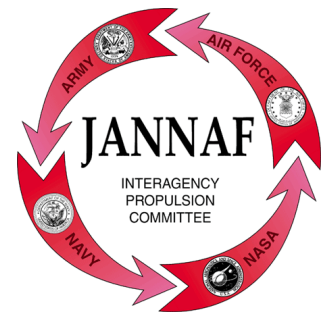


# **JANNAF** INTERAGENCY PROPULSION COMMITTEE JOINT ARMY-NAVY-NASA-AIR FORCE

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



**5 - 9 December 2016**

## **Announcement and Call For Papers**

**Abstract Deadline**  
**11 July 2016**

**Phoenix, Arizona**

Last updated 6/30/16

Photo Credit: NASA

The December 2016 meeting of the Joint Army-Navy-NASA-Air Force (JANNAF) will consist of the **Programmatic and Industrial Base (PIB) meeting**; and the Joint Meeting of the **11th Modeling and Simulation, 9th Liquid Propulsion, and 8th Spacecraft Propulsion Subcommittees**. Dr. Michael D. Watson with NASA Marshall Space Flight Center, Huntsville, Alabama, is the Meeting Chair. This meeting will be held **Monday through Friday, 5 - 9 December 2016, in Phoenix, Arizona**. The specific hotel will be announced at a later date. Please refer to page 4 for additional information.

## ATTENDANCE

The overall security level of the meeting is Unclassified. All sessions will be held at a hotel (to be announced) in Phoenix, Arizona. Attendance, applicable to presenters as well, is restricted to qualified U.S. citizens. *No foreign nationals will be permitted to attend.*

**ALL non-government attendees** (which includes contractors, consultants and universities) attending this meeting **must**:

1. Be working on a current government contract or certified by a Sponsoring Government Official
2. Provide their organization's DD 2345 Certification Number for receipt of militarily-critical technical data

**DD 2345:** For additional information, contact the Joint Certification Program Office (JCP) at 1-800-352-3572 or visit their Web site at [www.dlis.dla.mil/jcp/](http://www.dlis.dla.mil/jcp/).

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](mailto:mtg@jhu.edu).

## PURPOSE

The JANNAF Interagency Propulsion Committee focuses on the technology, development, and production capabilities for all types of propulsion systems and energetics for tactical, strategic and missile defense rockets and missiles, for space boost and orbit transfer, for in-space propulsion, and for gun systems. JANNAF provides a forum for discussion of propulsion issues, challenges, and opportunities across the Military Departments, Defense Agencies and NASA. JANNAF subcommittees focus their resources on technical issues of interest to the JANNAF agencies.

Work in all areas of DoD and NASA are solicited as defined below:

### 6.1 Basic Research:

Systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products.

### 6.2 Applied Research:

Systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.

### 6.3 Development:

Systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

JANNAF accepts papers that are unclassified/unlimited and unclassified/limited for all meetings; and up to classified Secret as announced in the specific meeting's announcement and call for papers.

## SCOPE

### Programmatic and Industrial Base

The JANNAF Programmatic and Industrial Base (PIB) Committee was created with the approval of the **updated JANNAF Charter** by the Department of Defense and the National Aeronautics and Space Administration in 2014. As stated in the **Charter**, 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."

### Modeling and Simulation Subcommittee

The 11th 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.

### Liquid Propulsion Subcommittee

The 9th LPS is seeking papers on the advancement of liquid engine systems, technical problems and issues associated with the design, analysis, fabrication and testing, including liquid and gel propulsion technology topics that include the overall engine system, combustion components, turbomachinery and propellant feed systems.

### Spacecraft Propulsion Subcommittee

The 8th SPS seeks abstracts 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.

## Please Note:

In addition to the Subcommittees listed on the previous page and described on pages 6 - 13, abstracts for technical areas covered by JANNAF subcommittees outside the current scope of this meeting will also be considered.

## ABSTRACT SUBMITTAL INSTRUCTIONS

- The technical areas to be addressed are defined in this announcement. Individuals who wish to submit an abstract should carefully review the topic areas and complete and submit the electronic [Abstract Submittal Form](#) posted on the [December meeting website](#).
- The submission of an abstract represents an agreement to **submit a final paper for publication by 7 November 2016**, attend the meeting, and deliver a 30-minute presentation. Your presentation will be heard by all qualified individuals within industry, government, and university organizations. If your paper cannot be presented to all qualified attendees, it cannot be presented in this program without specific approval from members of the JANNAF Executive Committee.
- Submit only unclassified abstracts. **Abstracts will not be published** and will only be used by the program committee members for paper selection purposes.
- Limit the abstract to 250-300 words and exclude tables and figures. State the objective of the work. Describe the scope, method of approach, and any new advances in the state of the art. Highlight important conclusions, and include a brief summary of the data used to substantiate them.
- Please submit using the [Abstract Submittal Form](#), which can be downloaded from the [December meeting website](#).
- Indicate confirmation of management support on the abstract form to ensure availability of resources for your participation in the meeting.
- **Many organizations require abstracts to be processed through an approval system prior to submission.** This process takes additional time, so authors should **plan accordingly and begin the process early in an effort to meet the abstract deadline date.**
- Remember, ***you must be a qualified U.S. Citizen to attend and present at this meeting.*** No foreign nationals are permitted to attend.
- The **deadline** date for submission of [Abstract Submittal Forms](#) to JHU WSE ERG is **11 July 2016**.

JHU WSE ERG accepts only **electronic submission** of abstracts and papers. **Abstracts must be submitted on the Abstract Submittal Form:**

- Via email to: [scohen@erg.jhu.edu](mailto:scohen@erg.jhu.edu); (*Distribution A only*);  
**OR**
- Uploaded to the ERG secure server as follows:
  1. Go to <https://webdatabase.cpia.jhu.edu/docorg/program/cgi-bin/Login.pl>
  2. **Choose Infobase:** *JANNAF Mtg Abstract Uploads*
  3. **Type in User Name:** *Abstract*
  4. **Type in Password** [contact ERG at (410) 992-7302 or 7300 for current password].
  5. Click the “Login” button.
  6. Click on “December 2016 JANNAF Meeting”; choose “Add Document” (to the left of the page)
  7. Complete the “Add Document” form, being sure to Title your Document, select “Upload from Client”, click the “Browse” button and navigate to where you have saved your completed Abstract Submittal Form on your computer. Select the file and click “Open”. Choose the appropriate file format (MS Word or PDF) under Document Type, and click on “Apply”.
  8. Email [scohen@erg.jhu.edu](mailto:scohen@erg.jhu.edu) to notify that the file has been successfully uploaded.

**Remember, the deadline to submit a completed [Abstract Submittal Form](#) is 11 July 2016.**

## PIB/MSS/LPS/SPS AUTHOR TIMELINE

Date	Weeks before Meeting	Action
11 July 2016	21	Deadline for receipt of <a href="#">Abstract Submittal Form</a> . Deadline for receipt of <a href="#">Workshop and Specialist Session Request Forms</a> .
22 Aug 2016	15	Acceptance/rejection letters sent to authors.
29 Aug 2016	14	Deadline for changes to Meeting Invitation and Preliminary Program
12 Sept 2016	12	Invitation, Preliminary Program, and registration information forwarded to propulsion community.
3 Oct 2016	9	Deadline for <a href="#">award nominations</a> .
24 Oct 2016	6	Deadline for submission of changes to the Final Program.
7 Nov 2016	4	Deadline for receipt of manuscripts and paper/presentation clearance forms. <b>Papers not received by this date may be removed from the program.</b>
7 Nov 2016	4	Deadline for reservations at Host Hotel (tba).
23 Nov 2016	2	Deadline for reduced registration fee. Deadline for completion of Registration Questionnaire.
23 Nov 2016	2	Deadline for receipt of presentations.
5 Dec 2016	0	PIB/MSS/LPS/SPS Joint Subcommittee Meeting

## AWARDS

Nominations for JANNAF Technical Executive Committee, MSS, LPS and SPS recognition awards are being solicited. Individuals interested in nominating an award recipient should follow the guidelines and instructions on pages 14 and 15.

## RECOMMENDATIONS FOR WORKSHOPS OR SPECIALIST SESSIONS

Recommendations for workshops or specialist sessions are solicited at this time. Individuals interested in organizing and chairing a workshop or specialist session should contact the JHU WSE ERG Technical Staff member in their respective subcommittee with suggestions for topics by **11 July 2016**. See page 14 for additional information and requirements.

## HOTEL INFORMATION

Sleeping rooms will be reserved at the host hotel (tba) in Phoenix, AZ, where all meeting sessions and activities will be held. Many options for dining, entertainment, and shopping will be located nearby. The current GSA FY 2016 per diem rate in Phoenix is \$113 per night plus tax. Any change to this rate for FY 2017 will be posted once announced by the GSA. Official JANNAF discounted room rates and other details will be posted on the December meeting website when the Meeting Invitation and Preliminary Program have been posted online, and registration has been opened in the Fall.

## REGISTRATION INFORMATION

Registration will open in the Fall of 2016. To take advantage of the lowest registration fee, please plan to complete the two-step registration process (registration questionnaire and payment of the registration fee) on or before 23 November, 2016.

Please be aware that there is a pre-requisite to registering for JANNAF meetings. You must have an active JANNAF Secure Portal Account. **If you do not currently have a Portal Account, or your account has expired, or you don't remember your password, we highly recommend addressing these issues now to simplify and speed up the registration process later.**

To apply for a JANNAF Secure Portal Account, go to <https://www.jannaf.org> and click on "Create new account" in the top right corner of the screen. Follow the instructions posted there to begin the application process. More information can be found on the JANNAF website by viewing the Portal Account Tutorial, found under "Resources".

If your account has expired or you don't remember your password, please contact [info@erg.jhu.edu](mailto:info@erg.jhu.edu) or call (410) 992-7300 for guidance.



## SUBCOMMITTEES / MISSION AREAS AT THIS MEETING

Mission Area	PIB	MSS	LPS	SPS
I	How Is Additive Manufacturing Changing The Way We Do Business?	Modeling and Simulation of Systems	Liquid Engine Systems	Chemical Propulsion
II	Challenges Integrating Multi-generational Technologies and Workforce	Virtual Engineering	Liquid Combustion Subsystems and Components	Electric Propulsion
III		Integrated Health Management	Liquid Propellant Feed and Pressurization Systems	Cube/Nano Satellite Propulsion
IV		Space and Launch Vehicle Cost Estimation	Advanced Materials for Liquid Propulsion Applications	Future Technologies
V		Simulation Credibility		Spacecraft Modeling and Simulation

**PLEASE NOTE:** In addition to the Subcommittees / Mission Areas listed above and on the following pages, abstracts for technical areas covered by JANNAF subcommittees outside the current scope of this meeting will also be considered.

## PIB CALL FOR PRESENTATIONS

Proposed Specialist Sessions for JANNAF PIB at December 2016 Meeting:

- 1) How Is Additive Manufacturing Changing The Way We Do Business?
  - Presentations from Industry
    - Advancing technology/performance (discussion on the business effects, not the technical benefits)
    - Reducing cost: time, logistics, people, etc.
    - Making the industry more competitive
    - Risks from a business perspective
  - Presentations from Government Program Offices
    - Investments in Additive Manufacturing (AM)
    - Technology gaps that AM could fill
    - Opportunities to on-ramp this technology into their systems
    - Value added with the incorporation of AM
    - Programmatic concerns about this technology
- 2) Challenges Integrating Multi-generational Technologies and Workforce
  - Presentations from Industry
    - What are the challenges for industry in valuing legacy information, knowledge and procedures, while trying to integrate innovative technologies and procedures? How can companies be more dynamic while still acknowledging and utilizing traditional ideas and techniques?
    - Are there workforce issues associated with differing generational mindsets and methodologies?
    - How does industry handle risk from newer technologies? For example: How do you ensure you have the right answer when using model based design and technologies like additive manufacturing?

### Programmatic & Industrial Base DoD Co-Chair

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## MSS MISSION AREAS

The Modeling and Simulation Subcommittee (MSS) provides an overarching focus on M&S across all disciplines related to JANNAF Interagency simulation-based acquisition of propulsion systems for aerospace plane, hypersonic aircraft, rocket-based space-access systems, high-speed missiles, and in-space propulsion systems, and gun propulsion systems. Virtual Engineering, Integrated Health Management, and Simulation Credibility Panels of MSS pursue this focus in the following current mission areas: Modeling and Simulation of Systems, Virtual Engineering, Integrated Health Management, System Assessment, Cost Estimation, and Simulation Credibility. At the 11th MSS Meeting, papers are sought to address specifics of these mission areas as described below.

### Mission Area I: Modeling and Simulation of Systems

Chair: Mr. Eric J. Paulson, AFRL/Edwards AFB

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Modeling and simulation analyses of missile, aircraft, and launch vehicle systems detailing the results of propulsion technology tradeoffs, technology parameter sensitivities, and technology payoff assessments as applied to vehicle level M&S are highly encouraged.

- M&S of vehicle system technology trades for space launch systems, prompt strike platforms, long-range ballistic missiles, cruise missiles, and hypersonic cruise vehicles
- Advances in the development of tools, models, and methods for vehicle-level modeling and simulation
- Simulations, methods, and models to evaluate performance capabilities, cost, and reliability of systems
- Vehicle and launch facility, weapon and weapon platform, propulsion system and test facility simulations, interactions, integration

### Mission Area II: Virtual Engineering

Chair: Mr. Gary C. Prybyla, NSWC/Indian Head

Telephone: (301) 744-1473

Email: [gary.prybyla@navy.mil](mailto:gary.prybyla@navy.mil)

Virtual engineering encompasses the Modeling and Simulation tools used to help develop, design, test, analyze and visualize systems, subsystems, and components for simulation-based acquisition. Virtual Engineering disciplines include computational fluid dynamics, Finite Element Method (FEM) thermostructural analysis, exterior and interior ballistics, 6-DOF trajectory modeling, and combustion modeling, among others. Virtual engineering uses rapid synthesis and simulation tools, which include traditional deterministic and non-deterministic simulation methods, and non-traditional or “soft computing” methods, including fuzzy logic, neural networks,

and genetic algorithms. The goal of virtual engineering is the application of high-credibility models for accurate analysis and rapid design-space evaluation, leading to increases in functionality with reduced cost and reduced safety risk.

Advances in virtual engineering tools and techniques that are applicable to all aspects of propulsion are highly encouraged.

- Design, integration, manufacturing, and testing—tools and techniques.
- Engineering decision support. Optimization, scheduling, and knowledge-based tools—integration into the engineering process.
- Advances in the development of models and methods for component modeling and simulation to aid design

### Mission Area III: Integrated Health Management

Chair: Mr. R. Scott Hyde, Orbital ATK/Brigham City

Telephone: (435) 863-6307

Email: [scott.hyde@orbitalatk.com](mailto:scott.hyde@orbitalatk.com)

Integrated Health Management (IHM) promotes advancement and development best practices for IHM of propulsion systems within a “system of systems” environment. IHM technologies are focused on reducing maintenance and logistics costs, and increasing reliability of propulsion systems. IHM includes methods and tools for: data management and mining; integrated communications, command and control; diagnostics; prognostics, and integrated sensors and sensing systems. These tools enable making redline and contingency decisions using knowledge-based expert systems, model-based diagnostic and reasoning, fault models, neural networks, fuzzy logic, genetic and evolutionary algorithms, and life-cycle analysis.

Seeking papers on the following, with the intent to establish a valuable interchange of technical solutions:

- Data Management and Mining: Advances in data mining, data fusion, machine learning, and statistics with applications to verification and validation of data, prognosis and diagnosis of system health.
- Integrated Communications, Command and Control: architecture, theory, test beds, and demonstrations.
- Diagnostic Systems: architecture, theory, simulations, and demonstrations of diagnosis of current state of health of propulsion and vehicle system.
- Prognostic Systems: architecture, theory, simulations, and demonstrations of prognosis of future state of health of propulsion and vehicle systems; mitigation of, and recovery from, degraded system health to enable condition based repairs and successful missions.
- Integrated Sensors and Sensing Systems: sensors and integrated sensing systems with broad applications including human health, aircraft, ground vehicles, ships, and energy, and methods for integrated sensing systems across multiple disciplines and end-use applications with

an emphasis on measurement technology, smart sensors, test beds, application considerations, lessons learned, and sensor fidelity.

### Mission Area IV: Space and Launch Vehicle Cost Estimation

Chair: Dr. Michael D. Watson, NASA-MSFC/Huntsville

Telephone: (256) 544-3186

Email: [michael.d.watson@nasa.gov](mailto:michael.d.watson@nasa.gov)

Many launch and space vehicle programs have come in over budget and behind schedule. There is a need for accurate cost estimation for launch and space vehicles including their subsystems and components. This cost specialist session will address cost estimating methods for various launch and space vehicles, their subsystems, and their components; current cost estimating practices; new models emerging in commercial space sector; supply chain management costs; what causes cost overruns; and current and past launch vehicle cost estimating. Of interest are cost models and estimating techniques for the emerging commercial space transportation sector for sub orbital flights, low earth orbit servicing, and future lunar servicing missions.

### Mission Area V: Simulation Credibility

Co-Chairs: Dr. Unmeel B. Mehta, NASA-ARC/Moffett Field

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Dr. Dean R. Eklund, AFRL/Wright-Patterson AFB

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The focus of this Mission Area is on facilitating credible simulations because the credibility of simulations is a major issue for incorporating simulation tools and data into a technology-development program, for conducting simulation-based acquisition, for assessing system reliability to assure human safety and/or mission success, for identifying and assessing risks, and for estimating cost of a component, subsystem or system. Modeling and simulation range from hard computing to soft computing to knowledge-based computing. This Mission Area includes simulation credibility assessment of simulations for design, engineering, manufacturing, health management, ground and flight tests, risk assessment, and cost estimation. Simulation credibility includes assessment and management of simulation uncertainty, sensitivity-uncertainty analysis, experimental uncertainty, modeling uncertainty, simulation verification, validation of models and simulations. Best practices, guidelines, and procedures are also necessary for assessing and improving simulation credibility. Papers are solicited on efforts and guidance on simulation credibility for unit, benchmark, subsystem, and system problems related to the following topics:

- Uncertainty sources and sensitivity analysis
- Propagation, quantification, and management of uncertainty
- Simulation verification
- Simulation validation and model validation
- Simulation credibility assessment
- Risk assessment and management
- Best practices, guidelines, and procedures for establishing simulation credibility.

### Modeling and Simulation Subcommittee Chair

Dr. Michael D. Watson, NASA-MSFC/Huntsville

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### Modeling and Simulation Subcommittee Deputy Chair

Mr. Gary C. Prybyla, NSWC/Indian Head

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### JHU WSE ERG Technical Representative

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## LPS MISSION AREAS

The JANNAF 9th Liquid Propulsion Subcommittee meeting will include sessions in five general technical areas: liquid engine systems; liquid combustion subsystems and components; liquid propellant feed and pressurization systems; tactical liquid and gel propulsion systems; and advanced materials for liquid propulsion applications. Papers are solicited that will aid in the design, development and test of efficient and stable liquid propulsion systems.

### Mission Area I: Liquid Engine Systems

Co-Chairs: Mr. Jason B. Turpin, NASA-MSFC/Huntsville

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**System Analysis and Trades:** Analytical tools, computational models, and methodologies for liquid engine system analysis and design trade methods; cost and weight models; boost/upper-stage engine design tools; model validation methods and criteria; technology and risk identification.

**Health Management and Controls:** New and innovative approaches for sensing engine system performance and hardware condition characteristics during all phases of operation (including preflight prep, prestart, start, flight, shutdown, safing and turnaround) with an emphasis on improving overall system reliability and maintainability. Papers discussing instrumentation innovations, failure prognostic and diagnostic algorithms, maintenance prognostic and diagnostic algorithms, and new and innovative target platforms for performing real-time health management are of interest.

**Test Practices, Standards, and Facilities:** Industry-consensus best practices and standards for the test and evaluation of liquid engines, components and propulsion/vehicle interaction. Status, capabilities, and operation of government and commercial rocket engine test facilities. This includes training, problem reporting, failure investigation, lessons learned, safety, FOD control, process control, and infrastructure improvements to meet aggressive technical goals. Concepts and innovations for engine life testing, engine fault detection, flight qualification testing practices, data reduction and uncertainty analysis methodologies, and other test needs to meet future demands are of interest.

**Long-Life, Reusable, and Long-Duration Engine Design and Integration:** Methodology for the design of long-life and long mission duration operable chemical rocket engine propulsion systems. Long-life engines with current performance levels that have extremely high reliability and operability with 40+ cycles of engine life. Design methodologies for engines with highly responsive, rapid turnaround operational capability.

**Small Launch Vehicle Engines:** Design, development, test, and evaluation approaches for small launch vehicle liquid propellant rocket engines: vehicle integration, safety and reliability, fabrication, testing, verification, validation, operations, and the affordable integration of those areas.

**Liquid Engine Systems for Human-Rated Launch Vehicles:** Design, analysis, development, test, and evaluation approaches and planning associated with liquid propellant rocket engines for use on human-rated launch vehicles; including NASA's Space Launch System (SLS) and vehicles intended for commercial space tourism applications. Functional requirements and design concepts and/or design modifications for the engines on these vehicles. Approaches for meeting government (NASA, FAA, or OCST) safety and reliability requirements for operation with crew and passengers, including fault tolerance; fault detection, isolation, and recovery; crew interaction, reliability predictions and models, and qualification/certification testing requirements and approaches.

**LRE Development History:** Papers addressing the important process which LRE have gone through in the course of their development. Particular subjects of note are successes, failures, mishaps, and lessons learned. Topics can be detailed in their information or can provide a general overview of the program. Papers are not limited to flight systems; testbeds, proof-of-concepts, and R and D programs are encouraged as well.



**Operability:** Papers addressing the operational needs of rocket engines. Operability entails all aspects with rapid turn-around, automated checkout, cleaning, rapid remove-and-replace, etc. This mission area seeks new techniques, processes, design requirements, and proposed design changes to the combustion devices that enable operability.

## Mission Area II: Liquid Combustion Subsystems and Components

Co-Chairs: Dr. Christopher S. Protz, NASA-MSFC/  
Huntsville

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Mr. Robert N. Bernstein, AFRL/Edwards AFB

Telephone: (661) 275-5109

Email: [robert.bernstein.1@us.af.mil](mailto:robert.bernstein.1@us.af.mil)

### **Thrust Chamber Assembly (TCA) Design and Applications:**

This mission area addresses the components and subcomponent features required in all sizes of liquid rocket engines. Components include main combustion chambers, preburners, gas generators, nozzles, and their subcomponent features including items such as injectors, stability aids, and coolant passages. Papers on combustion devices are being sought that cover all aspects of design analysis, component test results, test rig development, diagnostic techniques, and novel design features that are being made possible by manufacturing advances.

### **Hydrocarbon Fuel Properties, Performance, and Specifications:**

Papers addressing chemical composition, physical properties, fit-for-purpose quality, colling and combustion performance, and specification for various hydrocarbon fuels, including RP-1/RP-2, methane, LNG, JP-10 and other high energy density propellants, and alternatively derived fuels (F-T), fIPK, ATJ, etc.); experimental and numerical efforts to characterize operational performance of these fuels in terms of cooling, combustion, and other application-specific processes.

**Combustion Stability:** Papers addressing design and performance challenges, modeling and simulations techniques, and scaling methods associated with combustion stability in main combustion chambers, preburners, and gas generators for all sizes liquid rocket engines.

**Liquid Injection Systems:** The injection system of liquid rocket engines is critical to system performance. This mission area seeks papers describing new injector concepts, the physical processes required to understand injection concepts (including supercritical jets, sprays, and droplets), and methods to determine injector performance and stability.

**Modeling and Simulation:** Recent advances in modeling and simulation bring forward new capabilities to performance prediction and design of combustion devices. Papers are

sought that look at the recent developments, new techniques, results of implementation or comparison with tests. Aspects covered include, but are not limited to: hot gas flow fields, heat transfer, cooling mechanism, integrated models, and injector element dynamics.

**Advanced Liquid and Gel Propellants:** Papers are sought addressing advanced liquid and gel propellants and the development of supporting technologies such as “green” propellants, fuel management systems and lightweight tankage systems to advance state-of-the-art chemical capabilities.

**Hybrid Rocket Engines:** Papers addressing hybrid rocket engine systems and the combustion process in these systems.

## Mission Area III: Liquid Propellant Feed and Pressurization Systems

Co-Chairs: Mr. James L. Cannon, NASA-MSFC/Huntsville

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Mr. Alan M. Sutton, AFRL/Edwards AFB

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**Turbomachinery Design and Applications:** Turbopump-fed liquid rocket engine systems require the use of high speed and high performance rotating machinery. Turbomachinery for this application requires support from a wide range of technical disciplines. Technical areas typically considered include the design, analysis, and testing of inducers, impellers, turbines, seals, bearings and structural elements. Papers on liquid rocket engine turbomachinery are being sought that cover all aspects of design, analysis, code development, component test results, test rig development, diagnostics techniques, and system level testing.

### **Pressurization and Feed Subsystem Design and**

**Applications:** This area covers all aspects of design, analysis and testing of the propellant feed system and engine system specific elements. The propellant feed system is composed of tanks, major component lines, pressurization systems, ducts, feed system control valves, and suppression systems. Engine system specific elements include ducts, flow measurement devices and valves. Papers are being sought which address design, analysis, tool development, diagnostics techniques, and testing of propellant feed system elements and engine system specific elements.

## Mission Area IV: Advanced Materials for Liquid Propulsion Applications

Co-Chairs: Mr. Clyde “Chip” Jones, NASA-MSFC/Huntsville

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Mr. Jamie B. Malak, AFRL/Edwards AFB

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**Material Applications in Liquid Rocket Engines:** Papers are sought addressing advanced materials and processing for liquid rocket propulsion systems, including:

- Material technologies resulting in significant thrust-to-weight ratio increases and/or performance advantages over state-of-the-art capabilities
- Lightweight, high-temperature nozzle materials
- Polymer matrix composites (PMCs) for lightweight components and structures
- PMC resin development for high-temperature or cryogenic environments
- Materials for lightweight lines, ducts, valves, and tanks
- Metals, ceramics, and their composites for component applications
- Materials and production methods for lower lifecycle costs
- Near net shape production for components and structures
- Modeling of materials for liquid rocket engines

**Materials For Commercial Space Transportation:** The recent shift by NASA to commercial space transportation to the ISS under COTS has created the need for low-cost, high performance material solutions for a new generation of space vehicle engines. Papers are sought addressing areas such as:

- Materials selection criteria
- Material characterization requirements
- Flight qualification standards for materials
- Risk management as related to materials selections

**Heavy Lift Launch Vehicles:** A need for heavy lift launch vehicles (>100 metric tons payload) has been identified for future space exploration and other missions. Such a launch vehicle will likely require engines in the 1 million pound thrust class as well as smaller upper stage and other liquid-fueled engines. Papers are sought addressing materials and processes for:

- Manufacturing and production of new liquid fueled engines
- Integrated health management for materials and structures
- Lightweight tanks and composite ducts

- Materials for reusable engines
- Concepts for material solutions that optimize the entire propulsion system for improved performance

**Nanotechnology For Liquid Propulsion Systems:** Application of new nanomaterials to liquid propulsion systems has the potential to greatly increase performance of future engines. Papers are sought to address:

- Nanomaterials and nanoprocessing to improve strength, conductivity, density, modulus, and other properties
- Concepts of how to integrate nanotechnology into future liquid-fueled rocket engines
- Nanotechnology areas that may have high payoffs for liquid rocket engine systems

**Materials For Green Fuel Engines:** In addition to the traditional hydrogen, hydrocarbon and hypergolic engines, new engines with “green” fuels such as methane and ethanol as well as newer fuels that go beyond the traditional definition of green fuels have been proposed. Little work has been done to address the compatibility of these fuels and their combustion products with current and potential future engine materials. Papers are sought to address:

- Environmental corrosion issues for both the fuels and the combustion products
- Compatibility test methods
- Materials concepts for future green fueled engines
- Concepts for future engines and materials for them

**Turbomachinery Materials:** Turbomachinery require new materials or coatings to address new engine cycles such as oxygen-rich staged combustion. The chemical and temperature environments will be considerably different than prior expander or gas-generator cycles. Papers are sought to address potential issues such as:

- Hydrogen and oxygen compatibility
- Testing for oxygen promoted combustion and hydrogen embrittlement
- Development process for new materials
- Criteria for inserting new materials into turbomachinery for hydrogen-, hydrocarbon- and green-fueled engines

**Additive Manufacturing:** Processing methods using additive manufacturing techniques such as selective laser sintering, electron beam sintering, UV additive manufacturing, microwave additive manufacturing and other three-dimensional rapid prototyping methods offer considerable potential for reduction of times to produce parts, cost savings and increased part complexity. Papers are sought for both the development of techniques and the practical use of additive manufacturing technologies as applied to liquid propulsion applications.

## Liquid Propulsion Subcommittee Co-Chairs

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## SPS MISSION AREAS

The 8th JANNAF Spacecraft Propulsion Subcommittee (SPS) seeks abstracts on the full array of spacecraft propulsion technology interests including electric propulsion, chemical propulsion, micro-thrust propulsion, solar thermal propulsion, nuclear thermal propulsion, aerocapture, solar sails, tether systems, and technologies for the future.

### Mission Area I: Chemical Propulsion

Co-Chairs: Mr. A. Paul Zuttarelli, AFRL/Edwards AFB

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Papers are invited that cover all areas of chemical propulsion including monopropellant, bipropellant, gel, solid, and hybrid chemical propulsion systems. Some current areas of interest include, but are not limited to, green propellants and propulsion system developments for modern spacecraft.

Decreased toxicity monopropellant thruster technology development has been of primary interest for spacecraft applications in the last decade. Monopropellant technology is of critical importance to spacecraft operations and principally relies upon catalyst technology.

New propulsion system architecture approaches are being pursued to reduce cost and/or enable new capabilities. Also, reuse or modification of existing propulsion systems and

components has been an ongoing and emerging area of development. This includes the reuse of heritage components and developments in reusable vehicles, systems, or components.

Increasing community knowledge of lessons learned and the relative impact of forthcoming technologies and approaches will support the transition and evolution of these propulsion approaches. Papers are solicited on the following topics of particular interest for sessions supporting spacecraft chemical propulsion:

#### Propellant Factors -

- Formulation, pre-cursor considerations, synthesis, and quality control measures
- Propellant advantages, disadvantages and their impact to operations (ground and flight)
- Propellant (decreased toxicity and state of the art) storage and management
- Decomposition, kinetics, and combustion environment impact to materials and duty cycle
- Impact of propellant impurities on performance including catalytic life

#### Thruster/Engine/Component Factors -

- Impact of propellant impurities on performance including catalytic life
- Injection technologies and concerns such as propellant atomization or dispersion
- Decomposition and ignition means for all areas of chemical propulsion including:
  - Development and performance of alternative catalysts, substrate, and active materials with respect to response and life limiting factors
  - Augmented catalytic and non-catalytic decomposition for monopropellants
- Developments and issues in the reuse, modernization, and/or requalification of components
- Integrated performance and operations including:
  - Duty and thermal cycle impacts to response, repeatability, and useful life
  - Relationship of propellant conditions, component design, and ignition factors
  - Effectiveness in modeling variation of performance for system design and mission planning

## System/Mission Factors -

- Throttleable and pulsed system delivered performance
- Propulsion system architecture considerations, configuration trades, and mission optimization
- Propulsion system operations, diagnostics, and failure management
- Operational condition concerns such as conditioning of propellants
- Status, infusion viability, and impact of new propulsion technology and pathfinder activities

## Mission Area II: Electric Propulsion

Co-Chairs: Dr. Hani Kamhawi, NASA-GRC/Cleveland

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Dr. Robert B. Lobbia, AFRL/Edwards AFB

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Papers are invited in all areas of electric propulsion (including solar- and nuclear-powered systems). Topics of interest include:

- Basic Research and Development of Electric Propulsion Thrusters: This area includes physics of electric propulsion processes, thruster technology development, advanced and breakthrough concepts, high-power electric propulsion, hybrid and dual-mode systems using electric propulsion, alternate propellant research, laboratory and flight plasma diagnostic techniques, and electric propulsion test facilities.
- Systems Engineering of Electric Propulsion Subsystems: This includes electric propulsion subsystem design, propellant storage and feed systems development, power processing units design and testing, navigation and control systems development, and integrated system testing of electric propulsion subsystems.
- Electric Propulsion Flight Programs: This includes reporting on ground and flight system operations, space qualification programs, and in-flight programs status.
- Modeling of Electric Propulsion Thrusters, Plume, and Spacecraft Interaction: This includes modeling of the physics of electric propulsion thrusters, modeling of thruster and spacecraft interactions, development of plume models, and development of models to validate ground and flight measurements and operations.

## Mission Area III: Cube / Nano Satellite Propulsion

Co-Chairs: Dr. Juergen Mueller, JPL/Pasadena

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Dr. William A. Hargus, Jr., AFRL/Edwards AFB

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Papers are invited to discuss micro-propulsion and propulsion options for CubeSATS, NanoSATS, and other small satellites. Applications, concepts, and designs for propulsion systems or components in small satellites are of interest. Of particular interest are papers on components such as valves, tankage, propellant feed parts, and power conditioning for micro-propulsion applications. Other areas of interest include:

- Micro-propulsion
- Nano-propulsion
- Micro-thrust devices
- Cube satellite applications
- Micro satellite applications
- Nano-satellite applications
- Cube/Micro/Nano satellite propulsion systems
- Small component development and design for small propulsion applications
- Power conditioning for micro-EP applications
- System-level integration studies
- Mission design studies
- Nano-satellite applications

## Mission Area IV: Future Technologies

Chair: Dr. Kurt A. Polzin, NASA-MSFC/Huntsville

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Co-Chairs: TBD

Session includes all aspects of Nuclear Thermal Rocket (NTR) propulsion design, testing, and utilization for future human exploration missions of the solar system. Topics of interest for these sessions include, but are not limited to the following topics:

- NTR spacecraft and mission design for human Mars Exploration mission
- Solid core NTR concepts with or without bimodal capability
- Common reactor design for both propulsion and surface power generation
- Candidate nuclear fuel options



- Reactor controls and shielding
- NTR test methods and facilities
- NTR demonstration options
- Safety, reliability, risk analysis and crew-rating
- NTR vehicle operations and costs

Key focus areas of Solar Thermal Propulsion are engines and concentrators with specific interest in the following topics:

- Engine concepts (thermal storage, direct gain, bimodal, volumetric, etc.)
- Engine support structures, insulation techniques, and materials
- Inflatable, deployable or rigidizing and secondary concentrations
- Reflectors
- Engine/concentrator integration and alignment
- Sun acquisition
- Sun tracking and pointing
- Mission concepts and applications utilizing a solar thermal propulsion system to enable new mission scenarios or to enhance current mission capabilities.

Sessions include advanced concepts for both near- and far-term future space propulsion. Specific topics include technologies that promise significant gains in specific impulse, and/or power density, but are based on known fundamental physics, such as:

- Fusion Energy in Space Propulsion including conventional magnetic schemes, inertial fusion schemes, inertial electrostatic confinement, magnetically insulated inertial fusion, fission-fusion hybrid systems, and concepts that utilize fusion reaction directly or indirectly.
- High-energy fuels
- Use of antimatter in propulsion systems
- Laser or microwave propulsion
- Mass drivers

Session includes solar sail propulsion, electrodynamic and momentum exchange tether propulsion, aerocapture and other innovative technologies that use the natural environments of space to derive propulsion without the expenditure of conventional fuel. Atmospheric entry and thermal protection systems are also of interest.

- Review or summary of previous flight experiments
- Planned and/or funded missions
- Near-term mission concepts
- Advanced mission concepts
- Innovative system or subsystem designs
- Guidance, navigation and control
- Space environmental effects

Sessions include atmospheric entry and thermal protection systems.

- Development, characterization, modeling and testing of TPS materials

## Mission Area V: Spacecraft Modeling and Simulation

Chair: Dr. Justin Koo, AFRL, Edwards AFB

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Virtually all the mission areas represented at JANNAF SPS have some Modeling and Simulation (M&S) activity as an essential, yet underrepresented, component of successful technology development. We strongly encourage prospective authors to develop separate M&S papers, in addition to mission area specific papers, so that knowledge of the unique and promising computational aspect of SPS can be disseminated throughout the community. These include computational models for physical behavior, innovative numerical methods, development of robust computational validation techniques and exploitation of novel hardware configurations. Topics of particular interest to the organizing committee are those supporting: catalyst development; electromagnetic and electrostatic thruster development; prediction of plume signatures and spacecraft/plume interaction behavior.

## Spacecraft Propulsion Subcommittee Chair

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## WORKSHOPS/SPECIALIST SESSIONS

Recommendations for workshops or specialist sessions are solicited at this time. **Individuals interested in organizing and chairing a workshop or specialist session should contact the JHU WSE ERG Technical Staff member in their respective subcommittee by 11 July 2016.**

### Workshops

The JANNAF Workshop is reserved for bringing the community together to address a specific task or problem, the outcome of which is important and substantial enough to warrant the publication of a final report detailing the discussions, conclusions, and recommendations that resulted from the workshop.

Requirements for JANNAF workshops and established best practices can be found in the [Guide for JANNAF Workshop Chairs](#); this document will guide you through the planning and approval process for workshops held at a JANNAF meeting.

To request a workshop you must submit a [Workshop Request Form](#) to your JHU WSE ERG Technical Liaison or Shelley Cohen at [scohen@erg.jhu.edu](mailto:scohen@erg.jhu.edu). This form must be submitted to ERG by **Monday, 11 July 2016**. The agenda and invitation list is due **Monday, 29 August 2016** for inclusion in the Preliminary Program, and must be approved no later than **Monday, 24 October 2016** for inclusion in the Final Program.

### Specialist Sessions

A JANNAF Specialist Session is an opportunity for experts in a specific technical area to meet to stimulate ideas and contributions from the audience. These sessions are dedicated to a single topic and often include invited presentations. The organization of these sessions is similar to a regular JANNAF paper session with time allocated to individual presentations; however, specialist sessions often include moderator led discussion periods or a question and answer session with expert panelists.

To request a Specialist Session for this JANNAF meeting a [Specialist Session Request Form](#) must be submitted to JHU WSE ERG. This form requires a statement of justification for the Specialist Session as well as a well thought out agenda. Requests will be reviewed by the designated JANNAF subcommittee TSG chair and ERG for approval; this approval is necessary for any Specialist Sessions to be included in the Final Program.

**The deadline for submission of a Specialist Session request is 11 July 2016.** If you have any questions about planning a Specialist Session please contact your ERG Technical Liaison or Shelley Cohen at [scohen@erg.jhu.edu](mailto:scohen@erg.jhu.edu).

## JANNAF AWARDS PROGRAM

In the tradition of recognizing the outstanding achievements of the propulsion community, the JANNAF Technical Executive Committee and the Modeling and Simulation (MSS), Liquid Propulsion (LPS) and Spacecraft Propulsion (SPS) subcommittees are soliciting nominations for awards to be presented at the meeting. A TEC Award is justified if the achievement or service is in a technical area that is not covered by an existing subcommittee, or is of such scope or magnitude that merits this recognition.

### Special Recognition Awards

The Special Recognition awards for Sustained Contribution and Lifetime Achievement honor individual achievements, either in the last 18 months or for a lifetime of dedicated service. These awards are the most prestigious subcommittee awards and reflect on the awardees contributions to JANNAF.

Special recognition award winners will be selected by respective subcommittee Awards Committees based on review of the nomination in consideration of the following:

- Technical value of the achievement(s) including level of technical complexity and challenge, quality of results, degree of innovation and timeliness of research.
- Impact of the achievement on the broader propulsion community.
- For individuals nominated for lifetime achievement, demonstrated participation in technical societies as evidenced by positions held and papers published will be considered favorably.

### Outstanding Achievement Award

The Outstanding Achievement Award is given for the most outstanding technical achievement in the subcommittee's area by an individual, by a team within an organization, or by a team of organizations. To recognize the varied nature of the JANNAF subcommittees and the accomplishments of their communities, nominations may be solicited and given in the two focus areas of R&D Technology and Operational Systems.

The achievement shall have been accomplished in the previous 18 months. The nominees must work have worked for the organization during the same 18-month period of performance.

### Certificate of Commendation

The Certificate of Commendation is given to recognize an individual whose contributions within the last 18 months have been pivotal in ensuring the success of a JANNAF activity.

### Certificate of Appreciation

The Certificate of Appreciation is given to recognize individuals for outstanding contributions and dedicated service to JANNAF.

## Nominations

To nominate an individual for one of the above awards please use the “[JANNAF Executive Committee and Subcommittee Award Nomination Form](#).” Nomination submissions should include the following:

- A description of the achievement or distinguished service, of no less than 200 and no more than 1000 words. The description must be typed or provided in electronic format (Acrobat PDF or MS Word) via Email.
- Supporting data (if desired) of no more than 10 pages.
- Supporting curriculum vitae, list of publications, and/or professional activities as required to support the nomination.
- Contact information for the nominee(s) and the nominator, including organization affiliation, phone number, and Email address.

Nominations should be submitted to the appropriate JHU WSE ERG technical representative no later than **Monday, 3 October 2016**.

## Best Paper Awards

In addition to the nomination awards listed above JANNAF recognizes authors of papers that exhibit excellence and significant merit with the Best Paper Awards. Best Paper Awards from this meeting will be given at the next JANNAF Subcommittee meeting.

## Best Student Paper Awards

The Best Student Paper Award will be given to undergraduate or graduate students who author papers that exhibit excellence and significant merit. One paper will be selected to receive the Best Student Paper Award. All student-authored works will automatically be included in the initial round of consideration with the submission of an abstract; in order to facilitate identification of student-authored works please ensure to clearly state on your abstract that you wish to be considered for the Best Student Paper Award or contact the appropriate JHU WSE ERG technical representative.

As a reminder: student authors must conform to the same JANNAF eligibility requirements as other authors, per the policy on non-government attendees at JANNAF meetings given on page 2. Student authors are encouraged to work with their advisors to ensure they meet these requirements, and should contact JHU WSE ERG at their earliest convenience with questions regarding their eligibility and participation.

Student papers will be reviewed upon submission of their cleared manuscripts. In order to be considered for the student best paper selection, the completed paper must be provided to JHU WSE ERG by **3 October, 2016**. The Best Student Paper Award will be presented at the JANNAF meeting at which the paper is given.

## UPCOMING JANNAF MEETINGS

**Liquid Propulsion Subcommittee (LPS)  
Advanced Materials Panel Meeting (AMP)  
Additive Manufacturing for Propulsion Applications  
Technical Interchange Meeting (TIM)**

*23-25 August 2016  
The Jackson Center  
Huntsville, Alabama*

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

*December 5 - 9, 2016  
Phoenix, Arizona*