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JANNAF NEWS

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INTERAGENCY PROPULSION COMMITTEE

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Kansas City to Host Spring 2017 JANNAF Meeting

The Spring 2017 JANNAF Meeting will be held at the Westin Kansas City at Crown Center, in Kansas City, Mo., May 22-25, featuring the JANNAF Propulsion Meeting, the Programmatic Industrial Base, the Structures and Mechanical BehaviorSubcommittee, Propellant and Explosives Development and Characterization Subcommittee, Rocket Nozzle Technology Subcommittee, and Safety and Environmental Protection Subcommittee. This year's meeting will be chaired by Dr. Charles J. Trefny, NASA Glenn Research Center, Cleveland, Ohio.

Highlights of the meeting include specialist sessions on vehicle failures and industrial accidents; green energetics materials; thrust control; booster propulsion technology maturation project status; additive manufacturing of energetic materials; advanced thermal/structural modeling of carbon cloth phenolic; and verification, validation and uncertainty quantification.

James Free, Deputy Associate Administrator for Technical, Human Explorations and Operations at NASA, will serve as the keynote speaker on Tuesday,

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Dr. Charles J. Trefny, NASA Glenn Research Center, will chair the JANNAF meeting in Kansas City, Mo.

Editor: Benjamin Schwantes
410-992-7300, ext. 227
BSchwantes@erg.jhu.edu

ERG Director: Peter E. Zeender
The Johns Hopkins University WSE ERG
10630 Little Patuxent Parkway, Suite 202
Columbia, Maryland 21044-3286
https://www.erg.jhu.edu
Fax: 410-730-4969

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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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

- December 2016 meeting proceedings are available in the JANNAF Digital Online Collection (JDOC) database, accessible throught the JANNAF website (https//www.jannaf.org/).

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JANNAF Meeting, Kansas City, Missouri... *continued from page 1*

May 23. His presentation, "Propulsion for Deep Space Exploration," will provide an overview of a recently completed in-space propulsion study and its implication on future programs and technology development. Free provides strategic direction for all aspects of NASA's human spaceflight exploration mission. He provides cross-agency support functions of space communications and space launch vehicles, including direction for the operation and use of the International Space Station (ISS), development of the Space Launch System and Orion spacecraft, and direction for the commercial crew and cargo programs that will provide logistics and crew transportation to the ISS.

Since joining NASA in 1990 at Goddard Space Flight Center, Free has supported the development of the agency's Orion spacecraft in various roles, including the Orion Test and Verification Manager at NASA's Johnson Space Center, Houston. In this role, he was responsible for planning and executing all verification activities supporting development of NASA's next generation human space vehicle. Free also served as the Orion Service Module Manager, overseeing the team designing the service module, which propels the Orion Crew Module. He was also chief of NASA's Glenn Research Center (GRC) Orion Projects Office responsible for all Orion-related work at the Center.

Prior to joining NASA Headquarters, Free served as the Glenn deputy director, before being appointed as director, where he was responsible for planning, organizing and directing the activities required in accomplishing the missions assigned to the center. He had previously served in a number of other leadership positions at Glenn, including the ISS liaison for the Fluids and Combustion Facility. He also led the development of electric actuation technologies for NASA's Next Generation Launch Technology Project, and was the launch vehicle manager and autonomous rendezvous and docking manager for the Prometheus spacecraft. As director of Space Flight Systems at Glenn, he was responsible for overseeing the management of the Center's significant activities in the agency's Constellation, Space Shuttle, ISS, Space Communications, Human Research and Science Programs.

Mr. James M. Free, NASA Deputy Associate Administrator, Human Exploration and Operations, will be the keynote speaker at the JANNAF Meeting in Kansas City, Mo.

A native of Northeast Ohio, Free earned his bachelor's degree in aeronautics from Miami University in Oxford, Ohio and his master's degree in space systems engineering from Delft University in the Netherlands.

For additional information about the JANNAF meeting, please visit https://www.jannaf.org/mtgs/2017May/pages/index.html

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

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

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

In Memorium

On March 16, 2017, Carl A. Aukerman passed away due to natural causes in Westlate, Ohio. Carl spent his professional life investigating a wide variety of important technical challenges. He began his career at Douglas Aircraft in California, working on the team creating product improvements for the F-5D Skylancer in the early 1950's. He was always happy about and proud of the fact that a version of this aircraft is permanently displayed outside of the Neil Armstrong Air and Space Museum in Wapakoneta, Ohio.

After leaving Douglas Aircraft, he began work at NASA Lewis (later NASA Glenn) in Cleveland, Ohio, in approximately 1958. Some of his earliest work was with exotic propellants such as fluorine-based oxidizers. While these propellants were not used in operational space vehicles, the results were instrumental in gathering detailed data for informed future technical decisions.

He was involved in high-aspect-ratio nozzle testing and developed an extensive data set for many applications. Most importantly, the idea of a modified plug nozzle for more rapid nozzle expansion ratio investigations was a major contribution to the Space Shuttle and many other high performance space vehicles. The plug nozzle consisted of an injector, a constant-diameter outer cylinder, and a water-cooled center body, which, in effect, formed an annular rocket combustion chamber. Gaseous hydrogen and liquid oxygen were selected as propellants because the gases from this combination provided a high heat flux environment for the materials evaluation. The center body, or plug, was contoured to resemble the combustion chamber, throat, and the supersonic sections of a thrust chamber. The plug nozzle was coated with zirconium oxide to protect the surface from the hot combustion gases and to prolong its life. After several hundred thermal cycles, the coating would erode and the plug could again be coated so it could be reused for additional tests. The outer cylinder, or test article, had cooling passages machined into it and was cooled with liquid hydrogen.

At NASA Lewis, he also participated in many technology reviews and evaluations across the NASA Centers, with numerous industry partners, academia, and small businesses. His enthusiasm led to many collaborative investigations for future launch vehicle propulsion systems. At the time of his retirement, he had served for many years in management as a Section Head and then a Branch Chief.

Carl A. Aukerman (1933-2017)

Carl was active in the JANNAF community throughout his career. He served as a member of the Technical Executive Committee (TEC) and as Technical Executive Liaison to the Rocket Nozzle Technology Subcommittee from 1984-1989. He chaired the TEC in 1988-1989. He also chaired the JANNAF Propulsion Meeting when it was held in Cleveland in 1989. Lastly, he authored or co-authored eight technical papers on propulsion-related topics for the JANNAF IPC.

After his retirement, he continued to be an advocate for advanced rocket propellants and propulsion technologies working with a number of industry partners. He attended the AIAA Joint Propulsion Conferences for many years after his retirement, where he assisted many engineers with his sage advice.

Carl had a wonderful, upbeat attitude and a ready smile. He will be sorely missed.

Article contributed by Bryan Palaszewski, NASA Glenn Research Center, bryan.a.palaszewski@nasa.gov

Additive Manufacturing Insights from Programmatic and Industrial Base Meeting (PIB) Specialist Session

Additive Manufacturing (AM) technologies offer new and innovative approaches to manufacturing design, prototyping, parts production, repair, and sustainment. The investments by government, academia and industry are substantial and challenges are being tackled systematically. AM has permitted full-scale rocket engine components to be printed that are able to withstand hot fire system level tests. Parts printed in the zero gravity environment of space are showing higher densities and tensile strengths compared to those printed on earth. Consideration of recycling 3D printed materials on the International Space Station is also of great interest. Overall, AM has enabled a paradigm shift in the traditional steps of the manufacturing process. In contrast to the extensive modeling, simulation, and analysis that would be required prior to design consensus and manufacturing by traditional methods, AM permits the design and manufacturing of new components followed by testing. Therefore, AM offers an attractive option for many rapid response programs such as NASA's Centennial Challenge to design and print a habitat that could be used for deep space exploration, or a journey to Mars, using native or recyclable materials, and complex propulsion systems for which the environments cannot be accurately captured through analysis. AM is also being used extensively for programs such as the U.S. Air Force's (USAF) Evolved Expendable Launch Vehicle (EELV) program to develop and print complex next-generation rocket engine designs that would not be possible with traditional manufacturing methods.

The Joint Army-Navy-NASA-Air Force (JANNAF) Interagency Propulsion Committee has played a role in supporting the steady progress in qualifying new propulsion designs for use in flight applications. Because AM flight-critical parts are being fielded, one pressing question has emerged, "How Is Additive Manufacturing Changing the Way We Do Business?" This was the topic of a Government Specialist Session that was part of the JANNAF Programmatic and Industrial Base Meeting (PIB) in Phoenix, Ariz., in December 2016. The invited government speakers elaborated on the topics of: investments in AM; technology gaps that AM could fill; opportunities to on-ramp this technology into their systems; value added with the incorporation of AM; and programmatic concerns about this technology. Dr. Amanda Schrand of the Air Force Research Laboratory Munitions Directorate presented the opening talk of the session. Entitled "Implementing Additive Manufacturing for Innovation," Schrand's talk covered the Air Force Research Laboratory (AFRL) enterprise and vision for increasing agility and reducing cost with AM in modular and reconfigurable systems. The ability to refresh technology rapidly via AM is one means for moving toward a more agile and superior enterprise. However, some of the greatest momentum has been obtained by taking a different approach to development; one where manufacturing and testing come first and are later followed by optimization. Adopting early prototyping fits with many USAF doctrines on affordability including Global Horizons, the USAF Strategic Master Plan, the USAF Future Operating Concept, and more. Schrand described the government's role in working directly with printer companies to design custom systems in order to create functional prototypes for defense needs. Indeed, the majority of global investments are in functional parts. The network of Innovative Institutes established throughout the U.S. has expanded interactions in manufacturing with a broad defense-wide team consisting of industry, government, and universities. Additionally, an extensive network of working groups and workshops continue to be devoted to sharing the latest accomplishments and lessons learned.

Dr. Paul McConnaughey, NASA Marshall Space Flight Center (MSFC), presented a subsequent talk on "Human Exploration Enabled by Additive Manufacturing." This led to a discussion regarding several important

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Additive Manufacturing Insights... *continued from page 5*

questions that are broadly applicable to the JANNAF AM community: "How do we safely/securely/efficiently share data (cross-domain)?" and "How do we safely/securely/efficiently integrate AM with legacy systems?"

Next, Elizabeth Robertson, NASA MSFC, focused on "Retooling Rocket Engine Development." She emphasized a small team approach that enabled a high level of communication. During the discussion, the group agreed that, as government representatives, we should be testing AM manufactured components to failure. Industry is typically averse to this approach due to the additional costs involved. Critically, AM allows for a faster, more parallel development cycle by allowing for hardware fabrication and testing while analysis is still ongoing.

John Rice, Defense Acquisition University-DAU, presented a talk on "Additive Manufacturing Opportunities in Aerospace and Defense Acquisition." He offered a compelling argument that AM has the potential to revolutionize the acquisition process. He recommended some specific steps that could be streamlined and/or simplified in the acquisition process, specifically reducing decision points and reviews.

Finally, Dr. Teresa Clement, Raytheon Missile Systems-RMS, presented a talk entitled "America Makes Overview." The Innovative Institute currently has 66 projects totaling $97 million and is working on a Workforce Roadmap, as well as specifications and standards, that would be released along with their other roadmaps and activities to unify the AM community.

Jerry Feldmiller, Orbital ATK, and JANNAF PIB DoD Co-Chair Dr. Christine M. Michienzi, Office of the Secretary of Defense, chaired the session.

In order to encourage government, industry, and academia to implement some of the practices presented in the panel, a follow-up DAU "AM in Acquisition Update" was held on Feb. 23, 2017, and attended by 131 classroom and online participants. The session was organized and moderated by Rice and included panelists Schrand, representing the DoD, Robertson, NASA, Dr. Phillip Farrington, Professor of Industrial and Systems Engineering, University of Alabama, and Jimmy Allen, Dynetics-Director of Strategic Initiatives. An overarching theme was that AM is influencing positive change across the acquisition lifecycle and leading to reductions in cost, scheduling, and risk. However, many challenges relating to qualification/certification, reverse engineering, and cybersecurity must be tackled before AM finds widespread acceptance.

Article contributed by Dr. Amanda Schwand, AFRL Eglin AFB, amanda.schrand.2@us.af.mil

New Valve to Fly to International Space Station

Air Force Research Laboratory (AFRL) funded the development of a new valve design by VACCO Industries, Inc., which is working with Japan on the delivery of the part to the International Space Station (ISS). The Positive Isolation Valve (PIV) was delivered to Japan Aerospace Exploration Agency (JAXA), in December 2016. JAXA will send the PIV to the ISS for a long duration application known as the Small Return Capsule, which will enable JAXA to de-orbit Japanese Equipment Module experiment specimens. The PIV is an electrically-actuated alternative to pyrotechnically-actuated squib valves. The normally-closed valve is capable of 5,000 psi operating pressure. By eliminating the need for a pyrotechnic squib initiator, the PIV is capable of indefinite on-orbit service. AFRL and VACCO are continuing to design and develop additional variations of the PIV for satellite propulsion system applications.

PIV developed by VACCO Industries, Inc. with AFRL funding.

JANNAF Holds December 2016 Meeting in Phoenix, Arizona

The desert metropolis of Phoenix, Ariz., provided the setting for the fall 2016 meeting of the JANNAF Programmatic & Industrial Base (PIB) and the 11th Modeling & Simulation Subcommittee (MSS), 9th Liquid Propulsion Subcommittee (LPS), and 8th Spacecraft Propulsion Subcommittee. Dr. Michael D. Watson, NASA Marshall Space Flight Center, chaired the meeting, which included a keynote address and awards ceremony. Copies of Volume 7, Issue 1 of the JANNAF Journal were also distributed to meeting attendees throughout the week of the meeting.

Jeffrey M. Hanley, Principal Director for Human Exploration and Space Flight, NASA and Civil Space Division of the Aerospace Corporation, presented an informative keynote address that focused on the challenges and forces at play in shaping human spaceflight opportunities in the present and over the next half century. Entitled "Crossroads and Opportunities: Human Spaceflight Perspectives," Hanley reviewed the major accomplishments of NASA over the past fifty years, beginning with the Apollo moon landing and continuing through the Space Shuttle era and the present International Space Station mission, Hanley argued that the next fifty years of American spaceflight should look very different than the previous half century, as they would be shaped by a mix of government- and commercial-sector actors working in partnership to achieve both civil and national security objectives. He believed that NASA's focus should shift from operations to development as commercial space-launch firms began to shoulder the burden of placing astronauts and cargo in low earth orbit. Instead, through the Space Launch System and the Orion spacecraft, NASA should lead the way in "reclaim[ing] cis-lunar space," Hanley argued, and eventually pursue a deep-space Mars mission. Ideally, these actions would encourage commercial space-launch companies to pursue new profitable ventures beyond low earth orbit, such as transporting cargo to future Moon bases.

"As NASA presses out in its exploration program, it needs to pull commerce with it"

-Jeffrey M. Hanley, Aerospace Corp.

Keynote speaker Jeffrey M. Hanley, Principal Director for Human Exploration and Space Flight, NASA and Civil Space Division of the Aerospace Corporation

"As NASA presses out in its exploration program, it needs to pull commerce with it," Hanley stated.

In order to achieve this goal, however, current and future American political leaders would need to reevaluate NASA's budget with a specific mission in mind and consider funding objectives that prioritized human spaceflight. Hanley concluded that the future was bright for American spaceflight and government-industry relationships would play a key role in shaping how new technologies such as additive manufacturing would be applied to spacecraft development, as well as in developing next-generation technologies to support future American and multinational space endeavors.

Following Hanley's keynote address, Dr. Christine Michienzi and Frank Tse presented awards on behalf of the PIB and JANNAF. Dr. Michienzi presented Kendall Brown Awards to Robert Read, OUSD(AT&L)/DASD, Manufacturing and Industrial Base Policy (MIBP), and

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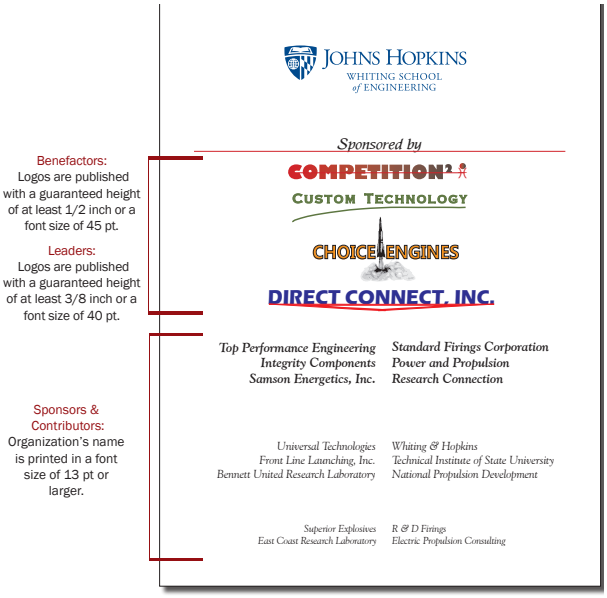

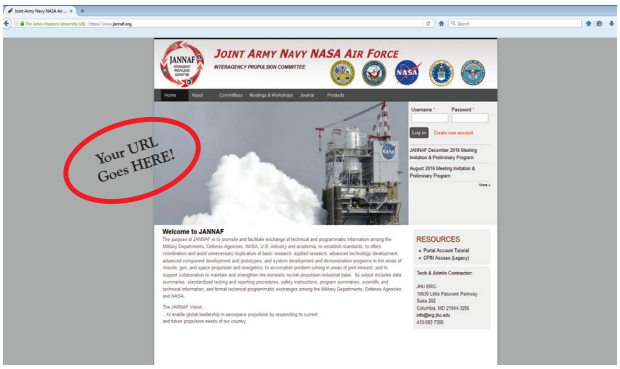

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Kirk Sharp receiving the Kendall Brown PIB award from Dr. Christine Michienzi.

Robert Read receiving the Kendall Brown PIB award from Dr. Christine Michienzi.

Kirk Sharp, Johns Hopkins University Energetics Research Group, for their work on behalf of the JANNAF PIB. Tse presented an award to Stuart Blashill, NAWCWD-China Lake, recognizing his 20 years of service to JANNAF, especially his contributions to the Rocket Nozzle Technology Subcommittee (PNTS), the Executive Committee, and the PIB.

Other meeting highlights included a popular, standing-room-only panel session on the future of liquid rocket engines. Panel members included various leaders from NASA, the U.S. Air Force Space and Missile Systems Center, and commercial firms including Blue Origin, SpaceX, Virgin Galactic, Aerojet Rocketdyne, and Interstellar Technologies. The panel discussed the unique challenges the commercial spaceflight sector is facing, how these compared to challenges that the U.S. government has encountered with spaceflight and propulsion, and how both government and industry can work more effectively together. Other events at the meeting included a 30-year recap of lessons learned by Carl Engelbrecht, lead propulsion engineer for the Europa Clipper spacecraft at Johns Hopkins University Applied Physics Laboratory, and a talk by Dr. Ephraim B. Washburn, NAWCWD-China Lake, for the Modeling And Simulation Subcommittee dealing with high-fidelity calculations at the system level.

64th JPM / PIB / 44th SMBS / 40th PEDCS / 31st RNTS / 29th SEPS / JSM to Meet
May 22–25, 2017

Westin Kansas City at Crown Center
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Technical questions may be addressed to the following ERG technical representatives:

- JPM – Peter Zeender (pzeender@erg.jhu.edu / 443-718-5001)
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- SMBS – David Owen (dowen@erg.jhu.edu / 443-718-5006)
- Tom Alsbrooks (talsbrooks@erg.jhu.edu / 443-718-5012)
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- RNTS – David Owen (dowen@erg.jhu.edu / 443-718-5006)
- SEPS – William Bagley (wbagley@erg.jhu.edu / 443-718-5009)

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

ERG Directory

DIRECTOR

Pete Zeender
pzeender@erg.jhu.edu / 443-718-5001

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General Inquiries
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Debbie Eggleston
Administrative Manager
dse@jhu.edu / 443-718-5002

Meetings

Shelley Cohen
JANNAF Meeting Manager
scohen@erg.jhu.edu / 410-992-7302

Kathleen Rowan
JANNAF Meeting Planner & Proceedings Editor
krowan@erg.jhu.edu / 410-992-7300 ext. 208

Security

Mary Gannaway
Facility Security Officer
mtg@jhu.edu / 410-992-7304 ext. 211

Tricia Reider
Assistant Facility Security Officer
treider@erg.jhu.edu / 410-992-7300

INFORMATION TECHNOLOGY

Bruce Dennett
IT Manager
bdennett@erg.jhu.edu / 443-718-5003

Valerie Dixon
LAN Administrator
vdixion@erg.jhu.edu / 410-992-7304 ext. 203

Paco Wong
Software Engineer
pwong@erg.jhu.edu / 410-992-7307

COMMUNICATIONS AND PUBLICATIONS

Linda McLean
Communications and Publications Group Manager
lmclean@erg.jhu.edu / 410-992-7304 ext. 225

Benjamin Schwantes
JANNAF Journal Managing Editor
bschwantes@erg.jhu.edu / 410-992-7300 ext. 227

TECHNICAL REPRESENTATIVES

Tom Alsbrooks
talsbrooks@erg.jhu.edu / 443-718-5012
Bill Bagley
wbagley@erg.jhu.edu / 443-718-5009
Alex Bishop
abishop@erg.jhu.edu / 443-718-5008
Bryan DeHoff
bryan.dehoff@aerospacetechnic.com / 513-378-7071
Ben Hill-Lam
bhill-lam@erg.jhu.edu / 443-718-5011

Nicholas Keim
nkeim@erg.jhu.edu / 443-718-5005
David Owen
dowen@erg.jhu.edu / 443-718-5006
Kirk Sharp
ksharp@erg.jhu.edu / 228-234-5423
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STRUCTURES and MECHANICAL BEHAVIOR (SMBS)		
Dr. Timothy C. Miller Air Force Research Laboratory/EAFB	**Dr. Jeremy R. Rice** U.S. Army AMRDEC/Redstone Arsenal	**Mr. David Owen** **Mr. Tom Alsbrooks**

JANNAF Programmatic & Industrial Base Working Groups

Working Group/Lead

LARGE LIQUID PROPULSION

Mr. Harry C. DuRette
U.S. Air Force SAF (AQ)/Chantilly

SMALL LIQUID PROPULSION

Mr. Charles W. Pierce
NASA Marshall Space Flight Center

LARGE SOLID ROCKET MOTOR

Mr. Timothy W. Lawrence
NASA Marshall Space Flight Center

SMALL SOLID ROCKET MOTOR

Mr. Frank C. Tse
Naval Surface Warfare Center-IH

ELECTRIC PROPULSION

Mr. David T. Jacobson
NASA Glenn Research Center

SCIENCE and TECHNOLOGY

Mr. Drew O. DeGeorge
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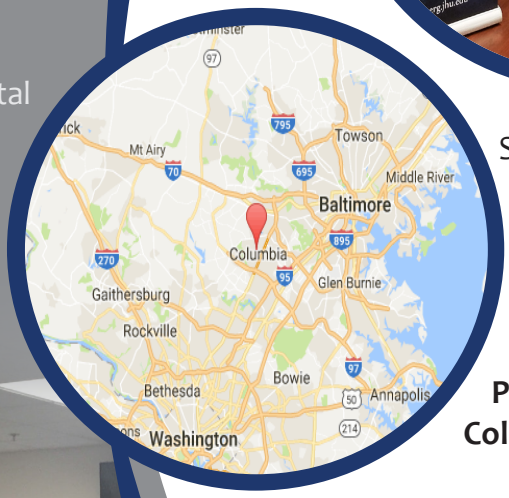

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