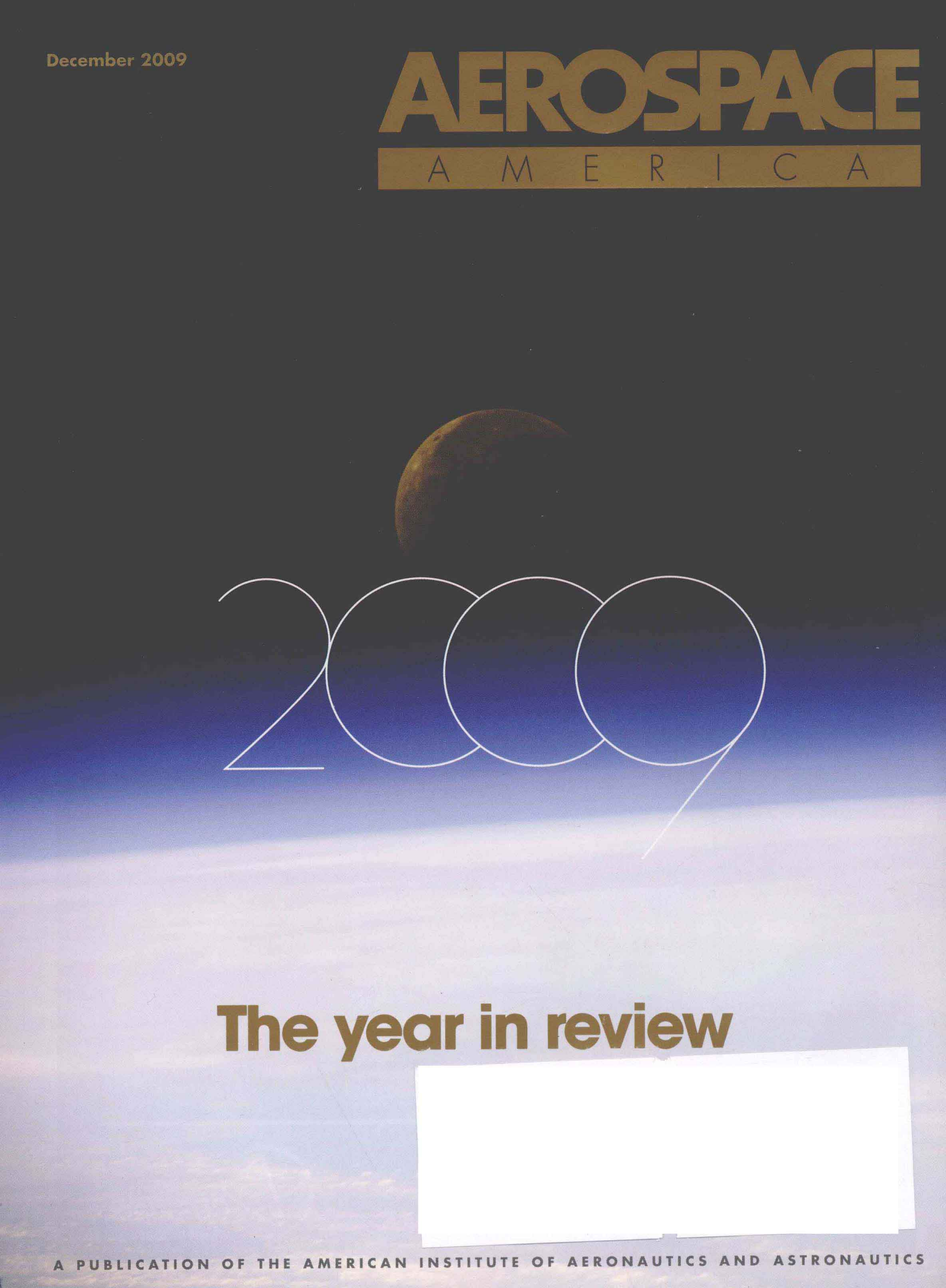
December 2009
AEROSPACE
AMERICA
2009
The year in review
A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS


09-0257
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Standard Information for all AIAA Conferences

This is general conference information, except as noted in the individual conference preliminary program information to address exceptions.

Photo ID Needed at Registration

All registrants must provide a valid photo ID (driver's license or passport) when they check in. For student registration, valid student ID is also required.

Conference Proceedings

This year's conference proceedings will be available in two formats: after-meeting DVD and online proceedings. The cost is included in the registration fee where indicated. If you register in advance for the online papers, you will be provided with instructions on how to access the conference technical papers. For those registering onsite, you will be provided with instructions at registration. The after-meeting DVD will be mailed six to eight weeks after the conference.

Journal Publication

Authors of appropriate papers are encouraged to submit them for possible publication in one of the Institute's archival journals: *AIAA Journal*; *Journal of Aircraft*; *Journal of Guidance, Control, and Dynamics*; *Journal of Propulsion and Power*; *Journal of Spacecraft and Rockets*; *Journal of Thermophysics and Heat Transfer*; or *Journal of Aerospace Computing, Information, and Communication*. WriteTrack will be replaced by ScholarOne Manuscripts (Thomson Reuters) during 2009. More information about the transition is available on the WriteTrack home page.

Speakers' Briefing

Authors who are presenting papers, session chairs, and co-chairs will meet for a short briefing at 0700 hrs on the mornings of the conference. Continental breakfast will be provided. Please plan to attend only on the day of your session(s). Location will be in final program.

Speakers' Practice

A speaker practice room will be available for speakers wishing to practice their presentations. A sign-up sheet will be posted on the door for half-hour increments.

Timing of Presentations

Each paper will be allotted 30 minutes (including introduction and question-and-answer period) except where noted.

Audiovisual

Each session room will be preset with the following: one LCD projector, one screen, and one microphone (if needed). A 1/2" VHS VCR and monitor, an overhead projector, and/or a 35-mm slide projector will only be provided if requested by presenters on their abstract submittal forms. AIAA does not provide computers or technicians to connect LCD projectors to the laptops. Should presenters wish to use the LCD projectors, it is their responsibility to bring or arrange for a computer on their own. Please note that AIAA does not provide security in the session rooms and recommends that items of value, including computers, not be left unattended. Any additional audiovisual requirements, or equipment not requested by the date provided in the preliminary conference information, will be at cost to the presenter.

Employment Opportunities

AIAA is assisting members who are searching for employment by providing a bulletin board at the technical meetings. This bulletin board is solely for "open position" and "available for employment" postings. Employers are encouraged to have personnel who are attending an AIAA technical conference bring "open position" job postings. Individual unemployed members may post "available for employment" notices. AIAA reserves the right to remove inappropriate notices, and cannot assume responsibility for notices forwarded to AIAA Headquarters. AIAA members can post and browse resumes and job listings, and access other online employment resources, by visiting the AIAA Career Center at http://careercenter.aiaa.org.

Committee Meetings

Meeting room locations for AIAA committees will be posted on the message board and will be available upon request in the registration area.

Messages and Information

Messages will be recorded and posted on a bulletin board in the registration area. It is not possible to page conferees. A telephone number will be provided in the final program.

Membership

Professionals registering at the nonmember rate will receive a one-year AIAA membership. Students who are not members may apply their registration fee toward their first year's student member dues.

Nondiscriminatory Practices

The AIAA accepts registrations irrespective of race, creed, sex, color, physical handicap, and national or ethnic origin.

Smoking Policy

Smoking is not permitted in the technical sessions.

Restrictions

Videotaping or audio recording of sessions or technical exhibits as well as the unauthorized sale of AIAA-copyrighted material is prohibited.

Department of Defense Approval

The DoD Public Affairs Office has determined that, for purposes of accepting a gift of reduced or free attendance, these events are widely attended gatherings pursuant to 5 CFR 2635.204(g). This determination is not a DoD endorsement of the events nor approval for widespread attendance. If individual DoD Component commands or organizations determine that attendance by particular personnel is in DoD interest, those personnel may accept the gift of free or reduced attendance. As other exceptions under 5 CFR 2635.204 may allow the acceptance of gifts, DoD personnel are urged to consult their Ethics Counselor.

International Traffic in Arms Regulations (ITAR)

AIAA speakers and attendees are reminded that some topics discussed in the conference could be controlled by the International Traffic in Arms Regulations (ITAR). U.S. Nationals (U.S. Citizens and Permanent Residents) are responsible for ensuring that technical data they present in open sessions to non-U.S. Nationals in attendance or in conference proceedings are not export restricted by the ITAR. U.S. Nationals are likewise responsible for ensuring that they do not discuss ITAR export-restricted information with non-U.S. Nationals in attendance.

AEROSPACE AMERICA

December 2009

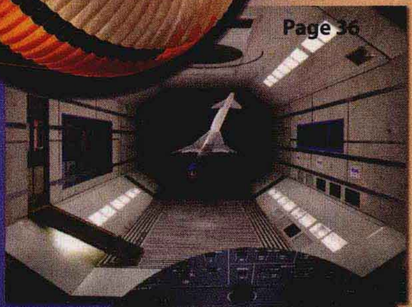
THE YEAR IN REVIEW

BULLETIN


Page 4


Page70

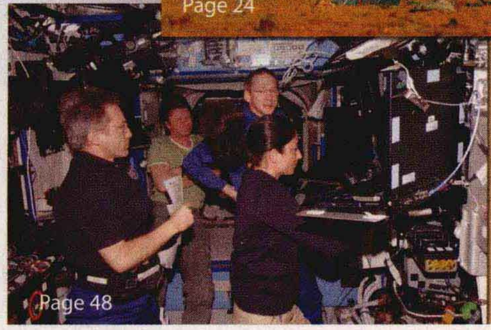

Page 30


Page 36


Page 60


Page 16


Page 24


Page 48

Cover: Type by Jane Fitzgerald; image from space shuttle Columbia, 2003.

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Send Letters to the Editor to Elaine Camhi at the same address or elainec@aiaa.org

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AIAA
American Institute of Aeronautics and Astronautics

Editorial

Inching toward reform

As the new year began, a new administration and a new Congress opened a door to long-sought efforts to rewrite the tangle of controls governing U.S. exports.

The International Traffic in Arms Regulations were enacted in 1976 and closely mirrored laws in place in eastern bloc nations. Over the subsequent 30+ years, political winds have shifted, both domestically and internationally, and those rules have been reinterpreted, refocused, and, in many cases, made even more restrictive.

But recently many, particularly in the aerospace industry, have come to recognize that the very regulations designed to protect the nation's technological edge and asymmetrical advantage over potential foes have, with their restrictions on the export of possible dual-use technologies, also hamstrung the ability of the U.S. to participate in international trade in many areas only marginally related to defense.

International aerospace companies loath to endure the months of red tape and deliberations required for the purchase of simple parts instead developed their own capabilities. The rise of the "ITAR-free satellite" was not a one-off.

But with the new administration, there seemed to be genuine interest in reexamining ITAR issues. Members of both houses of Congress began holding hearings, and many who had been adamantly opposed to change came to understand the damage being done to trade and now simply urged caution in moving forward. The House bill authorizing appropriations for the Dept. of State, where ITAR issues reside, and containing a section on reform of export controls was passed in June. (Unfortunately, its Senate equivalent remains stalled.) And in August, President Obama announced a comprehensive review of export controls.

This all might suggest a looming overhaul of the most trade-restrictive parts of the laws. However, there are other troubles weighing heavily on the president and the Congress. For example, even as the economy appears to be turning around, unemployment is still rising. And the world clock is ticking on climate change, as the longer we wait to act, the more damage will be done and the more mitigation will be necessary.

But these issues do truly tie together. The longer it takes to modify the antiquated sections of the export controls, the smaller the U.S. export market will become. As more and more of those who were once our customers become our competitors, that market shrinks, manufacturing numbers diminish, and the workforce required declines.

Export controls also hamper U.S. participation in GEOSS, the Global Earth Observation System of Systems. Climate change mitigation can only happen when action is taken on a global scale. But according to a report issued in 2008 by the Center for Strategic & International Studies, "Export control regulations are a fundamental disincentive and significant structural impediment to U.S. participation in international systems, to foreign cooperation with the United States, and to the development of GEOSS."

There are those who argue that ITAR reform must take a back seat as our government grapples with the larger issues of the day. But a closer look would suggest the opposite, that major strides in repairing what is broken or out-of-date in ITAR would go a long way in helping solve those issues.

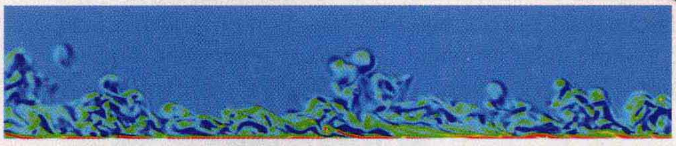
Elaine Camhi
Editor-in-Chief

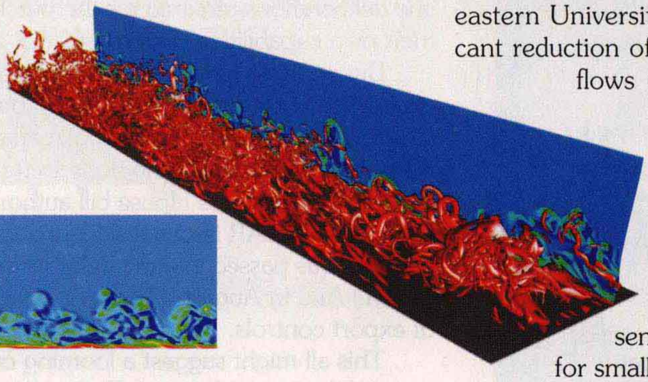
Fluid dynamics

The year has brought many significant and exciting developments in the study of fluid dynamic phenomena with a breadth of activities spanning from hypersonics to low Reynolds number regimes.

A significant development has been the establishment of three national hypersonics centers, overseen by NASA and the Air Force Research Laboratory (AFRL) Office of Scientific Research, to help forge a national direction for studying hypersonic flight. One center, led by Texas A&M University with several partners, is called the National Center for Hypersonic Laminar Turbulent Transition. It will specialize in boundary-layer control research.

AFRL, Caltech, and the University of Minnesota have collaborated in a numerical and experimental study on control of high-speed boundary layers. The team has demonstrated significant delays in transition through the suppression of instabilities with the injection of CO_2. Researchers at the University of Minnesota, CUBRC, NASA Langley, Purdue, and AFRL used a combination of stability analysis and ground test data to identify crossflow instability as a likely mechanism for transition on the leeward side of the X-51 demonstrator aircraft.





Complete transition to turbulence was initiated by one particular transition mechanism for a flat-plate boundary layer at Mach 3. (Left) Isosurfaces of the vortex identification criterion "Q" and contours of spanwise vorticity at one spanwise position illustrate small-scale structures close to the end of the computational domain. (Right) A close-up view shows contours of the spanwise vorticity (simulations carried out by the University of Arizona).

Additional efforts involving highly resolved numerical studies include a University of Arizona program examining the entire process of transition to turbulence in supersonic and hypersonic flows. The goal is to enable improved engineering and physical models for transition during high-speed flight.

On space shuttle Discovery's STS-119 and -128 missions, NASA flew a specially modified tile and instrumentation package to monitor heating effects from boundary-layer transition during reentry. The airflow on the port wing was deliberately disrupted by a protuberance built into a modified tile, enabling the effects of a known roughness geometry on the orbiter surface boundary layer to be quantified for the first time. Regular orbiter instrumentation was augmented by high-resolution calibrated imagery obtained by a Navy NP-3D Orion aircraft using a long-range infrared optical package known as Cast Glance.

In low Reynolds number aerodynamics, work continues on unsteady flow phenomena and control. Researchers at the University of Michigan found that for low-aspect-ratio flapping wings, tip vortices can increase lift by creating a low-pressure region near the wing tip and delaying the shedding of the leading-edge vortex (LEV). AFRL/RB researchers have demonstrated, with a high-order implicit large-eddy simulation (ILES) approach, that stall suppression can be achieved with small-amplitude high-frequency oscillations. The resulting new flow regime has no LEV shedding or thrust generation, and features the dramatic spanwise breakdown of the dynamic-stall vortex system. A joint effort by Caltech, Illinois Institute of Technology, Princeton, and Northeastern University has demonstrated significant reduction of lift fluctuations in unsteady flows through flow control, with applications in gust alleviation. Balanced POD (proper orthogonal decomposition)/observer models were shown to stabilize vortex shedding using only two velocity sensors, with important benefits for small autonomous air vehicles.

Control of the flow over a hemispherical turret for aerooptic applications is an important application of control of 3D flows, and has received considerable attention this year. Studies involving hybrid Reynolds-averaged Navier-Stokes/ILES simulations by researchers at AFRL, and experiments at AFRL, Syracuse University, Notre Dame, Georgia Tech, and the University of Florida demonstrated an array of actuation strategies in both open and closed loops.

Researchers at the University of Vermont have teamed with NASA to study micropropulsion and control of nanosats, to enable new propulsion technologies for these very small spacecraft using microfluidics.

Purdue and George Washington University, under FAA funding, conducted studies of air circulation patterns and particle transport in model aircraft cabins. A key finding is that people walking in the aisles disrupt the designed ventilation flow patterns and can promote the spread of airborne contaminants over 10 rows.

by **Lawrence Ukeiley**

Aeroacoustics

The development of civil supersonic aircraft capable of operating within the threshold of community noise regulations is continuing on different fronts. Wyle Laboratories, in collaboration with Penn State University and Eagle Aeronautics, has made significant strides in calculating sonic boom footprints from supersonic flight vehicles. Enhancements include sonic boom predictions over georeferenced terrain encompassing varying ground impedance, as well as distortions imposed by atmospheric turbulence.

Meanwhile, scientists at Stanford University, with support from NASA, are developing large eddy simulations (LES) capable of predicting the radiated sound from heated and unheated supersonic jets with complex geometries. Databases obtained at the small hot jet acoustic rig facility at NASA Glenn are being used to validate these models. Similar efforts at Boeing, under way since 2004, have demonstrated continued progress in the development and application of LES methodology. Accurate spectral predictions of jet noise, to within 2-3 dB over a meaningful range of frequencies, have been achieved from complex single-stream and dual-stream nozzle geometries and a wide range of jet operating conditions with the developed methodology.

Researchers at the University of Illinois at Urbana-Champaign are developing new theories for the dominant mechanisms responsible for the sources of core noise in aircraft engines. This effort is part of an NRA from NASA's subsonic fixed-wing program. The mechanism, often called "indirect combustion noise," is believed to be caused by thermodynamic interactions (entropy fluctuations) with the engine's turbine blades. Nonlinear simulations of the flow and acoustic radiation over an idealized turbine blade support the new theory.

Other activities in computational aeroacoustics and advanced measurement methods were sponsored this year by the Aeroacoustics Research Consortium. Managed by the Ohio Aerospace Institute, the consortium is a partnership among NASA Glenn, Boeing, General Electric Aircraft Engines, Honeywell International, Pratt & Whitney, and Rolls-Royce. Its programs include assessing the effectiveness of using phased microphone arrays to identify engine noise sources, the development of computational methods to predict high-speed jet noise, and the application of LES to acoustic liners.

The FAA sponsored an aircraft taxi noise study performed by Wyle Laboratories.

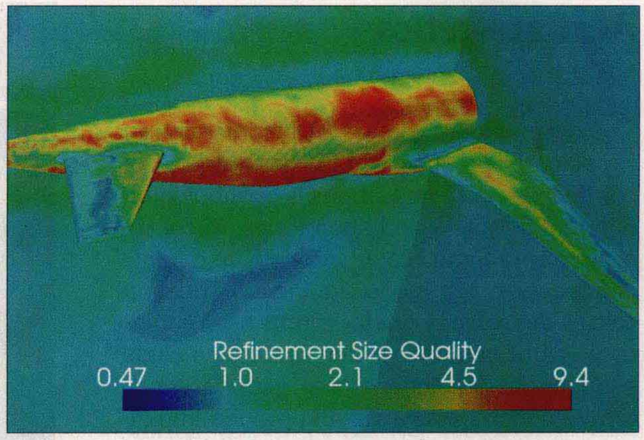
A collaboration between GKN Aerospace and Honeywell Aerospace brought continued progress in reducing engine fan noise. The two companies designed, fabricated, and tested a seamless double-layer engine inlet liner using a Hexcel HexWeb Acousti-Cap honeycomb core with a perforated composite facesheet. Far-field acoustic surveys on a full-scale demonstrator engine at Honeywell's Acoustic Test Facility demonstrated comparable results over a substantial range of engine speeds for the new design when compared to traditional liners. Testing also confirmed improvements in sound attenuation at high engine power settings using the seamless liners.

The counterrotating open fan engine architecture, successfully developed and flight tested by GE in the 1980s, is a candidate for the next generation of narrowbody aircraft. To meet community noise regulations, CFM International (a 50/50 joint partnership between GE and Snecma) has developed modern open rotor fan system designs using computational aeroacoustic prediction tools. Joint GE/NASA testing is scheduled to continue through early 2010 to demonstrate these concepts and validate the design tools.

In the area of space-based launch platforms, existing liftoff acoustic models used by NASA Marshall are being updated with new empirical data. One such set of experiments, conducted under a joint effort of NASA, Wyle Labs, and ATK Launch Systems, comprised three static firings incorporating more than 60 acoustic free-field microphones. The new acoustic models will be used to predict the liftoff acoustic environments of the Ares I and Ares V launch vehicles.

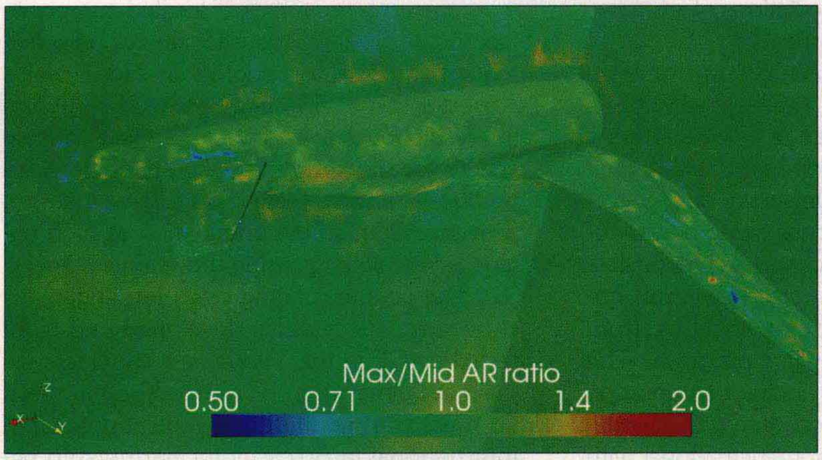
by **Charles E. Tinney**

Meshing, visualization, and computational environments



The length scale ratio for the coarse and medium meshes in the Langley cell-centered sequence is normalized by mesh size so that the expected value is one; the analysis suggests that the medium mesh has cells that are too large on the surface of the fuselage.

The overall problem of elucidating the interaction between mesh and solution is large and complex. Recent work by Carl Ollivier-Gooch of the University of British Columbia seeks to address a small but important part of the problem, that of determining whether a sequence of meshes truly constitutes a mesh refinement sequence for a mesh convergence study. Two meshes are said to form an ideal refinement pair if their cell sizes are uniformly proportional across the entire domain, and if cell aspect ratio and orientation are the same in anisotropic regions of the mesh. The size, shape, and orientation of a cell in an unstructured mesh can be computed in more than one way; one viable approach is to compute the moments problem to find the size, aspect ratio, and principal directions of the cell.



In a comparison of one of the two cell aspect ratios (roughly spanwise to streamwise) for the coarse and medium meshes in the Langley cell-centered sequence, with the exception of a few small regions on the wing and at the base of the tail, the aspect ratio is nearly the same for both meshes, as expected.

Once these quantities are known, a comparison between meshes can be accomplished by projecting data from one mesh to another. Although this is still a research tool, meshes from a Drag Prediction Workshop held this summer were analyzed successfully.

CRAFT Tech and CEI have jointly developed a computational environment that allows users to predict, visualize, and reduce grid-induced errors in CFD simulations. Through a custom interface, the software system combines an error quantification and unstructured mesh adaptation code, CRISP CFD, with the rendering capabilities of EnSight.

A variety of methods may be used to visualize predicted errors obtained from the solution of error transport equations. Techniques for simultaneous visualization of flow variables and their associated errors include multiple contours, multiple vectors or streamlines, texturing, and error bubbles. Error sources may be used to drive local adaptive mesh refinement, directly from the user interface. The system has been demonstrated for practical turbulent flows on 3D unstructured meshes.

Mesh generation developers worldwide came together to share technical information related to their research at the International Meshing Roundtable (IMR), a yearly conference devoted to mesh generation and general preprocessing techniques. Started by Sandia National Laboratory in 1992, the meeting continues to be one of the premier events focusing on mesh generation for field simulations and graphical display. The AIAA began cosponsoring the conference starting with the 18th IMR held in Salt Lake City in October.

An award given each year by the AIAA MVCE Technical Committee was renamed the Shahyar Pirzadeh Memorial Award for the Outstanding Paper in the discipline. The award was renamed in memory of a valued contributor to the field of unstructured numerical mesh generation. Pirzadeh, who died on March 18, was best known for his work with the VGRID unstructured mesh generator. His many innovations included the advancing layers method and early adoption of the Cartesian background grid to control mesh spacing. He was also the award's first recipient.

by **Anthony C. Iannetti**

Guidance, navigation, and control

Rockwell Collins demonstrated a damage-tolerant flight control system for DARPA's Joint Unmanned Combat Aircraft Systems program using an unmanned F/A-18 subscale aircraft model with 60% wing loss. The flight controller demonstrated automatic recovery and autonomous landing.

Aurora Flight Sciences demonstrated autonomous vertical takeoff, hover, and landing of the Excalibur unmanned combat aircraft, which combines high-speed flight with vertical takeoff and landing (VTOL). Its VTOL system gets its primary propulsion from a tilting jet engine and supplemental thrust and pitch control with electric lift fans.

An X-plane pushing the limits of flight control software is the tailless, X-48B blended wing body built by Boeing with NASA and the Air Force Research Laboratory (AFRL). The X-48B's flight controller is responsible for allocating the autopilot commands among 20 movable surfaces. The control surfaces are all independently actuated and clustered along the trailing edge. The centralized, highly coupled, nonlinear flight control system also incorporates envelope protection algorithms via limiters. More robust alpha and beta sideslip limiter algorithms are being developed to provide better envelope protection against unexpected lateral-mode oscillations seen in stall tests at high angles of attack.

NetFires completed the first moving target test flight of the non-line-of-sight launch system's precision attack missile in July. Raytheon's AIM-9X Sidewinder missile demonstrated surface-to-air capability when it engaged an unmanned air target in May. The AIM-9X is a fifth-generation, high off-boresight infrared-guided missile developed for the air-to-air mission.

Lockheed Martin launched DAGR rockets from an airborne AH-6 Little Bird helicopter and hit the targets in two trials in July. Lockheed Martin and the Missile Defense Agency demonstrated the ability of the Terminal High Altitude Area Defense weapon system to detect, track, and intercept a separating target inside Earth's atmosphere in March.

A Boeing Harpoon Block II missile equipped with a redesigned guidance control unit hit its land-based target in its first test flight in September. The Arrow II interceptor, produced by Boeing and Israel Aerospace Industries, shot down a ballistic missile target in April in an operationally realistic test conducted in Israel by the Israel Ministry of Defense and the Missile Defense Agency.

A Sidewinder missile demonstrated surface-to-air capability when it engaged an unmanned air target.

Shuttle mission STS-126 delivered ISS component modules that doubled the space station's crew capacity with new living quarters, regenerative environmental controls, and enhanced life support system. Follow-up STS missions installed the final pair of solar panels, several new multinational science laboratory modules, and a new astronaut treadmill. On July 30, two 5-in.-cube picosatellites, AggieSat2 (Texas A&M University) and Bevo-1 (University of Texas-Austin) were released from STS-127 Endeavour. They are the first of a series of test satellite pairs that will eventually demonstrate autonomous rendezvous and docking.

On June 18, NASA launched LCROSS (Lunar Crater Observation and Sensing Satellite) and LRO (Lunar Reconnaissance Orbiter). In an effort to detect water ice traces in a lunar polar crater, the LCROSS satellite flew into a heavy debris plume created when its spent upper-stage Centaur rocket impacted the Moon's Cabeus A crater on October 9. It collected and analyzed debris samples and relayed the data to Earth. LRO's one-year lunar surface mapping mission for subsequent lunar expeditions began when it entered its mapping orbit September 17 and started relaying high-resolution topographic imagery.

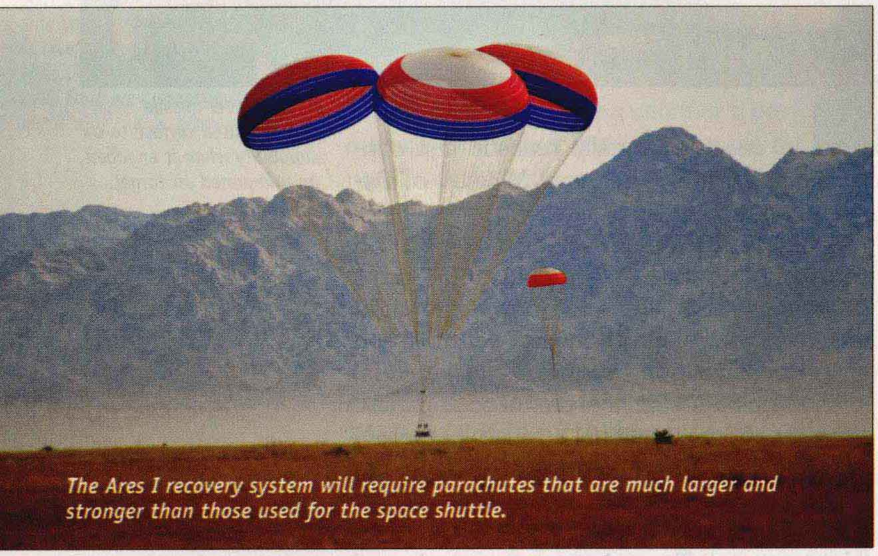
In October 2008, India launched its first lunar probe, Chandrayaan-1, which demonstrated launch to Earth orbit, departure, transfer, and insertion into low lunar orbit, finally releasing a lunar impactor for surface analysis missions. Chandrayaan-1 carried science payloads for NASA and ESA, among others, and completed its mission in June.

An AFRL experimental small satellite, TacSat-3, launched and deployed on May 19. TacSat-3 hosts a hyperspectral sensor that can be directly controlled by troops in the field, an ocean data telemetry microsatellite link, and a plug-and-play avionics package.

by **Leena Singh, Daniel J. Clancy,** and **Brett Ridgely**

Aerodynamic decelerator systems

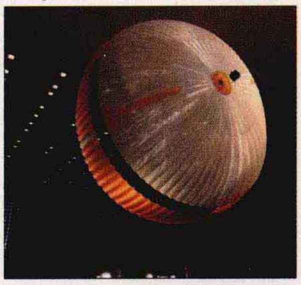
2009 was a very productive year for parachute development. Notable accomplishments include testing of the Mars Science Laboratory (MSL) parachute, the Ares I recovery system, and the Max Launch Abort System (MLAS), as well as significant work in the area of autonomous payload delivery.



The Ares I recovery system will require parachutes that are much larger and stronger than those used for the space shuttle.

The MSL parachute finished its final testing, successfully completing structural qualification and flight lot workmanship verification tests. The testing took place at the NASA Ames Full Scale Aerodynamics Complex 80 x 120-ft wind tunnel. The parachute was deployed at conditions that produced inflation loads 25% higher than the maximum expected flight limit load and included multiple inflations of the flight lot canopy. The final tally resulted in a single canopy withstanding 14 inflations at peak inflation loads ranging from 360 to 290 kN (81-65 klbf).

The Mars Science Laboratory parachute completed testing this year.



The Ares I solid rocket booster, which will launch the Orion crew exploration vehicle (CEV) following retirement of the space shuttle, is much heavier than the shuttle's booster and reenters the atmosphere at a much higher velocity; hence the parachutes must be larger and stronger. The 68-ft-diam drogue parachute will experience a load of 500,000 lb, while the three 150-ft-diam main parachutes will experience 300,000-lb loads. The final drogue parachute basic performance drop test was completed this year, along with a drop test of the clustered three main parachutes. The drogue drop test provided the drag area at various reefing ratios along with the corresponding opening loads and load factors. The cluster test provided the cluster degradation factor for the main parachute's drag area, as well as an observation of the parachute's deployment, inflation, and cluster interaction characteristics.

NASA's Engineering and Safety Center developed and tested MLAS as a risk-mitigation system should problems arise with Orion's launch abort design. The effort culminated in a highly successful July flight test. During the test, two mortar-deployed parachutes separated the coast skirt from the forward fairing, followed 3 sec later by two more mortar-deployed parachutes reorienting the fairing 180°, which placed the boilerplate CEV crew module (CM) in the heat-shield-first orientation. With the fairing stabilized, the boilerplate CM was released from inside the fairing. After a brief ride on two drogues, the boilerplate CM released its simulated forward bay cover and deployed four main parachutes.

This test demonstrated that the fairing could be successfully reoriented and the CM released without detrimental recontact. Thus it showed that the MLAS system is a viable concept should the baseline launch abort system encounter significant difficulties during development.

This year the Aerodynamic Decelerator Systems Center at the Naval Postgraduate School developed Snowflake, an autonomous networking aerial delivery system for a 3-lb payload. Networking capability allows target assignment and tracking from anywhere in the world through the Internet. Snowflake is currently being integrated with the Arcturus T-20 UAV, which will be able to carry up to 12 systems inside the payload bay and two payload containers under the wings.

Aerial delivery remains an increasingly critical and successful method of supply delivery for the military in all types of environments. Airdrops have nearly doubled every year since 2005 in Afghanistan, and are on track to exceed 30 million lb this year. The JPADS (joint precision airdrop system) family of autonomous air vehicle systems provides payload capability ranging from 1 to 42,000 lb, with most already demonstrated or in use. The largest precision airdrop demonstration ever held, conducted by the Army Natick Soldier Research, Development, and Engineering Center, took place in the U.S. October 19-22, 2008, allowing more than 500 U.S. and allied participants the opportunity to witness the capabilities and utility of precision airdrop systems.

by **Elsa Hennings**

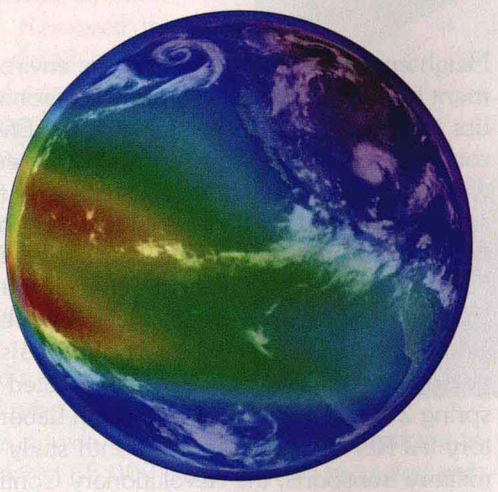
Atmospheric and space environments

Advancements in the areas of atmospheric and space environments continued, and this year saw a wide variety of developments in flight experiments, testing capabilities, terrestrial guidelines, and space weather.

Lockheed Martin Space Systems, NASA Marshall, and Kyushu Institute of Technology are collaborating with the Japanese Aerospace Exploration Agency and the U.S. Naval Research Laboratory (NRL) on a flight experiment scheduled to launch aboard STS-134. The PASCAL (primary arc effects on solar cells at LEO) experiment will characterize the cumulative effects of low-power plasma-induced arcing on the performance of a variety of typical and state-of-the-art space solar cell technologies. PASCAL is part of the MISSE-8 (materials ISS experiment-8) and the first PRELSE (platform for retrievable experiments in a LEO space environment) program managed by NRL. It will be an active experiment on the station with a design life of least two years and a goal of being returned to Earth for ground processing. Results will aid spacecraft designers, operators, and insurers responsible for solar arrays operating in a space plasma environment conducive to producing electrostatic discharges on the solar array surface.

The Air Force is currently developing a new testing capability, the space threat assessment testbed (STAT), at its Arnold Engineering Development Center. STAT will enable ground testing of space systems in the complex natural space environment at various orbits and will also provide the ability to induce man-made threats. An interactive connection to satellite operations centers will be included to bridge the gap between development and operational testing of space systems. This connectivity will allow ground station hardware, software, and operators to be involved in realistic test scenarios.

NASA Marshall's Natural Environments Branch has published the latest revision to *Terrestrial Environment (Climatic) Criteria Guidelines for Use in Aerospace Vehicle Development* (NASA/TM-2008-215633). This document provides guidelines for the terrestrial environment (Earth surface to 90-km altitude) that are specifically applicable in the development of design requirements and specifications, plus associated operational criteria, for NASA aerospace vehicles, payloads, and associated ground support equipment.



Google Earth displays an image of the global ionosphere.

The document contains considerable information of general engineering and scientific interest concerning the terrestrial environment. It also has information on ground and in-flight winds, atmospheric thermodynamic models, radiation, humidity, precipitation, severe weather, sea state, lightning, atmospheric chemistry, and seismic criteria. It includes a model to predict atmospheric dispersion of aerospace engine exhaust cloud rise and growth. It is available for download at the NASA Technical Reports Server: http://ntrs.nasa.gov.

Beginning this year, Utah State University is hosting a new organization to develop commercial space weather applications, with funding provided by the Utah Science Technology and Research (USTAR) initiative. The USTAR Center for Space Weather (UCSW) is developing innovative applications for mitigating adverse space weather effects in technological systems. Of the space environment domains affected by space weather, the ionosphere is the key region that impacts communication and navigation systems. The UCSW has developed products for users of systems affected by space-weather-driven ionospheric changes.

On September 1, in conjunction with Space Environment Technologies, UCSW released the world's first real-time space weather via an iPhone app. Space WX displays the real-time current global ionosphere total electron content along with its space weather drivers. Also, the global assimilation of ionospheric measurements system is now being run operationally in real time at UCSW with the continuous ingestion of hundreds of global data streams to dramatically improve characterization of the ionosphere.

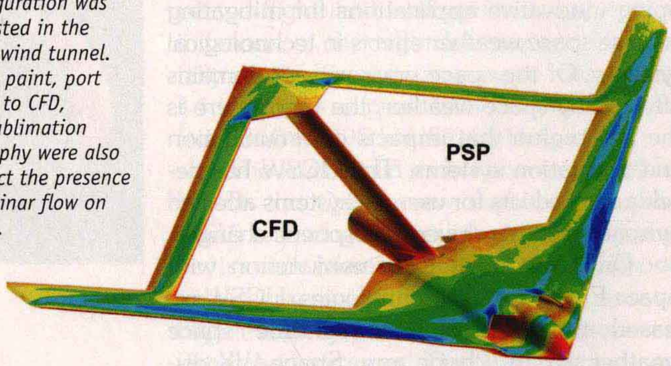
by **Dustin Crider** and the **AIAA Atmospheric and Space Environments Technical Committee**

Applied aerodynamics

Heightened focus on energy and the environment has led to new activities in the aeronautics community. NASA has initiated the Environmentally Responsible Aviation project, which focuses on integrated system-level research aimed at simultaneously achieving national noise, emissions, and fuel burn goals for N+2 (generation after next) civil aircraft. NASA's ongoing N+3 advanced concept studies, involving four subsonic and two supersonic civil missions, will be completed in spring 2010. The Air Force Research Laboratory (AFRL) kicked off an 18-month study of military transports, the Revolutionary Configurations for Energy Efficiency Program, to identify ways of achieving 90% reductions in fleet fuel usage by 2050.

The European Smart Fixed Wing Aircraft Integrated Technology Demonstrator is pursuing active wing technologies that adapt wing shape based on sensed airflow, as well as new aircraft configurations that can best incorporate these novel concepts.

An AFRL/Scaled Composites/Northrop Grumman/university team is maturing swept-wing laminar flow control technologies toward revolutionary ISR (intelligence, surveillance, and reconnaissance) capabilities as part of the SensorCraft concept. A variety of in-flight measurement techniques have been used, including infrared thermography and unique self-contained, in-flight boundary-layer measurement devices, to conduct flight tests of a 30-deg swept-wing test article attached to the White Knight One aircraft.



A 4%-scale Boeing joined-wing SensorCraft configuration was optimized and tested in the NASA Ames 11-ft wind tunnel. Pressure-sensitive paint, port side, is compared to CFD, starboard side. Sublimation and IR thermography were also employed to detect the presence of significant laminar flow on the configuration.

As part of the AFRL Aerodynamic Efficiency Improvement program, Boeing performed CFD-based aerodynamic optimization on a joined-wing SensorCraft configuration to minimize the configuration drag and inlet distortion. With NASA support, a 4% scale model of the optimized geometry was built and tested in the Ames 11-ft wind tunnel.

Preparations continue for Ares I-X flight tests. Development has relied heavily on CFD to predict aerodynamic characteristics on the pad, at liftoff, and during ascent, as well as to predict trajectories of vehicle components to ocean impact.

The Fourth Drag Prediction Workshop centered around the NASA common research model and emphasized trim drag and Reynolds number effects. The model will be tested to flight Reynolds numbers at NASA's National Transonic Facility. A test in the Ames 11-ft wind tunnel will follow.

Northrop Grumman conducted a series of tests to evaluate step excrescence effects on boundary transition in the presence of a pressure gradient. Results indicate that the allowable height of a step excrescence is larger than previously thought, enabling design of full-scale, subsonic, low-sweep aircraft with a better understanding of the tolerance requirements for laminar flow.

NASA and Georgia Tech Research Institute are collaborating on fundamental 2D circulation control experiments to be used for CFD validation. These data will provide the physical characteristics associated with separation and supercirculation flow control and will lead to a refinement of turbulence models, gridding techniques, and test techniques.

AFRL has begun an aggressive multidisciplinary project on micro air vehicle development, to include the flight sciences (aerodynamics, structures, and controls) and constituent subjects such as efficient energy transduction and storage. AFRL engineers are combining wind/water tunnel testing, benchtop testing, computations, and analysis to exploit unsteady aerodynamics for improved flight performance and flight control. These efforts will leverage the Air Force Office of Scientific Research multidisciplinary research on bio-inspired flight as well as the extensive and multidisciplinary research now being performed in the academic community. They include studies of bat flight, led by Brown University, and fundamental physics of flapping wings, led by the University of Michigan.

Operational control units on flight projectiles were tested at the wind tunnel of the Army Armament Research, Development, and Engineering Center (Picatinny Arsenal). Full-scale models of various configurations were tested at near-free-flight Reynolds numbers to validate performance. Testing resulted in a working software fix being implemented for a configuration that had failed during ballistic firing.

by **Gary Dale**, **Andrew McComas**, and the **AIAA Applied Aerodynamics Technical Committee**

Atmospheric flight mechanics

Boeing completed low-speed taxi tests on the 787 Dreamliner. These included evaluation of the ground handling and braking system during taxi speeds of up to 100 kt. The company continues to address wing attachment structural issues before first flight, which is expected by year's end. The latest variant in Boeing's largest aircraft, the 747-8, is scheduled to fly by early 2010. Design changes to the wing and engine have improved fuel efficiency, while the lengthened fuselage has increased capacity by up to 51 seats.

Boeing is also continuing its successful X-48B Blended Wing Body flight test program. As of October 21, 70 flights designed to expand the flight envelope up to and beyond stall and confirm the flight control software's capabilities, were successfully completed. The Boeing X-48C, a low-noise variant of the X-48B, completed a 300-hr test in the 30x60 wind tunnel facility at NASA Langley.

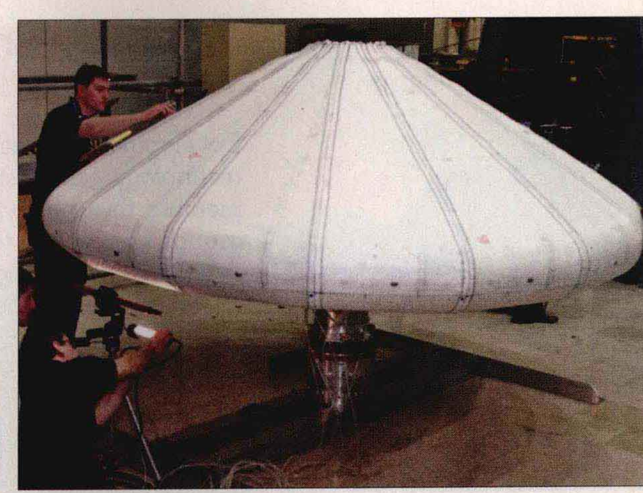
Currently under way are several efforts to develop autonomous and augmented control systems for general aviation aircraft. Hoh Aeronautics and S-TEC have received a supplemental type certificate for their stability augmentation and autopilot unit, called Heli-SAS, for the Robinson R44 helicopter. Flight testing is in progress for Bell's 206-B and 407 rotorcraft models.

For fixed-wing aircraft, Hawker Beechcraft and Rockwell Collins Athena have completed initial flight testing of a fly-by-wire autoland system for the Beechcraft Bonanza. The goal is to demonstrate adapting a UAV autopilot system to a manned aircraft to improve flight safety.

Cessna has flown the first production, single-engine model 162 Skycatcher, which is manufactured in China. Development and production continue despite two incidents with prototype aircraft involving unrecoverable spins. Cessna is reentering the primary training market with the aircraft, its first two-seat design since 1985. Skycatcher complies with the new LSA (light sport aircraft) category.

Roadable aircraft prototypes were announced and debuted, including Terrafugia's folding wing design and Maverick's parachute wing approach. Hybrid air-land vehicles face conflicting design requirements and environmental factors during the drive and flight phases. Both these and other companies say advancements in materials and systems enable a practical, dual-use roadable aircraft.

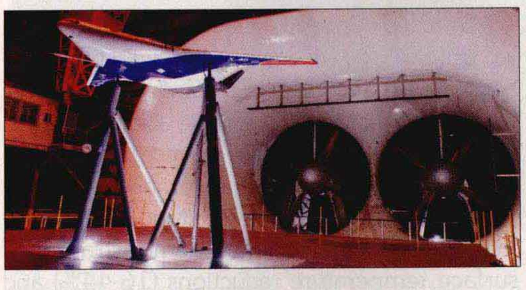
Renewed interest in dirigibles has led one company to offer Zeppelin tours over San Francisco Bay and the USAF to consider it for a long-duration, high-altitude mission. The current design uses a helium-filled hull to provide buoyancy and a solar panel array for propulsion and system power. The USAF vehicle is expected to hover at 65,000 ft for 10 years providing persistent surveillance.



The IRVE has an inflatable 10-ft-diam heat shield that generates sufficient drag to enable controlled descent through the atmosphere. (Photo by Sean Smith.)

In an alternate approach to high-altitude persistent loiter, the 61-m-wingspan Solar Impulse vehicle is being prepared for an initial flight late this year. The large wingspan and lightweight structure contribute to coupling between the aerodynamic and structural modes and offer unique handling qualities. An autonomous option is planned for the aircraft, which may compete with vehicles developed for DARPA's Vulture program.

Virgin Galactic conducted the inaugural flight of WhiteKnightTwo, which will be used to drop-test and eventually launch the commercial space tourism vehicle SpaceShipTwo. The spacecraft uses a morphing tail section to reconfigure from a streamlined ascent geometry to a high-drag reentry shape.

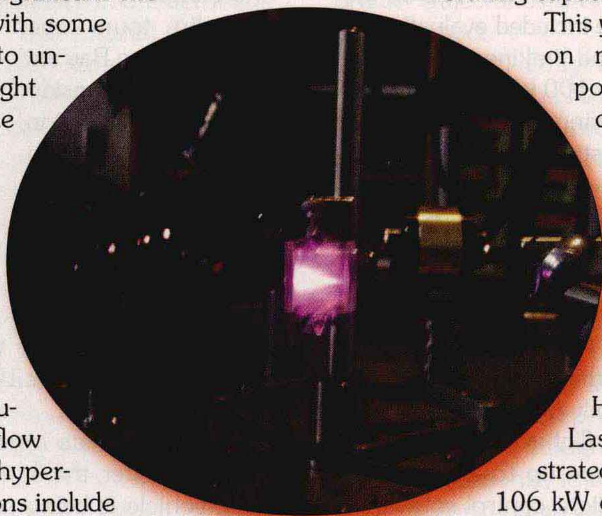


The X-48C completed a 300-hr test in the 30x60 wind tunnel facility at NASA Langley. (Photo by Bob Ferguson, Boeing.)

NASA Langley successfully tested the inflatable reentry vehicle experiment (IRVE), whose inflatable 10-ft-diam heat shield generates sufficient drag to enable uncontrolled descent through the atmosphere. Launched to an altitude of 131 mi. using a Black Brant IX rocket, the IRVE initiated inflation during descent while passing through an altitude of 124 mi. This demonstrator's success will lead to larger, more advanced aeroshells designed to withstand higher heat. Ultimately, a shield may be used for safely landing larger payloads to higher surface elevations on Mars.

by **Mujahid Abdulrahim** and **Dwayne F. Kimball**

Plasmadynamics and lasers



Fluorescence emanates from a diode pumped alkali laser experiment. (Courtesy Air Force Research Laboratory.)

Development of electrodynamic heat shield technology gained significant momentum this year, with some groups now poised to undertake pioneering flight test experiments. The basic idea is to project magnetic fields into the hypersonic boundary layer surrounding a reentry vehicle and induce strong magnetohydrodynamic interaction effects to manipulate and control flow structure. Potential hypersonic flight applications include active thermal protection systems, guidance and flight path control for endoatmospheric maneuverability, and magnetohydrodynamic power extraction with in-flight energy storage and/or burst power utilization.

The basic technological concept was originally conceived in the 1950s as a potential means of mitigating heat transfer to warhead nose cones but was set aside following the practical demonstration of ablative heat shield materials. However, advancements in superconducting magnet and cryocooler technologies combined with a desire for enhanced capabilities have generated renewed interest in the idea.

Detailed conceptual development has been led primarily by the Institute of High Temperatures in Russia. ESA, EADS Astrium Space Transportation, and DLR have also invested in experimental and theoretical research and recently completed milestone demonstration experiments in the L2K long-duration arc-heater facility at DLR, with clear demonstration of surface temperature reductions (16-44%) and heat flux mitigation (46-85%).

The group's current efforts focus on CFD validation using high-accuracy experimental data and flight test development. Flight tests are necessary to cover the complete environment parameter space, which cannot be precisely simulated in ground-based facilities, and to include the integrated effects of vehicle flight dynamics. The suborbital flight test scenario is based on submarine launch from the Barents Sea using well-established Volna/Volan hardware and infrastructure, with descent phase test article deployment and landing on the Kamchatka peninsula. Additional flight test planning is under way at JAXA's Institute of Space and Astronautical Science, with the aim of enhancing planetary aerobraking capabilities.

This year has seen advances on many fronts in high power-laser technology development. Emphasis is on developing electrically powered laser systems, including bulk solid-state, fiber lasers, and gas-electric hybrid lasers.

Northrop Grumman, under DOD's Joint High Power Solid-State Laser program, demonstrated a bulk solid laser with 106 kW of power, claiming the record for the highest continuous wave power produced by this type of laser. As part of this demonstration, Northrop Grumman also showed 19.3% electrical to optical conversion efficiency with a beam quality of approximately 3.0. Similar in orientation to DARPA's High Energy Liquid Laser Area Defense System, these programs are pushing bulk solid-state laser technology to higher powers, better beam quality, and improved specific power performance to enable placement of these lasers on aircraft and mobile ground platforms.

An alternative approach to bulk solid-state laser technology that incorporates the cooling function performed by the liquid into the gain media involves optically pumping a gas with diode sources to drive the lasing action. This approach has the potential to combine the beam quality and cooling advantages of gas lasers with the compactness and logistics advantages of electrically powered solid-state devices. Researchers at the Air Force Academy, teamed with the Air Force Research Laboratory and General Atomics, made significant demonstrations of increases in laser power in laboratory devices with diode pumped alkali lasers. While demonstrating increases in laser power, a critical finding was a decrease in optical input power to laser output power conversion efficiency with increasing input optical power, attributed to mounting losses to heat release and kinetic quenching in the gas. With this finding, it is clear that future development of this technology will involve the application of traditional aerospace technologies for controlling heat release in a gas.

by **Ron J. Litchford** and **Timothy J. Madden**

Thermophysics

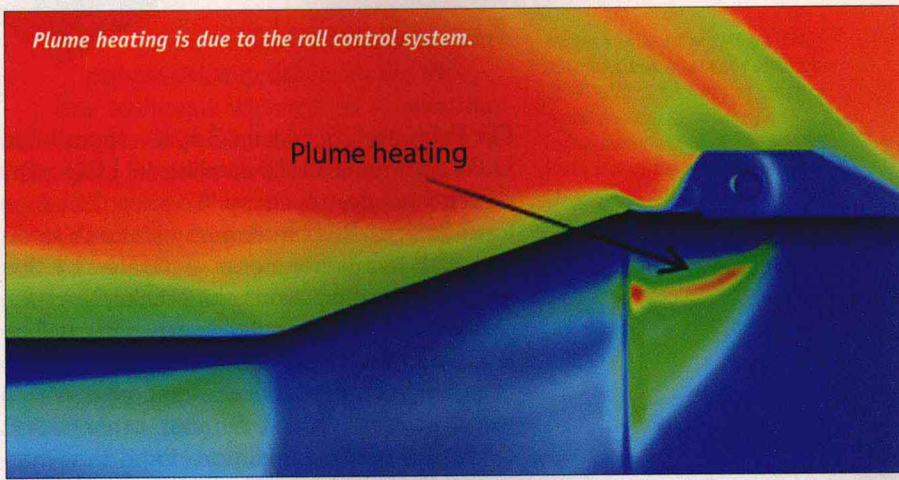
Ares I-X is the test flight for the CLV (crew launch vehicle) Ares I. Its first launch occurred on October 28 from NASA Kennedy in support of NASA's Constellation program. The vehicle's first stage includes a standard solid rocket booster from the space shuttle program. The upper stage and crew exploration vehicle portions of the craft are simulators, with a similar outer mold line to Ares I, but no active propulsion or crewed area in the upper stages. Thermal modeling was performed for Ares I-X to show that the vehicle design is thermally robust, and that all components and materials survive the expected conditions.

Several integrated product teams have come together to develop the Ares I-X first stage, upper stage simulator, crew module/launch abort system, avionics, and roll control system.

The Ares I-X achieved roughly Mach 4 before the separation of the upper stage from the first stage. Thus the amount of aerodynamic heating is relatively minor on most of the craft. The highest aerodynamic heating is at the pointed nose, where there is a probe installed to capture airspeed and angle of attack. This probe is manufactured from stainless steel to withstand the heating. Other high heating on the vehicle is from the roll control system, which will fire during ascent to maintain the vehicle in the proper orientation. Because of the velocity, the plumes from these roll control engines blow back along the vehicle, producing locally high heating. Thermal protection system materials are used in those locations to protect the vehicle skin.

Another thermal challenge for Ares I-X is to maintain the vehicle and avionics temperatures while on the launch pad and during rollout; there is no active environmental control system during rollout or for several hours before launch. The vehicle is painted white to limit absorbed solar heat flux, and fans and conductive thermal grease are used to maintain the avionics temperatures within limit.

The vehicle thermal model has been developed with input from four NASA centers and three contractors. The full model includes all parts of the 350-ft, 2-million-lb vehicle and the pad structures, as well as all physical effects, such as solar heat flux, radiation exchange with ground, sky, vehicle components, and pad, natural and forced convection, contact conduction, and avionics self-heating. Over 40 cases are run within the model and include everything from testing in the Vehicle Assembly Building, rollout, and on-pad sequences (nominal as well as extended hold and abort), through ascent and descent.



Plume heating is due to the roll control system.

Complex timelines of the avionics startup are captured during the on-pad sequence cases, and full mapping of skin-temperature dependent aerodynamic heating on the vehicle skin is done during ascent and descent. This vehicle includes the largest vented air volume ever launched by NASA. The behavior of that air, including venting on ascent, is also captured in the model. The thermal modeling shows that all components and materials are expected to remain within their specified thermal limits during all phases of the mission.

A bow shock forms around the Ares I-X traveling at supersonic speed. The rocket produces 2.96 million lb of thrust at liftoff and goes supersonic in 39 sec. Liftoff occurred on October 28.

Lessons learned on this program about large thermal model integration, analysis of on-pad conditions, and application of aerodynamic heating should prove useful to future programs.

by **John A. Dec** and **Ruth M. Amundsen**