

JANNAF

JOINT ARMY-NAVY-NASA-AIR FORCE
INTERAGENCY PROPULSION COMMITTEE



NEWS

Volume 5, Issue 1 Released May 4, 2016

JANNAF to Discuss Technical Advances at its 63rd Meeting in Newport News, Virginia

Final preparations are underway for the spring Joint Army-Navy-NASA-Air Force (JANNAF) Interagency Propulsion Committee meeting. The May 2016 meeting, which will consist of the 63rd JANNAF Propulsion Meeting; the Programmatic and Industrial Base (PIB) Meeting; and the Joint Meeting of the 47th Combustion, 35th Airbreathing Propulsion, 35th Exhaust Plume and Signatures, and the 29th Propulsion Systems Hazards Subcommittees, will be held Monday through Thursday, May 16-19, at the Newport News Marriott at City Center in historic Newport News, Virginia. The meeting will be chaired by Dr. Christine M. Michienzi, Office of the Under Secretary of Defense for Acquisitions, Technology and Logistics, Deputy Assistant Secretary of Defense for Manufacturing & Industrial Base Policy (OUSD(AT&L)/DASD, MIBP), Alexandria, VA., and the program currently includes 40 technical sessions with more than 200 presentations. In addition, five specialist sessions, two workshops, 10 panel meetings, two town hall meetings, and three working group meetings will take place during the conference. Welcoming remarks will be made by Dr. David E. Bowles, Director of NASA Langley Research Center (LaRC), before the awards ceremony. A tour of

several sites at the nearby NASA LaRC will be offered on Friday, May 20 for those interested in exploring and celebrating its history as 2015 marked NASA's, 100th anniversary under the names of NASA and NACA, the National Advisory Committee for Aeronautics.

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Dr. Christine M. Michienzi, Office of the Under Secretary of Defense for Acquisitions, Technology and Logistics, Deputy Assistant Secretary of Defense for Manufacturing & Industrial Base Policy, will chair the 63rd JANNAF meeting.

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The JHU WSE Energetics Research Group (ERG) is the technical support contractor of the Joint Army-Navy-NASA-Air Force (JANNAF) Interagency Propulsion Committee. The purpose of JANNAF is to solve propulsion problems, affect coordination of technical programs, and promote an exchange of technical information in the areas of missile, space, and gun propulsion technology.

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ERG's Technical/Bibliographic Inquiry Service

ERG offers a variety of services to its subscribers, including responses to technical/bibliographic inquiries. Answers are usually provided within three working days, in the form of telephoned, faxed, 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 ERG staff responds to nearly 400 inquiries per year, from over 150 customer organizations. For further information, please contact Nick Keim by email to nkeim@erg.jhu.edu. Representative recent inquiries include:

TECHNICAL INQUIRIES

- Data on nitrile rubber property degradation for long-term storage at elevated temperatures with exposure to air (Req. 28232)
- Information on HPLC or IC methods for determination of amide content in 2-(5-Cyanotetrazolato)Pentammine Cobalt(III) Perchlorate (BNCP) (Req. 28117)
- Sensitivity, impact (ERL/BOE), friction (Joules), VTS, and shock data for lead azide, lead styphnate, and RDX (Req. 28096)

BIBLIOGRAPHIC INQUIRIES

- Collection of reports related to the Scaled Composites accident in July 2007 (Req. 28221)
- Performance tailoring of extruded double-base propellants. Topics included I_{sp} modification, mechanical properties, sensitivity, etc. (Req. 28089) and noncompositional effects on double-base propellant performance. (Req. 27981)
- Literature on self-ignition or detonation of LOX-RP pools (Req. 28135)

RECENT JANNAF DOCUMENTS

- June 2015 meeting proceedings are available in the JANNAF Digital Online Collection (JDOC) database, accessible through the JANNAF website (<https://www.jannaf.org/>).

ERG Subscriptions

ERG forwarded GFY 2016 subscription renewal packets to its customer base for continued products and services. We would like to take this opportunity to inform the community that a minimum subscription of \$1,775 entitles subscribers to one complimentary suite of JANNAF databases; one complimentary *JANNAF Journal*; and six hours (prepaid) of technical/bibliographic inquiry hours. For information concerning a ERG subscription and/or products and services, please contact Hwei-Ru Chen at 410-992-7300, ext. 212 or email hchen@erg.jhu.edu. You may also visit <https://www.erg.jhu.edu/subscriptions>.

JANNAF Heads to Newport News...*continued from page 1*

The keynote for this spring's JANNAF meeting will be presented by Ms. Karen S. Burrows, Executive Director of the Naval Ordnance Safety and Security Activity (NOSSA) and the Deputy for Weapons Safety, Naval Sea Systems Command (NAVSEASYSKOM). Ms. Burrows, whose areas of expertise include energetic materials, insensitive munitions, and weapons research, development, testing, and evaluation, will focus on the Navy's Ordnance Safety Program in an address entitled, "An Overview of U.S. Naval Weapons and Ordnance Safety; Past and Present."

As the executive director of NOSSA, Ms. Burrows provides executive and technical direction for all weapons ordnance and safety programs in the Department of the Navy. She also chairs the Navy's Weapon System Explosives Safety Review Board. The board reviews the safety of all Navy and Marine Corps munitions, ordnance items, weapons, and combat systems prior to fielding to operating forces. Karen Burrows has 29 years of experience in the Department of Defense (DoD), and she was appointed to the Senior Executive Service in April 2012. During her time at the DoD, Ms. Burrows has held a number of key positions. From 2010-2012, she served as the deputy administrator and chief information officer for the Defense Technical Information Center. Previously, she held posts in the Naval Surface Warfare Center. Ms. Burrows has a B.A. in chemical engineering from Carnegie Mellon University, and she has authored numerous technical publications. She has also received a number of awards and recognitions including two Department of the Navy Meritorious Civilian Service Awards.

Besides the organized sessions and workshops, meeting participants will have many opportunities for networking and collaboration. As author Helen Keller once said, "Alone we can do so little; together we can do so much." This principle still holds true today. A networking room will be available for participants' use during the meeting. Refreshments will be provided during scheduled breaks in the program. JANNAF will also host a networking dinner on Wednesday evening at no cost for registered meeting attendees. The Newport News Marriott is located within a large town-center development with many nearby restaurants and shops. This will provide opportunities for meeting attendees to socialize and network in a casual setting away from the hustle and bustle of the JANNAF meeting. For



Karen S. Burrows, Executive Director of the Naval Ordnance Safety and Security Activity (NOSSA) and the Deputy for Weapons Safety, Naval Sea Systems Command, will focus on the Navy's Ordnance Safety Program in her keynote address at the JANNAF meeting in Newport News, Virginia.

attendees looking to explore further afield, the city of Newport News contains a number of cultural attractions including the Mariners' Museum and Park, a facility that houses an international collection of artifacts related to maritime history, including an exhibit on the *USS Monitor*, the innovative Civil War ironclad that fought against the *CSS Merrimack* in the 1862 Battle of Hampton Roads. The museum is located approximately three miles from the Marriott at City Center. Another location that may be of interest to meeting attendees is historic Fort Monroe National Monument in nearby Hampton, Virginia. Constructed in 1819, the stone fort—the largest ever built in the United States—guarded the entrance to Hampton Roads and the mouths of the James and Elizabeth Rivers throughout the 19th and 20th centuries.

For additional information about the JANNAF meeting, please visit <https://www.jannaf.org/meetings>.

In Memorium

On December 13, 2015, Dr. Kendall Brown, NASA JANNAF Programmatic and Industrial Base Committee Lead, lost his battle with cancer. At the time of his death, Brown, 52, led NASA's integrated support to the JANNAF Interagency Propulsion Committee's Programmatic and Industrial Base Committee (PIB), a role for which he received the 2015 JANNAF Management Award.

Brown's JANNAF PIB Committee co-chair, Dr. Christine Michienzi, noted, "It was clear to me that he was one of the main driving forces behind JANNAF PIB and that his enthusiasm and dedication were unmatched. Kendall came in at the ground floor of JANNAF PIB and he worked tirelessly to put together a cohesive organization that would fulfill the PIB mission. His knowledge of the rocket propulsion industrial base was extensive and he understood how vital this resource was for both NASA and the DoD." Michienzi concluded, "I know I share the feeling of others in the PIB by saying that Kendall's shoes are impossible to fill and that we still feel the void that he left to this day."

The PIB has established the Kendall Brown award in his honor, which will be conferred on individuals who demonstrate the same excellence as Brown in their work with the PIB.

Kendall Brown joined NASA's Marshall Space Flight Center in 2000 after serving as chief propulsion engineer for Space America, Inc., where he helped to design, develop, and test an ultra-low-cost launch vehicle employing a liquid oxygen and kerosene propulsion system. At NASA, he continued his work with liquid oxygen and kerosene propulsion technology, serving as lead system engineer for the RS-84 prototype engine. He also participated in design work on the J-2X and RS-83 engines and provided operational support for the Space Shuttle Main Engine. Brown later served as a manager for numerous projects including design and development of lunar lander propulsion systems for the Altair Lunar Lander Project and Mars entry, descent, and landing studies. In 2011, he co-led a study of interagency collaboration in the field of rocket



Dr. Kendall Brown (1963-2015)

propulsion systems that resulted from the National Rocket Propulsion Strategy congressional action. All of these activities provided a solid foundation for Brown's work with the JANNAF PIB community.

Kendall Brown was born in Oklahoma on October 3, 1963, and grew up in the region. He studied at Oklahoma State University, earning a B.S. in mechanical engineering in 1985, before moving to Washington State to complete an M.S. in aeronautics and astronautics at the University of Washington in 1991. He went on to earn a Ph.D. in mechanical engineering from the University of Alabama in Huntsville in 1996. In addition to his academic accomplishments, Brown served in the U.S. Air Force Reserve, retiring as a Lieutenant Colonel in 2008. He is survived by his wife, Robin Crow Brown, his son, Kevin Robert Brown, and his daughter, Cecily Anne Brown.

JANNAF News is seeking short technical articles for future editions.

All articles must be Distribution Statement A.

If you are interested in submitting an article or have any questions, please contact

***Managing Editor Benjamin Schwantes at
BSchwantes@erg.jhu.edu***

Johns Hopkins Researchers Aim for Safer, More Efficient Rocket Engines

The U.S. Air Force has awarded two contracts totaling \$1.48 million to the Energetics Research Group (ERG), based within Johns Hopkins University's Whiting School of Engineering, to help set the stage for the next generation of U.S.-made rocket engines.

The funding will be used to reduce risks associated with new technologies that may replace the widely-used, Russian-made RD-180 engine, which is employed for carrying communications satellites into orbit and delivering equipment to the International Space Station. U.S. officials are trying to move toward domestic-made, high-performance rocket engines for domestic launch applications. The new Air Force

***“Both of these new awards position the Johns Hopkins Whiting School of Engineering for significant participation in the development and sound operation of the next generation of liquid rocket engines”
-Peter Zeender, Director, ERG***

funds will be allocated over a two-year period linked to two separate contracts. The funding will enable researchers to study the viability of 3D-printed parts, as well as the use of methane and liquefied natural gas as fuels in future alternative rocket engines. Current engines utilize kerosene and liquid oxygen as propellants.

Johns Hopkins is the only university to receive funding from the U.S. Air Force Space and Missile Systems Center's recent program, which granted ten awards totaling \$34.6 million.

“Both of these new awards position the Johns Hopkins University Whiting School of Engineering for significant participation in the development and sound operation of the next generation of liquid rocket engines,” stated Peter Zeender, director of the Whiting School's ERG.



Fuel storage at the JHU WSE ERG AERo Fuels Lab.

“We are very excited for this opportunity to engage in research that will ensure the safe and efficient use of other liquid fuels in the next generation of rocket engines.”

The first contract, valued at \$545,000, will fund the study of 3D printing techniques to test production and performance of advanced cooling concepts within rocket engines. This new and fast-growing technique offers and allows more flexible design options for the critical cooling channels within the engines. The ERG will try to determine if the 3D printing method can provide better performance benefits than traditional manufacturing methods.

The second contract, valued at \$935,000, was awarded to evaluate the performance of two alternative fuels - methane and liquefied natural gas. The Johns Hopkins engineers will develop new equipment to test cooling channel performance, carbon deposition, and its ability to withstand high temperatures of these two fuels on a small scale.

The work will be performed at the Advanced Engine and Rocket Fuels Lab, WSE ERG's laboratory located in Columbia, MD. The lab was established to develop the equipment that tests the kerosene-based fuel that is currently used on RD-180 engines.

“These awards are a logical extension of the work we've conducted on thermal stability, propellants and materials that our lab has conducted

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JANNAF Continues to Examine Additive Manufacturing's Role in Propulsion Applications

The JANNAF community has expressed great interest in the topic of additive manufacturing. In September 2014, the Liquid Propulsion Subcommittee hosted an Advanced Materials Panel Technical Interchange Meeting on Additive Manufacturing in Propulsion Applications. Three months later, the JANNAF Executive Committee tasked the Energetics Research Group tech staff and the Liquid Propulsion Subcommittee with assessing how JANNAF can include the topic of additive manufacturing in all of its propulsion and energetics discussions and activities. In June 2015, the Liquid Propulsion Subcommittee dedicated two sessions and a total of 13 papers to the application of various additive manufacturing techniques to the solid and liquid components fields. The subcommittee concluded the day with an invited panel session on Flight Certification of Additive Manufacturing Parts. Along with the emphasis on additive manufacturing topics during conference planning, papers addressing the topic were presented in various regular conference sessions. For instance, during the December 2015 JANNAF meeting in Salt Lake City, multiple papers focused on additive manufacturing of energetic components.

Clearly, additive manufacturing has attracted widespread attention throughout JANNAF application areas, but the abundance of papers at the aforementioned sessions should not obscure the fact that technical unknowns remain. JANNAF provides an ideal forum for evaluating this new manufacturing technique and its qualification for flight processes. Within the Airbreathing Propulsion field, additive manufactured parts have already appeared in production jet engines and may form part of the engine hanging on the wing outside your airplane window the next time you travel. The Executive Committee's challenge is clear: What can the JANNAF community do to provide material

and component designers with the knowledge they need to accurately and safely use additive manufacturing techniques to reduce design/build timelines, parts counts, or to make previously unobtainable designs a standard feature of complex propulsion systems?

The JANNAF community should be aware of two initiatives related to additive manufacturing and should consider participating in them. First, the Advanced Materials Panel of the Liquid Propulsion Subcommittee has released the call for presentations for the Second Technical Interchange Meeting on Additive Manufacturing in Propulsion Applications, to be held in Huntsville, AL, Aug 23-25, 2016 (see below). The call for presentations is available to all JANNAF subscribers and accessible through the Meetings section of the website (<https://www.erg.jhu.edu/meetings>). Second, in response to the Executive Committee's Action Item, a special JANNAF Portal area for discussion and distribution of additive manufacturing information across all the JANNAF Subcommittees will be established in order to engage the JANNAF community. While each subcommittee portal is normally focused on engaging the community members of that subcommittee, the Additive Manufacturing Portal will grant access to any JANNAF member who requests it. The portal's capability to host virtual dialogs and running commentary on various subjects will be brought to bear on this diverse and complex area. Initially, the Executive Committee will identify individuals who will be granted membership to this portal, and the ERG tech staff will moderate, and populate the portal with papers from conferences, presentations made available by members, and additional highlights and news summaries related to the topic. To participate in either the TIM in August or the Additive Manufacturing Portal, please contact any member of the ERG tech staff for assistance.

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JANNAF Meeting Examines Programmatic Issues Facing Industry and Government, Scale-Up of Energetic Materials

The December 2015 JANNAF meeting in Salt Lake City, Utah, encompassed sessions from the Structures and Mechanical Behavior Subcommittee, Propellant and Explosives Development and Characterization Subcommittee, Rocket Nozzle Technology Subcommittee, and the Safety and Environmental Protection Subcommittee. A day-long event focusing on Programmatic Industrial Base (PIB) programmatic challenges facing rocket propulsion industry leaders as well as senior government leaders, and a full-day session on additive manufacturing were very popular events throughout the week. Dr. Louis Cannizzo, Director of Research and Development at Orbital ATK, gave a keynote speech about scale-up of energetic materials, during which he discussed the process, hazards characterization, property characterization, and material specification and process documentation for safe scale-up of energetic materials. During his speech, Dr. Cannizzo stressed the importance of studying changes in raw material and process details when working with energetics to determine if critical properties have also changed during scale-up from laboratory to production process environments.

“You really need to understand all the different chemical reactions used to make the material, what drives those reactions, what are the right conditions to maximize yield, to maximize purity,” Cannizzo noted about process chemistry studies. “And really understand as you go into production, if you have issues, which knobs can you turn to go ahead and dial in your process to make good material.”

The Programmatic Industrial Base held a morning panel discussion among industry leaders from Orbital ATK, Aerojet Rocketdyne, Raytheon, and Lockheed Martin. The panel, chaired by John McGinn, Office of the Under Secretary of Defense (OUSD) for Acquisitions, Technology and Logistics (AT&L), Manufacturing and Industrial Base Policy (MIBP), addressed the questions: “What are the real threats and impediments to meeting performance goals for the future weapons systems? How should Government be involved and how is your company addressing these threats?” This panel of industry leaders was followed by an afternoon specialist session, chaired



Keynote speaker Dr. Louis Cannizzo, Director of Research and Development, Orbital ATK.

by Dr. Christine Michienzi, OUSD AT&L/DASD, MIBP, which focused on the rocket motor industrial base. Senior government leaders at NASA and DoD program offices discussed their challenges and addressed the question: “What keeps program offices up at night?” The issues facing both the industry and government program offices were similar, according to Dr. Michienzi.

“One of the most interesting things that I took away from both the Panel Meeting and the Specialist Session is that both industry and government program offices have similar concerns, some of which are: workforce and innovation are hampered by decreasing budgets, that there is no funding and cohesive plan to address material obsolescence, small market shares and production rates due to low budgets preclude competition, lack of access by program offices to sub-tier suppliers,” Dr. Michienzi stated. “[The sessions] were well attended, there was a lot of interaction during the sessions, and I received many complimentary comments. We plan to conduct more panel meetings with other RPIB sectors in future JANNAF meetings, as well as additional specialist sessions, as we try to get Government Program Offices more involved in JANNAF PIB.”

During the JANNAF awards ceremony, the Bernard J. Alley Award was presented to Dr. James G. Carver for outstanding sustained service to Propellant Development and Characterization Technology. Dr. Carver also received a JANNAF Executive Committee Lifetime Achievement Award.

Orbital ATK and the JHU WSE ERG Host TIM Addressing Solid Rocket Motor Segmenting Best Practices

Orbital ATK, in collaboration with the Johns Hopkins University Whiting School of Engineering Energetics Research Group (ERG), hosted a Technical Interchange Meeting summarizing Solid Rocket Motor Segmenting Best Practices and Lessons Learned on March 21-23, 2016, at the Orbital ATK Conference Center in Ogden Canyon, Utah. Representatives from Aerojet Rocketdyne, the U.S. Air Force, AMRDEC, AFRL Edwards, Hill AFB, NAWC, NSWC, Gradient Technologies, Tooele Army Depot, and Orbital ATK were in attendance. The two-and-a-half day event was designed to promote safety through open discussions of solid rocket motor segmenting methods, process safety and hazards assessment practices, incident reporting and resolution, techniques congruent with current state of the practices, and emerging technologies. Electrochemical milling, band saw and diamond-wire saw cutting, and alternate dissection methods were among the current solid rocket motor dissection techniques discussed in detail.

Scott Hyde of Orbital ATK opened the meeting by welcoming the attendees and encouraging honest and open discussions with the shared goal of developing a more thorough understanding of hazards, future challenges, and the best path for supporting warfighters. Munitions expert Lt. Col. Vincent Krepps, formerly of Hill AFB, voiced an end-user's perspective on the value and impact of the work being executed by the

attendees, and engaged the audience in a productive question and answer exchange. Eleven technical presentations by industry experts spanned the invitation-only event, with periodic open-group discussions of the differing challenges of safely executing tasks associated with demilitarization, surveillance, and reclamation of solid rocket motors. Various methods and techniques for segmenting solid rocket motors were reviewed, and the benefits and liabilities of each technique were discussed. Foreign country capability and field expedient demilitarization techniques were also addressed. A cooperative exercise closed out the technical portion of the meeting. Small teams were tasked with developing a skeletal framework and recommending a course of action in order to meet the requirements of a client, for example, ordnance items of various types and serviceability. The exercise was intended to highlight attendees' range of experience and diverse skillsets.

The final half-day of the event included a tour of Orbital ATK's diamond wire cutting operation, propellant washout and reclamation facility, and solid rocket motor casting facility. TIM attendees gathered for lunch in a private Orbital ATK dining hall to share a meal and their impressions of the two-and-a-half day collaborative event. Several attendees voiced requests for a follow-up exchange on rocket segmenting, as well as a similarly structured meeting to discuss related topics, particularly surveillance and aging of propellants.



Stuart Blashill presents Dr. James G. Carver with the 2015 Bernard J. Alley Award for outstanding sustained service to Propellant Development and Characterization Technology (left). Paul F. Jones, Program Chair of the 2015 JANNAF Meeting, presents Dr. Carver with a JANNAF Executive Committee Lifetime Achievement Award (right).

Rocket Engines... *continued from page 5*

over the last three years,” said Nick Keim, principal investigator of the ERG’s AERo Fuels Lab. “It allows us to reduce the risks associated with new technologies that are being proposed for

“We are very excited for this opportunity to engage in research that will ensure the safe and efficient use of other liquid fuels in the next generation of rocket engines”

-Peter Zeender, Director, ERG

the next generation of liquid rocket engines.”

The results from this research will be made available to the U.S. Air Force and subsequently to other U.S. manufacturers that are working on the new liquid rocket engines that could replace the current Russian engines with a domestic-made model.



Andrew Taylor, ERG, works on the CRAFTI fuel analysis apparatus at the JHE WSE ERG AERo Fuels Lab.

64th JPM / PIB / 11th MSS / 9th LPS / 8th SPS to Meet

Date: December 5 – 9, 2016

Phoenix, Arizona

Plans are underway for the December 2016 meeting of the Joint Army-Navy-NASA-Air Force (JANNAF), which will consist of the 64th JANNAF Propulsion meeting (JPM); the Programmatic and Industrial Base meeting (PIB); and the Joint Meeting of the 11th Modeling & Simulation (MSS)/ 9th Liquid Propulsion (LPS) / 8th Spacecraft Propulsion (SPS) to be held Monday through Friday, December 5-9, 2016. The location will be Phoenix, Arizona

Call for Papers

The Call for Papers will be released after the May 2016 JANNAF meeting.

More Information

Program and keynote information will be available in October 2016.

A preview of the meeting will be featured in the Fall 2016 issue of *JANNAF News*.

Questions

Technical questions may be addressed to the following ERG technical representatives:

- JPM – Peter Zeender (pzeender@erg.jhu.edu / 443-718-5001)
- PIB – Kirk Sharp (ksharp@erg.jhu.edu / 228-234-5423)
- MSS – Nicholas Keim (nkeim@erg.jhu.edu / 443-718-5005)
- LPS – Peter Zeender (pzeender@erg.jhu.edu / 443-718-5001)
- SPS – David Owen (dowen@erg.jhu.edu / 443-718-5006)

For all other meeting-related matters, please contact Shelley Cohen (scohen@erg.jhu.edu / 410-992-7302).

APS Selects Best Paper Award Winners

A Message from Larry Huebner, Chairman, Airbreathing Propulsion Subcommittee

Following the very successful 34th Airbreathing Propulsion Subcommittee Meeting held December 8-11, 2014, in Albuquerque, NM, 11 of the 80 technical papers that were presented were nominated by APS Technical Steering Group Members and Session Chairs for detailed review to determine the Best Paper from the meeting. Two of those papers clearly stood out when the final scores were tabulated, so we have co-winners this year. The two papers are: “Analysis of Facility Thermodynamic Non-Equilibrium Effects on HIFiRE Ground Tests,” by Robert Baurle, NASA Langley Research Center, Hampton, VA, and “Morphing Ceramic Components for Hypersonic Ground Test Facilities,” by Jonathan Osborne, MIRA Facilities, Arnold AFB, TN; David Marshall, Sergio Lucato, and Brian Cox, Teledyne Scientific Co, Thousand Oaks, CA; Ryan Milligan, Taitech, Inc., Beaver Creek, OH; and Ed Massey, Teledyne Brown Engineering, Huntsville, AL.

The first paper presents a computational fluid dynamic analysis performed to address the impact of thermal non-equilibrium to bridge the gap from direct-connect ground tests to flight for the HIFiRE Flight 2 experiment. The approach used a two-temperature thermal non-equilibrium formulation (translational/rotational and vibrational/electronic temperatures) that has recently been added to the VULCAN-CFD code.

The second paper discusses the development of the technologies needed to build a shape-morphing ceramic two-dimensional variable Mach number direct-connect nozzle and a two-dimensional direct-connect flow distortion generator for hypersonic aero-propulsion ground test facilities to support future scramjet engine research programs.

On behalf of the best paper review committee, as well as the 11 APS members who reviewed papers, I hope you join me in offering a hearty congratulations to the recipients of this well-deserved honor.



*Lawrence D. “Larry” Huebner,
NASA Marshall Space Flight Center*

***JANNAF Journal Volume 6, Issue 2,
a special edition focusing on NASA’s HIFiRE Flight 2 experiment,
will be available in May 2016.
Keep an eye out for it!***

CADRE Announces New Name, Expanded Role at Johns Hopkins University Whiting School of Engineering

A message from Peter Zeender, Director, Energetics Research Group

Dear members of the JANNAF Community, I am pleased to announce that CADRE, formerly CPIAC, is embarking on an expansion of our research role in propulsion and energetics in an effort to strengthen our alignment with the Johns Hopkins University (JHU) Whiting School of Engineering's (WSE) research initiatives. This exciting change involves changing our name from CADRE to the JHU WSE Energetics Research Group (ERG); a fitting way to celebrate 25 years of service within the Whiting School. This repositioning has occurred in response to burgeoning interest at WSE in pursuing commercial and government research opportunities, specifically, research in the critically important field of energetics.

The ERG will continue to carry on our 75-year legacy of advancing scientific discovery through collaborative research, serving as a national resource for the energetics and propulsion research community. We are committed to connecting the public and private sectors to share solutions for technical challenges by forming targeted teams through industry partnerships and cooperation with universities. That mission is now enhanced with a stronger network of resources and expertise from JHU.

Additionally, because of the ERG's demonstrated success with DoD and NASA government research contracts through its support for JANNAF and other propulsion projects, I will also be leading the newly formed Commercial and Government Program Office (CGPO), which will fall directly under the auspices

of the WSE Dean's office. This office was established for the purposes of sharing our expertise in government relations and connecting members of industry, and government with the rest of the school to grow its relations in

those areas. The office will enable the ERG, as well as other parts of JHU WSE, to respond to growing needs from both DoD and NASA and other members of industry and government agencies.

It is an exciting time for our organization, and we are growing our support for DoD and NASA, as well as our research and testing of fuels for rocket applications in the Advanced Engine Rocket (AERo) Fuels Laboratory, which has recently moved off campus to a location closer to ERG's offices in Columbia, Maryland. The AERo Fuels Lab recently won two awards to design additive manufactured parts for components of solid rocket engines, and test the thermal stability of methane, under contract with the U.S. Air Force Space and Missile Systems Center.

For more information on the Energetics Research Group, please visit our website, at www.erg.jhu.edu.



*Peter Zeender, Director,
Energetics Research Group*



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JHU Undergrads Attempt to Replicate Ancient Chinese Rocket

Did you know that the 14th-century Chinese military developed multistage, dragon-shaped rockets that were probably more effective at frightening enemies than actually hitting a target? Two recipients of the year-long JHU Provost's Undergraduate Research Award investigated the topic of ancient Chinese rockets and presented their findings to the campus community. Seniors Alex De La Vega and Streit Cunningham, who study physics, wondered about the plausibility of a dragon-shaped weapon described in the *Huolongjing*, a military treatise from the early Ming Dynasty. They built a prototype from materials most likely used by the rocket's originators: bamboo for the body and a dragon-shaped head and tail fins made from 3D-printed plastic that mimicked the density of elm wood. They found recipes for gunpowder and (safely, they assure) tested various gunpowder and packing techniques to achieve



Streit Cunningham and Alex De La Vega

the trajectory described in the Ming papers. Though they had one semi-successful launch in which the thrust from the back rockets resulted in the device flopping forward, De La Vega and Cunningham did not succeed in creating the multistage rocket that launches into the sky and rains down fire, as described in the *Huolongjing*. They concluded that while it is possible that the rocket did exist, it was most likely used as a scare tactic or as military propaganda.

Story contributed by Saralyn Lyons, JHU Hub (<http://hub.jhu.edu/2016/04/28/provost-undergraduate-research-award>)

Calendar of JANNAF Meetings

JANNAF Liquid Propulsion Subcommittee (LPS) Advanced Materials Panel Technical Interchange Meeting (TIM) on Additive Manufacturing for Propulsion Applications: August 23-25, 2016

Huntsville, Alabama

Deadlines:

- | | |
|-------|--|
| Jul 1 | Deadline for changes to meeting invitation and preliminary program |
| Aug 5 | Deadline for receipt of charts and clearance forms |
| Aug 5 | Deadline for receipt of registration certification forms |

For additional information and registration, please visit:

https://www.jannaf.org/mtgs/Aug2016_LPS_AMP_TIM/pages/index.html

For additional information on the above JANNAF meetings, contact ERG at 410-992-7302.

JANNAF Meeting Attendance Policy:

Attendance is restricted to U.S. citizens qualified to receive unclassified, limited-distribution information. To qualify, the attendee must be employed by a U.S. Government facility, or with a U.S. Government contractor facility, or have a U.S. Government sponsor. No foreign nationals will be permitted to attend. Non-government attendees must provide the organization's DD 2345 Certification Number for receipt of militarily-critical technical data. DD 2345: For additional information, contact the Joint Certification Program Office (JCP) at 1-800-352-3572 or visit their Web site at www.dlis.dla.mil/jcp/.

Registration for JANNAF meetings is a **two-part process**; to complete this process:

- All attendees must have a JANNAF Secure Portal. If you do not have a JANNAF Secure Portal then go to: www.jannaf.org. When creating an account, please allow sufficient time for this process as it may take several days to complete.
- Once you have an approved JANNAF Secure Portal, then you can visit the TIM registration page (https://www.jannaf.org/mtgs/Aug2016_LPS_AMP_TIM/pages/registration.html) and complete the brief Registration Questionnaire.

Questions concerning attendance eligibility should be directed to the ERG Assistant Facility Security Officer, Tricia Reider, at treider@erg.jhu.edu or (410) 992-7300, ext. 222.