



NEWS

Volume 8, Issue 1 Released May 16, 2019

JANNAF to Meet in Dayton, Ohio, for Spring 2019 Meeting

JANNAF attendees head to the Buckeye State for the June 2019 JANNAF Meeting from June 3-7, 2019. The meeting will take place at the Dayton Convention Center in downtown Dayton, Ohio, a short distance from Wright-Patterson Air Force Base and the National Museum of the United States Air Force. Classified sessions will be hosted on base by the Air Force Research Laboratory. The June JANNAF Meeting will feature a joint gathering of the 49th Combustion Subcommittee (CS), 37th Airbreathing Propulsion Subcommittee (APS), 37th Exhaust Plume and Signatures Subcommittee (EPSS), and 31st Propulsion Systems Hazards Subcommittee (PSHS), as well as the 66th JANNAF Propulsion Meeting (JPM) with some joint sessions cohosted by the Modeling and Simulation Subcommittee (MSS) and a meeting of the Programmatic and Industrial Base (PIB). This spring's meeting will feature two new mission areas under MSS – Digital Engineering; and Simulation Credibility: Uncertainty, Verification, Validation and Risk. The Dayton meeting will be chaired by David R. Gon-

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David R. Gonzalez, Ph.D., NSWC-IHEODTD, Indian Head, Md., will chair the JANNAF Meeting in Dayton, Ohio.

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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 is the technical support contractor for the JANNAF Interagency Propulsion Committee operated by The Johns Hopkins University Whiting School of Engineering under contract FA9300-19-C-0002.

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PROCEEDINGS

- Abstract Number: 2018-0003
Meeting Proceedings from the "Additive Manufacturing for Propulsion Applications Technical Interchange Meeting"
Aug 2018
- Abstract Number: 2018-0004
Meeting Proceedings from the "In-Space Chemical Propulsion Technal Interchange Meeting"
Aug 2018
- Abstract Number: 2018-0005
Meeting Proceedings of the 45th SMBS, 41st PEDCS, 32nd RNTS, and 30th SEPS Joint Subcommittee Meeting / Programmatic and Industrial Base Meeting (Vancouver, Wash.)
Dec 2018
- Abstract Number: 2018-0009
JANNAF Journal, Volume 9, Issue 1 (2018)
Dec 2018
- All meeting proceedings are available in the JANNAF Digital Online Collection (JDOC) database, accessible through the JANNAF website (<https://www.jannaf.org/>).

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zalez, Ph.D., with the Naval Surface Warfare Center, Indian Head Explosive Ordnance Disposal Technology Division (NSWC-IHEODTD), Indian Head, Md.

Mark J. Lewis, Ph.D., Director of the Institute for Defense Analyses' Science and Technology Policy Institute (STPI), will serve as keynote speaker on Tuesday, June 4. Lewis leads more than 40 researchers at STPI, which is a federally funded research and development center that provides analysis of national and international science and technology issues to the Office of Science and Technology Policy in the White House, as well as to other federal agencies. Prior to joining the

JPM will collaborate with MSS to co-host two new mission areas at the Dayton JANNAF Meeting: Digital Engineering; and Simulation Credibility: Uncertainty, Verification, Validation and Risk.

STPI, Lewis served as the Willis Young Jr. Professor and Chair of the Department of Aerospace Engineering at the University of Maryland. A faculty member at Maryland for 24 years, Lewis taught and conducted basic and applied research. From 2004 to 2008, he served as the Chief Scientist of the U.S. Air Force. From 2010 to 2011 he held the position of President of the American Institute of Aeronautics and Astronautics (AIAA). He also served as a member of the Air Staff and principal scientific adviser to the Chief of Staff and Secretary of the Air Force, providing assessments on a wide range of scientific and technical issues affecting the Air Force mission. Lewis received his Ph.D. and M.S. in aeronautics and astronautics, as well as a B.S. in earth and planetary science, from the Massachusetts Institute of Technology. He is the author of more than 300 technical publications and has been an adviser to more than 60 graduate students. Lewis also served on various advisory boards for NASA, the Air Force, and the Department of Defense (DoD), including two terms on the Air Force Scientific Advisory Board. He is a Fellow of the Royal Aeronautical Society, a Fel-

low of the American Society of Mechanical Engineers, and an Honorary Fellow of the AIAA. His awards include the DoD Exemplary Civilian Service Award,



Mark J. Lewis, Ph.D., Director of the Science and Technology Policy Institute at the Institute for Defense Analyses, Washington, D.C., will be the keynote speaker at the JANNAF Meeting in Dayton, Ohio.

Meritorious Civilian Service Award, and Exceptional Civilian Service Award. Lewis was also recognized as the 1994 AIAA National Capital Young Scientist/Engineer of the Year. He has received the International Energy Conversion Engineering Conference/AIAA Lifetime Achievement Award and the Air Force Association's Theodore Von Karman Award. Lewis is an Aviation Week and Space Technology Laureate.

Lewis' keynote speech, "Towards a Coherent National Strategy in Hypersonics," will address the importance of hypersonics research and development for the United States. Hypersonic systems have been widely recognized as offering promising new military capabilities. In the hands of potential adversaries, these systems also represent a considerable threat. Hypersonics is more than just speed; in modern parlance, high-lift/low-drag concepts combine speed with maneuverability

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and trajectories that amplify survivability and complicate defensive measures. Hypersonics is also more than one system or type of system, with promising technologies that include both airbreathing and rocket propulsion options in both tactical and strategic deployments. Current systems and concepts have varying degrees of maturity, utility, and inherent developmental risk. There are also remaining fundamental research challenges. During his speech, Lewis will review the current state of the art with an eye towards identifying the attributes of a cross-agency strategy that would maximize military utility with a coherent national portfolio.

The four technical subcommittees meeting in Dayton, along with the JPM and PIB, have organized numerous paper sessions, specialist sessions, panels, and workshops that will be of interest to the JANNAF community.

JPM will collaborate with MSS to co-host two new mission areas at the Dayton JANNAF Meeting: Digital Engineering; and Simulation Credibility: Uncertainty, Verification, Validation and Risk. These joint mission areas provide MSS with a transition period in the JANNAF Meeting schedule. Going forward, the subcommittee will begin to meet alongside JPM every spring due to the wide range of modeling applications that the subcommittee covers. Once the schedule change has been fully implemented, MSS will hold annual sessions under four mission areas: Model-Based Engineering, Integrated Health Management, Simulation Credibility: Uncertainty, Verification, Validation and Risk, and Modeling and Simulation of System Autonomy.

The joint JPM-MSS Digital Engineering mission area will highlight the evolution from test-bed engineering to analysis-based engineering. It will cover topics in Model-Based Engineering specifically in rotating detonation engines. Model-Based Engineering generally covers development methodologies, particularly codes and simulations to quantitatively evaluate and optimize propulsion technologies, usually at a system level. Continuing the success of the last code demonstration held at the May 2018 JANNAF Meeting in Long Beach, Calif., MSS will offer additional tutorials for VULCAN and Kestrel codes at the Dayton JAN-

NAF Meeting. The goal is to provide a hands-on experience for attendees and to impart a solid basis of understanding for each tool that will allow participants to eventually gain a deeper understanding of the uses, assumptions, and limitations of these modeling products.

The overall objective of the Simulation Credibility Panel is to facilitate credible modeling and simulations, ranging from hard computing to soft computing, and to knowledge-based computing. The panel released the Simulation Credibility Advances in Verification, Validation, and Uncertainty Qualification report (JANNAF Digital Online Collection (JDOC) 20160-0002) at the December 2016 JANNAF meeting in Phoenix, Ariz. The publication focused on advances in verification, validation, and uncertainty quantification of models. With the release of the report, workshops have been held to discuss approaches for computing uncertainty quantification and to generate a set of examples for users to follow. These discussions will continue at the Dayton JANNAF Meeting, along with a panel meeting.

CS will present the latest in research on combustion research in airbreathing, rocket, and reactive materials technology. With over 100 papers in 15 technical sessions, plus panel meetings and workshops, researchers from across the DoD, industry, and academia will share their work aimed at furthering scientific knowledge and technological development. Among other offerings, CS contributions to the JANNAF Meeting will include a two-part session on Reactive Materials, five sessions on Green and Alternative Propellants, and sessions covering Explosive Effects.

APS will meet for the 37th time in its history, not far from the site of the Wright Brothers' original bicycle shop. APS sessions will provide researchers, technology leaders, and investment directors with a forum to discuss their latest work across many areas of airbreathing propulsion, including hypersonic designs and methods, ramjet and scramjet control, design, and testing, as well as pressure gain combustion devices, and medium-scale critical components testing. With more than 130 papers scheduled for presentation over five days, plus panel discussions and workshops, the APS sessions will provide an opportunity for participants to exchange in-

formation on challenges and opportunities for advancing airbreathing propulsion knowledge and technology.

EPSS will host seven sessions, including a number of joint specialist sessions with CS and APS. In order to accurately model signatures, the EPSS community must first model the demanding environments in which vehicles and systems operate. These environments include not just hypersonic flowfields but also freestream-body-plume interactions, as well as the turbulent chemistry for both internal and external flows. These technology areas and challenges are shared with both CS and APS. Monday is dedicated to flowfield phenomenon and a dedicated collaborative discussion is planned for the afternoon session to identify areas of potential collaboration between the DoD and NASA. Wednesday morning features a joint tutorial with CS and APS on turbulent chemistry from internal combustion in scramjets to external afterburning of rocket exhaust plumes. Accurate analysis of turbulent chemistry is critical for determining the operating conditions of propulsion systems and, in turn, the demanding environments in which vehicles operate. Lastly,

continuing an effort to educate future practitioners, a tutorial on signature prediction techniques for hypersonic plumes/hardbodies will be held on Thursday.

PSHS sessions will address hazards and related technology areas for strategic missile, tactical missile, gun, and rocket propulsion systems. Topics will include modeling studies of decomposition and ignition of propellants, combustion of ingredients, and propellants characterization of thermally damaged materials. Cook-off response of propulsion systems and components, cook-off mitigation technologies and small-scale test methodologies for predicting cook-off of full-scale systems will be discussed. Additionally, hazards from thermal environments produced in operational and accident scenarios, both studies of the environments and the response of propellants and explosives to those environments, will be addressed in PSHS sessions

For complete details on all the papers and topics at the June 2019 JANNAF Meeting, please see the meeting program, which is available through the JANNAF portal at <https://www.janaff.org/mtgs/2019June/pages/index.html>.

Hear It From Your Peers

The Best Reasons to Attend a JANNAF Meeting

Below are a list of testimonials from JANNAF attendees of the December 2018 JANNAF meeting held in Vancouver, Wash. Attendees were asked what impact JANNAF has had on their job or organization.

“It inspired me to have new ideas for innovations on testing that is currently going on in my laboratory.”

“Opened my eyes to work others are performing that my organization can supplement and/or pursue as well.”

“JANNAF provides a good opportunity to see where my company stands technology wise compared to the rest of the industry and helps us focus on areas of research where we see holes in knowledge and possibilities.”

“It helps us see what the state of the art is in our field. There is really no other meeting involving just the formation and development of energetic materials.”

“This meeting helped me carry vital information back to my program office. I was able to succinctly inform them of hot topics of concern.”

“The accessibility of great minds to a young person in the field was the most valuable thing about this JANNAF meeting. I had a wonderful time learning from as many people as I could.”

Many people also noted that JANNAF provides the only venue for publishing ITAR material, especially research for the hypersonics community.

JANNAF Members Gather in Vancouver for December 2018 JANNAF Meeting



Keynote speaker Robert M. Lightfoot Jr., President of LSINC Corporation, Huntsville, Ala.

JANNAF attendees met in Vancouver, Wash., in December 2018 for a joint gathering of the 45th Structures and Mechanical Behavior Subcommittee (SMBS), 41st Propellant and Explosives Development and Characterization Subcommittee (PEDCS), 32nd Rocket Nozzle Technology Subcommittee (RNTS), and 30th Safety and Environmental Protection Subcommittee (SEPS), as well as a meeting of the Programmatic and Industrial Base (PIB). J. Robert Esslinger Jr., Army Combat Capabilities Development Command Aviation & Missile Center (formerly Army Aviation and Missile Research, Development and Engineering Center (AMRDEC)), chaired the meeting, which included a keynote address and panels, workshops, and specialist sessions hosted by the subcommittees in attendance.

Keynote and Awards

Robert M. Lightfoot Jr., President of LSINC Corporation and former NASA Acting Administrator, delivered the keynote address, which focused on a concept he termed “risk leadership.” Lightfoot introduced his subject by contrasting it with the well-known idea of risk management. As he noted, projects begin with the premise that the mission will break new ground and provide a benefit of some kind to stakeholders, but once the project starts to move forward, these potential benefits often become perceived as risks that must be mitigated by the investigators and project managers in order for the mission to succeed. The more complex a project is, the greater the number of components (technical and programmatic) that must come together and work flawlessly in order for it to achieve success. To deal with these complex systems

and resolve problems before they reach a mission critical stage, traditional risk management practices are insufficient, Lightfoot argued. For instance, risk management is often more focused on the mitigation process itself than on the outcome of the process. Or sometimes, the risk management process itself essentially becomes perceived of as the product, without producing any meaningful solutions to the original problem. Instead risk leadership is about project leaders recognizing and accepting some degree of risk, whether it be financial, programmatic, or operational, in order to permit their project teams to move forward with the mission. Likewise, effective leaders will recognize when it is necessary to elevate the matter to higher levels of leadership for consideration and then do so in a timely manner. He also made suggestions to technical professionals about how to appeal successfully to decision makers when proposing a project with potential risk, and encouraged them to reframe proposals in a language that appealed to decision makers by addressing their broader concerns, instead of narrowly focusing on technical details of risk mitigation. Presenting the big picture and telling a story about how the project would offer benefits to all stakeholders involved in promoting and funding the project would provide the best route to securing support for the project from senior leadership. Lightfoot concluded by reminding the audience that risk was necessary for technical progress in fields like space exploration. Playing it safe might seem beneficial in the short run but would cede American technical and programmatic leadership to other nations in the long term. He hoped

that the audience would embrace his ideas about risk leadership and apply them to their own projects.

Following Lightfoot's keynote, Christine Michienzi, Ph.D., Office of the Secretary of Defense for Acquisition, Technology, and Logistics, Manufacturing and Industrial Base Policy, the Department of Defense, Alexandria, Va., and Robert Champion, NASA Marshall Space Flight Center (MSFC), Huntsville, Ala., provided an update regarding PIB activities at the JANNAF Meeting. Michienzi reminded the attendees that the PIB exists to provide support for the American propulsion and energetics industrial base and coordinate between the technical and programmatic sides of JANNAF. Michienzi highlighted PIB concerns about materials obsolescence due to the American industrial base condensing and production moving overseas. She also promoted PIB-sponsored sessions at the JANNAF Meeting addressing obsolescence of rocket-motor insulation and methods for addressing the problem, as well as other sessions dealing with obsolescence of chemicals and how to qualify replacement chemicals. Michienzi introduced Champion as the new NASA co-chair of the PIB, replacing Michael H. Kynard, NASA MSFC, Huntsville, Ala. Michienzi and Champion then proceeded to present a number of awards. First, they presented the PIB's Kendall K. Brown Award to Brad Perkins, NASA MSFC, Huntsville, Ala., for outstanding support of the JANNAF PIB, as well as his support of the National Institute for Rocket Propulsion Systems. Michienzi and Champion presented a second Kendall K. Brown Award to Michael H. Kynard for his support of the JANNAF PIB during his time as co-chair. Michienzi highlighted Kynard's leadership role in various PIB working groups, his efforts to organize a

JANNAF Meeting session on push gases, propellants, and commodities, and his work with subject matter experts on the reuse of liquid rocket engines to help government programs better understand the commercial rocket industry.

A commemoration and standing ovation was given for Brad Forch, Ph.D., by Stuart Blashill, Johns Hopkins University (JHU) Energetics Research Group (ERG), Columbia, Md. Forch passed away in September 2018. Blashill promoted Forch's outside-the-box thinking and his commitment to the JANNAF energetics community, particularly his support for the *JANNAF Journal*. He expressed awe at Forch's diligence, knowledge, and commitment to his work, and praised Forch as a good leader who made sure things were done correctly. Instead of a moment of silence, Blashill suggested a final standing ovation for his accomplishments was more appropriate.



Timothy Lawrence (right), NASA Marshall Space Flight Center, Huntsville, Ala., accepts the JANNAF Rocket Nozzle Technology Lifetime Achievement Award from J. Robert Esslinger, Army Combat Capabilities Development Command Aviation & Missile Center, Redstone Arsenal, Ala., on behalf of the late Jeppy Louis Clayton, NASA Marshall Space Flight Center, Huntsville, Ala.

Meeting Chair J. Robert Esslinger on behalf of the RNTS, presented the JANNAF Rocket Nozzle Technology Lifetime Achievement Award to the late Jeppy Louis Clayton, NASA MSFC, Huntsville, Ala., who passed away in March 2018. Esslinger praised Clayton for his broad knowledge of rocket propulsion encompassing chemistry, physics, and modeling, as well as his expertise in rocket nozzle analysis and his support for the JANNAF community, especially the RNTS. A moment of silence was held in honor of Clayton. Afterward, the award was accepted on Clayton's behalf by Timothy Lawrence, NASA MSFC, Huntsville, Ala.

JANNAF Journal Managing Editor Benjamin Schwantes, Ph.D., JHU ERG, Columbia, Md., spoke

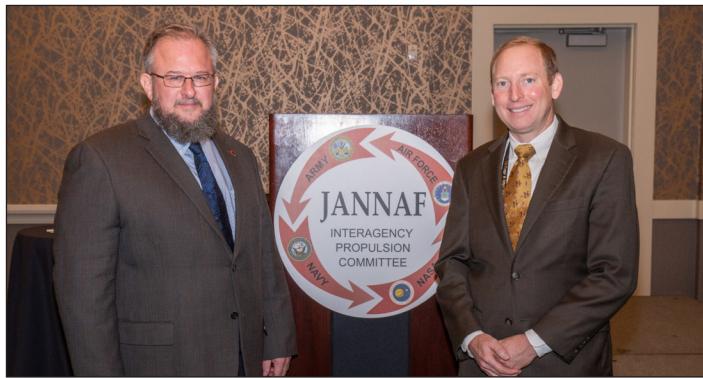
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briefly about the journal and its importance for the propulsion and energetics community. He encouraged members of the audience to submit manuscripts to the journal and serve as reviewers and associate editors. He noted that more than 76 authors, reviewers, and editors were involved in producing the most recent edition of the journal, and he could not do his job without support from the JANNAF community.

Technical Sessions

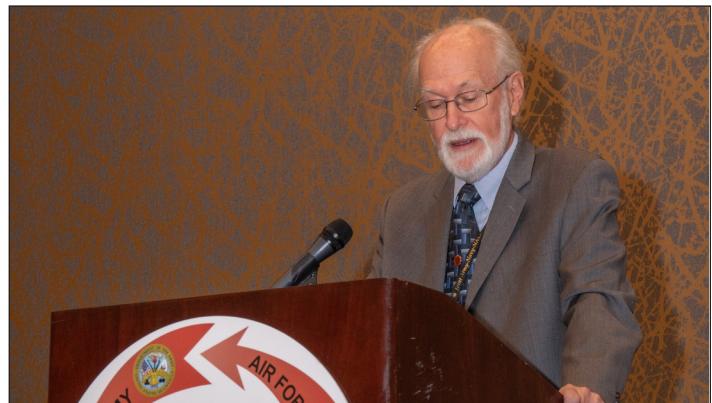
SMBS sessions addressed a wide variety of topics including the development, application, and verification



PEDCS Technical Steering Group Chair Mark Mason, Naval Air Warfare Center Weapons Division, China Lake, Calif. (left), and ANNAF Meeting Chair J. Robert Esslinger Jr., Army Combat Capabilities Development Command Aviation & Missile Center, Redstone Arsenal, Ala. (right).

of experimental, analytical, and statistical techniques required in the preliminary or detailed structural design of solid propellant rocket motors and gun ammunition; the assessment of their structural integrity; and the prediction of their service life based on structural or chemical aging mechanisms. SMBS panels at the meeting included Structural Analysis and Design, Non-Destructive Evaluation, Experimental Structural Analysis and Testing, and a joint meeting of the Service Life Panel and Materials Characterization Panel.

SMBS offered a specialist session on "Non-Destructive Evaluation (NDE) Needs and Capabilities for Solid Rocket Motors," followed immediately by the Non-Destructive Evaluation Panel discussion. The well-attended session and panel discussion allowed for more involvement from interested members of the JANNAF community. A number of NDE practitioners discussed the role of



Stuart Blashill, Johns Hopkins University Energetics Research Group, Columbia, Md., commemorates JANNAF Technical Executive Committee Chair Brad Forch, Ph.D., who passed away in September 2018.

NDE in solid rocket motors, munitions, and energetics; NDE for additively-manufactured materials; new algorithms and automation approaches; and new technologies and techniques. In the future, the NDE Panel Chairs may invite NDE specialists from other fields to present on new techniques, allowing for a community discussion about whether the technique would be applicable to rocket motors, shells, warheads, or other unique needs within the energetics and propulsion industry.

Additionally, Thomas Williams of Northrop Grumman Corporation, Bingham City, Utah, and Stephen CASH of QuantiTech Incorporated, Huntsville, Ala., presented a specialist session on "Solid Rocket Motor Lessons Learned." The focus was on propulsion lessons gained both from major accidents and from human spaceflight.

SMBS and RNTS jointly hosted a workshop entitled, "Verification, Validation, and Uncertainty Quantification," where participants worked in conjunction with the Modeling and Simulation Subcommittee's Verification, Validation, and Uncertainty Quantification Team to define approaches that can be used in the propulsion analytical community with an emphasis on Rocket Nozzle Technology and Structures and Mechanical Behavior.

PEDCS held 20 technical sessions and six specialist sessions on propellant development and characterization related topics. The specialist session "AOP-7 U.S. National Section Test Methodology Review" served as a forum for continued discussion of the complex issues surrounding test methods for energetic materials characterization and qualification for use. The goal of this

and future collaboration is to achieve consensus in the community regarding recommendations to regulators and decision makers in the energetics community for changes to NATO AOP-7 explosive materials standards. A two-part specialist session on “Small Scale Sensitivity Testing” and four sessions on the topic of “Propellant and Explosives Process Engineering” addressed topics related to the AOP-7 revision efforts. A specialist session on “CL-20 Efforts - Past, Present, Future Formulations” summarized issues related to the cost of production and potential solutions to further development and enable future use. The joint panel, Green Energetic Materials



PIB Executive Committee Co-Chairs Christine Michienzi, Ph.D., Office of the Secretary of Defense for Acquisition, Technology, and Logistics, Manufacturing and Industrial Base Policy, Department of Defense, Alexandria, Va. (right), and Robert Champion, NASA Marshall Space Flight Center, Huntsville, Ala. (left).

continued to advance collaboration between researchers as they work to meet the needs of the propulsion community for environmentally sustainable materials, and the Characterization and Raw Material Obsolescence panel convened to ensure future energetic capabilities can be met with available material resources.

RNTS organized 25 papers and invited presentations (including joint sessions) that addressed thermal, structural, fluids analysis, and modeling as it relates to nozzles; innovative nozzle materials; and nozzle design, test, and evaluation. The Nozzle Analysis and Modeling panel and the Rocket Nozzle Design, Test, and Evaluation panel both held discussions on the state of the industry for their respective areas.

RNTS teamed up with the PIB to hold a workshop on “Subscale Testing of Rocket Motor Insulation Candidates for Dechlorane Obsolescence.” The purpose of this workshop was to assess how well the small-scale testing used to evaluate rocket motor insulation formulations correlates to sub-scale and full-scale motor testing and



Keynote speaker Robert M. Lightfoot Jr., President of LSINC Corporation, Huntsville, Ala. (right) and JANNAF Meeting Chair J. Robert Esslinger Jr., Army Combat Capabilities Development Command Aviation & Missile Center, Redstone Arsenal, Ala. (left).

to establish best practices for test standardization. The chemistry of dechloranes was briefly discussed, as were problems with the industrial base not seeing a business case for producing certain materials. Through several presentations, this workshop provided valuable information about the small-scale testing currently being performed on numerous replacement insulation candidates. The workshop also provided guidance for the insulation replacement material testing efforts ongoing at several government and industry locations, with the goal of narrowing down the many possibilities to two or three formulations. The government and industry partners were encouraged to use this opportunity to improve upon, not simply replace, the obsolete materials, especially since direct replacements may not be an option.

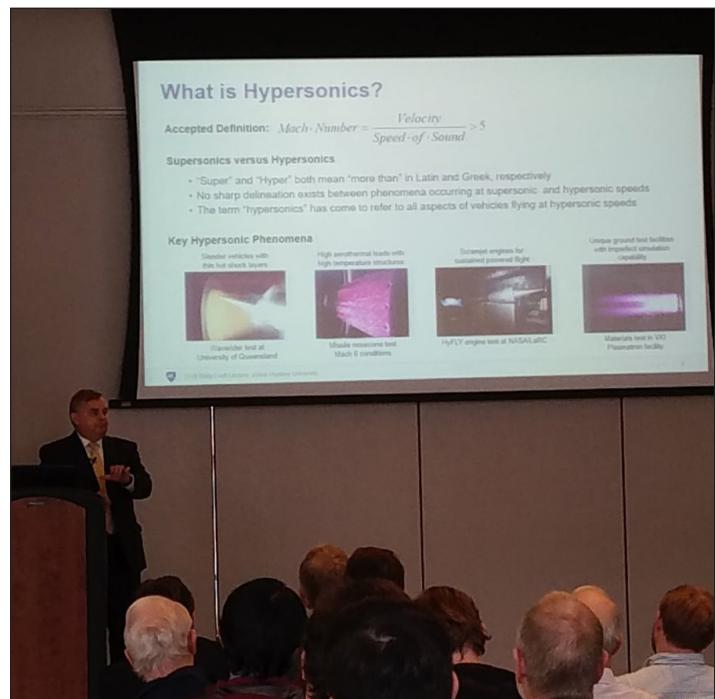
SEPS convened three technical sessions, two joint sessions and one panel to address issues related to the safety, health and environmental impacts associated with manufacture, storage, use and demilitarization of energetic materials. Topics addressed included safety and environmental protection considerations for additive manufacturing of energetic materials, wastewater from production of NTO, lead free propellant options, and toxicity of new insensitive high explosive formulations. SEPS jointly hosted a specialist session with PEDCS addressing “Green Energetic Materials,” followed by a meeting of the joint SEPS/PEDCS Green Energetic Materials Panel. A two-part session on “Regulations and New Materials,” addressed many of the needed changes in regulation due to changes in formulations and a renewed focus on performance. The “Toxicology” session addressed the need for new assessment methods appropriate for new and emerging formulations.

JANNAF Affiliate Delivers Annual Billig-Croft Lecture on Hypersonic Airbreathing Propulsion at Johns Hopkins University

JANNAF affiliate David M. Van Wie, Ph.D., Johns Hopkins University (JHU) Applied Physics Lab (APL), a 2017 inductee into the National Academy of Engineering, delivered the Fall 2018 Billig-Croft Lecture at JHU. Van Wie, the current head of APL's Air and Missile Defense Sector, spoke on the subject of hypersonic airbreathing propulsion and focused on APL's scramjet (supersonic-combusting ramjet) research and development efforts since the 1950s. In particular, he highlighted the contributions of researcher Frederick S. Billig, Ph.D., to the field of hypersonic airbreathing propulsion during his many years at APL. (The Billig-Croft lecture was named for Frederick S. Billig by its endower, L. Gordon Croft.)

Van Wie began by defining hypersonic flight, which in the United States is considered flight at five times the speed of sound (Mach 5) or greater. He noted that hypersonic research and development is a current national research priority and many researchers in the US and abroad are investigating hypersonic flight vehicles for both weapon and aircraft applications. Commercial development could include supersonic passenger transport vehicles or single-stage-to-orbit spacecraft.

APL has been a center for advanced airbreathing propulsion research and development since the 1940s, according to Van Wie, and some of the early pioneers in the field, including Frederick Billig, were still there in the early 1980s when he began working at APL, first as a graduate student and then as a full-time staff member. Van Wie praised Billig's accomplishments and highlighted some of the awards and honors he had received for his scramjet research, which included the American Institute of Aeronautics and Astronautics (AIAA) Dryden Research Lectureship and JHU/APL Lifetime Achievement Award in 1991, the Bondaruck Award for pioneering work on scramjet propulsion from the Soviet Academy of Sciences and USSR Avia-



David M. Van Wie, Ph.D., JHU APL presents the Fall 2018 Billig-Croft Lecture on hypersonics at JHU.

Photo courtesy JHU Office of Communications

tion Sport Federation in 1992, and induction into the National Academy of Engineering in 1995.

After discussing Billig's achievements, Van Wie shifted his focus to the broader topic of scramjet development at APL and elsewhere during the 20th and early 21st centuries. At the end of World War II, APL researchers began working on ramjet-powered missiles for air defense purposes. They flew the first supersonic ramjet vehicle, Cobra, and later developed and fielded the Talos surface-to-air missile system for the Navy, which utilized a rocket-boosted, ramjet powered missile that could reach speeds of Mach 2 for fleet air defense. The Talos system remained in service for more than 25 years and enjoyed a 96 percent success rate with more than 1,200 launches. In attempting to develop a next-generation Talos missile, APL researchers created the Typhon ramjet-powered flight vehicle, which was capable of Mach 4.8 flight. This was close to the practical limit for such a vehicle, since ramjet efficiency decreased as the vehicle went faster due to compressed air at the engine inlet heating up to

nearly the temperature of the engine exhaust as it slowed to subsonic speeds before passing through the combustor, thus robbing the engine of thrust. In order to mitigate this issue, APL researchers began working on a supersonic-combusting ramjet, in which the air entering the engine inlet mixed with fuel and ignited at supersonic speeds in the combustor. Such an engine would not experience loss of efficiency at high Mach speeds and would be ideal for hypersonic flight applications.

Frederick Billig was involved with early APL research into supersonic combustion. Such research required new wind tunnels that could produce hypersonic air flows. Using one of these wind tunnels, Billig demonstrated experimentally in 1959 that combustion could take place in supersonic air flow. This result opened the door to further research and development work in the field of scramjet propulsion. Throughout the 1960s, researchers at APL, NASA and other facilities began developing designs for scramjet combustors. A 1960 colloquium in Milan, Italy, hosted by the Advisory Group for Aeronautical Research and Development, a NATO-sponsored organization, proved to be an important jumping off point for work in the field. Researchers began with two-dimensional (i.e., rectangular) combustors, since they were less complex from a mathematical and engineering standpoint. Later work utilizing advances in computational fluid dynamics and computer-aided design permitted the development of three-dimensional (i.e., round or elliptical) combustors. Researchers also began looking at ways to use less exotic fuels to power scramjets. Billig's early work utilized triethyl aluminum, a toxic, pyrophoric liquid, to induce supersonic ignition. Later researchers employed liquid hydrogen and eventually JP-7 jet fuel for scramjet propulsion. Flight demonstrations of scramjets began outside the United States in the 1990s and in the early 2000s. NASA tested its X-43 vehicle, which utilized a two-dimensional combustor burning hydrogen fuel for thrust. In the mid-2000s, the U.S. and Australia achieved Mach 10 scramjet flight with the HyCAUSE test vehicle, and beginning in 2010, the Air Force launched a number of successful flights of its X-51a vehicle utilizing a two-dimensional combustor fueled with JP-7.

Van Wie noted that a number of technical hurdles must be overcome before scramjet-powered aircraft or space vehicles can become operational. These include a better understanding of boundary layer transition at supersonic speeds; more effective energy management as kinetic energy from the hypersonic vehicle's airstream creates excited energy states in atmospheric gases; new materials that can handle the high temperatures produced through sustained supersonic combustion and flight; and more effective means for cooling scramjet engines and other high-temperature airframe components. As these challenges are addressed, routine scramjet-powered hypersonic flight will become a reality.

Van Wie closed his lecture by noting that scramjets had been in development for more than 50 years, and he hoped to see continued development toward operational flight vehicles in the coming decades. He noted that such a long development period is not unusual for advanced technologies and offered the example of orbital rockets, which required nearly 60 years of research and development before the first successful space launches. He recalled that Frederick Billig prior to his death in 2006 had lamented that scramjet-powered flight had not been realized during his lifetime, but Van Wie argued that various flight test projects in the 1990s and 2000s had indeed proven the value of Billig's scramjet research in the years before his death. He felt that Billig should take pride in these achievements and he asserted that Billig's research legacy would continue to guide development of scramjet-powered vehicles well into the future.

The JANNAF Journal of Propulsion and Energetics is seeking reviewers and associate editors with knowledge of rotating detonation engine (RDE) technology.

If you are interested in reviewing RDE manuscripts, please contact:

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A Conversation with Hydrazine Expert Eckart Schmidt

Retired propellant chemist Eckart W. Schmidt, Ph.D., recently sat down for a brief chat with Johns Hopkins University Energetics Research Group (ERG) staff about his life-long work with hydrazine and his participation in the JANNAF community. Schmidt, whose email address “hydrazine_man” denotes his primary subject of professional interest, currently serves as a subject matter expert for ERG and an affiliate associate professor at the University of Washington.

Schmidt discussed his long career as a propellant chemist and noted that he had witnessed the development of hydrazine as a bi-propellant and monopropellant from early laboratory research on small samples to full-scale use in spacecraft propulsion applications. His research included developing different purity grades of hydrazine and catalysts for decomposing hydrazine for propulsion and gas generation purposes. Schmidt was on the team that selected hydrazine as a propellant for the two Voyager spacecraft, and he credited this decision with helping to ensure the remarkable operational longevity of the two craft, which continue returning data to Earth. “If we had not switched the choice of propellants several years before the Voyagers were launched, the mission would probably not have lasted as it has now, being 40 years out in space and still operating. This is obviously a record of longevity for many propulsion systems. Not a single other propellant claims to have that durability and storability,” Schmidt said. He was also responsible for developing the hydrazine catalyst used in the axillary power units of the Space Shuttle. Similarly, a hydrazine catalyst he developed during his years working at the Rocket Research Company in Washington was employed in two different Mars missions to ensure the soft landing of the Phoenix and InSight landers in 2008 and 2018, respectively.

Schmidt expressed mixed feelings about work promising to replace hydrazine with green monopropellants. He believed that hydrazine would continue to remain relevant as a spacecraft propellant, though he had pioneered green monopropellant development and felt that the field held promise. He was concerned that U.S. efforts to demonstrate green monopropellants in flight lagged behind European efforts and hoped that the Air Force Green Propellant Infusion Mission (GPIM-1) to test AF-M315E would be a success



Propellant chemist Eckart W. Schmidt, Ph.D., Energetics Research Group, Johns Hopkins University and University of Washington.

once it launched later in 2019. He felt that green monopropellants had limited applications compared to hydrazine since they require stabilizers and pre-heating of thrusters before a decomposition reaction can occur. He cited the example of small satellites, which might not have enough electrical power available to continuously pre-heat their thrusters in anticipation of maneuvering. Schmidt was skeptical of claims that green monopropellant use would produce significant cost savings for launch facilities. While personnel responsible for fueling upper rocket stages and satellites prior to launch would not need to wear positive-pressure hazmat suits when handling green monopropellants, such equipment would still need to be maintained at launch sites for use by personnel when working with toxic hypergolic bipropellants utilized in some rocket upper stages and large satellite propulsion systems. Thus, further study will be required to assess whether any savings can truly be realized..

Schmidt concluded by expressing concerns about efforts to curtail use of hydrazine for monopropellant applications. In his view, green monopropellants were not yet comparable to hydrazine and still needed to be tested rigorously and thoroughly in flight. Until this happens, hydrazine will continue to be the go-to monopropellant for spacecraft applications.

*The views expressed by Eckart Schmidt are his own and do not reflect the official views of JANNAF or the United States Air Force

ERG's Security Team Manages All Aspects of JANNAF Security

The Johns Hopkins University (JHU) Energetics Research Group (ERG) security team includes Mary Gannaway, Facility Security Officer, and Tricia Reider, Assistant Facility Security Officer. Together, they serve the ERG staff as well as the entire JANNAF community by overseeing all aspects of security for all JANNAF meetings, Technical Interchange Meetings, and RP21, as well as work conducted at the JHU ERG's office and on the JANNAF website.

They assist with site visits and the site selection process prior to any JANNAF meeting; oversee attendee registration and portal accounts; assist with meeting preparation and security needs; manage security teams at the meetings; ensure all meeting attendees are cleared to attend; and review and approve paper clearance forms prior to being published in the JANNAF Digital Online Collection (JDOC) as well as assisting with the review process of the *JANNAF Journal of Propulsion and Energetics* prior to publication and for inclusion in JDOC.



Mary Gannaway, Facility Security Officer



Tricia Reider, Assistant Facility Security Officer

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With the JANNAF portal, members can easily share sensitive documents with team members on the secure online platform through the small teams collaborative sites. Folder permissions can be set to restrict access to only those with a need to know.

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In Memoriam



Thomas William Christian III (1932-2018)

at the age of 86. Born April 4, 1932, in Halethorpe, Md., Christian grew up in the region, earning a B.S. in chemistry from Loyola College of Maryland in 1954 before enlisting in the Army and serving in the Chemical Corps in Germany until 1957. Following his Army service, Christian found employment at W.R. Grace & Co. and Joseph E. Seagrams & Sons. In 1965, he began working for CPIA as a member of its technical staff,

Thomas William Christian III, former director of the Chemical Propulsion Information Agency (CPIA) — now known as the Energetics Research Group (ERG) — and a longtime JANNAF member, passed away on December 30, 2018,

responsible for writing technical review articles, preparing literature searches, and providing technical support for the JANNAF Combustion Subcommittee and Executive Committee, among other duties. At the time, CPIA was part of Johns Hopkins University's (JHU's) Applied Physics Laboratory (APL). Christian advanced through the ranks at CPIA and was appointed its Director in 1985. As director, Christian oversaw the transfer of CPIA from APL to JHU's Whiting School of Engineering (WSE) in 1990. As a testament to his leadership, only a handful of CPIA's 21-member staff chose to stay at APL. The rest joined him in CPIA's transition to the WSE. Christian retired as CPIA director in 1995 and CPIA staff at the time expressed their "heartfelt thanks for his hard work, his leadership, his goofy humor, [and] his friendship" during his decade in charge of the agency and his 30-year career at CPIA. Following retirement, Christian continued to keep in touch with CPIA staff, as well as indulge in his love of golf, bridge, finance, music, and spending time with friends and family. He remained active in his church and community.

He is survived by his wife, Noreen; children, Thomas, James, and Margaret, and their families.

In Memoriam



Alex S. Priskos (1959-2018)

in Salt Lake City and graduated from Highland High School. He attended the University of Utah, where he obtained a B.S. in mining engineering. He later earned

The JANNAF community is deeply saddened to learn of the passing of Alex S. Priskos, NASA Marshall Space Flight Center (MSFC), on December 31, 2018. Born in Salt Lake City, Utah, on December 8, 1959,

Priskos grew up

an M.B.A. from Utah State University. Following employment with Hercules and ATK, Priskos joined NASA and worked for the agency for more than a decade. At the time of his death, he held the position of Space Launch System Systems Engineering & Integration Manager at NASA MSFC. Priskos was an active member and a staunch supporter of JANNF and believed strongly in the mission for which it was created. In recent years, he exerted his efforts toward helping the Programmatic and Industrial Base (PIB) side of JANNAF and was directly responsible for many key successes. His support for the PIB included serving as one of the NASA representatives to the PIB Executive Committee. In all, his career spanned more than 35 years in the aerospace field.

He was preceded in death by a daughter, Annicchia Priskos; and is survived by his wife, Lisa N. Davis; and two children, Stefani E. Priskos and Andrew A. Priskos.

ARL Commemorates Brad Forch's Life, Accomplishments

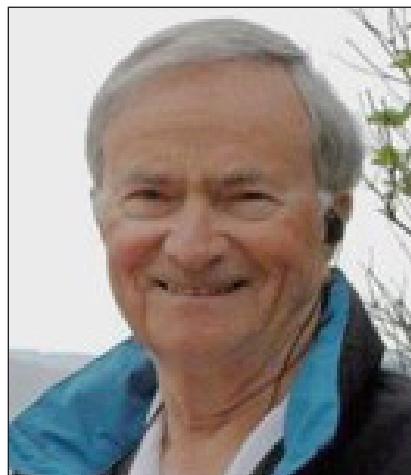
The Army Combat Capabilities Development Command Army Research Laboratory (ARL) is seeking to honor the life and accomplishments of the late JANNAF Technical Executive Committee Chair Brad Forch, Ph.D., who passed away suddenly in September 2018. ARL has launched a number of initiatives to celebrate Forch's career, which spanned more than three decades and led to numerous technical innovations and contributions to the energetics community. The Brad E. Forch Distinguished Postdoctoral Fellowship will recognize Forch's work in ballistics and energetic materials, in particular, his development of laser ignition technology for the Army 155-mm self-propelled howitzer. The Brad E. Forch Lifetime Mentorship Award will honor ARL staff who have served as mentors for 25 years or more. As the award description notes, "Nominees for this award must exemplify Brad's mentoring legacy and eagerness to advise mentees in order for them to develop and attain their full potential in their careers. Nominees should have demonstrated selfless generosity of their



Brad E. Forch, Ph.D. (1955-2018)

knowledge, experience and time. Like Brad, they will be known for never hesitating to step up when help is needed, and to have always found time to mentor anyone who needed their advice." Lastly, Forch's ARL co-workers are seeking to have the collaboration area in which his office was located named in his honor, in recognition of the many hours he spent there working.

In Memoriam



Herbert Richard Lander Jr. (1938-2018)

Herbert Richard Lander Jr. passed away on November 23, 2018, at the age of 80. Born on March 2, 1938, in Lucinda, Pa., Lander grew up in western Pennsylvania and attended the University of

chemical engineering. Lander developed an expertise as a fuels engineer and was widely known within the chemical propulsion community, particularly the JANNAF Combustion Subcommittee. He began his career at the Air Force Aero Propulsion Laboratory at Wright-Patterson Air Force Base (now part of the Air Force Research Laboratory). Later, he went to work for Rocketdyne. Lander retired in 1999, but continued serving as a consultant for aerospace fuels research and development. He enjoyed sports, particularly college football and professional baseball, and devoted his spare time to reading, journaling, and listening to music from his vast collection. He is survived by his wife, Jillene; six children, Elizabeth, Catherine, Laura, Tina, Tonya, and Brian; 20 grandchildren, and two great grandchildren.

PEDCS and SEPS Announce Best Papers Awards

The PEDCS Best Paper Award committee conferred the 2017 PEDCS Best Paper Award for a paper entitled “Development of High-Specific-Impulse, Hypercolic Borane Fuels” by Stefan Schneider, Air Force Research Laboratory, Edwards AFB, Calif.; Stephan Deplazes, Air Force Research Laboratory, Edwards AFB, Calif.; Yonis Ahmed, ERC, Inc., Edwards AFB, Calif.; Christina Gibson, no affiliation provided; Jeff Mills, Air Force Research Laboratory, Edwards AFB, Calif.; Adam Brand, Air Force Research Laboratory, Edwards AFB, Calif.; Phu Quach, Ultramet, Pacoima, Calif.; Logan Kamperschroer, Purdue University, West Lafayette, Ind.; and Timothée Pourpoint, Purdue University, West Lafayette, Ind.

The 2018 PEDCS Best Paper Award went to a paper entitled “HEHN Based Monopropellant for Dual Mode Propulsion” by Adam Brand, Air Force Research Laboratory, Edwards AFB, Calif., Jae Oh, ERC, Inc., Edwards AFB, Calif., Benjamin Price, Ph.D., Air Force Research Laboratory, Kirtland AFB, N.M., Shawn Miller, Ph.D., Air Force Research Laboratory, Kirtland AFB, N.M., Christopher Annesley, Ph.D., Air Force Research Laboratory, Kirtland AFB, N.M., Emily Herzog, Air Force Research Laboratory, Kirtland AFB, N.M., and Robert Masse, Ph.D., Aerojet Rocketdyne, Redmond, Wash.

The SEPS Best Paper Award committee conferred the 2018 award to a paper entitled “Addressing Key Knowledge Gaps in the Aquatic Ecotoxicology of IMX-101 and IMX-104” by Kurt Gust, Army Engineer Research and Development Center, Vicksburg, Miss., Alan Kennedy, Army Engineer Research and Development Center, Vicksburg, Miss., Lee Moores, Army Engineer Research and Development Center, Vicksburg, Miss., Guilherme Lotufo, Army Engineer Research and Development Center, Vicksburg, Miss., Michael Mayo., Army Engineer Research and Development Center, Vicksburg, Miss., Lauren Rabalais, Army Engineer Research and Development Center, Vicksburg, Miss., Mitchell Wilbanks, Army Engineer Research and Development Center, Vicksburg, Miss., Nicholas Melby, Army Engineer Research and Development Center, Vicksburg, Miss., Shinita Jordan, Army Engineer Research and Development Center, Vicksburg, Miss., Jacob Stanley, Stanley Environmental Consulting, Waynesboro, Miss., Arunthavarani Thiyagarajah, Environmental and Fish Health Solutions, Metairie, La., Natalie Barker, Bennett Aerospace, Inc., Cary, N.C., Qing Ji, Bennett Aerospace, Inc., Cary, N.C., Pornsawan Chappell, SOL Engineering, Vicksburg, Miss., and Karin Marshall, River City Early College, Vicksburg, Miss.

13th MSS / 11th LPS / 10th SPS / PIB December 9-13, 2019 Florida Location TBD

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- **PIB – Kirk Sharp** (ksharp@erg.jhu.edu / 228-234-5423)

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

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