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Planning for Performance Augmentation of Space Shuttle

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ABSTRACT

Augmented performance is necessary to assure that the full Space Shuttle payload deployment capability of 32,000 lbs can be achieved for the 98° inclination, 150 nautical mile circular mission launched from Vandenberg AFB, Calif. The performance-augmented Space Shuttle meets all design mission requirements, and offers potential payload growth to accommodate new payloads and new concepts. Consequently, it is important to the future national space capability that performance augmentation be developed and made available to meet payload requirements which exploit the capability of the Space Shuttle.

This paper presents the options under consideration which include uprating the Space Shuttle Main Engines (SSMEs) to the range of 115 percent of rated power level for nominal operations, Solid Rocket Motor (SRM) filament-wound case segments, and the Liquid Boost Module (LBM). These candidates will be studied in detail for the remainder of FY81 and FY82. Selection and initiation of development in FY83 will support the early 1987 need date.

INTRODUCTION

As the Space Shuttle system development has progressed, it has become clear that the payload capability will not be adequate to meet our commitment for civil and military missions launched from the Western Test Range (WTR). The WTR requirement, as defined by "Performance Reference Mission 4," is to deliver a 32,000 lb payload to a 150 nmi circular orbit at an inclination of 98° and to retrieve a 25,000 lb spacecraft from that orbit in a single flight.

SYSTEMS EVOLUTION

Some measures are already being taken to maximize the general payload delivery capability of the Space Shuttle. These include reducing crew size and mission duration from 4-men/7 days to 2-men/1 day; reducing inert weight in the Orbiters, the External Tank (ET) and the SRM cases; and improving SRM performance. As is shown in Figure 1 and Table 1, these measures will provide a full 65,000 lb payload delivery capability at the Eastern Test Range (ETR) with Orbiter 099 in April 1983 and with Orbiters 103 and 104 later in 1983 and 1984, respectively. Although these measures will help meet the ETR payload requirement, they will not be adequate to meet the WTR requirement for deployment and retrieval as set forth in "Performance Reference Mission 4." Baseline Space Shuttle capability projections for this mission indicate a shortfall on the order of 8,000 lbs for the deployed payload (i.e., 24,000 lbs versus 32,000 lbs). Some form of performance augmentation is, therefore, required to meet our commitment at WTR.

PREVIOUS STUDIES

NASA has been analyzing a variety of performance augmentation concepts since 1976. Initially, we studied two concepts which would increase ascent performance without changing the moldline of the Space Shuttle. One concept was to increase the main propulsion system propellant loadings in the baseline ET using subcooling techniques to densify the cryogenic hydrogen and oxygen. An increase of 8.8% was found to be possible without going beyond the Triple Point and incurring the uncertainties associated with the use of slush propellants. The other concept was to add a small propellant segment to the top of the SRM and shortening the avionics segment in order to retain the same overall external configuration. Our analyses showed that both of these options combined would not provide the required additional payload increment for WTR and the concepts were, therefore dropped.

Several concepts for using solid rocket motors strapped on to the baseline SRB were evaluated, and while some concepts were found to be adequate, their use would have resulted in higher loads in the region of maximum dynamic pressure early in the ascent trajectory.

PRESENT STUDIES

A slip in the first need date for performance augmentation from mid-calendar year 1985 to early 1987 has allowed us to evaluate several additional concepts.

A Liquid Boost Module (LBM) has been studied in detail and has been found to be practicable. The LBM concept would use a Titan first stage engine set with shortened Titan tanks mounted as a strap-on system under the ET. The space available under the ET is more than adequate to install an LBM system capable of increasing payload delivery capability on the order of 14,000 lbs for WTR missions. System impacts associated with use of the LBM were found to be acceptable.

During the remainder of FY81 and during FY82, two additional concepts will be studied which, if used in combination, would provide the same increase in capability as the LBM. These are: operation of the Space Shuttle Main Engines (SSMEs) at nominal throttle settings of 115% and reducing the inert weight of the SRM cases by development of filament-wound segments. It is interesting to note that these two concepts also satisfy one of our initial objectives; that is, they do not result in a change to the moldline of the overall Space Shuttle system.

Our studies of these last three concepts; the LBM, the 115% SSMEs and the filament-wound SRM case segments, will be completed in FY82 to allow a final recommendation and preparation of a program plan to support a request for "Authorization to Proceed" (ATP) at the beginning of FY83. The 1983 ATP date is considered adequate to develop and test flight hardware, for any of the three concepts, in time for a first flight at WTR in calendar year 1987.

FIGURE 1

SPACE SHUTTLE CAPABILITY EVOLUTION

Eastern Test Range (ETR)

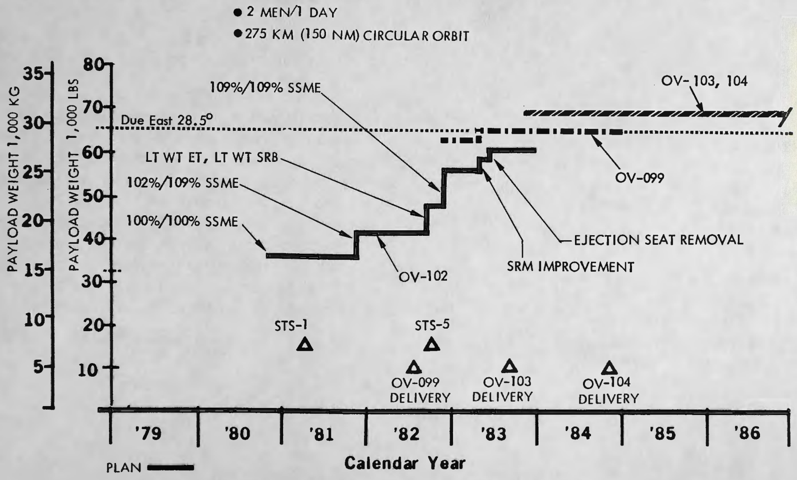

TABLE 1

SPACE SHUTTLE CAPABILITY EVOLUTION

- ETR
- 2-MEN/1-DAY
- 150 NMI

ETR PAYLOAD DELIVERY CAPABILITY AT 28.5°	PAYLOAD CAPABILITY	FLIGHT AVAILABILITY
● INITIAL CAPABILITY WITH OV-102 AT 100%/100% SSME	37,800 LBS	1980-1981
● 109% SSME FOR ABORT MODE (+4,000 LBS) 102% SSME FOR NOMINAL (+2,000 LBS)	43,800	DECEMBER 1981
● LIGHTWEIGHT SRM CASE (+500 LBS)	44,300	SEPTEMBER 1982
● LIGHTWEIGHT ET (+6,000 LBS)	50,300	SEPTEMBER 1982
● 109% SSME FOR NOMINAL OPERATION (Δ=+7,000 LBS)	57,300	NOVEMBER 1982
● IMPROVED SRM THRUST-TIME, BURN RATE, MAX (+2,000 LBS)	59,300	APRIL 1983
● OV-102 WEIGHT REMOVAL, EJECTION SEATS (+1,000 LBS)	60,300	MAY 1983
● OV-099 WITH WEIGHT REDUCTION (+6,000 LBS)	50,300	NOVEMBER 1982
– WITH LIGHTWEIGHT ET & 109% NOMINAL SSME INCORPORATED	63,300	NOVEMBER 1982
– WITH IMPROVED SRM (+2,000 LBS)	65,000 (65,300)*	APRIL 1983
● OV-103 WITH WEIGHT REDUCTION (+3,000 LBS)	65,000 (68,300)*	DECEMBER 1983

NOTE: 2-DAY MISSION COULD BE ACCOMPLISHED WITH ~475 LBS ADDITIONAL EXPENDABLES (CREW AND CRYO) AND ~1,000 LBS ADDITIONAL OMS & RCS PROPELLANT

*PERFORMANCE CAPABILITY LIMITED TO 65,000 LBS DUE TO STRUCTURAL CONSTRAINTS