It takes several years to develop, test, qualify, and field state-of-the-art weapon system technologies. It can take ten years or more to field a new explosive or propellant. By the time a new energetic is ready for fielding, the original requirement or threat it was developed for has passed. This is unacceptable, especially in a time of national conflict. The rapid development of energetics technologies, as well as the critical and essential acquisitions for timely fielding, have become more challenging within the Department of Defense (DoD). The DoD Ordnance Technology Consortium (DOTC) has embraced innovative processes, making use of a Section 845 Other Transaction Agreement (OTA) for the purpose of conducting research and development leading to technology demonstrations. DOTC’s goal is to assure DoD Services that they will receive rapid and agile acquisitions and to provide United States soldiers with timely solutions to their warfighting needs.

DOTC was established in 1999 and became a DoD initiative commissioned by The Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD AT&L) in 2002 for voluntary use by all Service munitions laboratories, Defense Agencies and the Special Operations Command (SOCOM). The DOTC Charter established the organization as the DoD focal point for ordnance system technologies with particular focus on explosives, propellants, pyrotechnics, warheads, fuzing/sensors, demilitarization, Joint Insensitive Munitions Technology Programs (JIMTP) and applicable enabling technologies. DOTC includes the National Warheads and Energetics Consortium (NWEC) to bring the resources of over 120 industry, academia, and non-profit organizations to bear on the lethality and energetic challenges of the U.S. Armed Forces. The DOTC

Electric Propulsion Activities at the NASA Glenn Research Center

By Michael J. Patterson, Senior Technologist, In-Space Propulsion, NASA GRC, and Hani Kamhawi, Propulsion Engineer, Propulsion and Propellants Branch, NASA GRC

NASA’s Glenn Research Center (GRC) has a long history of electric propulsion (EP) research and development activities, starting with the invention of the ion engine in 1958. Past NASA GRC research and development activities included work to advance the Technology Readiness Level (TRL) of electrothermal (resistojet and arcjets), electromagnetic (magnetoplasmadynamic and pulsed plasma), and electrostatic (ion and Hall) electric thrusters. In addition, NASA GRC has 16 major vacuum facilities for EP testing, including the largest facility and the highest pumping speed facility. Recent EP activities have been focused on advanced ion propulsion system and Hall thruster technology development to support future NASA missions and other national objectives.

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 programs, 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

- Thermal Decomposition Kinetics of HNS (Req. 26275)
- Generation of Oxygen or Other Oxidizing Gas Using Solid Propellants (Req. 26303)
- EPDM Burning Rate and Thermal Properties (Req. 26330)
- Current Thinking on GAP Usage in Propellants and Explosives (Req. 26333)
- Monopropellant AF-M315 Material compatibility (Req. 26337)
- Wound Elastomeric Insulation Manufacturing Processes and Materials Tested (Req. 26341)

BIBLIOGRAPHIC INQUIRIES

- Broad, Distribution A PIRS Search on “hyperciglic ignition” and “gel propellant” (Req. 26361)
- High Burn Rate Solid Propellant Technology for Composite and Double Base Propellants (Req. 26488)
- STANAG 4493 on IM Testing (Req. 26510)
- Aluminide Coating of Columbium/Niobium (Req. 26535)

Looking for an opportunity to share news of your work and accomplishments?

Write a technical article and submit it to the Bulletin.
We’ll share it with our readers.

For more information, e-mail bulletin@cpiac.jhu.edu.
Meeting Reminders

JANNAF
43rd Combustion/
31st Airbreathing Propulsion/
25th Propulsion Systems Hazards
Joint Subcommittee Meeting

December 7-11, 2009
La Jolla, CA

The Joint Army-Navy-NASA-Air Force (JANNAF) 43rd Combustion/31st Airbreathing Propulsion/25th Propulsion Systems Hazards Joint Subcommittee Meeting will be held December 7-11, 2009 in La Jolla, California. Unclassified sessions will be conducted at the Hyatt Regency La Jolla at Aventine; classified sessions will be held at the Naval Fleet Intelligence Training Center in San Diego.

CPIAC distributed the Meeting Announcement and Call for Papers in March. Abstracts were due May 25; proposals for workshops were due June 8. The Preliminary Program will be distributed the week of August 31.

For a full description of the hotel’s available amenities, visit www.lajolla.hyatt.com. Room rates for this JANNAF meeting are $139 for government and $209 for industry attendees.

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.

Please contact Patricia Szybist at pats@jhu.edu or 410-992-7302, ext. 215, if you require additional information, or if you did not receive the Meeting Announcement and Call for Papers.

The Bulletin Board

Various propulsion-related meetings are listed below. If you know of an event that may be of interest to the propulsion community, please forward the details to bulletin@cpiac.jhu.edu. Additional industry meetings are posted on the CPIAC Web site, Meetings & Symposia: http://www.cpiac.jhu.edu/templates/cppiacTemplate/meetings/. The JANNAF Calendar appears on the back page.

22nd International Colloquium on the Dynamics of Explosions and Reactive Systems (ICDERS)
27-31 July 2009
Minsk, Belarus
POC: www.icders2009.com

45th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit
2-5 August 2009
Denver, Colorado
POC: www.aiaa.org

36th International Pyrotechnics Seminar
22-28 August 2009
Rotterdam, The Netherlands
POC: www.intlpyro.org/

7th International Workshop on Structural Health Monitoring 2009
9-11 September 2009
Stanford University, Stanford, CA
POC: http://young-sacl.stanford.edu/member.php

2009 International Autumn Seminar on Propellants, Explosives and Propellants
22-25 September 2009
Kunming, Yunnan, China
POC: http://www.iaspep.com.cn

6th International Symposium on Beamed Energy Propulsion
1-5 November 2009
Scottsdale, Arizona

8th International Symposium on Special Topics in Chemical Propulsion
2-6 November 2009
Cape Town, South Africa
POC: Prof. Ken Kuo at kenkuo@psu.edu, or call (1-814) 863-6270

AVT-176 Symposium on Advances in Service Life Determination and Health Monitoring of Munitions
April/May 2010
Turkey
POC: Dr. Gregory A. Ruderman at gregory.ruderman@us.af.mil or Sandra Cheyne at cheynes@rta.nato.int
ABSTRACTS STILL BEING ACCEPTED
Ion Propulsion Technology Development

One of the focus areas for NASA GRC is the development of NASA’s Evolutionary Xenon Thruster (NEXT) ion propulsion system (IPS). The objective of the NEXT project is to advance next generation ion propulsion technology to NASA TRL 6, and play a major role in its infusion into a flight mission. This project is sponsored by NASA’s Science Mission Directorate (SMD), conducted under the In-Space Propulsion Technology Program (ISPT). NEXT was implemented through a competitively selected NASA Research Announcement (NRA) awarded in 2002 with the first phase completed in August 2003. The second phase of the project was initiated in October 2003 and will be essentially completed by the end of calendar year 2009 with all subsystems at TRL 6. The maturity of the NEXT IPS hardware is such as to support delivery of flight hardware within 36 months. NEXT project activities in 2010 and beyond will include completion of NEXT technology and flight development documentation, and continued thruster life validation test and modeling.

The NEXT system (depicted in Fig. 1) elements consist of a high performance, 0.5–7 kW ion thruster; a modular, high-efficiency power processor unit (PPU); an advanced xenon propellant management system consisting of a single High Pressure Assembly (HPA) and one Low Pressure Assembly (LPA) per thruster; a lightweight thruster gimbal; and elements of a digital control interface unit (DCIU) which includes software algorithms. This design approach was selected to provide future NASA science missions with the greatest value in mission-performance benefits at a low total development cost.

Table 1. Performance Characteristics of NEXT vs. NSTAR SOA.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>NEXT</th>
<th>NSTAR SOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thruster Power Range, kW</td>
<td>0.5–6.9</td>
<td>0.5–2.3</td>
</tr>
<tr>
<td>Max. Specific Impulse, sec</td>
<td>&gt;4100</td>
<td>&gt;3100</td>
</tr>
<tr>
<td>Max. Thrust, mN</td>
<td>236</td>
<td>92</td>
</tr>
<tr>
<td>Max. Thruster Efficiency</td>
<td>&gt;70%</td>
<td>&gt;61%</td>
</tr>
<tr>
<td>Max. PPU Efficiency</td>
<td>95%</td>
<td>92%</td>
</tr>
<tr>
<td>PPU Specific Mass, kg/kW</td>
<td>4.8</td>
<td>6.0</td>
</tr>
<tr>
<td>PMS Single-String Mass, kg</td>
<td>5.0</td>
<td>11.4</td>
</tr>
<tr>
<td>PMS Unusable Propellant Residual</td>
<td>1.00%</td>
<td>2.40%</td>
</tr>
</tbody>
</table>

The NEXT thruster (shown in Fig. 2) is a 0.54 – 6.9 kW input power, 36-cm-beam-dia. xenon ion thruster with 2-grid ion optics. The beam current at full power of 6.9 kW is 3.52 A. At beginning-of-life (BOL), it has a specific impulse of 4190 s and a maximum thrust of 236 mN, with peak efficiency in excess of 70%. The xenon throughput project requirement is > 300 kg (1.23x10⁷ N-s total impulse), with a 450 kg qualification level. A NEXT thruster undergoing life testing at NASA GRC has to date demonstrated > 22,900 hours of operation, processing over 423 kg of xenon, for a total impulse of 1.60x10⁷ N-s.

The NEXT thruster and other component technologies represent a significant advancement in technology beyond state-of-the-art (SOA) NASA Solar Electric Propulsion Technology Application Readiness (NSTAR) thruster systems. NEXT performance exceeds single or multiple NSTAR thrusters over most of the thruster input power range. Higher efficiency and specific impulse, and lower specific mass reduce the wet propulsion system mass and parts count. The NEXT thruster xenon propellant throughput capability is more than twice NSTAR’s, so fewer thrusters are needed. The NEXT power processor and propellant feed system technologies provide mass and performance benefits when compared to NSTAR. Comparisons of NEXT and SOA NSTAR performance characteristics are listed in Table 1. The NEXT IPS project has also placed particular emphasis on key aspects of IPS development with the intention of avoiding the difficulties experienced by the Dawn mission in transitioning the NSTAR-based technology to an operational ion propulsion system.

continued on page 5
Table 2. Summary of NEXT IPS Mission Benefits.

<table>
<thead>
<tr>
<th>Mission</th>
<th>NEXT Mission Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Discovery- Small Body Missions:</strong></td>
<td></td>
</tr>
<tr>
<td>✓ Near Earth Asteroid Rendezvous</td>
<td>Higher net payload mass with fewer thrusters than NSTAR system</td>
</tr>
<tr>
<td>✓ Vesta-Ceres Rendezvous (Dawn)</td>
<td></td>
</tr>
<tr>
<td>✓ Comet Rendezvous</td>
<td></td>
</tr>
<tr>
<td>✓ Deimos Sample Return</td>
<td></td>
</tr>
<tr>
<td>✓ Wild 2 Perihelion Passage Rendezvous</td>
<td></td>
</tr>
<tr>
<td><strong>New Frontiers:</strong></td>
<td></td>
</tr>
<tr>
<td>✓ Comet Surface Sample Return</td>
<td>Higher net payload mass than NSTAR, with, simpler EP System: 2+1 NEXT vs. 4+1 NSTAR thrusters</td>
</tr>
<tr>
<td>✓ Titan Orbiter</td>
<td></td>
</tr>
<tr>
<td><strong>New Frontiers:</strong></td>
<td>&gt;700 kg entry package with 1+1 NEXT system, potentially within New Frontiers cost cap</td>
</tr>
<tr>
<td>✓ Titan Direct Lander</td>
<td></td>
</tr>
<tr>
<td><strong>Flagship Missions:</strong></td>
<td>&gt; 2400 kg to Saturn Orbit Insertion with 1+1 NEXT system, EGA and Atlas 5 EELV - doubles delivered mass of chemical/JGA approach</td>
</tr>
<tr>
<td>✓ Titan Explorer</td>
<td>&gt; 4000 kg to Saturn Orbit Insertion with 3+1 NEXT system, EGA and Delta IV Heavy</td>
</tr>
<tr>
<td>✓ Neptune Orbiter</td>
<td></td>
</tr>
<tr>
<td>✓ Mars Sample Return</td>
<td></td>
</tr>
<tr>
<td>✓ Venus Sample Return</td>
<td></td>
</tr>
<tr>
<td>✓ New Worlds Observer</td>
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</tbody>
</table>

The NEXT project began with Flagship-class Deep Space Design Reference Missions (a Titan Explorer and Neptune Orbiter, both assuming aero-capture at the destinations) as the “design driver” mission applications. A refocus study was conducted in 2004 to investigate NEXT IPS applications to both Discovery- and New Frontiers-class missions. Several Discovery-class mission studies show that NEXT outperforms SOA NSTAR, yielding higher net payload mass with fewer thrusters. NEXT also was either mission-enhancing (relative to chemical propulsion) or mission-enabling for several New Frontiers- and Flagship-class studies. A summary of these findings are listed in Table 2, indicating that NEXT provides mission benefits across all planetary science mission classes. NEXT affords larger delivered payloads and smaller launch vehicle size for Discovery, New Frontiers, Mars Exploration, and Flagship outer-planet exploration missions.

**Hall Thruster Technology Development**

Over the past 16 years, NASA GRC has been engaging in Hall thruster testing, research, and development. Starting in the early 1990s, NASA GRC evaluated the performance and characterized the plume of Russian Hall thrusters, including the SPT-100 and SPT-140. Starting in 1996, NASA GRC began researching and developing Hall thrusters for implementation in various NASA missions. The research activities included testing of alternate propellants and optimization of thruster configurations and magnetic topology for low and high power operation. During the time period from 1996 to 2005, and under the support of various programs, NASA GRC demonstrated various thrusters to TRL 3. Hall thruster development included the NASA-120M-v3 (2 kW), the NASA-173M-v2 (5 kW), the NASA-457M-v1/v2 (50 kW), the NASA-400M (50 kW), and the NASA-300M (20 kW). An image of the NASA-457M thruster undergoing testing is shown in Fig. 3.

In 2003, NASA GRC won an NRA award to develop a Hall thruster for implementation in future cost-capped NASA science missions through the High Voltage Hall Accelerator (HIVHAC) task. The HIVHAC task is being supported by NASA’s SMD ISPT Program. The goal is to design, verify, and validate a thruster capable of operating at power levels ranging from 300 W up to 3500 W while providing specific impulses up to 2800 s and a xenon propellant throughput capability of over 300 kg. During the first phase of the NRA, NASA GRC and Aerojet designed, built, and tested the NASA-77M. The NASA-77M demonstrated the performance levels and throttle-ability that is required for NASA science missions but was not designed to have the lifetime required

![Image of the NASA-457M thruster undergoing performance testing at NASA GRC.](image-url)
for these missions. To demonstrate the lifetime capability required for NASA missions, the NASA-103M.XL was designed and built. It incorporates a life-extending discharge channel innovation that meets NASA Discovery’s mission throughput requirements while having performance levels that enable NASA missions. The NASA-103M.XL was operated at a discharge voltage of 700 volts for over 4800 hours, demonstrating a xenon throughput of over 100 kg. The long duration test successfully demonstrated the life-extending innovation and the HIVHAC task transitioned to the development of a 3.5 kW engineering model (EM) thruster. In December of 2007, a contract was initiated with Aerojet to design and fabricate two HIVHAC EM 3.5 kW thrusters that incorporate the life-extending innovation. The EM thruster design has completed the preliminary design review process, and its parts and pieces have been manufactured. Thruster assembly is scheduled for August of 2009; functional performance and environmental testing of the EM thruster will be started thereafter. A 3-D model of the HIVHAC thruster is shown in Fig. 4. Upon completion of all tests, one EM thruster will be entered into a long-duration test to demonstrate capability for NASA missions. Finally, NASA GRC is also working with the Busek Company to modify the Busek’s BHT-600 (600 W) thruster to incorporate the life-extending innovation. The goal is to extend the 600 W thruster’s throughput capability for implementation in proposed NASA missions employing a radioisotope power system.

**Recent Flight Project Activities**

NASA GRC has been a major participant in a number of EP flight projects and has made major contribution to the success of the EP propulsion systems. These flight projects include:

- **Deep Space 1** – NASA GRC developed the thruster and power processor technology, and managed the flight hardware build for these subsystems for the single string primary ion propulsion system used on the Deep Space 1 spacecraft.

- **International Space Station Plasma Contactor** – A plasma contactor system is used on the International Space Station (ISS) to eliminate/mitigate damaging interactions with the space environment. The system represents a dual-use technology which is a direct outgrowth of the NASA electric propulsion program and, in particular, the technology development efforts on ion thruster systems. The plasma contactor includes a hollow cathode assembly manufactured by NASA GRC. The first two plasma contactor systems were delivered to ISS in October 2000 by the crew of STS-92. To date, both HCAs aboard ISS have operated flawlessly, accumulating more than 15,000 hours of operation combined. NASA GRC continues to support ISS plasma contactor operations, including analysis of on-orbit data and acceptance testing of flight contactor systems.

- **Earth Observing 1** – NASA GRC and the Primex Aerospace Company jointly developed the pulsed plasma thruster (PPT) for the New Millennium EO-1 flight demonstration technology experiment.

- **Dawn** – NASA GRC participation included providing support for design reviews of the thruster and other subsystems, Dawn project reviews, and fabrication of thruster flight hardware including ion optics hydro-forming and manufacturing of cathode heaters.

For more information on the electric propulsion activities at NASA GRC, please contact Michael J. Patterson by e-mail to Michael.J.Patterson@nasa.gov.
Government organization consists of the 14 munitions laboratories in the Department of Defense and the Department of Energy. The current Program Director of DOTC is Mr. Donald A. Geiss Jr. Through this unique government/industry/academia joint munitions organization, there are increased efficiencies in the acquisition process and new and expanded collaborations which enhance the development of state-of-the-art weapons-related technologies and leverage the resources of all the partners.

The leveraging of resources, facilities, programs, and people provides for a high return on investment and information sharing, allowing government/industry/academia to focus on advancing our military technological superiority. Examples of joint munitions program technologies include the following:

- High fidelity physics-based computational codes
- Statistical code suites for system lifetime reliability prediction
- New energetic materials and processing technologies
- High performance linear shape charge warhead technology
- Triggered vacuum switches for advanced fuzing and firing systems

DOTC has recently begun preparing the 2010 Annual Technology Plan. The plan should be finalized this month and released in August 2009.

The Quick Reference Guide, on right, provides a summary of DOTC. For more detailed information and instructions on how to use DOTC, visit the following Web site: www.nwec-dotc.org.

**DOTC Quick Reference Guide**

- **National Warheads & Energetics Consortium (NWEC) Members**
  NWEC Members (over 120 industry and academia organizations) are listed on the Web site. Confirm that defense contractors of interest are listed as NWEC members. If a defense contractor of interest is not listed as a NWEC member, they can join for a one-time fee of $500. Instructions are provided on the Web site.

- **Communication**
  DOTC is a consortium made up of world class experts for the (8) technology areas included in its charter. The key to DOTC success is maintaining open lines of communication and to promote collaboration between Government labs as well as the formation of innovative government/industry/academia partnerships.

- **Annual Technology Plan (starts the yearly process)**
  - Review Annual Technology Plan. Ensure that the technology requirements and POC/alternate POC are properly listed. If not, e-mail updates to Ms. Tabitha Chase by COB the specified deadline.
  - Attend Technology Subcommittee Meetings, typically held in May of each year (schedule listed on Web site), to review good ideas and collaborate with industry and academia for future requirements.

- **White Paper**
  - An annual Request for Ordnance Technology Initiatives is derived from the Annual Technology Plan. The first step in the process is for the NWEC member to provide White Papers. NWEC members can not submit a proposal if they do not first submit a White Paper. White Paper feedback is required to provide the contractor with an honest assessment of the proposed ideas and further guidance for proposal submission.

- **Funding**
  - Initiatives can be funded anytime after an acceptable White Paper is received. RDT&E type funding is preferred. Using other sources of funding, other than RDT&E, will require justification.
  - Funding will be shown as “obligated and dispersed” once received by the DOTC office.
  - Detailed Funding Instructions are listed on the Web site.

- **Evaluation of Proposed Technical Solutions**
  - Timely and thorough technical evaluations allow for a streamlined source selection and award process.
  - Mandatory Source Selection Training required each year prior to source selection evaluations.
  - Unfunded proposals can be placed in a “basket” and may be pulled out and funded anytime within 3 years.

- **Statement of Work (SOW)**
  - SOWs awarded through DOTC include research and development through low rate initial production LRIP for prototype demonstration
  - Government representatives may choose to accept the SOW as proposed by the NWEC member or provide a specific government-formatted SOW that better meets Initiative requirements. As required, SOWs will need Safety, Environmental and Security concurrences.

- **Initiative Execution**
  - The Agreement Officer Representative (AOR) for each Initiative is responsible for monitoring the effort and approving completion of milestones.
Over the last few months, there has been increasing interest in property measurements taken and the subsequent Equation of State and Transport properties models (REFPROP) created by the National Institute for Standards and Technology (NIST) for RP-1 and RP-2 rocket grade kerosene. At the Joint NIST/AFRL Workshop on Rocket Propellants in September 2008 and again at the Joint LPS Hydrocarbon Fuels and APS Airbreathing Fuels Panel meeting in December 2008, questions were raised about the compositional variability of RP as produced, compared to the single cuts of RP-1 and RP-2 that were measured and characterized by NIST. This variability has raised concerns about the performance of launch vehicles in the recent past and has been shown to impact the cooling performance of RP greatly when subjected to conditions typical of those expected in hypersonic or advanced reusable liquid rocket engine applications.

On June 9th, 18 individuals representing Air Force Research Laboratory (AFRL), Defense Energy Support Center (DESC), National Aeronautics and Space Administration (NASA), Aerojet, Pratt & Whitney Rocketdyne (PWR), United Technologies Research Center (UTRC), Orbital Sciences, The Aerospace Corporation, and the Chemical Propulsion Information and Analysis Center (CPIAC) met with representatives of Johann Haltermann Ltd. at their facilities in Houston, Texas, to discuss Haltermann’s operations with respect to the production of RP-1 and RP-2. Key topics of interest revolved around potential sources of compositional variability for RP as well as areas where the specification might allow for poor or limited characterization of this variability.

RP-1 and RP-2 are produced by Haltermann in a pure blending process which involves no chemical reactions between any of the ingredients. The ingredients, called feedstocks, are commercially available products which, when blended correctly, result in RP-1 or RP-2. Haltermann currently has three robust recipes for RP-1 using feedstocks from three suppliers and two recipes for RP-2, only one of which Haltermann currently considers a robust route to RP-2 production. Multiple production routes are desirable to Haltermann so that in the event that a feedstock becomes unavailable due to unforeseen circumstances, such as hurricane activity or other supplier interruptions, the production of in-spec blends of RP-1 or RP-2 is still possible. This means that in the event that a feedstock supply becomes scarce or if the composition of a particular feedstock changes, then changes in the composition of RP should be expected. This type of variability is inherent in a blended fuel with a specification that only specifies bulk fluid properties. It should be noted however that Haltermann is comfortable with the current recipe for RP-1 and will be unlikely to switch to an alternate recipe unless forced to do so by supply constraints. All of the feedstock suppliers are U.S.-based companies and Haltermann does not anticipate interruptions in supply.

For the last 18 months, the same recipe for RP-1 has been consistently used (a recipe that is essentially the same as for the production of RP-2, Haltermann noted) and the compositional variability of each batch is expected to be minimal, however, Haltermann does not continuously check the composition of the ingredients of RP, instead relying on target properties from the RP specification such as density, flash point, and particulates during production and analytical characterization by an outside laboratory to guarantee the
finished product is within specification. Approximately 2 years ago, one specific issue with RP-1 variability occurred when a “low” density batch was produced. This particular batch of RP-1 was within the MIL-DTL for RP but had a significantly lower density than the historical trend for RP-1. Haltermann was not previously aware that density was such a sensitive issue and while they cannot guarantee a specific density, they are currently pursuing production that leads to the historically provided RP-1 density.

Haltermann has agreed to create hand blends of each of the three recipes for RP-1 and provide them to AFRL for compositional analysis and testing, this will give the RP user community insight into the potential variability of RP-1 in the future as well as assist the Hydrocarbon Fuels Panel in determining accuracy of the RP-1 REFPROP model in predicting fuel properties.

A discussion on whether the density range for RP-1 and RP-2 should be tightened revolved around needs/impact to the user community and whether it would drive up the cost of RP-1. Haltermann was not able to speculate on the cost increases which might result from a tightened specification. Other potential spec changes were generally discussed including possible new testing methods which would be more accurate and repeatable than those that are currently required in the RP MIL spec. A review of these testing methods to determine whether the current accuracies are sufficient for the specified target property ranges is in order. In addition, for future hydrocarbon fuels it may be advantageous to more selectively specify the composition of the fuel. Currently, the percentage by volume of Aromatics and Olefins is specified, a future fuel specification may, in addition to a total percentage by volume maximum of a chemical class, specify volume percentages of functional groups such as Iso-alkanes, n-alkanes, 1-ring cycloalkanes, etc. The hydrocarbon fuels community needs to determine which specific functional groups are advantageous to performance in order to create a more compositionally descriptive specification. Haltermann is capable in principle of producing fuels to this type of compositionally constrained specification and could produce custom blends with which parametric studies on the effect of functional groups on engine performance can be performed.

The visit to Haltermann was a successful exchange of information between the producers and users of RP-1 and RP-2. Based on the interaction at the meeting, continued successful cooperation between Haltermann and the JANNAF community is expected.

<table>
<thead>
<tr>
<th>Course</th>
<th>Location</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Nitrogen Handlers Course</td>
<td>NASA Wallops Flight Facility NASA OHP Training (See contact info below)</td>
<td>July 9th 2009</td>
</tr>
<tr>
<td>Flexible Hose Safety</td>
<td>NASA Stennis Space Center NASA OHP Training</td>
<td>July 23rd 2009</td>
</tr>
<tr>
<td>SPIRITS Training Course</td>
<td>Aerodyne Research, Inc. <a href="mailto:jconant@aerodyne.com">jconant@aerodyne.com</a></td>
<td>July/Aug. 2009 – TBD</td>
</tr>
<tr>
<td>Cryogenics Safety</td>
<td>NASA Plum Brook Station NASA Glenn Research Center NASA OHP Training</td>
<td>Aug. 4-5th 2009  Aug. 6-7th 2009</td>
</tr>
<tr>
<td>Range Safety Orientation</td>
<td>NASA Kennedy Space Flight Center NASA OHP Training</td>
<td>Sep. 2-3rd 2009</td>
</tr>
<tr>
<td>Hybrid Rocket Propulsion</td>
<td>AIAA Course, Denver CO <a href="http://www.aiaa.org/">http://www.aiaa.org/</a></td>
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<td>Air Breathing Propulsion Design</td>
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<td>Aug. 6-7th 2009</td>
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<tr>
<td>Space Mission Structures: From Concept to Launch</td>
<td>ATI Courses, Beltsville, MD <a href="http://www.ATIcourses.com">http://www.ATIcourses.com</a></td>
<td>Sep. 14-17th 2009</td>
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</tbody>
</table>
The Propulsion Training Calendar is published biannually. If your organization sponsors a course offering that you would like to publicize, please send an e-mail with course information, points of contact and the dates of the event to bulletin@cpiac.jhu.edu.

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<td>The University of Tennessee Space Institute; Tullahoma, TN</td>
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NASA OHP training courses are available to employees operating at NASA Centers. For more information, call (281) 244-1278 or go to [http://ohp.nasa.gov/training/](http://ohp.nasa.gov/training/).

NASA Engineering & Safety Center (NESC) Academy courses are available to any ITAR compliant US government or contractor organization. For more information go to [http://www.nescacademy.org](http://www.nescacademy.org)

The Propulsion Training Calendar is published biannually. If your organization sponsors a course offering that you would like to publicize, please send an e-mail with course information, points of contact and the dates of the event to bulletin@cpiac.jhu.edu.

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**New Data on AF-M315E Propellant Added to CPIAC’s Liquid Propellants and Fuels Database**

As of March 2009, new recommended properties have been established for the development of propellant AF-M315E. Improved values include heat of combustion, viscosity, coefficient of thermal expansion, surface tension, thermal conductivity, heat capacity, and electrical conductivity. In addition, toxicology and hazards information have been updated. New data for this propellant has been provided and reviewed by the U.S. Air Force Research Laboratory at Edwards Air Force Base and is available now through the Liquid Propellants and Fuels Database (LPFD).

For information on accessing LPFD, please contact Lisa Nance at lnance@cpiac.jhu.edu. The information contained in LPFD is for U.S. Government agencies and their U.S. contractors only.
IHPRPT Phase II Demonstration Motor Static Test conducted December 12, 2008 at the ATK Space Systems, T-6 Test Facility, Promontory, Utah.
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People in Propulsion

Wisconsin Students Win 7th Annual Team America Rocketry Challenge (TARC)

A team from Madison West High School in Madison, Wis., took first place at the seventh annual Team America Rocketry Challenge (TARC) on May 16, beating out about 7,000 middle- and high school-aged students who made up hundreds of teams from 45 states and the District of Columbia. Festus High School from Festus, Mo., took second place while New Site High School from New Site, Miss., placed third.

For the competition, teams were asked to design, build, and launch a model rocket to the altitude of 750 feet with a flight time of 45 seconds, carrying a raw-egg payload. The egg had to return to earth unbroken in order for the launch to qualify. Scores were based upon deviations from the altitude and flight time requirements, so the lower the score, the better. The Madison team, made up of four high school juniors, scored 20.54, the Festus team scored 25.92, and the New Site team scored 36.3.

Madison team member Ben Winokur said, “Hard work, perseverance, teamwork, and custom electronics are the reasons our rocket performed well today.” He also added that a key component to the rocket’s success was, “a very intricate active parachute ejection on ascent.”

The Madison team’s win earned them an opportunity to compete against the winners of the UK Aerospace Youth Rocketry Challenge from Royal Liberty School in Essex; a trip to the International Paris Air Show in June, sponsored by Raytheon; and a share in a prize pool of more than $60,000. Lockheed Martin provided the top three teams with $5,000 scholarships. Teams also will receive an invitation from NASA to participate in its Student Launch Initiative, an advanced rocketry program. Other sponsors include the Defense Department, the American Association of Physics Teachers and 34 AIA member companies.

The Team America Rocketry Challenge was created by the Aerospace Industries Association (AIA) in 2003 to celebrate the centennial of flight and to generate interest in aerospace careers among young people, as 60 percent of the aerospace workforce is 45 or older, according to AIA statistics. But, despite the challenging economic times, the aerospace and defense sector is still hiring technical talent to replace the baby boomer generation as they start to retire.

The winning team was one of three participating teams from Madison West High School. The members of the winning team were Jacqui German, Tenzin Sonam, John Schoech and Ben Winokur. Their mentor is Dr. Pavel Pinkas, an engineer, and their teacher is Chris Hager, who teaches biology. The team raised money for the trip to the finals in the low-tech manner of raking leaves.

Competition results, images, and video are available at http://www.rocketcontest.org.

This article was excerpted from an AIA press release, dated May 16, 2009, and reprinted with permission.
Calendar of JANNAF Meetings

JANNAF 43rd Combustion Subcommittee (CS)/
31st Airbreathing Propulsion Subcommittee (APS)/
25th Propulsion Systems Hazards Subcommittee (PSHS) Joint Meeting
December 7-11, 2009
Hyatt Regency La Jolla at Aventine; La Jolla, CA
Abstract deadline: past
www.lajolla.hyatt.com

57th JANNAF Propulsion Meeting (JPM)/
7th Modeling and Simulation Subcommittee (MSS)/
5th Liquid Propulsion Subcommittee (LPS)/
4th Spacecraft Propulsion Subcommittee (SPS) Joint Meeting
May 3-7, 2010
Cheyenne Mountain Resort; Colorado Springs, CO
Abstracts deadline: November 16, 2009
www.cheyennemountain.com

For additional information on the above JANNAF meetings, contact CPIAC
Meeting Planner Pat Szybist at 410-992-7302, ext. 215, or by e-mail to pats@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).

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