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MANNED MARS MISSION
EARTH-TO-ORBIT (ETO) DELIVERY AND ORBIT ASSEMBLY OF THE MANNED MARS VEHICLE

B. Barisa and G. Solmon
Marshall Space Flight Center
Marshall Space Flight Center, AL

ABSTRACT

The contents of this section contain the initial concepts developed for the in-orbit assembly of a Manned Mars Vehicle and for the Earth-to-Orbit (ETO) delivery of the required hardware and propellant. Two (2) Mars vehicle concepts (all-propulsive and all-aerobrake) and two (2) ETO Vehicle concepts were investigated. Both Mars Vehicle concepts are described in Reference 1, and both ETO Vehicle concepts are described in Reference 2. The all-aerobrake configuration reduces the number of launches and time required to deliver the necessary hardware/propellent to orbit. Use of the larger of the 2 ETO Vehicles (HLLV) further reduces the number of launches and delivery time; however, this option requires a completely new vehicle and supporting facilities.

INTRODUCTION

Two (2) Mars vehicle concepts were investigated. An "all-propulsive" vehicle (i.e , one using propulsive braking for capture at Mars and Earth) concept (Figure 1) was analyzed and found to require twenty-five (25) Shuttle-derived (SDV-3R) Vehicle (Figure 2) launches to deliver the required hardware and propellant to Earth orbit. The SDV-3R vehicle is described in Reference 2. An additional Space Shuttle launch is required for the delivery of the supporting equipment (Assembly System plus associated equipment) and crew. Most of this study was performed on the all-propulsive vehicle; however, the same assumptions were applied to an all-aerobrake concept (Figure 3). This second configuration requires nine (9) SDV-3R hardware and propellant deliveries to orbit and two (2) Space Shuttle deliveries. Additional crew deliveries would be required if the crew is rotated. The assumptions and description of the operations are presented below, followed by a KSC ground flow concept (Figure 4) for the processing of the SDV-3R vehicle and payloads. Data is also provided for utilization of the Heavy Lift Launch Vehicle (HLLV) for delivery of the Mars vehicle elements to LEO.

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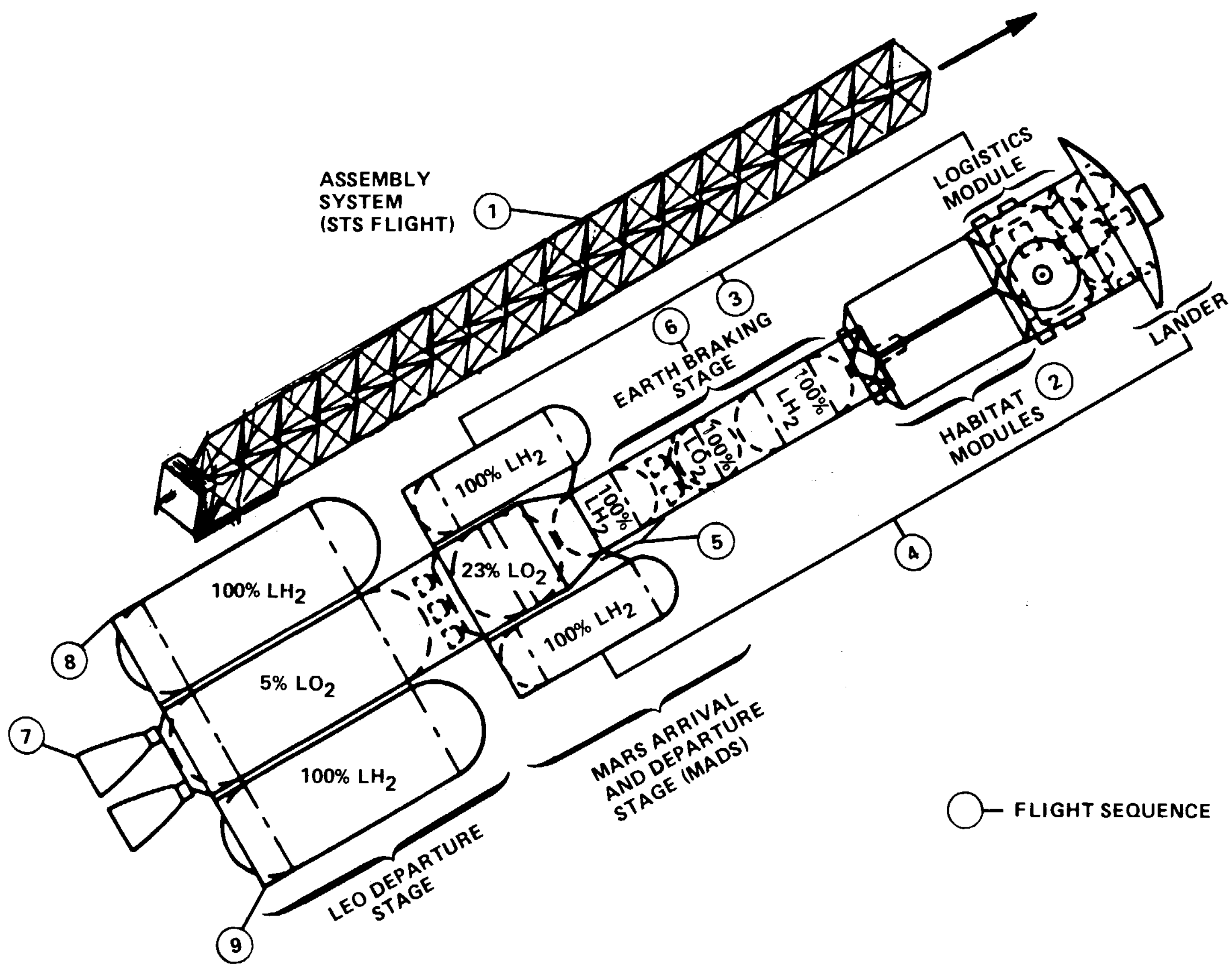

ALL–PROPULSIVE CONCEPT
FIGURE 1

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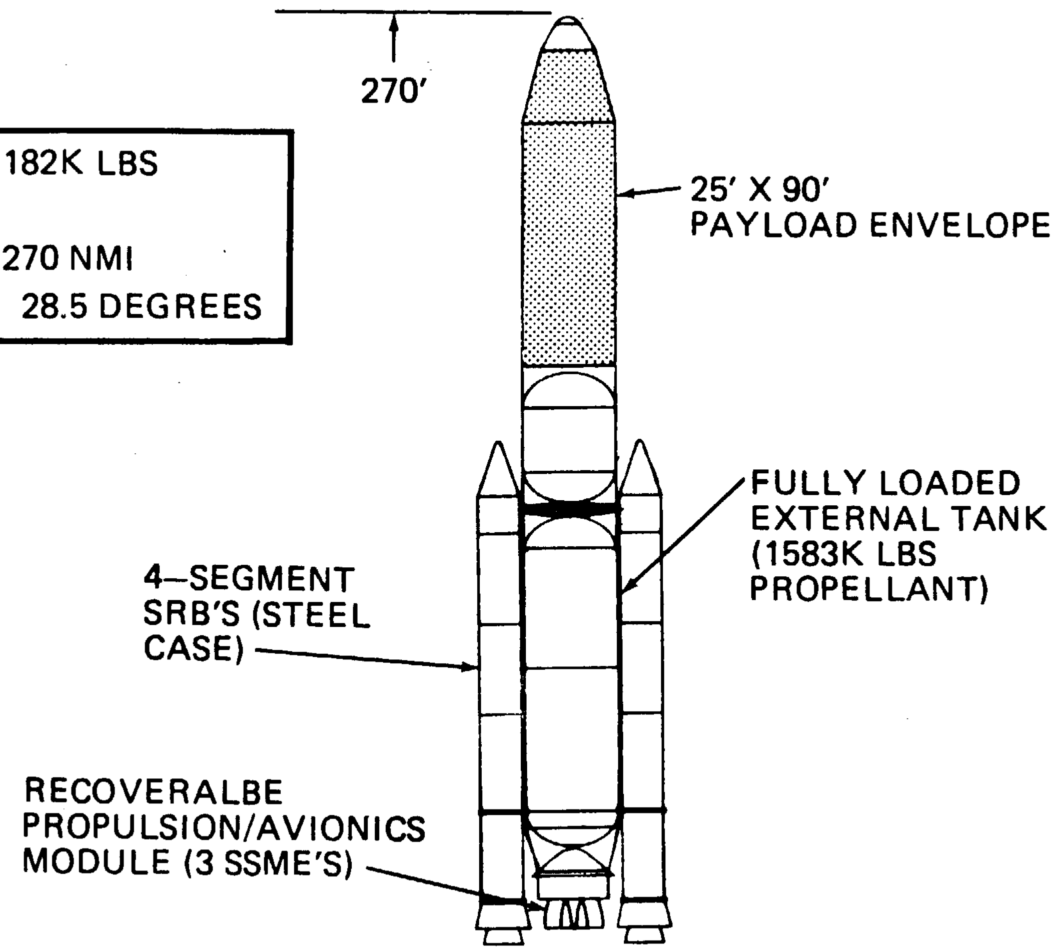
FIGURE 2
IN–LINE SHUTTLE DERIVED VEHICLE

PAYLOAD		182K LBS
ORBIT		
	ALTITUDE	270 NMI
	INCLINATION	28.5 DEGREES



SDV–3R

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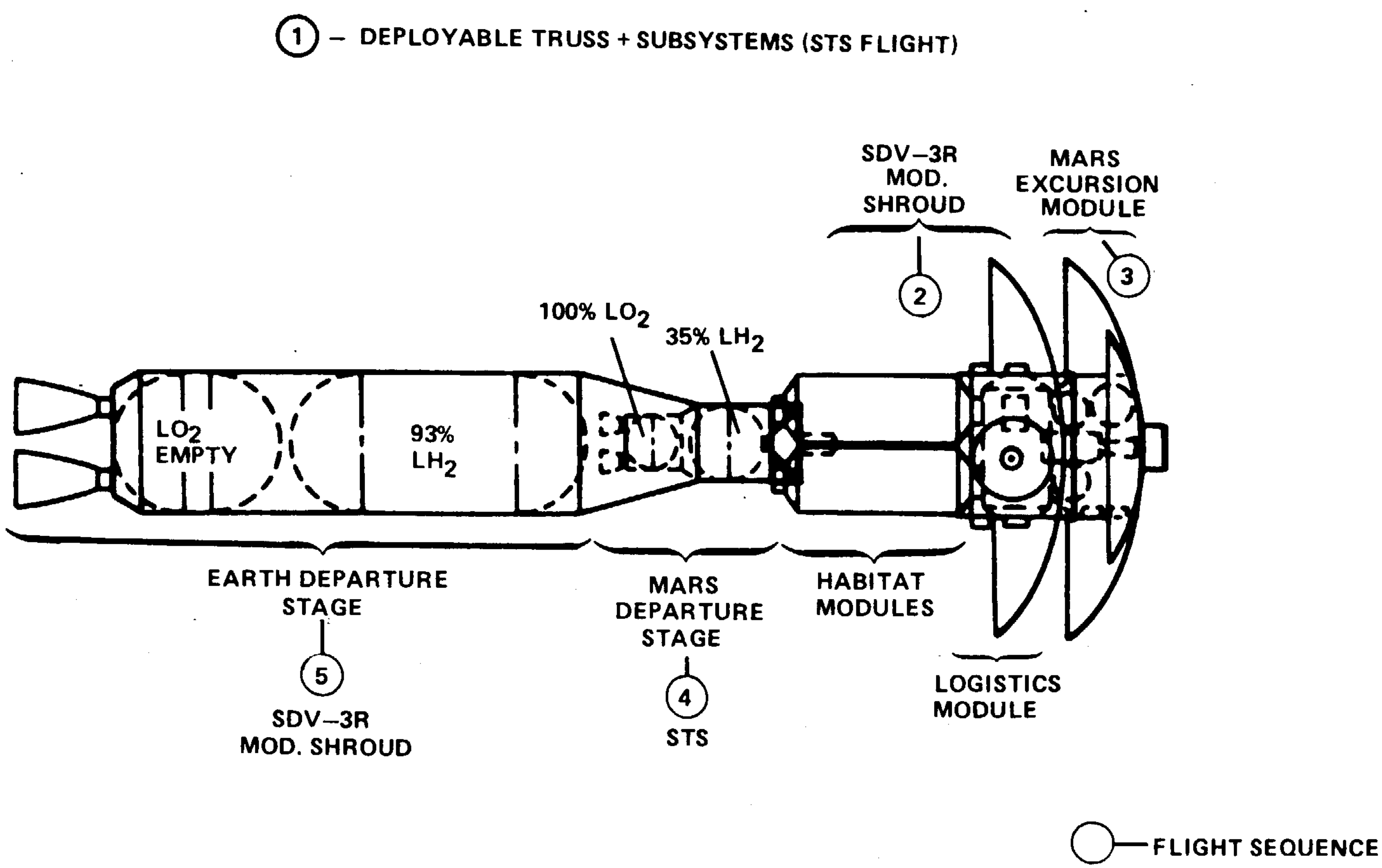

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ALL AEROBRAKE CONCEPT
FIGURE 3

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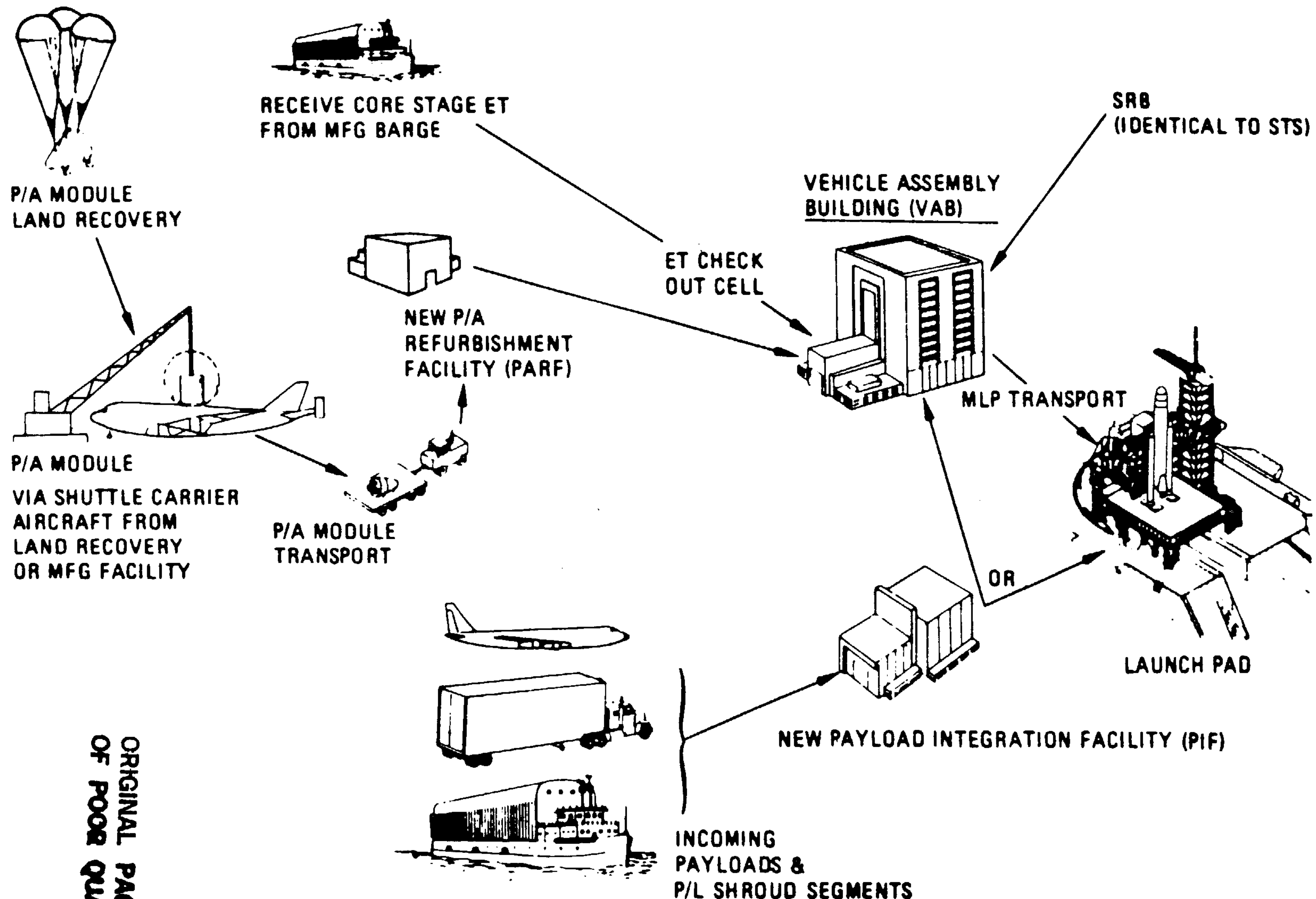

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MANNED MARS KSC GROUND OPERATIONS FLOW
FIGURE 4

ASSUMPTIONS

The assumptions given here are applicable to both configurations. The vehicle buildup crews would be transported to orbit and returned by the Space Shuttle. More than one crew may be necessary due to specialized requirements, such as propellant transfer, electrical or mechanical operations and possiby due to fairly long assembly times. The habitat modules would be used by the buildup crews and would be refurbished for the flight mission, if assembly times can be kept reasonable.

The Shuttle-derived Vehicle (SDV-3R) would be the primary vehicle for hardware and propellant deliveries. The aerobrake(s) would be deployable for SDV-3R payload integration and ETO delivery.

Based on the studies performed by the Martin Marietta Corp. (May 1985) on the KSC ground operations (Reference 3), the launch frequency of the SDV-3R is six (6) per year for minimum impact to the KSC operations. An increased launch frequency would require facilities beyond those presented (Figure 4).

The facility (Assembly System) for orbital assembly of the Mars vehicle was conceptually viewed as an erectable or deployable structure with integral subsystems capabilities, derivable from the Space Station (SS) as discussed in Reference 4. The subsystems required are: (a) Atitude stabilization, (b) Communication and data handling*, (c) Electrical Power*, (d) Mobil RMS (MRMS) or equivalent, and (e) Crew aids (lighting, restraints, tools, etc.) The post-assembly disposition alternatives for the Assembly System and associated equipment are: (a) Leave in orbit for future applications (e.g., other Mars vehicles or growth station), (b) Transfer to Space Station via Orbital Maneuvering Vehicle/Orbital Transfer Vehicle (OMV/OTV), and (c) Return to Earth (Requires disassembly if >32,000 lbs). Potential uses of the SS to augment the Mars vehicle assembly are discussed in Reference 4.

ALL-PROPULSIVE CONFIGURATION

The all-propulsive configuration is illustrated in Figure 1. The concept of SDV-3R delivery for the propellant and hardware for the Mars mission vehicle buildup consists of: (a) One (1) Space Shuttle (STS) flight, (b) Eight (8) hardware flights (SDV-3R), and (c) Seventeen (17) propellant flights (SDV-3R).

* Possibly supplied by the Mars vehicle.

Ideally, the vehicle elements would all be delivered "dry" to LEO, would be assembled into the Mars vehicle, then would be loaded with propellant just prior to departure. However, efficient use of the SDV-3R requires "wet" and partially wet launches of these elements. The flight sequence is defined in Figure 1. The STS flight would carry the Assembly System and associated equipment to orbit. The two (2) habitat modules on the SDV-3R would follow or be launched concurrently with the STS flight. These modules would be used for the buildup-phase crew quarters and would later, if necessary, be refurbished prior to the scheduled mission. The STS crew could assist the buildup crew in the initial setup of the Assembly System. The remaining seven (7) illustrated hardware/propellant deliveries have been derived based on the SDV-3R capability and are listed as follows: (1) Logistic module + one (1) fully loaded LH_2 tank; (2) Lander + one (1) fully loaded LH_2 tank; (3) Mars Arrival/Departure Stage engine + one (1) fully loaded LH_2 tank and one (1) partially loaded (approx. 23%) LO_2 tank; (4) Earth braking stage (fully loaded LH_2 + LO_2 tanks); (5) Partially loaded (5%) LO_2 tank + engines (LEO Departure Stage); (6) Fully loaded LH_2 tank for Lower Earth Orbit (LEO) Departure Stage; and (7) Fully loaded LH_2 tank for LEO Departure Stage. The seventeen (17) propellant flights (163,800 lbs/flight) required to fill and replenish boiloff of the vehicle tanks may be meshed with the above hardware delivery flights for optimization. As previously stated, the maximum launch rate of SDV-3R vehicles on a minimium impact basis to the KSC facilities is 6 vehicles per year. Hence, delivery to LEO of the Mars vehicle hardware elements alone would require 14 months. Based on 17 required propellant flights, an additional 32 months would be required, but so much additional boiloff would occur over this time period, the vehicle may never get fully loaded. Obviously, this is not a viable approach.

ALL AEROBRAKING CONFIGURATION

The all aerobraking configuration concept is illustrated in Figure 3. This configuration saves approximately 2 million pounds over the all-propulsive configuration. The concept for ETO delivery of hardware and propellant consists of: (a) Two (2) Space Shuttle (STS) flights; (b) Three (3) hardware flights - SDV-3R (2 of the 3 flights will have a modified shroud to accomodate the larger diameter/length of the payload);

and (6) Six (6) propellant flights - SDV-3R. The Assembly System would be delivered to orbit by the STS as in the all-propulsive configuration. The second STS flight would deliver the second stage (OTV size). The SDV-3R would require (2) flights with a modified shroud to deliver the habitat module, logistics module and one aerobrake as one flight, and the first stage of the Mars vehicle as the other. The Mars excursion module (2 aerobrakes) would be the third SDV-3R flight.

This configuration can be delivered to orbit in approximately 1 1/2 years as compared with approximately 4 years for the all-propulsive configuration, based on the limitaion of 6 SDV flights per year. This analysis includes 172,800 lbs of boiloff propellant. Some expansion of the facilities at KSC and acquisition of additional SDV hardware could increase the launch frequency. If an HLLV, as described in reference 2 (see Figure 5) is used instead of the SDV-3R, the situation would be further improved. Using HLLV's, the total number of flights to deliver the Mars vehicle elements (all-aerobrake) to LEO would be 4 flights, of which 2 are for hardware/propellant and 2 are for propellant only. If one flight were available every 2 weeks, the delivery time spans would be 6 weeks for hardware and propellant. The significant time advantage of using an HLLV is readily apparent from these figures. Other related advantages are that larger segments of the Mars vehicle can be delivered at a time, reducing the on-orbit assembly, integration, and checkout effort and time required. The developement of a completely new vehicle and related facilities may be required, however, unless these were developed as part of other NASA programs or other agencies' activities.

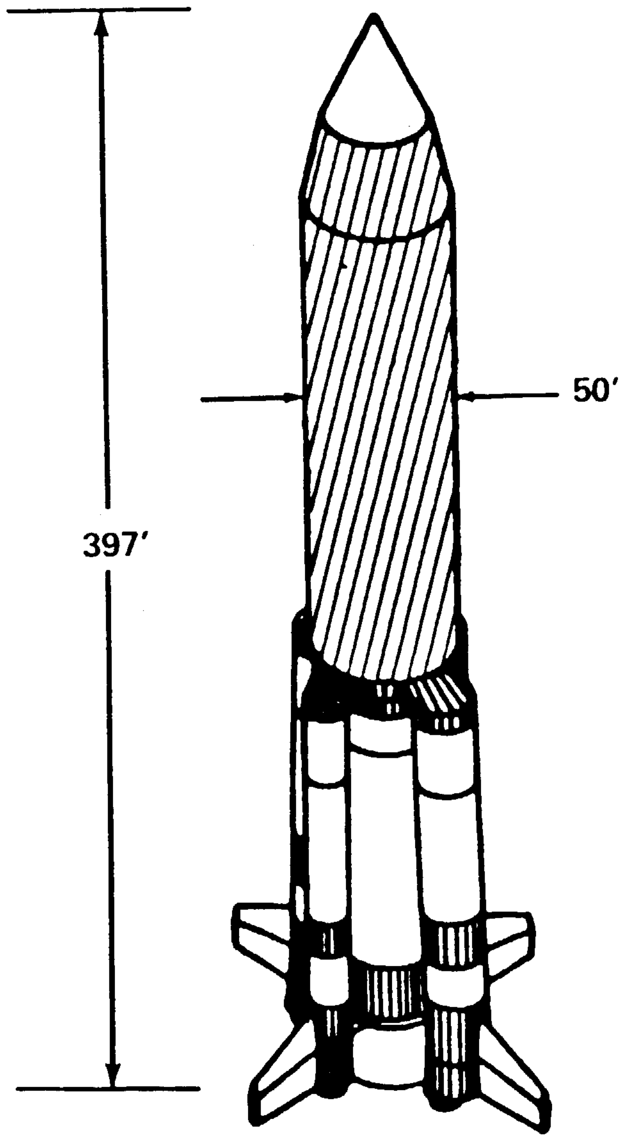
GROUND OPERATIONS

A conceptual ground operations flow is established for the SDV-3R vehicle. This concept is based on a minimum impact to KSC, avoiding new launch facilities. Six (6) SDV flights per year can be accomplished, resulting in approximately 4 years for hardware delivery for the all-propulsive concept and 1 1/2 years for the all aerobrake concept. The ground flow requires a new P/A facility and payload integration facility.

FUTURE STUDY CONSIDERATION

Items which require future study are: (a) Methods/procedures for propellant transfer from the ETO vehicle payload tanks to the Mars vehicle; (b) Disposition of the ETO vehicle (Mars vehicle propellant)

FIGURE 5. HEAVY–LIFT LAUNCH VEHICLE (HLLV) (RECOVERABLE PROPULSION AND AVIONICS (P/A) MODULE)



- REUSABLE P/A MODULE
  - 5 X STME'S @ 100%
- 4 X LIQUID BOOSTERS (RECOVERABLE)
  - 2 W/2 X 1.616 MLBF ENGINES
  - 2 W/1 X 1.616 MLBF ENGINE
- 33 FT. DIA. EXPENDABLE CORE STAGE TANKAGE
- USABLE P/L ENVELOPE – 45′ X 200′
- PERFORMANCE*
  - 270 NM/28.5° – 401K
  - 160 NM/28.5° – 418K
  - 540 NM/90° – 302K
- IOC 1995

* ORBITS CIRCULARIZED WITH KICK STAGE

tanks; (c) Assembly system and it's subsystems configuration; (d) Disposition of the assembly system after Mars mission departures; (e) Vehicle assembly optimization and procedures; (f) Berthing procedures; (g) Procedures to transfer payload from ETO delivery vehicle (SDV-3R) to Assembly System; (h) Increased launch frequency impact on KSC; (i) Schedule for buildup crews (may not be required for duration between deliveries); and (j) Trades of on-orbit-deployable vs. on-orbit-assembleable aeroshells.

SUMMARY

The all-propulsive Mars vehicle is not pracical to utilize if the SDV-3R ETO vehicle must be used, due to the extensive number of ETO delivery flights for propellants and hardware and the time it would take to assemble and load the vehicle. Obviously, a prefered approach for ETO delivery and on-orbit assembly of the Mars vehicle would be to use an all-aerobraking vehicle and deliver its elements to LEO with the SDV-3R. The ETO delivery of the Mars vehicle concepts could be shortened by expansion of the KSC facilities. Use of the HLLV for the ETO delivery appears most desireable except that a new vehicle would need to be developed with costly new facilities. However, if the HLLV vehicles and facilities costs could be shared with other programs, it would be of significant benefit for the Mars mission ETO delivery.

REFERENCES

1. Paper in Section III of this report, entitled "Space Vehicle Concepts," by M. Tucker, O. Meredith, and B. Brothers of MSFC.
2. Paper in Section III of this report, entitled "Earth-to-Launch Vehicles for MMM Application," by M. Page of MSFC.
3. Final review of "Advanced Space Transportation Systems Ground Operations Study Extension," by Martin Marietta for KSC Operations, May 1985, Contract # NAS.10-10572.
4. Paper in Section IX of this report, entitled "Space Station Utilization and Commonality," by J. Butler of MSFC.