

JANNAF Gathers in La Jolla for Joint Meeting of Combustion, Airbreathing Propulsion, and Propulsion Systems Hazards Subcommittees

The Joint Army-Navy-NASA-Air Force (JANNAF) 43rd Combustion Subcommittee (CS), 31st Airbreathing Propulsion Subcommittee (APS), and 25th Propulsion Systems Hazards Subcommittee (PSHS) held a joint meeting the week of December 7–11, 2009, at the Hyatt Regency La Jolla in La Jolla, California, and at the Naval Fleet Intelligence Training Center in San Diego. The Joint Meeting offered a full program including a wide variety of complementary technical sessions, workshops, and meetings, continuing JANNAF's rich history of providing a valuable venue for focused interchanges on U.S. propulsion technology. Dr. Michael J. Nusca of the Army Research Laboratory, Aberdeen Proving Ground, Maryland, served as the Joint Technical Meeting Chairman for this year's meeting. Over 350 scientists, engineers, and managers attended the meeting, with 179 papers presented in 40 technical sessions, representing excellent attendance for Subcommittee Meetings not also accompanied by the JANNAF Propulsion Meeting.

Program highlights included a special reception held Monday evening to promote the *JANNAF Journal of Propulsion and Energetics* and to introduce newly appointed Editor-in-Chief of the Journal, Professor Vigor Yang of the Georgia Institute of Technology. The reception was open to all meeting attendees as an informal opportunity to discuss the publication with Professor Yang, members of the editorial advisory board, associate editors, reviewers, published Journal authors, and the editorial staff. Participants at the reception enjoyed candlelight ambience when the hotel experienced a brief storm-related power failure.

The community enjoyed a focused keynote address Tuesday morning entitled, “*Appropriate Experimental Data for Large Eddy Simulation Model Validation*,” by Dr. Josette Bellan, Senior Research Scientist at the Jet Propulsion Laboratory in Pasadena, California. Considering the increased importance of simulations to today's R&D programs, Dr. Bellan's material was applicable to a majority of the propulsion community's work. Her address discussed the current technical progress, as well as future challenges in the areas of combustion science, reacting flow modeling/simulation, and multiphase phenomena — specifically in relation to validation of simulations to ensure credible results. With the keynote and two workshops specifically focused on uncertainty quantification of experiments and simulations, this JANNAF Meeting more than any in recent history served to highlight the necessity for evaluation of decision making tools used by the community. Dr. Bellan was a welcome and willing participant in the full week of technical sessions.

Following the keynote, Professor Vigor Yang talked briefly about the *JANNAF Journal of Propulsion and Energetics* and shared his vision for the publication, which is aimed at achieving considerable impact upon the propulsion community by publishing significant accomplishments and guiding the community toward the future.

JANNAF Meeting attendees were treated to a sumptuous Taste of San Diego on Wednesday evening with a reception dinner held in the hotel's atrium pavilion.

43rd CS Technical Program

The CS program included presentation of 80 technical papers in 16 technical sessions, 4 panel meetings, and 4 town meetings covering solid, liquid, guns, and airbreathing combustion. These numbers represent an approximate 30% decrease from the 2008 Meeting in Boston. The CS technical sessions

covered the following: Insensitive Munitions (IM) Technology–Propellant Binders, Cookoff and Combustion Studies, and Technology for Gun Propellants; Gun Propellant Ingredients and Characterization; Guns and Mortars–System Designs and Design Tools; Insensitive Gun Primers and Igniters; Enhanced Blast Applications; Enhanced Blast Phenomenology; Reactive Materials; Liquid and Novel Propellants; Combustion Diagnostics; Combustion Instability and Combustion Modeling; Aluminum and Thermite Combustion; Thermal Decomposition and Condensed Phase Kinetics; and High Speed Airbreathing Combustion.

CS Panel Meetings

All four CS technical panels held meetings during the week, many in conjunction with CS town meetings in the same technical areas. The *Reactive Materials Panel*, a joint panel with the PEDCS, is seeking more intelligent use of the power contained within an energetic material. Panel members are currently examining the chemistry of reactive materials and munitions applications and are considering future workshops in these areas. The *Liquid Fuel Kinetics and Properties Panel* is successfully working jointly with APS and Liquid Propulsion Subcommittee (LPS) panels on hydrocarbon fuel issues. The hydrocarbon fuels community includes many that are engaged in AIAA and the Combustion Institute as well as JANNAF. The *Kinetics and Related Aspects of Propellant Combustion Panel* is considering developing an industry survey of the national state-of-the-art in solid rocket technology. The panel has developed recommendations on the R&D required to implement new energetic ingredients in munitions and has promised to complete a final report documenting their findings. The *Flowfield Diagnostics Panel* is continuing to foster better collaboration between the computational and experimental communities. This panel organized technical sessions at the meeting, with healthy participation aimed toward enhancing resources and raising awareness of needs and concerns. The panel is supporting MSS Credibility Guide activities and is seeking to identify useful state-of-the-art flight test diagnostics and technology gaps.

31st APS Technical Program

The APS program included presentation of 54 technical papers in 12 technical sessions, 4 panel meetings, an airbreathing town meeting and 3 workshops. The paper and session numbers represent a 20% decrease from the 2008 Boston Meeting. Technical sessions covered the following: Airbreathing Systems Overviews; Test Techniques for JAWS; ASET Technology; SED SJX61-2 R&D; Hypersonic Flight Experiments; Scramjet Technologies; Pulse Detonation Combustion; Combined-Cycle Propulsion; Falcon Combined-Cycle Engine Technology; and Component Modeling and Simulation.

A “Turbine-Based Combined Cycle (TBCC) Distortion” workshop was held Tuesday afternoon, which was co-chaired by Kenneth L. Suder of NASA Glenn Research Center and Heidi L. Wilkin of AFRL, Wright-Patterson AFB. The workshop sought to identify current state-of-the-art on turbine and inlet distortion, experimental analytical techniques, technology gaps as applied to TBCC systems, and to seek opportunities to address these issues as a community.

A workshop on “Experimental Uncertainty in Scramjet Ground and Flight Testing and Simulation” was held Tuesday evening, co-chaired by James W. Weber of AFRL, Wright-Patterson AFB; Unmeel B. Mehta of NASA Ames Research Center; and uncertainty specialist Ronald H. Dieck, Ron Dieck Associates. This workshop sought to define a framework and approach for developing recommended practices and guidelines that address proper consideration and treatment of experimental uncertainty in deducing results from ground and flight testing and applying modeling and simulation methods, which are anchored and validated with test data, to develop and design scramjet propulsion systems. Widespread

Government and industry support was expressed for these objectives with over 50 participants, good presentations, lively discussion and follow-up plans.

A “Rocket-Based Combined Cycle (RBCC) Technology Assessment II” workshop was held Thursday evening, co-chaired by Chuck Bauer of AFRL, Wright-Patterson AFB and Jeff Pearce of Universal Technology Corp. This workshop provided the JANNAF community with a review of initial findings to assess the current Technology Readiness Levels (TRLs) of the RBCC propulsion system and its component technologies from Workshop I, which was held in Boston. This workshop was especially focused on examining and prioritizing RBCC technology gaps that have been identified to date for the purpose of guiding future Air Force investment in RBCC technology, assessing the risk associated with obtaining a specified level of performance and operability, and defining risk mitigation activities to meet the technology objectives. Accomplishments of all workshops will be summarized in the meeting proceedings to be published on CD-ROM.

APS Panel Meetings

Four APS technical panels held meetings during the week, with many directly following related technical sessions. The ***Engine Test and Validation Panel*** is continuing to develop standards for scramjet engine testing, drawn from the second edition of CPIAC Publication 710, which was released in December 2005. They are also working on improvements and additions for a third edition to be published in 2010. The influences of test medium effects in scramjet testing are under investigation; panel members are focusing their analysis activities on a facility and flowpath engaged in active testing. A newly proposed working group on Large Scale Scramjet Engine Development Technology received broad community interest and approval of the Technical Steering Group. The ***Advanced Engine Cycle Panel*** has pursued multiple areas of interest. JANNAF workshops by the Pulse Detonation Combustion Working Group have contributed to characterizing Pulse Detonation Engine (PDE) technology and engine performance. Technology developments will continue with a future PDE workshop proposal on engine performance sensitivity and propagation of performance uncertainty planned for the future. This panel’s Scramjet (SJ) Engine Working Group continues to pursue activities aimed at identifying the accuracy of engine performance prediction tools for scramjet operation. The DARPA-funded HyCAUSE engine has been selected as one reference test case for a computational round-robin. The panel agreed to establish a Combined-Cycle Working Group to support the need for improved performance prediction capabilities, since this area has seen continued development interest. Panel activities supporting distortion impact on engine performance and operability will be assessed following completion of a TBCC workshop held at this meeting. The ***Component Level and Physical Modeling Panel*** continues its activities in two areas: turbulent mixing, Schmidt number modeling, and data collection; and isolator CFD modeling. They are working to identify best practices for isolator modeling. The panel continues to validate the need for databases containing data that can be used for CFD validation for component analysis and is exploring use of the new DoD Techpedia as a resource. The ***Fuels Panel*** is engaged in joint activities with CS and LPS involving the kinetics of liquid hydrocarbon fuels. The community is interested in organizing a workshop to guide the development of a chemical specification to meet the endothermic fuel needs of scramjet engines. There is additional interest in identifying surrogates for fuels in modeling activities. The ***Structures and Materials Panel*** seeks to foster productive interchange between propulsion and airframe specialists and structures and materials specialists in such areas as the state of the art in non-metallic high temperature materials, identifying a technology roadmap for needed developments and identifying existing and needed test facilities. The panel has adopted a unique solution by gaining

JANNAF Executive Committee and CPIAC support to co-sponsor JANNAF specialist sessions for the third year on “Materials and Structures for Airframe and Propulsion Systems” at the Annual Conference on Composites, Materials, and Structures (CMS). The next conference, scheduled for January 2010 in Cocoa Beach, Florida, is sponsored by the Ceramic, Metal, and Carbon Composites Committee (CMC3) of the Advanced Composites Working Group (ACWG), and will be held in cooperation with the U.S. Air Force, U.S. Army, U.S. Navy, U.S. Department of Energy, NASA, and the Defense Advanced Research Projects Agency (DARPA). These JANNAF sessions have been organized in order to improve the archiving of ITAR information on advanced materials technologies for possible U.S. hypersonic applications. The CD-ROM proceedings of these JANNAF specialist sessions will be available to CPIAC subscribers and other organizations registered with the Defense Technical Information Center (DTIC) and the Defense Logistics Information Service (DLIS).

25th PSHS Technical Program

The PSHS program consisted of 37 technical papers, presented in 9 sessions and 4 panel meetings. The papers covered IM assessment methodology; IM technology as applied to propellant binders, gun propellants, rocket motors, bombs, and warheads; impact- and shock-induced reactions; reactions of new materials for IM applications; and propulsion system safety/hazard classification. Three joint PSHS/CS sessions were also conducted. They comprised 17 papers on cookoff and combustion studies and insensitive gun primers and igniters.

PSHS Panel Meetings

The ***Cookoff Hazards Panel*** is planning a “round robin” bonfire testing of subscale rocket motors to better define test conditions and better understand sources of variability. The panel is also considering a workshop on improving the relevance of slow cookoff tests. Panel discussions included such topics as shortcomings of a “standard” heating rate in slow cookoff testing, the need to review past literature regarding the effect of heating rate on test results, metrics to better define the degree of confinement during a test, relative merits of using propane versus kerosene in fast cookoff testing, and the use of ignition data to characterize IM response. Some panel members plan to participate in a 2010 IM Technology meeting in Meppen, Germany.

At the ***Impact/Shock-Induced Reactions Panel*** meeting, discussion centered mainly on two topics: the need to minimize variability in large scale gap tests and more realistic conditions for the bullet impact test. Regarding the former, a round robin series of tests is planned. The possibility of using explosively formed projectiles in small-scale tests to screen for resistance to fragment impact was also discussed.

The ***Insensitive Munitions (IM) Technology Panel*** is seeking better organization of full-scale IM test data, preferably in databases that would allow investigators to discern trends. This was the focus of many of the meeting’s discussions. Rather than have one group try to handle all kinds of munitions, the panel agreed that it would be preferable to divide up the work. Various members volunteered to take on specific munition types, namely general purpose bombs, advanced bombs, artillery rounds, and mortar rounds. The ***IM Technology Panel*** will also work with the ***Cookoff Hazards Panel*** on a task to examine how the heating rate in a slow cookoff test should be established. The possibility of including a workshop was discussed.

Current concerns of the ***Safety and Hazard Classification Panel*** meeting are the coordination of DoD and Department of Transportation (DOT) regulations, the use of TNT equivalency in determination

of hazard classification and quantity-distance relations, the correct definition of a commercial carrier, the proper usage of interim hazard classification, criteria for Hazard Divisions 1.4 and 1.6, and difficulties in dealing with DOT due to ongoing reorganization within that department. The panel will develop a workshop on how best to derive and utilize TNT equivalency and will also aid in coordinating a Department of Defense Explosive Safety Board (DDESB) training class in the analysis of blast energy/pressure/impulse data.

PEDCS Workshop on HTPB Variability

The objectives of the PEDCS workshop were to share information that would be helpful in identifying causes of the variability of hydroxyl-terminated polybutadiene (HTPB), a workhorse polymer for production of rocket propellants, and to provide feedback to the manufacturer.

In recent years, Sartomer Company, Inc. has been the only domestic producer of HTPB. Accordingly, the workshop began with a presentation by the Sartomer HTPB product manager, who discussed the history of HTPB production and present measures taken for quality assurance. He also described a reorganization that is to occur in 2010; one effect of which is that the manufacturer of HTPB will be known as Cray Valley USA. The essential aspects of HTPB production will remain the same. One advantage of the reorganization will be better stability of raw material supply.

The Sartomer presentation was followed by presentations by five HTPB users, each describing variability issues they have investigated. Much of the variability could be explained by a combination of aging (storage conditions), the presence or lack of an antioxidant, and slight differences in composition. The Sartomer representative agreed to send samples of a particular lot to any interested and qualified users in order to get better definition and understanding of variability from the users' point of view.

MSS Credibility Guide Workshop

The Modeling and Simulation Subcommittee (MSS) Simulation Credibility – Uncertainty, Verification, Validation and Risk – Panel held the third workshop in a series to continue cross-subcommittee efforts in the development of a JANNAF guide for quantifying and reporting uncertainty in simulations. The guide effort has produced a number of draft chapters with more that are currently being written, specifically in the areas of canonical physics, models, objects in propulsion and energetic modeling, and model-assisted design of validation experiments. Participants of the workshops should look for an invitation to review draft chapters in the near future; those interested in receiving correspondence about the credibility guide should contact Nick Keim at CPIAC via e-mail to nkeim@cpiac.jhu.edu.

SMBS Space Launch Wireless Sensors Workshop II

The goal of the Space Launch Wireless Sensor Workshop (SLWSW) was to provide an informal and unclassified forum for the exchange of ideas and information on development of design guidelines for integrated structural health monitoring (ISHM) systems for applications to space launch vehicles. There have been numerous damaging incidents in launch vehicle components, resulting in wasted hardware or actual failures, especially in solid rocket motor (SRM) cases. These incidents could have been detected with modern ISHM systems and evaluated for their effect on the hardware's flight worthiness. Many composite structures, large and small, are being used in space launch vehicles by NASA and the defense industry and would benefit from an overarching vehicle health monitoring effort to develop guidelines for the design of wireless sensors in space launch vehicles. The second Space Launch Wireless Sensor Workshop focused on surveying users' current and future needs; assessing the

current capabilities and identifying their technology readiness levels; discussing integrated architectures and system engineering approaches and issues; sharing experience and lessons learned; and promoting cross training, collaboration, and research to better support space launch customers in program definition, development, test, anomaly resolution, and operations.

Aerospace Corporation's S.R. Lin provided the opening remarks. Dr. F.K. Chang of Stanford then spoke about the need for a business case to attract companies for developing wireless sensors for health management and the need for development of JANNAF guidelines for wireless sensors. Dr. Chang also talked about Stanford's research into sensor system grids and learning from bio neurological sensors systems. Nathan Wells of NASA Johnson Space Center discussed the subject of fitting Space Shuttle Atlantis' main engines with wireless sensors for STS-129 to measure the engine ignition acoustic pressure loads. Scott Hyde of ATK discussed integrated vehicle health management systems for solid rocket motors. Aaron Trott of Invocon, Inc. spoke about using wireless sensors for impact detection and strain measurements, including for use on the Space Shuttle Orbiter wings' leading edge. The Navy's Rob Pritchard presented on the JANNAF guidelines for stress sensor applications in SRMs. Gary Hunter of NASA Glenn Research Center spoke about Smart Sensor Systems for Intelligent Vehicle Monitoring. Steven Arms of MicroStrain, Inc. presented on wireless sensors capable of energy harvesting to eliminate the need for battery-powered sensor systems. Jackie Hines of ASR&D Corporation gave a presentation focused on SAW Passive Wireless Sensor-RFID Tags. Garvey Spacecraft's John Garvey spoke on using wireless to eliminate connection issues and change configuration mismatches, and testing sensor packages on Nanosat Launch Vehicles. Lastly, Dr. F. G. Yuan presented on wireless sensor systems under development at North Carolina State University.

The next wireless sensors workshop will be held in Colorado Springs in conjunction with the May 2010 JANNAF Meeting, with the goal of gathering a common set of user needs, their problems with current sensor systems (both wired and wireless), and requirements for sensors, along with gathering suggestions of currently available wireless sensors that could solve users' problems.

JANNAF continues to be effective in addressing propulsion-related issues of mutual interest to the Government, industry and academia. Fruitful meetings of current CS, APS, and PSHS Technical Steering Groups were held throughout the week, contributing to the future direction of technical activities. Overall, the 43rd CS, 31st APS, and 25th PSHS Joint Meeting was considered a success by participants. Meeting attendees are encouraged to help improve future JANNAF Meetings by responding to an electronic meeting survey that was distributed on December 23. All comments and suggestions are greatly appreciated.

The JANNAF community can expect to see Volume 3 of the *JANNAF Journal* released in May 2010. Manuscripts are now being accepted for Volume 4, with publication planned for 2011.

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