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Shuttle Derived Space Transportation The Next Step Beyond STS

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ABSTRACT

This paper describes future space transportation launch vehicles presently under study by the NASA and DOD. The program activities of several recent and ongoing contracts have been merged to show insight into the present status and future plans for the United States space transportation system. Major emphasis is placed on a shuttle derived launch vehicle concept. This concept, using fully developed and tested space shuttle system hardware, allows early implementation of a low cost, low risk launch systems.

Growth shuttle derived configurations, utilizing a "building block" concept to allow efficient optimization of a broad spectrum of performance capabilities, are also presented.

INTRODUCTION

The evolution of space launch vehicles in the past has been motivated by increasing payload weights, volumes and improved economics. Therefore it is reasonable to assume that the same motivation will govern the development of launch vehicles in the STS era. For example, there is an increasing recognition that, later in this decade, additional investments will be required to support the growth in volume and weight of payloads to low and geosynchronous Earth orbits. The recent U.S. committment for manned presence in space will result in on-orbit space stations consisting of large structural elements as typified by the concept illustrated in Figure 1. Additionally, the "star wars" scenario -- a space based defense against ballistic missiles program -- includes large, massive spacecraft such as the space based laser shown in Figure 2. These laser spacecraft require diameters of ten meters or greater depending on the total power requirements, and will weigh several hundred thousand pounds.

Shuttle Derived Vehicles (SDV) are a potential companion to the ongoing manned launches of the STS to satisfy these future requirements and will enable the growing needs of the nation's space program to be met in an extremely cost effective manner.

SHUTTLE DERIVED VEHICLES

Many types of SDV launch configurations have evolved with payload capabilities in the 100,000 to 200,000 pound range as shown in Figure 3. All SDCV configurations presented here share a common STS major element heritage: the external tank (ET), Space Shuttle main engines (SSMEs), solid rocket boosters (SRBs) and, to a major extent, orbiter avionics. Cost advantages accrue from shared STS/SDCV production, logistics and operations base and provide a near term heavy lift performance capability while avoiding major new DDT&E expenditures.

The configurations are generally denoted inline or sidemount based on the location of the payload with respect to the external tank core stage. Other variations include the number of SSMEs, the length of the core stage, and whether or not the high cost propulsion and avionics components are recoverable. One of the more promising configurations is a sidemount version, denoted Shuttle Derived Cargo Vehicle, which minimizes the impacts to the existing STS facilities and operations. (Reference 1)

SDCV SIDEMOUNT CONFIGURATION

The SDCV Sidemount configuration, shown in Figure 4, retains the standard ET and two SRBs. A cargo carrier, consisting of a recoverable propulsion/avionics (P/A) module and an expendable payload (P/L) module, replaces the orbiter in the STS stack. The P/L module is capable of supporting payloads up to 25 feet in diameter and 90 feet in length. The P/A module contains the main (3 SSMEs) and secondary propulsion systems, avionics, electrical power auxiliary power and thermal control systems. Reentry and recovery systems include the aeroshell structure, thermal protection system, parachutes, retrorockets, and landing gear.

SDCV MISSION PROFILE

A typical SDCV mission profile is depicted in Figure 6. The nominal mission is 24 hours in length, including recovery of the P/A module.

After lift-off, the SRB separation, reentry and splashdown occur as currently schedule for the STS. The cargo carrier shroud is jettisoned at approximately t + 250 seconds. Main engine cutoff occurs at t - 475 seconds and ET separation at t + 507 seconds while the ET is still suborbital in velocity. The ET ballistically reenters the Earth's atmosphere where breakup takes place prior to impact in the ocean.

Payload deployment activities begin at approximately t + 2 hours. At t + 22 hours, or sooner, the P/L module is pointed for reentry by the P/A module and a deorbit burn initiated. The P/A module then separates and undergoes reentry maneuvers while the P/L module enters the atmosphere where breakup occurs.

SDCV PERFORMANCE

The SDCV sidemount performance is shown in Figure 7. The payload capability to standard reference orbits of 160 nautical miles at 28.5 degree inclination and geosynchronous are compared with that of the basic STS. Also indicated are alternate launch site mission capabilities in which "KSC type" missions are launched from VAFB and "VAFB type" missions are launched from KSC. Note that the SDCV performance capability enables STS geosyncronous missions to be launched from either launch site in the event one of the launch sites is inoperative.

SDCV WIND TUNNEL TESTS

Wind tunnel tests were performed in the Marshall Space Flight Centers 14 inch trisonic wind tunnel using 1/250 scale models of the SDCV (Reference 2). The test hardware, shown in Figure 8, consisted of various cargo carrier diameters (15, 25 and 33 feet), lengths (70, 90 and 110 feet) and nose cones (ogive, biconic, and 16 1/2, 21 1/2, and 31 1/2 degree conics). Aerodynamic force and moment data were obtained with a series of test runs up to Mach 4.96, with varying angle of attack and sideslip.

Schlierens were taken during the runs at Mach 2.74. These photographs, typified by Figure 9, illustrate the shock intersection regions which would be areas of high pressure and heating.

These tests validated the aerodynamic and static stability characteristics of the SDCV configuration family.

STS FACILITIES IMPACTS

The SDCV impacts on the existing STS operation facilities of both Kennedy Space Center (KSC) and Vandenberg Air Force Base (VAFB) are limited to those summarized in Figure 10 (Reference 3). These impacts are a direct result of the large cargo carrier payload bay size. Operationally, all P/A modules will be refurbished at KSC selected as a result of higher launch rates. The only new facility required is a cargo integration building, shown in Figure 11, where the P/A module is refurbished and mated to the payload module and the payload is installed. This requires modification and use of the existing 747 orbiter air transport for P/A module return to VAFB.

SDCV SCHEDULE CONSIDERATIONS

A representative SDCV hardware development schedule was prepared to include the period of time from the authority to proceed (ATP) for a phase C/D contract through certification of initial operational capability (IOC) of the overall SDCV program (Reference 4). This schedule, as shown in Figure 12, indicates that a program initiated in late 1985 will have SDCVs on-line early in 1991 -- a 78 month span under normal scheduling practices. An analysis was also conducted to evaluate how quickly the SDCV could be made available in the event of a national committment for an alternate shuttle derived non-recoverable launch vehicle. Since the vehicle was no longer recoverable, the design, production and test activities associated with the recoverable P/A module were no longer required. This along with reduced time required for facilities, tooling and hardware procurement led to expendable launch vehicle availability in early 1991 -- a 62 month time span from ATP.

SUMMARY

The SDCV presents a near term technically viable and operationally attractive complement to the present STS. Growth configurations of SDVs are already under study which will expand performance capabilities up to 500,000 pounds to low earth orbit through consideration of dual P/A modules, stretched external tanks, and replacement of SRBs with liquid rocket boosters.

Thus an SDV evolutionary approach exists, capitalizing on the technology base incorporated within the present STS, which will provide increased flexibility in meeting potential space transportation needs while simultaneously offering the capability of reducing future launch costs in the 1990s.

References

1. Aft Cargo Carrier and Shuttle Derived Cargo Vehicle Definition Study, NAS8-34183, Martin Marietta, Michoud Division, New Orleans, LA, February, 1983.

2. SDV Wind Tunnel Test Evaluation, Final Report, NAS8-34183, Martin Marietta, Michoud Division, New Orleans, LA, October, 1983.

3. Advanced Space Transportation System Ground Operations Study NAS10-10572, Martin Marietta, KSC Operations, Kennedy Space Center, Florida, November, 1983.

4. Shuttle Derived Cargo Vehicle Accelerated Schedule Study, Final Report, NAS8-35613, Martin Marietta, Michoud Division, New Orleans, LA, March, 1984.

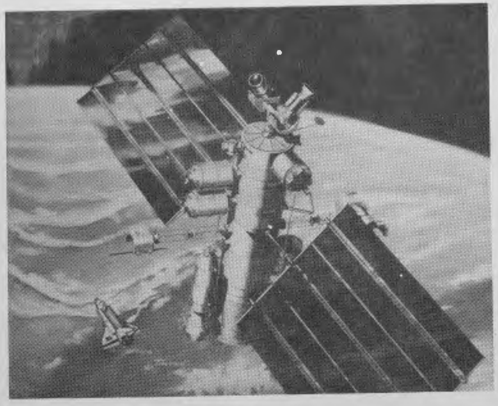

Figure 1 Typical Space Station Configuration

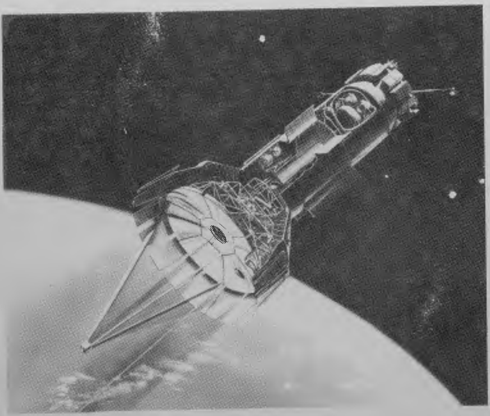

Figure 2 Space Based Laser Concept

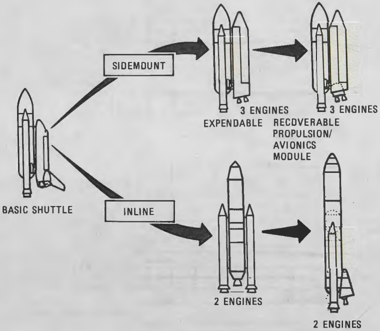

Figure 3 Shuttle Derived Vehicles

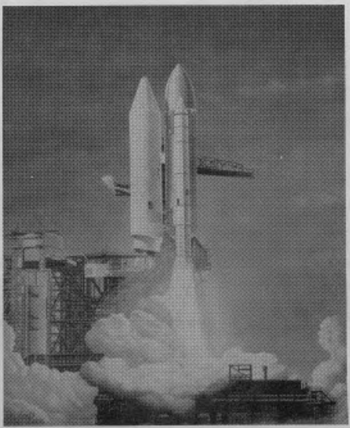

Figure 4 SDCV Sidemount

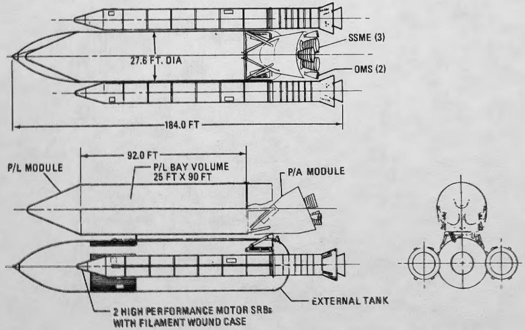

Figure 5 SDCV Sidemount Dimensional Data

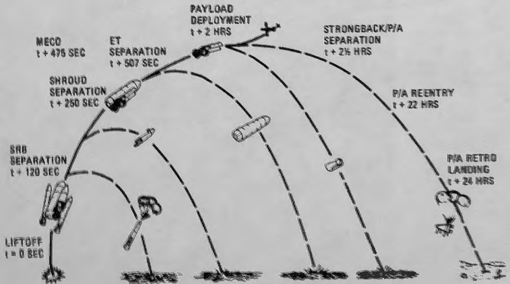

Figure 6 Typical SDCV Mission Profile

LAUNCH SITE	KENNEDY SPACE CENTER		VANDENBERG AIR FORCE BASE	
LAUNCH INCLINATION	28.5°	60°	60°	98°
PAYLOAD CAPABILITY TO FINAL CIRCULAR ORBIT (LB)	STS: 69,300 SDCV: 150,000 TO 160 NM @ 28.5°	STS: 7,500 SDCV: 28,200 TO 160 NM @ 98°	STS: 11,900 SDCV: 37,900 TO 160 NM @ 28.5°	STS: 30,900 SDCV: 111.600 TO 160 NM @ 98°
	STS: 15,900 SDCV: 41,400 TO EQUATORIAL GEOSYNC	—	STS: 8,100 SDCV: 28,700 TO EQUATORIAL GEOSYNC	—

Figure 7 SDCV Performance

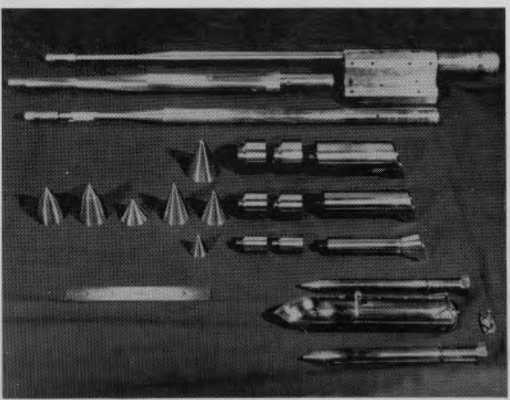

Figure 8 Wind Tunnel Test Hardware

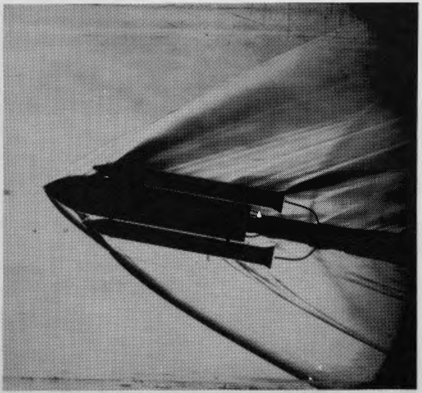

Figure 9 Schlieren Photograph

KSC FACILITY	IMPACT
MOBILE LAUNCH PLATFORM	NO MAJOR CHANGES ARE REQUIRED
ROTATING SERVICE STRUCTURE	NO MAJOR CHANGES REQUIRED FOR HORIZONTAL INTEGRATION NEW RSS, OR EQUIVALENT, NEEDED IF VERTICAL INTEGRATION IS REQUIRED
VERTICAL ASSEMBLY BUILDING	MODIFY ACCESS PLATFORM FOR LARGER DIAMETER & LONGER PAYLOADS
CARGO INTEGRATION BUILDING	A NEW INTEGRATED CARGO PROCESSING & P/A REFURB FACILITY IS REQUIRED

VAFB FACILITY	IMPACT
LAUNCH PAD	NO MAJOR CHANGES ARE REQUIRED
PAYLOAD CHANGEOUT ROOM/PAYLOAD PREPARATION ROOM	NO MAJOR CHANGES ARE REQUIRED FOR HORIZONTAL INTEGRATION. NEW PCR/PPR IS REQUIRED IF LARGE VERTICAL PAYLOAD INSTALLATION IS REQUIRED
MOBILE SERVICE TOWER	NO SIGNIFICANT CHANGES ARE REQUIRED
CARGO INTEGRATION BUILDING	A NEW HORIZONTAL CARGO INSTALLATION & P/A MATE FACILITY IS REQUIRED

Figure 10 STS Facilities Impacts

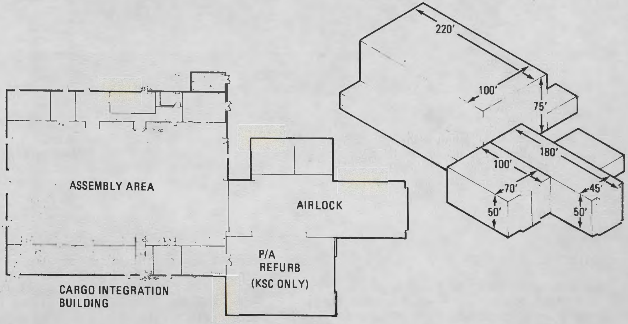

Figure 11 Cargo Integration Building Layout

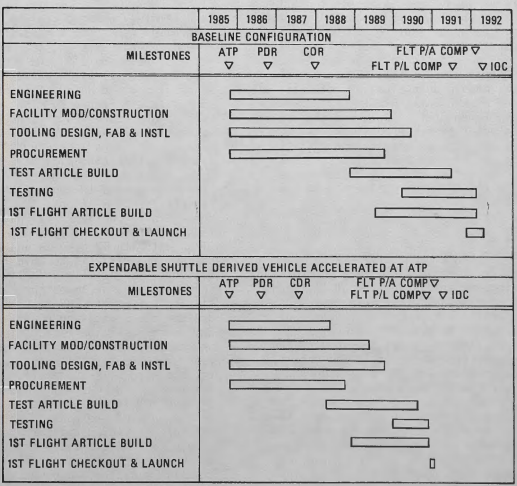

Figure 12 SDCV ATP to IOC Schedule