The Cryogenic Orbital Testbed (CRYOTE) ground test article remains on schedule for vacuum chamber testing in the latter half of 2010. Atlas V launch opportunities are being evaluated for as early as 2012.

The basic CRYOTE concept consists of installing an insulated cryogenic receiver tank inside an EELV Secondary Payload Adapter (ESPA) payload adapter ring, launching as a secondary payload on an Atlas V mission with the receiver tank empty, and then transferring residual liquid hydrogen propellant from the Centaur upper stage into the CRYOTE receiver tank after the primary payload has been deployed. The CRYOTE concept provides a unique, low-cost opportunity to study zero gravity cryogenic fluid transfer and management in a true space environment, with options to be readily evolved into a diverse test platform for thrusters and other advanced space hardware, a secondary payload delivery vehicle, an orbital transfer vehicle, or a robotic servicing platform. A number of future Atlas missions are planned for which the Centaur upper stage will reach orbit with substantial propellant residuals and adequate excess performance to carry CRYOTE and perform these operations. A CRYOTE ground test article has already been fabricated and is being prepared for cryogenic vacuum chamber testing. The current ground test hardware includes a thermodynamic vent system with vapor cooled structure and a cryogenic mass.

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

• Processes and equipment used to manufacture air frames for surface-to-air missiles (Req. 26403)
• Updated Aerojet Atlas V SRM Data (public release) (Req. 26605)
• Ozawa Flame Stability for non-premixed flames (Req. 26653)
• Butane and Pentane Properties (Req. 26721)
• Weapon Application of chlorine trifluoride (CTF) (Req. 26735)

BIBLIOGRAPHIC INQUIRIES

• SRM Explosions Due to Pre-damage (Req. 26886)
• NATO STANAGs - Source and specific interests (Req. 26923)
• 9-DT-NIDA and ORP-2 Energetic Binders (Req. 26950)
• Propellants Containing Ammonia Borane (Borazane) (Req. 26976)

Recent CPIAC Products and Publications


**Meeting Reminders**

**40th Structures and Mechanical Behavior Subcommittee (SMBS)/**

**36th Propellant and Explosives Development and Characterization Subcommittee (PEDCS)/**

**27th Rocket Nozzle Technology Subcommittee (RNTS)/**

**25th Safety and Environmental Protection Subcommittee (SEPS)**

**Joint Meeting**

6-10 December 2010

Buena Vista Palace Hotel

[www.buenavistapalace.com](http://www.buenavistapalace.com)

Orlando, FL

**Abstract Deadline:**

20 June 2010

The Call for Papers and abstract forms can be viewed and downloaded at [https://www2.cpiac.jhu.edu/meetings/dec2010/pages/index.html](https://www2.cpiac.jhu.edu/meetings/dec2010/pages/index.html).

Abstracts will be accepted in electronic form only.

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**The Bulletin Board**

The various propulsion-related meetings listed below may be of interest to the propulsion community. To have your event included, please forward details to bulletin@cpiac.jhu.edu. Additional industry meetings are posted on the CPIAC Web site at [http://www.cpiac.jhu.edu/templates/cpiacTemplate/meetings/](http://www.cpiac.jhu.edu/templates/cpiacTemplate/meetings/). The JANNAF Meeting Calendar appears on the back page.

**37th International Pyrotechnics Seminar**

11-16 July 2010

Grand Junction, CO

POC: [http://www.ipsusa.org/index2.htm](http://www.ipsusa.org/index2.htm)

**34th Department of Defense Explosives Safety Board (DDESB) Seminar**

13-15 July 2010

Portland, Oregon

POC: [www.ddesbseminar.org](http://www.ddesbseminar.org) or e-mail: service@ddesbseminar.org

**46th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit**

25-28 July 2010

Nashville, TN

POC: [http://www.aiaa.org/content.cfm?pageid=230&lumeetingid=2347](http://www.aiaa.org/content.cfm?pageid=230&lumeetingid=2347)

**NDIA Warheads and Ballistics Classified Symposium**

23-28 August 2010

Monterey, California

POC: [http://www.ndia.org/meetings/0480/Pages/default.aspx](http://www.ndia.org/meetings/0480/Pages/default.aspx)

**AIAA SPACE 2010 Conference & Exposition**

30 August - 2 September 2010

Anaheim, California

POC: [http://www.aiaa.org/content.cfm?pageid=230&lumeetingid=2387](http://www.aiaa.org/content.cfm?pageid=230&lumeetingid=2387)

**19th International Shock Interaction Symposium (ISIS 19)**

31 August - 3 September 2010

Moscow, Russia


**MSIAC Workshop on Mitigating the Effects of Shaped Charge Jets, Fragments and Explosively Formed Projectiles**

14 September 2010

Washington, DC

Additional information will be provided at a later date.

**2010 International Conference on High Energetic Materials and Dynamics of Ultrafast Reactive Systems**

4-18 October 2010

On-line conference


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For additional information, contact CPIAC Meeting Planner Pat Szybist at 410-992-7302, ext. 215, or by e-mail to [pats@jhu.edu](mailto:pats@jhu.edu).
gauging system. Additional test elements will likely be added to the ground test article prior to testing, depending on schedule and funding availability. The ground test article is representative of flight hardware, and could likely be made flight worthy with relatively minor structural changes. Some mission planning has begun, and integration options with selected upcoming Atlas missions are being evaluated.

The CRYOTE concept and project was conceived and pioneered by United Launch Alliance (ULA) and Innovative Engineering Solutions (IES) in late 2007 and 2008. As the value of the project became apparent, multiple parties began showing interest throughout late 2008 and 2009. These include Sierra Lobo, Lockheed Martin, multiple NASA Centers, Ball Aerospace, Yetispace, and others. Notably, Sierra Lobo, with funding from NASA, has agreed to provide a Cryo-Tracker™ for the ground and first flight article, the Jet Propulsion Laboratory (JPL) donated surplus flight-qualified titanium tanks to use as receiver tanks, Kennedy Space Center (KSC) funded avionics studies and has agreed to install the multi-layer insulation (MLI) system, and IES has led the initial design effort, designed and coordinated fabrication of the composite structural skirt (built by Scorpius Space Launch Company), and is performing structural and fluid systems assembly of the first test article. A ground test plan is being developed by Yetispace, Huntsville; NASA’s Marshall Space Flight Center (MSFC), KSC, and Glenn Research Center (GRC) have expressed interest in supporting ground vacuum testing of the ground test article. At the time of this writing, assembly of the ground test article at IES facilities is nearly complete, with Cryo-Tracker and structural cooling loops installed, and being readied for shipping to KSC for MLI installation. The first flight article scope is currently being assessed with help from Ball Aerospace, and several spacecraft primes have expressed interest in helping to carry this part of the project forward.

Recent changes in direction of the U.S. space program are likely to favor cryogenic fluid and propulsion systems, as well as require improved methods for extended storage and management of propellants in a zero-g, space environment. CRYOTE serves as an excellent near-term platform for advancing many of the required Cryogenic Fluid Management (CFM) technologies. Key CFM technologies to be demonstrated on early CRYOTE missions include the following: 1) cryogenic tank chilldown and transfer in micro-g, 2) propellant mass gauging, 3) true space evaluation of advanced MLI and sunshield insulation concepts, 4) space demonstration of active propellant management systems such as thermodynamic vent systems, actively cooled tank support structure, and requirements for mixing devices, 5) cryo-coolers, and 6) zero-g cryogenic liquid acquisition devices (LADs or PMDs).

An exciting aspect of the CRYOTE project is the extent to which it can be readily evolved into a number of different testbeds or vehicles, with a variety of useful applications. For initial applications, high performance propulsion is not strictly necessary, even for a fully functional separated CRYOTE, since momentum wheels can be used by the avionics for controlling the vehicle in space. However, with a large fraction of the vehicle volume being a tank of liquid hydrogen, CRYOTE becomes a natural platform on which to employ small, high performance thrusters. Simple, heated hydrogen thrusters, using either electrical or direct solar energy, can theoretically yield specific impulse values greater than that of traditional hydrogen/oxygen chemical propulsion systems, due to the low molecular weight of hydrogen. Good total impulse per unit system mass can also be realized due to the efficient storage of the hydrogen as a low pressure liquid. Electrical or direct solar heating will yield limited power output, but with adequate insulation all that is needed is to match the thrust system usage to the relatively low boiloff rate. This would be suitable for applications where a large orbital change is needed, and days or weeks are available to make this transfer. More advanced thrusters (e.g., ion) could also, of course, be employed. Should traditional bi-propellant thrusters be desirable for

continued on page 5
higher thrust requirements, a relatively small tank of oxygen could be loaded and carried along, or it is conceivable that a future version of CRYOTE could also use liquid oxygen transferred from Centaur, thereby maintaining the highly safe, inert launch characteristics of the baseline CRYOTE concept.

For payload delivery, once an autonomous CRYOTE platform is operational, it is a very easy evolution into a versatile small, secondary payload delivery vehicle. The “backbone” ESPA ring is already designed specifically for carrying multiple small payloads, and as currently envisioned, CRYOTE avionics and hardware will only occupy two of the six available payload ports on the ESPA ring. This leaves the remaining four ports available for experiments or small payloads. With maneuvering capability, the secondary payloads can be transferred to a variety of orbits prior to release, thereby minimizing impact or compromises between primary and secondary payload requirements. Furthermore, each of the secondary payloads could be maneuvered to different orbits prior to release, allowing simultaneous launching of secondary payloads that might otherwise not be compatible. With high performance thrusters and modest weight reduction efforts, CRYOTE could potentially send secondary payloads to very high—or even Earth escape or lunar transfer—trajectories. Another potential advantage of CRYOTE as a small payload delivery system, where performance is less critical, might be the ability to loiter on orbit for days, weeks, or even over a month, prior to maneuvering and deploying its payload.

CRYOTE also has potential as a robotic vehicle. By attaching various robotic devices to spare ESPA ports, CRYOTE could conceivably be used to rendezvous with satellites, make repairs, refuel them, or become a small space “tug” by attaching itself to a space craft and hauling it to new orbits or to the international space station, etc. CRYOTE could also be used to attach to and then de-orbit spacecraft or space debris in a controlled fashion.

In summary, CRYOTE presents a unique opportunity to develop and launch a cryogenic fluid management testbed at a very reasonable cost, and can readily be evolved in a number of directions, useful for space-based fluids and thruster research, small payload delivery, spacecraft servicing, orbital rendezvous and maneuvering, and numerous other applications. Considerable groundwork has been laid, with very modest seed funding and in-kind support, from a number of existing partners and NASA, to develop and demonstrate a ground test article, as well as to start mission planning and design of a flight article. Demonstration of multiple technologies, combined with evolutionary potential, should make this project highly interesting to numerous parties with a stake in space exploration and space operations. Involvement of additional interested parties is being sought to allow “more to be accomplished with less” and help realize the full potential of this concept.

For additional information about the Cryogenic Orbital Testbed (CRYOTE), contact Mark A. Wollen, VP Research and Development, Innovative Engineering Solutions, by e-mail to mwollen@iesnet.com.

Have an article that you would like to publish in the Bulletin? Submit it to bulletin@cpiac.jhu.edu.
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First discovered in 1818, hydrogen peroxide was mainly used for medicinal purposes at low concentrations (3%). Following growth in manufacturing for use in the paper pulp and textile industries at moderate concentrations (27.5-35%) during the mid to late 1800s, high-concentration hydrogen peroxide, or High-Test Peroxide (HTP) as it is commonly referred to when concentrations exceed 70%, began to be used for numerous propulsion and power applications in 1935. Historically, HTP has been of interest primarily for its lack of high toxicity, as compared to other alternatives such as nitrogen tetroxide, which can help to improve the operability characteristics of a given system design while reducing operational costs and vehicle processing timelines.

CPTR-SOAR 80, Hydrogen Peroxide Applications in Propulsion, is now available from CPIAC. The report provides a technical review of high-concentration hydrogen peroxide propulsion technology development initiatives. Historical applications of HTP are reviewed along with a discussion of the operational and performance attributes of HTP. In addition, the physical properties, storage and handling characteristics, and safety and hazard characteristics of HTP are summarized. Further discussion emphasizes the goals and objectives of recent HTP technology initiatives and the technical challenges which were addressed.

CPIAC offers products and services to individuals employed by organizations who maintain active registration with the Defense Logistics Information Service (DLIS) to receive export-controlled, militarily critical technical information, and are registered with the Defense Technical Information Center (DTIC) with an appropriately classified contract in the propulsion technology area. Additional information on products, services, or annual subscriptions can be obtained by contacting the CPIAC Customer Support Team at (410) 992-7300 or by e-mail: cpiac@cpiac.jhu.edu.
Colorado Springs JANNAF Meeting Draws Largest Audience in Years

The arrival of spring once again heralded the annual cornerstone of the JANNAF year, the Joint Propulsion Meeting. This year’s 57th JANNAF Propulsion Meeting (JPM), held jointly with the 7th Modeling and Simulation (MSS), 5th Liquid Propulsion (LPS) and 4th Spacecraft Propulsion (SPS) Joint Subcommittee Meeting, was held May 3–7, 2010, at the Cheyenne Mountain Resort in Colorado Springs, Colorado. Mr. Parker L. Buckley of the Universal Technology Corporation (UTC) in Dayton, Ohio, presided over a weeklong meeting attended by more than 550 of the nation’s engineers, scientists, program managers, and propulsion enthusiasts. Technical information was shared across the breadth of the JANNAF propulsion field in over 375 papers, the largest collection in recent memory—and a testament to the continuing need to share knowledge and accomplishments in the industry.

Meeting Highlights

Dr. Richard P. Hallion, an internationally recognized aerospace historian, former Smithsonian curator and retired Air Force executive, delivered the keynote address on Tuesday to a packed ballroom. Dr. Hallion’s presentation covered the entire history of development in propulsion for aerospace systems from piston engine and propeller design up through scramjet and rocket technology. Dr. Hallion’s breadth of knowledge on all things propulsion made this keynote especially engaging; after his presentation, Hallion answered a wide variety of questions posed by attendees concerning our current propulsion technology programs and lessons learned from the past. Having received multiple spontaneous rounds of applause and a standing ovation, it is apparent that Dr. Hallion will be fondly remembered as one of the best keynote speakers in JANNAF history.

The JANNAF awards ceremony was held immediately following the keynote. Three distinguished members of the propulsion community were recognized with the JANNAF Lifetime Achievement Award: Mr. Lee G. Meyer (Aerojet), Dr. J. Michael Lyon (Army RDECOM), and Mr. Parker L. Buckley (Universal Technology and AFRL, retired). JANNAF Executive Committee Chairman, Mr. James L. Taylor of the NASA Marshall Space Flight Center (MSFC) presented the awards, thanking each recipient for his exceptional contributions and long-standing service to JANNAF. The Modeling and Simulation Subcommittee recognized one of their own with a JANNAF Certificate of Appreciation. Session Chair Mr. James A. Larkin of Pratt & Whitney/West Palm Beach received the acknowledgment for outstanding contributions to the MSS and dedicated service to JANNAF. The Best Student Paper Award was given by the LPS to Mark A. Trinidad for his paper, “An Update on the Development of NGC’s TR408, 100lbf LOX/LCH4 Reaction Control Engine.” Mr. Trinidad is currently with Northrop Grumman/Redondo Beach.

JPM Technical Highlights

The JPM Program Committee hosted 12 technical sessions across the range of the propulsion field, including sessions on gun propulsion, space access systems, advanced concepts, insensitive munitions, tactical systems, and ARES-Orion program technologies.
JANNAF Meeting....continued from page 8

The JPM Program supported the 3rd Wireless Sensors Workshop, sponsored by the Structures and Mechanical Behavior Subcommittee (SMBS) and jointly chaired by S.R. Lin of the Aerospace Corporation and Edmund K.S. Liu of CPIAC. Presentations and an executive summary from the workshop will be included in the JPM proceedings, available shortly from CPIAC.

MSS Technical Highlights

The MSS Program Committee hosted eight technical sessions during the week, including one that was co-hosted with the JPM. Sessions on diagnostics systems and data mining, and simulation credibility were particularly strong draws. Members from the MSS community met in a working group to discuss needs, requirements, and progress on the development of a sensors database for propulsion system diagnostics and health management. A workshop on the development of a JANNAF Simulation Credibility Guide was jointly chaired by Dean Eklund of the Air Force Research Laboratory (AFRL) and Unmeel B. Mehta of the NASA Ames Research Center. Presentations and executive summaries from all of the subcommittees (MSS, LPS and SPS) workshops will be included in the JPM proceedings, available shortly from CPIAC.

LPS Technical Highlights

The LPS Program Committee hosted 17 regular sessions and 6 specialist sessions; over 150 technical papers were presented, the largest in its eight year history. Sessions on Third Generation Reusable Boost technology, Reusable Booster Flight Experiment engine studies were large draws, as were two day dedicated sessions on both Lunar Lander technology and Space Shuttle Main Engine (SSME) overview and history. A workshop in the continuing series of Hydrocarbon Fuels Development for Airbreathing/Hypersonics/Rocket Propulsion was hosted jointly with the Airbreathing Propulsion Subcommittee, and chaired by Matthew Billingsley of AFRL, Ron Bates of CPIAC, and Rick Wills of AFRL.

SPS Technical Highlights

The SPS Program Committee hosted a total of 20 sessions during the week, and were kicked off by a heavily attended discussion panel on the domestic research and development activities in electric propulsion. Hani Kamhawi of NASA Glenn Research Center (GRC) moderated the panel of experts from NASA, the Department of Defense, industry, and academia. NASA GRC and Lockheed Martin teamed up to host two full days of sessions on the propulsion systems and technology of the Orion Crew Service Module.

Steve Richards, retired from NASA MSFC, and formerly of the JANNAF Executive Committee, chaired a remarkable panel discussion on the lessons learned from the Apollo era; David Owen of CPIAC moderated the panel of experts, including Mr. Richards, who currently works for Bangham Engineering of Huntsville, Clay Boyce (formerly of Aerojet Corporation), Carl Stechman of Aerojet, and James “Skip” Urquhart of Jacobs Technology/Huntsville. The session was strongly supported by a wide array of attendees, spanning all levels of experience—and seemed equally engaging for young engineers and seasoned veterans.

A technical interchange meeting on the status and future of solar sail technology was hosted by C. Les Johnson of NASA MSFC. Those gathered expressed encouragement and excitement over the recent breakthroughs in the field, and the near term opportunities on the horizon. A workshop on the decomposition and ignition of advanced monopropellants was chaired by Anthony Zuttarelli of AFRL, which provided a forum to brief the industry on the latest advancements from AFRL funded programs, and to discuss a path forward for near term research goals and focus.

Meeting Proceedings

Meeting proceedings will be available soon on CD-ROM. Qualified customers may contact CPIAC Customer Service at 410-992-7300 or by e-mail to cpiac@cpiac.jhu.edu for more information or to order the proceedings.

Specialists from the Apollo Era held a session that was engaging for both young and veteran engineers. Left to right: Steve Richards, Clay Boyce, David Owen (CPIAC moderator), Skip Urquhart, and Carl Stechman.
A team from Penn Manor High School in Millersville, Penn., took first place at the eighth annual Team America Rocketry Challenge (TARC) in Washington, D.C., on Saturday, May 15, earning the title of national champion and the opportunity to compete against the UK and French national champions in July’s International Youth Rocketry Challenge.

The twelfth-grade team members, pictured on right, won the world’s largest rocket contest after spending months designing, building, and test-launching their model rockets, beating out 699 teams from across the nation. “In preparation for the national finals, we analyzed our data and adjusted our rocket as we repeatedly test-launched,” said Stoeckl. “Today we anticipated some wind and increased afternoon temperatures, and made just the right adjustments to bring home the victory.”

This year, student teams were challenged to design, build and launch a model rocket to an altitude of 825 feet with a flight time of 40–45 seconds, as well as return a raw egg payload to the ground unbroken without a parachute. Scores were based upon deviations from the altitude and flight time requirements.

The contest, sponsored by the Aerospace Industries Association (AIA) and the National Association of Rocketry, is intended to spark students’ interest in aerospace careers and in science, technology, engineering and mathematics—or STEM—college degree programs. The Team America Rocketry Challenge was created by AIA in 2003 to celebrate the centennial of flight and to generate interest in aerospace careers among young people. Since its inception, more than 50,000 youth have participated in the contest.

Scott C. Donnelly, AIA chairman and president and CEO of Textron Inc., noted how TARC has proven to be a great success in attracting young people to consider careers in aerospace and advancing their studies in STEM fields. “The enthusiasm these talented students brought today was truly electric,” Donnelly said. “The teams not only come away with a real aerospace product after months of hands-on trial and error, but also demonstrate a keen understanding of the fundamentals of rocketry using physics, math and teamwork. We also had the pleasure of welcoming back TARC alumni who, as rising stars in the industry, are a testament to the success of the program in inspiring the next generation of aerospace innovators.”

Complete competition results, images, and video are available at www.rocketcontest.org.
Propulsion News Highlights

**Modified Ground-Based Interceptor Completes Successful Flight Test (06-06-10)**
Source: U.S. Missile Defense Agency

The Missile Defense Agency successfully conducted a flight test of a two-stage Ground-Based Interceptor (GBI), launching from Vandenberg Air Force Base, Calif., at 3:25 p.m. PDT. The two-stage GBI is undergoing developmental testing as part of the Department of Defense’s strategy to invest in a new missile defense option which can contribute to our homeland’s defense. Results from the test will characterize two-stage performance and design for potential future missile defense applications.

A target missile was not launched for this flight test. After performing flyout maneuvers, the two-stage booster delivered an exoatmospheric kill vehicle to a designated point in space.

Initial indications are that all components performed as designed. Program officials will evaluate system performance based upon telemetry and other data obtained during the test.


**X-51A Team Eyes Results Of Scramjet Flight (06-01-10)**
Source: Aviation Week

Following the longest flight yet by an air-breathing scramjet engine, the X-51A Waverider team is waiting to see whether the largely successful first launch of the hypersonic demonstrator will unlock funding for further development of the technology. The X-51A was launched over the Pacific on May 26, achieving scramjet ignition and acceleration, but the engine ran for only 200 sec. rather than the 300 sec. planned, and the vehicle reached around Mach 5 instead of accelerating beyond Mach 6. “We were 95% successful,” Charles Brink says, adding that the cause of the slow acceleration and short duration is not yet known. Three more X-51As have been built, but their flights are on hold because delays in flying the first vehicle have consumed most of the available funding. The team hopes the flight’s success will unlock new sources of funding and allow tests to resume in 2011.


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**New CPIAC Unit on Nitrous Oxide**

Users of the Liquid Propellant and Fuels Database (LPFD) now have access to information on nitrous oxide (N₂O), including physical and thermal properties, compatibility, and hazards information. N₂O is the eighth propellant available in LPFD, which utilizes NIST’s REFPROP equations of state to produce fluid data at user-specified state points, either graphically or in tabular format.

Nitrous oxide as a liquid rocket propellant is stable, nontoxic, and storable as a high pressure liquid for long periods of time, on earth or in space. It can be used as a monopropellant or a bipropellant and can be catalytically decomposed by a wide variety of metals. N₂O is commonly used as an oxidizer with HTPB in hybrid rocket motors, and has been used for auxiliary power units and resistojets.

This latest addition brings the total number of propellants and fuels in LPFD to 53, including major propellants of interest in today’s emerging commercial space industry: nitrous oxide, methane, RP-1, and liquid oxygen.
The Defense Energy Support Center (DESC) gathered with members of the U.S. armed forces and the fuel and energy industry for this year’s Worldwide Energy Conference, which focused on “Energy Solutions for the Future.” The event was held May 10–12 at the Gaylord Hotel and Convention Center in National Harbor, Maryland.

The conference exists to communicate the needs of the DoD and the warfighter with respect to fuel and energy to the industry and DESC themselves while at the same time educating industry on how to respond to those needs and the specific hurdles and barriers which may exist in order to implement new technology. The EUCOM and AFRICOM Unified Combatant Command (UCC) Joint Petroleum Offices (JPO) were present at the conference and their importance cannot be understated; the JPOs are responsible for planning, coordinating, and overseeing the synchronization of bulk petroleum to ensure uninterrupted supply to the warfighters. In this respect, the UCC JPOs can provide the information to DESC and industry on exactly what the warfighters need to complete their missions.

Alternate fuels were a large part of this year’s conference, specifically the legislative barriers which are in place that make it more difficult for the DoD to utilize alternate fuels. The Air Force, DESC, and the EPA were all present to discuss their plans to assess the lifecycle greenhouse gas (GHG) emissions of alternate fuels, a necessity borne out of the Energy Independence and Security Act of 2007 which prevents the U.S. Government from entering into a procurement contract for alternate fuels for mobility unless the lifecycle GHG emissions are less than or equal to the equivalent petroleum-based conventional fuel.

Although alternative fuels receive most of the mindshare when discussing the future of DoD energy, current projections are that conventional petroleum-based fuel will remain the dominant energy source for DoD operations beyond 2025. Bulk fuels and water comprise 70% of convoy cargo in Iraq and Afghanistan; since most of this fuel is used to drive generators, the energy efficiency of forward-operating bases is a key area needing improvement. Current technologies such as insulated tents and intelligent configuration of generators are being implemented to increase energy efficiency and reduce the number of on road fuel convoys required to these remote areas.


SpaceX Achieves Success with Maiden Flight of Falcon 9

On Friday, June 4, SpaceX achieved launch and orbit of the Falcon 9 rocket, which, according to CEO/CTO Elon Musk, had a “50/50 shot of the first flight succeeding.” The Falcon 9 was test launched from the Cape Canaveral Air Force Station in Florida around 2:45 pm. The 180-foot rocket was powered by 10 engines, fueled by liquid oxygen and RP-1 kerosene fuel. The spacecraft achieved nearly the exact orbit SpaceX had planned, a 250km circular orbit at an inclination of 34.5°. Videos of the launch can be found on SpaceX’s Web site.

The Falcon 9 is designed to commute between earth and the international space station (ISS), and is able to carry higher payloads than the previous Falcon 1 model. Falcon 9 is expected to deliver 29 tons of cargo to low earth orbit. The rocket is intended to deliver supplies to the station, as well as bring back equipment and experimental supplies.

SpaceX has three planned missions, in agreement with NASA, as part of its Commercial Orbital Transportation Services (COTS). The first mission involves the Dragon capsule, which is designed to seat up to seven. A Dragon capsule is expected to take launch in a test flight aboard a Falcon 9 rocket later this summer, pending final reviews. The second COTS flight, planned for spring of 2011, will launch a Dragon set to approach the ISS, but will not land on the station. COTS 3 is planned to have the Dragon deliver cargo to the ISS, but no date has been set for this launch.

SpaceX is under a $1.6 billion Commercial Resupply Service Contract with NASA, which covers 12 flights for delivering supplies to the ISS. SpaceX also has Falcon 9 missions scheduled for Canada, Argentina, Israel and Europe.
Energy harvesting represents a new way to power wireless devices by ambient energy sources, including vibration, strain, heat, radio frequency fields, and light. MicroStrain, Inc. has pioneered ways to harness these energy sources to transform the wireless sensor market in large part through work it has conducted with the U.S. Navy through the SBIR funding program.

The U.S. military operates large fleets of aircraft with many moving parts. As a fleet ages, it is critical to track structural fatigue caused by cyclic stress and strain. The military believed that if a wireless sensor network could be developed that could automatically report on the health of aircraft, machines, and other structures for their entire lifetimes without battery maintenance, the potential benefits would be enormous. These new systems could extend aircraft structural lifetimes, streamline maintenance and repair operations, enhance mission readiness, and increase safety.

MicroStrain’s mission in the project was to harvest the energies of machine strains and vibrations to power wireless sensors on helicopters. With this technology, the critical rotating structural elements of helicopters can be continually monitored. Because these sensors are energized by the existing strain and vibration already occurring in aircraft in motion, there is no need to conduct battery maintenance. In addition to this breakthrough technology, MicroStrain has developed a beaconing method to synchronize the wireless sensor nodes.

Going forward, MicroStrain is finding new ways to apply energy harvesting wireless sensor networks to monitor advanced solid rocket propulsion systems and auxiliary rocket motors for space and defense applications. By working closely with several firms that have a long history of designing and building rockets, MicroStrain is now adapting its wireless sensor technology for rocket propulsion monitoring during short-term transport and long-term storage.

Project Description

MicroStrain developed a synchronized, secure wireless sensor network that is powered by energy harvesting. The wireless sensors can be programmed for a wide range of applications that provide data to enable the assessment of the structural health of structures and machines. In this energy harvesting project, the sensors are used to monitor the aircraft’s gearbox as well as the mast and pitch-links of rotorcraft. All wireless data, along with hard-wired aircraft bus data, are aggregated into a single database that can be accessed through an open architecture application programming interface (API). MicroStrain also developed a protocol for beacon-timed synchronization and successfully overcame the problem of maintaining secure wireless communication for very low-power sensing networks.

On the gearbox of the aircraft, MicroStrain implemented an energy harvesting sensor (HS-Link™), which is equipped with a vibration sensor and energy harvester. This was tuned to be resonant at peak frequencies, and the vibration sensor accurately measured the gearbox vibrations at sample rates of 100K S/sec.

Another sensor, located on the pitch-link—a critical rotating element that is extremely difficult to monitor with existing technologies—is powered by strains that occur in the pitch-link, which vary strongly with flight regimes. During pull-ups and gunnery turns, loads are approximately eight times that of straight and level flight. MicroStrain demonstrated that the operational strains in the pitch-link could generate enough power to allow continuous, wireless operational load monitoring, even during conditions of straight and level flight.

Another component of the aircraft, the spinning mast, is unique because it converts cyclic bending strains from the mast, induced by rotor blade flap. MicroStrain converts those strains to power, transmitting at 200 times/sec over three variables: the torque on the shaft and the bending on two axes. Additionally, a shear pin monitors such applications as landing gear, or parts of the aircraft where equipment is pined together and energy can be harvested for power.

A wide variety of active RFID tags were installed to track components, and sensors (3DM-GX3™-25) were used to track orientation and measure the vertical component of acceleration, which is necessary because acceleration causes stress on the structure.

The Wireless Sensor Data Aggregator (WSDA®), which is responsible for sending timed beacons out, was incorporated in the flight tests allowing various nodes’ data to be collected and aggregated with time as the unifying variable (See Fig. 1). All data collected from the sensors can be monitored through the WSDA, which displays a graph that tracks the entire data set, and another graph that tracks the data at any specified point. With security protocols that meet strict encryption standards, the WSDA has shown that the entire system of wireless and wired devices can work together.

MicroStrain has enabled helicopter manufacturers and operators to view concluded on page 15
People in Propulsion

Semmel Named Next Director of the Johns Hopkins Applied Physics Laboratory

Dr. Ralph D. Semmel, who currently oversees various research and development activities of the Applied Physics Laboratory at Johns Hopkins University, has been chosen as the Laboratory’s new director, effective July 1. Dr. Semmel will succeed APL’s director since January 2000, Dr. Richard T. Roca.

APL Board of Managers chair, Stuart J. Janney, says “the Board is confident that Ralph Semmel is highly qualified to lead the Laboratory as it takes on national critical challenges. Ralph will be leading a strong institution with an impressive record of accomplishments. He has proven ability to lead such a dynamic institution.” Dr. Roca agrees, “I’m delighted that such a remarkable R&D executive as Ralph Semmel will be leading this prestigious laboratory.”

Dr. Semmel has worked at APL for 23 years, and for the past five, he has served as head of APL’s Applied Information Sciences Department and its Infocentric Operations Business Area. He has been influential in making infocentric operations a core business for the Laboratory, enabling APL to develop critical technologies that enhance the security of the nation.

Dr. Semmel also served as assistant head of the Power Projection Systems Department, deputy director of the Milton S. Eisenhower Research Center, and executive of the Science and Technology Business Area. He also chairs The Johns Hopkins University computer science, information assurance, and information systems engineering programs in the JHU Engineering for Professionals graduate program.

Dr. Semmel is a graduate of the United States Military Academy at West Point; he received his master’s degrees from the University of Southern California and The Johns Hopkins University, and received his doctorate in computer science from the University of Maryland, Baltimore.

Dr. Semmel will be the eighth director in APL’s 68-year history; he was selected after an extensive nationwide search by the APL Board of Managers.

APL, a division of the University located in Laurel, Md., performs research and development on behalf of the Department of Defense, NASA and other government sponsors. More than 70% of APL’s nearly 5,000 staff members are scientists and engineers. Dr. Semmel lives in Columbia, Md., with his wife, Esta. The couple has two grown children.

New Employees at CPIAC

CPIAC recently welcomed two new employees: Ashley Hajnos and Heather Lemire. Ashley began employment on May 10. A copy editor, she supports the production of various CPIAC publications including the JANNAF Journal of Propulsion and Energetics and the CPIAC Bulletin. Ashley completed a writing internship with Maryland Capital Enterprises, Inc., and graduated in December 2009 from Salisbury University with a B.A. in English and a minor in Journalistic Communications.

Heather Lemire has joined CPIAC for the summer as an intern with the technical department. She is working alongside Dr. Richard Cartwright on two projects for publication, a Multilayer Insulation State of the Art Report (SOAR) and an Azotetrazole SOAR. Heather also maintains and updates the Propulsion News links and is helping with an Emerging Launch Vehicles project. In the fall she will begin her junior year at Case Western Reserve University, where she is studying to become a chemical engineer.

MicroStrain, Inc. is a privately held corporation, founded in 1987 and based in Williston, Vt. For more information, visit the company’s Web site at www.microstrain.com.

MicroStrain....continued from page 14

data from the entire structure while it is in the air, something that was previously impossible. These game-changing technology breakthroughs will enable advanced condition-based maintenance and structural health monitoring to sustain airframe worthiness, reduce maintenance, and increase aircraft availability.

CPIAC Bulletin/Vol. 36, No. 4, July 2010
**SPP SHORT COURSE**

2 - 6 August 2010

- Introduction to Basic Concepts in SRM Grain Design
- 3-D and Axisymmetric Grain Design, Internal Ballistics and Motor Stability
- Introduction to Basic Concepts in SRM Nozzle Performance
- Two-Phase Flow Expansions, Nozzle Flow Loss Mechanisms
- Familiarization of SPP/SRM Modeling Techniques
- Modeling Techniques, Recommended Practices
- User-Oriented Training
- SPP Input/Output Usage's and Interpretation
- Hands-On Design and Performance Analyses

The workshop consists of two sections: a three day course which will include an Introduction to Solid Rocket Grain Design and Internal Ballistics as well as two days of instruction in the use of the code, and two days of instruction for Nozzle Performance and the use of the code. The course level covers novice through expert for all topics. The two sections will be held sequentially to allow participants to enroll in either or both sessions. A computer laboratory session is also included.

For more information contact: **Software & Engineering Associates, Inc.**

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telephone: (775) 882-1966
fax: (775) 882-1827

**Prices:**

- Grain Design $2,250.
- Motor Performance $1,500.