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DIRECTIONS FOR FUTURE EARTH-TO-ORBIT VEHICLES

Prepared By:	James A. Martin
Academic Rank:	Associate Professor
Institution and Department:	The University of Alabama Dept. of Aerospace Engineering
NASA/MSFC:	
Office:	Space Transportation and Expl.
Group:	Upper Stages
Office:	Preliminary Design
Division:	Subsystem Design
Branch:	Propulsion Systems
MSFC Colleague(s):	Robert F. Nixon James F. Thompson

INTRODUCTION

NASA is currently assessing several programmatic possibilities. The desire is to maintain the current capability for transportation to orbit provided by the Space Shuttle and the existing fleet of commercial vehicles, develop the Space Station Freedom, and initiate a new program of exploration of the moon and Mars, called the Space Exploration Initiative (SEI). At the same time, the NASA budget is likely to be held to current levels. Cost estimates indicate that it will not be possible to satisfy all the goals without cost reductions.

One of the concepts being considered for cost reduction is to replace the Space Shuttle and existing commercial vehicles with a new set of vehicles called the National Launch System (NLS). Several concepts have been studied, but none of the concepts studied to date provides the desired combination of cost/flight reduction, acceptable development cost, and technology readiness. An additional goal is to provide a path to grow the NLS capability into a heavy-lift capability for SEI missions.

PRESSURE-FED BOOSTERS

One concept that has not been considered for NLS is the reusable pressure-fed booster. This concept uses propellants stored in tanks on the vehicle at high pressure, such as 600 psi, to eliminate the need for turbopumps on the rocket engine. The result is a heavy but simple vehicle that is well suited to recovery and reuse after an ocean landing.

An initial design for the smaller NLS-3 vehicle is shown in Fig. 1. A reusable pressure-fed booster is used with an expendable hydrogen and oxygen upper stage. In Fig. 2, the larger NLS-2 capability is provided by a first stage with 4 of the same reusable boosters, a second stage with an expendable version of the same pressure-fed design, and the same hydrogen and oxygen stage.

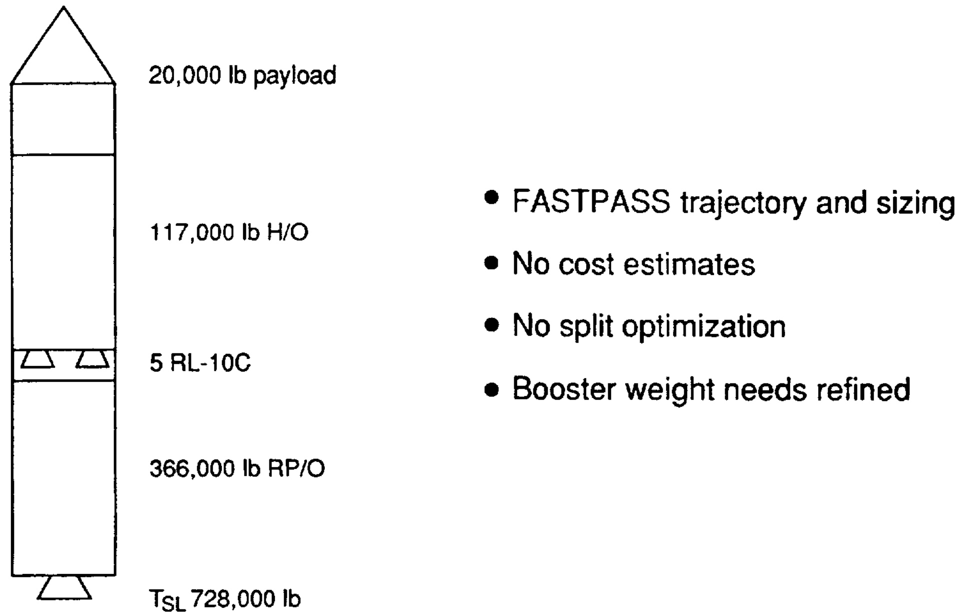

Figure 1. NLS-3 Design with Reusable Pressure-Fed Booster.

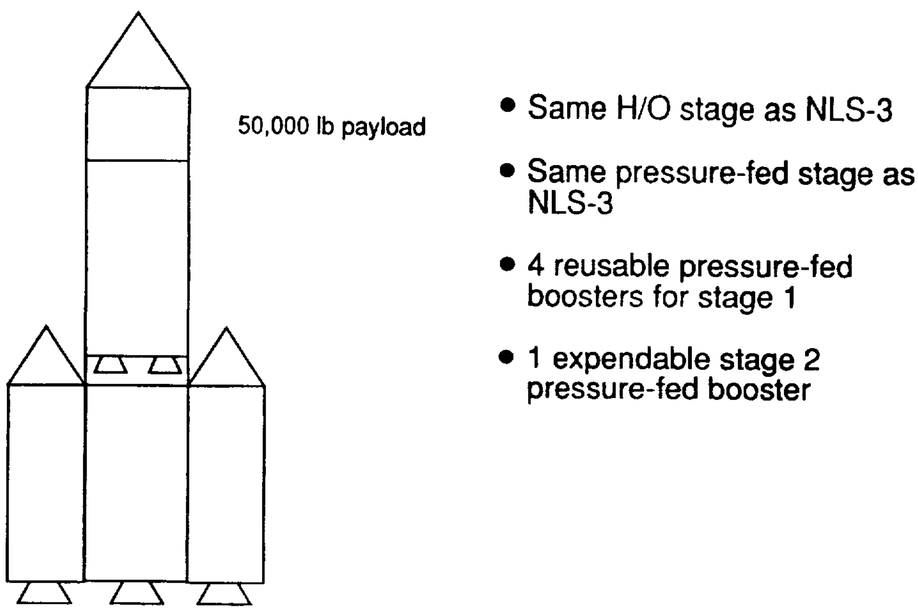

Figure 2. NLS-2 Design with Reusable Pressure-Fed Boosters.

BUILDING CONFIDENCE

Estimating the cost of Earth-to-orbit vehicles is difficult. The technical design is subject to some uncertainty, and the performance requirement is quite stringent. Cost/flight estimates are particularly uncertain because much of the cost is related to people who are responsible for assuring the success of the mission. Because an especially large number of people are involved with the operation of the Space Shuttle, it has not proven that reusable hardware reduces cost/flight.

While estimates of the cost/flight of reusable pressure-fed boosters have indicated a cost advantage, it will probably be necessary to build confidence that the cost advantage can be achieved before selecting this concept for NLS. The confidence can be built by developing pressure-fed boosters at a smaller scale and applying them to an existing vehicle. A study was conducted that indicated that 2 reusable pressure-fed boosters could be used to replace the 9 expendable solid rocket motors used by the Delta-II commercial vehicle. By using the reusable boosters on the Delta-II, real data on the cost advantage of reusable hardware could be accumulated.

PULSED DETONATION ENGINES

A survey of the literature and discussions with experts was conducted to determine the status of pulsed detonation engines. Figure 3 shows how such engine operate. A charge of air is mixed with fuel and flows into the main combustion chamber. A detonation wave is started which travels forward through the chamber and reflects off of the thrust wall as a shock wave. The shock wave travels out the aft end of the chamber and takes the combusted mixture with it.

The survey indicated that there is great potential for the pulsed detonation engine. It might provide high specific impulse, high thrust-to-weight, and simple, low-cost engines. It might provide thrust at flight speeds from zero to hypersonic.

The survey also indicated that there is much work that needs to be done before the potential of the pulsed detonation engine can be realized. Some experimental work has been completed, and some computation analyses have been done, but no experimental work has been done that verifies the performance potential of the engine. An experimental aircraft that has been sighted over the western U. S. leaves a contrail that could be created by a pulsed engine. No information was found to verify what propulsion this aircraft uses.

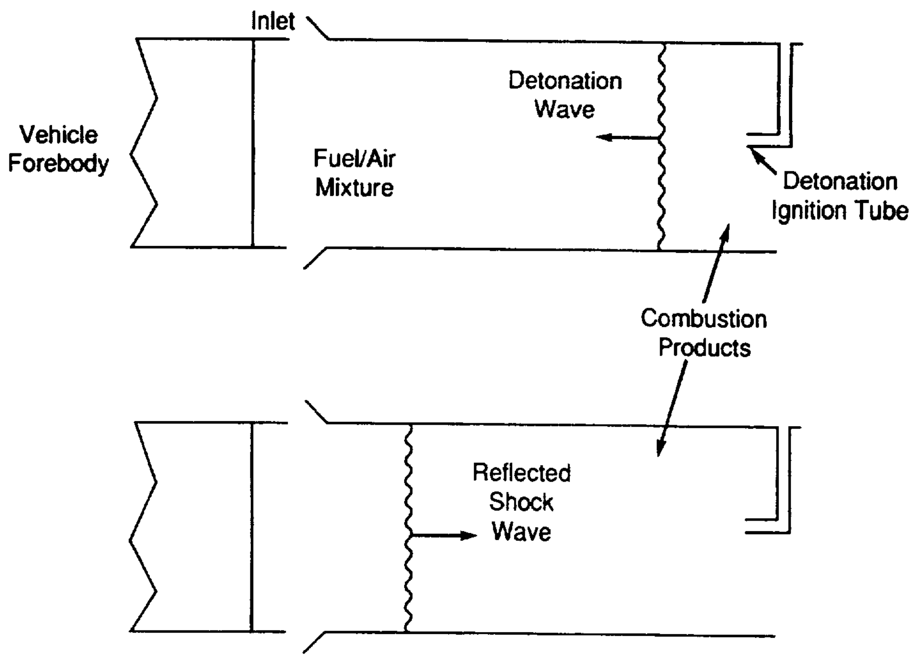

Figure 3.- Operation of Pulsed Detonation Engine.

CONCLUDING REMARKS

Pressure-fed boosters have potential to reduce the cost of Earth-to-orbit transportation. Reduced-scale demonstrations could determine the value of this potential and lead to development of an economical National Launch System.