

## Space Astronomy, Sounding Rockets, and Closing the Gap in Low-Cost Access to Space

By Dr. Stephan R. McCandliss, The Johns Hopkins University

**S**ounding rockets today play as critical a role in the development of space astronomy as they did over half a century ago. Their primary goal is to enable cutting edge science by exploiting new technologies and training the next generation of space experimentalists. The first missions in the late 1950s and early 1960s were launched using two-stage Aerobee variants with solid propellant boosters and liquid fuel sustainers (i.e., fuming nitric acid/aniline). They carried relatively simple payloads with pulse-counting photomultiplier or Geiger tubes looking out the sides of spin-stabilized platforms and scanning large swaths of the sky.

The pioneering astronomical discoveries and developments of those days included the discovery of the ultraviolet (UV) radiation emitted from the stars in the constellation of Orion (Kuperian, Byram and Boggess at the Naval Research Laboratory); detection of the first extra solar x-ray source in the constellation of Scorpius (Giacconi et al. at American Science and Engineering); and the construction of cryogenic infrared (IR) telescopes (Harwit et al. at Cornell and McNutt et al. at NRL), all of which were seminal developments that opened the doors of astronomical inquiry into entirely new portions of the electromagnetic spectrum only accessible from space.

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## JANNAF to Meet in Las Vegas April 14-17, 2009 for JPM and Joint Subcommittee Meeting

**T**he 56th Joint Army-Navy-NASA-Air Force (JANNAF) Propulsion Meeting and 39th Structures and Mechanical Behavior / 35th Propellant and Explosives Development and Characterization / 26th Rocket Nozzle Technology / 24th Safety and Environmental Protection / 17th Nondestructive Evaluation Joint Subcommittee Meeting will be held April 14-17, 2009, at the Renaissance Las Vegas, in Las Vegas, Nevada. Mr. Bruce R. Askins of NASA Marshall Space Flight Center in Huntsville, Alabama, is the Program Chair of this meeting. On Wednesday, April 15, Mr. Stephen A. Cook, Project Manager for the NASA Ares vehicle, will present the keynote address on the Ares I and Ares V Project as part of NASA's future in leading the support of the *Nation's Vision for Exploration*.

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## CPIAC's Technical/Bibliographic Inquiry Service

CPIAC offers a variety of services to its subscribers, including responses to technical/bibliographic inquiries. Answers are usually provided within three working days and take the form of telephoned, telefaxed, electronic, or written technical summaries. Customers are provided with copies of JANNAF papers, excerpts from technical reports, bibliographies of pertinent literature, names of recognized experts, propellant/ingredient data sheets, computer programs, and/or theoretical performance calculations. The CPIAC staff responds to nearly 800 inquiries per year from over 180 customer organizations. CPIAC invites inquiries via telephone, fax, e-mail, or letter. For further information, please contact Ron Fry by e-mail to [rs\\_fry@jhu.edu](mailto:rs_fry@jhu.edu). Representative recent inquiries include:

### TECHNICAL INQUIRIES

- Methods to reduce risk for using THF as a solvent with water dilution to dissolve the AP out of the propellant matrix. (Req. 26237)
- Information on thermobaric explosives formulations; techniques to measure, characterize and quantify explosive effects; and IM characteristics of TBX munitions (Req. 26247)
- Increasing the regression rate of hybrid rocket fuels using oxidizer injector variations for different fuel formulations. (Req. 26251)
- Formulation information for MK 104 DTRM propellants. (Req. 26279)
- Propulsion stage information for Minuteman III, AMRAAM, Hellfire, and Standard Missile (Req. 26281)

### BIBLIOGRAPHIC INQUIRIES

- Boeing Dynamic Start Inlet Concept of the 1980s (Req. 26282)
- CPIA-LS79-6, "Underwater Vehicle Propellants" (Req. 26298)
- Understanding Flow Blockages in Small Thrusters (Req. 26358)
- Hypergolic Ignition of Gel Propellants (Req. 26361)
- Shaped charge explosive formulations (Req. 26248)

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The Chemical Propulsion Information Analysis Center (CPIAC), a DoD Information Analysis Center, is sponsored and administratively managed by the Defense Technical Information Center (DTIC). CPIAC is responsible for the acquisition, compilation, analysis, and dissemination of information and data relevant to chemical, electric, and nuclear propulsion technology. In addition, CPIAC provides technical and administrative support to the Joint Army-Navy-NASA-Air Force (JANNAF) Interagency Propulsion Committee. The purpose of JANNAF is to solve propulsion problems, affect coordination of technical programs, and promote an exchange of technical information in the areas of missile, space, and gun propulsion technology. A fee commensurate with CPIAC products and services is charged to subscribers, who must meet security and need-to-know requirements.

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## Meeting Reminders

**JANNAF**  
**43rd Combustion/  
31st Airbreathing  
Propulsion/  
25th Propulsion Systems  
Hazards  
Joint Subcommittee Meeting**  
**December 6-11, 2009**  
**La Jolla, CA**

The Joint Army-Navy-NASA-Air Force (JANNAF) 43rd Combustion / 31st Airbreathing Propulsion / 25th Propulsion Systems Hazards Joint Subcommittee Meeting will be held December 6-11, 2009, at the Hyatt Regency La Jolla in La Jolla, California.

CPIAC will distribute the meeting announcement and call for papers in late February; please contact Patricia Szybist at [pats@jhu.edu](mailto:pats@jhu.edu) or 410-992-7302, ext. 215, if you do not receive a copy or require additional information.

Attendance at this JANNAF meeting is restricted to U.S. citizens whose organizations are registered with an appropriately classified contract with the Defense Technical Information Center and certified for receipt of export-controlled technical data with the Defense Logistics Information Service.



## The Bulletin Board

Various propulsion-related meetings are listed below. If you know of an event that may be of interest to the propulsion community, please forward the details to [bulletin@cpiac.jhu.edu](mailto:bulletin@cpiac.jhu.edu). Additional industry meetings are posted on the CPIAC Web site, *Meetings & Symposia*: <http://www.cpia.jhu.edu/templates/cpiaTemplate/meetings/>. The JANNAF Calendar appears on the [back page](#).

### *12th Seminar on "New Trends in Research of Energetic Materials"*

1-3 April 2009  
Pardubice, Czech Republic  
POC: [www.ntrem.com/](http://www.ntrem.com/)

### *DTIC 2009 Conference - "From Discovery to Access"*

6-8 April 2009  
Hilton Alexandria Old Town, Alexandria, Virginia  
POC: 703-767-8236 or e-mail [confinfo@dtic.mil](mailto:confinfo@dtic.mil)

### *Fundamentals of Explosives*

5-7 May 2009  
University of Rhode Island, Kingston, Rhode Island  
POC: Dr. Jimmie Oxley, 401-874-210 or e-mail: [joxley@chm.uri.edu](mailto:joxley@chm.uri.edu)

### *2009 Insensitive Munitions and Energetic Materials Technology Symposium*

11-14 May 2009  
Tucson, Arizona  
POC: [www.ndia.org](http://www.ndia.org)

### *45th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit*

2-5 August 2009  
Denver, Colorado  
POC: [www.aiaa.org](http://www.aiaa.org)

### *7th International Workshop on Structural Health Monitoring 2009*

9-11 September 2009  
Stanford University, Stanford, CA  
POC: <http://young-sacl.stanford.edu/member.php>

### *2009 Int'l. Autumn Seminar on Propellants, Explosives and Propellants*

22-25 September 2009  
Kunming, Yunnan, China  
POC: <http://www.iaspep.com.cn>

### *6th International Symposium on Beamed Energy Propulsion*

1-5 November 2009  
Scottsdale, Arizona  
POC: [http://aibep.org/ISBEP\\_6/ISBEP\\_6.htm](http://aibep.org/ISBEP_6/ISBEP_6.htm)

### *8th International Symposium on Special Topics in Chemical Propulsion*

2-6 November 2009  
Cape Town, South Africa  
POC: Prof. Ken Kuo at [kenkuo@psu.edu](mailto:kenkuo@psu.edu), or call (1-814) 863-6270



# Space Astronomy, Sounding Rockets, and Closing the Gap in Low Cost Access to Space....continued from page 1

An astronomical gold rush issued from these and other groups at The Johns Hopkins University; Massachusetts Institute of Technology; the Universities of Colorado, California, and Wisconsin; Princeton University; Columbia Astrophysics Laboratory; Lockheed Martin Corp.; NASA Goddard Space Flight Center; and Kitt Peak National Observatory, all of which were initially supported, not only by NASA, but by the Air Force, Navy, and the National Science Foundation. Launch rates skyrocketed, peaking in 1969 at 27 missions year<sup>-1</sup> as indicated by Fig. 1.

Entrepreneurial principal investigators (PI) competed with each other, seeking to develop the most innovative and cost-effective instrumentation that could survive the rigors of space flight and yield a tenfold improvement in capability. The technologies they matured by “pushing the envelope” in these risk-tolerant missions have been regularly incorporated into long-duration missions where failure is not acceptable. This process effectively created a space astronomy guild based on an oral tradition of PIs, research scientists, and engineers mentoring graduate and undergraduate students through all phases of a space mission.

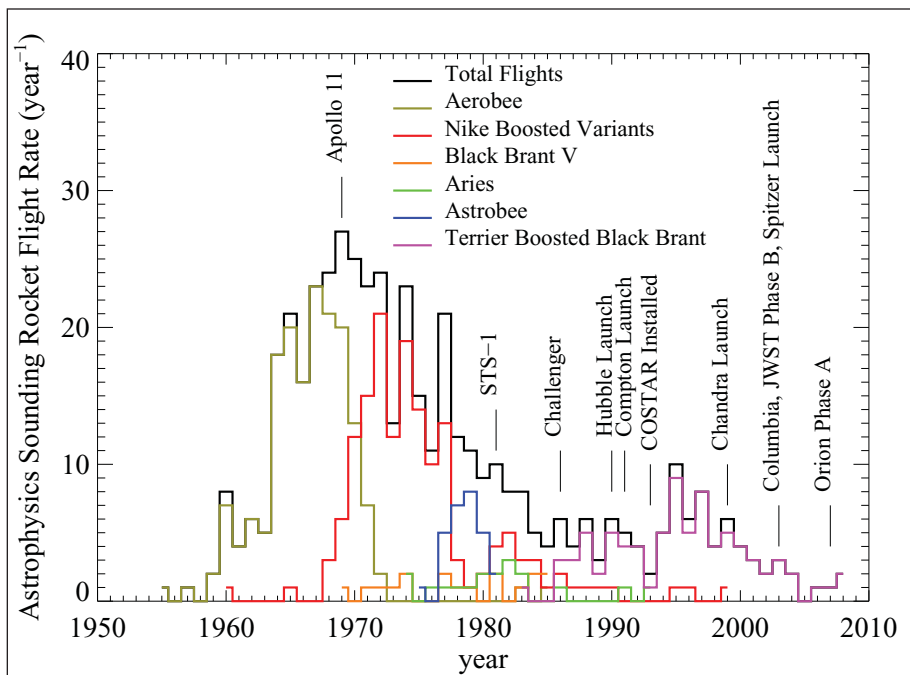


Figure 1. The launch rate of astrophysics sounding rocket payloads from 1955 to the present, delineated by launch vehicle. NASA milestones are marked.

Courtesy of Jonathan's Space Report

The process of identifying a new science thrust, synthesizing it into a mission concept, nurturing an immature technology and wresting science from it, is a crystallizing experience for a young researcher. Lessons are captured and passed on, creating a self-perpetuating, technically literate workforce capable of leading and supporting instrument development and operations for NASA flagship missions like the Great Observatories, James Webb Space Telescope, and the more focused projects carried out by the Explorer programs.

Unfortunately, as of late, the launch rate for sounding rockets in all disciplines, astrophysics (Fig. 2), heliophysics, and space plasma physics, has fallen to pre-1960s rates because of the reduced number of launch groups that NASA has been able to support.

Consequently, the pipeline of science, technology, and workforce development required in the long term to maintain a competitive spacefaring community is at risk (c.f. the National Academies Press Report entitled, “Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,” by

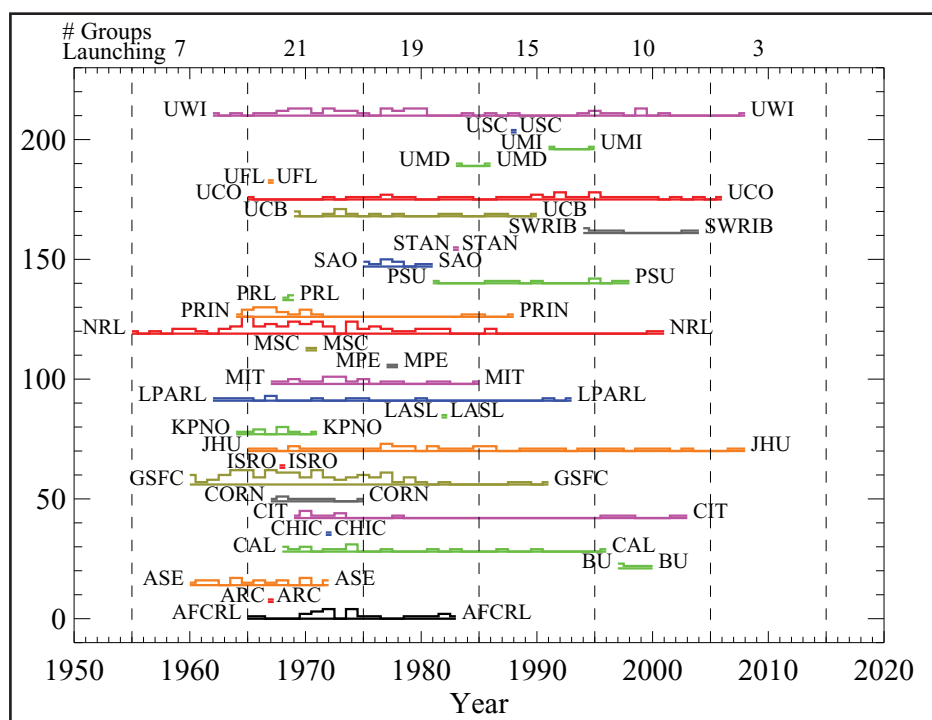


Figure 2. The number of groups launching astrophysics payloads from sounding rockets; 1955 to the present.

Courtesy of Jonathan's Space Report

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## Space Astronomy, Sounding Rockets, and Closing the Gap in Low Cost Access to Space....continued from page 4

Augustine et al.). The reductions have been brought on in part by the extreme expense of launching risk-intolerant orbital missions.

Our efforts to improve the sophistication and capability of our instrumentation have outpaced our efforts to develop reliable low-cost delivery systems. There currently is no proven orbital analog to the highly reliable, commercially maintained Terrier Boosted Black Brant (the BB IX) which, since the mid-1980s, has been the vehicle of choice for sub-orbital astrophysics missions. The BB IX and its suite of standardized, modular support systems can provide 3-axis sub-arcsecond pointing to a 1000-lb payload and an exo-atmospheric time of over 400 seconds above 120 km for approximately \$2 million. This cost is approximately two orders of magnitude lower than the current lowest cost orbital opportunity provided by NASA's Explorer program. If a launch vehicle, such as the SpaceX Falcon 1 for example, really can deliver a previously proven sounding rocket payload to orbit for several days for the advertised cost of approximately \$8 million, then it would provide more than a factor of ten improvement in science return. We, in the astrophysics sounding rocket community, hope that the competitive spirit, which lives in our community also lives in the chemical propulsion community and that it is willing and able to rise to this challenge. Now more than ever we need competitive launch vehicle systems, which can close the gap in low-cost access to space.

### Origins of the JHU Sounding Rocket Program

Founded in 1961 by G.H. Dieke and W.G. Fastie under support from NASA, the sounding rocket program at JHU has provided many graduate students the opportunity to use sounding rocket-born telescopes and spectrographs to make unique astronomical and atmospheric observations. The group specializes in the development of spectroscopic instrumentation; a natural outgrowth from the legacy of diffraction grating research led by Professor Henry A. Rowland of JHU at the end of the nineteenth century. Most of the JHU's current suite of rocket-born spectrographs work in the 900-2000 Angstrom wavelength range where the Earth's atmosphere is strongly attenuating and observations can only be made by sounding rockets or orbiting telescopes. Past missions include observations of Earth's aurorae, several comets including Hale-Bopp and Halley, Jupiter, Venus, Io's plasma torus, a number of hot stars and nebulae, and the first ultraviolet spectrum of the quasar 3C273.


### About the Author



Dr. Stephan R. McCandliss is a Principal Research Scientist with the Henry A. Rowland Department of Physics and Astronomy at The Johns Hopkins University. He is a Principal Investigator with the JHU Sounding Rocket group, responsible for the design, procurement, fabrication, calibration, and integration of spectroscopic telescope experiments into sounding rocket delivery systems provided by the NASA Sounding Rocket Operations Contractor (NSROC) at the Wallops Flight Facility, Virginia. More information can be found at <http://www.pha.jhu.edu/groups/rocket/> and by following the links therein. Dr. McCandliss may be reached at [stephan@pha.jhu.edu](mailto:stephan@pha.jhu.edu).

### Acknowledgments

The author gratefully acknowledges the use of data from the *Orbital and Suborbital Launch Database on Jonathan's Space Report* (<http://www.planet4589.org/>), which is a personal Web site maintained by Jonathan McDowell, an astrophysicist with the Harvard-Smithsonian Center for Astrophysics.

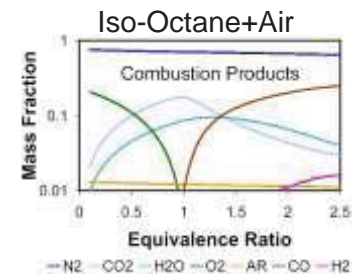


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The meeting invitation and preliminary program, a link to the remittance site, and the required registration certification form are available online at [http://jannaf.org/April\\_2009\\_meeting.php](http://jannaf.org/April_2009_meeting.php).

Attendance at this JANNAF meeting is restricted to U.S. citizens whose organizations are registered with an appropriately classified contract with the Defense Technical Information Center and certified for receipt of export-controlled technical data with the Defense Logistics Information Service.

All attendees of the meeting will receive a complimentary copy of the *JANNAF Journal of Propulsion and Energetics* (Vol. 2), which contains eight peer-reviewed articles on such topics as solid propellants and combustion, solid rocket motor technology, scramjet propulsion, electric propulsion, and explosive performance.

Program Chair Bruce Askins was named the Project Integration Manager for the Ares I-X test flight project in 2008. With this assignment, Askins assists in the overall management and development of the Ares I-X mission that is scheduled for launch in 2009. His work includes technical leadership of the multi-disciplinary team performing project integration and responsibility for the integrated mission products. Askins' work at NASA has earned him numerous commendations for outstanding performance and various achievement recognition awards from NASA, including the Marshall Space Flight Center Director's Commendation, several Special Service Awards, and the NASA Silver Snoopy award. Mr. Askins earned a bachelor's degree in 1987 in mechanical engineering from the University of Alabama in Huntsville.

Keynote Speaker Stephen Cook was named to his position as manager of the Ares Projects in September 2005. Cook is responsible for overall project management and direction of NASA's Ares I crew launch vehicle, which



*Bruce R. Askins  
Program Chair*



*Stephen A. Cook  
Keynote Speaker*

will transport the Orion crew exploration vehicle into space and deliver uncrewed cargo payloads to space – key to the U.S. Space Exploration Policy. The objective of the project is overall integration of the launch vehicle system, and development of a first stage derived from the current space shuttle booster and motor elements and a new upper stage powered by a J-2X main engine. The project is also aimed at

development of NASA's future Ares V cargo launch vehicle and Earth Departure Stage, which will carry heavy-lift payloads to space for use by exploration missions on the moon and destinations beyond.

Cook holds a bachelor's degree in aerospace engineering and mechanics from the University of Minnesota.

### *Technical Program*

This year's technical program consists of 39 technical sessions, 2 specialist sessions, 5 workshops, and 3 short courses, plus numerous panel meetings. It encompasses an unprecedented degree of cooperative activities among the JPM and subcommittees. The preliminary block diagram of the program is included on [page 10](#).

The JPM will host 12 technical sessions, of which 2 are joint with PEDCS and SMBS, 1 is joint with PEDCS, and 1 is joint with RNTS. The JPM will also conduct a 10X Scramjet Technology Workshop. A specialist session on the methodology and application of technology and manufacturing readiness levels, conducted jointly with PEDCS and SMBS, will also be part of the JPM program.

NDES and RNTS will jointly host two technical sessions. PEDCS will host 13 sessions, of which 2 are joint with SEPS. PEDCS will also conduct a specialist session on the status of selected propellant ingredients. RNTS and SEPS will host three and four sessions, respectively. SMBS will host five sessions, of which two are joint with PEDCS and one is joint with RNTS, plus two workshops – one on wireless sensors and one on the business case for health monitoring. The latter will be conducted jointly with the Liquid Propulsion Subcommittee and the Modeling and Simulation Subcommittee (MSS). "Health" in this context refers to the ability of a missile system to perform its intended functions over the course of its service life.

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MSS will also host two workshops independently, one on simulation credibility and the other on prediction of solid-propellant rocket motor performance. JANNAF Executive Committee and Subcommittee Technical Achievement Awards will be presented after the keynote address. A special feature of the meeting will be the inclusion of two short courses: "Basic Measurement Uncertainty, Methods and Applications," taught by Ronald H. Dieck of Ron Dieck Associates, Inc., and "Space Propulsion Systems: Learning from the Past and Looking to the Future," conducted by George Hopson. Details provided in the following article.



*The Renaissance Las Vegas*

## **CPIAC Sponsors Three Tutorials at 56th JPM in April 2009**

CPIAC will sponsor three tutorials in conjunction with the 56th JANNAF Propulsion Meeting (JPM) and 39th Structures and Mechanical Behavior / 35th Propellant and Explosives Development and Characterization / 26th Rocket Nozzle Technology / 24th Safety and Environmental Protection / 17th Nondestructive Evaluation Joint Subcommittee Meeting being held Tuesday through Friday, April 14-17, 2009, at the Renaissance Las Vegas. Registration for all courses includes complimentary meeting registration and can be completed at the meeting remittance site: [http://jannaf.org/April\\_2009\\_meeting.php](http://jannaf.org/April_2009_meeting.php). Participants must meet the attendance criteria as outlined in the meeting invitation. The deadline date for registration is March 11, 2009. Further details are provided in the meeting's Preliminary Program: [http://jannaf.org/April\\_2009\\_meeting.php](http://jannaf.org/April_2009_meeting.php). The registration fee for each course is \$1,000, which includes conference registration and covers all course materials.

### **MEASUREMENT UNCERTAINTY, CONCEPTS AND APPLICATIONS**

For the third time, CPIAC is sponsoring the tutorial "Measurement Uncertainty, Concepts and Applications," which will be conducted on Tuesday and Wednesday, April 14 and 15. Led by Ron Dieck, a recognized leader in the field with over 35 years of experience, the course will run for 2 full days.

Intended for scientists and engineers interested in evaluating experimental accuracy, this course is in complete harmony with the principles of the ISO and other international standards on measurement uncertainty. Included are the basics of the measurement uncertainty model, the use of correlation, curve fitting problems, probability plotting, combining results from different test methods, calibration errors and error propagation for both independent and dependent error sources. Extra attention is placed on the personal problems of developing confidence in uncertainty analysis

results and on using measurement uncertainty to select instrumentation systems. Special emphasis on understanding is achieved through discussion, class experiments and the in-class working of problems.

The course will conclude with a guest lecture by Scott McFarlane of Force Measurement Systems (FMS), who will explain the theory and application of thrust measurement for rocket propulsion testing, with particular focus on the characteristics of load cells and thrust measurement systems; including definitions, requirements, specifications, and lessons learned during design and implementation.

Course materials include a complete set of notes and a copy of the course text "Measurement Uncertainty, Methods and Applications, 3rd Edition," by Ron Dieck (<http://www.rondieckassociates.com>).

### **SPACE PROPULSION SYSTEMS: LEARNING FROM THE PAST AND LOOKING TO THE FUTURE**

JANNAF has teamed with the NASA Engineering and Safety Center (NESC) Academy and the National Institute of Aerospace to provide a two-day offering of the much-lauded technical course with George Hopson, "Space Propulsion Systems: Learning from the Past and Looking to the Future." The course will be conducted on Thursday, April 16 and Friday, April 17; the course runs for 2 full days. George Hopson's four decades of contributions to the American space program include work on Skylab, the Space Shuttle, and the International Space Station. He was awarded NASA's Distinguished Service Medal, the highest honor that NASA confers.

This course will present detailed case studies and problem-solving activities involving space propulsion systems

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# CPIAC

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- ⇒ **Computer Programs and Theoretical Performance Calculations**
- ⇒ **Propellant/ingredient data sheets**
- ⇒ **Excerpts from technical reports**
  - ⇒ **Bibliographies**
  - ⇒ **JANNAF papers**
- ⇒ **Names of Recognized Experts**

### What about those 4 free hours?

As one of the Information Analysis Centers (IACs) established by the Department of Defense (DoD), CPIAC provides a variety of services to support researchers, scientists, engineers, and program managers with expertise in the areas of chemical propulsion and energetics research. In support of this effort, customers may receive up to four free hours of service to obtain answers to technical and bibliographic inquiries related to CPIAC's scope. This time is subsidized by the DoD.



## How do I submit an Inquiry?

To place an inquiry, eligible individuals and organizations may contact the CPIAC Technical Inquiries line at 410-992-7306. Inquiries may also be submitted by fax, e-mail, or letter. For more information, please contact Ron Fry by e-mail to [rs\\_fry@jhu.edu](mailto:rs_fry@jhu.edu).

## How do I know if I'm Eligible?

Generally, U.S. citizens working for or on contract to DoD or U.S. Government agencies are eligible.

Satisfactory completion of a simple 1-page Customer Verification Form (DLIS/DTIC) is all that is necessary.

## How long will it take to get an answer?

CPIAC responds to most routine inquiries within 48 hours.

Other more detailed requests are considered "extended" technical inquiries and may take several days or weeks to complete.

## Sharing the Knowledge

Results are permanently retained in the CPIAC database so that critical information may be shared among the U.S. propulsion community. Interested parties can review CPIAC's regularly published list of recently completed technical and bibliographic inquiries.

Customer and proprietary topic privacy is maintained.

*The CPIAC technical staff responds to approximately 400 inquiries per year from over 180 customer organizations. Recent Technical Inquiries that have been approved for public release are provided below:*

What are the best testing methods to determine the burning rate for air bag propellants? (Req. 26185)

What are the safety issues associated with the use of titanium pressure bottles submerged in liquid oxygen? (Req. 26221)

What are the design considerations for hypergolic fuel vapor scrubbing systems? (Req. 26304)

What are the chemical constituents and ingredient formulations for shaped charge explosives? (Req. 26248)

What is the state of the art in rocket engine health monitoring by spectroscopic measurement of plume metallic species? (Req. 26228)

What are the effects of porosity on Burning Rate for NC-based composite propellants? (Req. 26111)

*The answers to the above inquiries are available, simply for the asking. Contact CPIAC Customer Service at 410-992-7300 and reference the Request (Req.) number above.*

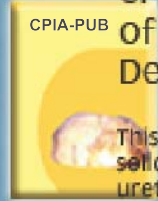
**Preliminary Block Diagram**  
**56<sup>th</sup> JANNAF Propulsion Meeting / 39<sup>th</sup> Structures and Mechanical Behavior / 35<sup>th</sup> Propellant and Explosives Development and Characterization /**  
**26<sup>th</sup> Rocket Nozzle Technology / 24<sup>th</sup> Safety and Environmental Protection / 17<sup>th</sup> Nondestructive Evaluation Subcommittee Joint Meeting**  
Renaissance Las Vegas · Las Vegas, NV · April 14-17, 2009

Renaissance Las Vegas	Copa A	Copa B	Copa C	Five Spot	Paramount	Rainbow	Capital	Renaissance Ballroom 2	Chairman
Tuesday AM April 14, 2009	(1A) SMBS Material Properties and Characterization	(1B) RNTS/JPM IHRPT - I	(1C) NDES/RNTS Inspection and Evaluation - I	(1D) JPM Gun and Gun Launched Propulsion - I	(1E) PEDCS/SEPS Green Energetic Materials - I	(1F) PEDCS Status of Selected Propellant Ingredients Specialist Session	(1G)	(1H) SEPS Hazardous Material Management	(II) Measurement Uncertainty Course
Tuesday PM	(1J) SMBS Aging and Service Life - I	(1K) RNTS/JPM IHRPT - II	(1L) NDES/RNTS Inspection and Evaluation - II	(1M) JPM Gun and Gun Launched Propulsion - II	(1N) PEDCS/SEPS Green Energetic Materials - II	(1O) PEDCS/JPM Process Engineering - I	(1P)	(1Q) PEDCS Solid Propellant Test Methods	(1R) Measurement Uncertainty Course
Keynote Address 8 – 10am April 15, 2009 Renaissance Ballroom 2 and 3									
Wednesday AM April 15, 2009	(2A)	(2B) SMBS/RNTS Rocket Motor Technologies	(2C) PEDCS Guns and High Gas Output Devices - I	(2D) PEDCS Explosives Formulation and Development - I	(2E) PEDCS/JPM Process Engineering - II	(2F) JPM/PEDCS/SMBS Tactical Propulsion - I	(2G)	(2H) JPM Propulsion Systems for Space Access - I	(2I) Measurement Uncertainty Course
Wednesday PM	(2J) SMBS/LPS/SPS Health Monitoring Business Case Workshop	(2K) RNTS Rocket Nozzle Technologies	(2L) PEDCS Guns and High Gas Output Devices - II	(2M) PEDCS Explosives Formulation and Development - II	(2N) SEPS Toxic Substances Detection and Characterization	(2O) JPM/PEDCS/SMBS Tactical Propulsion - II	(2P) JPM Scramjet Technologies	(2Q) JPM Propulsion Systems for Space Access - II	(2R) Measurement Uncertainty Course
Thursday AM April 16, 2009	(3A) MSS Solid Rocket Motor Performance Prediction	(3B) RNTS Nozzle Design, Test and Evaluation - I	(3C) SMBS/PEDCS Aging and Service Life - II	(3D) PEDCS Explosives Formulation and Development - III	(3E) PEDCS Liquid Propellants - I	(3F) PEDCS Solid Propellant Ingredients - I	(3G) JPM 10x Scramjet Technology Workshop I	(3H) JPM Launch Abort Motor - I	(3I) JPM Missile Defense/Strategic Propulsion
Thursday PM	(3J) SEPS Demilitarization, Reclamation and Reuse Technology	(3K) RNTS Nozzle Design, Test and Evaluation - II	(3L) SMBS/PEDCS Aging and Service Life - III	(3M) PEDCS Explosives Formulation and Development - IV	(3N) PEDCS Liquid Propellants - II	(3O) PEDCS Solid Propellant Ingredients - II	(3P) JPM 10x Scramjet Technology Workshop - II	(3Q) JPM Launch Abort Motor - II	(3R) SMBS Wireless Sensors Workshop - I
Friday AM April 17, 2009	(4A)	(4B) JPM/PEDCS/SMBS TRL/MRL Specialist Session	(4C)	(4D)	(4E)	(4F) PEDCS Solid Propellant Ingredients III	(4G)	(4H)	(4I) SMBS Wireless Sensors Workshop - II
Friday PM	(4J)	(4K)	(4L)	(4M)	(4N)	(4O)	(4P)	(4Q)	(4R) SMBS Wireless Sensors Workshop - III



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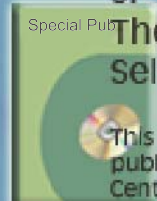
**CPIA-PUB-469 – Principles of Solid Propellant Development**



This publication covers many aspects of solid propellant development, including urethane reaction and cure chemistry, binder networks and their analysis, binder-filler interactions, mechanical properties, influence of composition and temperature on burning rate, propellant-to-case bonding, and propellant aging. (299 pages)

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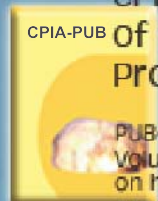
**SP-0802 – Ignition and Thermal Hazards of Selected Aerospace Fluids**



This reference document was originally published by the NASA Johnson Space Center White Sands Test Facility. CPIAC has made it available on a searchable CD. It discusses the hazards encountered when using liquid propellants, hydraulic fluids, lubricants and coatings in aerospace applications.

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**CPIA-PUB-394 – Hazards of Chemical Rockets and Propellants**



PUB-394 consists of three volumes. Volume 1 provides general information on hazards associated with propellant production and use, including explosion effects and damage, acoustic energy hazards, health effects, environmental effects, hazard analysis, risk analysis, hazard classification, hazard monitoring and identification, packaging, transportation, fire prevention and fire protection. Volumes 2 and 3 address specific hazards of solid and liquid propellants respectively. (Total of 1,077 pages in 3 volumes)

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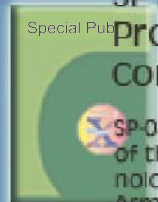
**CPTR 74 – Solid Propellant Subscale Burning Rate Test Techniques and Hardware for U.S. and Selected NATO Facilities**



This report stems from accomplishments of the NATO Research and Technology Organization, Advanced Vehicle Technology Working Group. It describes the evaluation of methods used within the NATO propulsion community to measure burning rate in solid propellant rocket systems, identifies similarities and differences among the member nations, addresses issues that have arisen due to those differences, and makes recommendations to support improved prediction of internal ballistics of full-scale rocket motors. (144 pages)

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**SP-0801 – NASA Hyper-X Project Overview Compilation, 1997-2006**



SP-0801 is an unclassified compilation of the X-43A hypersonic aircraft technology advances reported in Joint Army-Navy-NASA-Air Force (JANNAF) Meetings from 1997 to 2006, including recognition of the authors and their organizations that contributed to the X-43A flight demonstrations. It is available on a searchable CD.

~~\$360~~ **\$180**

**CPTR 96-64 – Electric Propulsion for Spacecraft Applications**



This review focuses on operational issues associated with the use of electric propulsion systems and their mission applications. For select missions, replacing current chemical propulsion systems with high performance electric propulsion systems can provide substantial mass and cost savings, increased orbiting lifetimes, and increased mission capability/flexibility. (72 pages)

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**MATERIALS DURABILITY—UNDERSTANDING DAMAGE MODES: LEARNING FROM THE PAST AND LOOKING TO THE FUTURE**

JANNAF has teamed with the NASA Engineering and Safety Center (NESC) Academy and the National Institute of Aerospace to provide a two-day offering of *Materials Durability—Understanding Damage Modes: Learning from the Past and Looking to the Future* technical course with Dr. Robert Piascik and Dr. William H. Prosser. The course will be conducted on Thursday, April 16 and Friday, April 17, 8:00 AM to 5:00 PM, with a 1.5-hour break for lunch.

This course will present elements of the following topics:

- Materials durability
- Damage modes
- Fracture control
- Composites
- Nondestructive evaluation
- Inspection process
- Proof testing
- Dynamic fracture
- Materials processing
- Insitu NDE and health monitoring
- Welding and joining
- Best practices and lessons learned

Attendees should be aware that, in accordance with JANNAF meeting attendance requirements, data and information restricted by the International Traffic in Arms Regulations (ITAR) will be included and discussed during the course.

**Instructors: Dr. Robert Piascik and Dr. William H. Prosser**

This course will be led by Dr. Robert Piascik, Technical Fellow for Materials; Dr. William H. Prosser, Technical Fellow for NDE; and colleagues from NASA, industry, and the U.S. Department of Defense.

*The Technical Steering Groups of the various JANNAF subcommittees select the “best” papers presented at their meetings, in order to increase public recognition of the exceptional work accomplished by JANNAF participants. Specific titles of papers are not published due to possible sensitivity. The following subcommittees are highlighted in this issue of the Bulletin.*

<b>JANNAF Subcommittee Meeting</b>	<b>Topic Area</b>	<b>Authors of Best-in-Session Papers</b>
<b>3rd Liquid Propulsion Subcommittee, May 2007</b>	Metallics	A.B. Pandey, K.L. Kendig, and J.E. Spowart Pratt and Whitney Rocketdyne, West Palm Beach, FL
	Turbo Machinery Design, Modeling and Experimental Results	A. Hosangadi, V. Ahuja, and R.J. Ungewitter Combustion Research and Flow Technology, Inc. Pipersville, PA
	Gelled Propellant Properties and Transportation	M.A. Coil and M.J. Chiaverini Orbital Technologies Corp., Madison, WI
<b>2nd Spacecraft Propulsion Subcommittee, May 2007</b>	Thruster Development	T. Cook, E.J. Wucherer, and E. Driscoll, Aerojet, Redmond, CA; A.P. Zuttarelli, Air Force Research Laboratory, Edwards AFB, CA
	Best SPS Student Paper	E. Dambach, Purdue University, West Lafayette, IN
<b>6th Modeling and Simulation Subcommittee, May 2007</b>	Simulation Credibility	M.D. Brandyberry and E. Egejuru University of Illinois, Urbana, IL

# New Faces – and Talent – at CPIAC

The next time you call CPIAC or attend a JANNAF meeting, there's a good chance that you'll receive assistance from one of our newest staff members. Matt Larson, Janelle Martin, and Kelly Bennett joined our organization in recent months, and we're quite happy to introduce them. While Matt was hired by CPIAC last spring, Janelle came on board in November, and Kelly joined us in January. We hope you have the opportunity to meet them soon.

Matt Larson, Senior Technical Support Analyst, provides workstation/server support and maintenance; network security scans, antivirus and Windows patching; and, general CPIAC computer assistance. At JANNAF meetings, you'll be sure to see him in the IT room, providing technical support for presentations. His professional background is in network and computer support and incident response. Prior to joining CPIAC, Matt was a technical assistant at Anne Arundel Community College in Arnold, Maryland, where he received his AAS in Information Systems Security. He is also a Cisco Academy graduate (CCNA 1-4). Matt is available at 410-992-7307, ext 213, or by e-mail to [mlarson@cpiac.jhu.edu](mailto:mlarson@cpiac.jhu.edu).


Janelle Martin, Publications Specialist, is responsible for compiling JANNAF meeting proceedings and producing CDs of those proceedings. She was previously employed as a scholarship coordinator at the University of Maryland, University College. Janelle is currently pursuing a B.S.



(Left to right) Kelly Bennett, Janelle Martin, and Matt Larson.


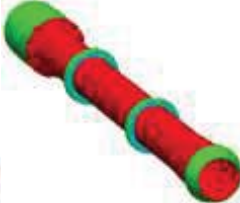

degree in Computer Studies. She may be reached at 410-992-7301, ext. 201, or by e-mail to [jmartin@cpiac.jhu.edu](mailto:jmartin@cpiac.jhu.edu).

Kelly Bennett, Copy Editor, supports the production of various technical publications, such as the *JANNAF Journal*, the *CPIAC Bulletin* and state of the art reports (SOARs), also referred to within CPIAC as Chemical Propulsion Technology Reviews (CPTRs). Kelly also supports CPIAC marketing and advertising efforts. She is a December 2008 graduate of Gettysburg College and has a B.A. in English and Management and a minor in Creative Writing. She has interned at the Johns Hopkins University Press, the Howard Morheim Literary Agency, and *The Gettysburg Review*. Kelly may be reached at 410-992-7307, ext. 227, or by e-mail to [kbennett@cpiac.jhu.edu](mailto:kbennett@cpiac.jhu.edu).



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# Propulsion News Highlights

## Nammo Talley Acquires Composite Solutions

**Source: Nammo Talley (2-12-09)**

Composite Solutions, LLC, Murray, Utah, and Nammo Talley, Inc., Mesa, Arizona, announced today the acquisition of Composite Solutions by Nammo Talley. Terms of the transaction were not disclosed. Composite Solutions has over 20 years of experience in the design and manufacture of technically challenging composite structures for commercial, aerospace and defense markets. Nammo Talley, a member of the Norway based Nammo Group since 2007, has been involved in the design and manufacture of components and systems based upon the creative application of energetic materials and devices since the 1950s. The addition of Composite Solutions to the Nammo family expands the technical offerings that Nammo Talley can offer its aerospace and defense customer base and further diversifies the company through addition of Composite Solutions commercial customers. Composite Solutions will continue to be led by its founder and president, Brian Lundy, who has agreed to remain with the company. Mr. Lundy will now report to Nammo Talley's president and CEO, Steven Wegener. The company will be a wholly owned subsidiary of Nammo Talley and its operations will remain in Murray, Utah. Full press release: <http://www.nammo.com/templates/page.aspx?id=583>.

## Thruster Swap Planned for the Cassini Spacecraft

**Source: NASA (2-2-09)**

The Cassini spacecraft will swap to a backup set of propulsion thrusters in mid-March due to degradation in the performance of the current set of thrusters. The thrusters are used for making small corrections to the spacecraft's course, for some attitude control functions, and for making angular momentum adjustments in the reaction wheels, which also are used for attitude control. The current set of eight thrusters, referred to as branch A, has been in use since Cassini's launch more than 11 years ago. The redundant set, branch B, is an identical set of eight thrusters. The swap involves commanding a latch valve to open hydrazine flow to the B side, and powering on some thruster control electronics. No pyrotechnic devices are involved in the swap, and the action is fully reversible if necessary. Full press release:

[http://www.nasa.gov/mission\\_pages/cassini/media/cassini-20090202.html](http://www.nasa.gov/mission_pages/cassini/media/cassini-20090202.html).



*Artist's concept of Cassini at Saturn.*

Courtesy of NASA/JPL

## NASA Awards Space Station Commercial Resupply Services Contracts

**Source: NASA (12-23-08)**

NASA has awarded two contracts — one to Orbital Sciences Corp. of Dulles, Va., and one to Space Exploration Technologies (SpaceX) of Hawthorne, Calif. — for commercial cargo resupply services to the International Space Station. At the time of award, NASA has ordered eight flights valued at about \$1.9 billion from Orbital and 12 flights valued at about \$1.6 billion from SpaceX. These fixed-price indefinite delivery, indefinite quantity contracts will begin January 1, 2009, and are effective through December 31, 2016. The contracts each call for the delivery of a minimum of 20 metric tons of upmass cargo to the space station. The contracts also call for delivery of non-standard services in support of the cargo resupply, including analysis and special tasks as the government determines are necessary. NASA has set production milestones and reviews on the contracts to monitor progress toward providing services. The maximum potential value of each contract is about \$3.1 billion. Based on known requirements, the value of both contracts combined is projected at \$3.5 billion. These agreements will fulfill NASA's need to procure cargo delivery services to the space station using a U.S. commercial carrier after the retirement of the space shuttle. Full press release: [http://www.nasa.gov/home/hqnews/2008/dec/HQ\\_C08-069\\_ISS\\_Resupply.html](http://www.nasa.gov/home/hqnews/2008/dec/HQ_C08-069_ISS_Resupply.html).

*These excerpts have been taken from press releases approved for public release and reprinted with permission.*



## People in Propulsion

### Dr. Vigor Yang Selected Chair of Georgia Tech's School of Aerospace Engineering

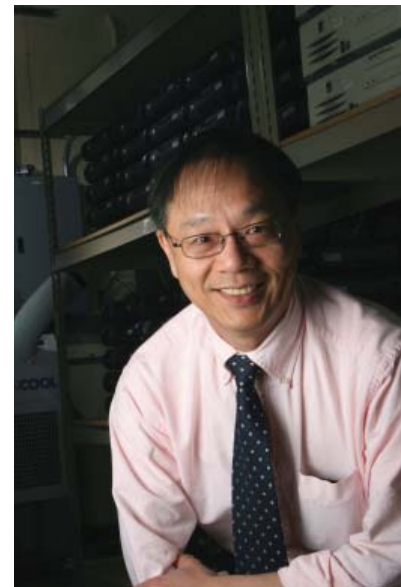
The Georgia Institute of Technology announced the selection of Dr. Vigor Yang as chair of the Daniel Guggenheim School of Aerospace Engineering, effective January 1, 2009, delivering a seasoned and accomplished researcher to lead the school to impressive new heights.

The selection of Dr. Yang ends an extensive search to fill the position, which included several highly qualified candidates in the field of aerospace engineering.

"Dr. Yang's professional contributions and activities offer the School of Aerospace Engineering a national and international visibility that adds to our reputation," said Don Giddens, Dean of the Georgia Tech College of Engineering. "His passion for research and ambition for the department set us on a course for new successes in academics and discovery."

Dr. Yang received his Ph.D. from the California Institute of Technology (Caltech) in 1984. He spent a year as a Research Fellow in Jet Propulsion at Caltech before joining the faculty of Pennsylvania State University in 1985. He was the John L. and Genevieve H. McCain Chair of Engineering at Penn State, teaching classes on thermodynamics, fluid mechanics, heat transfer, propulsion, combustion, and mathematics.

"It is with a deep sense of humility and honor that I accept the responsibility of Chair for the School of Aerospace Engineering," Yang said. "The position is challenging, but also exciting. My top priority is to continue the traditions of excellence at the school in



Dr. Vigor Yang

**[Dr. Yang's] passion for research and ambition for the department set us on a course for new successes in academics and discovery.**

*Don Giddens  
Dean of the Georgia Tech  
College of Engineering*

both teaching and research, as well as in service. The Aerospace Engineering school already has a wonderful reputation for excellence but I hope that I can work to further advance educational goals."

Currently, eight graduate students are working under Dr. Yang's direction at Penn State. He has previously supervised 41 Ph.D. and 15 M.S. theses.

Dr. Yang's research interests include combustion instabilities in propulsion systems, chemically reacting flows in rocket engines and high-pressure thermodynamics and transport. He received the Penn State Engineering Society Outstanding Teaching

and Premier Research Awards and several publication and technical awards from The American Institute of Aeronautics and Astronautics (AIAA), including the Air-Breathing Propulsion and Pendray Aerospace Literature Awards.

Dr. Yang has authored or co-authored more than 300 technical papers, and he has been the Editor-in-Chief of the AIAA *Journal of Propulsion and Power* since 2001. He also serves on the editorial advisory boards of *Progress in Energy and Combustion Science*; *Combustion, Explosion, and Shock Waves*; *the Journal of Aeronautics, Astronautics, and Aviation*; *the Journal of the Chinese Institute of Engineers*; and the *JANNAF Journal of Propulsion and Energetics*.

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# Calendar of JANNAF Meetings

56th JANNAF Propulsion Meeting (JPM) and  
39th Structures and Mechanical Behavior Subcommittee (SMBS)/  
35th Propellant and Explosives Development and Characterization Subcommittee (PEDCS)/  
26th Rocket Nozzle Technology Subcommittee (RNTS)/  
24th Safety and Environmental Protection Subcommittee (SEPS)/  
17th Nondestructive Evaluation Subcommittee (NDES) Joint Meeting

Date: April 14-17, 2009

Paper/Paper Clearance Deadline: March 9, 2009

Location: Renaissance Las Vegas; Las Vegas, NV; Phone: 702-784-5700  
(Refer to JANNAF government and JANNAF industry for room block rates.)

Hotel Reservation Deadline: March 13, 2009

Presentations and Reg. Forms due at CPIAC by: March 30, 2009

JANNAF 43rd Combustion Subcommittee (CS)/  
31st Airbreathing Propulsion Subcommittee (APS)/  
25th Propulsion Systems Hazards Subcommittee (PSHS) Joint Meeting

Date: December 6-11, 2009

Location: La Jolla, CA

For additional information on the above JANNAF meetings, contact CPIAC  
Meeting Planner Pat Szybist at 410-992-7302, ext. 215, or or by e-mail to [pats@jhu.edu](mailto:pats@jhu.edu).

Visit the JANNAF Web site at [www.jannaf.org](http://www.jannaf.org) for meeting updates.

**Policy on Non-Government Attendees at JANNAF Meetings.** Attendance at JANNAF meetings for non-government employees is restricted to U.S. citizens only and whose organizations are 1) registered with the Defense Logistics Information Service (DLIS) AND 2) have a government contract registered with the Defense Technical Information Center (DTIC). If the government contract is not registered with DTIC, the attendee's registration form can be certified by a sponsoring government official from one of the participating JANNAF agencies. Additional information concerning registrations with DLIS and DTIC can be obtained by contacting DLIS at 1-800-352-3572 ([www.dlis.dla.mil/jcp/](http://www.dlis.dla.mil/jcp/)) or DTIC at 1-800-225-3842 ([www.dtic.mil/dtic/registration/index.html](http://www.dtic.mil/dtic/registration/index.html)).

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