Performance Comparison Of Reusable Launch Vehicles

On June 15, 2011, the Air Force Space Command established a new vision, mission, and set of goals to ensure continued U.S. dominance in space ar cyberspace mission areas. Subsequently, and in coordination with the Air Force Research Laboratory, the Space and Missile Systems Center, and the 14th and 24th Air Forces, the Air Force Space Command identified four long-term science and technology (S&T) challenges critical to meeting these goals. One of these challenges is to provide full-spectrum launch capability at dramatically lower cost, and a reusable booster system (RBS) has been proposed as an approach to meet this challenge. The Air Force Space Command asked the Aeronautics and Space Engineering Board of the National Research Council to conduct an independent review and assessment of the RBS concept prior to considering a continuation of RBS-related activities within the Air Force Research Laboratory portfolio and before initiating a more extensive RBS development program. The committee for the Reusable Booster System: Review and Assessment was formed in response to that request and charged with reviewing and assessing the criteria and assumpti used in the current RBS plans, the cost model methodologies used to fame [frame?] the RBS business case, and the technical maturity and developme plans of key elements critical to RBS implementation. The committee consisted of experts not connected with current RBS activities who have significant expertise in launch vehicle design and operation, research and technology development and implementation, space system operations, and cost analysis. The committee solicited and received input on the Air Force launch requirements, the baseline RBS concept, cost models and assessme and technology readiness. The committee also received input from industry associated with RBS concept, industry independent of the RBS concept, a propulsion system providers which is summarized in Reusable Booster System: Review and Assessment.

Previously, the Air Force has been investigating high performance salt-based, liquid monopropellants for low thrust spacecraft applications. The focus of this effort has been on finding a reduced toxicity monopropellant with a predicted density performance impulse greater than 50% over hydrazne. During this same period of time, NASA has been investigating reusable launch vehicle (KLV) concepts and has considered using monopropellants in this application. Anticipating a possible RLV payoff, NASA and the Air Force are working on a trade study to gauge the potential applicability of the salt-based monopropellants in booster applications. This study will include a performance comparison of salt-based monopropellants; a list of minimum safety, hazard, and physical property requirements based on operational and logistical support environments for an RLV.

Dictionary of Space Technology

Air and Space Power for the 21st Century : Materials Volume

A Selected Listing

Technology Development and Test Program

Parametric Weight Comparison of Advanced Metallic, Ceramic Tile, and Ceramic Blanket Thermal Protection Systems

As part of NASAs focused technology programs for future reusable launch vehicles, a task is underway to study the feasibility of using the polymer matrix composite feedlines instead of metal ones on propulsion systems. This is desirable to reduce weight and manufacturing costs. The task consists of comparing several prototype composite feedlines made by various methods. These methods are electron-beam curing, standard hand lay-up and autoclave cure, solvent assisted resin transfer molding, and thermoplastic tape laying. One of the critical technology drivers for composite components is resistance to foreign objects damage. This paper presents results of an experimental study of the damage resistance of the candidate materials that the prototype feedlines are manufactured

from. The materials examined all have a 5-harness weave of IM7 as the fiber constituent (except for the thermoplastic, which is unidirectional tape laid up in a bidirectional configuration). The resin tested were 977-6, PR 520, SE-SA-1, RS-E3 (e-beam curable), Cycom 823 and PEEK. The results showed that the 977-6 and PEEK were the most damage resistant in all tested cases.Nettles, A. TMarshall Space Flight CenterCOMPOSITE MATERIALS; CURING; DAMAGE; TECHNOLOGY ASSESSMENT; HARNESSES; MANUFACTURING; POLYMER MATRIX COMPOSITES; AUTOCLAVES; COSTS; ELECTRON BEAMS; FEED SYSTEMS; LAY-UP; PROPULSION SYSTEM CONFIGURATIONS; PROPULSION SYSTEM PERFORMANCE; PROTOTYPES; RESIN TRANSFER MOLDING; REUSABLE LAUNCH VEHICLES; THERMOPLASTICITY; WEIGHT REDUCTION...

The design of the next generation of space access vehicles has led to a unique flight test that blends the space and flight research worlds. The new vehicle designs, such as the X-33 vehicle and Reusable Launch Vehicle (RLV) are powered by linear aerospike rocket engines. Conceived of in the 1960's, these aerospike engines have yet to be flown, and many questions remain regarding aerospike engine performance and efficiency in flight. To provide some of these data before flying on the X-33 vehicle and the RLV, a spacecraft rocket engine had been flight-tested atop the NASA SR-71 aircraft as the Linear Aerospike SR-71 Experiment (LASRE). A 20 percent-scale, semispan model of the X-33 vehicle, the aerospike engine, and all the required fuel and oxidizer tanks and propellant feed systems have been mounted atop the SR-71 airplane for this experiment. A major technical objective of the LASRE flight test is to obtain installed-engine performance flight data for comparison to wind-tunnel results and for the development of computational fluid dynamics-based design methodologies. The ultimate goal of firing the aerospike rocket engine in flight is still forthcoming. An extensive design and development phase of the experiment hardware has been completed, including approximately 40 ground tests. Five flights of the LASRE and firing the rocket engine using inert liquid nitrogen and helium in place of liquid oxygen and hydrogen have been successfully completed.

Reusable Booster System

Summary of a Conference

Proceedings

Review and Assessment

Probabilistic Performance Comparison of RBCC- and TBCC-based Reusable Launch Vehicles with Enhancing Technologies

Originally published in 1981, the completely revised and updated second edition of the Dictionary of Space Technology illustrates the advances of the last 20 years and makes accessible nearly every word, concept, and event relating to this branch of science. It guides lay persons and professionals alike through humankind's activities in space, the beginnings of our extraterrestrial society, and the increasingly important role of space sciences in everyday life. Defines more than 1,500 terms, including: science basics; historic events; defence and armed forces terminology; and planetary sciences. Enhanced by more than 175 photographs and drawings, this Dictionary covers the past, the present and the future of space, space flight, and space technology.

As a result of technological progress, we are now on verge of developing cost-effective reusable launch vehicles (RLV) for space. This study reviews the strategic implications of the emerging vision within the U.S. Department of Defense for using these

vehicles. Although the U.S. Air Force is making the transition to a force that relies increasingly on space, the best path does not necessarily involve replicating the traditional air missions in space. This study of potential missions for RLVs concludes that, while these are capable of numerous missions (e.g., reconnaissance, global strike, cargo and personnel transport), the most important mission for the immediate future for both the U.S. military and commercial firms is in the area of traditional spacelift. The two broad conclusions that emerge from this study are that the U.S. military should move away from the spacelift business by obtaining spacelift through commercially procured launch services, and second, that the U.S. military should not develop militarized RLVs that are designed to perform the traditional air operations in space.

A Review of United States Air Force and Department of Defense Aerospace Propulsion Needs

Highly Operable Propulsion for Reusable Launch Vehicle Applications

Hearings Before the Subcommittee of the Committee on Appropriations, United States Senate, Ninety-first Congress, Second Session, on H.R. [19590].

Reliability Abstracts and Technical Reviews

Department of the Air Force

With growing interest in space activity and numerous new launchers in development, this book is a timely, comprehensive survey of important concepts and applications. It enhances understanding and provides exposure to practical aspects of design, manufacturing, testing, and engineering associated with these topics.

This volume presents selected papers from the 7th International Congress on Computational Mechanics and Simulation held at IIT Mandi, India. The papers discuss the development of mathematical models representing physical phenomena and applying modern computing methods and simulations to analyse them. The studies cover recent advances in the fields of nano mechanics and biomechanics, simulations of multiscale and multiphysics problems, developments in solid mechanics and finite element method, advancements in computational fluid dynamics and transport phenomena, and applications of computational mechanics and techniques in emerging areas. The volume will be of interest to researchers and academics from civil engineering, mechanical engineering, aerospace engineering, materials engineering/science, physics, mathematics and other disciplines.

Science and Technology

Hearings Before the Subcommittee of the Committee on Appropriations, United States Senate, Ninety-first Congress, Second Session

Space Launch Initiative

A Program Review : Hearing Before the Subcommittee on Space and Aeronautics, Committee on Science, House of Representatives, One Hundred Seventh Congress, First Session, June 20, 2001

Scientific and Technical Aerospace Reports

Third-generation reusable launch vehicle (RLV) systems are envisioned that utilize airbreathing and combined-cycle propulsion to take advantage of potential performance benefits over conventional rocket propulsion and address goals of reducing the cost and enhancing the safety of systems to reach earth orbit. The dual-mode scramjet (DMSJ) forms the core of combined-cycle or combination-cycle propulsion systems for single-stage-to-orbit (SSTO) vehicles and provides most of the orbital ascent energy. These concepts are also relevant to two-stage-to-orbit (TSTO) systems with an airbreathing first or second stage. Foundation technology investments in scramjet propulsion are driven by the goal to develop efficient Mach 3-15 concepts with sufficient performance and operability to meet operational system goals. A brief historical review of NASA scramjet development is presented along with a summary of current technology efforts and a proposed roadmap. The technology addresses hydrogen-fueled combustor development, hypervelocity scramjets, multi-speed flowpath performance and operability, propulsion-airframe integration, and analysis and diagnostic tools. Cockrell, Charles E., Jr. and Auslender, Aaron H. and Guy, R. Wayne and McClinton, Charles R. and Welch, Sharon S. Langley Research Center AIAA Paper 2002-5188

The reusable launch vehicle (RLV) thrust cell liner, or thrust chamber, is a critical component of the Space Shuttle Main Engine (SSME). It is designed to operate in some of the most severe conditions seen in engineering practice. This requirement, in conjunction with experimentally observed 'dog-house' failure modes characterized by bulging and thinning of the cooling channel wall, provides the motivation to study the factors that influence RLV thrust cell liner performance. Factors or parameters believed to be directly related to the observed characteristic deformation modes leading to failure under in-service loading conditions are identified, and subsequently investigated using the cylindrical version of the higher-order theory for functionally graded materials in conjunction with the Robinson's unified viscoplasticity theory and the power-law creep model for modeling the response of the liner s constituents. Configurations are analyzed in which specific modifications in cooling channel wall thickness or constituent materials are made to determine the influence of these parameters on the deformations resulting in the observed failure modes in the outer walls of the cooling channel. The application of thermal barrier coatings and functional grading are also investigated within this context. Comparison of the higher-order theory results based on the Robinson and power-law creep model predictions has demonstrated that, using the available material parameters, the power-law creep model predicts more precisely the experimentally observed deformation leading to the 'dog-house' failure mode for multiple short cycles, while also providing much improved computational efficiency. However, for a single long cycle, both models predict virtually identical deformations. Increasing the power-law creep model coefficients produces appreciable deformations after just one long cycle that would normally be obtained after multiple cycles, thereby enhancing the efficiency of the anal

Applied Mechanics Reviews

Technology Roadmap for Dual-Mode Scramjet Propulsion to Support Space-Access Vision Vehicle Development

Aerospace Environmental Technology Conference

New World Vistas

Improvements to Progressive Wave Tube Performance Through Closed-Loop Control

As part of NASAs focused technology programs for future reusable launch vehicles, a task is underway to study the feasibility of using the polymer matrix composite feedlines instead of metal ones on propulsion systems. This is desirable to reduce weight and manufacturing costs. The task consists of comparing several prototype composite feedlines made by various methods. These methods are electron-beam curing, standard hand lay-up and autoclave cure, solvent assisted resin transfer molding, and thermoplastic tape laying. One of the critical technology drivers for composite components is resistance to foreign objects damage. This paper presents results of an experimental study of the damage resistance of the candidate materials that the prototype feedlines are manufactured from. The materials examined all have a 5-harness weave of IM7 as the fiber constituent (except for the thermoplastic, which is unidirectional tape laid up in a bidirectional configuration). The resin tested were 977-6, PR 520, SE-SA-1, RS-E3 (e-beam curable), Cycom 823 and PEEK. The results showed that the 977-6 and PEEK were the most damage resistant in all tested cases.Nettles, A. TMarshall Space Flight CenterCOMPOSITE MATERIALS; CURING; DAMAGE; TECHNOLOGY ASSESSMENT; HARNESSES; MANUFACTURING; POLYMER MATRIX COMPOSITES; AUTOCLAVES; COSTS; ELECTRON BEAMS; FEED SYSTEMS; LAY-UP; PROPULSION SYSTEM CONFIGURATIONS; PROPULSION SYSTEM PERFORMANCE; PROTOTYPES; RESIN TRANSFER MOLDING; REUSABLE LAUNCH VEHICLES; THERMOPLASTICITY; WEIGHT REDUCTION

Rocket and air-breathing propulsion systems are the foundation on which planning for future aerospace systems rests. A Review of United States Air Force and Department of Defense Aerospace Propulsion Needs assesses the existing technical base in these areas and examines the future Air Force capabilities the base will be expected to support. This report also defines gaps and recommends where future warfighter capabilities not yet fully defined could be met by current science and technology development plans.

Second Aerospace Environmental Technology Conference

Department of Defense Appropriations for Fiscal Year 1971, Hearings Before ..., 91-2

A History of the Johnson Space Center

Department of Defense Appropriations for Fiscal Year 1971

Volume-II: Nano to Macro

This publication is divided into seven sections: future development of economical launch vehicles; space vehicle system concepts near term; space vehicle system concepts far term; European reusable launch vehicle studies; operations and economics; partially recoverable systems; and pacing technology implications.

The key to opening the use of space to private enterprise and to broader public uses lies in reducing the cost of the transportation to space. More routine, affordable access to space will entail aircraft-like quick turnaround and reliable operations. Currently, the space Shuttle is the only reusable launch vehicle, and even parts of it are expendable while other parts require frequent and extensive refurbishment. NASA's highest priority new activity, the Reusable Launch Vehicle program, is directed toward developing technologies to enable a new generation of space launchers, perhaps but not necessarily with single stage to orbit capability. This book assesses whether the technology development, test and analysis programs in propulsion and materials-related technologies are properly constituted to provide the information required to

support a December 1996 decision to build the X-33, a technology demonstrator vehicle; and suggest, as appropriate, necessary changes in these programs to ensure that they will support vehicle feasibility goals.

NASA Scientific and Technical Reports

Suddenly, Tomorrow Came--

A Damage Resistance Comparison Between Candidate Polymer Matrix Composite Feedline Materials

Evaluation of Monopropellants for Reusable Launch Vehicles

AIAA Bulletin

Lists citations with abstracts for aerospace related reports obtained from world wide sources and announces documents that have recently been entered into the NASA Scientific and Technical Information Database.

This report documents recent improvements to the acoustic and thermal control systems of the Thermal Acoustic Fatigue Apparatus (TAFA), a progressive wave tube test facility at the NASA Langley Research Center, Hampton, Virginia. A brief summary of past acoustic performance is given first to serve as a basis for comparison with the new performance data using a multiple-input, closed-loop, narrow-band controller. Performance data in the form of test section acoustic power spectral densities and coherence are presented in three of six facility configurations for a variety of input spectra. Tested spectra include uniform, two cases of pink noise, three cases of narrow-band random, a simulated launch payload bay environment for an expendable launch vehicle, and a simulated external acoustic load for the aft section of a reusable launch vehicle. In addition, a new closed-loop temperature controller and thermocouple data acquisition system are described.Rizzi, Stephen A.Langley Research CenterPERFORMANCE TESTS; TEST CHAMBERS; TEST FACILITIES; RESEARCH AND DEVELOPMENT; EXPERIMENTATION; RESEARCH FACILITIES; LAUNCHING; SPECTRA; SIMULATION

Journal of the British Interplanetary Society

Design of Rockets and Space Launch Vehicles

Reusable Launch Vehicles and Space Operations

Proceedings of American Astronautical Society Seventh Goddard Memorial Symposium, March 4-5, 1969, Washington, D. C.

International Aerospace Abstracts

A wide variety of reusable launch vehicle concepts for placing various payloads into low earth orbit are currently being evaluated for potential civil, commercial and military applications. This recent interest is being driven by a desire to achieve reduced payload launch costs and, in some cases, very rapid response capability. In most of these cases, the general requirements of the main propulsion system are similar: a high level of operational availability with minimal

operational support activity. Consequently, evaluation of traditional expendable rocket engines as candidates for reusable applications has begun, with an emphasis on understanding whether or not a given engine's operating characteristics are inherently more reusable than another. In support of a planned program to demonstrate a low cost, rapid response reusable launch vehicle, several existing rocket engines were evaluated for feasibility to meet the requirements of a sub-scale reusable launch vehicle demonstrator. Critical propulsion characteristics were defined based on the demonstration objectives of the overall program. Potential candidate engines were selected and then evaluated against these critical propulsion characteristics, and a comparative assessment of each engine's ability to satisfy each critical characteristic was generated. Finally, a reference engine was designated along with a reference demonstrator vehicle concept. This vehicle concept was evaluated for its feasibility to satisty the reusable launch vehicle demonstrator program objectives, and determined to meet the stated goals with residual capability for possible later applications.

Aerospace America

Reusable Launch Vehicle

Air Traffic Management and Conflict Analysis for Reusable Launch Vehicles

Analysis of Factors Affecting the Performance of Rlv Thrust Cell Liners

Performance Comparison of Reusable Launch Vehicles