On January 14, 2004, President Bush released the Vision for Space Exploration as a new directive for NASA that includes an objective to promote commercial participation. The 2005 NASA Authorization Act also required the agency to support advancements in space commerce. To fulfill these mandates, NASA created the Commercial Orbital Transportation Services (COTS) program, which offers hope for an alternative to dependence on foreign vehicles for manned space access between the shuttle’s retirement and the introduction of the Crew Exploration Vehicle (CEV). The three objectives for COTS are (1) to implement a U.S. Space Exploration Policy that includes investments in the commercial industry; (2) to facilitate U.S. private industry demonstrations of safe, reliable, and cost-effective cargo and crew transportation capabilities to low-Earth orbit (LEO); and (3) to create a market environment where commercial space transportation services are available for government and private customers.

NASA dedicated approximately $500 million (about the same amount as the cost of one shuttle launch) to the two-phase COTS program. The first phase involves demonstrations by each contractor’s spacecraft to successfully dock at the International Space Station (ISS), deliver cargo, and then either safely return to Earth or be disposed. A follow-on option is to demonstrate crew transportation. In the second phase, NASA will competitively purchase transportation services, particularly supply missions to the ISS.

Under the COTS program, the spacecraft and supporting architecture are owned and operated by contractors. NASA specifies only the highest level of objectives wherever possible, leaving the contractors to make their own decisions on how to achieve the desired results. Each contractor must provide private funding for all costs beyond the amount specified by the agreement. Agreements are tailored to each contractor, specifying rules for payments based on their progress against a series of performance milestones, both financial and technical.

Nearly 100 companies expressed interest in COTS and more than 20 submitted initial proposals. On August 18, 2006, NASA selected and signed agreements with SpaceX and Rocketplane Kistler (RpK), awarding SpaceX $278 million and RpK $206.8 million. The performance milestones for the agreements are shown in Fig. 1. NASA has since signed unfunded Space Act Agreements with SpaceDEV, SPACEHAB, Transformational Space continued on page 4
CPIAC’s Technical/Bibliographic Inquiry Service

CPIAC offers a variety of services to its subscribers, including responses to technical/bibliographic inquiries. Answers are usually provided within three working days and take the form of telephoned, telefaxed, electronic or written technical summaries. Customers are provided with copies of JANNAF papers, excerpts from technical reports, bibliographies of pertinent literature, names of recognized experts, propellant/ingredient data sheets, computer program tapes and instructions, and/or theoretical performance calculations. The CPIAC staff responds to nearly 800 inquiries per year from over 180 customer organizations. CPIAC invites inquiries via telephone, fax, e-mail, or letter. For further information, please contact Ron Fry by e-mail to rs_fry@jhu.edu. Representative recent inquiries include:

TECHNICAL INQUIRIES

• Exhaust products of large LOX/RP-1 boosters (Req. 25831)
• LOX/RP-1 liquid detonations (Req. 25832)
• Passivation of Aluminum tanks for IRFNA storage (Req. 25997)
• Inhibited Red Fuming Nitric Acid (IRFNA) compatibility and chemical composition break down under high temperatures (Req. 25987)
• Availability of JANAF Thermochemistry Tables (Req. 25949)

BIBLIOGRAPHIC INQUIRIES

• “Burn-to-Violent Reaction Test” background related to solid propellant IM (Req. 25950)
• TAGN/RDX propellant development activities (Req. 25898)

Recent CPIAC Products and Publications


Editor’s Note: The initial release of the March 2008 issue of the Bulletin included an article titled “A Brief View of ATK and XCOR Aerospace’s Liquid Oxygen and Methane Engine Development” that erroneously appeared under the heading Spotlight on SBIRs. The work described in the article is not related to an SBIR contract. The heading was revised to Small Business Spotlight. The Bulletin staff regrets the error.
**Meeting Reminders**

**JANNAF 6th Modeling and Simulation Subcommittee (MSS)/4th Liquid Propulsion Subcommittee (LPS)/3rd Spacecraft Propulsion Subcommittee (SPS) Joint Meeting December 8-12, 2008**

The Joint Army Navy NASA Air Force (JANNAF) 6th Modeling and Simulation Subcommittee/4th Liquid Propulsion Subcommittee/3rd Spacecraft Propulsion Subcommittee Joint Meeting will be held December 8-12, 2008, at the Hilton Walt Disney World, in Orlando, Florida. James M. Haas of the Air Force Research Laboratory, Edwards AFB, California, is the Program Chair of this meeting.

CPIAC distributed the meeting announcement and call for papers for this meeting in April. Please contact Meeting Planner Patricia Szybist at pats@jhu.edu or 410-992-7302, ext. 215, if you did not receive a copy or require additional information. Abstracts are due July 7, 2008.

Attendance at this JANNAF meeting is restricted to U.S. citizens whose organizations are registered with an appropriately classified contract with the Defense Technical Information Center and certified for receipt of export-controlled technical data with the Defense Logistics Information Service.

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**The Bulletin Board**

Various meetings and events of interest are listed below. We welcome all such announcements, so that the propulsion community can be better served with timely information. For information on additional industry meetings, visit the CPIAC calendar of *Meetings & Symposia* available at http://www.cpia.jhu.edu/templates/cpiacTemplate/meetings/. The JANNAF Calendar appears on the back page.

**Space Propulsion 2008 - 5th International Spacecraft Propulsion Conference AND 2nd International Symposium on Propulsion for Space Transportation**
5-9 May 2008
HERAKLION, Crete, Greece

**Fundamentals of Explosives - Short Course on Chemical and Physical Principles including Blast Effects and Forensics**
6-8 May 2008
Kingston, RI
POC: Dr. Jimmie Oxley, 401-874-2103 or e-mail to joxley@chm.uri.edu

**Space Ops 2008**
11-17 May 2008
Heidelberg, Germany
POC: www.aiaa.org

**26th International Symposium on Space Technology and Science (ISTS)**
1-8 June 2008
Hanamatsu City, Shizuoka Prefecture, Japan
POC: www.ists.or.jp

**Gordon Research Conference on Energetic Materials**
15-20 June 2008
Tilton, NH
POC: www.grc.org/programs.aspx

**39th Annual Conference of ICT**
24-27 June 2008
Karlsruhe, Germany
POC: www.ict.fhg.de

**35th International Pyrotechnics Seminar**
13-18 July 2008
Fort Collins, CO
POC: www.ipsusa.org

**44th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit**
20-23 July 2008
Hartford, CT
POC: www.aiaa.org

**Advanced Solid Rockets - AIAA SRTC 2008 Short Course**
24-25 July 2008
Hartford, CT
POC: http://qiqq.org/content.cfm?pageid=161&lumeetingid=1725

**Department of Defense Explosives Safety Board Seminar**
12-14 August 2008
Palm Springs, CA
POC: www.ddesbseminar.org
SpaceX has completed the first eight milestones as part of their agreement to build the Falcon 9 launch vehicle and the Dragon cargo and crew spacecraft. In addition, SpaceX successfully completed the Critical Design Review (CDR) for the Falcon 9 and Dragon on October 18, 2007 and gained NASA’s approval to proceed with the project. Two months later, SpaceX announced that they had completed the System Requirements Review (SRR) for the third Falcon 9 and Dragon demonstration, in which they hope to berth the Dragon capsule at the ISS, as well as the Preliminary Design Review (PDR) for the second flight demonstration.

On January 18, 2008, SpaceX completed its first multiple engine firing of the Falcon 9 rocket by testing two of their engines at the same time. Plans were progressing smoothly until the end of February, when SpaceX announced a six-month delay for the Falcon 9 demo launches, due to the large volume of regulatory work required to certify the vehicle for launch. Their Space Act Agreement was modified to accommodate the delay, and additional hardware development milestones were established. They remain on track toward completing their COTS goals.

The Falcon 9 is a medium lift launch vehicle derived from SpaceX’s Falcon 1 small lift launch vehicle. It is 178 ft in length and 12 ft in width, with a mass of 716,000 lbs. The vehicle will utilize SpaceX’s high performance and reusable Merlin 1C gas generator cycle RP engines. The Merlin 1C has a pintle style injector, first used in the Apollo lunar module landing engine. Merlin has a thrust of 115,400 lb in vacuum, 101,900 lb at sea level, a vacuum Isp of 304 seconds, and a thrust to weight ratio of 96. During the two-engine test of the Falcon 9, the engines produced 180,000 lb of thrust and consumed 700 lbs/s of fuel. Falcon 9 testing is planned to proceed with five, seven, and then finally all nine engines. When all nine engines are fired, the Falcon first stage will produce a total thrust of 1 million lb. The second stage will use a single Merlin engine.

SpaceX plans to use the Falcon 9 to launch the Dragon spacecraft, as well as to provide launch services for satellites. The Dragon spacecraft is designed to carry more than 2500 kg of cargo or seven passengers in a 14-cubic-meter pressurized capsule. The 1200 kg of monomethylhydrazine/nitrogen tetroxide (MMH/NT) propellant powers 18 Draco thrusters for attitude control and orbital maneuvering. Like Apollo, the Dragon capsule is designed for a water landing.

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RpK worked on a two-stage fully reusable launch vehicle called the K-1, along with interchangeable pressurized and unpressurized payload modules. The K-1 is 121 ft in length and 22 ft in diameter, with a launch mass of 845,000 lb. It is intended that the first stage will include three Aerojet AJ-26-58/-59 LOX/RP engines (Fig. 2), providing a total sea level thrust of 1,020,000 lb. The second stage consists of one AJ26-60 engine producing a vacuum thrust of 395,000 lb. The engines have a lifetime of 100 cycles. The payload modules’ Orbital Maneuvering System uses one Aerojet LOX/ethanol engine to produce a vacuum thrust of 870 lb. RpK plans to launch over 12,000 lbm to low earth orbit (LEO) from Woomera, Australia. An optional third stage called the K-1 Active Dispenser could be used to launch 3,400 lbm into geostationary orbit (GEO), or 2,200 lbm into a Mars rendezvous trajectory. RpK designed the K-1 and payload modules to deliver up to 6,118 lbm of pressurized cargo to the ISS.

Despite alliances with Orbital and Alliant Techsystems (ATK), RpK was unable to raise the private funding required to complete the K-1 and conduct flight demonstrations. Subsequently, their COTS agreement was terminated October 18, 2007. RpK had received $32.1 million of the $206.8 million.

NASA announced a competition for a Space Act Agreement funded by the remaining $174.7 million, accepting proposals for 30 days starting October 22. On February 19, NASA signed a new Space Act Agreement with Orbital Sciences for $170 million. As part of this agreement, Orbital will invest $150 million in the three-year project, which includes and Chandler, Arizona.

The Cygnus will be capable of delivering 2,300 kg of pressurized cargo, or 2,000 kg of unpressurized cargo, to the ISS and returning 1,200 kg to the Earth. This will allow the Cygnus to deliver the NASA-estimated 16 tons per year of material to the ISS in 8 launches per year. Orbital has partnered with Thales Alenia Space for the pressurized cargo module, basing the design on the Leonardo Multipurpose Logistics Module that Thales built as part of the Italian Space Agency’s contribution to the ISS. The unpressurized cargo module is based on the Express Logistics Pallet that NASA’s Goddard Space Flight Center is building to aid the shuttle in delivering spare parts to the ISS. The Cygnus will be built in Dulles and in Greenbelt, Maryland. Orbital plans to launch the COTS demonstrations from NASA’s Wallops Flight Facility in Virginia, with integrated mission operations in Dulles and Houston. The COTS demonstration mission is scheduled for the fourth quarter of 2010, with operational missions to begin in the first half of 2011.

A more detailed examination of this topic will be conducted in the future and will appear as a Special Feature on the CPIAC Web site.

About the Author: David Owen is an engineer with the Chemical Propulsion Information Analysis Center. His specific roles include enhancement and expansion of the Rocket Propulsion Test Facilities (RPTF) Database and test community support activities, and the development of the upcoming Spacecraft Propulsion Database (SCPD). Contact: dowen@cpiac.jhu.edu or 410-992-7300, ext. 210.
In Memoriam,
Dr. Wei Shing Chang
Hazardous Materials Expert

Dr. Wei Shing Chang passed away February 9, 2008. He was a pillar in the hazardous materials industry, and his unique expertise in the testing, analysis and transportation of hazardous materials was recognized both nationwide and internationally. Working in conjunction with the U.S. Department of Transportation (DOT), Dr. Chang’s recommendations on shipping classifications enabled the safe transport and storage of hazardous materials throughout the industry.

Dr. Chang’s tireless devotion to his craft and the camaraderie that he shared with others in the explosives industry fueled his work, which he continued up until his passing. In his 36 years in the explosives industry, his breadth of knowledge spanned from the shipment of lighters and fireworks to sophisticated aerospace and defense equipment. Dr. Chang was an invaluable resource to both the commercial explosives and defense industries.

Dr. Chang began his career with The Association of American Railroads/Bureau of Explosives in New Jersey, where he worked for over 20 years, from 1972 to 1995. He served as Chief Chemist and, later, as Chief. In 1996, Dr. Chang founded Explosives Bureau as a consulting company dedicated to the testing, analysis and transportation of hazardous materials. Dr. Chang’s son, Thomas, worked alongside his father from 1998 until Chang’s passing; Thomas will carry on his father’s work through Explosives Bureau.

Born in 1934 in Shanghai, China, Dr. Chang received his B.S. in Chemical Engineering from Chung Cheng Institute of Technology in Taipei, Taiwan. After graduation, he remained at the school as a teacher. He left Taiwan in 1961 and moved to Darmstadt, West Germany, where he earned his Ph.D. in chemical engineering from the Technical University Darmstadt. Dr. Chang came to the United States in 1969 to work on his post doctorate at University of Wisconsin-Madison. He completed his post doctorate at Stony Brook in Long Island, New York.

Dr. Chang dedicated his life to his work, friends and family. He had a generous heart, sharp mind, quick sense of humor and passionate spirit. Individuals whose paths he crossed through his work would inevitably become his friends over the years.

Dr. Chang is survived by his wife, Teresa; a daughter, Sandra; and a son, Thomas Chang.

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Please join the Department of Defense Explosives Safety Board (DDESB) in Palm Springs, Calif., as we explore “Operationalizing Explosives Safety” at the 2008 DDESB Seminar. During this three-day event to be held August 12-14, 2008, a host of official and social activities will provide you opportunities to interact with leading explosives safety experts from the military, government agencies, technology community, and academia and to discuss the latest developments in explosives safety.

Over 150 technical papers will be presented on topics ranging from munitions response, risk analysis/assessment/management, demilitarization and disposal, chemical weapons disposal, insensitive munitions, to manufacturing. The exhibit hall will feature exhibits of the latest technologies in explosives safety, program management, transport, and other important mission areas. Through technical presentations and exhibits, attendees can explore and identify the new technologies, tactics, and methods to eliminate accidents and protect personnel from explosives hazards. If you are military, government, or contractor personnel charged with developing, producing and presenting relevant technologies and solutions, you cannot afford to miss this conference!

Details and up-to-date program information available on the 2008 DDESB Seminar website: www.ddesbseminar.org. Questions may be directed to Impact Associates at 865-379-7065 or by e-mail to service@ddesbseminar.org.

In Memoriam,
Dr. Clark W. Hawk
Director of UA Huntsville Propulsion Research Center

Dr. Clark W. Hawk, director of the University of Alabama in Huntsville (UA Huntsville) Propulsion Research Center and esteemed member of the JANNAF community, died suddenly February 26, 2008, while on a family ski trip in Utah. Hawk was 71.

Dr. Hawk received his bachelor’s degree in mechanical engineering in 1958 from The Pennsylvania State University, his master’s degree in 1968, and his Ph.D. in 1970 from Purdue University. He retired as Director of the Propulsion Division at the Air Force Rocket Propulsion Laboratory at Edwards AFB, California, where he served from 1958 to 1991. In 1991, he became founder and director of the Propulsion Research Center at UA Huntsville, where he was also a full professor of mechanical and aerospace engineering. Hawk received a research award from the University in 2005 in recognition of the Center’s work.

Dr. Hawk was a Fellow of the American Institute of Aeronautics and Astronautics (AIAA) as well as the NASA Institute for Advanced Concepts. Dr. Hawk was an executive member of the Joint Army/Navy/NASA/Air Force Interagency Propulsion Group and advisor to Congress on National Space Transportation Policy. In addition, he received a JANNAF Distinguished Recognition Award for his lengthy career of achievement and contributions to the field of liquid rocket propulsion and The Hermann Oberth Award for Outstanding Scientific Achievement in the fields of Aeronautics and the Space Sciences from the AIAA.

Dr. Hawk was an elder and teacher in the Presbyterian Church. He taught Amateur Ice Hockey, was an avid supporter of the UA Huntsville Hockey Team, and played in Senior Men’s Baseball Tournaments. Survivors include his wife, Julia Hawk; daughter, Sandra Smith and husband, Randall; son, Brian Hawk and wife, Marcela; sisters, Betty Aderman and Mary Beth Stemitz; and two grandsons. Memorials may be made to Covenant Presbyterian Church, 301 Drake Ave., SE, Huntsville, AL 35802, or Dr. and Mrs. Clark W. Hawk Scholarship at The University of Alabama in Huntsville, 311 Shelby King Hall, Huntsville, AL 35899 (256-824-4438).
An Overview of the Modeling and Simulation Information Analysis Center (MSIAC)

The Modeling and Simulation Information Analysis Center (MSIAC) is the Department of Defense’s (DoD) single integrated support activity dedicated to helping both developers and users of modeling and simulation technologies. As one of a family of Department of Defense Information Analysis Centers (IACs) sponsored by the Defense Technical Information Center (DTIC), MSIAC’s directive is to access, acquire, collect, analyze, synthesize, generate, and disseminate scientific, technical, and operational support information in the area of M&S.

The MSIAC’s task-organized structure leverages DoD’s M&S investments through education and mission-tailored services. It offers access to a wide range of commercial, academic, and U.S. Government M&S knowledge through existing strategic alliances. MSIAC’s educational component offers M&S courses and instructional services in support of one of DoD’s highest priorities – workforce development.

Subject-matter experts within the MSIAC provide timely answers to technical inquiries from all segments of the DoD. The MSIAC Help Desk provides users with focused, expert assistance and unbiased scientific, technical, and operational support information. M&S experts can prepare state of the art reports and technology assessments on any subject of interest or concern to M&S users, with the aim of enhancing information exchange throughout the DoD.

The MSIAC also performs a wide range of projects for DoD components, U.S. Government agencies and departments, and other approved organizations. These projects entail technical analyses of problems and provide solutions on topics within the scope of the MSIAC charter. MSIAC support also includes verification and validation of the technical accuracy and reliability of existing data, the generation and evaluation of data collection and analysis techniques reported in literature, and the development of alternative approaches to collection and/or analysis of the same or similar forms of information related to assigned technical areas.

For additional information on MSIAC resources, visit www.dod-msiac.org. You may also use the Web site to submit a request to the Help Desk or to reserve a copy of the latest issue of the MSIAC Journal and/or MSIAC Newsletter.

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Inaugural Issue to be Released

The JANNAF Executive Committee is pleased to announce the publication and upcoming distribution of the inaugural issue of the JANNAF Journal of Propulsion and Energetics. It will be offered complimentary to all qualified attendees upon registration at the JANNAF Propulsion Meeting and Joint Subcommittee Meetings to be held May 12-16, 2008.

The JANNAF Journal is a limited-distribution, export-controlled document dedicated to the publication of scholarly work in the fields of aerospace propulsion and energetic materials research and development.

This first issue will include a total of eight select manuscripts related to the following topics areas:

- solid propellants and combustion
- scramjet propulsion
- gel technology
- underwater propulsion
- explosive performance and enhanced blast

Authors are from a variety of organizations representing Government, industry and academia.

Security restrictions are associated with this publication. All who accept a copy will be responsible for safeguarding it in accordance with warning and destruction notices published on its cover and within the document.

Individuals not attending the meeting who wish to purchase a copy should contact CPIAC Customer Service at 410-992-7300, ext. 212.

The second issue of the JANNAF Journal is scheduled for release at the JPM in May 2009.

General questions on the Journal may be directed to Managing Editor Rosemary Dodds at rdodds@jhu.edu. Technical questions may be forwarded to Editors-in-Chief Bill Hufferd at hufferd@jhu.edu or Ron Fry at rs_fry@jhu.edu.
Call for Papers

The JANNAF Journal of Propulsion and Energetics is an unclassified, limited-distribution technical journal dedicated to the publication of scholarly work in the fields of aerospace propulsion and energetic materials research and development. The inaugural issue of the JANNAF Journal has been published for distribution in May 2008.

The Call for Papers for future issues is ongoing; however, authors who wish to have their manuscript considered for publication in the next issue of the JANNAF Journal should submit their manuscript no later than July 30, 2008, to allow sufficient time for the peer review.

The second issue of the JANNAF Journal is scheduled for release at the JPM in May 2009.

Consult the Author’s Guide for complete instructions on how to prepare and submit a manuscript. Go to http://www.jannaf.org/pdfs/Author_Guide.pdf. Questions concerning manuscript preparation and submission may be directed to Managing Editor Rosemary Dodds at rdodds@jhu.edu. Authors who wish to receive a preliminary review of their manuscript may contact Editor-in-Chief Bill Hufferd at hufferd@jhu.edu or Assistant Editor-in-Chief Ron Fry at rs_fry@jhu.edu.
Industry/Academia Days Held in San Diego

The Test Resource Management Center (TRMC) Test and Evaluation/Science and Technology (T&E/S&T) Program held their Industry/Academia Days on February 13-14, in San Diego, California. The T&E/S&T program focuses on technology that enables or advances the ability to perform tests and experiments in seven focus areas:

- Directed Energy Test (DET)
- High-Speed/Hypersonics Test (HSHT)
- Non-Intrusive Instrumentation (NII)
- Multi-Spectral Test (MST)
- Netcentric Systems Test (NST)
- Spectrum Efficient Technology (SET)
- Unmanned and Autonomous Systems Test (UAST)

All of these areas, with the exception of the NII focus area, will be releasing their Broad Agency Announcements (BAAs) at approximately the same time (spring 2008). The NII area will not be releasing a BAA this year. Current funding levels for new programs are not large; however, funding is expected to increase dramatically in the next few years.

The meeting consisted primarily of presentations by each focus area, giving their research interests and goals, as well as an overview of currently funded programs. Each area also presented the planned subject areas for the BAAs. There were also opportunities for brief one-on-one meetings with the executing agents for each focus area.

Each area seeks projects that satisfy a specific test and evaluation need and addresses a science and technology challenge. The initial technology readiness level (TRL) should be approximately 3 or 4, with the expectation that the TRL will be 6 by the project’s end. The goal is to bring a given technology from a low TRL up to a level where it can be transitioned for use in an experimental environment. Market pull is desired for any given technology so that there is a demand for it once it has transitioned.

As of press time, the following five BAAs have been released:

1. **Solicitation number:** W91ZLK08T0211
   **Title:** A--MULTI-SPECTRAL AND HYPER-SPECTRAL TEST AND EVALUATION, U.S. Aberdeen Test Center, Broad Agency Announcement:
   “The U.S. Army Contracting Agency, Aberdeen Proving Ground, MD 21005-3013, is soliciting concepts for innovative research and developmental projects in the areas of Multi-Spectral (MS) and Hyperspectral (HS) Test and Evaluation (T&E), including Scene and Signature Composition, Scene and Signature Presentation, Multi-Spectral and Hyperspectral Test Tools and Support Technologies and Infra-Red Countermeasures (IRCM) and Missile Warning System (MWS) Test Technology.”

2. **Solicitation number:** W900KK-08-R-0012
   **Title:** A--TRMC DET S&T BAA (Directed Energy Test Science and Technology)
   “This BAA is issued to satisfy the TRMC requirement to support Test and Evaluation of Directed Energy Weapon Systems spanning the high energy laser (HEL) and high power microwave (HPM) domains.”

3. **Solicitation number:** W900KK-08-R-0017
   **Title:** A--TRMC HSHT S&T BAA (High Speed/Hypersonic Test Science & Technology)
   “This BAA is issued to satisfy the TRMC requirement to support test and evaluation of high speed/hypersonic systems.”

4. **Solicitation number:** W900KK-08-R-0018
   **Title:** A--TRMC NST S&T BAA (Netcentric Systems Test Science and Technology)
   “The BAA will be issued to satisfy the TRMC requirement to support test and evaluation of Joint Netcentric Operations (JNO).”

5. **Solicitation number:** W900KK-08-R-0019
   **Title:** A--TRMC SET S&T BAA (Spectrum Efficient Technology Science & Technology)
   “This BAA is issued to satisfy the TRMC requirement to support test and evaluation of weapon systems using network telemetry.”

All of the presentations given at the meeting are to be placed online at [http://www.fedbizopps.gov/](http://www.fedbizopps.gov/). There are also individual websites for two of the focus areas:

- Directed energy: [www.detecteam.org](http://www.detecteam.org)
- Spectrum Efficient Technology: [www.inetprogram.org](http://www.inetprogram.org)

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**SEA is proud to announce the release of CEQUEL, our new Excel spreadsheet add-in. CEQUEL allows the user to solve chemical equilibrium problems entirely within a Microsoft Excel® spreadsheet.**

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- **CEQUEL** solves TP, HP, SP, TV, UV, SV, Rocket, Detonation and Shock problems
- **CEQUEL** is a spreadsheet function that allows input values to be cell references
- **CEQUEL** eliminates the need to cut and paste output from other chemical equilibrium codes into Excel®
- **CEQUEL** can be used to perform cycle analyses and optimizations, evaluate experimental thermodynamic data and predict rocket motor performance
- **CEQUEL** is available for purchase in both single user and network license configurations

For more information contact: [http://www.seainc.com](http://www.seainc.com) or contact us by email at: info@seainc.com

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**Microsoft Excel is a registered trademark of Microsoft Corporation.**
The Materials and Processes Technical Information System, (MAPTIS), is a NASA-wide materials database established for the purpose of recording and disseminating information about materials to ensure the selection of safe materials for spaceflight. All candidate materials for space flight hardware are tested to identify usability and safety issues (toxicity, flammability, corrosion). These test results are collected, verified, and disseminated throughout the Agency via secure databases.

A comprehensive collection of databases, MAPTIS, contains information on almost 40,000 materials, including materials test data, materials properties, and design allowables. MAPTIS is sponsored by the Materials and Processes Laboratory at NASA’s Marshall Space Flight Center.

Historically, the lineage of MAPTIS can be traced to the Apollo I accident. At that time, although materials selection was important, the danger of using certain materials in a 100 percent oxygen atmosphere was poorly understood. The Apollo I accident demonstrated the need for a comprehensive materials testing program and lists of materials certified as safe for use in flight hardware.

MAPTIS supports an international community of over 3,000 registered users, most of whom work for private industry supporting a variety of NASA programs. Included are international users that support the work of the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA) and the Russian Federal Space Agency for the International Space Station. On average MAPTIS receives over 45,000 page hits per month.

Examples of NASA projects supported by MAPTIS include the following: Space Transportation System (Space Shuttle), International Space Station, a variety of science experiments utilizing the “Glovebox” Facility, International Microgravity Laboratory (IML1 & 2), Gravity Probe-B, Hubble Space Telescope, Spacelab, James Webb Space Telescope and the Constellation Project, an initiative to support the International Space Station by developing the ARES Launch Vehicles and Orion Crew Exploration Vehicle, as well as the continued exploration of the Moon and beyond.

Accessing MAPTIS

MAPTIS is accessible with most standard web browsers. No additional software or plugins are needed, although some features require the Java Runtime Engine. Access to MAPTIS is open to employees and contractors of the Federal government. MAPTIS also supports materials researchers at a variety of colleges and universities. All users must be registered and are assigned a unique user name and password. Application for access can be requested using the online form, which is available on the MAPTIS homepage (See Fig. 1) at http://maptis.nasa.gov.

Database Tools

MAPTIS includes several tools, including the MetaSearch tool that allows simultaneous searching of several MAPTIS databases. GrantaMi™ also provides a materials selection technique called the Ashby Selection Method. This process generates an Ashby Chart, a pictorial diagram (Fig. 2) that presents materials in a way that allows quick assessment of the design objective.

Some of the offerings in the MAPTIS databases are detailed as follows:

Materials Selection List for Space Hardware (Fig. 3)

This is a comprehensive list of over 32,000 materials that have been tested for safety and performance characteristics in spacecraft applications and rated for use in flight hardware. Test data includes Flammability, Toxicity (offgassing), continued on page 13
Thermal Vacuum Stability (outgassing), Stress Corrosion Cracking (fracture), and compatibility with oxygen, hydrogen, and other reactive fluids such as hypergolic fuels. Also included in this database are thermophysical properties of metals, lap shear test results, and the results of tensile/compression testing of various ablators and insulating foams.

Aerospace Materials Database
This commercial database provides the following features:

- GrantaMi™ MaterialUniverse database of about 3,700 commercially available materials including ceramics/glasses, composites/foams, polymers, and metals. Most materials have over 50 properties listed with links to processing and supplier information.

- MMPDS-02 Metallic Materials Properties Development and Standardization volume, which evolved from MIL-HDBK-5J, and contains statistically-derived design allowables for a variety of metallic materials. This database provides a searchable database version of MMPDS-02, in addition to access to the handbook itself. Each database entry provides links to the appropriate pages. The next release, MMPDS-03 is forthcoming.

- MIL-HDBK-17, the database version of the Composite Materials Handbook, which contains graphical and test data for a variety of composites, including polymer and metal matrix composites.

- PMP-Handbook: Preliminary Materials Properties Design Data, which contains aerospace materials, not yet certified for inclusion in MMPDS-02, include graphical data, e.g., stress/strain curves, fatigue cracking, and design data, e.g., physical and mechanical properties of aluminum, titanium, nickel and beryllium alloys.

In addition, the following databases will be added to MAPTIS this year: ESDU Metallic Materials Data Handbook; CAMPUS Plastics Database; IDES Plastics Database; ChemRes Module; and Restricted Substances Database (in development).

ASM Handbooks
Marshall Materials and Processes Laboratory also provides licensed access to the ASM Handbook, Alloy Center and other products on the ASM International website.

Aerospace Structural Metals Handbook
This is a compilation of typical characteristics of metallic alloys for use in aerospace, in a searchable PDF format. It is maintained by the Center for Information, Numerical Data Analysis and Synthesis (CINDAS) at Purdue University, in cooperation with Wright Patterson Air Force Base. Marshall Space Flight Center provides periodic updates.

MAPTIS has been supporting NASA’s design and materials community for over twenty years, and the MAPTIS team looks forward to continued support of new hardware designs and materials research for the next twenty years!
Currently evolving missile designs are moving towards greater pressures, higher aeroheat temperatures, longer duration, increased maneuverability, and additional emphasis on meeting Insensitive Munitions (IM) standards. Higher motor operating pressures and increased missile stiffness, both longitudinal [EI] and torsional [GJ], will require materials and manufacturing processes exhibiting higher specific strength and stiffness than current state-of-the-art steel can provide. The application of innovative metal matrix composite (MMC) manufacturing process technology to solid rocket motors will lead to better performance and greater reliability. MMC motor cases can deliver better performance through an increase in closing speed when compared to metal and composite cases, while maintaining or improving bending stiffness and temperature capabilities. These factors will allow for missile designs with enhanced capability to defeat highly maneuverable air targets of the future.

MMCs consist of a metal matrix reinforced by whiskers, particulates, or fibers. The advantages of MMCs over monolithic metals are higher specific strength and specific stiffness, improved fatigue, and better mechanical properties at elevated temperatures. Touchstone Research Laboratory (Touchstone) has established a process capable of filament winding MMC materials in the production of pressure vessels with support from the Air Force Research Laboratory, Missile Defense Agency, and the Navy under the Small Business Innovation Research (SBIR) program. Since a solid propellant rocket motor case is essentially a pressure vessel, this technology is a good fit for these applications. In recent years, the aerospace industry has been moving towards the use of filament wound composites for manufacturing rocket motor cases. The filament winding process is a method of achieving high-speed, precise lay-down of continuous reinforcement in prescribed patterns. Pressure vessels and other types of containers are routinely produced this way. The process consists of pulling a roving or tow (a bundle of fibers or filaments) through the matrix material in a liquefied form (for example, a resin bath), impregnating or infiltrating the roving material with the matrix material, and “wrapping” the impregnated roving over a mandrel. Filament winding is considered to be a very robust, inexpensive means of creating large, high-fiber-volume composite structures. Some claim that filament winding is the oldest manufacturing process employed in the composites industry.

Despite the tremendous potential of continuous fiber reinforced MMC materials, adoption of MMC technology into applications has been slow for several reasons, including high relative cost, immaturity of production processes, and the lack of a reasonably large production base. Filament winding has been around for decades, but no attempts to filament wind MMCs have ever been made. The confluence of these two diverse technologies, namely a low-cost filament winding process with high-performance MMC materials, can lead to great improvements in the ability to produce affordable MMC structures by driving down costs.

Figure 1. Filament Wound MMC Cylinders.

Figure 2. Filament Wound MMC Pressure Vessel.

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continued on page 15
and improving manufacturing capabilities. Filament winding of MMC cylinders and other shapes can be accomplished in the same manner as described above. The resin, of course, must be replaced with aluminum, and the aluminum must be kept molten. The way in which the infiltrated fiber bundle is laid down and the build-up of plies or layers forms the desired laminate is completely analogous to a polymer composite wet filament winding process (See Figs. 1 and 2).

Materials and systems trade studies have consistently shown benefits to using MMC materials for motor cases. One trade study performed by a solid rocket motor prime contractor on a generic tactical missile showed a potential weight savings of 36% and an increase of 3% in delta velocity for a MMC case compared to the baseline metal case. A second trade study evaluated the potential performance of an advanced technology dual-pulse solid propellant motor design incorporating MMC case material. The MMC case option provided the potential for a 19% increase in idealized sea level delta velocity over that of the currently fielded medium range air to air missile system. Preliminary testing and physics-based modeling have also indicated a potential benefit in the area of IM. IM testing and a static firing of MMC analog cases are being pursued in order to validate these predictions (See Fig. 3). Some of this testing should be completed by the end of FY08.

Significant work remains to mature the capabilities of the current MMC filament winding process towards full-scale manufacturing of solid propellant motor cases. Touchstone will continue to work with the major rocket motor manufacturers in order to maximize the potential of transitioning this technology into the manufacturing sector.

Touchstone is also the developer of CFoam, a lightweight multi-functional carbon foam material, and CStone, a coal-based high density carbon material. For more information on Touchstone Research Laboratory and its technologies, please visit the company’s website at www.trl.com.

Figure 3. Static Firing of a Solid Rocket Motor with MMC Motor Case.

Rocket Motor Electronic Database (RMED)

The Rocket Motor Electronic Database (RMED) combines the assets of CPIAC’s standard solid propulsion reference manuals and other data sources to provide the most comprehensive and versatile source of solid propulsion for rockets, missiles, launch vehicles, jet-assist units, ejection devices, test vehicles, and orbit transfer. RMED contains motors that have been qualified or, in the case of selected development motors, have successfully completed at least one static firing of a flightweight design.

RMED contains the entire unclassified contents of CPIA/M1 and more. Over 400 rocket motor data records can be searched, displayed, and/or printed. RMED also contains unclassified data on motors that have classified performance or propellant characteristics. Users can search the database by Motor Name, Origin, Status, Application, Manufacturer, Motor Measurements, Propellant Characteristics, Hazard Class.

RMED is a limited-distribution product, as prescribed by Department of Defense Directive 5230.24. Access is restricted to U.S. Government organizations and contractors who meet the requirements for receipt of militarily critical technical data and have a current contract registered with the Defense Technical Information Center. For more information and details about eligibility to receive CPIAC products and services, please call (410) 992-7300, ext. 212 or 211, or visit the CPIAC Web site at http://www.cpiac.jhu.edu.

Have you been awarded a Small Business Innovative Research (SBIR) contract for propulsion-related development or design? Write about it and submit it to the CPIAC Bulletin so that we can share your news with our 5500 subscribers! Guidelines are available at http://www.cpiac.jhu.edu/media/SBIR_Guidelines.pdf.

For additional information, contact CPIAC Editor Rosemary Dodds at 410-992-1905, ext. 219, or by e-mail to rdodds@jhu.edu.
Propulsion News Highlights

**Cause of Last Month’s Proton Launch Failure Determined**  

The Russian State Commission investigating the AMC-14 failure of a Proton Breeze M launch has traced the cause to the rupture of the gas duct between the gas generator and the propellant pump turbine in the Breeze M main engine. This led to the Breeze M upper stage engine shutting down 2 minutes before the end of the second Breeze M burn on March 15. As a precaution, the AMC-14 satellite payload was released into a lower-than-planned orbit. Owner SES AMERICOM announced that it is declaring AMC-14 a total loss. The mission was managed by International Launch Services (ILS), which markets commercial missions on the Proton vehicle. The Russian investigative commission said that the most probable cause of the gas duct rupture was due to the combined effects of duct wall erosion, high temperatures and prolonged low frequency pressure fluctuation in the duct. The Commission recommended corrective actions to comprehensively address each of the contributing factors. Khrunichev, which manufactures both the Proton 3-stage booster and the Breeze M upper stage, was further directed to perform corrective action to improve the reliability of the Breeze M main engine. These corrective actions must be taken before the Breeze M can be returned to flight, according to Russian procedure. Full press release: [http://www.spaceflightnow.com/proton/amc14/080421report.html](http://www.spaceflightnow.com/proton/amc14/080421report.html).

**SPACEX Conducts First Three-Engine Firing of Falcon 9 Rocket**  
Source: SpaceX, 29 Mar. 2008

Space Exploration Technologies Corp. (SpaceX) conducted the first three-engine firing of its Falcon 9 medium to heavy lift rocket at its Texas Test Facility outside McGregor, on March 8, 2008. At full power the engines generated over 270,000 pounds of force, and consumed 1,050 lbs of fuel and liquid oxygen per second. This three-engine test again sets the record as the most powerful test yet on the towering 235-foot tall test stand. A total of nine Merlin 1C engines will power the Falcon 9 rocket. The test series continues with the addition of two engines for a total of five, then finally the full complement of nine engines. With all engines firing, the Falcon 9 can generate over one million pounds of thrust in vacuum - four times the maximum thrust of a 747 aircraft. Full press release: [http://spacex.com/press.php?page=40](http://spacex.com/press.php?page=40).

**XCOR to Unveil New Suborbital Rocketship**  
Source: Space.com, 26 Mar. 2008

XCOR Aerospace, of Mojave, Calif., is expected to unveil plans today for a new entry in the suborbital spaceship business — a rocket-powered space plane to be known as the Lynx. The Lynx is being designed to carry a pilot and a passenger or payload on flights into suborbital space. Company officials are eyeing 2010 as the date for the inaugural launch of the vehicle. Lynx is roughly the size of a small private airplane. It would be capable of flying several times a day making use of reusable, nontoxic engines to help keep the space plane’s operating costs low, according to company officials XCOR officials hope to obtain some funding from the Air Vehicles Directorate of the Air Force Research Laboratory (AFRL) at Wright-Patterson Air Force Base in Ohio to showcase the operationally responsive attributes of Lynx. That Small Business Innovation Research Phase II award is, however, pending successful contract negotiations and sign off by the Government Contracting Officer. Full press release: [http://www.space.com/news/080326-xcor-lynx-spaceplane.html](http://www.space.com/news/080326-xcor-lynx-spaceplane.html).

These excerpts have been taken from press releases approved for public release.
Distinguished JANNAF member and former JANNAF Executive Committee Chair Parker L. Buckley retired in February as Chief of the Aerospace Propulsion Division in the U.S. Air Force Research Laboratory’s (AFRL) Propulsion Directorate at Wright-Patterson Air Force Base. Prior to his retirement he contributed technically to the early development, and was ultimately responsible for the current development, of ramjet and scramjet propulsion technology and the integration of these cycles into future combined cycle engines.

Parker graduated in 1972 from the University of Cincinnati with a Bachelor of Science degree in Aerospace Engineering. After taking time to earn his pilot’s wings in the Ohio Air National Guard, he joined the (then) Air Force Aero Propulsion Laboratory team in January 1974. One of his first duties was to help with installation of the ramjet thrust stand in Research Cell 18, still in regular use. As a junior engineer, he provided analysis and test support for the Advanced Strategic Air Launched Missile Program. In 1981, he earned a Master of Science degree in Mechanical Engineering from the University of Dayton. Following this, he opened up a new area of research, leading development of swirl combustion systems for compact ramjet engines. In 1986, Parker was selected for a position with the Aeronautical Research Laboratory in Melbourne, Australia, under the Air Force Scientist and Engineer Exchange Program, where he developed a gas generator for ducted rocket research. Upon his return in 1988, he further developed this work into an important research capability in the Propulsion Directorate, enabling a new era of ducted rocket combustor development.

Parker was selected as deputy of the Advanced Propulsion Division in 1995. While in this capacity, he worked with the division chief to establish the HyTech hypersonic technology program as the Air Force follow-on to the National Aerospace Plane. With the formation of the AFRL in 1997, he was named deputy of a new division split between Edwards AFB and Wright-Patterson AFB. In this capacity, Parker was responsible for the division’s high speed air breathing propulsion activities. He was selected by the director to form the new Aerospace Propulsion Office in October 2000. While leading this office, he and his team established a cooperative agreement with NASA to fly the Air Force HyTech scramjet engine on the NASA X-43C vehicle. In February 2003, the Aerospace Propulsion Office grew its programs and support under Parker’s guidance to become a regular line division of the Propulsion Directorate. In 2004, NASA cancelled the X-43C program, but Parker and his team were ready with the X-51 program. This effort is now the flagship Air Force hypersonic flight demonstration and research program. After 34 years of service, he leaves the Aerospace Propulsion Division on firm footing and looking forward to bright futures.

Parker’s leadership was evident not only at AFRL, but within the JANNAF community as well. He was an active contributor to the JANNAF Ramjet Subcommittee (which was renamed the Airbreathing Propulsion Subcommittee in 1989) from 1988-1996 as a technical member of the Engine Test and Validation Panel. He coauthored 16 JANNAF technical papers from 1976 to 1993 and became chairman of the APS Technical Steering Group in 1997, helping to guide the subcommittee and its panel activities. He was also selected as an AF member on the JANNAF Executive Committee, serving in this capacity and as the APS Liaison, from 1997 until his retirement. Parker fulfilled the role of Chair of the JANNAF Executive Committee from 2005-2006. He was a leading supporter of the nascent JANNAF Journal of Propulsion and Energetics and continues to serve as a member of its Editorial Advisory Board.

Parker retired as a Lieutenant Colonel from the Ohio Air National Guard in 1994. He is a Command Pilot with 3,000 hours in KC-97 and KC-135 tanker aircraft. JANNAF and the Airbreathing Propulsion Subcommittee and its technical community are better for his involvement and contributions. Parker was always a pleasure to work with, whether technically in the early years or when he enabled the contributions of others as his own managerial responsibilities increased. All of us at CPIAC wish him the best in his future endeavors, be they enhancing the interests of the U.S. Propulsion Community or just running the wheels off his vacation trailer in cross-country jaunts.
Calendar of 2008 JANNAF Meetings and Events

55th JANNAF Propulsion Meeting/42nd Combustion Subcommittee/30th Airbreathing Propulsion Subcommittee/30th Exhaust Plume Technology Subcommittee/
24th Propulsion Systems Hazards Subcommittee/12th SPIRITS Users Group

Date: May 12-16, 2008
Boston Marriott Newton, Newton, MA and Hanscom AFB
Ph. 617-969-1000/800-228-9290 (Refer to JANNAF Meeting)

JANNAF 6th Modeling and Simulation Subcommittee (MSS)/4th Liquid Propulsion Subcommittee (LPS)/3rd Spacecraft Propulsion Subcommittee (SPS) Joint Meeting

Date: December 8-12, 2008
Abstract Deadline: July 7, 2008
Paper/Presentation/ Paper Clearance Deadline: November 3, 2008
Hilton Walt Disney World; Orlando, FL
Ph. 407-827-4000/800-782-4414 (Refer to JANNAF Meeting)
Hotel Reservation Deadline: November 17, 2008
Reg. Forms due at CPIAC by: November 24, 2008

For additional information on the above JANNAF meetings, contact CPIAC
Meeting Planners Pat Szybist or Krystle Jones at 410-992-7302, ext. 215, or 410-992-7301, respectively, or by e-mail to pats@jhu.edu or kjones@jhu.edu.

Visit the JANNAF Web site at www.jannaf.org for meeting updates.

Policy on Non-Government Attendees at JANNAF Meetings. Attendance at JANNAF meetings for non-government employees is restricted to U.S. citizens only and whose organizations are 1) registered with the Defense Logistics Information Service (DLIS) AND 2) have a government contract registered with the Defense Technical Information Center (DTIC). If the government contract is not registered with DTIC, the attendee’s registration form can be certified by a sponsoring government official from one of the participating JANNAF agencies. Additional information concerning registrations with DLIS and DTIC can be obtained by contacting DLIS at 1-800-352-3572 (www.dlis.dla.mil/jcp/) or DTIC at 1-800-225-3842 (www.dtic.mil/dtic/registration/index.html).

AIAA SRTC 2008 Short Course
“Advanced Solid Rockets”

A short course will be held directly after the Joint Propulsion Conference in Hartford, Conn., on Thursday and Friday, July 24-25, 2008. Solid propulsion is vital to tactical, space, strategic and launch vehicles. The course examines fundamental and advanced concepts related to solid rockets. Theoretical and practical aspects of the field are covered. This course is based on the “Advanced Solid Rocket Propulsion” graduate-level mechanical engineering course taught at the University of Alabama at Huntsville (UAH). All instructors are experienced solid rocket experts and many were involved with the UAH course taught in the spring of 2007 and 2008. The individual presentations included in this short course include broad rocket motor and system design principles, internal ballistics modeling, propellant fundamentals, component design (motor case, nozzle, and igniters), component and motor manufacturing, combustion instability, and motor failures.

This course is ideal for those involved in solid rocket motor design (especially those relatively new to the field), or those managing solid rocket motor programs who want a deeper insight into the design and manufacturing issues with solid rocket motors.

To register for this course, contact Ms. Airron Jordan at airronj@aiaa.org, or register online at https://aiaa.org/content.cfm?pageid=161&viewpd=register&lumeetingid=1725.