Over 750 scientists, engineers, and managers attended the 1989 JANNAF Propulsion Meeting (JPM) held at the Cleveland Convention Center, Ohio on 23-25 May 1989. Mr. Carl A. Aukerman of the NASA Lewis Research Center was the meeting chairman.

The JPM traditionally covers all aspects of propulsion, and this year was no exception. Approximately 250 technical presentations on propulsion systems and related technologies were given in 38 main sessions and six specialist sessions. The sessions were organized in the nine broad areas of ballistic missile, missile defense, air launched tactical, ground launched tactical, airbreathing, launch vehicle, gun, upper stage, and satellite propulsion technologies. In addition, two workshops and 15 business meetings of the JANNAF Executive Committee, Subcommittees, and panels were held.

In the tactical missile area, the development of insensitive munitions and minimum signature propulsion continue to be dominant themes and many papers covered these topics. Nondestructive evaluation of tactical missiles is receiving increased attention as evidenced by papers on real-time radiography and computed tomography. Nondestructive evaluation of ballistic missiles and launch vehicles was covered in depth in a separate specialist session.

In the airbreathing area, presentations reflected the recent emphasis on high speed propulsion. An entire session was devoted to combined cycle engines such as the air turboramjet which shows promise for speeds up to Mach 6. The hypersonic propulsion test technique session featured an excellent review of current and near-term high speed test facilities. For the first time this year, an entire session was devoted to expendable turbine engines which show promise in a number of tactical applications.

Industry concern over the availability of ammonium perchlorate (AP) was reflected in two specialist sessions that featured the results of requalification testing by the major solid propellant manufacturers. Results of AP transportation, storage, and sensitivity testing at several government facilities indicate that AP should retain its current 5.1 hazard classification. Overviews of the AP manufacturing process were also presented by Kerr-McGee and the Western Electric Chemical Company (formerly PEPCON).

It is not possible to adequately summarize a meeting as comprehensive as the JPM in a few paragraphs. CPIA subscribers should be sure to obtain a copy of the meeting proceedings, as these volumes are an invaluable guide to the state of the art of propulsion technology. Future issues of the Bulletin will feature articles on primary technological areas as addressed at the 1989 JPM.
Recent CPIA Publications


CPIA/M1, "Rocket Motor Manual (U)," Units 595 (Rocket Motor Mk 96, Harpoon), 596 (Mk 216 RF Distraction Decoy, Sea Gnat), and 597 (Mk 66 Mod 1 and 2, 2.75-in Rocket Motor, Skychief), Feb 1989.

CPTR 88-44, "GAP Minimum/Reduced Smoke Propellants (U)," Dec 1988.


LS88-17: Reclamation, Reuse, and Disposal of Propellants, Explosives, and Pyrotechnics (Supersedes LS83-21); period covered 1966-1988B; 192 citations.

LS89-03: Survivability/Vulnerability of Rocket Propulsion and Gun Systems (Supersedes LS86-22); period covered 1975-1988C; 258 citations.

LS89-04: Bullet, Fragment, and Thermal Hazards to Tactical Rocket Motors (Supersedes LS86-05); period covered 1969-1988C; 151 citations.

detailed panel meetings covering the five major areas of emphasis of the Subcommittee: solid propulsion, liquid propulsion, and space systems NDE, component inspection standards, and advanced inspection systems and implementation.

As a means of introducing the ongoing work at various facilities, overview presentations of the Air Force NDE efforts at the Wright Research and Development Center (formerly AFWAL) and at the Astronautics Laboratory started the meeting. An update of NASA/Langley NDE efforts was also presented. An overview of Magnetic Resonance Imaging (MRI), a newly emerging NDE technology, and a briefing on the interface between fracture mechanics methodologies and NDE were included.

The meeting was divided into technology and applications sessions/panels to foster interaction between NDE method developers and users. A specialist session featuring panels of NDE technologists and structural analysts was held to present the concerns and possible modes of improved cooperation between these two groups.

The component inspections standards and advanced inspection systems and implementation technology panels focused on factors affecting ultrasonic NDE measurements, MRI, employment of backscatter radiography and thermography to ensure bondline integrity, and the use of dynamic computer tomography (CT) on burning rocket motors. This year, the panel members intend to generate a compilation of active NDE standards and specifications, review NDE technologies available for inspection of adhesive joints, sponsor a tutorial on MRI, and conduct a review of real-time radiography standard methods and equipment.

continued on page 4
ALS Program
Focusing on Propulsion Technology

The Advanced Launch System (ALS) Program should fulfill future needs for a reliable, low cost, high launch rate, heavy-lift launch vehicle for civil, defense, and industrial missions, supplementing an existing fleet of Titan, Delta, and Atlas expendable launch vehicles. A joint Air Force/NASA/industry team has been assembled to capitalize on recent advances in structural materials, automation, propulsion technology, and innovative launch processing methods. Goals of the ALS program include reducing the cost to orbit to $300/lb (Titan IV will be approximately $3,600/lb), with a vehicle that can deliver approximately 100-150,000 lb to low earth orbit, due east inclination (which equates to approximately 70% of the payload weight into polar orbit).

Background

A number of launch vehicle failures in 1986 focused the efforts of ongoing military and NASA studies that were assessing the U.S. ability to provide assured access to space and outline the future vehicle needs into the next century. The Space Transportation Architecture Study recommendations called for a follow-on manned launch system (e.g., Shuttle II, NASP), upper stage, improved ground/control operations, and an unmanned cargo vehicle (e.g., ALS).

The need for and cost effectiveness of an ALS were shown to be dependent on the choice of among five possible mission requirement sets, from a constrained scenario (1 million lbs/yr to orbit, 80% civilian missions) to a growth scenario (3.8 million lbs/yr, 75% DoD/SDI).

Technology Development

The Air Force’s Space Division ALS Program Office envisions a family of modular vehicles with improved reliability, high resiliency, a combination of surge capability, greater than 0.98 reliability, and less than 4-6 months downtime following a failure. It is hoped that ALS will also serve as a technology base to upgrade existing launch vehicles. The first test flight of the ALS is scheduled for 1998, with initial operational capability by 2000. Approximately 6-10 flights per year are planned from each available launch complex.

Three prime contractors (General Dynamics, Martin Marietta teamed with McDonnell Douglas, and Boeing) are currently in the concept definition phase of the program, with a Defense Acquisition Board review decision scheduled for June 1990. Award of vehicle production contracts will follow.

Eighty-four Advanced Development Programs are currently being conducted through various NASA and Air Force centers to develop the key technologies needed for ALS. A large proportion of these programs are propulsion or propulsion-related efforts. Key technologies identified for development include advanced thermal protection systems, cryogenic tankage, fault-tolerant avionics, cryogenic engine design, and built-in vehicle diagnostics.

Launch Logistics

The Office of Technology Assessment has reported that each Shuttle currently requires a minimum of 580 hours of launch processing time, limiting possible Shuttle missions to about one per month. Furthermore, launch operations reportedly constitute up to 45% of launch costs. For these reasons, the ALS program will evaluate the use of automated launch processing and other operational improvements that may offer a means of reducing the cost and time required for a launch, perhaps eventually approaching the impressive Soviet rate of one launch every three days.

ALS operational trade studies have analyzed launch facility design, automation of launch operations, and manufacturing/launch facility location options. Development of standard/simple payload-to-vehicle interfaces (to allow payloads to fly on various launch vehicles), incorporation of an adverse weather capability, automation of flight software production, and the use of automated/universal launch complexes for a variety of vehicle types may also improve ground and flight operations.

Vehicle design will have a major impact on ALS cost effectiveness and reliability. Since propulsion systems have been responsible for approximately 60% of launch failures, and avionics an additional 20%, engine-out capability for the propulsion system and fault tolerant avionics designs are expected to be employed to increase vehicle reliability.

Trade studies have been conducted to assess vehicle sizing, stage and/or propulsion/avionics module reusability issues, engine combustion cycle selection, and the use of advanced structural materials for weight savings. Built-in payload and vehicle diagnostics systems, and payload feed lines that extend to the bottom of the vehicle, eliminating the need for a gantry, may also reduce launch processing time and costs.

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NDES Meeting
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The applications sessions covered solid propulsion unique issues, liquid propulsion unique issues, and space systems issues. Topics addressed included application of CT to liquid rocket engines, NDE techniques for in-space composite structure monitoring, engine instability analysis via speckle interferometry, and use of ultrasonic and backscatter radiography to evaluate rocket motor bondlines. Panel plans for the coming year include coordinating with the Space Station Freedom NDE efforts, obtaining long duration exposure facility data to generate a list of prospective in-space NDE tools, focusing on test methods and acceptance criteria for engine bearing and weld inspections, reviewing the manufacture of motor debond standards, and evaluating ‘kissing debond’ evaluation methods.

The proceedings of this meeting will be published by CPIA and will be distributed to qualified subscribers in July 1989. For further information, please contact CPIA at (301) 992-7302. The next meeting of the NDES is scheduled for the spring of 1990 in Idaho Falls at the Idaho National Engineering Laboratory.

S&EPS Meeting Held at Brooks AFB

The 1989 Safety and Environmental Protection Subcommittee (S&EPS) Meeting was held on 3-7 April at the Air Force School of Aerospace Medicine (SAM), Brooks AFB, San Antonio, Texas. Col. William D. Christensen, USAF/SAM, served as the meeting chairman. One hundred twenty-three engineers and scientists attended the meeting, which featured 25 paper presentations given in four plenary sessions.

Col. Dennis Jarvis, Vice Commander of the Human Systems Division, Brooks AFB, welcomed the meeting attendees and gave a brief history on the role that SAM has played in the development of aerospace medical science.

The atmospheric hazards and modeling session featured discussions on atmospheric dispersion models such as FEM3 and SLAB. Also presented were toxic air emissions and emissions dispersion data from the Kennedy Space Center and the Naval Ordnance Station. Presenters in the safety, transportation hazards, and hazardous waste session discussed hazardous waste minimization efforts at various federal facilities. Sensitivity issues peculiar to industrial processes (e.g., core pulling and water jet washout operations) were also considered.

The instrumentation session addressed hydrazine fuel spill and HCl vapor detection instrumentation. The results of passive HCl dosimeter field evaluations conducted at Kennedy Space Center, Edwards AFB, and Ft. Detrick were presented. Another presentation was on the backscatter absorption gas imaging (BAGI) device developed by Lawrence Livermore National Laboratory. This is a portable system that is capable of imaging approximately 60 gases that are invisible to the human observer, which makes this system useful in detecting gas leaks and for spill emergency response. Toxicity data for JP-4 and nitroguanidine were given in the toxicology and environment session.

Two workshops were held in conjunction with the annual meeting, one on large solid rocket motor manufacturing hazards, and the other on the propulsion community's compliance with the Resource Conservation and Recovery Act (RCRA). In light of recent federal employee convictions on RCRA violations at the Aberdeen Proving Ground, it is clear that RCRA enforcement at federal facilities is a high priority for the EPA.

The proceedings for the meeting and the two workshops are being published by CPIA and will be distributed to qualified subscribers. The next S&EPS meeting is scheduled for late May 1990 at the Lawrence Livermore National Laboratory, Livermore, California. Feel free to direct questions and/or comments concerning this meeting to Tom Moskios, CPIA, 301-992-7305.

Nitrocellulose-Based Propellant Workshop

The Propellant Development and Characterization Subcommittee will sponsor a workshop on nitrocellulose (NC)-based propellant characterization on 15-16 August 1989 at the Virginia Polytechnic Institute and State University (VPI&SU), Blacksburg, Virginia. Issues to be addressed include methods of NC feedstock characterization, NC-based propellant processing, and rocket and gun propellant characterization and surveillance.

For further information, contact the workshop chairmen, George W. Nauflett, Naval Surface Weapons Center, at (301) 743-4436, James Rancourt, Department of Chemistry, VPI&SU, at (703) 231-8223, or Leland B. Piper, CPIA at (301) 992-7307. This meeting will be unclassified, but attendance is limited to U.S. citizens specifically invited by the workshop chairman.
USAF/McDonnell Douglas Delta II Launched

The successful launch of the USAF/McDonnell Douglas Delta II on 14 February 1989 ushers in a new era of Air Force space launch operations. Boost propulsion was provided by a Rocketdyne built LOX/RP-1 engine and six of nine 32-foot Morton Thiokol Castor IV-A strap-on solid rocket motors. The solids burned out at T+56s. After another 5s, the remaining three Castors were ignited, and burned out at T+122s. Main engine cutoff occurred at T+265s. The third stage separated at T+1,258s. Final payload propulsion lasted for another 87s to put the unit in a 91 nautical miles orbit.

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This was not only the first launch of the McDonnell Douglas Delta II, but also the initial launch of a NAVSTAR Global Positioning System (GPS) satellite, and the first time that the Consolidated Space Operations Center at Falcon AFB, Colorado, has taken command of a satellite. Approximately 35 minutes after launch, control was assumed by the Air Force Space Command 2nd Space Wing. Controllers spent the first 2 days collecting data on the satellite’s functioning and analyzing its orbit relative to the earth. On 16 February the apogee motor was fired, boosting the NAVSTAR orbit to approximately 11,000 nautical miles.

The GPS will be complete when 18 Rockwell built NAVSTAR satellites are in orbit. Another three satellites will orbit as spares. The GPS will provide global, continual velocity, and position information to U.S. and NATO forces. This system will provide useful navigation information to the civilian sector as well. Users will be able to access the GPS passively, which will allow such operations as midair refueling without the use of radar and potential detection by the enemy.

McDonnell Douglas contracted to provide 20 Delta II launchers to the USAF. These additions to the Air Force fleet, currently consisting of the General Dynamics Atlas and several versions of the Martin Marietta Titans, should accelerate the Air Force’s near-term launch manifest.

NDES Holds CT Workshop for Minuteman

The JANNAF Nondestructive Evaluation Subcommittee (NDES) sponsored a technical workshop on the application of X-ray computed tomography (CT) to the Minuteman missile system on 15-16 March 1989 at the TRW Aerospace Center in Ogden, Utah. Joseph Sciabica of the Air Force Astronautics Laboratory served as the workshop chairman for this gathering of over 80 missile and NDE specialists.

The operational life of the Minuteman missile fleet has recently been extended to the year 2010, requiring new motors to be fabricated and allowing the use of advanced NDE technology, such as CT, to assure motor reliability. The workshop subject was introduced with background briefings on the Minuteman missile program, the NDE facilities at Hill AFB, and the surveillance/service life depot for Minuteman in Utah. Following this overview, detailed descriptions were presented for a number of ongoing Air Force and Navy CT system development and image analysis programs. Some recent data on the application of CT to a Minuteman II 3rd stage motor surveillance problem were also exhibited.

Other NDE techniques, such as ultrasonics, were also discussed, particularly as applied to bondline integrity characterization. The concluding workshop discussions covered Minuteman failure modes, NDE method applicability and requirements, and future needs, such as standardization and data compatibility between CT systems and other NDE methods. These topics are sure to be addressed again at the NDES annual meeting at NASA Langley Research Center in May.

The presentations from this workshop will be published as CPIA Publication 511. Copies of this document will be available to CPIA subscribers by calling (301) 992-7301.

NASP Engine Test Successful

Rockwell International announced the achievement of a significant milestone in the National Aero-Space Plane (NASP) program with successful tests of a subscale supersonic combustion ramjet engine. The tests were conducted by a team of Rocketdyne and NASA engineers in facilities at the NASA Langley Research Center in Hampton, Virginia. Tests were conducted on a 1/7 scale model of a complete NASP engine and included all components from the inlet to the exit nozzle. Simulated flight conditions ranged from Mach 5 to Mach 8, and engine performance validated expected results at these conditions. The performance of the model test engine was particularly encouraging since most of the scramjet engine’s internal processes are expected to become more efficient at larger engine sizes.

Hydrogen-fueled scramjet engines of this type are candidates for future single-stage-to-orbit conventional takeoff and landing vehicles. In hypersonic vehicles of this type, the airframe is considered part of the propulsion system and requires a high degree of integration with the scramjet engine. External compression over the vehicle forebody provides a significant part of the overall compression process. Similarly, external expansion over the vehicle aftbody provides a major portion of the nozzle expansion process.

The NASP program is a joint effort by the DoD and NASA to develop the required technology for such hypersonic missions. The program plans call for the development of a manned experimental vehicle, the X-30. The program is being accomplished in three phases. Phase 1, 1982-85, defined the technical concept. Phase 2, 1985-90, involves developing the technology in the areas of aerodynamics, propulsion system, airframe structures, and materials. At the end of phase 2, possibly late 1990, a decision will be made as to whether to build the experimental X-30 aircraft.

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ALS Program

Applications

While upper stage vehicles are not addressed in the basic ALS program, they are a major cost and reliability driver for placing payloads into working orbits. Therefore, upper stage cost and reliability issues can be expected to be addressed in the coming years as the ALS program proceeds. Spacecraft design philosophy will also be impacted by the ALS as launch operation changes mandate reduced and/or standardized payload-to-launch vehicle interfaces as a means of reducing launch pad processing.

Since ALS is strongly influenced by SDI launch requirements, the need and cost effectiveness of the program may be jeopardized if the SDI mission is scaled back to a ground-based silo defense. The technology currently being developed for the ALS offers attractive technology transfer opportunities for existing vehicles and will also feed into the research programs for the next generation of launch vehicles beyond ALS.

NASP Engine Test

Meanwhile, ground has been broken for construction of the Rocketdyne Hypersonic Flow Laboratory (RHYFL) near the Santa Susana Field Laboratories in California. RHYFL is a free-piston shock tunnel operating in the reflected shock mode, which allows attainment of very high temperatures and pressures for brief periods. It will be capable of simulating flight conditions of up to Mach 25 for the X-30. The facility will operate under the auspices of the U.S. interagency Joint Program Office at the Wright-Patterson AFB, Ohio. RHYFL is scheduled for completion in March of 1990.

CPIA Compiling Data for New Manual

The CPIA is presently compiling data for a new manual on U.S. solid propulsion test facilities. The purpose of the manual is to provide the propulsion community with a single-source reference of the nation's solid propulsion test facilities and their adequacy to support current, near-term, and long-range national program requirements. The manual will include both government and industry test facilities.

The manual will be designated CPIA/M8 and titled “Solid Rocket Motor Static Test Facilities.” The M8 will be an unclassified limited distribution publication that is similar in format to CPIA/M7, "Liquid Rocket Engine Static Test Facilities." These two companion manuals should provide government and industry with a valuable tool in coordinating rocket engine and motor testing.

The facility characteristics that are to be included in the manual are the testing environmental constraints, testing thrust range, number of test stands, minimum buffer zone, on-site support capabilities, data acquisition and sensor systems, additional stand capabilities, facility status, and any plans for modifications and additions. The test stand data sheets will include the test type (altitude/ambient), firing orientation, maximum thrust, test article envelope, level, and propellant types.

Every effort is being made to send the questionnaire to all government and industry sites that support a solid static test facility. If your facility has not received a questionnaire to complete, you are encouraged to contact the editor, Sharon Hasty, at (301) 992-7306.

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### JANNAF MEETING CALENDAR

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<th>Meeting</th>
<th>Type</th>
<th>Location</th>
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<td>15-16 Aug</td>
<td>Nitrocellulose Problem Areas</td>
<td>Workshop</td>
<td>VPI&amp;SU Blacksburg, VA</td>
<td>Unclassified/Limited</td>
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<td>17-19 Oct</td>
<td>JANNAF Rocket Nozzle Technology Subcommittee Meeting</td>
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<td>NSWC White Oak, MD</td>
<td>Unclassified/Limited</td>
<td>Past 26 Sep</td>
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<tr>
<td>23-27 Oct</td>
<td>JANNAF Combustion Subcommittee Meeting</td>
<td>Conference/Workshops</td>
<td>JPL Pasadena, CA</td>
<td>Confidential/Limited</td>
<td>Past 9 Oct</td>
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<td>6-9 Nov</td>
<td>JANNAF Joint Composite Motor Case Subcommittee/Structures &amp; Mechanical Behavior Subcommittee Meeting</td>
<td>Conference/Workshops</td>
<td>JPL Pasadena, CA</td>
<td>Unclassified/Limited</td>
<td>Past 6 Oct</td>
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<tr>
<td>14-17 Nov</td>
<td>JANNAF Exhaust Plume Technology Subcommittee Meeting</td>
<td>Conference/Workshops</td>
<td>NPS Monterey, CA</td>
<td>Secret</td>
<td>Past 6 Oct</td>
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<tr>
<td>28 Nov-1 Dec</td>
<td>JANNAF Propellant Development and Characterization Subcommittee Meeting</td>
<td>Conference/Workshops</td>
<td>JHU/APL Laurel, MD</td>
<td>Unclassified</td>
<td>Past 10 Nov</td>
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#### 1990

| 2-6 Apr | JANNAF Propulsion Systems Hazards Subcommittee Meeting | Conference/Workshops | JHU/APL Laurel, MD | Confidential/Limited | TBA TBA |

Attendance at JANNAF Conferences and Workshops is by invitation only.

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