Programmatic and Industrial Base Meeting (PIB)
11th Modeling and Simulation (MSS)
9th Liquid Propulsion (LPS)
8th Spacecraft Propulsion (SPS)
Joint Subcommittee Meeting

Meeting Invitation

Hyatt Regency Phoenix
Phoenix, Arizona

5 - 8 December 2016
You are invited to attend the December 2016 meeting of the Joint Army-Navy-NASA-Air Force (JANNAF), which will consist of the Programmatic and Industrial Base (PIB) Meeting; and the Joint Meeting of the 11th Modeling and Simulation / 9th Liquid Propulsion / 8th Spacecraft Propulsion Subcommittees. This meeting will be held Monday through Thursday, 5 - 8 December 2016, at the Hyatt Regency Phoenix in downtown Phoenix, Arizona.

The Program Chair for the meeting is Dr. Michael D. Watson, NASA Marshall Space Flight Center, Huntsville, AL. A complete list of Program Committee Members can be found on pages 6-7.

The JANNAF Interagency Propulsion Committee coordinates fundamental research, exploratory development, and advanced development programs; standardizes procedures for nomenclature; promotes and facilitates the exchange of technical information; and accomplishes problem solving in the areas of joint agency interest on propulsion systems for missiles, rockets, boosters, spacecraft, satellites, and guns.

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The **Programmatic and Industrial Base** areas of interest include integrated program plans and key decision points; industrial base assessments; risks and opportunities with respect to skills, knowledge, and experience; identification of commonality, innovative acquisition, and partnership opportunities; integrated assessments to identify rocket propulsion industrial base (RPIB) rationalization opportunities; special actions from senior agency, department, or Executive Office of the President (EOP) leadership; and information provided to decision makers for either situational awareness or policy decisions.

JANNAF subcommittees focus their resources on technical issues of interest to the JANNAF agencies.

The **Modeling and Simulation Subcommittee (MSS)** activities include modeling and simulation of systems; virtual engineering; development of software analogs of propulsion devices or systems; software integration-coupling of diverse simulation tools to enable more detailed, system-of-systems analysis and simulation; simulation credibility-uncertainty, verification, validation, reliability, and risk; and integrated health management-identification and management of off-nominal conditions in propulsion.

The **Liquid Propulsion Subcommittee (LPS)** addresses technical problems and issues of greatest national needs associated with liquid engine systems, including liquid and gel propulsion technology topics that include the overall engine system, combustion components, and propellant feed systems.

The **Spacecraft Propulsion Subcommittee (SPS)** focuses on the full array of spacecraft propulsion technology interests including electric propulsion, advanced chemical propulsion, solar thermal propulsion, nuclear thermal propulsion, aerocapture, solar sails, tether systems, and technologies for the future.
Hotel Information

Sleeping rooms have been reserved with the **Hyatt Regency Phoenix**, located at 122 North Second Street, Phoenix, AZ 85004. Amenities include complimentary high speed internet access in guestrooms and discounted parking.

The JANNAF room rate per night for all attendees will be at the FY2017 GSA per diem rate, currently $118 plus tax (12.57% at this time), for single or double occupancy.

These discounted rooms will be held for JANNAF attendees until the deadline of Friday, 18 November 2016 at 5:00 p.m. MST, or until they sell out, whichever comes first. Each individual is responsible for his/her own reservation. Reservations may be made either on the Web (recommended) or by telephone.

**MAKE YOUR RESERVATION ONLINE:**

Click on the reservation link on the Hotel Page of the meeting website to make your reservation. Using this link will give you direct access to the JANNAF meeting discounted room block. Changes to your reservation can also be made via this weblink.

For additional reservation assistance, please call (888) 421-1442. Be sure to reference the JANNAF Propulsion Meeting.

Need to cancel your reservation? Be sure to do so no less than 48 hours prior to arrival to avoid paying a cancellation penalty.

Transportation and Parking

The Phoenix Sky Harbor International Airport (PHX) is located just 6 miles from the Hyatt Regency Phoenix. The hotel does not offer airport shuttle service. However, **SuperShuttle** is offering a discounted rate to JANNAF attendees for shared-ride van service between the airport and hotel. See below for more information.

There may be specific travel guidelines/restrictions for DoD employees. Please check the meeting website, with respect to restrictions regarding use of personal vehicles or rental cars.

Airport transportation costs range from $2 per person for the Valley Metro Light Rail, which stops less than one block from the Hyatt, to $13-18 for a cab or Uber, or **SuperShuttle**, which costs $11 per person each way when booked online with the JANNAF attendee discount code. More information can be found on the Hotel Page of the meeting website.

Meeting Site

All sessions will be held at the Hyatt Regency Phoenix in downtown Phoenix, Arizona. For attendance at this meeting, please see the Security/Attendance Requirements and Registration instructions below.

Security/Attendance Requirements

The overall security classification of this meeting is Unclassified.

To qualify to attend this meeting, all attendees must be employed by a DoD, DoE, or NASA facility, or with a DoD, DoE, or NASA contractor facility eligible for receipt of militarily-critical technical data. All attendees must also be U.S. citizens qualified to receive unclassified, limited-distribution information. No foreign nationals will be permitted to attend.

Questions concerning attendance eligibility should be directed to the JHU WSE ERG Facility Security Officer, Mary Gannaway, at (410) 992-7304, ext. 211 or mtg@jhu.edu.

Registration

Registration is now open. Register by Monday, 28 November to take advantage of the lowest fee.

To register, you must have a JANNAF Secure Portal account. Please visit the Registration Page of the meeting website for additional information and important links.

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

1. Register for the meeting via the JANNAF Secure Portal.
2. Pay the registration fee (Portal account not required).

Additional information and important links for completing your meeting registration can be found at [https://www.jannaf.org/mtgs/2016Dec/pages/registration.html](https://www.jannaf.org/mtgs/2016Dec/pages/registration.html).
Registration Fee

For details of what the registration fee includes, please go to the Registration Page of the meeting website. Please reference the registration fee chart below to determine the amount applicable to your registration. The dates noted below are based on payment being received.

<table>
<thead>
<tr>
<th>Payment Received</th>
<th>Regular Attendee</th>
<th>Student*</th>
</tr>
</thead>
<tbody>
<tr>
<td>on or before 11/28/16</td>
<td>$1,150.00</td>
<td>$250.00</td>
</tr>
<tr>
<td>11/29/16 or later</td>
<td>$1,300.00</td>
<td>$250.00</td>
</tr>
</tbody>
</table>

* A discounted registration fee is offered for full time students, interns, and cooperative education students. Students must meet the security/attendance requirements noted above and present current student identification upon registration on-site.

Registration payment will be accepted via check payable to JHU WSE Energetics Research Group, purchase order (government only), or by credit card (VISA, MasterCard, American Express) using the Registration Payment site available online. Go to the Registration Page of the meeting website, and click on “Pay Registration Fee.”

Attendees are encouraged to complete step one of the registration process via the JANNAF Secure Portal, and submit payment, on or before Monday, 28 November 2016 to ensure prompt registration upon arrival at the meeting. Credit card payments made electronically via the Web will be charged immediately; a receipt will be sent to you via email.

Cancellation Policy

Please note our cancellation policy—Written (email) cancellations submitted on or before 28 November 2016 will receive a full refund minus an administrative fee of $50.00. Cancellations made after 28 November 2016 will not be refunded. Substitutes are welcome as long as the request for substitution is from the original attendee; attendance eligibility is appropriately met by the substitute; and the original and substitute attendee are from the same organization to facilitate transfer of registration funds. Please contact Shelley Cohen via email to scohen@erg.jhu.edu to transfer or cancel your registration.

Attention DoD

An approval package to certify the December 2016 JANNAF Meeting as a “government approved” conference has been submitted by Mr. Frank Tse, member of the JANNAF Executive Committee from the Naval Surface Warfare Center in Indian Head, MD.

DoD approval of conferences takes several months and judging from past meetings, may not be received until just prior to the start of the December meeting. Interested DoD attendees are strongly encouraged to obtain a JANNAF Secure Portal account now and register for the meeting (step 1). This step does not require travel or training office authorization as it does not include a financial commitment. Payment of the registration fee may be completed as soon as permitted.

Attire

There is no official dress code for JANNAF conferences; however, most attendees wear business or business casual attire. When packing, keep in mind that it can be difficult to regulate the temperature in meeting rooms to everyone’s liking, and any changes may not be noticeable quickly, so it is best to bring a sweater or jacket and dress in layers.

Dining

Approximately one and one-half hours for lunch has been built into the program each day. Restaurants in the hotel include Terrace Cafe (breakfast), Einstein Bros. Cafe (breakfast and lunch), Networks Bar & Grill (lunch, dinner, and late night), and Compass Arizona Grill and Lounge (dinner and late night). Additionally, the hotel is located in downtown Phoenix with many dining options within a short walk.

Networking Room

The Atrium on the 2nd floor of the hotel will serve as the JANNAF networking area; a light continental breakfast and mid-morning coffee break along with mid-afternoon refreshments will be served at the times stated in the program. This area will be open Monday from 10:00 a.m. - 5:00 p.m., and Tuesday - Thursday from 7:00 a.m. - 5:00 p.m. Please note that scheduled breaks are included in session agendas where time permits.

On-Site Registration / Check-in

The JANNAF Registration desk will be located on the second floor of the Hyatt Regency Phoenix. Photo identification is required upon registration or check-in. The desk will be open Monday, 5 December from 10:00 a.m. - 5:00 p.m., and Tuesday, 6 December through Thursday, 8 December from 7:00 a.m. - 5:00 p.m.
Networking Night
Come enjoy an evening with fellow JANNAF attendees on Wednesday, 7 December 2016, from 6:30-8:00 p.m., in Regency Ballroom Salons C & D at the Hyatt Regency Phoenix. A complimentary meal is included. There is no charge for meeting attendees; however, guest tickets may be purchased on the Registration Payment site for $40 (admission is free for children five and under). Be sure to wear your JANNAF badge to attend the event.

Reading Room
All papers presented in the technical sessions and received in time will be available to read via JANNAF touch-screen tablets. The reading room, located in the Borein Room, will be open Monday from 1:30 p.m. - 4:30 p.m., and Tuesday through Thursday from 8:00 a.m. - 4:30 p.m. Reproduction of reading room papers is not permitted.

Side Meetings
A limited number of meeting rooms of varying sizes, located on the 2nd and 3rd floors of the hotel, are available for JANNAF-related side meetings. Audiovisual equipment will not be provided. Please contact Shelley Cohen at scohen@erg.jhu.edu to reserve a room as soon as possible. Requests may also be made on-site during the meeting. Rooms will be assigned first-come, first-served.

Program Changes
Meeting programs will be distributed to attendees upon registration/check-in on-site. Note that Final Programs are Distribution Statement C and should be secured when not in your possession. Changes to the Final Program will be posted on touch screen monitors located in the Atrium. Attendees should periodically check for program updates and administrative announcements and note these updates in their copy of the Final Program.

Meeting Proceedings
Proceedings from this meeting will be published by the JHU WSE Energetics Research Group. Papers, and in limited cases, presentations will be provided complimentary to attendees of this meeting who have paid the full registration fee (early or regular). These attendees will have access to these materials beginning approximately 12 weeks following the meeting via the JANNAF Digital Online Collection (JDOC) Database accessible through your account on the JANNAF Secure Portal. This benefit is not available for student attendees.

Questions
Questions concerning this meeting and/or payment of the registration fee should be directed to Shelley Cohen at (410) 992-7302, ext. 215 or email: scohen@erg.jhu.edu.

Questions pertaining to registering via the JANNAF Secure Portal should be directed to:
Mary Gannaway: Call (410) 992-7304, ext. 211 or email mtg@jhu.edu
OR
Tricia Reider: Call (410) 992-7300, ext. 222 or email treider@erg.jhu.edu

Upcoming JANNAF Meetings
Programmatic and Industrial Base Meeting
11th Modeling and Simulation
9th Liquid Propulsion
8th Spacecraft Propulsion
Joint Subcommittee Meeting
5-9 December 2016
Hyatt Regency Phoenix
Phoenix, Arizona

64th JANNAF Propulsion Meeting
Programmatic and Industrial Base Meeting
44th Structures and Mechanical Behavior
40th Propellant and Explosives Development and Characterization
31st Rocket Nozzle Technology
29th Safety and Environmental Protection
Spring 2017
Location TBA
Program Committee Members

PROGRAM CHAIR
Dr. Michael D. Watson
NASA Marshall Space Flight Center
Huntsville, AL

PROGRAMMATIC AND INDUSTRIAL BASE

PIB Executive Committee Co-Chair
Dr. Christine M. Michienzi
OUSD(AT&L)/DASD, MIBP / Alexandria, VA

PIB Executive Committee Co-Chair
Dr. Rajiv Doreswamy
NASA Marshall Space Flight Center / Huntsville, AL

JHU WSE ERG Technical Representative
Kirk V. Sharp
JHU WSE Energetics Research Group
Columbia, MD

MODELING AND SIMULATION SUBCOMMITTEE

Technical Steering Group Chair
Dr. Michael D. Watson
NASA Marshall Space Flight Center / Huntsville, AL

Technical Steering Group Deputy Chair
Mr. Gary C. Prybyla
Naval Surface Warfare Center / Indian Head, MD

JANNAF Executive Committee Liaison
Dr. Thomas M. Brown
NASA Glenn Research Center / Cleveland, OH

JHU WSE ERG Technical Representatives
Mr. Nicholas S. Keim
JHU WSE Energetics Research Group / Columbia, MD

Mission Area I: Modeling and Simulation of Systems
Mr. Eric J. Paulson
Air Force Research Laboratory / Edwards AFB, CA
Mr. Joseph C. Boyle
Naval Air Warfare Center Weapons Division / China Lake, CA

Mission Area II: Virtual Engineering
Mr. Gary C. Prybyla
Naval Surface Warfare Center / Indian Head, MD

Mission Area III: Integrated Health Management
Mr R. Scott Hyde
Orbital ATK / Brigham City, UT
Mr. David K. Hogan
Army Aviation and Missile Research, Development and Engineering Center / Redstone Arsenal, AL

Mission Area IV: Space and Launch Vehicle Cost Estimation
Dr. Michael D. Watson
NASA Marshall Space Flight Center / Huntsville, AL

Mission Area V: Simulation Credibility
Dr. Unmeel B. Mehta
NASA Ames Research Center / Moffett Field, CA
Dr. Dean R. Eklund
Air Force Research Laboratory / Wright-Patterson AFB, OH

LIQUID PROPULSION SUBCOMMITTEE

Technical Steering Group Co-Chair
Dr. Daniel L. Brown
Air Force Research Laboratory / Edwards AFB, CA

Technical Steering Group Co-Chair
Mr. James L. Cannon
NASA Marshall Space Flight Center / Huntsville, AL

JANNAF Executive Committee Liaison
Dr. Dhannireddy R. Reddy
NASA Marshall Space Flight Center / Huntsville, AL

JHU WSE ERG Technical Representative
Mr. Peter Zeender
JHU WSE Energetics Research Group / Columbia, MD

Mission Area I: Liquid Engine Systems
Mr. Jason B. Turpin
NASA Marshall Space Flight Center / Huntsville, AL
Mr. Nils M. Sedano
Air Force Research Laboratory / Edwards AFB, CA

Mission Area II: Liquid Combustion Subsystems and Components
Dr. Christopher S. Protz
NASA Marshall Space Flight Center / Huntsville, AL
Mr. Robert N. Bernstein
Air Force Research Laboratory / Edwards AFB, CA

Mission Area III: Liquid Propellant Feed and Pressurization Systems
Mr. James L. Cannon
NASA Marshall Space Flight Center / Huntsville, AL
Mr. Alan M. Sutton
Air Force Research Laboratory / Edwards AFB, CA

Mission Area IV: Advanced Materials for Liquid Propulsion Applications
Mr. Clyde “Chip” Jones
NASA Marshall Space Flight Center / Huntsville, AL
Mr. Jamie B. Malak
Air Force Research Laboratory / Edwards AFB, CA

Mission Area II: Electric Propulsion
Dr. Hani Kamhawi
NASA Glenn Research Center / Cleveland, OH
Dr. Robert B. Lobbia
Jet Propulsion Laboratory / Pasadena, CA

Mission Area III: Cube / Nano Satellite Propulsion
Dr. Juergen Mueller
Jet Propulsion Laboratory / Pasadena, CA
Dr. William A. Hargus, Jr.
Air Force Research Laboratory / Edwards AFB, CA

Mission Area IV: Future Technologies
Dr. Kurt A. Polzin
NASA Marshall Space Flight Center / Huntsville, AL

Mission Area V: Spacecraft Modeling and Simulation
Dr. Justin Koo
Air Force Research Laboratory / Edwards AFB, CA

JANNAF MEETING MANAGER
Shelley S. Cohen
JHU WSE Energetics Research Group / Columbia, MD

JANNAF MEETING PROCEEDINGS EDITOR
Kathleen Rowan
JHU WSE Energetics Research Group / Columbia, MD

SECURITY OFFICER
Mary T. Gannaway
JHU WSE Energetics Research Group / Columbia, MD
Program Highlights

Keynote Address

Mr. Jeffrey M. Hanley, Principal Director for Human Exploration and Space Flight, NASA and Civil Space Division of The Aerospace Corporation in Houston, Texas, will present the keynote at this year's conference. The title of Mr. Hanley's address is “Crossroads and Opportunities – Human Space Flight Perspectives.” In the midst of addressing the “what” and the “how” of human space flight in NASA’s “capability driven” exploration strategy, a new administration will soon once again be facing the “where” and “why” of US space policy to come. Mr. Hanley will discuss the challenges and forces at play shaping the future now and in the months and years ahead as the 50th anniversary of Apollo 11 approaches during the first term of the next US President.

Mr. Hanley has more than 33 years’ experience in human spaceflight, technical management, operations, and program management. He joined The Aerospace Corporation in 2015 where he is responsible for all civil human space flight and transportation systems such as the ISS, and future NASA programs including the Orion/MPCV, Space Launch System (SLS), and Commercial Crew Programs.

Prior to joining Aerospace, Mr. Hanley served as Director of the Extravehicular Activity (EVA) Management Office at NASAs Johnson Space Center, where he was responsible for managing the development, production, logistics, and sustaining engineering of all flight hardware used to support the agency’s EVA capability within the Human Exploration and Operations Directorate (HEOMD).

At NASA, Mr. Hanley previously served as Director of the Human Exploration Development Support Office. He also served as Deputy Project Manager for Verification on the James Webb Space Telescope (JWST) Project at NASA Goddard; Manager of the Constellation Program; and was a NASA Flight Director for a number of Shuttle and International Space Station missions.

Mr. Hanley earned his B.S. in Electrical Engineering, and his M.S. in Natural and Applied Sciences, from the University of Houston.

All attendees are invited to participate. The Keynote Address begins at 8:00 a.m. on Tuesday, 6 December, in Salons C & D of the Regency Ballroom on the first floor of the hotel.

Subcommittee Plenary Presentations

Each subcommittee will hold a Plenary presentation or panel discussion during the December meeting.

Modeling and Simulation

Dr. Ephraim B. Washburn, head of the Combustion Sciences and Propulsion Research branch, Naval Air Warfare Center Weapons Division, will discuss “Bringing Increased Fidelity to System Level Calculations,” on Tuesday afternoon at the start of session 2Q (1:30 p.m.). Dr. Washburn’s presentation will use the modeling and simulation of the combustion of energetic materials to show the ability to utilize information from the detailed high-fidelity calculations at the system level.

Ephraim Washburn received his B.S. and Ph.D. in chemical engineering from Brigham Young University. In 2004 he joined the Energetics Research Division of the Naval Air Warfare Center Weapons Division (NAWCWD). Dr. Washburn’s research deals with modeling and simulation of various forms of combustion. His work has included simulation of solid propellant combustion, metal combustion, and hydrocarbon combustion. Current applications of his work include rocket propulsion, explosives, and internal combustion engines. He is also involved in improving insensitive munitions technology and reestablishing air-breathing propulsion technology development at NAWCWD. He has published in and is an active reviewer for Combustion publications.
Liquid Propulsion
Mr. N. Wayne Hale, Jr., Director of Human Spaceflight, Special Aerospace Services, LLC, and former NASA Space Shuttle Program Manager, will moderate a panel discussion entitled, “Future of Liquid Rocket Engine (LRE) in the US,” at the start of session 3B (8:00 a.m.) on Wednesday morning. Panel Members will be representatives form Industry and Government.

Since the early 2000’s the US Liquid Rocket Engine (LRE) sector has evolved from having multiple LRE propulsion suppliers to Launch Service Providers (LSP) who are vertically integrated and develop their own propulsion systems. Dynamics in the LRE market is the result of emerging companies entering the market with disruptive business models, which have reshaped the traditional role of government in the development of LRE’s and Launch Vehicles (LV). As a result of this trend, the US has one remaining LRE supplier. The shift toward vertically integrated LSPs has also shaped how the government invests in LRE technology and development. Potential discussion topics:

- Transitioning of LRE development to industry.
- Evolution/revolution of the LRE and LV industry in the next decade.
- Challenges in establishing/developing engineering guidelines, processes, and capabilities for LRE development.
- Key observations on the different approaches to developing LRE’s in support of LSP’s.
- US government role in developing LRE’s going forward.

Spacecraft Propulsion
On Thursday morning, at the start of session 4G (8:00 a.m.), Mr. Carl Engelbrecht, Johns Hopkins University Applied Physics Laboratory, will discuss “Some Lessons I Learned in 30 Years of Interplanetary Propulsion,” sharing anecdotes with resulting technical and non-technical lessons learned from the design, development, integration and test of several propulsion systems.

Mr. Engelbrecht is the lead propulsion engineer for the Europa Clipper spacecraft. He has over 30 years of experience at JPL, Aerojet (Redmond, WA), DASA (Germany) and JHU/APL working on a wide range of types of space propulsion components and systems. Mr. Engelbrecht received his BS and MS in Aeronautics and Astronautics from the University of Washington and was the chairman of the AIAA’s Liquid Propulsion Technical Committee from 2007-2009.

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JANNAF PIB Specialist Sessions: Modern technology and the next generation workforce are changing the way the propulsion industrial base is designing and producing rocket propulsion systems. For instance, Additive Manufacturing (AM) has the potential to revolutionize the way rocket propulsion systems are designed - allowing for more intricate designs and quicker turnaround time between design and testing work. But AM also comes with its own set of challenges, risks and questions. The younger generation workforce also brings different ways of doing things to the industrial base, but also brings challenges - especially when integrating with the existing legacy workforce, techniques and ideas. The JANNAF PIB will have 3 Specialist Sessions (3A, 3M, and 4F) highlighting these topics and is still accepting presentations. All are welcome to attend.

On Wednesday, the Modeling and Simulation Subcommittee will present an all-day Specialist Session on Simulation Credibility: Advances in Verification, Validation, and Uncertainty Quantification, scheduled in sessions 3G and 3S. Simulation verification, simulation validation, and uncertainty propagation and quantification validation are the key processes used to quantify numerical, model, and input credibility, respectively. The Simulation Credibility (SC) Panel of the Modeling and Simulation Subcommittee, initiated a voluntary endeavor to develop a simulation credibility guide to describe and demonstrate these state-of-the-art processes, resulting in a joint NASA and JANNAF Interagency Propulsion Committee publication titled, “Simulation Credibility in Continuum Physics: Advances in Verification, Validation, and Uncertainty Propagation and Quantification.” This publication presents a compilation of some key advances in these processes over the last 10 years. Creators of continuum physics simulations will find the detailed processes and illustrated examples in this volume very useful to guide and assist them in conveying the credibility of their simulations to decision makers for many years to come. The contributing authors will present the publication during this session. Refer to pages 27 and 30 in the Preliminary Program to review the draft agenda for this all-day specialist session.

continued on page 10
Additional Highlights - continued

The Spacecraft Propulsion Subcommittee will present an all-day workshop on Thursday entitled, Electric Propulsion Operation in the Space Environment and Facility Interactions II (EPOSE II), in sessions 4E and 4Q. The Electric Propulsion Operation in Space Environment (EPOSE II) will continue the discussions initiated in EPOSE I. The workshop will provide an overview of the EPOSE I workshop findings. Additionally, this workshop will also present an overview of recent EP system flight data, overview of NASA Asteroid Retrieval Mission (ARM) plasma diagnostics package, results from recent experiments on ground facility effects, updates on modeling and simulation progress, and an update on the JANNAF data repository. See pages 33 and 36 for the draft agenda for this all-day workshop.

Several sessions throughout the program have been scheduled with a focus on Additive Manufacturing. These sessions include:

- Specialist Session: How is Additive Manufacturing Changing the Way We Do Business? I (Industry Briefs) and II (Government Briefs) (3A / 3M - Programmatic and Industrial Base).

Technical Program

This year's technical program currently consists of 37 technical sessions with more than 200 presentations, plus 7 specialist sessions, 4 workshops, 11 panel meetings, 2 subcommittee plenary presentations and a panel discussion. A detailed daily schedule of all sessions, workshops, meetings and networking activities is provided below and continues through page 13. Detailed agendas of the technical sessions, specialist sessions, and workshops are listed in the Program Section of the Preliminary Program beginning on page 14.

A Schedule Color Key has been provided on pages 11 and 13.
**SCHEDULE - Tuesday, 6 December**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Location</th>
<th>Status</th>
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<tbody>
<tr>
<td>7:00 a.m. - 5:00 p.m.</td>
<td>On-Site Check-In and Registration Desk Open</td>
<td></td>
<td></td>
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<tr>
<td>7:00 a.m. - 5:00 p.m.</td>
<td>I.T. Office Open (for Presenters and Session Chairs needing technical assistance)</td>
<td>Cowboy Artists</td>
<td>Open</td>
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<tr>
<td>7:00 a.m. - 8:00 a.m.</td>
<td>Networking Area Refreshments</td>
<td>Atrium</td>
<td>Open</td>
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<tr>
<td>7:15 a.m. - 7:30 a.m.</td>
<td>Session Chair Meeting (Tuesday Sessions)</td>
<td>Borein</td>
<td>Closed</td>
</tr>
<tr>
<td>8:00 a.m. - 10:00 a.m.</td>
<td>KEYNOTE ADDRESS: “Crossroads and Opportunities – Human Space Flight Perspectives” - Mr. Jeffrey M. Hanley Awards and Announcements</td>
<td>Regency Ballroom C-D</td>
<td>Open</td>
</tr>
<tr>
<td>8:00 a.m. - 4:30 p.m.</td>
<td>Reading Room</td>
<td>Borein</td>
<td>Open</td>
</tr>
<tr>
<td>9:30 a.m. - 10:00 a.m.</td>
<td>Networking Area Refreshments</td>
<td>Atrium</td>
<td>Open</td>
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<tr>
<td>10:00 a.m. - 6:00 p.m.</td>
<td>JANNAF Technical Executive Committee Meeting</td>
<td>Meeting Suite 316</td>
<td>Closed</td>
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<tr>
<td>10:00 a.m. - 12:05 p.m.</td>
<td><strong>Tuesday Morning Technical Sessions and Panel Meetings</strong></td>
<td></td>
<td></td>
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<tr>
<td>10:00 a.m. - 12:05 p.m.</td>
<td>2A LPS Liquid Rocket Engine Model and System Studies</td>
<td>Phoenix Ballroom East</td>
<td>Open</td>
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<tr>
<td>10:00 a.m. - 12:05 p.m.</td>
<td>2B LPS Hydrocarbon Fuels Properties and Performance Characterization - I</td>
<td>Phoenix Ballroom West</td>
<td>Open</td>
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<tr>
<td>10:00 a.m. - 12:05 p.m.</td>
<td>2C LPS PANEL MEETING: Combustion Stability</td>
<td>Remington A-C</td>
<td>Open</td>
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<tr>
<td>10:00 a.m. - 12:05 p.m.</td>
<td>2D SPS Overview / Propellant Summaries - II (Bipropellants)</td>
<td>Russell A-C</td>
<td>Open</td>
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<tr>
<td>10:00 a.m. - 11:35 a.m.</td>
<td>2E SPS Electric Propulsion Flight Projects</td>
<td>Curtis A-B</td>
<td>Open</td>
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<tr>
<td>10:00 a.m. - 12:05 p.m.</td>
<td>2F LPS Liquid Propulsion Component Test and Development</td>
<td>Ellis Room West</td>
<td>Open</td>
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<tr>
<td>10:00 a.m. - 12:05 p.m.</td>
<td>2G LPS Propellant Feed System Development</td>
<td>Ellis Room East</td>
<td>Open</td>
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<tr>
<td>10:00 a.m. - 1:30 p.m.</td>
<td>2H PIB Large Liquid Propulsion Working Group Meeting</td>
<td>Boardroom</td>
<td>Closed</td>
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<tr>
<td>12:00 p.m. - 1:30 p.m.</td>
<td>Lunch Break - On Your Own</td>
<td></td>
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<tr>
<td>1:30 p.m. - 6:05 p.m.</td>
<td><strong>Tuesday Afternoon Technical Sessions, Panel, and Working Group Meetings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:30 p.m. - 4:35 p.m.</td>
<td>2M LPS Advanced Materials and Additive Manufacturing for Liquid Propulsion Systems</td>
<td>Phoenix Ballroom East</td>
<td>Open</td>
</tr>
<tr>
<td>1:30 p.m. - 6:05 p.m.</td>
<td>2N SPS MicroPropulsion Systems and Development</td>
<td>Phoenix Ballroom West</td>
<td>Open</td>
</tr>
<tr>
<td>1:30 p.m. - 5:35 p.m.</td>
<td>2O LPS Hydrocarbon Boost Subscale Preburner Testing</td>
<td>Remington A-C</td>
<td>Open</td>
</tr>
<tr>
<td>2:30 p.m. - 5:35 p.m.</td>
<td>2P MSS PANEL MEETING: Integrated Health Management Modeling and Sensing - I</td>
<td>Russell A-C</td>
<td>Open</td>
</tr>
<tr>
<td>3:35 p.m. - 5:35 p.m.</td>
<td>2R MSS PANEL MEETING: Turbomachinery</td>
<td>Ellis Room West</td>
<td>Open</td>
</tr>
<tr>
<td>3:35 p.m. - 5:10 p.m.</td>
<td>2S SPS PANEL MEETING: HERMeS Hall Thruster Development / High Power Electric Propulsion Development</td>
<td>Ellis Room East</td>
<td>Open</td>
</tr>
<tr>
<td>1:30 p.m. - 5:00 p.m.</td>
<td>PIB Test and Evaluation Working Group Meeting</td>
<td>Meeting Suite 314</td>
<td>Closed</td>
</tr>
<tr>
<td>2:00 p.m. - 5:00 p.m.</td>
<td>CSTD Technical Interchange Meeting (TIM) 7</td>
<td>Boardroom</td>
<td>Closed</td>
</tr>
<tr>
<td>3:05 p.m. - 4:10 p.m.</td>
<td>Networking Area Refreshments</td>
<td>Atrium</td>
<td>Open</td>
</tr>
</tbody>
</table>

**Schedule Color Key**

- **Meeting Services**
- **Concurrent Sessions or Panel Meetings**
- **Networking Opportunities**
- **Session Details**
- **Closed Meetings**
- **Panel, Town Hall, & Working Group Meetings**
# SCHEDULE - Wednesday, 7 December

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Location</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 a.m. - 5:00 p.m.</td>
<td>On-Site Check-In and Registration Desk Open</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:00 a.m. - 5:00 p.m.</td>
<td>I.T. Office Open (for Presenters and Session Chairs needing technical assistance)</td>
<td>Cowboy Artists</td>
<td>Open</td>
</tr>
<tr>
<td>7:00 a.m. - 8:00 a.m.</td>
<td>Networking Area Refreshments</td>
<td>Atrium</td>
<td>Open</td>
</tr>
<tr>
<td>7:15 a.m. - 7:30 a.m.</td>
<td>Session Chair Meeting (Wednesday Sessions)</td>
<td>Borein</td>
<td>Closed</td>
</tr>
<tr>
<td>8:00 a.m. - 4:30 p.m.</td>
<td>Reading Room</td>
<td>Borein</td>
<td>Open</td>
</tr>
<tr>
<td>8:00 a.m. - 12:35 p.m.</td>
<td><strong>Wednesday Morning Technical Sessions, Specialist Sessions and Panel Meetings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:00 a.m. - 12:35 p.m.</td>
<td>3A PIB SPECIALIST SESSION: How is Additive Manufacturing Changing the Way We Do Business? - I (Industry Briefs)</td>
<td>Phoenix Ballroom East</td>
<td>Open</td>
</tr>
<tr>
<td>8:00 a.m. - 10:00 a.m.</td>
<td>3B LPS PANEL DISCUSSION: Future of Liquid Rocket Engine (LRE) in the US</td>
<td>Phoenix Ballroom West</td>
<td>Open</td>
</tr>
<tr>
<td>10:30 a.m. - 12:05 p.m.</td>
<td>3B LPS Hydrocarbon Boost Full Scale Components - I</td>
<td>Phoenix Ballroom West</td>
<td>Open</td>
</tr>
<tr>
<td>8:00 a.m. - 11:35 a.m.</td>
<td>3C SPS Green Propellants</td>
<td>Remington A-C</td>
<td>Open</td>
</tr>
<tr>
<td>8:00 a.m. - 11:35 a.m.</td>
<td>3D MSS Motor A&amp;S Technology Embedded Sensors Design Placement and Analysis</td>
<td>Russell A-C</td>
<td>Open</td>
</tr>
<tr>
<td>10:00 a.m. - 12:05 p.m.</td>
<td>3E LPS SPECIALIST SESSION: The Combustion Stability Tool Development (CSTD) Project and the Stable COmbustion in Rocket Engines (SCORE) Stability Assessment Tool Suite - I</td>
<td>Curtis A-B</td>
<td>Open</td>
</tr>
<tr>
<td>8:00 a.m. - 11:05 a.m.</td>
<td>3F SPS Ground Facility Effects on Hall Thruster Operation</td>
<td>Cassidy</td>
<td>Open</td>
</tr>
<tr>
<td>11:05 a.m. - 12:35 p.m.</td>
<td>3F SPS PANEL MEETING: Electric Propulsion</td>
<td>Cassidy</td>
<td>Open</td>
</tr>
<tr>
<td>8:00 a.m. - 12:30 p.m.</td>
<td>3G MSS SPECIALIST SESSION: Simulation Credibility: Advances in Verification, Validation, and Uncertainty Quantification - I</td>
<td>Ellis Room East-West</td>
<td>Open</td>
</tr>
<tr>
<td>10:00 a.m. - 10:35 a.m.</td>
<td>Networking Area Refreshments</td>
<td>Atrium</td>
<td>Open</td>
</tr>
<tr>
<td>12:00 p.m. - 1:30 p.m.</td>
<td>Lunch Break - On Your Own</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:10 p.m. - 1:20 p.m.</td>
<td>SPS Technical Steering Group Meeting</td>
<td>Boardroom</td>
<td>Closed</td>
</tr>
<tr>
<td>1:30 p.m. - 4:30 p.m.</td>
<td>PIB Science and Technology Working Group</td>
<td>Meeting Suite 314</td>
<td>Closed</td>
</tr>
<tr>
<td>1:30 p.m. - 5:35 p.m.</td>
<td><strong>Wednesday Afternoon Technical Sessions and Specialist Sessions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:30 p.m. - 5:35 p.m.</td>
<td>3M PIB SPECIALIST SESSION: How is Additive Manufacturing Changing the Way We Do Business? - II (Government Briefs)</td>
<td>Phoenix Ballroom East</td>
<td>Open</td>
</tr>
<tr>
<td>1:30 p.m. - 4:35 p.m.</td>
<td>3N LPS Hydrocarbon Boost Full Scale Components - II</td>
<td>Phoenix Ballroom West</td>
<td>Open</td>
</tr>
<tr>
<td>1:30 p.m. - 5:05 p.m.</td>
<td>3O SPS/MSS Diagnostics and Modeling of Thrusters and Combustors</td>
<td>Remington A-C</td>
<td>Open</td>
</tr>
<tr>
<td>1:30 p.m. - 2:35 p.m.</td>
<td>3P MSS Integrated Health Management Modeling and Sensing - II</td>
<td>Russell A-C</td>
<td>Open</td>
</tr>
<tr>
<td>1:30 p.m. - 5:30 p.m.</td>
<td>3Q LPS Part 1 - SPECIALIST SESSION: The Combustion Stability Tool Development (CSTD) Project and the Stable Combustion in Rocket Engines (SCORE) Stability Assessment Tool Suite – Part II</td>
<td>Curtis A-B</td>
<td>Open</td>
</tr>
<tr>
<td>1:30 p.m. - 3:35 p.m.</td>
<td>3R SPS Hall Thruster Development</td>
<td>Cassidy</td>
<td>Open</td>
</tr>
<tr>
<td>1:30 p.m. - 5:30 p.m.</td>
<td>3S MSS SPECIALIST SESSION: Simulation Credibility: Advances in Verification, Validation, and Uncertainty Quantification - II</td>
<td>Ellis Room East-West</td>
<td>Open</td>
</tr>
<tr>
<td>3:00 p.m. - 4:05 p.m.</td>
<td>Networking Area Refreshments</td>
<td>Atrium</td>
<td>Open</td>
</tr>
<tr>
<td>6:00 p.m. - 8:00 p.m.</td>
<td>Networking Night - Dinner and Cash Bar - JANNAF Badge or Guest Ticket required</td>
<td>Regency Ballroom C-D</td>
<td>Open</td>
</tr>
</tbody>
</table>
**SCHEDULE - Thursday, 8 December**

7:00 a.m. - 5:00 p.m. | On-Site Check-In and Registration Desk Open
---|---
7:00 a.m. - 5:00 p.m. | I.T. Office Open (for Presenters and Session Chairs needing technical assistance) Cowboy Artists Open
7:15 a.m. - 7:30 a.m. | Session Chair Meeting (Thursday Sessions) Borein Closed
8:00 a.m. - 4:30 p.m. | Reading Room Borein Open
8:00 a.m. - 4:35 p.m. | Thursday Morning Technical Sessions, Workshops, Specialist Session, and Panel Meetings

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 a.m. - 11:35 a.m.</td>
<td>4A LPS Advanced Materials and Processes for Combustion Devices Phoenix Ballroom East Open</td>
</tr>
<tr>
<td>8:00 a.m. - 12:05 p.m.</td>
<td>4B LPS Combustion Stability Tool Development at AFRL and MSFC - I Phoenix Ballroom West Open</td>
</tr>
<tr>
<td>8:00 a.m. - 10:05 a.m.</td>
<td>4C LPS Fuel Film Cooling Measurements and Modeling Remington A-C Open</td>
</tr>
<tr>
<td>8:00 a.m. - 11:35 a.m.</td>
<td>4D MSS Model Validation and Uncertainty Assessment Russell A-C Open</td>
</tr>
<tr>
<td>11:35 a.m. - 12:05 p.m.</td>
<td>4D MSS PANEL MEETING: Simulation Credibility Russell A-C Open</td>
</tr>
<tr>
<td>9:00 a.m. - 12:15 p.m.</td>
<td>4E SPS WORKSHOP: Electric Propulsion Operation in the Space Environment and Facility Interactions II (EPOSE II) - Part I Curtis A-B Open</td>
</tr>
<tr>
<td>8:00 a.m. - 12:05 p.m.</td>
<td>4F PIB SPECIALIST SESSION: Challenges Integrating Multi-generational Technologies and Workforce Ellis Room West Open</td>
</tr>
<tr>
<td>8:00 a.m. - 9:00 a.m.</td>
<td>4G SPS PLENARY: Some Lessons I Learned in 30 Years of Interplanetary Propulsion Ellis Room East Open</td>
</tr>
<tr>
<td>9:00 a.m. - 12:35 p.m.</td>
<td>4G SPS Vehicle Orion / European Service Module Ellis Room East Open</td>
</tr>
<tr>
<td>8:00 a.m. - 12:00 p.m.</td>
<td>4I SPS SPECIALIST SESSION: Challenges Integrating Multi-generational Technologies and Workforce Ellis Room East Open</td>
</tr>
<tr>
<td>9:35 a.m. - 10:35 a.m.</td>
<td>Networking Area Refreshments Atrium Open</td>
</tr>
<tr>
<td>12:00 p.m. - 1:00 p.m.</td>
<td>MSS Technical Steering Group Meeting Boardroom Closed</td>
</tr>
<tr>
<td>12:00 p.m. - 1:15 p.m.</td>
<td>LPS Technical Steering Group Meeting Meeting Suite 314 Closed</td>
</tr>
<tr>
<td>12:00 p.m. - 1:30 p.m.</td>
<td>PIB LLP Working Group Data Analysis Presentation to PIB Working Group Leads Meeting Suite 312 Closed</td>
</tr>
<tr>
<td>12:00 p.m. - 1:30 p.m.</td>
<td>Lunch Break - On Your Own Meeting Suite 316 Closed</td>
</tr>
<tr>
<td>1:30 p.m. - 4:30 p.m.</td>
<td>PIB Executive Committee Meeting Meeting Suite 316 Closed</td>
</tr>
</tbody>
</table>
| 1:30 p.m. - 6:35 p.m. | Thursday Afternoon Technical Sessions, Workshops, and Panel Meetings

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:30 p.m. - 4:35 p.m.</td>
<td>4M LPS Advanced Materials and Processes for Propulsion Systems Phoenix Ballroom East Open</td>
</tr>
<tr>
<td>1:30 p.m. - 3:35 p.m.</td>
<td>4N LPS Combustion Stability Tool Development at AFRL and MSFC - II Phoenix Ballroom West Open</td>
</tr>
<tr>
<td>1:30 p.m. - 5:35 p.m.</td>
<td>4O LPS Hydrocarbon Fuels Properties and Performance Characterization - II Remington A-C Open</td>
</tr>
<tr>
<td>5:35 p.m. - 6:35 p.m.</td>
<td>4P MSS PANEL MEETING: Hydrocarbon Fuels Remington A-C Open</td>
</tr>
<tr>
<td>1:30 p.m. - 5:45 p.m.</td>
<td>4Q SPS WORKSHOP: Electric Propulsion Operation in the Space Environment and Facility Interactions II (EPOSE II) – Part II Curtis A-B Open</td>
</tr>
<tr>
<td>1:30 p.m. - 5:05 p.m.</td>
<td>4R MSS Modeling and Simulation of Systems Ellis Room West Open</td>
</tr>
<tr>
<td>1:30 p.m. - 3:35 p.m.</td>
<td>4S SPS Vehicle - Other Ellis Room East Open</td>
</tr>
<tr>
<td>1:30 p.m. - 3:00 p.m.</td>
<td>4T MSS WORKSHOP: Development of Sensor and Sensing System Standard for Aerospace Propulsion Systems - II Cassidy Open</td>
</tr>
<tr>
<td>3:05 p.m. - 4:05 p.m.</td>
<td>Networking Area Refreshments Atrium Open</td>
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**Schedule Color Key**

<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
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<tbody>
<tr>
<td>Light Blue</td>
<td>Meeting Services</td>
</tr>
<tr>
<td>Pink</td>
<td>Concurrent Sessions or Panel Meetings</td>
</tr>
<tr>
<td>Yellow</td>
<td>Networking Opportunities</td>
</tr>
<tr>
<td>Dark Gray</td>
<td>Closed Meetings</td>
</tr>
<tr>
<td>Green</td>
<td>Session Details</td>
</tr>
<tr>
<td>Light Green</td>
<td>Panel, Town Hall, &amp; Working Group Meetings</td>
</tr>
</tbody>
</table>