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THE NATIONAL LAUNCH SYSTEM ADVANCED DEVELOPMENT PROGRAM A BRIEF OVERVIEW

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Abstract

A broad-based Advanced Development Program is being conducted to modernize the technological base and support the systems design of the National Launch System. While the principal concentration of efforts has been in propulsion, significant work is being accomplished in all of the disciplinary areas associated with space launch. Tasks are selected that offer reduced costs. increased reliability, and enhanced operability with anticipated task completion times which are consistent with NLS development.

Introduction

Reaching the NLS goals for a low cost, highly reliable, highly operational launch system presents a challenge which requires a combination of strategies. These strategies include launch system design for operations, exploitation of vehicle scale and flight rate effects where appropriate, simplified operational and payload interfaces, and use of existing and advanced technologies properly focused and applied to the space launch discipline. Technology activities of the NLS are conducted in an Advanced Development Program (ADP) which is closely coupled to the system design and whose purpose is to validate those cost effective technologies which support NLS requirements, are applicable to the NLS system design and operational concepts, and are available to support the NLS schedule.

The ADP is implemented as a set of technology tasks which are selected to provide the maximum benefit to the NLS. The objective of each task is to demonstrate those benefits so the applicable technology can be incorporated into the NLS with high confidence and low risk. These demonstrations will include design of prototypes at as near full scale as practical. The most important products of these demonstrations are the validation of cost, producibility, operability, and performance characteristics. The ADP is organized in five major areas: (1) Propulsion; (2) Avionics and Software; (3) Structures, Materials and Manufacturing; (4) Aerothermodynamics and (5) Operations. Objectives of each of these areas in support of a low cost, highly reliable NLS are summarized below.

Propulsion

The focus of the propulsion area is to enable the development of a low cost, robust liquid oxygen-liquid hydrogen engine. In order to achieve the objective of low cost, emphasis has been placed on reducing manufacturing and fabrication costs at the piece-parts level. This is best accomplished by reducing the number of parts in each sub-element of the engine assembly, by fabricating in a near net shape form. One technique for accomplishing this is the use of precision castings to replace current expensive machining operations A structural jacket and all manifolds of the main combustion chamber has been successfully cast as a single piece using an advanced precision casting process. Housing components of the hydrogen turbopump have also been cast. Several other techniques are being investigated that show promise to significantly reduce the cost of previously labor-intensive processes. A vacuum plasma spray process has been successfully used in the fabrication of the cooler liner of the combustion chamber. This, along with several other techniques for fabricating the cooler liner, show promise of reducing the time required to build this item. In addition to the development of these processes funding has been allocated to bring on-line a complete set of cryogenic engine test facilities to allow for the full-scale development and testing of the turbomachinery components as well as prototype and and production engines.

Avionics and Software

With the rapid turnover in avionic component technology, the primary focus in the avionics area is to develop open ended avionic architectures to serve the entire family of NLS vehicles. Designing in the ability to easily upgrade avionics as new technology becomes available is critical. This program emphasizes the development of common hardware and software as well as standardized interfaces. This work is expected to allow the eventual design of the avionics system for the initial NLS vehicles to inexpensively accept improvements in the avionics (without redesigning the whole system) when initial components become obsolete. Work in the adaptive guidance area will enhance meeting initial vehicle requirements for engine-out capability and for accommodating changes in weather (primarily winds aloft), payloads and orbital requirements.

Guidance, navigation, and control mission data loads have historically required long lead times and significant manpower to prepare and validate. Only slight variations in mission, payload and/or environmental conditions require a recomputation and validation of the mission data load. The development of modern adaptive and robust AGN&C techniques in this program will eliminate a vast portion of the initial preparation work and will accommodate a wide variation in mission requirements and environmental deviations on the day of the launch. To further improve launch reliability and reduce stand-down time we are developing a Light Detection and Ranging (LIDAR) system to obtain wind profiles and atmospheric density along the booster's predicted flight path, rather than relying on current methods which are unable to provide timely data when the atmospheric conditions are rapidly changing.

Structures, Materials and Manufacturing

Key projects in the structures, materials and manufacturing area include efforts to develop and fully characterize a new family of aluminum alloys using lithium as an alloying element. The resultant materials offer significant improvement in strength, stiffness, and weight reductions over conventional alloys. Developing aluminum-lithium will provide for significant weight and risk reduction in the vehicle structures presently baselined in conventional aluminum for both the launch vehicles and the new upper stage. (Structural weight reduction is particularly critical for the 1.5 stage NLS 2 and for the NLS upper stage since it translates pound-for-pound into payload growth). Alternatively, the incorporation of aluminum-lithium could result in higher structural margins. The overall effect is expected to produce meaningful cost savings for the NLS program. Further, cost reductions will be accrued by demonstrating net shape technology for manufacturing sub-elements of the tank and dry bay structure. Very large extrusions of T-stiffened barrel sections have been fabricated to replace the expensive and time-consuming machining operations that are currently used in tank walls. Superplastically formed stiffeners that may have application for the dry bay structure (intertank, shroud and aft adaptor) have also been successfully fabricated. A welding process has been demonstrated that automatically tracks the seam, provides data for statistical process control, and practically eliminates manual inspection.

Aerothermodynamics and Recovery

While initial NLS vehicles are not required to have recoverable systems, sufficient effort is required to insure that detailed vehicle design activity can proceed and still preserve the ability to implement recovery features in the future. Funding in this area has been used to validate the viability of currently developed recovery methods and understand the significant cost trade-offs for recovery in general. It is vital to obtain this understanding prior to finally establishing vehicle designs since features to accommodate future recovery must be incorporated. A large-scale parafoil has been successfully drop tested with a 14,000 lb payload to demonstrate precision recovery of high cost elements of the vehicle. Another project is designed to show feasibility of recovering a propulsion/avionics module. A wind tunnel program to determine aerodynamic properties of the reentry body has been completed; a sub-scale water drop test demonstrated flotation properties; and a half-scale ocean recovery of the module has been demonstrated. The current effort is concentrating on the design of a deployable spray shield that will inhibit sea water entry into the module when entering and floating in the ocean. Future efforts will concentrate on developing specific full scale recoverable designs consistent with established system configurations.

Operations

A significant percentage of current launch system costs are due to manpower intensive launch processing, checkout and "on-pad" time. The objectives of the operations area are to adapt current technologies for application to the NLS to significantly reduce manpower and the time required for vehicle assembly, checkout, and launch operations. Object oriented data base and expert systems technologies are being developed to enable program-wide administrative, design, functional health and operations information to be readily accessed. Electromechanical actuators and laser initiated pyrotechnics are also being developed to minimize delays caused by hydraulic systems tests and pyrotechnics safe-arming procedures. Future tasks are planned to lay the foundation to establish an efficient and flexible launch complex supported by an effective decision support system.

Summary

The fundamental success of the NLS program depends on modernizing the technology base of our current launch vehicles and enabling technological innovations to be introduced in the future to facilitate continuous improvement. The ADP has concentrated on developing the launch system technologies which are currently (or nearly) available, that offer low risk and high payoff, through the demonstration of readiness for designers to utilize for NLS.