2008 JANNAF Propulsion Meeting and Joint CS/APS/EPTS/PSHS/SPIRITS User Group Meeting Held in Boston

The 55th Joint Army-Navy-NASA-Air Force (JANNAF) Propulsion Meeting (JPM) and 42nd Combustion Subcommittee (CS), 30th Airbreathing Propulsion Subcommittee (APS), 30th Exhaust Plume Technology Subcommittee (EPTS), 24th Propulsion Systems Hazards Subcommittee (PSHS), and 12th Spectral and In-band Radiometric Imaging of Targets and Scenes (SPIRITS) User Group Joint Meeting were held during the week of May 12-16, 2008, at the Boston Marriott Newton and Hanscom AFB in Newton, Mass. It was one of the largest JANNAF Propulsion and Joint Subcommittee Meetings to be held in years. The Meeting provided a full program with a wide variety of complementary technical topics and continued the current efforts of the JANNAF Executive Committee (EC) to create a different technical interchange and flavor for each JPM by having it meet successively, every 12 months, with a different group of JANNAF Technical Subcommittees. Mr. John B. Moore of the Naval Air Warfare Center Weapons Division in China Lake, Calif., served as the Joint

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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 the following:

TECHNICAL INQUIRIES

- Compatibility of Nitinol with a variety of substances: 1) Hydrazine; 2) Monomethyl hydrazine (MMH); 3) Nitrogen Tetroxide (MON 3); 4) Gaseous Nitrogen (GN2); 5) Gaseous Helium (GHe); 6) Isopropyl Alcohol (IPA); 7) Argon (Ar); 8) de-ionized water; 9) Research grade Xenon gas. (Req. 26148)
- Information on the compatibility of NBR insulation with solvents such as MEK and TCA (sic). (Req. 26120)
- Space Shuttle Redesigned Solid Rocket Motor (RSRM) History and Description. (Req. 26097)
- Hazard Assessment orInsensitive Munitions testing sites and POC at the sites. (Req. 26075)

BIBLIOGRAPHIC INQUIRIES

- Hypergolic propellants for a liquid DACs applications. (Req. 26084)
- Aging reaction mechanisms in HTPB propellant and binders. (Req. 26033)
- CD SP-0801 Volume 1 – Compilation of X-43A technology advances in JANNAF Papers from 1997-2006. (Req. 23920)

Recent CPIAC Publications

JPM CD-07, 55th JANNAF Propulsion Meeting (JPM), May 2008.


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.cpiac.jhu.edu/templates/cpiacTemplate/meetings/. The JANNAF Calendar appears on the back page.

**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://aiaa.org/content.cfm?pageid=161&lumeetingid=1725

**32nd International Symposium on Combustion**  
3-8 August 2008  
McGill University in Montreal, Canada  
POC: www.combustioninstitute.org/

**Department of Defense Explosives Safety Board Seminar**  
12-14 August 2008  
Palm Springs, CA  
POC: www.ddesbseminar.org

**AIAA SPACE 2008 Conference & Exposition**  
9-11 September 2008  
San Diego, CA  
POC: www.aiaa.org

**International Seminar on Safety Science and Technology**  
24-27 September 2008  
China  
POC: www.issst.com.cn

**24th International Symposium on Ballistics (NDIA)**  
24-28 September 2008  
New Orleans, LA  
POC: www.ndia.org

**46th SAFE Association Symposium**  
27-29 October 2008  
Reno, NV  
POC: www.safeassociation.com

**AIAA Missile Sciences Conference**  
18-20 November 2008  
Monterey, CA  
POC: www.aiaa.org

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**Summer Lecture Series at ARL by Professor Ken Kuo**

Professor Kenneth K. Kuo, Distinguished Professor of Mechanical Engineering and Director of the High Pressure Combustion Laboratory, Department of Mechanical and Nuclear Engineering, The Pennsylvania State University, presented Part I of a two-part series on “Fundamentals of Solid Propellant Combustion Characteristics,” at the U.S. Army Research Laboratory (ARL), Aberdeen, Md., on June 18, 2008.

During the three-hour lecture, Ken covered half of his general introduction to solid propellant formulations and their combustion characteristics, including classifications of different types of propellants; major ingredients and their properties and functions; burning rate behavior of solid propellants; steady-state temperature profiles in burning solid propellant strands; burn-rate temperature sensitivity; performance parameters of a solid-propellant rocket motor; and performance parameters of solid-propellant gun systems. Part II is scheduled for July 10, 2008.

Professor Kuo will be presenting approximately 14 seminars/lectures on a variety of topics on propulsion, propellants, and energetic materials at ARL throughout the year. CPIAC will post information about these lectures as it becomes available on its Home page.

This lecture series is being sponsored by the Weapons and Materials Research Directorate (WMRD) through the Army Research Office. Attendees must be U.S. citizens to access the ARL facility.

**Visitor Information**

If your organization uses JPAS, you can submit a visit request by providing the following information: 1) Name; 2) Reason for visit and POC; 3) Security Management Office (SMO) Code (ARL’s SMO code: W26218); 4) First day of visit; and 5) Last day of visit. Visitors who wish to attend but do not have JPAS access may contact Amanda Porter at 410-306-0713. Ms. Porter is the Project Liaison, WMRD/BWCD-Propulsion Science Branch, U.S. Army Research Laboratory, and will assist visitors with their requests, which can be faxed to the reception desk. All visit requests should be submitted several working days prior to the date of the visit.
expending on-board ordnance, discharging batteries (electrical), and decontaminating propellant tanks.

White Sands Test Facility (WSTF) was selected by Hill Air Force Base to store the PBPS as the facility was familiar with the stage from aging and surveillance hot-fire testing during Peacekeeper deployment. WSTF’s unique background and expertise in hypergolic propellant handling and safety, and the site’s ability to hot-fire hypergolic rocket systems utilizing the propellants, made WSTF highly desirable for the safing project.

Specifications of the PBPS:

- The PBPS has ~92 in. diameter and 42 in. height.
- The loaded weight of the PBPS is 4000 lb.
- The PBPS provides roll control torque during Stage III operation in response to commands from the missile guidance and control set. It also provides the forces and torques required for establishing the desired post-boost vehicle velocity vector and for deployment of the reentry vehicles.
- The PBPS consists of an isogrid structure, axial and attitude control propulsion systems coupled with a helium pressurization system, propellant storage assemblies, propellant manifolds, and an in-flight coolant assembly (IFCA) used to cool the missile guidance control set.
- The structure is fabricated from aluminum and includes a Stage III/PBPS separation joint, access panels, and external protection material.
- The liquid bipropellant propulsion system uses hypergolic propellants, monomethylhydrazine (MMH) and MON-1 nitrogen tetroxide (NTO).
- The PBPS contains eight attitude control engines (ACEs) (70 lbf) and one axial engine (AXE) (2563 lbf).
- The propulsion system includes all required propellants, tanks, pressurant gas, valves, ordnance, and thrust vector actuation system.

- The PBPS fluid/gas systems include propellants ~543 lb MMH (0.8 psia), 882 lb NTO (29.0 psia), and ~7.3 lb helium (3370 +100/-0 psia at 70°F).
- The IFCA contains ~17.7 lb of Freon* R-12 at 73.5 psia (61°F) and 0.02 ft³ helium at 5200 psia (98°F).
- Battery subsystem contains 1.45 L 32% potassium hydroxide.
- Pyro isolation valves isolate the helium storage from the propellant tanks, the propellant tanks from the propellant manifolds, and the helium supply from the Freon in the IFCA.

With NASA Marshall Space Flight Center (MSFC) looking at options for the new Crew Launch Vehicle (CLV) system Ares I-X for roll control, and a very short timeframe to develop, qualify, and build a flight unit by April 15, 2009, the use of existing proven hardware became essential. The Peacekeeper PBPS hardware fit within the design parameters for the roll control system, is already qualified, and is readily available. The Air Force agreed the plans to reuse selected hardware for NASA projects would benefit both organizations. NASA would receive qualified flight hardware with extensive development and manufacturing cost for the simple cost of removal and shipment (Fig. 2). The Air Force would have a suitable disposition of these components for non-military purposes and would have much less equipment to transport and dispose of after safing operations, and the reuse of the hardware for nonmilitary purposes saves the taxpayer money.

The Peacekeeper PBPS stage hardware that was selected for reuse by MSFC for the Ares 1-X roll control includes the

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*Freon is a registered trademark of E.I. duPont de Nemours and Company Corporation, Wilmington, Del.
axial engine (~ 2560 lbf), propellant feed-line components including filters and helium pressure check valves, helium pressure system including storage tank, regulator and relief valve, pyro actuated isolation valves for propellants, and helium system and various flight transducers (Fig. 3). Because the Ares 1-X roll control engine requirements are slightly different than the Peacekeeper axial engine requirements, the engine would have to be modified:

- Approximately 1600 lbf thrust is needed for Ares 1-X. Typical PBPS axial engine thrust is ~ 2560 lbf; solution is to change the area ratio of the nozzle by cutting the nozzle down to achieve 1600 lbf thrust.
- Ability to pulse the engine (typical for a roll control application) is required. The Peacekeeper axial engine was designed to fire longer burns in use as an ICBM. The attitude control engines on the PBPS were used for roll control. The question became “Can we pulse the axial engine bi-propellant valve without problems?”
- Ability of the PBPS axial engine to ingest gas (air) is necessary. The Peacekeeper PBPS axial engine was not designed to ingest gas when the manifolds were primed. The manifolds were to be subjected to vacuum (prior to manifold priming), removing all gas. With the application for Ares 1-X, the manifolds will be primed at ambient air induction.

Work began in March 2006 on system design and facility build-up to safe 67 PBPS stages. The safing facility was completed in December 2006, and the first PBPS safing was completed in April 2007. Due to the immediate need for test data, the axial engine from the first stage received at WSTF was removed and used as the test article for the Ares 1-X testing (ARET). The testing provided needed data to MSFC, proving that the engine valve needed modifications and that continued testing was warranted. Additional testing was performed in 2008 using another axial engine harvested at WSTF. This testing, the Ares Roll Control System (RoCS) test (Fig. 4), qualified the modification made to the engine valves and approved the use of the modified axial engine for the Ares 1-X program.

After Marshall’s interest in Peacekeeper hardware, NASA Glenn Research Center (GRC) also began taking advantage of available hardware by utilizing an attitude control engine (70 lbf) to test instrumentation to verify engine ignition (ACE-1). This hot-fire test took place at WSTF in April 2008.

Other reusable items coming from the Peacekeeper PBPS stages are the propellants monomethylhydrazine (MMH) and nitrogen tetroxide (NTO). Each stage contains 80 gallons of each propellant. The propellants from the first 15 stages processed have proven to be pristine, falling well within NASA shuttle specifications for propellants (SE-S-0073) with the exception of the MON rating for the oxidizer (shuttle uses MON 3 and the Peacekeeper was MON 1).

With the mandate to discontinue shuttle flight in 2010 and develop replacement craft quickly, the PBPS hardware and consumables provide inexpensive, proven, and readily available options to NASA. The reuse of pristine hypergolic propellants for testing saves both in the cost to acquire SE-S-0073 specification propellants, and the disposal cost for the existing propellants if they had not been able to be reused. The project has proven to be an excellent example of reuse of military hardware for peaceful purposes.

This article has been approved for public release in its entirety.

JANNAF Meeting .... continued from page 1

Technical Meeting Chairman for this year’s event. Nearly 600 scientists, engineers, and managers attended the joint meeting, with over 325 papers presented in nearly 60 technical sessions, representing a significant attendance growth from previous JANNAF Meetings. All attendees received a complimentary copy of the inaugural issue of the JANNAF Journal of Propulsion and Energetics.

Program highlights included an interesting keynote address by Dr. Steven H. Walker, Deputy Director of the Tactical Technology Office of the Defense Advanced Research Projects Agency (DARPA). Dr. Walker oversees the critical mission areas of Air/Space/Land/Sea Platforms, Precision Strike, Laser Systems, Unmanned Systems, and Space Operations. In his keynote entitled “Air-Breathing Hypersonic Flight – Closer Than We Have Ever Been,” Dr. Walker highlighted the U.S.-sponsored programs and hypersonic flight test activities that can contribute in a crucial way toward establishing airbreathing hypersonic propulsion for vastly improved capabilities for high-speed missile and space-launch system applications.

Technical Program ceremonies included the honoring of various individuals for their outstanding contributions to the JANNAF Propulsion Community. The Executive Committee recognized Lifetime Achievement Award recipients Dr. Merrill W. Beckstead of Brigham Young University and Mr. David Booth of Aerojet Culpeper. Mr. Parker L. Buckley, U.S. Air Force Research Laboratory (AFRL) (retired) received a Special Service Award from the EC along with a recognition award for service in the EC. Mr. James (Steve) Richards, NASA Marshall Space Flight Center (retired), also received a recognition award for service in the EC.

The Combustion Subcommittee presented awards for Outstanding Sustained Contribution to Dr. William M. Chew, U.S. Army Research, Development and Engineering Command (REDCOM); Mr. Ronald S. Fry, The Johns Hopkins University, Chemical Propulsion Information Analysis Center, and Dr. Gerald L. Pellet, NASA Langley Research Center (LaRC). The Airbreathing Propulsion Subcommittee presented awards for Outstanding Sustained Contribution to Mr. Parker L. Buckley, AFRL (retired) now with Universal Technology Corporation, and Dr. Thomas A. Jackson, AFRL, Wright-Patterson AFB, Ohio. The Propulsion Systems Hazards Subcommittee award for Outstanding Sustained Contribution was presented posthumously to Dr. Robert Bennett, ATK Launch Systems, who died in a biking accident in 2007. Mr. Hank Dovey of ATK Thiokol accepted the award and will present it to Dr. Bennett’s widow in Utah.

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JANNAF Achievement and Service Awards

Mr. David Booth accepts his Lifetime Achievement award from Dr. Jamie Neidert, U.S. Army RDECOM.

Mr. Parker L. Buckley receives a Special Service Award from EC Member Mr. Stuart Blashill, Naval Air Warfare Center Weapons Division, China Lake, Calif.

Mr. Steve Richards, NASA MFSC, proudly displays his recognition award for service in the EC.

Dr. Merrill W. Beckstead (at left) was unable to attend the JANNAF meeting and will receive his Lifetime Achievement Award this summer.
55th JPM Technical Program

The JPM program included the presentation of 49 papers in nine sessions. Almost half of this technical program was focused upon Propulsion Systems for Space Access (22 papers), followed in interest by Tactical Propulsion (11), Propulsion and Energetics (11), Missile Defense/Strategic (8), and Guns and Gun-Launched Propulsion (3). Joint JPM/CS technical sessions were also conducted on interior ballistics and propellant combustion (3), gun propellants and ingredients (4), and gun systems and charge design (3).

42nd CS Technical Program

The CS program included presentation of 124 technical papers in 16 technical sessions, four panel meetings and four town meetings in solid, liquid, guns and airbreathing combustion. Additionally, eight papers and supporting discussions were held in two sessions on Ambient Atmosphere Solid Propellant Combustion that were cosponsored with the PSHS. These numbers represent approximately a 25% increase over the 2006 Meeting in San Diego, Calif.

The CS technical sessions covered reactive materials; ignition and combustion of solid propellants; ambient combustion of solid propellants; modeling and data for combustion simulation; enhanced blast; solid propellant burn rate augmentation and combustion; interior ballistics and propellant combustion modeling; solid propellant combustion modeling and combustion instability; combustion diagnostics; aluminum combustion and combustion efficiency; modeling engine flowfields in test facilities; analysis and modeling of gun propellant and igniter ingredients; ballistic studies of small and medium caliber guns; and, novel liquid rocket propellants and combustion.

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CS Panels

All four CS technical panels held meetings during the week; many were in conjunction with CS Town Meetings in the same technical areas. The Reactive Materials Panel, a joint panel with the PEDCS, is seeking more intelligent use of the power contained within an energetic material. The panel conducted a successful workshop in February 2008 on “Reactive Material Technology for Enhanced Lethality,” and presented a paper at this meeting summarizing this workshop. Additionally, they organized three technical sessions that are serving to guide the panel’s future activities. The Liquid Fuel Kinetics and Properties Panel is successfully working jointly with the APS and Liquid Propulsion Subcommittee (LPS) panels on hydrocarbon fuel issues. Members of the hydrocarbon fuels community, many of whom are engaged in the American Institute of Aeronautics and Astronautics (AIAA) and The Combustion Institute, as well as JANNAF, need to assess how the public release work that is being conducted will mesh with what is being pursued within JANNAF. The Kinetics and Related Aspects of Propellant Combustion Panel has been focused on developing a report on recommendations on the R&D required to implement new energetic ingredients in munitions. A workshop report was completed documenting findings developed over a year’s efforts that are anticipated to contribute greatly toward defining such recommendations. The Flowfield Diagnostics Panel is continuing to foster better collaboration between the computational and experimental communities. During the meeting, this panel organized technical sessions on “Combustion Diagnostics.”

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Participation has grown four-fold, which will enhance membership resources and raise awareness of needs and concerns. The panel is identifying solution approaches to selected diagnostic problems of concern.

30th APS Technical Program

The APS program included presentation of 68 technical papers in 11 technical sessions, five panel meetings, an airbreathing Town Meeting and a workshop. The paper and session numbers represent a slight increase from the 2006 San Diego Meeting. The technical sessions covered conventional ramjet propulsion; hypersonic technology overviews; scramjet component engine testing; scramjet test facilities and flight tests; axisymmetric scramjet engine technology (ASET); scramjet propulsion structures; component modeling and simulation; ground test of X-51A SED flight development engine SJX61-1; rocket-based combined cycle (RBCC) and pulse detonation engine (PDE) technology; scramjet propulsion; and turbine-based combined cycle (TBCC) and inlet technology.

The APS technical program also included an RBCC Technology Assessment Workshop, which was cochaired by 2nd Lt. Katherine Andrews and Mr. Glenn Liston of the Air Force Research Laboratory, and Mr. Jeff Pearce of Universal Technology Corporation (UTC). The purpose of this evening workshop was to introduce a new Air Force program to assess the current state of technology for RBCC propulsion systems and to solicit the participation of the community in a comprehensive review team. This program will include assessment of Technology Readiness Levels (TRLs), definition of technology gaps, completion of a comprehensive risk assessment, and the definition of risk mitigation activities. Ultimately, the Air Force plans to use the results of this assessment as a tool for planning future RBCC technology development activities. During the workshop, attendees were welcomed, introduced and then presented with an overview of the program's plan. Following the presentation, the floor was opened for comments and there was a spirited interchange, with Mr. Liston responding to most of the questions. Participation in the workshop was excellent with more than 50 attendees, indicating that the technical community has a keen interest in this topic. The workshop attendees were asked to participate in the study both by providing inputs on RBCC system concepts, current TRLs, and perceived technology gaps, and also by periodically reviewing the results of the assessment. A general willingness to participate in the study was indicated by the workshop attendees. There are tentative plans to hold a follow-up workshop at the next JANNAF APS meeting.

APS Panels

All five active APS technical panels held meetings during the week, many following directly after related technical sessions. The Engine Test and Validation Panel is continuing to develop standards for scramjet engine testing, drawn from the 2nd Edition of CPIA Publication 710, Scramjet Propulsion Testing Standards, Recommended Practices and Guidelines, released in December 2005, and they are working on improvements and additions for a third edition of Publication 710. In addition, this panel is continuing to examine test medium effects in scramjet testing by focusing their analysis activities on a facility and flowpath engaged in active testing. The Advanced Engine Cycle Panel has pursued multiple areas of interest. JANNAF workshops have contributed to characterizing PDE technology and engine performance. Workshop findings are to be summarized in a planned CD publication. A follow-on PDE workshop has been recommended. There is continued interest in having multiple independent analysts examine a standard set of hypersonic test data for comparison of methods and results. Use of public release
HYCAUSE data was suggested as a candidate topic for a workshop. The panel has identified recent interest in two new tasks: 1) comparing analysis anticipated high quality 3-D inward-turning inlet data with analysis results; and, 2) refining the assumptions and analysis basis for the classic Isp versus Engine Mach number curves used by so many over the years. The Component Level and Physical Modeling Panel continues its activities in two areas: 1) turbulent mixing, Schmidt number modeling and data collection; and, 2) isolator CFD modeling. Panel members have developed an outline of best practices for isolator modeling, and they continue to validate the need for databases containing data that can be used for CFD validation for component analysis. The Structures and Materials Panel was organized to foster productive interchange between propulsion and airframe specialists and structures and materials specialists in such areas as the SOA in non-metallic high temperature materials, identifying a technology roadmap for needed developments and identifying existing and needed test facilities. The panel adopted a unique solution by encouraging JANNAF and CPIAC to cosponsor, for the first time, JANNAF specialist sessions on “Hypersonic Thermal Protection Systems (TPS) and Hot Structures” at a non-JANNAF meeting. These sessions were held at the 32nd Annual Conference on Composites, Materials and Structures (CMS) in January 2008 in Daytona Beach, Fla. The CMS Conference was sponsored by the Ceramic, Metal and Carbon Composites Committee (CMC3) of the Advanced Composites Working Group (ACWG), and held in cooperation with the U.S. Air Force, U.S. Army, U.S. Navy, U.S. Department of Energy, National Aeronautics and Space Administration (NASA) and DARPA. The JANNAF sessions were organized in order to improve the archiving of ITAR information on advanced materials technologies for possible U.S. hypersonic applications. The field of TPS and Hot Structures addressed here encompasses multiple technologies for both rocket- and airbreathing-based systems. Future such sessions are being planned. The proceedings of these JANNAF Specialist Sessions consist of 14 technical papers.

CPIAC subscribers and other organizations registered with the Defense Technical Information Center (DTIC) and the Defense Logistics Information Service (DLIS) may request copies of this CD-ROM or individual papers. The Fuels Panel is engaged in joint activities with CS and LPS involving the kinetics of liquid hydrocarbon fuels. REFPROF data modules are being worked upon for a number of high profile hydrocarbon fuels.

30th EPTS and 12th SPIRITS Technical Program

This program included 50 technical papers presented in 10 sessions. Sessions covered technical areas such as plume signatures, code development, applications, and flowfield data and modeling. Dr. Kevin Kennedy of the U.S. Army AMRDEC, Redstone Arsenal, served as the EPTS Meeting Chair and Ms. Robin Miller of Naval Air Warfare Center Weapons Division, Point Mugu, served as the SPIRITS Meeting Chair. Papers presented included plume radiation transfer, vehicle induced glows, helicopter modeling, plume model validation, infrared (IR) sensor performance, flowfield simulations, model-data
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comparisons, plume signature measurements, plume signature prediction studies, signature anomalies/phenomenology, signature identification, new data collections, data analysis, hard body signatures, afterburner plumes, and code development and enhancements. Dr. Kennedy and Ms. Miller will continue their roles as chairpersons for the next EPTS and SPIRITS meeting. Mr. Nick Keim will replace Mr. Peter Zeender as the CPIAC technical representative for EPTS.

A SPIRITS training course conducted by Aerodyne Research, Inc. was held in conjunction with the meeting. There were a total of eight participants in the four-day course, which provided an introduction to SPIRITS and its usage. The course was taught by Mr. John Conant, the industry coordinator for SPIRITS.

24th PSHS Technical Program

The PSHS program consisted of 40 technical papers in seven sessions, four panel meetings, and one workshop. The papers covered general insensitive munitions technology, thermal decomposition leading to cookoff, impact/shock-induced reactions, propulsion system safety/hazard classification, and gun propellant vulnerability. Two joint PSHS/CS sessions were also conducted. They comprised 14 papers on ambient atmosphere solid propellant combustion.

PSHS Panels

The four PSHS panel meetings included discussions of topics of current interest to members and possible future activities. The Cookoff Hazards Panel meeting discussions included the May 16 workshop (more on this workshop below) and the need to improve the accessibility of insensitive munitions (IM) data. At the Impact/Shock-Induced Reactions Panel meeting, topics of discussion were definition of parameters of the bullet-impact threat spectrum, quantification of real-world shock/impact threats, relations between IM performance and weapon platform survivability, effects of improvised explosive device (IED) attacks on insensitive munitions, energetic material characteristics required to mitigate shaped charge jet attacks, and shock desensitization of energetic materials. The panel decided to study shock desensitization of energetic materials as a new task. Discussions at the Insensitive Munitions Technology Panel meeting included a possible tutorial on insensitive munitions at a future PEDCS meeting and the status of a continuing panel task to generate a historical compilation of IM data. Several members volunteered to provide additional input for that task. The panel also agreed to support a CPIAC state-of-the-art report on prediction of IM performance from subscale and laboratory tests, as a new panel task. At the Safety and Hazard Classification Panel meeting, topics of discussion were revised energetic materials safety standards and requirements, transportation issues with munitions shipped overseas and then modified, UN Series 7 hazard classification, hazard classification by analogy, safety standards for hypergolic liquid propellants, suitability of card gap tests for classification of ExtremelyInsensitiveDetonatingSubstances, and ambiguity within the divisions of Hazard Class 1.2.

PSHS Workshop: “Scaling Approaches for Hazards Assessment of Cookoff”

During this May 16 workshop, participants cooperated in establishing a best estimate of the current state of knowledge regarding the use of small-scale tests and modeling to predict the outcome of a specific accident scenario, namely a collision and subsequent fire involving a truck carrying a rocket motor. The workshop utilized a process known as... continued on page 11
PIRT (Phenomena Identification and Ranking Tables). Participants first identified every phenomenon that could conceivably affect the violence of the rocket motor’s reaction to the accident, as exhibited by energy of thrown fragments. It was assumed that violent reaction would be initiated by the fire rather than by the impact, although the impact could conceivably affect the severity of the violent reaction. Participants then ranked the importance of each phenomenon by a voting procedure. For selected phenomena, participants ranked the adequacy of available data, adequacy of available models, validation of available models, and confidence in scaling of predictions, by the same kind of voting procedure. This process showed how areas of technology where more work is needed can be identified and prioritized.

Drs. Unmeel Mehta (NASA Ames) and Dean Eklund (AFRL WPAFB), representatives from the Uncertainty Panel of the Modeling and Simulation Subcommittee (MSS), briefed all members of the CS, APS, EPTS and PSHS Technical Steering Groups (TSGs) on their efforts to develop a JANNAF publication, “Guide for Uncertainty Quantification for Credible Propulsion and Energetic Simulations.”

The guide has two main objectives: 1) to describe procedures and processes for uncertainty quantification, including those for verification, validation, model conditioning, and predictions; and, 2) to serve as a useful tool for all members of the Technical Subcommittees of the JANNAF propulsion community for generating credible simulations for making simulation-based critical decisions. The guide is aimed at fostering a strong dialogue between simulation model developers and simulation users. The briefings to the TSGs were made in an effort to identify people who would have interest in contributing toward the development of the proposed guide and identify representative case studies of worked problems in propulsion and energetics applications, both for a public release publication and a restricted distribution publication (limited/export controlled). Significant progress was made toward both objectives.

Overall, the 55th JPM, 42nd CS, 30th APS, 30th EPTS, 24th PSHS and 12th SPIRITS Joint Meeting met with much success. JANNAF continues to be effective in addressing problems of mutual interest to the Government, industry and academia, as evidenced by the collaboratively fruitful meetings of current CS, APS, EPTS and PSHS Technical Steering Groups that were held throughout the week and will contribute to the future direction of technical activities. We at CPIAC wish to thank all who responded to our follow-up meeting survey. Many fine suggestions were made that will certainly be useful in enhancing the technical program content for the next meeting. The next JPM is scheduled for May 2009 and will be held in conjunction with the Rocket Nozzle Technology Subcommittee, Nondestructive Evaluation Subcommittee, Structures and Mechanical Behavior Subcommittee, Propellant and Explosives Development and Characterization Subcommittee and the Safety and Environmental Protection Subcommittee. The location has not yet been determined.

Finally, we hope that you have had a chance to read through your complimentary copy of the new JANNAF Journal. The Editorial Staff of the Journal recently distributed a survey to solicit your feedback. Your opinion and perception of this new JANNAF effort is very important as we move forward with plans for the second issue, which is scheduled for release at the next JPM.


The hydrazine family of propellants is the benchmark fuel by which all other hypergolic and monopropellant fuels are measured. The U.S. space industry has used hydrazines since the 1950s for such applications as the retired Messerschmitt aircraft, rocket and missile engines, and thrusters on both satellites and rockets. The Titan rocket was heavily dependent on hydrazine for the first stage engines throughout most of its venerable service career. Although there is increased industry interest in using less toxic fuels, hydrazine propellants are still the propellants of choice for use on the space shuttle, Delta II and IV rockets, missiles, the F-16 aircraft emergency power unit and satellite thrusters, as well as for many future programs.

Anhydrous hydrazine (AH), unsymmetrical dimethylhydrazine (UDMH) and monomethylhydrazine (MMH) were first produced to support the early U.S. space programs. AH, UDMH and MMH are produced by the Raschig process, in which chloramine reacts with ammonia or with an amine. High purity hydrazine (HPH) and aerozine-50 or A-50 (a blend of AH and UDMH) were later produced to support the Titan rockets. Hydrazine 70 or H-70 (a 70/30 blend of hydrazine and water) was added to the hydrazine family in support of the F-16 aircraft. Mixing of hydrazine with other fuels or with water lowers its freezing point and improves stability.

The Defense Energy Support Center (DESC) Aerospace Energy Commodity Business Unit, located in San Antonio, Texas, procures and stores several hydrazine propellants for the U.S. space industry, including UDMH, MMH, HPH, A-50, H-70 and monopropellant hydrazine (MPH). UDMH is used to make A-50 and often used with inhibited red fuming nitric acid (IRFNA) for target drones. MMH is used for shuttle Orbital Maneuvering System (OMS) engines, space station and ground testing operations. HPH is used primarily for satellite thrusters, and MPH is used for space shuttle auxiliary power units. A-50 is currently used for the Delta II second stage. H-70 is used in the F-16 fighter aircraft to drive an auxiliary power unit, should the single engine fail in flight. AH is used for blending with UDMH to make A-50.

All hydrazine propellant types continue to be available to government and U.S. commercial space programs. The Department of Defense (DoD), NASA and U.S. commercial contractors are the largest consumers.

Program usage for all hydrazine propellants exceeded 132,000 pounds for fiscal 2007. The usage remains fairly steady; however, changes in programs, such as the retirement of the Titan rocket, occasionally affect overall production of hydrazines. DESC maintains sufficient inventory in ready storage to support projected programs, as well as minimal contingent quantities to cover unexpected production interruptions and requirements. Each hydrazine propellant must be produced on a “campaign” basis, which means that the production plant must be converted to generate one type of hydrazine at a time. Maintaining adequate inventory to account for both lead time and usage is vital. DESC provides meticulous inventory planning and management to ensure hydrazine is available to all U.S. users in the most efficient and cost-effective manner possible.

DESC also transports and maintains specialized contain-ers of all hydrazine propellants for the U.S. space industry. The Department of Transportation has granted four special permits for use of MC 338 cargo tanks, 42B drums, and stainless steel 4BW cylinders in transporting the various types of hydrazine in both bulk and non-bulk quantities. Due to the hazardous nature of hydrazines, special requirements must be satisfied to convey these commodities over the road, including special hazmat routes, dual drivers and satellite tracking. Several types of hydrazine even require protective services.

Hydrazine propellants have an enduring role in future U.S. space programs. DESC strives diligently to support the evolving nature of hydrazine propellants’ usage and to ensure that hydrazine is available to U.S. space industry customers by the most economical means. DESC has received 20-year contracting authority, assuring long-term availability of hydrazine products in a market environment that only supports one production facility at a time. The current DESC contract extends through 2015 and includes two five-year options to provide uninterrupted support through 2025. This approach will enable effective support for such programs as NASA’s future Orion program, which has selected proven hydrazine fuels for new missions to the moon, and for near-term DoD launch and in-space systems. Current and future space programs can rely assuredly on hydrazine product support for years to come.

For additional information on hydrazine propellants, please contact AerospaceEnergyInfo@dla.mil or call 210-925-9950.

Tell us what your organization is working on and we’ll publish it in the Bulletin. Guidelines for submitting an article are available at http://www.cpiac.jhu.edu/images/media/authorguidelinesmay08.pdf.
Questions? Contact Editor Rosemary Dodds at rdodds@jhu.edu or call 410-992-1905, ext. 219.
The Air Force Research Laboratory (AFRL) System Safety Engineering Office of the Space and Missile Propulsion Division located at Edwards AFB, Calif., performs system safety analyses designed to determine safe test stand design and operational practices for the use of liquid rocket propellants. As the desire to increase performance and operability of liquid rocket propulsion systems has grown, interest in the use of liquid methane (LCH4)/liquid oxygen (LOX), or M/OX, propellants has also grown. As part of an ongoing contract with a small local commercial defense contractor, the System Safety Engineering Office has assisted in the safety and hazards analysis of M/OX propellants for use in static ground testing. Typically DoD 4145.26-M is used to establish liquid propellant explosive equivalents; however, specific information on the M/OX combination is not listed. Instead a general guideline is given which is intended to cover all other hydrocarbon propellants.

CPIAC was engaged to make an assessment of the available information on M/OX propellant mixtures, including the explosive equivalency. CPIAC research showed that while information on many hazards associated with M/OX mixtures were available and a study in 1957 showed the explosive limits of M/OX solutions, only a qualitative comparison of brisance to TNT existed and no calculation of explosive equivalency had been performed. The AFRL System Safety Office engaged CPIAC to perform the calculation of M/OX explosive equivalency.

CPIAC analysis showed that although theoretical explosive yields are always greater than TNT for typical propellant combinations including liquid hydrogen, liquid RP-1, and liquid methane, extensive study of detonations of liquid hydrogen and liquid RP-1 mixtures with liquid oxygen consistently show energy releases proportionally less than TNT. Due to the relative lack of physical detonation testing of M/OX mixtures, a comparative explosive equivalency analysis was performed based on both theoretical explosive yields as scaled by existing measurements of LH2/LOX TNT equivalency, as well as peak detonation pressures produced - where a calculated M/OX combination peak pressure had to be scaled by the ratio of the measured to calculated kinetic energy of the detonation waves produced. Both methods produced explosive equivalencies of near identical value, which are significantly greater than that of the DoD 4145.26-M, DoD Contractors Safety Manual for Ammunition and Explosives, guideline for generic hydrocarbons.

AFRL System Safety Engineering Office personnel plan to use the CPIAC analysis as the basis for an update to the guideline specifically recognizing the increased potential explosive hazard of M/OX mixtures.
The successful Mach-7 and Mach-10 flight tests of the Hyper-X/X-43A research vehicle have provided a major, essential demonstration of the capability of the airframe-integrated scramjet engine and hypersonic airbreathing vehicle design tools and vision vehicles. Such flights were a crucial step toward establishing airbreathing hypersonic propulsion for application to space-launch vehicles and other hypersonic systems. Many scientists, engineers and managers have contributed to these successful flight demonstrations, advancing the state-of-the science for achieving the dream for safe, efficient and reliable space access with airbreathing propulsion.

This special publication, NASA Hyper-X Project Overview Compilation, 1997-2006 (CD SP-0801 Volumes 1 and 2), is a compilation of the technology advances reported in Joint Army-Navy-NASA-Air Force (JANNAF) Meetings from 1997 to 2006, and recognition of the authors and their organizations that contributed to these X-43A flight demonstrations. Proceedings relevant to the X-43A technology advances were compiled from eight JANNAF Airbreathing Propulsion Subcommittee (APS)/Combustion Subcommittee (CS) Joint Meetings, representing a total of 113 technical papers; Volume 1 includes 57 unclassified papers and Volume 2 contains 56 classified papers. The two-volume publication may be purchased as a set or individually. Volume 1 is available for distribution now. An announcement will be made when Volume 2 is available for distribution.

CPIAC subscribers and other organizations registered with the Defense Technical Information Center (DTIC) and the Defense Logistics Information Service (DLIS) may request copies of this CD-ROM or individual papers herein by contacting The Johns Hopkins University, Chemical Propulsion Information Analysis Center, (CPIAC), 10630 Little Patuxent Parkway, Suite 202, Columbia, Md., 21044-3286, or by calling CPIAC’s Customer Service at 410-992-7305, ext. 212 or 202.
Congratulations, Phoenix Team!

CPIAC extends its congratulations to NASA’s Phoenix Mars Lander team for a successful landing on 25 May 2008. Phoenix (shown, at left) used twelve monopropellant hydrazine thrusters, each producing 293 N of thrust, in the first soft touch down on Mars in 32 years. This was the first successful landing without using airbags since Viking 2 in 1976. Lockheed Martin Space Systems, Denver, Colo., built the spacecraft using thrusters provided by Aerojet, Sacramento, Calif. Thruster cold flow and hot fire testing was performed at Lockheed Martin’s Engineering Propulsion Laboratory. The science mission is led by the University of Arizona, Tucson, and managed by NASA’s Jet Propulsion Laboratory, Pasadena, Calif.

Reliability, maintainability, quality, supportability and interoperability (RMQSI) are inherent design and performance attributes that are critical to mission success and customer satisfaction. The Reliability Information Analysis Center (RIAC), formerly the Reliability Analysis Center (RAC), has served as the U.S. DoD Center of Excellence for the identification, collection, analysis and dissemination of technical data and information on components, up through weapons systems, for 40 years.

Mission and Scope: The RIAC was created to provide technical support to the military, industry and academia in all areas of RMQSI. The breadth of expertise/experience of the RIAC team allows them to assist their customers in the cost-effective identification/implementation of solutions for their qualitative and quantitative problems. The scope of the RIAC encompasses RMQSI issues associated with hardware, software, human factors and processes over all phases of the system/product life cycle, from Concept Definition through Lifetime Extension/Disposal. The RIAC offers extensive services in Acquisition Support; Design and Process Support; Testing and Screening Support; and Logistics Support.

Publications and Training: The RIAC is one of the most successful IACs in developing products/tools (>85) and training courses (>25) that support the DoD and industrial RMQSI communities. The free, quarterly “Journal of the Reliability Information Analysis Center” addresses topics ranging from overviews for managers and new practitioners, to detailed state-of-the-art advances in technology and processes for experienced engineers and practitioners. Publications of note include (1) the 217PlusTM System Reliability Assessment methodology, (2) the RIAC failure rate and failure mode databook series (such as the Nonelectronic Parts Reliability Data (NPRD)), and (3) the Toolkit Series, which has evolved from the “RADC Reliability Engineer’s Toolkit” developed by the USAF Rome Air Development Center in 1988 into the current “System Reliability Toolkit”.

For additional information, visit http://theRIAC.org, or call 877-363-RIAC (toll free) or 315-351-4200.
In Memoriam

Dr. Thomas Rudy
Retired CSD Chemist

Dr. Thomas P. Rudy passed away April 29, 2008, of congestive heart failure and complications from a stroke. He was 84. Tom grew up in Illinois and attended Oberlin College until WWII. During the war, he served aboard Navy PBYs, and was awarded the Air Medal with three gold stars. After the war he earned a Master of Science and a Ph.D. in Organic Chemistry from the University of Chicago. He was elected to both Phi Beta Kappa and Sigma Xi.

Tom then worked at Shell Development in Emeryville, California, and later served as Assistant Professor in the Department of Chemistry and Institute of Organic Chemistry at the University of Chicago. He then joined United Technologies Chemical Systems Division (CSD), where he spent the remainder of his career. During his 30 years at CSD, he worked in the Research and Advanced Technology Department on polymers, burning rate catalysts and related chemicals for propellants. He holds 21 patents.

Tom was an enthusiastic but patient counselor and teacher. He was highly respected in the industry, especially at the Rocket Laboratory at Edwards Air Force Base. Outside of work, Tom loved Dixieland music. He traveled to many Dixieland festivals every year and played the banjo in a local jazz band. An innovative chemist and fine person, Tom Rudy will be missed.

Sidney E. Solomon
Former CPIA Senior Engineer

Sidney E. Solomon, age 84, died on February 13, 2008, at his home in San Bernardino, Calif. Sid’s long and dedicated career began at General Electric and concluded at the Aerojet General Corporation. But we, at CPIAC, remember him most for his contributions to The Johns Hopkins University Applied Physics Laboratory (JHU/APL) as a Senior Engineer with the, then, CPIA.

Mr. Solomon received his B.M.E. degree from Rensselaer Polytechnic Institute in Troy, New York, in 1949. His tenure with CPIA, which began in 1971, included service as the Chairman of the Joint Army-Navy-NASA-Air Force (JANNAF) Operational Serviceability Working Group. He was the first non-government employee to serve as an elected Chairman to the JANNAF organization. Sid’s contributions to JANNAF and CPIA were numerous, including technical initiatives and marketing efforts. His talent and humor are remembered fondly by those who had the fortune to work with and learn from him. He was predeceased by his wife, Phyliss, and is survived by his wife, Doris McDaniel Solomon and his children, Steven L. Solomon and his wife Louis of Myersville, Md., and Jerri Lynn Solomon of Mission Vieja, Calif.

AIAA Instructor-Led Course in Liquid Propulsion Systems Evolution and Advancements

July 24 - 25, 2008
Connecticut Convention Center
Hartford, CT

Synopsis

Liquid propulsion systems are critical to launch vehicle and spacecraft performance, safety, and cost. This two-day course, taught by a team of propulsion experts, will cover Rocket Propulsion Fundamentals; Propulsion Chemistry; Converting Chemistry into Performance; Launch Vehicle Propulsion; Spacecraft Propulsion; and Applying Propulsion Lessons Learned.

Who Should Attend

Engineers and managers involved in liquid propulsion component and system design, analysis, development, and certification for flight should attend. For additional information, visit www.aiaa.org.

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O
n April 23, 2008, CPIAC participated in the 5th An-
nual Physics Fair, sponsored by Johns Hopkins
University Physics and Astronomy Department.
Founded by Dr. Bruce Barnett in 2003, the Physics Fair was
a one-day educational event, featuring hundreds of demon-
strations on various properties of physics, a construction
project competition, a physics bowl for elementary, middle
and high school students, and sunspot observation through
the Astronomy Department telescope.

Michael McPherson of Aerojet, Gainesville, Va., present-
ed a continuous demonstration of his program, “Adventures
in Aerospace.” Both children and adults were especially
fascinated by his demonstration of surface properties using
balloons and skewers.

CPIAC’s exhibit at the event featured
a ball toss game; CPIAC employees
and their families assisting at the event
included CPIAC Director Edmund Liu
and Edwina Liu; Debbie Eggleston and
Allison Eggleston; Ndola and Amina
Carlest; Lisa, Scott, and Anna Nance;
and Patricia and Daniel Szybist.

At right, CPIAC Director Ed Liu (left) and Michael
McPherson take a break during the JHU Physics Fair.
India, Russia Develop Airborne Supersonic Cruise Missile
Source: RIA Novosti, 20 June 2008

The Russian-Indian BrahMos Aerospace joint venture has finished the development of the airborne version of an advanced supersonic missile, the company’s managing director has said. Established in 1998, BrahMos Aerospace designs, produces, and markets supersonic missiles, whose sea-based and land-based versions have been successfully tested and put into service with the Indian Army and Navy. The BrahMos missile has a range of 180 miles (290 kms) and can carry a conventional warhead of up to 660 pounds. It can hit surface targets while flying at an altitude as low as 10 meters (30 feet) and at a speed of Mach 2.8, which is about three times faster than the U.S.-made subsonic Tomahawk cruise missile. India is planning to produce at least 140 Su-30MKI fighters by 2014 under a Russian license with full technology transfer. Experts estimate that India might purchase up to 1,000 BrahMos missiles for its Armed Forces in the next decade. Full press release: http://en.rian.ru/world/20080620/111457741.html.

NASA, ATK Conduct First Launch Abort System Igniter Test for Orion
Source: SpaceRef.com, 16 June 2008

NASA and Alliant Techsystems, or ATK, reached another milestone Friday with the successful test firing of a critical safety component for the Orion crew exploration vehicle, NASA's next generation of spaceships. A 36-inch-long igniter for the abort motor of Orion’s launch abort system was fired at ATK’s facility in Promontory, Utah. In less than a second, the igniter generated approximately 21,000 pounds of thrust and produced combustion gas temperatures of more than 5,800 degrees Fahrenheit. Engineers will use the test firing to evaluate the igniter’s ballistic properties and pressure created inside its chamber. Preliminary data indicate the igniter performed as expected. The igniter is designed to fit inside the aft end of the abort motor for Orion’s launch abort system. In the event of an emergency, it will be used to ignite the solid propellant inside the abort motor casing. The motor uses a unique reverse flow technology with four nozzles mounted on the forward end. Once ignited, it will produce nearly a half-million pounds of thrust within milliseconds to pull the Orion crew module safely away from the Ares I rocket. Friday’s test was the first in a series of three igniter open air tests scheduled for 2008. A full-scale abort motor ground test will be conducted in September. In December, the entire Orion launch abort system will be demonstrated during a flight test at the U.S. Army’s White Sands Missile Range in N. Mex. Full press release: http://www.spaceref.com/news/viewpr.html?pid=25665.

Small Raytheon Missile Deployed On Predator
Source: Aviation Week, 13 June 2008

A small air-to-surface missile developed as a private venture by Raytheon is being deployed on the Predator unmanned aircraft by an unidentified customer. The Griffin is a 42-inch-long, tube-launched missile with a semi-active laser seeker, and is intended to give the Predator and smaller UAVs an organic, self-guided direct attack capability, Raytheon says. The short-range missile including its launcher weigh around 45 pounds, and the Predator will be able to carry up to three rounds for each Hellfire missile now carried. Although longer than Hellfire, the Griffin has a narrower diameter at 5.5 inches and a smaller warhead, reducing collateral damage. Raytheon says the low-cost weapon is modular, using technology from several of the company’s existing weapons including Javelin, AIM-9X and guided projectiles. Other seekers and warheads could be installed, the company says. Full press release: http://www.aviationweek.com/aw/generic/story.jsp?id=news/GRIFFIN061308.xml&headline=Small%20Raytheon%20 Missile%20Deployed%20On%20 Predator&channel=defense.
People in Propulsion

Team from Raleigh, North Carolina, Wins National Team America Rocketry Challenge
Students to Compete in U.K. this Summer

A team from Enloe High School in Raleigh, N.C., won this year’s sixth annual Team America Rocketry Challenge May 17, beating out 99 rivals for the national title. The 10-member team rose to the top of squads of middle- and high school-aged students facing off in the final round of the world’s largest rocket competition held outside of Washington, D.C. About 7,000 middle and high school students on 643 teams from 43 states and the District of Columbia took part in the qualifying rounds of competition.

The rocket contest presented the top 100 teams from around the country with a dual challenge. They had to launch their rockets as close as possible to an altitude of 750 feet with a flight time of 45 seconds, while returning a payload of two raw eggs unbroken to the ground. The Enloe High team logged a score of 23.94 to take the title. Each point represents a deviation from altitude and time aloft targets, so the lower the score, the better. Mulberry Grove (Ill.) High School took second place with a score of 29.88, while Kickapoo High School from Springfield, Mo., placed third with a score of 30.54.

The contest, sponsored by the Aerospace Industries Association and the National Association of Rocketry, is designed to encourage students to consider careers in aerospace, as nearly 60 percent of the U.S. aerospace workforce is 45 or older, according to AIA statistics. Upcoming plans for the winning team include a summertime trip to the Farnborough International Airshow and a fly-off against the winners of the U.K. Aerospace Youth Rocketry Challenge from Horsforth Secondary School in Yorkshire. Raytheon Company, a major supporter of the competition, is sponsoring the team’s trip as part of the TARC winners’ first prize package for the third year.

“’I applaud not only the winners, but every student who took part, and the teachers and mentors who helped along the way. This is an encouraging sign as the aerospace industry faces a looming workforce shortage.’”

Marion Blakey
AIA President and CEO

In addition to a trip to London, the winners share a prize pool of more than $60,000 with other top finishers. Lockheed Martin Corporation will provide $5,000 scholarships to each of the top three teams, and the 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. AIA President and CEO Marion Blakey said the contest was a great success in achieving its goal of attracting young people to consider careers in the aerospace field.

“These middle and high school students showed their ability to take mathematics and physics concepts and apply them to the real world,” Blakey said. “I applaud not only the winners, but every student who took part, and the teachers and mentors who helped along the way. This is an encouraging sign as the aerospace industry faces a looming workforce shortage.”

Members of the Enloe High School team are Levon Keusseyan, Alexander Viten, Julianne Schmitz, Zachariah Smith, Timothy Kijewski, Christopher Cox, A.J. Grant, James Cuffney, Francisco Cobo and Justin Bost. Their teacher/advisor is Bradley Bowen.

Complete competition results are available at http://www.rocketcontest.org.
Calendar of 2008 JANNAF Meetings and Events

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 JCC for the government rate of $99.00/night; refer to LSM for the industry rate of $199.00/night)
Hotel Reservation Deadline: November 17, 2008
Reg. Forms due at CPIAC by: November 24, 2008

For additional information on the above JANNAF meeting, contact CPIAC Meeting Planners Pat Szybist or Krystle Jones at 410-992-7302, ext. 215, or 410-992-7301, ext. 201, 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).

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