPTIONS AND ETO VEHICLE OPTIONS.
- DEFINE THE NUMBER OF ATTACHMENT LOCATIONS REQUIRED ON THE SSF GROWTH/EVOLUTION OPTIONS.
- IDENTIFY HOOKS AND SCARS REQUIREMENTS ON INITIAL SS TO SUPPORT EVOLUTIONARY LOGISTICS SYSTEMS.

Scope

The task involves analyzing all elements required for any of the various growth options of Space Station Freedom. Once the uplift has been determined, the elements are broken down into categories that include:

- Space Station Truss and Pressurized Cargo
- Special Equipment
- Lunar Equipment
- Mars Equipment
- Crew Equipment
- Propellant

SSF propellant is resupplied, however Lunar/Mars propellant is not in this study.

Once categories are set, logistics requirements are determined. "ETO" vehicles are then selected to support these logistics requirements.

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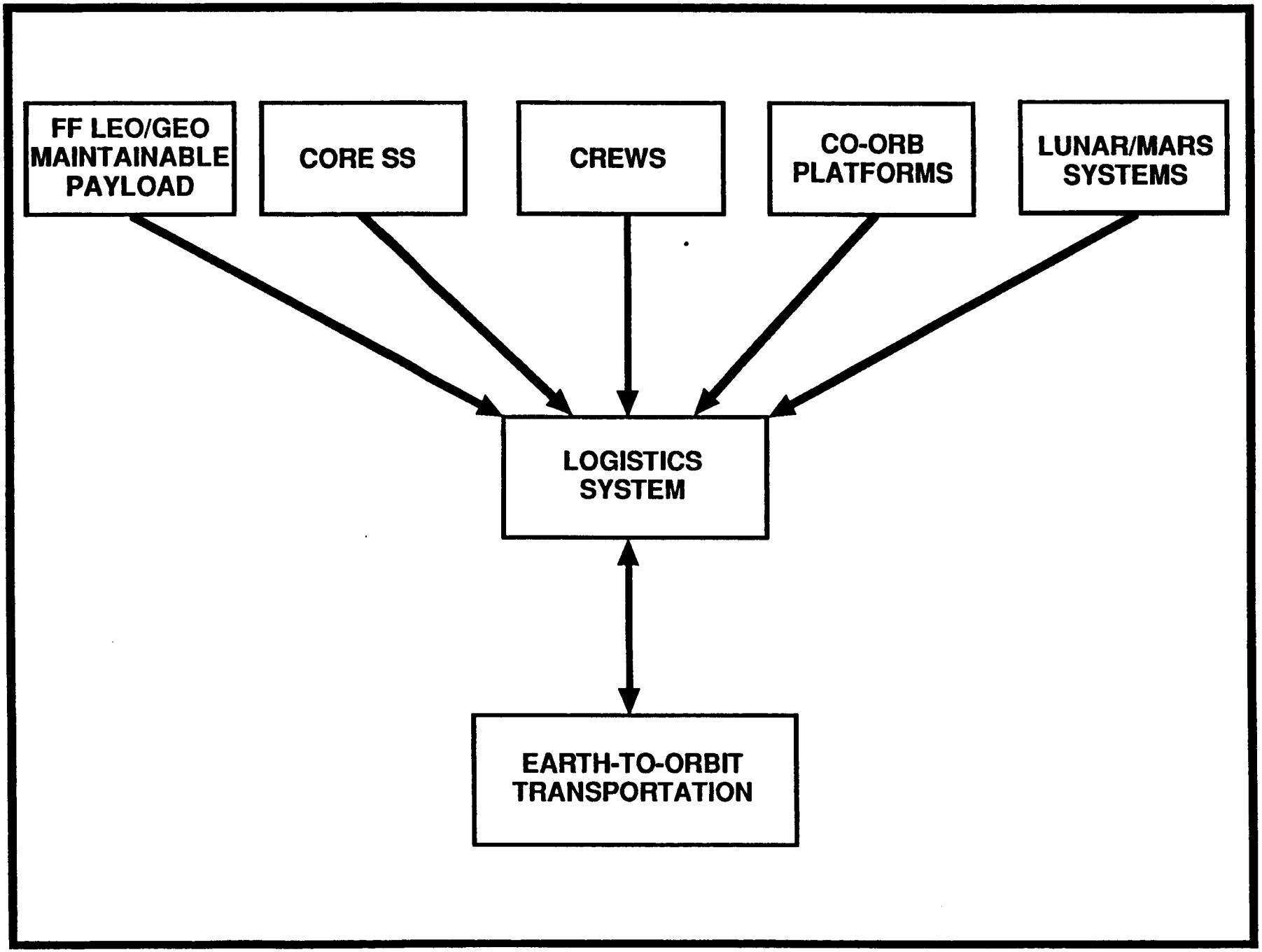
SCOPE



SSF Evolution Roadmap: 2

Analysis of the logistics requirements for two different SSF growth scenarios has been completed. The first option results in a SSF devoted to research and development and is based on the Phase I SSF. The first growth phase adds power, structure, the space based OMV and accommodations to house a 16-man crew. The second phase adds another 50 KW of power with servicing facilities, space based STV and hangar, a second U. S. Lab Module and a pocket lab. Phase Three adds more power and another Lab and Hab for accommodations to house a 24 man crew. The final changes include two pocket labs and an additional 50 KW of power. The result is an R & D space station with large amounts of available rack space and associated resources for the user community.

The second growth option is designed to satisfy the requirements of the baseline Lunar/Mars Initiative case. This space station's main objective is supplying LEO transportation node for lunar/Mars missions. The build-up consisits of four definable stages which represent an increasing capability for supporting the lunar/Mars manifest. In order to meet the first Node Event, an LTV test flight, and 50 KW of power will be added along with the associated thermal control, space based OMV, lower keel and booms, LTV servicing track with lunar OSE, an airlock and SSEMU's. The Lunar Node adds the LTV Hangar for debris protection, an additional Hab module and additional OSE. Lunar Node 2 adds the Customer Servicing Facility, 50 KW of power, H2O2 propulsion, a pocket lab (to support the addition of the Mars program), upper keels and booms which are added with a second MSC and MT, another Hab Module and the Mars OSE.

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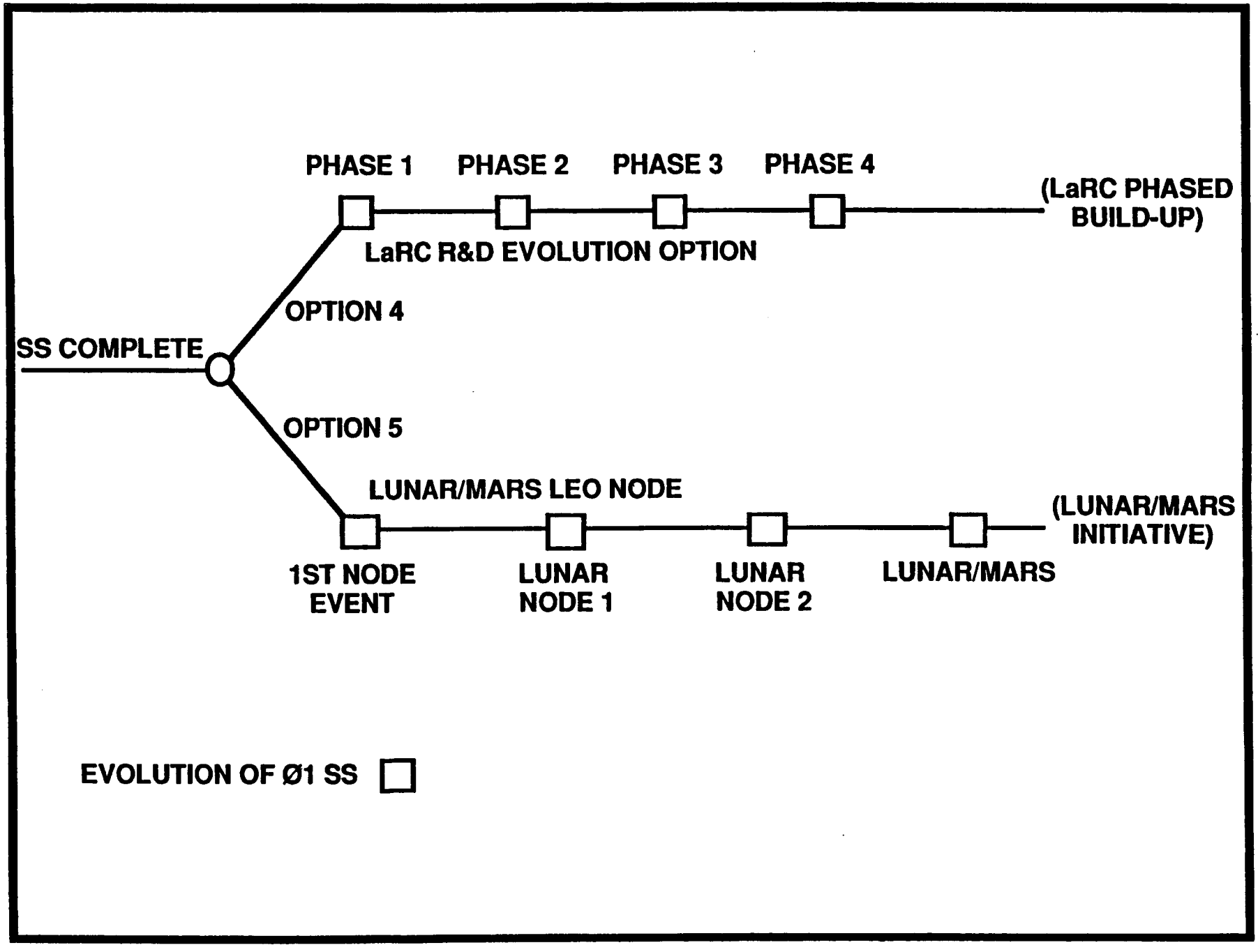
SSF EVOLUTION ROADMAP: 2



SSF WP01 Logistics System

Logistics Carriers:

	Empty Mass (kg)	P/L (kg)
• Pressurized Logistics Module	6632	13636
• Unpressuried Logistics Carrier	1091	9091
• Hydrazine Subcarrier *	306	1057
• Bipropellant Subcarrier *	665	2313
• Fluids Subcarrier *	759	1063
• Dry Cargo Subcarrier *	88	682

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* Each hydrazine subcarrier, bipropellant subcarrier, fluids subcarrier, or dry cargo subcarrier require an unpressurized logistics carrier to transport aboard launch vehicle.

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SSF WP01 LOGISTICS SYSTEM

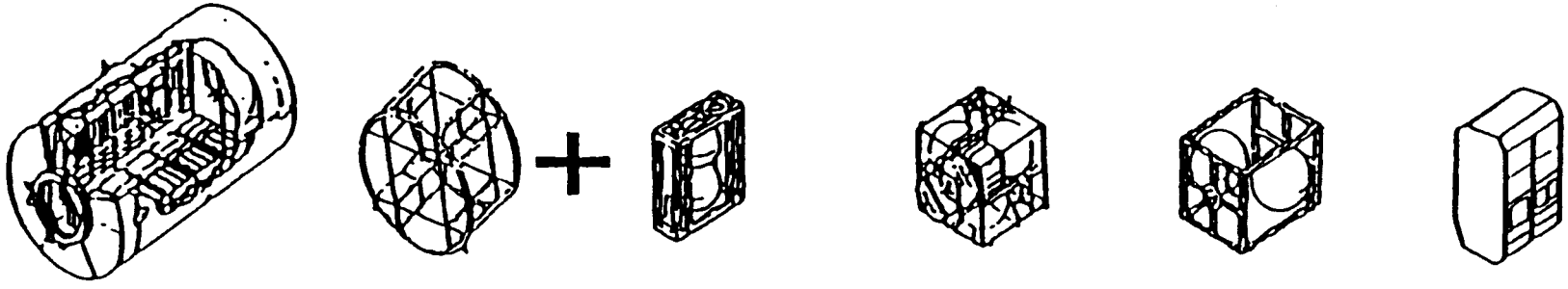
- Baseline Cargo Requirements

		Annual Quantity (kgs) Resupply	Return
Crew	Pressurized	36669	33091
Station	Unpressurized	18700	18700
Customers	Fluids	2909	696
	Propellants	6742	0
		65020	52487

- Launch And Landing Resources - STS

  Launch Capability - 17969 kgs to 220 NM
  Landing Capability - 18864 kgs (OV 102 is 3818 kgs less)

- SSF Logistics Elements



Empty Mass (kgs)	6632	1091	306	665	759	88
P/L (kgs)	13636	9091	1057	2313	1063	682

Logistics Model

A Microsoft Excel spreadsheet program has been written which compiles a complete set of annual logistics mass to orbit as shown in the chart below. By using the growth breakdown for space station elements initial spares uplift is calculated as 5% of that element mass. For subsequent years, 50% of the initial spares mass is required per year for resupply. Fluids, Propellant & Customer Support resupply are all based on a % of the size of SSF. Crew Support is based on the total number of crewpersons on-orbit. All spares or resupply items are subject to a carrier factor based on the particular carrier they ride on. All of these factors are computed in the spreadsheet program to derive total mass to orbit per year.

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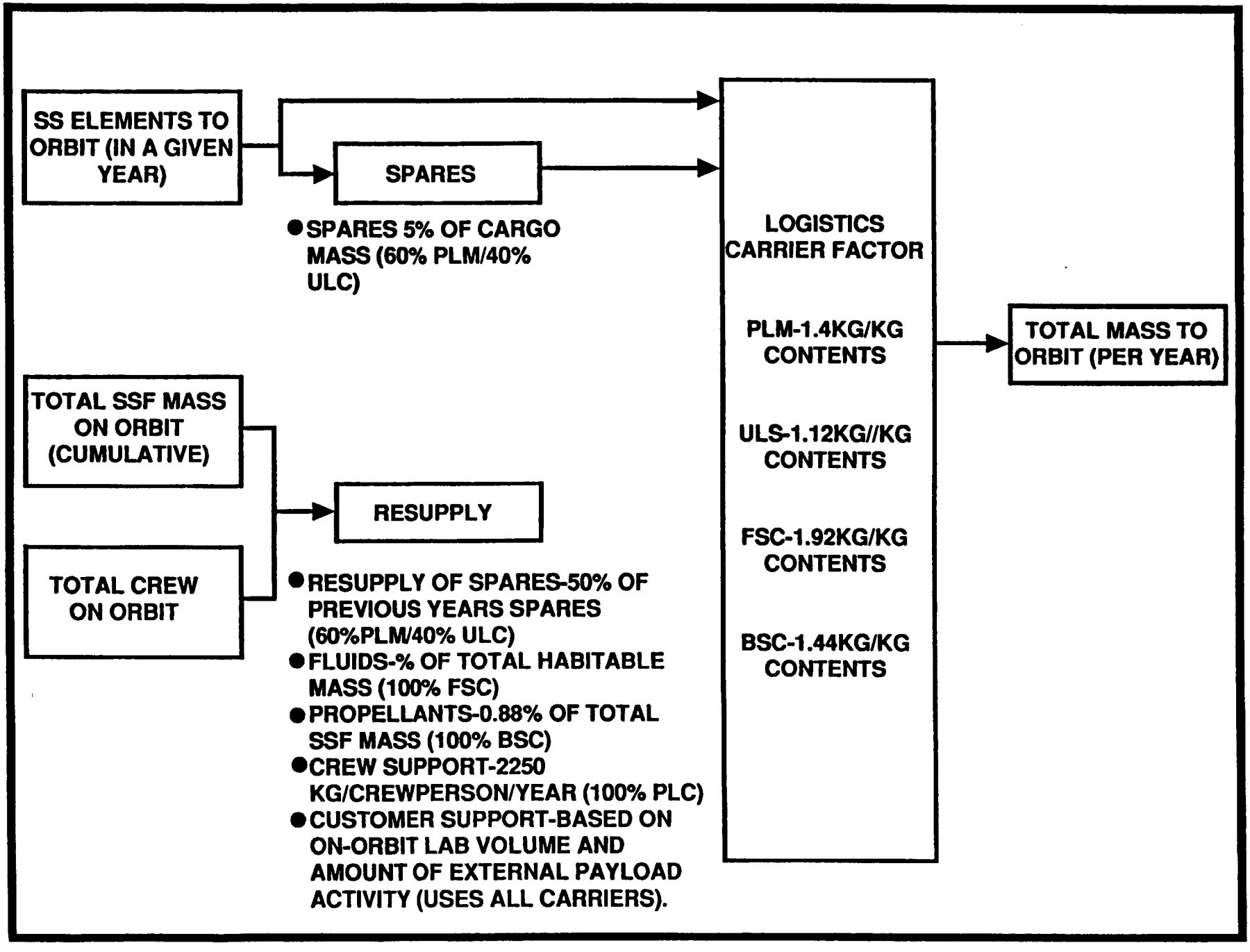
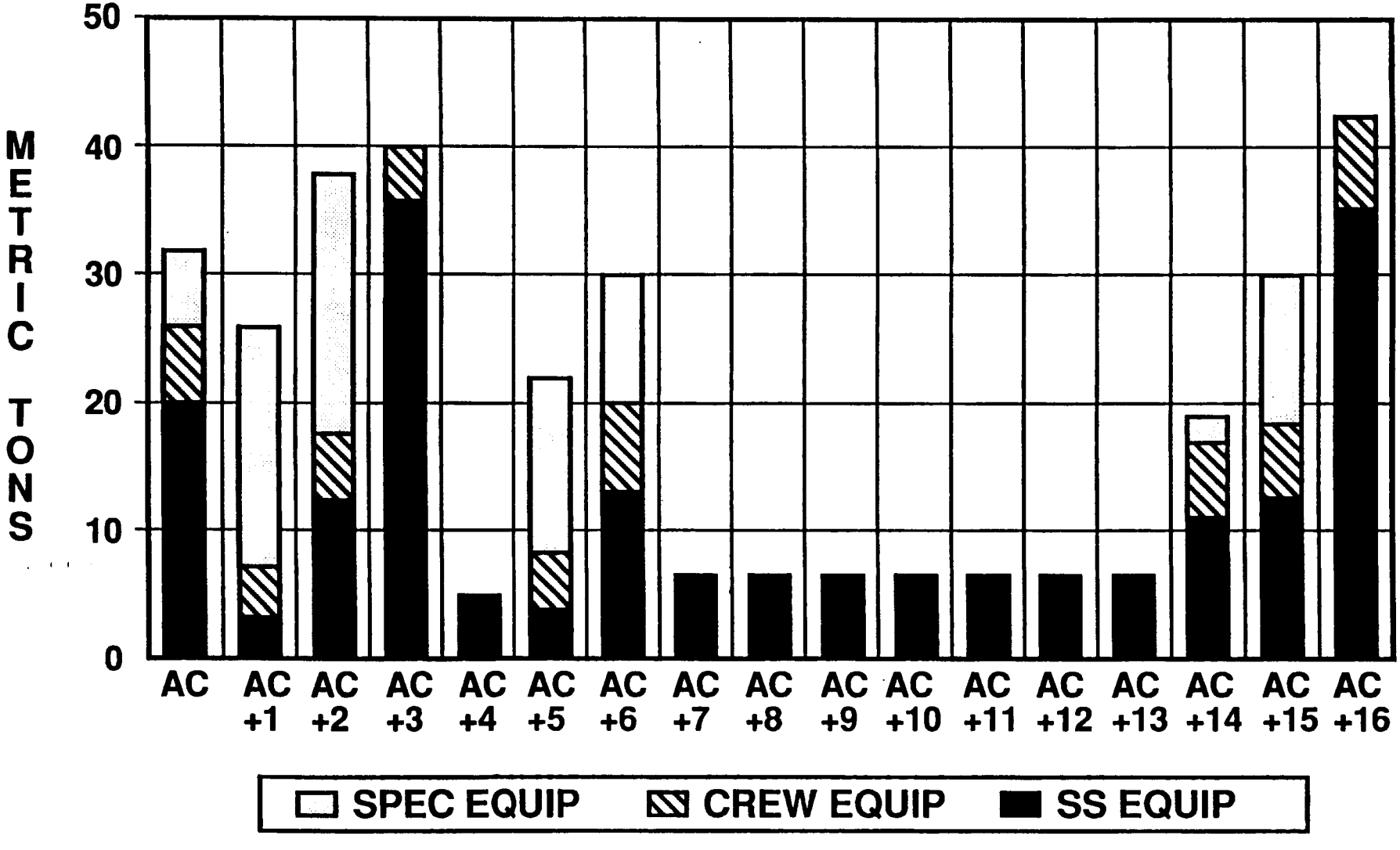
LOGISTICS MODEL



Total SS Elements to Orbit (Carriers Included) (Lunar/Mars Initiative)

The same hardware uplift as in the previous chart but with the inclusion of carrier/ETO interface mass. This factor is calculated as 13% of SS hardware and special equipment. The equipment tare factor is included in payload mass. These calculations are based on WP01 data.

TOTAL SS ELEMENTS TO ORBIT
(CARRIERS INCLUDED)
(LUNAR/MARS INITIATIVE)



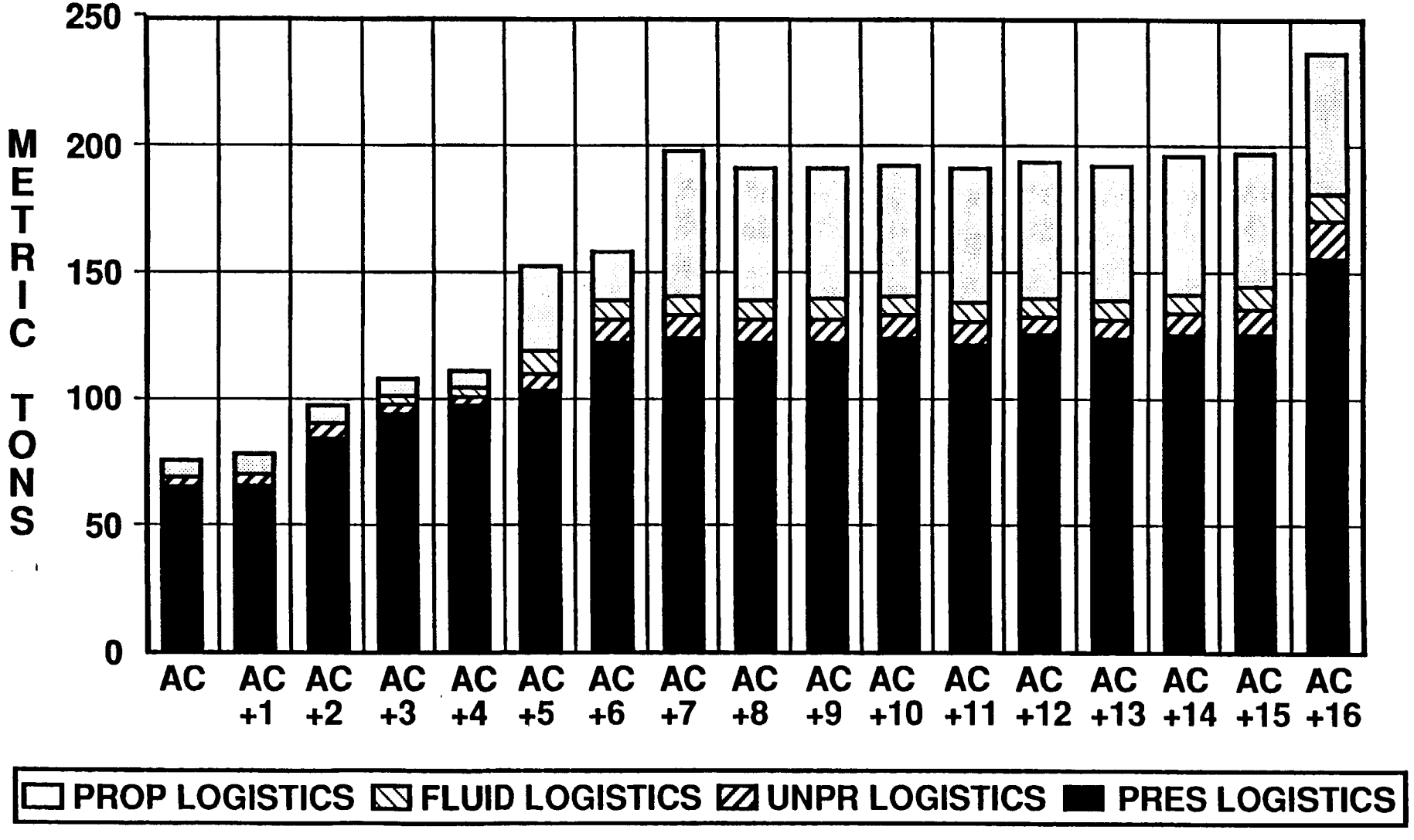
Total Logistics to Orbit
(Carriers Included)
(Lunar/Mars Initiative)

Carrier Factor for Logistics Carriers

• Pressurized Carrier	1.486kg	for each kg of spares or resupply
• Unpressurized Carrier	1.12kg	for each kg of spares or resupply
• Fluids Carrier	1.92kg	for each kg of spares or resupply
• Propellant Carrier	1.442kg	for each kg of spares or resupply

Carrier factors are imposed on logistics to account for the weight of the carriers required to accommodate them during flight.

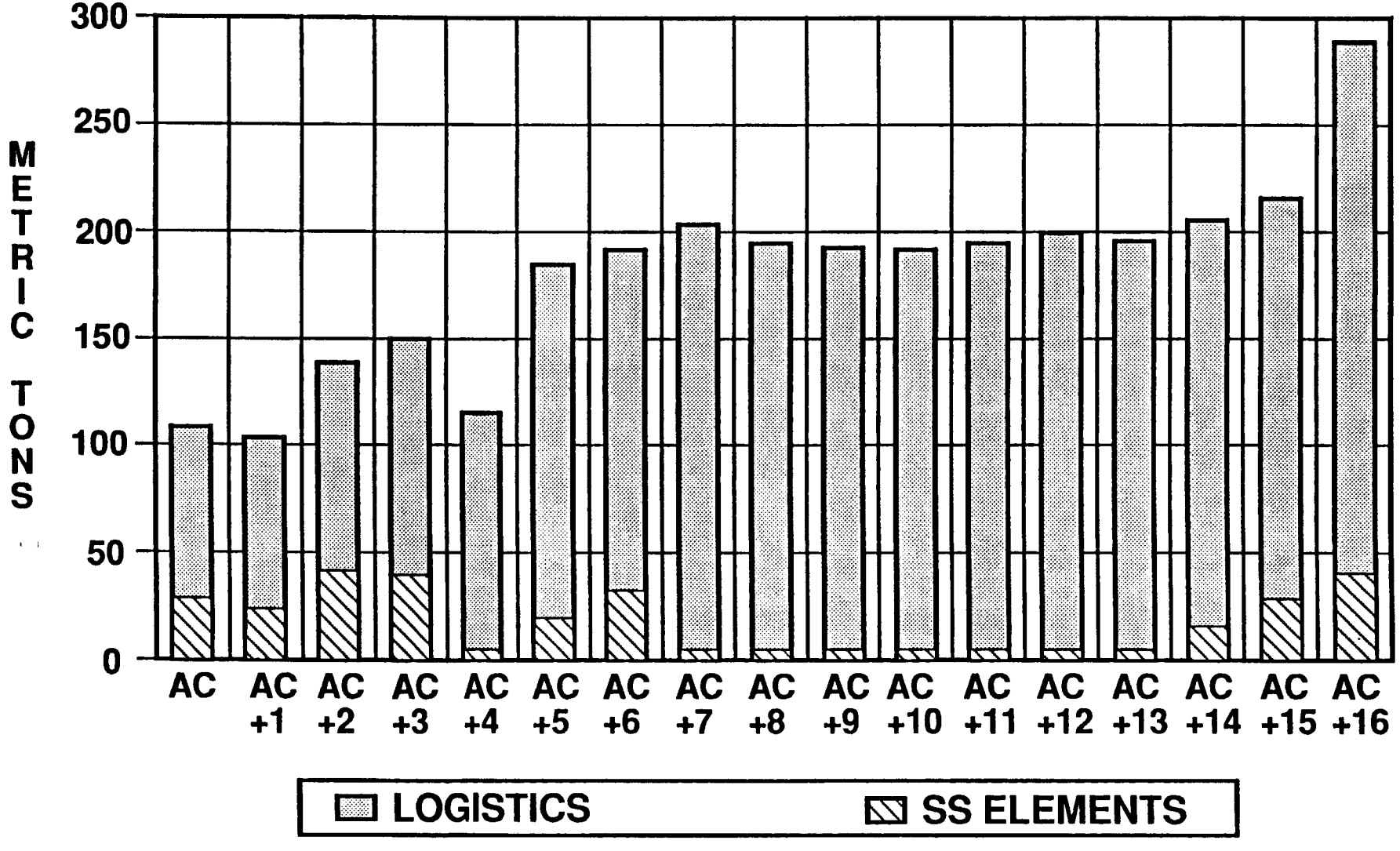
TOTAL LOGISTICS TO ORBIT
(CARRIERS INCLUDED)
(LUNAR/MARS INITIATIVE)



Total Logistics & SS Elements to Orbit
(Carriers Included)
(Lunar/Mars Initiative)

The logistics requirements of the growth SSF combined with hardware mass on a yearly basis with carrier/ETO interface mass. This represents the total SSF requirements for growth.

TOTAL LOGISTICS & SS ELEMENTS TO ORBIT
(CARRIERS INCLUDED)
(LUNAR/MARS INITIATIVE)

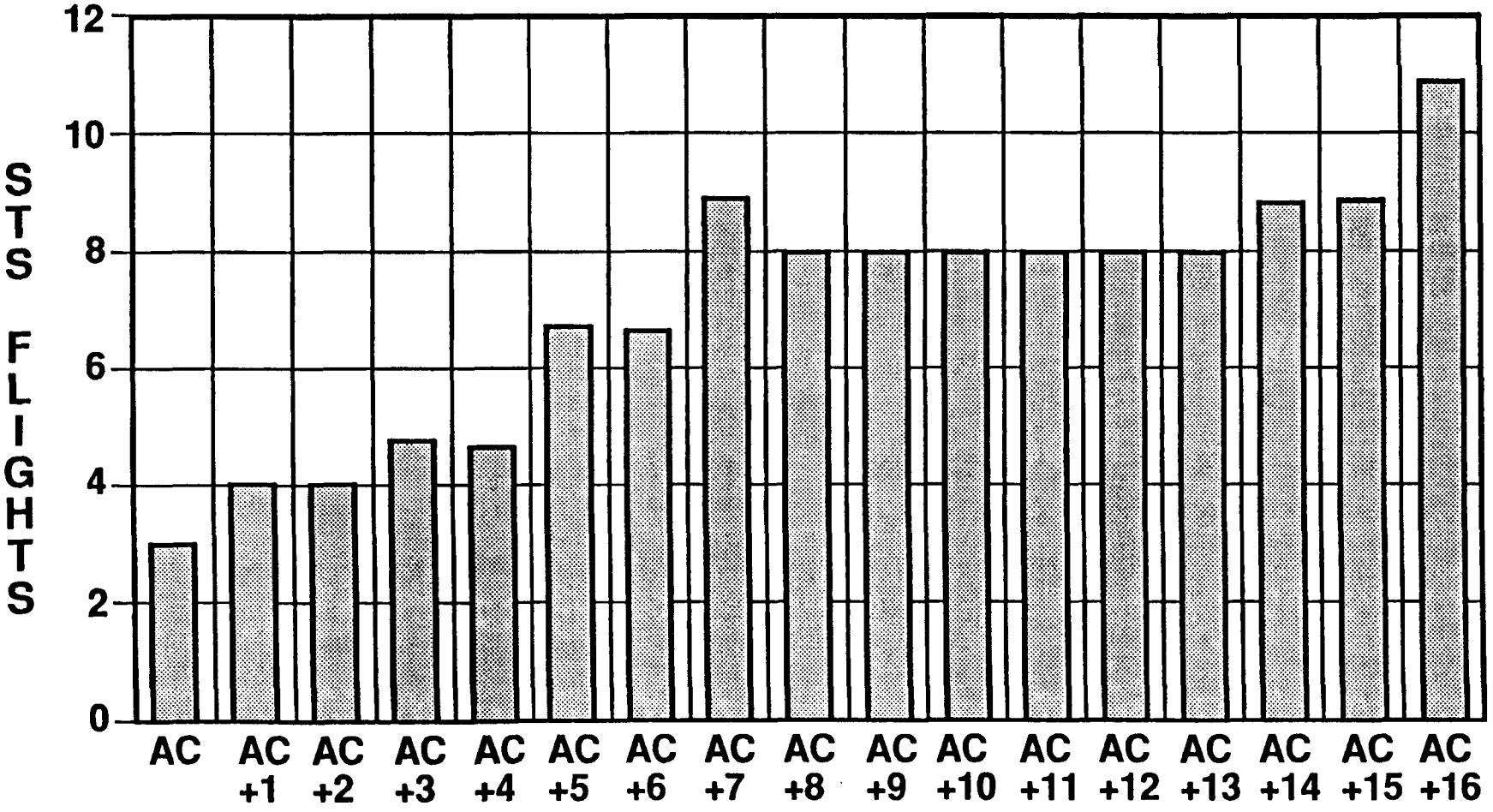


STS Flights Required for Logistics & Carriers Uplift (Lunar/Mars Initiative)

STS launches required to accommodate logistics uplift to support SSF. Shuttle assumed to be able to accommodate 22,727 kg of cargo per launch.

Chart indicates that the groundruled 8 Shuttle flights per year for logistics is violated in 2004 and after 2011 if only the Shuttle is used for uplift.

STS FLIGHTS REQUIRED FOR LOGISTICS & CARRIERS UPLIFT (LUNAR/MARS INITIATIVE)

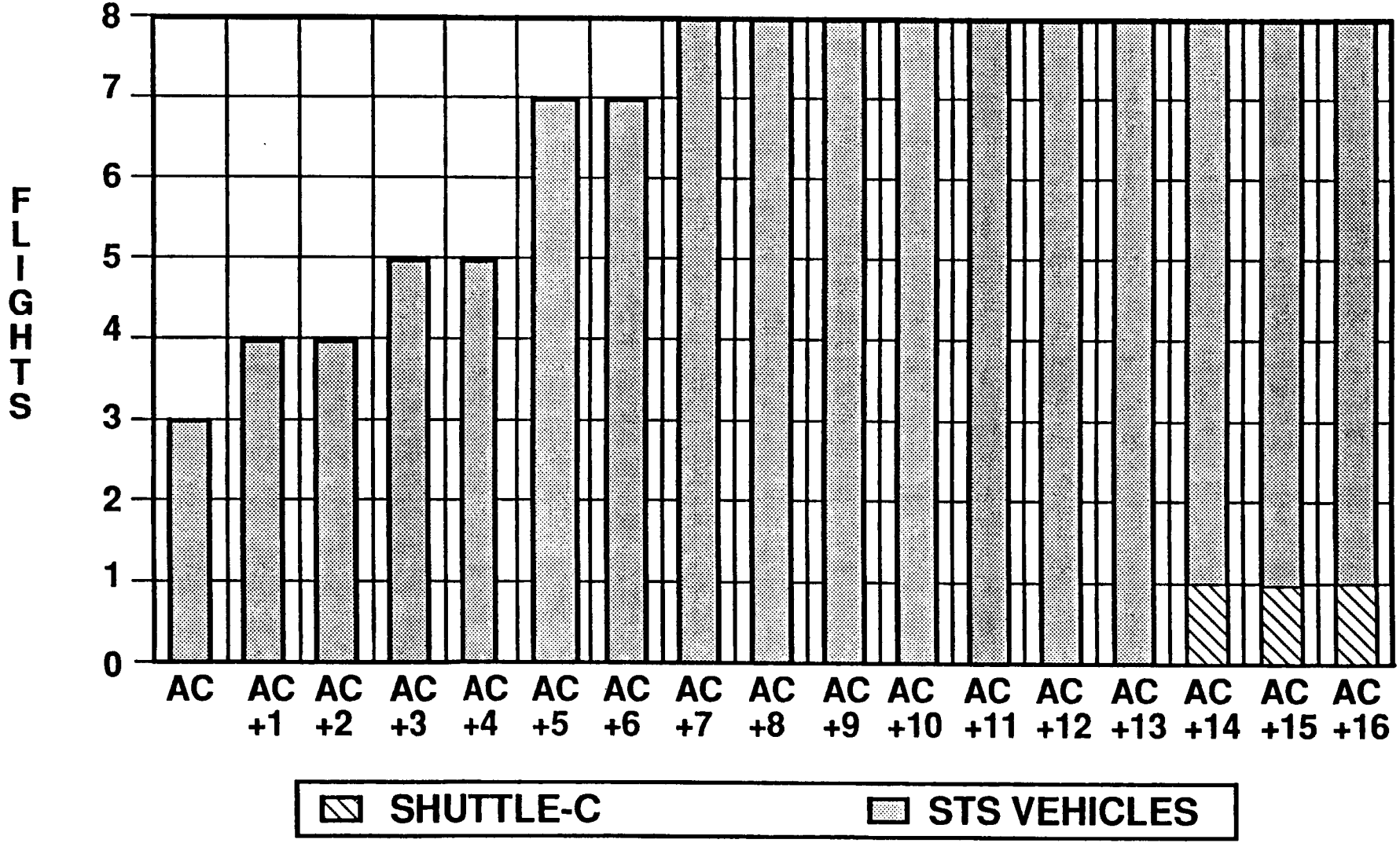


Total ETO Logistics Flights Required (Lunar/Mars Initiative)

Shuttle and Shuttle-C flights required to accommodate logistics uplift to support SSF. Assumed a maximum of (8) dedicated shuttle missions for logistics and crew rotation. The remainder being launched on Shuttle-C

Shuttle-C has an assumed cargo capacity of 68,127 kg per launch.

TOTAL ETO LOGISTICS FLIGHTS REQUIRED (LUNAR/MARS INITIATIVE)



POTENTIAL HOOKS AND SCARS

HOOKS

- REQUIREMENT FOR A HOOK RELATES PRIMARILY TO REVISIONS IN INVENTORY MANAGEMENT
- ANOTHER NEED IS TO CONTROL TRAFFIC IN PROX-OPS

SCARS

- GROWTH SSF HAS A POTENTIAL STORAGE PROBLEM TO BE SOLVED BY:
  - ADDITIONAL BERTHING PORTS, OR AT LEAST PARKING POSITIONS
  - "WAREHOUSING" IN A STORAGE FACILITY, AND/OR
  - USE OF LOGISTICS CARRIERS AS ON-ORBIT SEMI-PERMANENT STORAGE
- LONGER UNPRESSURIZED LOGISTICS CARRIERS (ULC's) TO TAKE MAXIMUM ADVANTAGE OF SHUTTLE-C's LONG CARGO COMPARTMENT AND LIFT CAPABILITY
- ENLARGED PROPELLANT AND FLUIDS SUBCARRIERS (BSC & FSC) TO ACCOMMODATE GROWTH
- TETHER ATTACHMENT LOCATION FOR TETHERED REENTRY OF DISPOSABLE WASTE (POTENTIAL)

CONCLUSIONS/FUTURE WORK

1. CONCLUSIONS FOR THE R & D SSF AND THE LUNAR/MARS INITIATIVE
   - INITIAL SSF LOGISTICS SYSTEM IS INADEQUATE TO SUPPORT GROWTH/EVOLUTION
   - DURING PEAK YEARS FOLLOWING SSF ASSEMBLY COMPLETE THERE ARE INSUFFICIENT NUMBERS OF CARRIERS
   - PROJECTED STS LAUNCH RATE IS INADEQUATE TO SUPPORT GROWTH/EVOLUTION
   - SHUTTLE-C COULD PROVIDE THE ADDITIONAL LIFT TO LEO
   - PARKING LOCATIONS FOR UNPRESSURIZED CARGO IN INADEQUATE

2. FUTURE WORK
   - PERFORM DETAILED ANALYSIS OF NEW CARRIER CONCEPTS FOR GROWTH/EVOLUTION
   - DEVELOP UNPRESSURIZED STOWAGE SYSTEM AT SSF
   - UPDATE AND REFINE LOGISTICS REQUIREMENTS FOR THE GROWTH/EVOLUTION PHASE

3. NEEDS
   - MAINTENANCE PLAN AND STRATEGY FROM CURRENT SSF PROGRAM TO ESTABLISH FIRM SET OF SPARES PERCENTAGES AND RESUPPLY REQUIREMENTS