Scientific and Technical
Information Program

Click the ? icon for help

Affordable Heavy Lift Capability: 2000-2004

This custom bibliography from the NASA Scientific and Technical Information Program lists a sampling of records found in the NASA Aeronautics and Space Database. The scope of this topic includes technologies to allow robust, affordable access of cargo, particularly to low-Earth orbit. This area of focus is one of the enabling technologies as defined by NASA's *Report of the President's Commission on Implementation of United States Space Exploration Policy*, published in June 2004.

Browse Subject Terms

Browse Corporate Sources

Browse Document Authors

Search for Text

PRINT

Affordable Heavy Lift Capability: 2000-2004

A Custom Bibliography From the
NASA Scientific and Technical Information Program

October 2004

Affordable Heavy Lift Capability: 2000-2004

This custom bibliography from the NASA Scientific and Technical Information Program lists a sampling of records found in the NASA Aeronautics and Space Database. The scope of this topic includes technologies to allow robust, affordable access of cargo, particularly to low-Earth orbit. This area of focus is one of the enabling technologies as defined by NASA's *Report of the President's Commission on Implementation of United States Space Exploration Policy*, published in June 2004.

OCTOBER 2004

20040095274

EAC trains its first international astronaut class

Bolender, Hans, Author; Bessone, Loredana, Author; Schoen, Andreas, Author; Stevenin, Herve, Author; ESA bulletin. Bulletin ASE. European Space Agency; Nov 2002; ISSN 0376-4265; Volume 112, 50-5; In English; Copyright; Avail: Other Sources

After several years of planning and preparation, ESA's ISS training programme has become operational. Between 26 August and 6 September, the European Astronaut Centre (EAC) near Cologne gave the first ESA advanced training course for an international ISS astronaut class. The ten astronauts who took part--two from NASA, four from Japan and four from ESA--had begun their advanced training programme back in 2001 with sessions at the Johnson Space Center (JSC) in Houston and at the Japanese Training Centre in Tsukuba. During their stay in Cologne, the ten astronauts participated in a total of 33 classroom lessons and hands-on training sessions, which gave them a detailed overview of the systems and subsystems of the Columbus module, the Automated Transfer Vehicle (ATV), and the related crew operations tasks. They were also introduced to the four ESA experiment facilities to be operated inside the Columbus module. After their first week of training at EAC, the astronauts were given the opportunity to see the flight model of the Columbus module being integrated at the site of ESA's ISS prime contractor, Astrium in Bremen. The second week of training at EAC included hands-on instruction on the Columbus Data Management System (DMS) using the recently installed Columbus Crew Training Facility. In preparation for the first advanced crew training session at EAC, two Training Readiness Reviews (TRR) were conducted there in June and August. These reviews were supported by training experts and astronauts from NASA, NASDA and CSA (Canada), who were introduced to ESA's advanced training concept and the development process, and then analysed and evaluated the training flow, content and instructional soundness of lessons and courses, as well as the fidelity of the training facilities and the skills of the ESA training instructors. The International Training Control Board (ITCB), made up of representatives from all of the ISS International Partners and mandated to control and coordinate all multilateral training for ISS crew and ground-support personnel, testified to ESA's readiness to provide Advanced Training by declaring the EAC TRR successful. The completion of this first training course was therefore a good opportunity for the Astronaut Training Division to assess the status of its training programme. The comments and recommendations of the training experts and the astronauts who took part have been carefully evaluated and the results are being fed back into the ongoing training development process.

NLM

Astronauts; Personnel Development

20040082376 NASA Marshall Space Flight Center, Huntsville, AL, USA

Application of Probabilistic Risk Assessment (PRA) During Conceptual Design for the NASA Orbital Space Plane (OSP)

Rogers, James H.; Safie, Fayssal M.; Stott, James E.; Lo, Yunnhon; [2004]; In English, 14-18 Jun. 2004, Berlin, Germany; No Copyright; Avail: CASI; A02, Hardcopy

In order to meet the space transportation needs for a new century, America's National Aeronautics and Space Administration (NASA) has implemented an Integrated Space Transportation Plan to produce safe, economical, and reliable access to space. One near term objective of this initiative is the design and development of a next-generation vehicle and launch system that will transport crew and cargo to and from the International Space Station (ISS), the Orbital Space Plane (OSP). The OSP system is composed of a manned launch vehicle by an existing Evolved Expendable Launch Vehicle (EELV). The OSP will provide emergency crew rescue from the ISS by 2008, and provide crew and limited cargo transfer to and from

the ISS by 2012. A key requirement is for the OSP to be safer and more reliable than the Soyuz and Space Shuttle, which currently provide these capabilities.
Author
Aerospace Planes; Risk; Space Transportation; Spacecrews; Launch Vehicles

20040082309 Boeing Phantom Works, Huntsville, AL, USA
Cargo Assured Access to International Space Station
Smith, David A.; June 06, 2004; In English, 30 May - 6 Jun. 2004, Miyazaki, Japan; Original contains color and black and white illustrations
Contract(s)/Grant(s): NAS8-02093; Copyright; Avail: CASI; A02, Hardcopy

Boeing's Cargo Assured Access logistics delivery system will provide a means to transport cargo to/from the International Space Station, Low Earth Orbit and the moon using Expendable Launch Vehicles. For Space Station, this capability will reduce cargo resupply backlog during nominal operations (e.g., supplement Shuttle, Progress, ATV and HTV) and augment cargo resupply capability during contingency operations (e.g., Shuttle delay and/or unavailability of International Partner launch or transfer vehicles). This capability can also provide an autonomous means to deliver cargo to lunar orbit, a lunar orbit refueling and work platform, and a contingency crew safe haven in support of NASA's new Exploration Initiative.
Author
Cargo; International Space Station; Logistics; Launch Vehicles

20040077136 NASA Ames Research Center, Moffett Field, CA, USA
Propellant Preservation for Mars Missions
Kittel, Peter; Research and Technology 1999; December 2000, 134; In English; No Copyright; Avail: CASI; A01, Hardcopy

The last few years have seen extensive technology planning for human missions to Mars. These missions will make extensive use of cryogenic propellants, some of which will be transported to Mars. Additional propellants will be manufactured, liquefied, and stored on Mars. The missions that use these propellants could start early this century. Although many of the plans are still evolving, it has been possible to derive a set of cooler requirements. Recent estimates of these requirements are given here along with a discussion of whether the requirements can be met with existing coolers and coolers currently being developed. In recent years, a variety of transportation scenarios have been considered. The analysis reported here relates to one of the more promising nonnuclear options. It makes use of solar electric propulsion (SEP). The SEP baseline concept follows: 1. A SEP tug boosts the TMI (trans-Mars injection) stage to a highly elliptical orbit. This phase requires 400 days of propellant storage for the TMI piloted stage and 250 days for the TMI cargo stages. 2. The ascent and descent stages require about 580 days of propellant storage for the piloted mission and 550 days for the cargo case. These stages use oxygen (O_2) and methane (CH_4) for propellants. 3. The TEI (trans-Earth injection) stage requires a storage duration of 1200 days. This stage uses hydrogen (H_2) as the propellant. 4. All tanks are cooled by cryocoolers to eliminate boil off. 5. The tank design is standardized to 3.29-meter-diameter spheres. Fixing the volume results in the stages having multiple tanks, with many of the tanks full at launch. A thermal model was used to estimate the cooler requirements. This model could estimate the tank size and mass for MLI (multilayer insulation) insulated tanks with and without coolers. The cooling power and the mass of the power source and radiators were included for ZBO (zero boil-off) storage. In the first case, the volume of the tank was variable. The volume was adjusted until it was large enough to accommodate the boil-off during the mission and still preserve the required propellant until it was needed. In the latter case, the volume was fixed. An optional cooled shield has been included in the model for hydrogen tanks. The results of the model are presented.
Derived from text
Mars Missions; Preserving; Propellant Storage; Cryogenic Rocket Propellants

20040068088 American Inst. of Aeronautics and Astronautics, Reston, VA, USA
Will the ATV Deliver?
Iannotta, Ben; Aerospace America; July 2003; ISSN 0740-722X; In English; Copyright; Avail: Other Sources

he European Space Agency's work on a fleet of expendable cargo spacecraft for the International Space Station (ISS) has long been viewed as a form of payment-in-kind by European space leaders for the right to attach their Columbus laboratory to the station starting in October 2004. With the grounding of the U S space shuttle fleet, timely development of the Automated Transfer Vehicle (ATV) has acquired new importance for the partners of the ISS.The ATV is the most technically challenging spacecraft Europe has ever designed, because of its automated navigation capabilities and multiple duties. Each ATV will dock

automatically at the station s Russian-built Zvezda service module and will remain there for up to six months.
Derived from text
Automated Transfer Vehicle; Planning

20040020231
StarTram: Ultra Low Cost Launch For Large Space Architectures
Powell, J.; Maise, G.; Paniagua, J.; AIP Conference Proceedings; February 04, 2004; ISSN 0094-243X; Volume 699, Issue no. 1, 863-874; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNAT. FORUM-STAIF 2004: Conf.on Thermophys.in Microgravity; Commercial/Civil Next Gen.Space Transp.; 21st Symp.Space Nuclear Power & Propulsion; Human Space Explor.; Space Colonization; New Frontiers & Future Concepts, 8-11 February 2004, Albuquerque, New Mexico, USA; Copyright

The StarTram Maglev system can launch hundreds of thousands of tons of cargo per year to orbit ([approx]1000 times present capability) plus many thousands of passengers. The launch cost is only $30/kilogram of cargo, [approx] 1/300 th of present cost. Magnetically levitated spacecraft accelerate to [greater-than-or-equal, slanted]8 km/see in an evacuated ground tunnel using superconducting (SC) Maglev technology now operating in Japan for high speed trains. No propellant is used; energy from the electrical grid costs $0. 50 per kg of launch weight. After reaching orbital speed, the levitated craft ascend in a curving evacuated launch tube that is magnetically levitated above Earth's surface by the repulsion force between SC cables attached to it and an opposing set of SC cables on the surface. The levitation force is 4 tons/meter of tube length at 20 km altitude, and exceeds the tube weight. High strength Kevlar tethers to the ground prevent vertical and lateral motion. Craft enter the atmosphere at 20 km through an open exit that prevents in-leakage of low density air by high speed gas ejectors and an MHD (Magnetic Hydro Dynamic) pump, and coast to apogee, where a small V burn ([approx]500 m/s) establishes orbit. Deceleration as it enters the atmosphere at 20 km is modest, [approx]1 g. Peak heating is [approx]5 KW/cm2 for times of a few seconds before the craft reaches space. The technology for StarTram-C now exists, and no breakthroughs in materials are required. Two possible StarTram systems are compared, one for cargo only, and the second for both passengers and cargo. [copyright] 2004 American Institute of Physics
Author (AIP)
Architecture; Atmospheric Pressure; Cost Analysis; Cost Effectiveness; Cryogenics; Heating; Low Cost; Magnetic Suspension; Spacecraft; Superconducting Magnets

20040020177
NASA GRC High Power Electromagnetic Thruster Program
LaPointe, Michael R.; Pencil, Eric J.; AIP Conference Proceedings; February 04, 2004; ISSN 0094-243X; Volume 699, Issue no. 1, 388-398; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNAT. FORUM-STAIF 2004: Conf.on Thermophys.in Microgravity; Commercial/Civil Next Gen.Space Transp.; 21st Symp.Space Nuclear Power & Propulsion; Human Space Explor.; Space Colonization; New Frontiers & Future Concepts, 8-11 February 2004, Albuquerque, New Mexico, USA; Copyright

Interest in high power electromagnetic propulsion has been revived to support a variety of future space missions, such as platform maneuvering in low earth orbit, cost-effective cargo transport to lunar and Mars bases, asteroid and outer planet sample return, deep space robotic exploration, and piloted missions to Mars and the outer planets. Magnetoplasmadynamic (MPD) thrusters have demonstrated, at the laboratory level, the capacity to process megawatts of electrical power while providing higher thrust densities than current electric propulsion systems. The ability to generate higher thrust densities permits a reduction in the number of thrusters required to perform a given mission and alleviates the system complexity associated with multiple thruster arrays. The specific impulse of an MPD thruster can be optimized to meet given mission requirements, from a few thousand seconds with heavier gas propellants up to 10,000 seconds with hydrogen propellant. In support of NASA space science and human exploration strategic initiatives, Glenn Research Center is developing and testing pulsed, MW-class MPD thrusters as a prelude to long-duration high power thruster tests. The research effort includes numerical modeling of self-field and applied-field MPD thrusters and experimental testing of quasi-steady MW-class MPD thrusters in a high power pulsed thruster facility. This paper provides an overview of the GRC high power electromagnetic thruster program and the pulsed thruster test facility. [copyright] 2004 American Institute of Physics
Author (AIP)
Asteroid Missions; Cost Effectiveness; Deep Space; Electric Generators; Electric Propulsion; Electromagnetic Propulsion; Gas Giant Planets; Grand Tours; Ion Engines; Low Earth Orbits; Lunar Bases; Magnetohydrodynamics; Mars (Planet); Mars Bases; Mars Missions; Plasmas (Physics); Propulsion; Research Projects; Sample Return Missions; Space Exploration; Space Missions; Spacecraft; Spacecraft Power Supplies

20040005901 NASA Glenn Research Center, Cleveland, OH, USA

High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto

McGuire, Melissa L.; Borowski, Stanley K.; Mason, Lee M.; Gilland, James; December 2003; In English, 2-6 Feb. 2003, Albuquerque, NM, USA

Contract(s)/Grant(s): WBS 22-706-87-02

Report No.(s): NASA/TM-2003-212349; E-13937; No Copyright; Avail: CASI; A03, Hardcopy

This documents the results of a one-year multi-center NASA study on the prospect of sending humans to Jupiter's moon, Callisto, using an all Nuclear Electric Propulsion (NEP) space transportation system architecture with magnetoplasmadynamic (MPD) thrusters. The fission reactor system utilizes high temperature uranium dioxide (UO2) in tungsten (W) metal matrix cermet fuel and electricity is generated using advanced dynamic Brayton power conversion technology. The mission timeframe assumes on-going human Moon and Mars missions and existing space infrastructure to support launch of cargo and crewed spacecraft to Jupiter in 2041 and 2045, respectively.

Author

Nuclear Electric Propulsion; Artificial Gravity; Callisto; Magnetoplasmadynamic Thrusters; NASA Space Programs; Space Transportation System; Manned Space Flight

20030111797 Lockheed Martin Space Mission Systems and Services, Littleton, CO, USA

Orbital Space Plane (OSP) Program

McKenzie, Patrick M.; September 19, 2003; In English, 29 Sep. - 3 Oct. 2003, Bremen, Germany

Contract(s)/Grant(s): NAS8-01098; No Copyright; Avail: CASI; A02, Hardcopy

Lockheed Martin has been an active participant in NASA's Space Launch Initiative (SLI) programs over the past several years. SLI, part of NASA's Integrated Space Transportation Plan (ISTP), was restructured in November of 2002 to focus the overall theme of safer, more afford-able space transportation along two paths - the Orbital Space Plane Program and the Next Generation Launch Technology programs. The Orbital Space Plane Program has the goal of providing rescue capability from the International Space Station by 2008 and transfer capability for crew (and limited cargo) by 2012. The Next Generation Launch Technology program is combining research and development efforts from the 2nd Generation Reusable Launch Vehicle (2GRLV) program with cutting-edge, advanced space transportation programs (previously designated 3rd Generation) into one program aimed at enabling safe, reliable, cost-effective reusable launch systems by the middle of the next decade. Lockheed Martin is one of three prime contractors working to bring Orbital Space Plane system concepts to a system definition level of maturity by December of 2003. This paper and presentation will update the international community on the progress of the' OSP program, from an industry perspective, and provide insights into Lockheed Martin's role in enabling the vision of a safer, more affordable means of taking people to and from space.

Author

Space Transportation; International Space Station; Systems Analysis; Aerospace Planes

20030106071 Lockheed Martin Space Systems Co., Huntsville, AL, USA

Orbital Space Plane (OSP) Program at Lockheed Martin

Ford, Robert; September 19, 2003; In English, 24 Sep.2003, Long Beach, CA, USA

Contract(s)/Grant(s): NAS8-01098; No Copyright; Avail: CASI; A02, Hardcopy

Lockheed Martin has been an active participant in NASA's Space Launch Initiative (SLI) programs over the past several years. SLI, part of NASA's Integrated Space Transportation Plan (ISTP), was restructured in November 2002 to focus the overall theme of safer, more affordable space transportation along two paths the Orbital Space Plane (OSP) and the Next Generation Launch Technology programs. The Orbital Space Plane program has the goal of providing rescue capability from the International Space Station by 2008 or earlier and transfer capability for crew (and contingency cargo) by 2012. The Next Generation Launch Technology program is combining research and development efforts from the 2d Generation Reusable Launch Vehicle (2GRLV) program with cutting-edge, advanced space transportation programs (previously designated 31d Generation) into one program aimed at enabling safe, reliable, cost-effective reusable launch systems by the middle of the next decade. Lockheed Martin is one of three prime contractors working to bring Orbital Space Plane system concepts to a system design level of maturity by December 2003. This paper and presentation will update the aerospace community on the progress of the OSP program, from an industry perspective, and provide insights into Lockheed Martin's role in enabling the vision of a safer, more affordable means of taking people to and from space.

Author

Aerospace Planes; Space Transportation; Reusable Launch Vehicles; NASA Space Programs; Spacecraft Orbits; Spacecraft Configurations

20030093602 Rose-Hulman Inst. of Tech., Terre Haute, IN, USA

Fuzzy Logic Trajectory Design and Guidance for Terminal Area Energy Management

Burchett, Bradley; The 2002 NASA Faculty Fellowship Program Research Reports; April 2003, IX-1 - IX-5; In English

Contract(s)/Grant(s): NAG8-1859; No Copyright; Avail: CASI; C01, CD-ROM; A01, Hardcopy

The second generation reusable launch vehicle will leverage many new technologies to make flight to low earth orbit safer and more cost effective. One important capability will be completely autonomous flight during reentry and landing, thus making it unnecessary to man the vehicle for cargo missions with stringent weight constraints. Implementation of sophisticated new guidance and control methods will enable the vehicle to return to earth under less than favorable conditions. The return to earth consists of three phases--Entry, Terminal Area Energy Management (TAEM), and Approach and Landing. The Space Shuttle is programmed to fly all three phases of flight automatically, and under normal circumstances the astronaut-pilot takes manual control only during the Approach and Landing phase. The automatic control algorithms used in the Shuttle for TAEM and Approach and Landing have been developed over the past 30 years. They are computationally efficient, and based on careful study of the spacecraft's flight dynamics, and heuristic reasoning. The gliding return trajectory is planned prior to the mission, and only minor adjustments are made during flight for perturbations in the vehicle energy state. With the advent of the X-33 and X-34 technology demonstration vehicles, several authors investigated implementing advanced control methods to provide autonomous real-time design of gliding return trajectories thus enhancing the ability of the vehicle to adjust to unusual energy states. The bulk of work published to date deals primarily with the approach and landing phase of flight where changes in heading angle are small, and range to the runway is monotonically decreasing. These benign flight conditions allow for model simplification and fairly straightforward optimization. This project focuses on the TAEM phase of flight where mathematically precise methods have produced limited results. Fuzzy Logic methods are used to make onboard autonomous gliding return trajectory design robust to a wider energy envelope, and the possibility of control surface failures, thus increasing the flexibility of unmanned gliding recovery and landing.

Derived from text

Fuzzy Systems; Logic Design; Trajectories; Terminal Area Energy Management; Automatic Control

20030067885 NASA Marshall Space Flight Center, Huntsville, AL, USA

NASA's Orbital Space Plane Risk Reduction Strategy

Dumbacher, Dan; [2003]; In English, 14-17 Jul. 2003, Dayton, OH, USA

Report No.(s): AIAA Paper 2003-3332; Copyright; Avail: CASI; A02, Hardcopy

This paper documents the transformation of NASA s Space Launch Initiative (SLI) Second Generation Reusable Launch Vehicle Program under the revised Integrated Space Transportation Plan, announced November 2002. Outlining the technology development approach followed by the original SLI, this paper gives insight into the current risk-reduction strategy that will enable confident development of the Nation s first orbital space plane (OSP). The OSP will perform an astronaut and contingency cargo transportation function, with an early crew rescue capability, thus enabling increased crew size and enhanced science operations aboard the International Space Station. The OSP design chosen for full-scale development will take advantage of the latest innovations American industry has to offer. The OSP Program identifies critical technologies that must be advanced to field a safe, reliable, affordable space transportation system for U.S. access to the Station and low-Earth orbit. OSP flight demonstrators will test crew safety features, validate autonomous operations, and mature thermal protection systems. Additional enabling technologies may be identified during the OSP design process as part of an overall risk-management strategy. The OSP Program uses a comprehensive and evolutionary systems acquisition approach, while applying appropriate lessons learned.

Author

Risk; NASA Space Programs; Aerospace Planes; Reusable Launch Vehicles; Autonomy; Orbital Maneuvering Vehicles

20030067855 NASA Glenn Research Center, Cleveland, OH, USA

High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space

Falck, Robert D.; Borowski, Stanley K.; July 2003; In English, 2-6 Feb. 2003, Albuquerque, NM, USA

Contract(s)/Grant(s): WBS 22-706-87-02

Report No.(s): NASA/TM-2003-212227; E-13847; NAS 1.15:212227; No Copyright; Avail: CASI; A02, Hardcopy

The performance of Nuclear Electric Propulsion (NEP) in transporting cargo and propellant from Low Earth Orbit (LEO) to the first Earth-Moon Lagrange point (EML1) is examined. The baseline NEP vehicle utilizes a fission reactor system with Brayton power conversion for electric power generation to power multiple liquid hydrogen magnetoplasmadynamic (MPD)

thrusters. Vehicle characteristics and performance levels are based on technology availability in a fifteen to twenty year timeframe. Results of numerical trajectory analyses are also provided.
Author
Cislunar Space; Low Earth Orbits; Nuclear Electric Propulsion; Propellant Transfer; Brayton Cycle

20030046833

Solar Sails for Mars Cargo Missions

Frisbee, Robert H.; AIP Conference Proceedings; January 14, 2002; ISSN 0094-243X; Volume 608, Issue no. 1, 374-380; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNATIONAL FORUM- STAIF 2002, 3-6 Feb 2002, Albuquerque, New Mexico, USA; Copyright

This paper presents an analysis of Solar Sails for the Mars Cargo Mission. The figures-of-merit used are the total system Initial Mass in Low Earth Orbit (IMLEO) and Trip Time. The total IMLEO includes the payload, solar sail, and any orbit transfer vehicle (OTV) required to move the sail and its payload to the operational altitude of the sail (e.g., 2. 000 km minimum altitude Earth orbit for the solar sail due to air drag). Once the sail and its payload are transported to the sail's minimum operational orbit by the OTV, the sail begins its Earth-escape spiral and heliocentric transfer to the orbit of Mars. In order to minimize the payload's Earth-to-Mars trip time, the sail does not perform a Mars orbit insertion capture spiral but rather deploys its payload during Mars flyby. The payload then aerobrakes into Mars orbit or to the surface to await arrival of the crewed portion of the mission. The sail loiters in heliocentric space until it is time to return to Earth. Note that one important constraint on the payload's Earth-to-Mars trip time is the requirement that the payload be delivered to Mars (and be checked-out and verified operational) before the crew departs Earth at the next Earth-Mars launch opportunity. We further assumed that the solar sail would be a reusable system; thus, in addition to delivering the payload to Mars prior to the next crew departure, the solar sail must return to Earth before the next sail Earth-departure opportunity. With these constraints, the solar sail areas required for a 58 and 72 metric ton (MT) payload are, respectively, 20 and 25 km2. The corresponding IMLEO values are 149 and 185 MT, such that the total transportation system (sail and OTV) is only 1.6 times the payload mass. [copyright] 2002 American Institute of Physics.
Author (AIP)
Earth Orbits; Mars (Planet); Mars Missions; Solar Corpuscular Radiation; Solar Sails; Solar Wind; Spacecraft; Spacecraft Propulsion; Transportation

20030006889

An Interplanetary Rapid Transit System Between Earth and Mars

Nock, Kerry; Duke, Michael; King, Robert; Jacobs, Mark; Johnson, Lee; McRonald, Angus; Penzo, Paul; Rauwolf, Jerry; Wyszkowski, Chris; AIP Conference Proceedings; January 28, 2003; ISSN 0094-243X; Volume 654, Issue no. 1, 1075-1086; In English; SPACE TECHNOLOGY and APPLICATIONS INT.FORUM-STAIF 2003: Conf.on Thermophysics in Microgravity; Commercial/Civil Next Generation Space Transportation; Human Space Exploration, 2-5 February 2003, Albuquerque, New Mexico, USA
Contract(s)/Grant(s): 07600-49; 07600-59; Copyright

A revolutionary interplanetary rapid transit concept for transporting scientists and explorers between Earth and Mars is presented by Global Aerospace Corporation under funding from the NASA Institute for Advanced Concepts (NIAC) with support from the Colorado School of Mines (CSM), Science Applications International Corporation (SAIC), and others. We describe an innovative architecture that uses highly autonomous, solar-powered, xenon ion-propelled spaceships, dubbed Astrotels; small Taxis for trips between Astrotels and planetary Spaceports; Shuttles that transport crews to and from orbital space stations and planetary surfaces; and low-thrust cargo freighters that deliver hardware, fuels and consumables to Astrotels and Spaceports. Astrotels can orbit the Sun in cyclic orbits between Earth and Mars and Taxis fly hyperbolic planetary trajectories between Astrotel and Spaceport rendezvous. Together these vehicles transport replacement crews of 10 people on frequent, short trips between Earth and Mars. Two crews work on Mars with alternating periods of duty, each spending about 4 years there with crew transfers occurring about every two years. We also discuss the production of rocket fuels using materials mined from the surfaces of the Moon, Mars and the Martian satellites: the use of aerocapture to slow Taxis at the planets; and finally the life-cycle cost estimation. [copyright] 2003 American Institute of Physics
Author (AIP)
Mars (Planet); Photoelectric Cells; Rapid Transit Systems; Spacecraft

20030006861

High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space

Falck, Robert D.; Borowski, Stanley K.; AIP Conference Proceedings; January 28, 2003; ISSN 0094-243X; Volume 654, Issue no. 1, 844-852; In English; SPACE TECHNOLOGY and APPLICATIONS INT.FORUM-STAIF 2003: Conf.on Thermophysics in Microgravity; Commercial/Civil Next Generation Space Transportation; Human Space Exploration, 2-5 February 2003, Albuquerque, New Mexico, USA; Copyright

The performance of Nuclear Electric Propulsion (NEP) in transporting cargo and propellant from Low Earth Orbit (LEO) to the first Earth-Moon Lagrange point (EML1) is examined. The baseline NEP vehicle utilizes a fission reactor system with Brayton power conversion for electric power generation to power multiple liquid hydrogen magnetoplasmadynamic (MPD) thrusters. Vehicle characteristics and performance levels are based on technology availability in a fifteen to twenty year timeframe. Results of numerical trajectory analyses are also provided. [copyright] 2003 American Institute of Physics

Author (AIP)

Cislunar Space; Electric Propulsion; Jupiter (Planet); Low Earth Orbits; Nuclear Electric Propulsion; Nuclear Propulsion; Nuclear Reactors; Propellant Transfer; Spacecraft; Spacecraft Propulsion

20030006860

High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto

McGuire, Melissa L.; Borowski, Stanley K.; Mason, Lee M.; Gilland, James; AIP Conference Proceedings; January 28, 2003; ISSN 0094-243X; Volume 654, Issue no. 1, 837-843; In English; SPACE TECHNOLOGY and APPLICATIONS INT.FORUM-STAIF 2003: Conf.on Thermophysics in Microgravity; Commercial/Civil Next Generation Space Transportation; Human Space Exploration, 2-5 February 2003, Albuquerque, New Mexico, USA; Copyright

The following paper documents the results of a one-year multi-center NASA study on the prospect of sending humans to Jupiter's moon, Callisto, using an all Nuclear Electric Propulsion (NEP) space transportation system architecture with magnetoplasmadynamic (MPD) thrusters. The fission reactor system utilizes high temperature uranium dioxide (UO2) in tungsten (W) metal matrix 'cermet' fuel and electricity is generated using advanced dynamic Brayton power conversion technology. The mission timeframe assumes on-going human Moon and Mars missions and existing space infrastructure to support launch of cargo and crewed spacecraft to Jupiter in 2041 and 2045, respectively. [copyright] 2003 American Institute of Physics

Author (AIP)

Architecture (Computers); Artificial Gravity; Electric Propulsion; Electromagnetic Propulsion; Jupiter (Planet); Magnetoplasmadynamic Thrusters; Natural Satellites; Nuclear Electric Propulsion; Nuclear Propulsion; Nuclear Reactors; Space Transportation System; Spacecraft; Spacecraft Propulsion

20030003756 Embry-Riddle Aeronautical Univ., USA

PARTS: (Plasma Accelerated Reusable Transport System)

Aherne, Michael; Davis, Phil; England, Matt; Gustavsson, Jake; Pankow, Steve; Sampaio, Chere; Savella, Phil; RASC-AL (Revolutionary Aerospace Systems Concepts-Academic Linkage): 2002 Advanced Concept Design Presentation; 2002, 23-38; In English; No Copyright; Avail: CASI; A03, Hardcopy

The Plasma Accelerated Reusable Transport System (PARTS) is an unmanned cargo shuttle intended to ferry large payloads to and from Martian orbit using a highly efficient VAriable Specific Impulse Magnetoplasma Rocket (VASIMR). The design of PARTS focuses on balancing cost and minimizing transit time for a chosen payload consisting of vehicles, satellites, and other components provided by interested parties.

Author

Mars (Planet); Cargo; VASIMR (Propulsion System); Reusable Spacecraft; Spacecraft Design; Plasma Propulsion

20030001590 NASA Marshall Space Flight Center, Huntsville, AL USA

Launch Vehicle/Carrier Interaction, Improving the Analytical Integration Process

Shariett, Charles A.; McClendon, Randy, Technical Monitor; [2002]; In English; Space Ops 2002 Conference, 9-12 Oct. 2002, Houston, TX, USA; No Copyright; Avail: Other Sources; Abstract Only

A goal of the aerospace industry is to reduce the cost of space transportation by a significant within the next decade. The present cost of launching a space transportation system which includes propulsion system, vehicle, carrier, and payload integrated together to form a system, encompasses much more than the design of the propulsion system and vehicle. The total cost includes the recurring cost of the process of integrating carriers, and payloads into the vehicle for each flight. The

recurring cost of the integration of carrier/payloads systems is driven by the interaction of the vehicle. If the interaction can be well characterized and made to be very predictable for a range of payloads, or if it can be minimized then the cost of integrating a payload can be reduced significantly from today's levels. The Space Shuttle is very interactive with the payload. The interaction has been well characterized through finite element modeling and is reasonably predictable for a specific payload. Experience has shown, however, that the interaction is very manifest dependent, and small changes in one portion of a payload complement can change the interaction significantly in another portion. That is the affects of one on the other are such that if one or the other is changed slightly the environment at the interfaces can change significantly. To date the Shuttle has made in excess of one hundred flights. For each of these flights several iterations of dynamic analyses have been required in the development of each vehicle/carrier/payload system. The iterative analyses are needed because of the sensitivity of the interaction of the launch vehicle to the attached carrier/payload. The Multi Purpose Logistics Module (MPLM) is a carrier designed for flight in the Space Shuttle carrying a wide variation of cargo, supplies, and experiments to and from Space Station. Its integration process provides a unique area for improvement in the template in use today for transporting items to space. Discussion of the present MPLM integration analysis requirements and possible areas for improvement of the process are provided in the subject paper. Special emphasis is placed on reduction of requirements based on similarity of items being transported, and the use of carrier hardware for protection of the Shuttle Orbiter.
Author
Analogies; Finite Element Method; Logistics; Mathematical Models; Payloads; Propulsion; Launch Vehicles

20020092010 NASA Marshall Space Flight Center, Huntsville, AL USA
A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle
Safie, Fayssal M.; Daniel, Charles; Kalia, Prince; Smith, Charles A., Technical Monitor; [2002]; In English; Workshop on Life Cycle System Engineering, 6-7 Nov. 2002, Redstone Arsenal, AL, USA; No Copyright; Avail: CASI; A03, Hardcopy

The USA National Aeronautics and Space Administration (NASA) is in the midst of a 10-year Second Generation Reusable Launch Vehicle (RLV) program to improve its space transportation capabilities for both cargo and crewed missions. The objectives of the program are to: significantly increase safety and reliability, reduce the cost of accessing low-earth orbit, attempt to leverage commercial launch capabilities, and provide a growth path for manned space exploration. The safety, reliability and life cycle cost of the next generation vehicles are major concerns, and NASA aims to achieve orders of magnitude improvement in these areas. To get these significant improvements, requires a rigorous process that addresses Reliability, Maintainability and Supportability (RMS) and safety through all the phases of the life cycle of the program. This paper discusses the RMS process being implemented for the Second Generation RLV program.
Author
Reliability; Reusable Launch Vehicles; Safety; Maintainability; Life Cycle Costs; Life (Durability)

20020091874 NASA Marshall Space Flight Center, Huntsville, AL USA
Operations Analysis of the 2nd Generation Reusable Launch Vehicle
Noneman, Steven R.; Smith, C. A., Technical Monitor; [2002]; In English; Space Ops 2002, 9-12 Oct. 2002, Houston, TX, USA; No Copyright; Avail: CASI; A03, Hardcopy

The Space Launch Initiative (SLI) program is developing a second-generation reusable launch vehicle. The program goals include lowering the risk of loss of crew to 1 in 10,000 and reducing annual operations cost to one third of the cost of the Space Shuttle. The SLI missions include NASA, military and commercial satellite launches and crew and cargo launches to the space station. The SLI operations analyses provide an assessment of the operational support and infrastructure needed to operate candidate system architectures. Measures of the operability are estimated (i.e. system dependability, responsiveness, and efficiency). Operations analysis is used to determine the impact of specific technologies on operations. A conceptual path to reducing annual operations costs by two thirds is based on key design characteristics, such as reusability, and improved processes lowering labor costs. New operations risks can be expected to emerge. They can be mitigated with effective risk management with careful identification, assignment, tracking, and closure. SLI design characteristics such as nearly full reusability, high reliability, advanced automation, and lowered maintenance and servicing coupled with improved processes are contributors to operability and large operating cost reductions.
Author
Reusable Launch Vehicles; Spacecraft Launching; Design Analysis; Maintenance

20020068832 Louisiana State Univ., Shreveport, LA USA

Operations Analysis of Space Shuttle System

Sarker, Bhaba R.; Research Reports: 2001 NASA/ASEE Summer Faculty Fellowship Program; July 2002, XLVI-1 - XLVI-5; In English

Contract(s)/Grant(s): NAG8-1786; No Copyright; Avail: CASI; A01, Hardcopy

The space science program at NASA since 1950's has gone through stages of development and implementation in rocketry and scientific advancement. It has become the nation's largest scientific institution of research and innovation for space exploration and military research, and overall a pride of the nation at an exorbitant cost. After placing man on moon, space shuttle program at NASA is an on-going project with a high success rate at an average cost of about $450m per flight. A future endeavor from both government and private sectors needs to be undertaken for commercialization of this expensive mission. In order to attract private enterprises, it needs to boost up its operations with better technology at lower cost to cope with rapid changes in scientific advancement and economic competition. Thus, a second-generation reusable launch vehicle (2GRLV) will play a major role in future operation of NASA centers. Envisioning this potential way of saving the program by reducing the cost, NASA is currently managing an innovative program called the Space Launch Initiative (SLI) to develop key technologies that will support the development of second-generation reusable launch vehicles (RLV) which will be more economical and safer and reliable than the existing space shuttle system. The selection of which technologies to fund for further development is being based on their likelihood to contribute to providing cost reduction or safety improvements. It is envisioned that in the 2006 timeframe, NASA will make a decision as to whether or not to commit to the replacement of the current space shuttle system with a new RLV. The decision to proceed with a new RLV will be partly based on the likelihood that the new system will be better than the existing space shuttle. Government and private entrepreneurs are currently considering four different types of RLV projects: commercial programs, government programs, international concepts, and X Prize competitors. NASA has already commissioned a series of X-programs to study the future RLV program. Today, NASA decision makers need analytical tools to help determine which technologies to fund the development of this technology. In the 2006 timeframe, these same decision makers will need analytical tools to evaluate and compare various RLV architectures, including the existing space shuttle so as to make the best decision for whether or not to proceed with the development of a new RLV, and if so, then which one. A study is conducted here to establish ground level knowledge from the historical data and expertise experiences of the field personnel. Such information is compiled in the form of mission statement, goals, space shuttle operations, payloads and cargo constraints, resource constraints, and bottlenecks to the enhancement vector.

Derived from text

Reusable Launch Vehicles; Research and Development; Space Shuttles; Assessments; Project Planning; Operations Research

20020049427 NASA Marshall Space Flight Center, Huntsville, AL USA

Modal Testing of Seven Shuttle Cargo Elements for Space Station

Kappus, Kathy O.; Driskill, Timothy C.; Parks, Russel A.; Patterson, Alan, Technical Monitor; [2001]; In English; International Modal Analysis Conference, 4-7 Feb. 2002, Los Angeles, CA, USA; No Copyright; Avail: CASI; A02, Hardcopy

From December 1996 to May 2001, the Modal and Control Dynamics Team at NASA's Marshall Space Flight Center (MSFC) conducted modal tests on seven large elements of the International Space Station. Each of these elements has been or will be launched as a Space Shuttle payload for transport to the International Space Station (ISS). Like other Shuttle payloads, modal testing of these elements was required for verification of the finite element models used in coupled loads analyses for launch and landing. The seven modal tests included three modules - Node, Laboratory, and Airlock, and four truss segments - P6, P3/P4, S1/P1, and P5. Each element was installed and tested in the Shuttle Payload Modal Test Bed at MSFC. This unique facility can accommodate any Shuttle cargo element for modal test qualification. Flexure assemblies were utilized at each Shuttle-to-payload interface to simulate a constrained boundary in the load carrying degrees of freedom. For each element, multiple-input, multiple-output burst random modal testing was the primary approach with controlled input sine sweeps for linearity assessments. The accelerometer channel counts ranged from 252 channels to 1251 channels. An overview of these tests, as well as some lessons learned, will be provided in this paper.

Author

Space Station Modules; Space Shuttle Payloads; Performance Tests; Test Stands

20020030127 Auburn Univ., AL USA

Power Without Wires (POWOW)

Brandhorst, Henry W., Jr.; Howell, Joe, Technical Monitor; Feb. 20, 2002; In English

Contract(s)/Grant(s): NAG8-1617; No Copyright; Avail: CASI; A03, Hardcopy

Electric propulsion has emerged as a cost-effective solution to a wide range of satellite applications. Deep Space 1

successfully demonstrated electric propulsion as the primary propulsion source for a satellite. The POWOW concept is a solar-electric propelled spacecraft capable of significant cargo and short trip times for traveling to Mars. There it would enter areosynchronous orbit (Mars GEO equivalent) and beam power to surface installations via lasers. The concept has been developed with industrial partner expertise in high efficiency solar cells, advanced concentrator modules, innovative arrays, and high power electric propulsion systems. The present baseline spacecraft design providing 898 kW using technologies expected to be available in 2003 will be described. Areal power densities approaching 350 W/sq m at 80 C operating temperatures and wing level specific powers of over 350 W/kg are projected. Details of trip times and payloads to Mars are presented. Electric propulsion options include Hall, MPD, and ion thrusters of various power levels and trade studies have been conducted to define the most advantageous options. Because the design is modular, learning curve methodology has been applied to determine expected cost reductions and is included.
Author
Electric Propulsion; Propulsion System Configurations; Mars Missions; Laser Power Beaming; Solar Arrays

20020020427 NASA Marshall Space Flight Center, Huntsville, AL USA
NASA Alternate Access to Station Service Concept
Bailey, Michelle D.; Crumbly, Chris; [2002]; In English, 10-19 Oct. 2002, Houston, TX, USA; No Copyright; Avail: Other Sources; Abstract Only

The evolving nature of the NASA space enterprise compels the agency to develop new and innovative space systems concepts. NASA, working with increasingly strained budgets and a declining manpower base, is attempting to transform from operational activities to procurement of commercial services. NASA's current generation reusable launch vehicle, the Shuttle, is in transition from a government owned and operated entity to a commercial venture to reduce the civil servant necessities for that program. NASA foresees its second generation launch vehicles being designed and operated by industry for commercial and government services. The 'service' concept is a pioneering effort by NASA. The purpose the 'service' is not only to reduce the civil servant overhead but will free up government resources for further research - and enable industry to develop a space business case so that industry can sustain itself beyond government programs. In addition, NASA desires a decreased responsibility thereby decreasing liability. The Second Generation Reusable Launch Vehicle (RLV) program is implementing NASA's Space Launch Initiative (SLI) to enable industry to develop the launch vehicles of the future. The Alternate Access to Station (AAS) project office within this program is chartered with enabling industry to demonstrate an alternate access capability for the International Space Station (ISS). The project will not accomplish this by traditional government procurement methods, not by integrating the space system within the project office, or by providing the only source of business for the new capability. The project funds will ultimately be used to purchase a service to take re-supply cargo to the ISS, much the same as any business might purchase a service from FedEx to deliver a package to its customer. In the near term, the project will fund risk mitigation efforts for enabling technologies. AAS is in some ways a precursor to the 2nd Generation RLV. By accomplishing ISS resupply with existing technologies, not only will a new category of autonomous vehicles deliver cargo, but a commercial business base will be incubated that will improve the likelihood of commercial convergence with the next generation of RLVs. Traditional paradigms in government management and acquisition philosophy are being challenged in order to bring about the objective of the AAS project. The phased procurement approach is proving to be the most questionable aspect to date. This work addresses the fresh approach AAS is adopting in management and procurement through a study of the AAS history, current solutions, key technologies, procurement complications, and an incremental forward plan leading to the purchase of a service to deliver goods to ISS. Included in this work is a discussion of the Commercial Space Act of 1998 and how it affects government purchase of space launch and space vehicle services. Industry should find these topics pertinent to their current state of business.
Author
Reusable Launch Vehicles; International Space Station; Space Commercialization

20020015696 Washington Univ., Seattle, WA USA
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars
Cummings, Hillary; Ross, Mike; Welsh, Daren; Choe, Paul; Inaba, Derek; Kachel, Chris; Ready, Katherine; Suthers, Elspeth; Warrick, Ben; Winstrom, Luke, et al.; Fourth Annual HEDS-UP Forum; 2001, 168-182; In English; No Copyright; Avail: CASI; A03, Hardcopy

This paper presents two variations of a manned mission to Mars incorporating the Mini-Magnetospheric Plasma Propulsion (M2P2) System, under development at the University of Washington by Professor Robert Winglee, as a less expensive, flexible alternative to the traditional nuclear propulsion systems proposed in the NASA Mars Reference Mission. The M2P2 produces a magnetic plasma bubble that interacts with the ambient solar wind to produce an energy-efficient, high

specific impulse thrust. Two scenarios are presented to show the versatility of the M2P2 propulsion system. The first consists of a standard mission similar to the NASA Mars Reference Mission, in which cargo is sent to the Martian surface prior to the piloted mission. The second scenario is a non-traditional mission, in which a single, piloted mission is sent to Mars with multiple landers. These landers would be able to explore multiple sites on the surface of Mars. Multiple orbit trajectories with varying total and Martian surface stay times have been calculated to show the time flexibility of this advanced propulsion system versus the limited launch windows dictated by traditional propulsion systems. The minimum round trip time is shown to be 1.7 years, with potentially 50% less departure mass from low Earth orbit than required by the Mars Reference Mission.
Author
Manned Mars Missions; Plasma Bubbles; Plasma Propulsion; Propulsion System Configurations

20010094060 NASA Glenn Research Center, Cleveland, OH USA
High Power MPD Thruster Development at the NASA Glenn Research Center
LaPointe, Michael R.; Mikellides, Pavlos G.; Reddy, Dhanireddy, Technical Monitor; August 2001; In English; 37th Joint Propulsion Conference and Exhibit, 8-11 Jul. 2001, Salt Lake City, UT, USA
Contract(s)/Grant(s): NCC3-860; RTOP 755-B4-07
Report No.(s): NASA/CR-2001-211114; E-12961; NAS 1.26:211114; AIAA Paper 2001-3499; No Copyright; Avail: CASI; A03, Hardcopy

Propulsion requirements for large platform orbit raising, cargo and piloted planetary missions, and robotic deep space exploration have rekindled interest in the development and deployment of high power electromagnetic thrusters. Magnetoplasmadynamic (MPD) thrusters can effectively process megawatts of power over a broad range of specific impulse values to meet these diverse in-space propulsion requirements. As NASA's lead center for electric propulsion, the Glenn Research Center has established an MW-class pulsed thruster test facility and is refurbishing a high-power steady-state facility to design, build, and test efficient gas-fed MPD thrusters. A complimentary numerical modeling effort based on the robust MACH2 code provides a well-balanced program of numerical analysis and experimental validation leading to improved high power MPD thruster performance. This paper reviews the current and planned experimental facilities and numerical modeling capabilities at the Glenn Research Center and outlines program plans for the development of new, efficient high power MPD thrusters.
Author
Electromagnetic Propulsion; Plasma Propulsion; Magnetoplasmadynamic Thrusters; Rocket Test Facilities; Mathematical Models; Research Facilities

20000120038 FDC/NYMA, Inc., Hampton, VA USA
International Space Station Evolution Data Book, Volume 1, Baseline Design
Jorgensen, Catherine A., Editor; Antol, Jeffrey, Technical Monitor; October 2000; In English; Original contains color illustrations
Contract(s)/Grant(s): NAS1-96013
Report No.(s): NASA/SP-2000-6109/VOL1/REV1; NAS 1.21:6109/VOL1/REV1; No Copyright; Avail: CASI; A10, Hardcopy

The International Space Station (ISS) will provide an Earth-orbiting facility that will accommodate engineering experiments as well as research in a microgravity environment for life and natural sciences. The ISS will distribute resource utilities and support permanent human habitation for conducting this research and experimentation in a safe and habitable environment. The objectives of the ISS program are to develop a world-class, international orbiting laboratory for conducting high-value scientific research for the benefit of humans on Earth; to provide access to the microgravity environment; to develop the ability to live and work in space for extended periods; and to provide a research test bed for developing advanced technology for human and robotic exploration of space. The current design and development of the ISS has been achieved through the outstanding efforts of many talented engineers, designers, technicians, and support personnel who have dedicated their time and hard work to producing a state-of-the-art Space Station. Despite these efforts, the current design of the ISS has limitations that have resulted from cost and technology issues. Regardless, the ISS must evolve during its operational lifetime to respond to changing user needs and long-term national and international goals. As technologies develop and user needs change, the ISS will be modified to meet these demands. The design and development of these modifications should begin now to prevent a significant lapse in time between the baseline design and the realization of future opportunities. For this effort to begin, an understanding of the baseline systems and current available opportunities for utilization needs to be achieved. Volume I of this document provides the consolidated overview of the ISS baseline systems. It also provides information on the current facilities available for pressurized and unpressurized payloads. Information on current plans for crew availability

and utilization; resource timelines and margin summaries including power, thermal, and storage volumes; and an overview of the ISS cargo traffic and the vehicle traffic model is also included.
Author
International Space Station; Evolution (Development); Large Space Structures; Space Station Modules; Space Commercialization; Life Support Systems

20000094226 Georgia Inst. of Tech., Atlanta, GA USA
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project
Alexander, Roger; Bechtel, Ryan; Chen, Ted; Cormier, Tim; Kalaver, Sachin; Kirtas, Mehmet; Lewe, Jung-Ho; Marcus, Leland; Marshall, Dave; Medlin, Matt, et al.; Third Annual HEDS-UP Forum; 2000, 206-224; In English; No Copyright; Avail: CASI; A03, Hardcopy

The Moon-based Advanced Reusable Transportation Architecture (MARTA) Project conducted an in-depth investigation of possible Low Earth Orbit (LEO) to lunar surface transportation systems capable of sending both astronauts and large masses of cargo to the Moon and back. This investigation was conducted from the perspective of a private company operating the transportation system for a profit. The goal of this company was to provide an Internal Rate of Return (IRR) of 25% to its shareholders. The technical aspect of the study began with a wide open design space that included nuclear rockets and tether systems as possible propulsion systems. Based on technical, political, and business considerations, the architecture was quickly narrowed down to a traditional chemical rocket using liquid oxygen and liquid hydrogen. However, three additional technologies were identified for further investigation: aerobraking, in-situ resource utilization (ISRU), and a mass driver on the lunar surface. These three technologies were identified because they reduce the mass of propellant used. Operational costs are the largest expense with propellant cost the largest contributor. ISRU, the production of materials using resources on the Moon, was considered because an Earth to Orbit (ETO) launch cost of $1600 per kilogram made taking propellant from the Earth's surface an expensive proposition. The use of an aerobrake to circularize the orbit of a vehicle coming from the Moon towards Earth eliminated 3, 100 meters per second of velocity change (Delta V), eliminating almost 30% of the 11,200 m/s required for one complete round trip. The use of a mass driver on the lunar surface, in conjunction with an ISRU production facility, would reduce the amount of propellant required by eliminating using propellant to take additional propellant from the lunar surface to Low Lunar Orbit (LLO). However, developing and operating such a system required further study to identify if it was cost effective. The vehicle was modeled using the Simulated Probabilistic Parametric Lunar Architecture Tool (SPPLAT), which incorporated the disciplines of Weights and Sizing, Trajectories, and Cost. This tool used ISRU propellant cost, Technology Reduction Factor (a dry weight reduction due to improved technology), and vehicle engine specific impulse as inputs. Outputs were vehicle dry weight, total propellant used per trip, and cost to charge the customer in order to guarantee an IRR of 25%. SPPLAT also incorporated cost estimation error, weight estimation error, market growth, and ETO launch cost as uncertainty variables. Based on the stipulation that the venture be profitable, the price to charge the customer was highly dependent on ISRU propellant cost and relatively insensitive to the other inputs. The best estimate of ISRU cost is $1000/kg, and results in a price to charge the customer of $2600/kg of payload. If ISRU cost can be reduced to $160/kg, the price to the customer is reduced to just $800/kg of payload. Additionally, the mass driver was only cost effective at an ISRU propellant cost greater than $250/kg, although it reduced total propellant used by 35%. In conclusion, this mission is achievable with current technology, but is only profitable with greater research into the enabling technology of ISRU propellant production.
Author
Commerce; Cost Effectiveness; Lunar Surface; Propellants; Propulsion System Configurations; Lunar Resources; Space Logistics

20000094224 Rowan Univ., Glassboro, NJ USA
A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants
Conley, Jordan; Lefler, Devon; Shaw, Steve; Third Annual HEDS-UP Forum; 2000, 169-185; In English; No Copyright; Avail: CASI; A03, Hardcopy

With a mission to Mars no longer merely an idea of science fiction, it is not too early to determine the technology requirements that will ultimately make it possible for humans to establish a long term outpost on Mars. One key aspect is the development of a reliable, reusable launch vehicle to shuttle astronauts between the Mars surface and low Martian orbit. This preliminary design study serves to provide an in depth comparison of liquid, solid, and hybrid propulsion concepts for a long-term In-Situ Mars Ascent Vehicle (IMAV) which relies only on propellants which can be harvested from the Mars atmosphere or soil. Because of the low Delta-v, a Single Stage to Orbit (SSTO) launch vehicle can be used to carry the crew plus cargo from the Martian surface back to, the command module. Theoretical chemical equilibrium calculations have been

performed to determine the optimum in-situ propellant combination for each propulsion type. The approach we took in performing a comparison of the possible design configurations contained several steps. First, we identified a baseline configuration against which we compared our design. The baseline configuration we choose was the Mars Ascent Vehicle (MAV) outlined in the current Mars Reference Mission. The second step was the addition of several constraints not specified in the baseline configuration, but which have been deemed important for this analysis. One significant constraint was that only non-hydrogen containing fuels - -were considered. Finally, we compared three different design alternatives to the baseline configuration. The areas of comparison were performance, safety, and feasibility. Based on these evaluation criteria, we have recommended a liquid propulsion system using CO/O2 propellants as the most favorable configuration for the development of a long-term, Mars ascent vehicle.
Author
Mars Missions; Reusable Launch Vehicles; Single Stage to Orbit Vehicles; Manned Mars Missions; Mars Bases; Hybrid Propulsion; Liquid Rocket Propellants; Chemical Fuels

20000094220 California Inst. of Tech., Pasadena, CA USA
Mars SCHEME: The Mars Society of Caltech Human Exploration of Mars Endeavor
Hirata, Christopher; Brown, Nathan; Shannon, Derek; Third Annual HEDS-UP Forum; 2000, 96-115; In English; No Copyright; Avail: CASI; A03, Hardcopy

The Mars Society of Caltech Human Exploration of Mars Endeavor (Mars SCHEME) is a detailed description of robotic and human missions necessary to establish a permanent human presence on the surface of Mars. The sequence begins in 2009 with a robotic Mars sample return mission on a larger scale than that currently planned. This is followed in 2011 by a pair of HEDS landers designed to test in-situ propellant production and other necessary technologies. Cargo for the human crews is sent in 2016 and in 2018, with the first five-member crew traveling to Mars during the 2020 opportunity. The Mars SCHEME features design redundancy; for example, the capsules for Earth ascent, Mars ascent, and Earth arrival are based upon a common design. Systems redundancy is also included to provide multiple habitats on Mars and in interplanetary space. The plan uses only chemical propulsion, starting with the Z-5 launch vehicle that can deliver up to 112,000 kg to low Earth orbit. Costs of human missions are comparable with those of the NASA Design Reference Mission 3.0. Human missions have low recurring costs, high reliability, and high scientific return. Extensive computer simulations were used to develop launch vehicles and trajectories. Further details are available at http://mars.caltech.edu/.
Author
Mars (Planet); Mars Exploration; Mars Bases; Mission Planning; Manned Mars Missions; NASA Space Programs

20000094217 Texas Univ., Austin, TX USA
Automated Construction of a Martian Base
Braun, Angela Nicole; Butler, Dan Bordeaux Burk; Kirk, Benjamin Shelton; White, Scott William; Third Annual HEDS-UP Forum; 2000, 44-56; In English; No Copyright; Avail: CASI; A03, Hardcopy

This document describes the construction of a Martian base that will support human exploration. The base will be constructed without a human presence in order to minimize the risk to the crew. The base will be verified remotely before the crew leaves Earth to ensure that all systems are performing as expected. Life support is the most obvious function the base will have to perform. The crew will require consumables such as food and water. They must also be provided with a controlled atmosphere. The base will use in-situ resource generation (ISRG) as the primary means to provide these services. The ISRG system will extract chemicals from the Martian atmosphere and convert them to usable resources. Power is a key resource for the base. The primary power needs will be met by an SP-100 nuclear reactor and three Stirling engines. This primary power source can provide 375 kW of power under nominal conditions, which is sufficient to support all base operations. Backup systems are present that can sustain critical functions such as life support and communications in the case of primary system failure. The base will provide a substantial communications infrastructure. Both Earth to Mars and surface communications are supported. A satellite constellation will be used to provide this capability. Backup systems are also provided that can be used in the event of primary system failure. Surface operations and science capability is an important aspect of the base design. The base includes two primary laboratories. One laboratory is contained in a lab module that is stationary, and the other is part of a pressurized rover. This mobile science unit (MSU) gives the exploration team the capability of collecting samples and exploring geologic features up to 500 km away. The MSU can operate autonomously from the base for periods up to two weeks with a crew, or it can function robotically for longer periods of time. A transportation and delivery scheme has also been developed. This scheme requires 4 cargo and assembly missions. The cargo modules will transfer from Earth to Mars on a low energy, near-Hohmann trajectory and then aerocapture into Martian orbit. The cargo modules will then descend to the Martian surface and land within 1km of the chosen landing site. Each cargo module can land up to 15 metric tons on the

surface.Construction will begin as soon as the cargo modules land. The first launch opportunity will send the power and resource generation systems for the base as well as the surface communications infrastructure and two unpressurized rovers in a single launch package. Resource generation will begin as soon as possible. The second launch package will contain the water extraction system, an ascent vehicle, and scientific equipment and instruments. The remainder of the base will be arrive with the second launch opportunity. The first cargo mission in this opportunity will transport the science and utility modules and a pressurized science rover to the surface. The final launch will contain the habitation module, crew consumables, and a supplemental life support system. Base assembly is accomplished through component movement and integration. This work is accomplished primarily with the two unpressurized rovers. The assembly procedure is controlled from the surface with the help of artificial intelligence. The final base is comprised of a central hub, three inflatable utility modules, the power system, and the ascent module. The base is validated using telemetry from each subsystem. The validation must be successfully completed before sending a crew to Mars.
Author

Construction; Life Support Systems; Mars (Planet); Mars Surface; Mars Bases; Extraterrestrial Environments; Space Habitats; Extraterrestrial Resources; Space Logistics

Subject Terms

AEROSPACE PLANES
Application of Probabilistic Risk Assessment (PRA) During Conceptual Design for the NASA Orbital Space Plane (OSP) – 1
NASA's Orbital Space Plane Risk Reduction Strategy – 5
Orbital Space Plane (OSP) Program at Lockheed Martin – 4
Orbital Space Plane (OSP) Program – 4

ANALOGIES
Launch Vehicle/Carrier Interaction, Improving the Analytical Integration Process – 7

ARCHITECTURE (COMPUTERS)
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 7

ARCHITECTURE
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

ARTIFICIAL GRAVITY
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

ASSESSMENTS
Operations Analysis of Space Shuttle System – 9

ASTEROID MISSIONS
NASA GRC High Power Electromagnetic Thruster Program – 3

ASTRONAUTS
EAC trains its first international astronaut class – 1

ATMOSPHERIC PRESSURE
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

AUTOMATED TRANSFER VEHICLE
Will the ATV Deliver? – 2

AUTOMATIC CONTROL
Fuzzy Logic Trajectory Design and Guidance for Terminal Area Energy Management – 5

AUTONOMY
NASA's Orbital Space Plane Risk Reduction Strategy – 5

BRAYTON CYCLE
High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 5

CALLISTO
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

CARGO
Cargo Assured Access to International Space Station – 2
PARTS: (Plasma Accelerated Reusable Transport System) – 7

CHEMICAL FUELS
A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

CISLUNAR SPACE
High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 5

COMMERCE
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

CONSTRUCTION
Automated Construction of a Martian Base – 13

COST ANALYSIS
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

COST EFFECTIVENESS
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12
NASA GRC High Power Electromagnetic Thruster Program – 3
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

CRYOGENIC ROCKET PROPELLANTS
Propellant Preservation for Mars Missions – 2

CRYOGENICS
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

DEEP SPACE
NASA GRC High Power Electromagnetic Thruster Program – 3

DESIGN ANALYSIS
Operations Analysis of the 2nd Generation Reusable Launch Vehicle – 8

EARTH ORBITS
Solar Sails for Mars Cargo Missions – 6

ELECTRIC GENERATORS
NASA GRC High Power Electromagnetic Thruster Program – 3

ELECTRIC PROPULSION
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 7
High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 7
NASA GRC High Power Electromagnetic Thruster Program – 3
Power Without Wires (POWOW) – 9

ELECTROMAGNETIC PROPULSION
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 7
High Power MPD Thruster Development at the NASA Glenn Research Center – 11
NASA GRC High Power Electromagnetic Thruster Program – 3

EVOLUTION (DEVELOPMENT)
International Space Station Evolution Data Book – 11

EXTRATERRESTRIAL ENVIRONMENTS
Automated Construction of a Martian Base – 13

EXTRATERRESTRIAL RESOURCES
Automated Construction of a Martian Base – 13

FINITE ELEMENT METHOD
Launch Vehicle/Carrier Interaction, Improving the Analytical Integration Process – 7

FUZZY SYSTEMS
Fuzzy Logic Trajectory Design and Guidance for Terminal Area Energy Management – 5

GAS GIANT PLANETS
NASA GRC High Power Electromagnetic Thruster Program – 3

GRAND TOURS
NASA GRC High Power Electromagnetic Thruster Program – 3

HEATING
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

HYBRID PROPULSION
A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

INTERNATIONAL SPACE STATION
Cargo Assured Access to International Space Station – 2
International Space Station Evolution Data Book – 11
NASA Alternate Access to Station Service Concept – 10
Orbital Space Plane (OSP) Program – 4

ION ENGINES
NASA GRC High Power Electromagnetic Thruster Program – 3

JUPITER (PLANET)
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 7

High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 7

LARGE SPACE STRUCTURES
International Space Station Evolution Data Book – 11

LASER POWER BEAMING
Power Without Wires (POWOW) – 9

LAUNCH VEHICLES
Application of Probabilistic Risk Assessment (PRA) During Conceptual Design for the NASA Orbital Space Plane (OSP) – 1

Cargo Assured Access to International Space Station – 2

Launch Vehicle/Carrier Interaction, Improving the Analytical Integration Process – 7

LIFE CYCLE COSTS
A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle – 8

LIFE (DURABILITY)
A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle – 8

LIFE SUPPORT SYSTEMS
Automated Construction of a Martian Base – 13

International Space Station Evolution Data Book – 11

LIQUID ROCKET PROPELLANTS
A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

LOGIC DESIGN
Fuzzy Logic Trajectory Design and Guidance for Terminal Area Energy Management – 5

LOGISTICS
Cargo Assured Access to International Space Station – 2

Launch Vehicle/Carrier Interaction, Improving the Analytical Integration Process – 7

LOW COST
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

LOW EARTH ORBITS
High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 5

NASA GRC High Power Electromagnetic Thruster Program – 3

LUNAR BASES
NASA GRC High Power Electromagnetic Thruster Program – 3

LUNAR RESOURCES
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

LUNAR SURFACE
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

MAGNETIC SUSPENSION
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

MAGNETOHYDRODYNAMICS
NASA GRC High Power Electromagnetic Thruster Program – 3

MAGNETOPLASMADYNAMIC THRUSTERS
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

High Power MPD Thruster Development at the NASA Glenn Research Center – 11

MAINTAINABILITY
A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle – 8

MAINTENANCE
Operations Analysis of the 2nd Generation Reusable Launch Vehicle – 8

MANNED MARS MISSIONS
A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Mars SCHEME: The Mars Society of Caltech Human Exploration of Mars Endeavor – 13

MANNED SPACE FLIGHT
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

MARS BASES
A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

Automated Construction of a Martian Base – 13

Mars SCHEME: The Mars Society of Caltech Human Exploration of Mars Endeavor – 13

NASA GRC High Power Electromagnetic Thruster Program – 3

MARS EXPLORATION
Mars SCHEME: The Mars Society of Caltech Human Exploration of Mars Endeavor – 13

MARS MISSIONS
A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

NASA GRC High Power Electromagnetic Thruster Program – 3

Power Without Wires (POWOW) – 9

Propellant Preservation for Mars Missions – 2

Solar Sails for Mars Cargo Missions – 6

MARS (PLANET)
An Interplanetary Rapid Transit System Between Earth and Mars – 6

Automated Construction of a Martian Base – 13

Mars SCHEME: The Mars Society of Caltech Human Exploration of Mars Endeavor – 13

NASA GRC High Power Electromagnetic Thruster Program – 3

PARTS: (Plasma Accelerated Reusable Transport System) – 7

Solar Sails for Mars Cargo Missions – 6

MARS SURFACE
Automated Construction of a Martian Base – 13

MATHEMATICAL MODELS
High Power MPD Thruster Development at the NASA Glenn Research Center – 11

Launch Vehicle/Carrier Interaction, Improving the Analytical Integration Process – 7

MISSION PLANNING
Mars SCHEME: The Mars Society of Caltech Human Exploration of Mars Endeavor – 13

NASA SPACE PROGRAMS
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

Mars SCHEME: The Mars Society of Caltech Human Exploration of Mars Endeavor – 13

NASA's Orbital Space Plane Risk Reduction Strategy – 5

Orbital Space Plane (OSP) Program at Lockheed Martin – 4

NATURAL SATELLITES
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 7

NUCLEAR ELECTRIC PROPULSION
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 5

NUCLEAR PROPULSION

High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 7

High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 7

NUCLEAR REACTORS

High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 7

High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 7

OPERATIONS RESEARCH

Operations Analysis of Space Shuttle System – 9

ORBITAL MANEUVERING VEHICLES

NASA's Orbital Space Plane Risk Reduction Strategy – 5

PAYLOADS

Launch Vehicle/Carrier Interaction, Improving the Analytical Integration Process – 7

PERFORMANCE TESTS

Modal Testing of Seven Shuttle Cargo Elements for Space Station – 9

PERSONNEL DEVELOPMENT

EAC trains its first international astronaut class – 1

PHOTOELECTRIC CELLS

An Interplanetary Rapid Transit System Between Earth and Mars – 6

PLANNING

Will the ATV Deliver? – 2

PLASMA BUBBLES

Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

PLASMA PROPULSION

High Power MPD Thruster Development at the NASA Glenn Research Center – 11

Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

PARTS: (Plasma Accelerated Reusable Transport System) – 7

PLASMAS (PHYSICS)

NASA GRC High Power Electromagnetic Thruster Program – 3

PRESERVING

Propellant Preservation for Mars Missions – 2

PROJECT PLANNING

Operations Analysis of Space Shuttle System – 9

PROPELLANT STORAGE

Propellant Preservation for Mars Missions – 2

PROPELLANT TRANSFER

High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 5

PROPELLANTS

Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

PROPULSION SYSTEM CONFIGURATIONS

Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Power Without Wires (POWOW) – 9

PROPULSION

Launch Vehicle/Carrier Interaction, Improving the Analytical Integration Process – 7

NASA GRC High Power Electromagnetic Thruster Program – 3

RAPID TRANSIT SYSTEMS

An Interplanetary Rapid Transit System Between Earth and Mars – 6

RELIABILITY

A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle – 8

RESEARCH AND DEVELOPMENT

Operations Analysis of Space Shuttle System – 9

RESEARCH FACILITIES

High Power MPD Thruster Development at the NASA Glenn Research Center – 11

RESEARCH PROJECTS

NASA GRC High Power Electromagnetic Thruster Program – 3

REUSABLE LAUNCH VEHICLES

A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle – 8

NASA Alternate Access to Station Service Concept – 10

NASA's Orbital Space Plane Risk Reduction Strategy – 5

Operations Analysis of Space Shuttle System – 9

Operations Analysis of the 2nd Generation Reusable Launch Vehicle – 8

Orbital Space Plane (OSP) Program at Lockheed Martin – 4

REUSABLE SPACECRAFT

PARTS: (Plasma Accelerated Reusable Transport System) – 7

RISK

Application of Probabilistic Risk Assessment (PRA) During Conceptual Design for the NASA Orbital Space Plane (OSP) – 1

NASA's Orbital Space Plane Risk Reduction Strategy – 5

ROCKET TEST FACILITIES

High Power MPD Thruster Development at the NASA Glenn Research Center – 11

SAFETY

A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle – 8

SAMPLE RETURN MISSIONS

NASA GRC High Power Electromagnetic Thruster Program – 3

SINGLE STAGE TO ORBIT VEHICLES

A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

SOLAR ARRAYS

Power Without Wires (POWOW) – 9

SOLAR CORPUSCULAR RADIATION

Solar Sails for Mars Cargo Missions – 6

SOLAR SAILS

Solar Sails for Mars Cargo Missions – 6

SOLAR WIND

Solar Sails for Mars Cargo Missions – 6

SPACE COMMERCIALIZATION

International Space Station Evolution Data Book – 11

NASA Alternate Access to Station Service Concept – 10

SPACE EXPLORATION

NASA GRC High Power Electromagnetic Thruster Program – 3

SPACE HABITATS

Automated Construction of a Martian Base – 13

SPACE LOGISTICS

Automated Construction of a Martian Base – 13

Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

SPACE MISSIONS

NASA GRC High Power Electromagnetic Thruster Program – 3

SPACE SHUTTLE PAYLOADS
Modal Testing of Seven Shuttle Cargo Elements for Space Station – 9

SPACE SHUTTLES
Operations Analysis of Space Shuttle System – 9

SPACE STATION MODULES
International Space Station Evolution Data Book – 11

Modal Testing of Seven Shuttle Cargo Elements for Space Station – 9

SPACE TRANSPORTATION SYSTEM
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

SPACE TRANSPORTATION
Application of Probabilistic Risk Assessment (PRA) During Conceptual Design for the NASA Orbital Space Plane (OSP) – 1

Orbital Space Plane (OSP) Program at Lockheed Martin – 4

Orbital Space Plane (OSP) Program – 4

SPACECRAFT CONFIGURATIONS
Orbital Space Plane (OSP) Program at Lockheed Martin – 4

SPACECRAFT DESIGN
PARTS: (Plasma Accelerated Reusable Transport System) – 7

SPACECRAFT LAUNCHING
Operations Analysis of the 2nd Generation Reusable Launch Vehicle – 8

SPACECRAFT ORBITS
Orbital Space Plane (OSP) Program at Lockheed Martin – 4

SPACECRAFT POWER SUPPLIES
NASA GRC High Power Electromagnetic Thruster Program – 3

SPACECRAFT PROPULSION
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 7

High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 7

Solar Sails for Mars Cargo Missions – 6

SPACECRAFT
An Interplanetary Rapid Transit System Between Earth and Mars – 6

High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 7

High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 7

NASA GRC High Power Electromagnetic Thruster Program – 3

Solar Sails for Mars Cargo Missions – 6

StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

SPACECREWS
Application of Probabilistic Risk Assessment (PRA) During Conceptual Design for the NASA Orbital Space Plane (OSP) – 1

SUPERCONDUCTING MAGNETS
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

SYSTEMS ANALYSIS
Orbital Space Plane (OSP) Program – 4

TERMINAL AREA ENERGY MANAGEMENT
Fuzzy Logic Trajectory Design and Guidance for Terminal Area Energy Management – 5

TEST STANDS
Modal Testing of Seven Shuttle Cargo Elements for Space Station – 9

TRAJECTORIES
Fuzzy Logic Trajectory Design and Guidance for Terminal Area Energy Management – 5

TRANSPORTATION
Solar Sails for Mars Cargo Missions – 6

VASIMR (PROPULSION SYSTEM)
PARTS: (Plasma Accelerated Reusable Transport System) – 7

Corporate Sources

American Inst. of Aeronautics and Astronautics
Will the ATV Deliver? – 2

Auburn Univ.
Power Without Wires (POWOW) – 9

Boeing Phantom Works
Cargo Assured Access to International Space Station – 2

California Inst. of Tech.
Mars SCHEME: The Mars Society of Caltech Human Exploration of Mars Endeavor – 13

Embry-Riddle Aeronautical Univ.
PARTS: (Plasma Accelerated Reusable Transport System) – 7

FDC/NYMA, Inc.
International Space Station Evolution Data Book – 11

Georgia Inst. of Tech.
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Lockheed Martin Space Mission Systems and Services
Orbital Space Plane (OSP) Program – 4

Lockheed Martin Space Systems Co.
Orbital Space Plane (OSP) Program at Lockheed Martin – 4

Louisiana State Univ.
Operations Analysis of Space Shuttle System – 9

NASA Ames Research Center
Propellant Preservation for Mars Missions – 2

NASA Glenn Research Center
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

High Power MPD Thruster Development at the NASA Glenn Research Center – 11

High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 5

NASA Marshall Space Flight Center
A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle – 8

Application of Probabilistic Risk Assessment (PRA) During Conceptual Design for the NASA Orbital Space Plane (OSP) – 1

Launch Vehicle/Carrier Interaction, Improving the Analytical Integration Process – 7

Modal Testing of Seven Shuttle Cargo Elements for Space Station – 9

NASA Alternate Access to Station Service Concept – 10

NASA's Orbital Space Plane Risk Reduction Strategy – 5

Operations Analysis of the 2nd Generation Reusable Launch Vehicle – 8

Rose-Hulman Inst. of Tech.
Fuzzy Logic Trajectory Design and Guidance for Terminal Area Energy Management – 5

Rowan Univ.
A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

Texas Univ.
Automated Construction of a Martian Base – 13

Washington Univ.
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Document Authors

Aherne, Michael
PARTS: (Plasma Accelerated Reusable Transport System) – 7

Alexander, Roger
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Antol, Jeffrey
International Space Station Evolution Data Book – 11

Bailey, Michelle D.
NASA Alternate Access to Station Service Concept – 10

Bechtel, Ryan
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Bessone, Loredana
EAC trains its first international astronaut class – 1

Bolender, Hans
EAC trains its first international astronaut class – 1

Borowski, Stanley K.
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 5

Brandhorst, Henry W., Jr.
Power Without Wires (POWOW) – 9

Braun, Angela Nicole
Automated Construction of a Martian Base – 13

Brown, Nathan
Mars SCHEME: The Mars Society of Caltech Human Exploration of Mars Endeavor – 13

Burchett, Bradley
Fuzzy Logic Trajectory Design and Guidance for Terminal Area Energy Management – 5

Butler, Dan Bordeaux Burk
Automated Construction of a Martian Base – 13

Chen, Ted
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Choe, Paul
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Conley, Jordan
A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

Cormier, Tim
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Crumbly, Chris
NASA Alternate Access to Station Service Concept – 10

Cummings, Hillary
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Daniel, Charles
A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle – 8

Davis, Phil
PARTS: (Plasma Accelerated Reusable Transport System) – 7

Driskill, Timothy C.
Modal Testing of Seven Shuttle Cargo Elements for Space Station – 9

Duke, Michael
An Interplanetary Rapid Transit System Between Earth and Mars – 6

Dumbacher, Dan
NASA's Orbital Space Plane Risk Reduction Strategy – 5

England, Matt
PARTS: (Plasma Accelerated Reusable Transport System) – 7

Falck, Robert D.
High Power Nuclear Electric Propulsion (NEP) for Cargo and Propellant Transfer Missions in Cislunar Space – 5

Ford, Robert
Orbital Space Plane (OSP) Program at Lockheed Martin – 4

Frisbee, Robert H.
Solar Sails for Mars Cargo Missions – 6

Gilland, James
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

Gustavsson, Jake
PARTS: (Plasma Accelerated Reusable Transport System) – 7

Hirata, Christopher
Mars SCHEME: The Mars Society of Caltech Human Exploration of Mars Endeavor – 13

Howell, Joe
Power Without Wires (POWOW) – 9

Iannotta, Ben
Will the ATV Deliver? – 2

Inaba, Derek
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Jacobs, Mark
An Interplanetary Rapid Transit System Between Earth and Mars – 6

Johnson, Lee
An Interplanetary Rapid Transit System Between Earth and Mars – 6

Jorgensen, Catherine A.
International Space Station Evolution Data Book – 11

Kachel, Chris
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Kalaver, Sachin
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Kalia, Prince
A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle – 8

Kappus, Kathy O.
Modal Testing of Seven Shuttle Cargo Elements for Space Station – 9

King, Robert
An Interplanetary Rapid Transit System Between Earth and Mars – 6

Kirk, Benjamin Shelton
Automated Construction of a Martian Base – 13

Kirtas, Mehmet
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Kittel, Peter
Propellant Preservation for Mars Missions – 2

LaPointe, Michael R.
High Power MPD Thruster Development at the NASA Glenn Research Center – 11

NASA GRC High Power Electromagnetic Thruster Program – 3

Lefler, Devon
A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

Lewe, Jung-Ho
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Lo, Yunnhon
Application of Probabilistic Risk Assessment (PRA) During Conceptual Design for the NASA Orbital Space Plane (OSP) – 1

Maise, G.
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

Marcus, Leland
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Marshall, Dave
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Mason, Lee M.
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

McClendon, Randy
Launch Vehicle/Carrier Interaction, Improving the Analytical Integration Process – 7

McGuire, Melissa L.
High Power MPD Nuclear Electric Propulsion (NEP) for Artificial Gravity HOPE Missions to Callisto – 4

McKenzie, Patrick M.
Orbital Space Plane (OSP) Program – 4

McRonald, Angus
An Interplanetary Rapid Transit System Between Earth and Mars – 6

Medlin, Matt
Moon-Based Advanced Reusable Transportation Architecture: The MARTA Project – 12

Mikellides, Pavlos G.
High Power MPD Thruster Development at the NASA Glenn Research Center – 11

Nock, Kerry
An Interplanetary Rapid Transit System Between Earth and Mars – 6

Noneman, Steven R.
Operations Analysis of the 2nd Generation Reusable Launch Vehicle – 8

Paniagua, J.
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

Pankow, Steve
PARTS: (Plasma Accelerated Reusable Transport System) – 7

Parks, Russel A.
Modal Testing of Seven Shuttle Cargo Elements for Space Station – 9

Patterson, Alan
Modal Testing of Seven Shuttle Cargo Elements for Space Station – 9

Pencil, Eric J.
NASA GRC High Power Electromagnetic Thruster Program – 3

Penzo, Paul
An Interplanetary Rapid Transit System Between Earth and Mars – 6

Powell, J.
StarTram: Ultra Low Cost Launch For Large Space Architectures – 3

Rauwolf, Jerry
An Interplanetary Rapid Transit System Between Earth and Mars – 6

Ready, Katherine
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Reddy, Dhanireddy
High Power MPD Thruster Development at the NASA Glenn Research Center – 11

Rogers, James H.
Application of Probabilistic Risk Assessment (PRA) During Conceptual Design for the NASA Orbital Space Plane (OSP) – 1

Ross, Mike
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Safie, Fayssal M.
A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle – 8

Application of Probabilistic Risk Assessment (PRA) During Conceptual Design for the NASA Orbital Space Plane (OSP) – 1

Sampaio, Chere
PARTS: (Plasma Accelerated Reusable Transport System) – 7

Sarker, Bhaba R.
Operations Analysis of Space Shuttle System – 9

Savella, Phil
PARTS: (Plasma Accelerated Reusable Transport System) – 7

Schoen, Andreas
EAC trains its first international astronaut class – 1

Shannon, Derek
Mars SCHEME: The Mars Society of Caltech Human Exploration of Mars Endeavor – 13

Shariett, Charles A.
Launch Vehicle/Carrier Interaction, Improving the Analytical Integration Process – 7

Shaw, Steve
A Comparison of Preliminary Design Concepts for Liquid, Solid and Hybrid Propelled Mars Ascent Vehicles Using In-Situ Propellants – 12

Smith, C. A.
Operations Analysis of the 2nd Generation Reusable Launch Vehicle – 8

Smith, Charles A.
A Quantitative Reliability, Maintainability and Supportability Approach for NASA's Second Generation Reusable Launch Vehicle – 8

Smith, David A.
Cargo Assured Access to International Space Station – 2

Stevenin, Herve
EAC trains its first international astronaut class – 1

Stott, James E.
Application of Probabilistic Risk Assessment (PRA) During Conceptual Design for the NASA Orbital Space Plane (OSP) – 1

Suthers, Elspeth
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Warrick, Ben
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Welsh, Daren
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

White, Scott William
Automated Construction of a Martian Base – 13

Winstrom, Luke
Incorporation of the Mini-Magnetospheric Plasma Propulsion System (M2P2) in a Manned Mission to Mars – 10

Wyszkowski, Chris
An Interplanetary Rapid Transit System Between Earth and Mars – 6