2013 AIAA-RM Annual Technical Symposium

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2013 AIAA-RM Annual Technical Symposium

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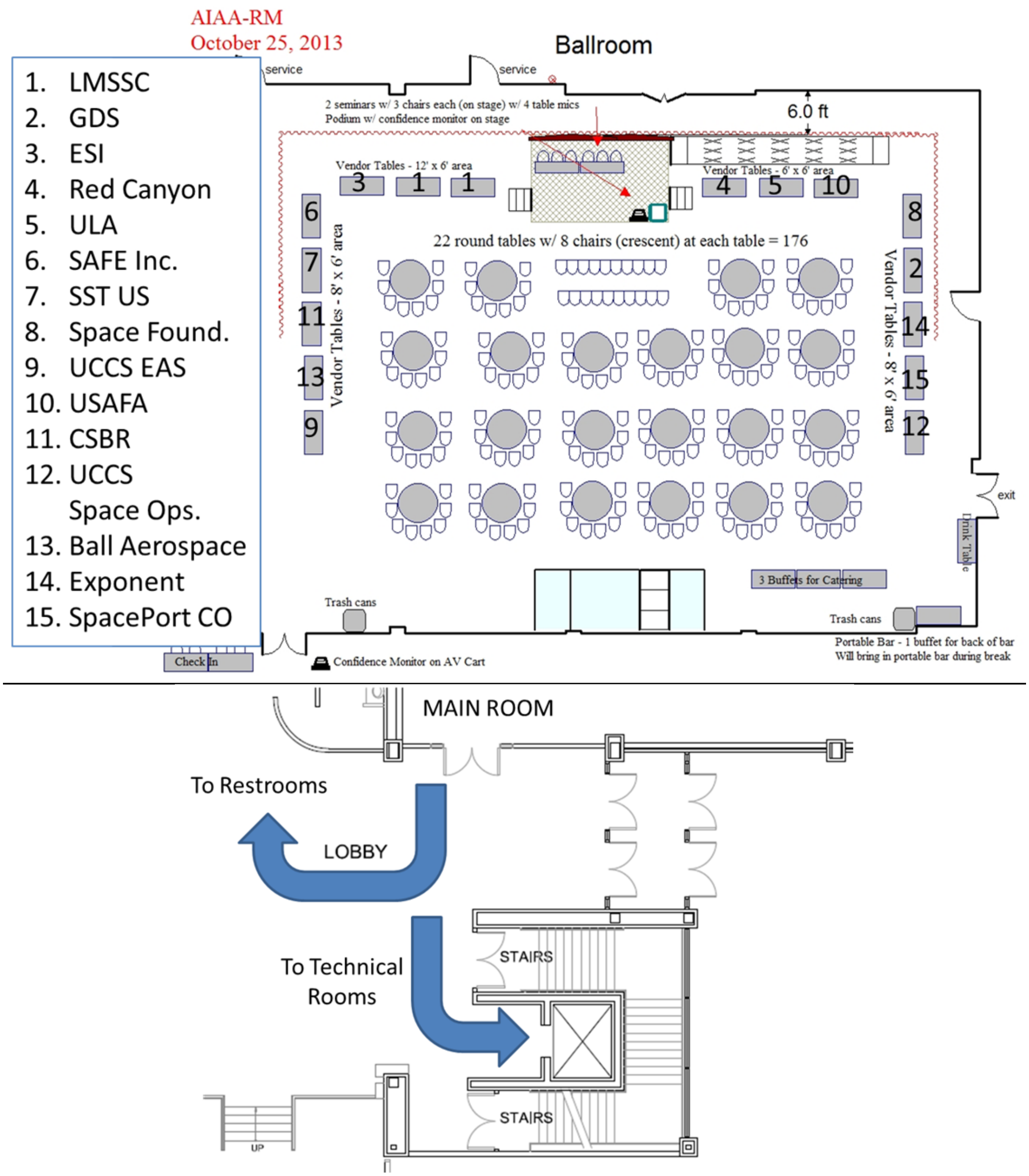
2013 AIAA-RM Annual Technical Symposium

Layout & Agenda

SETUP STARTS AT 0730   REGISTRATION STARTS AT 0800



2013 AIAA-RM Annual Technical Symposium

	Main Room	Technical A UC 307	Technical B UC 122	Technical C UC 309
0900	**Welcome by Chancellor Pamela S. Shockley-Zalabak & Symposium Introduction**			
0930	A025. Norris. Orion Program EFT-1 Status	A1 A019. Blomquist. Solar Cube Heliogyro Cubesat	B1 A024. Bosworth. Modeling of Non-Equilibrium Hypersonic Flow	C1 A038. Griffitt. Understanding the Flight Test Discipline...
0955	A022. Schiller. Innovation at United Launch Alliance	A2 A012. Joslyn. Droplet Stream Orbital Debris Mitigation	B2 A030. Lofthouse. CFD Characterization of the USAFA Ludwig Tube	C2 A039. VanderWerf. Unmanned Aircraft System (UAS) Missions, Business Value, and National Airspace Integration
1020	**Panel: Job Market / Career Advancement**	A3 A018. Zubrin. Lunar Organic Waste Reformer	B3 A011. Calvisi. CFD Modeling of Multiphase Flows	C3 A037. Perez. The Convergence of Hardware Reliability Analyses and Software Fault Management Design
1045		A4 A014. Pendleton. Creation and Implementation of the Revolutionary ORS-1 Satellite Program	B4 A028. Rouser. Passive Turbulence Generating Grid Configurations in a Turbine Cascade Facility	C4 A020. Shelley. Experimental UAV Design
1110	**Cleanup / Prep**	A5 A002. Moore. Polar Orbiting Passive Atmospheric Calibration Spheres (POPACS)	B5 A031. Lofthouse. Cavity Resonance and Store Force and Moment Loading Using the Kestrel CFD Code	C5 A017. Patterson. Balloon Enabled Atmospheric Convection Obervation Network (BEACON):

The World's Forum for Aerospace Leadership

2013 AIAA-RM Annual Technical Symposium

	Main Room	Technical A UC 307	Technical B UC 122	Technical C UC 309
1135	**The History of Hypersonics by Dr. Richard P. Hallion**			
1235	1235 Remarks by Lt. Gov. Joseph A. Garcia **Lockheed Martin Space Systems Company**			
1325	**Panel: Industry Direction**	A8 A026. Bille. Disaggregation to Dematerialization: Evolving Toward the Second Space Age	B8 A032. Lofthouse. Computational Investigation of Unsteady Aerodynamics …	C8 A004. George. Incorporating Space Sciences Into The General Sciences …
1350		A9 A013. Chappell. Human Exploration of Near Earth Asteroids: Integrated Findings from Analog Testing.	B9 A033. Lofthouse. Stability and Control Predictions of the X-31 and a Generic UCAV Model Using the Kestrel CFD Code	C9 A010. Hecht. Aerospace Engineering in the Classroom: A GNC Engineer Takes on Student Labs
1415	**Cleanup / Prep**	A10 A040. Maldonado. Orbital Drag Measurements in the ChAOSS Facility	B10 A029. Lofthouse. Transonic Aerodynamics and Pitch Stability of Land Speed Record Contenders	C10 A016. Schmidt. Achieving Research Success through High School STEM Collaboration:
1440	**Afternoon Snack**			

2013 AIAA-RM Annual Technical Symposium

	Main Room	Technical A UC 307	Technical B UC 122	Technical C UC 309
1505	**Panel: STEM**	A11 A003. Newcamp. Utilization of Airborne Sound and Light Countermeasures to Reduce Birdstrikes	B11 A021. Graul. Gas Flow Diagnostic and Modification at the CLEER High Energy Laser Lab	C11 A042. Rakow. Vibration-Related Failures of Combustion and Steam Turbines
1530		A12 TBD	B12 A041. Windom. The Role of Low Temperature Fuel Chemistry on Turbulent Flame Propagation	C12 A043. Rudoff. TBD Red Canyon
1555	**Panel: Cross-Sector Collaboration**	A13 A008. Dreyer. CSoM Sr Design Propellent Tank Mass Gauging Test Apparatus Development	B13 A015. Ventura. Negative Thermophoresis in Radiometric Flows	C13 A001. Hecht. Visualizing the Rotation of a Rigid Body
1620		A14 A007. Dreyer. Blasterbotica, the 2012-13 NASA Lunabotics Competition Team from CSoM	B14 A023. Sloan. Microwave Lens	C14 A034. Herron. Re-Use Your CAD! Integrating Space Vehicle 3-D Models with Heritage and Common Parts
1645	**Closing**			
1700	**After Event Sponsored By:**			

Message from the 2013 AIAA-RM ATS Chair

Ladies and Gentlemen,

Reflecting the mandate that professional societies should serve their communities, the AIAA Rocky Mountain Section is proud and very pleased to offer you, our membership, a section-wide event to call your own. The 2013 AIAA-RM Annual Technical Symposium, the second in hopefully a long line, is being hosted to highlight new ideas, methodologies, concepts, and technical innovations home grown here, in the local community. Sharing these concepts at a local level will create new and bolster existing partnerships to promote growth and national competitiveness in the Rocky Mountain Section. The purpose of this event is to establish flagship visibility for the creativity, resourcefulness, and competency of our local personnel, companies, and institutions and to sustain a dialog between these groups for mutual support and progress. Participation and attendance in this event will include neighbors and potential collaborators throughout the area whose proximity and availability make them as-of-yet unrealized solutions to tomorrow's challenges.

I would like to take this opportunity to thank those who have made this event possible, particularly a tireless and talented team of volunteers, to whom I am greatly indebted and without whom this event would not be possible. I would like to thank the Lt. Gov. of Colorado, Joseph Garcia, for participating in this year's event. I would also like to thank our sponsors and affiliated organizations. Please take a moment to check this document for a list of these groups and remember to express your thanks in person in October. Specifically, I would like to recognize Lockheed Martin Space Systems Company and the University of Colorado Colorado Springs. LMSSC has, for the second year, shown its dedication to investing in the community and developing valuable partnerships by substantial sponsorship of this event. Through LMSSC's leadership, the Section, as a whole, has a venue to exchange concepts, promote ideas, and network solutions. Similarly, I would like to thank UCCS for showing its established leadership in growing Colorado's technical expertise by opening its doors to this event and assisting in its planning and execution. The AIAA-RM is happy to recognize UCCS' ongoing role in research, innovation, and education of Aerospace in the state of Colorado.

We look forward to your feedback on the event, its successes, and the areas where it may miss the mark. It is vital to our community, if we are to serve it faithfully, that we close the loop with our constituency and continue to evolve this event into what you need it to be. The Organizing Committee has worked diligently this year to assure relevance and interest in the technical program while maintaining broad applicability and minimal cost to attendees. This year's agenda includes approximately 40 technical presentations from local companies, students, and research groups. In addition to traditional presentations, four panel sessions will be held on career advancement, the direction of the industry, collaboration, and our responsibility to the next generation. The symposium will also include a keynote presentation on the history of Hypersonics, food, snacks, and an after-symposium event sponsored by Bristol Brewery.

This event has been designed to establish local connections and to promote local success. Please help us create an engaging opportunity for every facet of the community, from new professional to seasoned manager, from startups to Fortune 500s, and from educators to executers. I look forward to seeing you all at the 2013 Annual Technical Symposium.

Taylor Lilly, PhD
AIAA-RM Southern Vice Chair

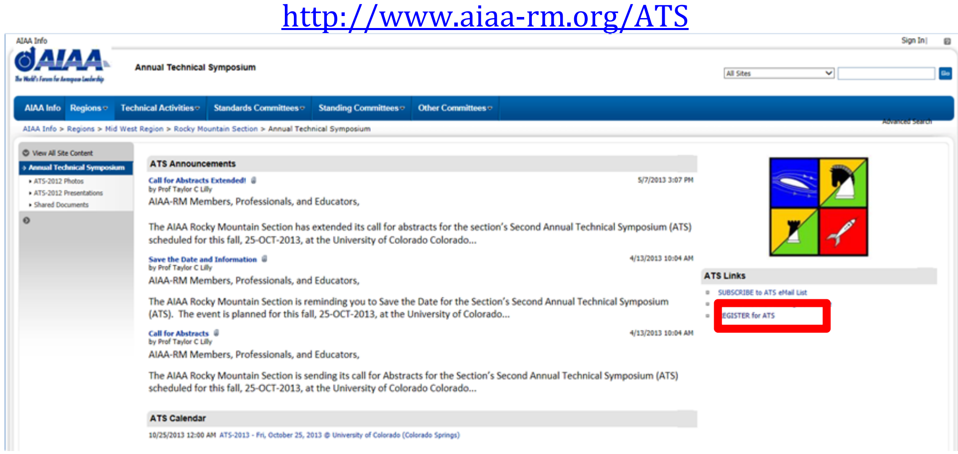
Symposium Abstract

The AIAA Rocky Mountain Section is hosting its 2nd Annual Technical Symposium. Last year's symposium offered presenters and attendees the opportunity to exhibit and discuss "Game Changing Technologies and Strategies." Bolstered by last year's enthusiastic participation, the AIAA-RM 2013 ATS is facilitating presentations and participation from the organizations and individuals who will usher tomorrow's aeronautical and astronautical future into the present. The 2013 ATS seeks to join the wisdom and practical experience of tried and tested professionals with the enthusiasm and promise of newly trained members of the aerospace community. Together, these groups will continue the ATS tradition of "Collaboration to Explore Burgeoning Technology Horizons." This year's symposium will include keynote speeches, panel sessions on important topics to the section, exhibit booths and tables from local companies, and technical presentations on cutting edge technologies. Registration for the symposium will include a light breakfast, lunch, snacks, and an after event social. This extraordinary opportunity for local aerospace and supporting industries is being hosted by the AIAA Rocky Mountain Section, at the University of Colorado Colorado Springs, for a moderate registration fee of $40 for professionals and $25 for students. Please take a few moments to visit the website and read more about this exciting event. http://www.aiaa-rm.org/ATS

Registration

Registration is now open, please follow the website link to register today!

http://www.aiaa-rm.org/ATS



The World's Forum for Aerospace Leadership

Keynote Speaker

Richard P. Hallion

"The History of Hypersonics." The advent of supersonic flight opened the path to the hypersonic frontier, first crossed by rockets and missiles and then by uninhabited and piloted winged vehicles and spacecraft. Dr. Hallion examines how hypersonic flight evolved from a dream of the great pioneers of astronautics to a practical field of technical inquiry. Key programs and technical developments in aerodynamics, structures, propulsion, and controls are examined, together with lessons learned, and an assessment of the current state and future prospects of this exciting field.

Dr. Hallion received a BA in 1970 and a Ph.D in 1975, both from University of Maryland. He also graduated from the National Security Studies Program for Senior Executives, Kennedy School of Government, Harvard University, 1993. He was the Curator of Science and Technology, National Air and Space Museum, 1974-1980; the NASA Contract Historian, and Adjunct Faculty at the University of Maryland, 1980-1982; the Air Force Historian at Edwards AFB, Wright-Patterson AFB, Andrews AFB, and the Pentagon, 1982-2004; the Senior Advisor for Air and Space Issues, Office of the Secretary of the Air Force 2004-2006; the Special Advisor for Aerospace Technology to the Air Force Chief Scientist, 2006-2008; the Senior Advisor, Commonwealth Research Institute/Concurrent Technologies Corporation, 2007-present; the Vice President, Earth Shine Institute, 2009-present; and a Research Associate in Aeronautics, National Air and Space Museum, Smithsonian Institution, 2010-present. Dr. Hallion is the author of: 13 books; 12 monographs and special studies; 31 chapters; numerous articles, essays, and presentations; and the editor of 6 books. He is a Fellow of AIAA, RAes, and the Royal Historical Society; and a member of the Air Force Association; the Association of Naval Aviation; the United States Naval Institute; the International Test and Evaluation Association, the National Defense Industrial Association; the Royal United Services Institute for Defence Studies; the American Aviation Historical Society; and the Society for the History of Technology.

Career Opportunities and HR Representation

As part of the Symposium's sponsorship and exhibit tables, the following Career Opportunities and HR Representation has been confirmed:

Surrey Satellite Technology US LLC

Surrey Satellite Technology US LLC is accepting résumés for positions at our Englewood, Colorado, office. View current vacancies at http://www.sst-us.com/careers/current-vacancies. Interested? Stop by the Surrey US table or email your résumé to jobs@surreysatellite.com.

Panel Sessions

Panel Sessions, Next Page.

Job Market / Career Advancement

This panel aims to discuss the current Rocky Mountain job market and atmosphere for job advancement in the section. This discussion will also include how local university resources prepare the work force, opportunities for ongoing career enhancement such as professional societies, and the tools and techniques pertinent to those looking to start or advance their career. This panel seeks involvement from industry human relations, collegiate student groups, university educators, professional societies, and industry management executives.

	Penny Axelrad, *Professor and Chair of the Department of Aerospace Engineering Sciences, University of Colorado Boulder*
	Jeff Forrest, *Chair of the Department of Aviation and Aerospace Science, Metropolitan State University of Denver*
	Bill Hoffman, *Director – Space and Cyberspace Programs, Webster University*
	Jim Paradise, *Engineering and Science Manager, Engineering Staffing Manager, and Graduate Studies Manager, Lockheed Martin Space Systems Company*
	Al Ronn, *Director, Engineering Center, Ground Systems Business Unit, Northrop Grumman Corporation*
	Mike Shilkitus, *Program Area Manager, Boeing Mission Operations Support Center*

Direction of the Industry

This panel aims to discuss the direction of aerospace and related industries in the Rocky Mountain section. This panel seeks involvement from Air Force users, space asset manufacturers, aircraft companies, aeronautical and space operators, and the smaller firms which supply these groups.

	Joseph A. Garcia, *Lt. Governor, State of Colorado*
	Brig Gen Russ Anarde, USAF (ret), *Corporate Lead Executive for Colorado Springs and Omaha, Northrup Grumman Corporation / Vice President, Rocky Mountain Region, National Defense Industrial Association, Space Division*
	Col Neal Barlow, USAF, *AIAA Director-At Large (previous Vice President for Education) / US Air Force Space Command Chief Scientist (Acting) / Permanent Professor, Department of Aeronautics, USAF Academy (on sabbatical to USAF Space Command for 2013-14)*
	Edgar Johansson, *President, Colorado Space Business Roundtable*
	Sean McClung, *Executive Director for Space Innovation and Director of Colorado Operations at MEI / Co-Chair of the Defense Development Advisory Council and Aerospace Defense Team at the Colorado Springs Regional Business Alliance / member of the Executive Leadership Council of the UCCS College of Engineering*
	Elliot Pulham, *Chief Executive Officer, Space Foundation*

Cross Sector Collaboration

This panel aims to discuss opportunities for collaboration between large and small private-industry firms, government public sector users and buyers, university and private research firms, and legislative entities in the current Rocky Mountain section. This panel seeks involvement from university researchers, small and large industry executives, Air Force users, and regulatory and legislative bodies.

	Kathy Boe, *Founder and Chief Executive Officer, Boecore, Inc.*
	Col Martin France, USAF, *Permanent Professor and Head, Department of Astronautics, USAF Academy*
	Prof. Andrew Ketsdever, *Chair of the Department of Mechanical and Aerospace Engineering, University of Colorado Colorado Springs / former Group Leader for Advanced Concepts, AFRL Propulsion Directorate*
	Monisha Merchant, *Senior Advisor for Business Affairs for U.S. Senator Michael Bennet*
	Andy Merritt, *Chief Defense Industry Officer, Colorado Springs Regional Business Alliance*
	Joe Rice, *Director of Government Relations, Lockheed Martin Space Systems Company*

STEM Education & Outreach

This panel aims to discuss opportunities available to the professional community for promoting interest, education, and involvement in fields necessary to a long lasting, sustainable, and competitive future for the industry. This panel seeks involvement from K12 through post-secondary educators, education professionals (district, government, legislative), and industry outreach and philanthropic contacts.

	James Adams, *Chief Technology Officer, TAEUS International Corporation*
	Lt Col David J. Barnhart, USAF, *Director, AIAA Region V STEM Program / Assistant Professor and Director, Space Systems Research Center, Department of Astronautics, USAF Academy*
	Dave Khaliqi, *Executive Director, Center for STEM Education and PIPES, University of Colorado Colorado Springs*
	Bill Klaers, *President, National Museum of World War II Aviation / President, WestPac Restoration*
	Iain Probert, *Vice President – Education and Discovery, Space Foundation*

The World's Forum for Aerospace Leadership

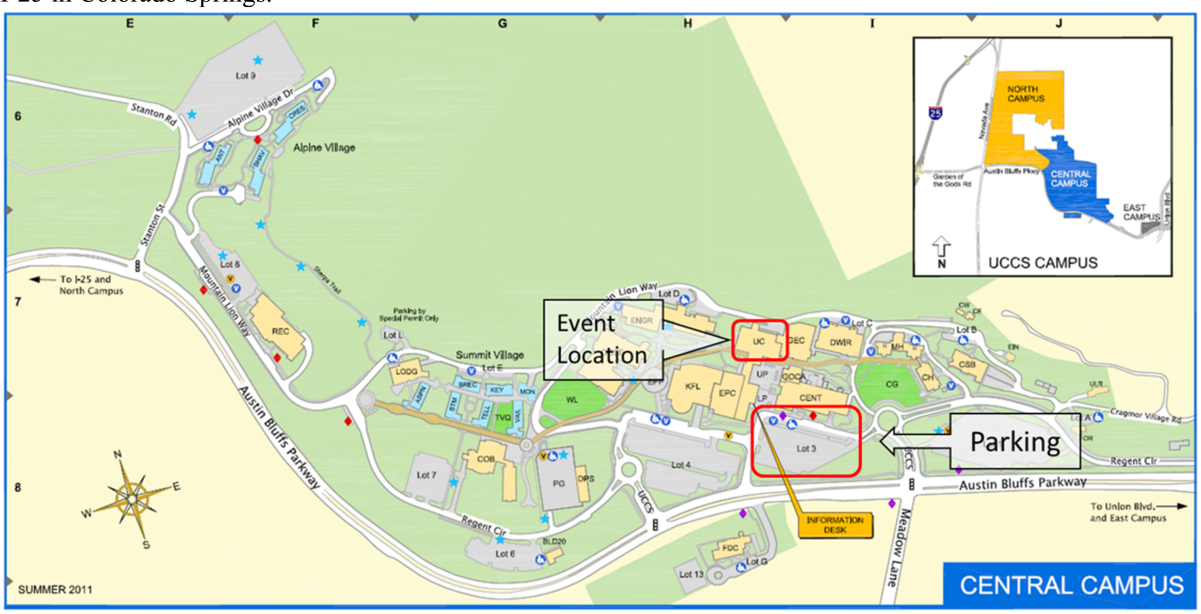
After Symposium Event

Wait out the traffic and relax at the symposium's on-site after-event sponsored by **Bristol Brewery!**

Red Rocket Pale Ale complimentary to attendees w/ cash bar for further refreshment.

Symposium Logistics

This year's symposium will be hosted on the University of Colorado Colorado Springs campus, 2 minutes from I-25 in Colorado Springs.



UCCS Conference Services
UNIVERSITY OF COLORADO **COLORADO SPRINGS**

UCCS Visitor Event Parking in Lot 3 &4

Conference Services Office University Center

Directions from I-25 Southbound

- Take I-25 Southbound to the exit marked "Corporate Center Drive/North Nevada/ Rockrimmon," exit 148 (first exit after Woodman Road).
- After exiting, take the first left (marked 148A) to access North Nevada Avenue.
- Continue on North Nevada and turn left (east) at the Austin Bluffs Parkway/Garden of the Gods intersection (first stoplight).
- Turn left into UCCS at the third stoplight (Meadow Lane).
- Follow roundabout around on Meadow Lane. (Take second spoke of the roundabout into Lot 3)
- You may park anywhere in Lot 3 or 4 - THERE IS NO TICKETING.

– OR –

Directions from I-25 Northbound

- Take I-25 Northbound to the "Garden of the
- Gods Exit," exit 146.
- Keep right to merge right (east) onto Garden of
- the Gods Road. Garden of the Gods Road will
- become Austin Bluffs Parkway at North Nevada
- Avenue.
- Turn left into UCCS at the third stoplight (Meadow Lane).
- Follow roundabout around on Meadow Lane. (Take second spoke of the roundabout into Lot 3)
- You may park anywhere in Lot 3 or 4 - THERE IS NO TICKETING.

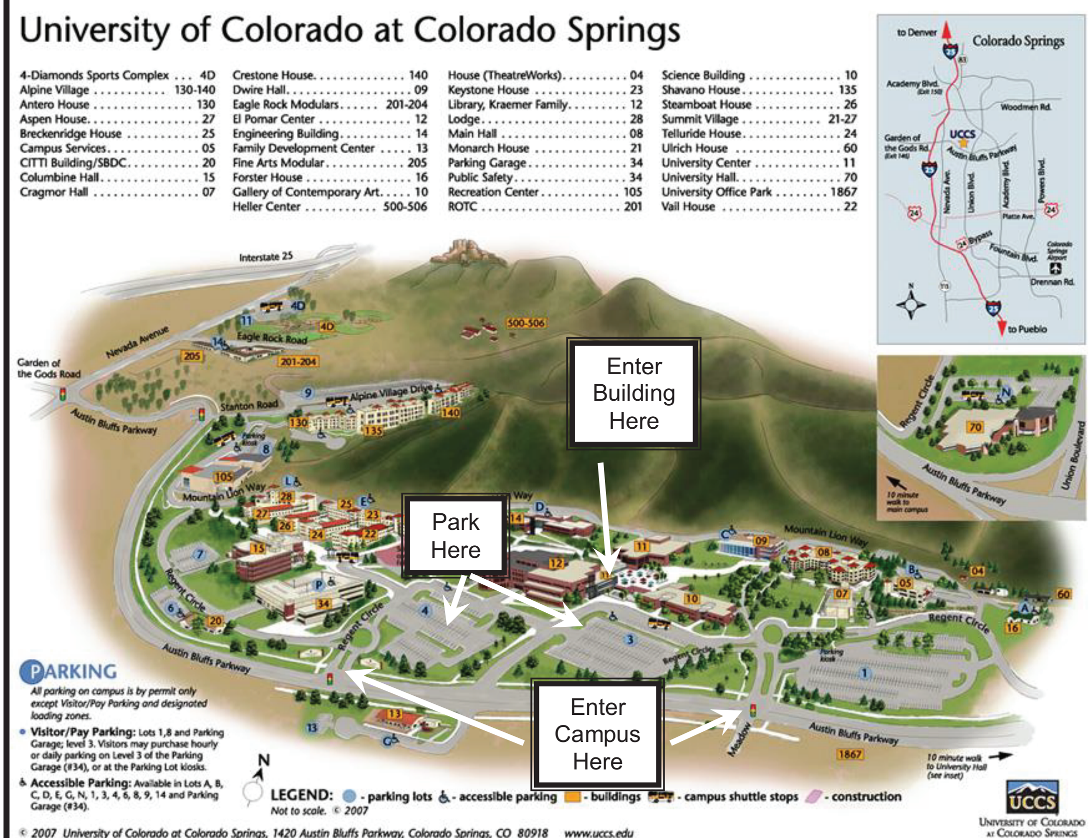
Instructions to Meeting Location:

- Proceed to the University Center (#11 on map)
- University Center is west of Centennial Hall/Science Building (#10 on map)
- Enter through the main double doors of the University Center (left of the mountain lion statue)
- After entering in the building go to the second floor, walk past the Jazzman's Coffee Shop through the glass breezeway to Berger Hall.

If you should need help, please contact Conference Services at 719-255-4445.

Exiting the Campus:

- Enter the roundabout and circle around to the exit on Regent Circle for both east and westbound travel on Austin Bluffs Parkway.


University of Colorado at Colorado Springs
4-Diamonds Sports Complex ... 4D
Alpine Village ... 130-140
Antero House ... 130
Aspen House ... 27
Breckenridge House ... 25
Campus Services ... 05
CITTI Building/SBDC ... 20
Columbine Hall ... 15
Cragmor Hall ... 07
Crestone House ... 140
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Eagle Rock Modulars ... 201-204
El Pomar Center ... 12
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ROTC ... 201
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Shavano House ... 135
Steamboat House ... 26
Summit Village ... 21-27
Telluride House ... 24
Ulrich House ... 60
University Center ... 11
University Hall ... 70
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Vail House ... 22
Colorado Springs
to Denver
to Pueblo
Interstate 25
Nevada Avenue
Garden of the Gods Road
Austin Bluffs Parkway
Eagle Rock Road
Stanton Road
Alpine Village Drive
Mountain Lion Way
Regent Circle
Meadow
Enter Building Here
Park Here
Enter Campus Here
PARKING
All parking on campus is by permit only except Visitor/Pay Parking and designated loading zones.
Visitor/Pay Parking: Lots 1,8 and Parking Garage; level 3. Visitors may purchase hourly or daily parking on Level 3 of the Parking Garage (#34), or at the Parking Lot kiosks.
Accessible Parking: Available in Lots A, B, C, D, E, G, N, 1, 3, 4, 6, 8, 9, 14 and Parking Garage (#34).
N
LEGEND: - parking lots - accessible parking - buildings - campus shuttle stops - construction
Not to scale. © 2007
10 minute walk to University Hall (see inset)
10 minute walk to main campus
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Technical Abstracts: Part 1

A001: Visualizing the Rotation of a Rigid Body

Norm Hecht (Colorado School of Mines)

nhecht@mines.edu

The torque-free rotation of a rigid body has long been a topic of interest to physicists, mathematicians and engineers, including Euler in the 18th century, and continuing to the present day. Numerical solutions to Euler's equations are easy to achieve in an era of cheap computation, but classic solutions to the problem have used principles of angular momentum and energy to develop geometric insights to the problem, with the Binet ellipsoid and the Poinsot construction being of particular interest. Static diagrams can help display these insights, but modern computer graphics hardware and software can truly bring these solutions to life via user-controlled animation. I hope you will find this combination of physics, mathematics, and computer graphics an engaging way of approaching this classic problem.

A002: Polar Orbiting Passive Atmospheric Calibration Spheres (POPACS)

Gil Moore (Director, Project POPACS)

GilMoore12@aol.com

Three polished 10-cm-diameter hollow Aluminum spheres were launched from Vandenberg Air Force Base, CA into initial 318 km x 1488 km orbits, inclined 80 degrees to the earth's equator, by a SpaceX Falcon 9v1.1 ELV on September 29, 2013. The spheres weigh 1kg, 1.5kg and 2kg, respectively. They are predicted to remain in orbit for 10, 12.5 and 15 years, during which their elliptical orbits will gradually decay, due to aerodynamic drag at perigee, following which they will be consumed by aerodynamic heating, with the lighter sphere de-orbiting first. They are being radar tracked by the Air Force Space Command and optically tracked by an international network of university student observers equipped with small "Go To" telescopes. Professional and student analysts are calculating the spheres' rates of orbital decay, from which they will be able to measure variations in the global density of Earth's upper atmosphere in the altitude interval between 318 km and 500 km, starting near the second peak of Solar Cycle 24 and extending throughout all of Solar Cycle 25. The U.S. Naval Research Laboratory and the U.S. Air Force Space Command will use the results of this project to refine their models of variations that occur in upper atmospheric density in response to various types of solar eruptions and thus improve the accuracy of orbital debris collision avoidance warnings.

A003: Utilization of Airborne Sound and Light Countermeasures to Reduce Birdstrikes

Jeffrey Newcamp () ; Cadet Carson Fugal () ; Cadet Michael Foley ()

jeffrey.newcamp@usafa.edu

The Air Force Academy Airborne BirdStrike Countermeasure team conducted an experiment to understand the possible utility of employing airborne countermeasures to prevent bird strikes. This presentation describes a cadet-run test program to that end. U.S. Airways Flight 1549, which was struck by a flock of Canada geese (Branta Canadensis) in 2009, resulting in a water landing on the Hudson River in New York, was taken as a baseline event with a negative outcome. Position data were taken from that accident to model the audio and visual stimuli incident on the geese to design an experimental countermeasure for bird strike reduction. This effort added modeling of the visual environment and a ground test of a system capable of approximately mimicking the history of the engine noise and visual irradiance of the Airbus 320 involved in the accident. During testing, the response times of geese movement were recorded for the baseline Airbus stimuli and a combination of specific acoustic and visual countermeasures. The acoustic countermeasure was the addition of a proprietary Canada goose distress call. The second variable was flashing the simulated Airbus landing lights at 0.75 Hz. The testing was conducted using a ground-based system on Canada goose populations on fields at and near the Air Force Academy. The experiment is awaiting further data collection, but the project's current status will be briefed, to include a human factors test and a wind tunnel analysis of the speaker used for the testing.

A004: Incorporating Space Sciences Into The General Sciences Curriculum At Colorado Technical University

Lynnane George (Colorado Technical University) ; Jennifer Daines (Colorado Technical University)

lynnanegt@yahoo.com

This presentation will provide information about a new course at Colorado Technical University (CTU) in Colorado Springs - Science 101, "Introduction to the Sciences." The focus of the class is to gain an appreciation for the many dynamic disciplines involved in science and technology. It endeavors to produce greater insight about the ways science shapes the world in which we live. Although not normally thought of as one of the "core" sciences, space sciences affect every aspect of the world we live in today and is truly cross-disciplinary. The basics of orbital motion are described by Newton's and Kepler's laws (physics) while observatories provide key evidence to help us understand the origins of the universe and life (chemistry and biology). Orbiting satellites provide critical communication (electricity and magnetism) as well as information about everything from weather to geographic information (earth sciences). This presentation will explain how space sciences were incorporated into Science 101. It also will include more detailed information on two lessons devoted entirely to space sciences as well as describe an exercise in which the students individually explore the heavens and our current satellite database. The presentation will conclude with lessons learned from Winter and Spring 2013 and future plans for the course.

A007: Blasterbotica, the NASA Robotic Mining Competition Team from the Colorado School of Mines

Dr. Christopher Dreyer (Colorado School of Mines, Golden, CO)

cdreyer@mines.edu

The Colorado School of Mines has participated in the NASA Robotic Mining Competition (formerly NASA Lunabotics) since the inception in 2010. Blasterbotica is a Senior Design group composed of students in the College of Engineering and Computational Sciences. The 5th Annual NASA Robotic Mining Competition is a competition requiring participating teams to design and fabricate a robot capable of excavating and transporting regolith simulant (BP-1) within a small arena. The competition is held annually in May at the Kennedy Space Center in Cape Canaveral, Florida. The robot must navigate a field of obstacles, excavate in the designated area, bring the regolith back to the starting location, and deposit it in a collection bin. To qualify for the competition, the robot must mine at least 10 kg of BP-1 in 10 minutes, as well as meet a mass and volume constraint. Points are awarded based on mass of BP-1 collected, robot weight, autonomy, dust mitigation, bandwidth, and power consumption. Teams are free to pursue whatever designs they want so long as the concept is viable for the moon and mars (i.e. no vacuums or fluids). Team Blasterbotica’s design consists of four individually controlled wheels for locomotion, a bucket ladder digging system for excavation, an onboard hopper to store and transport the regolith, and finally a conveyor belt built into the hopper capable of depositing BP-1 into the collection bin. The robot’s autonomous system is built around a Microsoft Xbox Kinect to detect obstacles and a LIDAR system for positioning the robot within the arena. The robot is controlled by a laptop and Arduino microcontrollers. Results of Blasterbotica at the 4th annual Lunabotics competition held in May 2013 will be presented. Lessons learned in building and competing in a space exploration robotics competition and Blasterbotica's plans for the 5th annual competition will also be presented.

A008: Colorado School of Mines Senior Design Propellant Tank Mass Gauging Test Apparatus Development

Theodore Agerton, Martin Cowell, Peter Furness, Margaret Hunt, Nadine Janecek, Tyler King, Sarah Spangler, Dr. Christopher B. Dreyer (Colorado School of Mines, Golden CO 80401) ; Dr. Daniel Ladner, Daniel Scheld (N-Science, Golden CO, 80401)

cdreyer@mines.edu

A Senior Design group composed of students in the College of Engineering and Computational Sciences at the Colorado School of Mines will describe the development of a student-led project to develop a test apparatus for micro-gravity aircraft flight. The project was sponsored by N-Science Corp., a small local aerospace company. The motivation behind the project is to characterize the fluid mass and distribution within a spherical tank through modal analysis and the resonant frequency of the tank. Accurate mass gauging technology will be beneficial to refueling depots that are needed for deep space travel. Our system will enable the accurate measurement of residual fluid in orbital fuel tanks instead of the more complex and less accurate methods used today. The method should be accurate for different levels of gravity and fill volumes, and independent of fluid type. We have also experimented to find the lowest acceptable excitation amplitude required to produce a measurable, consistent output signal. The end goal of this project is to run our experiment in a zero gravity environment. The CSM student team has designed an apparatus consisting of an outer frame containing a spherical tank, plunger system, and required instrumentation. The spherical tank is excited using a voice coil linear actuator and excitation is monitored by strain gauges and accelerometers. The resonant frequency found using this method is used to determine the mass of the fluid in the tank. The plunger system consists of an 8-inch diameter pipe filled with water. The system incrementally transfers water into the spherical tank using a DC servo motor. This allows for an accurate volume of water to be transferred into the tank during experimentation. The experiment is controlled using a LabVIEW program.

A010: Aerospace Engineering in the Classroom: A GNC Engineer Takes on Student Labs

Norm Hecht (Colorado School of Mines & Front Range Community College)

nhecht@mines.edu

Understanding and using uncertain measurements is a necessity in spacecraft guidance and control problems, and developing students' knowledge of these ideas can begin early in the undergraduate curriculum. Instructors are usually dealing with low-budget, sometimes poorly documented sensors and laboratory equipment, and bright, but inexperienced personnel (their students). Examples from student labs at the Colorado School of Mines and Front Range Community College show how instructors can successfully characterize the uncertainty in laboratory sensors, and integrate concepts of determining uncertainties and using uncertain data into student experiments.

A011: CFD Modeling of Multiphase Flows

Michael Calvisi ()

mcalvisi@uccs.edu

In this talk, research being conducted in computational fluid dynamics (CFD) at the University of Colorado, Colorado Springs will be presented with an emphasis on modeling multiphase and interfacial flows. General CFD methods will be discussed that are potentially applicable to a wide array of fluids problems in aerospace engineering. For example, the Boundary Element Method (BEM) is an efficient numerical technique for tracking moving interfaces and is widely used in modeling cavitation. The BEM will be presented and illustrative examples provided. In addition, recent results of computational modeling of acoustically-driven cavitation in ionic liquids will be discussed. The influence of various parameters such as acoustic frequency, amplitude, and fluid properties on cavitation intensity is analyzed through computational models that yield insight into the mechanisms that maximize the temperatures achieved through bubble collapse.

AIAA Professional Membership

The World's Forum for Aerospace Leadership

AIAA Student Membership

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Technical Abstracts: Part 2

A012: Droplet Stream Orbital Debris Remediation

Thomas Joslyn (U.S. Air Force Academy) ; David H. Besson (USAF) ; Johnathan R. Weed (USAF)

Thomas.Joslyn@usafa.edu

The population of hazardous objects in low earth orbit is expected to increase significantly in the coming decades if active debris removal is not undertaken. A method to shorten space debris orbital life is presented. The method calls for satellites capable of generating liquid droplet streams, which can be accurately projected into the path of on-coming objects. When droplets impact objects with high relative velocity, the target's orbital velocity will decrease. The momentum transfer will lower the object's perigee altitude and hasten atmospheric reentry. The method can also be used to alter the trajectories of hazardous objects, protecting operational spacecraft. Challenges to projecting droplet streams accurately include knowledge of targeted object position, atmospheric drag, solar radiation pressure, spacecraft attitude knowledge, and machining limitations. Additionally, knowledge of droplet charging is needed to predict the effects of Lorentz forces during droplet transit. Methods of refining drag and charging models through in-space experiments are described. A demonstration spacecraft capable of in-space experiments and demonstration intercepts is proposed.

A013: Human Exploration of Near-Earth Asteroids: Integrated Findings from Analog Testing

Steven Chappell (Wyle Science, Technology, & Engineering, Houston, TX) ; Andrew F. Abercromby (Wyle Science, Technology, & Engineering, Houston, TX) ; Michael L. Gernhardt (NASA Johnson Space Center, Houston, TX)

steven.p.chappell@nasa.gov

The 2011-2012 NASA analog testing seasons were focused on evaluation of systems and techniques for human exploration of near-Earth asteroids (NEAs). NASA's Research and Technology Studies (RATS) is a land-based spaceflight analog project that provides a 1-g high-fidelity hardware and simulation environment. The NASA Extreme Environment Mission Operations (NEEMO) project is an underwater spaceflight analog that allows a true mission-like operational environment and uses buoyancy effects and added weight to simulate different gravity levels. Complementary and cross-over studies were designed to take advantage of each analog's strengths and provide results that could be used to guide exploration architectures, mission design, and technology development for human NEA exploration missions. NEEMO deployed an exploration circuit on the sea floor outside the Aquarius habitat for the crew to evaluate different methods of translation, body stabilization, geologic sampling, and instrument deployment on an NEA surface in simulated microgravity. During RATS testing, crewmembers lived in and used prototypes of the Multi-Mission Space Exploration Vehicle (MMSEV) cabin that were combined with an immersive simulation environment using projection and computer screens placed just outside the cabin windows. Simulated virtual-reality EVA and field-based testing for geologic science were also performed. All tests in both analog environments were performed with representative Earth-NEA communication latencies and protocols. A major finding was that the only totally acceptable method for performing all NEA EVA exploration tasks was from a foot restraint on an MMSEV. Consensus ratings from separate teams of crewmembers (including astronauts and experienced test subjects), flight controllers, and scientists rated the MMSEV as "significantly enhancing" or "enabling" for all of the simulated NEA human exploration operations. With an Earth-NEA communication latency of 50 seconds each way, effective nominal operations were acceptable, but improvements in software, procedures, and likely in hardware design will be required to better accommodate contingency operations.

A014: Creation and Implementation of the Revolutionary ORS-1 Satellite Program

Dane Skousen (1st Space Operations Squadron, Operations Flight Commander) ; Ryan Pendleton (Missile Defense Agency)

dane.skousen@us.af.mil

Operationally Responsive Space Satellite 1 (ORS-1) represents a highly innovative approach to developing, fielding, and operating space-based imaging systems. It began as a rapid developmental effort to meet a Central Command urgent operational need for an intelligence, surveillance, and reconnaissance (ISR) system capable of direct tasking by warfighters. Since launch in June 2011 ORS-1 has been providing significant military surveillance capability achieved via this small satellite system designed as an extension of the airborne ISR model with a tactically-focused architecture traditionally used for UAVs and manned ISR aircraft. This paper covers the initial systems design, the innovative differences from previous space-based ISR systems, program updates, and current performance results after more than two years on orbit.

A015: Negative Thermophoresis in Radiometric Flows

Austin Ventura (Austin Ventura) ; Andrew Ketsdever (Austin Ventura) ; Natalia Gimelshein (Gimel, Inc) ; Sergey Gimelshein (University of Colorado Colorado Springs)

aventura@uccs.edu

Thermophoresis is a rarefied gas phenomenon characterized by the migration of particles in a fluid with a macro level temperature gradient. This particle migration occurs in the direction of the heat flow. Accordingly, an object immersed in a gas with a macro scale temperature gradient experiences a force acting from hot to cold. Applications for this thermophoretic force include commercial precipitators, micro contamination control, particle extraction from a flow for sampling, and particle manipulation in vapor deposition processes. Thermophoretic force on a sphere is experimentally measured across a range of Knudsen numbers with a rotational thrust stand. Argon is used as the carrier gas for the experiment. Results indicate that the highest force experienced by the sphere occurs at a Knudsen number of 0.3 based on the sphere diameter.

A016: Achieving Research Success through High School STEM Collaboration: South Jeffco Robotics and EDGE Research Laboratory Collaboration

William Schmidt ()

wschmidt@jeffco.k12.co.us

The need for integration of practical curricular and extra-curricular projects into STEM education has been clearly demonstrated: successful projects improve students' understanding of the scientific method, value of science, and self-confidence to apply technology appropriately (Snyder, et al., 2010). Recent collaboration between EDGE Research Laboratory and South Jeffco Robotics (SJR) demonstrates what is possible when an organization recognizes this need and responds with real-world engineering challenges. The SJR team exists to compete in the yearly FIRST Robotics Competition, and includes representatives from 5 area high schools. The experience that FIRST gives SJR students includes discovering and working with mentors with engineering backgrounds, scheduling, and group cooperation, in addition to the engineering practice in mechanical, hardware, and software engineering. The FIRST competitions and the EDGE Engineering Project give students experience in building life skills and provide the opportunity to make connections with professionals across many different backgrounds. EDGE assigned SJR a project to design an experiment enclosure to protect high-altitude communications equipment. After descending from 90-120 thousand feet up and landing, the entirely student designed and built system uprights itself and deploys an antenna that is 12-18 inches long, enabling better communications with the payload after landing. SJR students that are working on the EDGE project are positively influenced in many ways. When asked to define why he enjoyed working on the FIRST robots and the EDGE project, student Nate Watts said, "It's as close to 'real-world engineering' as a student can get." While there are challenges associated with engaging the educational system to provide solutions to real-world problems, the potential of mutual benefit to students and engineering organizations clearly justifies the effort.

A017: Balloon Enabled Atmospheric Convection Observation Network (BEACON): Improving the Resolution of Electrodynamic Models of Convective Weather Systems

David Patterson, Emily Allen, Jeremy Allen, Jeff Anderton, Luke Christian, Trevor Henderson, David Hughes, Shawn Koehler, Zach Palmer, Theresa Patterson, John Patty, Matt Rasband, Mason Winsauer (EDGE Research Laboratory)

david.patterson@edgeresearchlab.com

To date, the maximum number of vertical electrical profiles in a single thunderstorm is 8, achieved in 2003-2004 by Dr. MacGorman and Dr. Rust in the TELEX project, limiting the resolution of the electrical model of convective weather systems. Further complicating elements – including theories that lightning is triggered by ionizing radiation, a relative lack of understanding of vertical lightning phenomena, and the recently discovered "Dark Lightning" phenomena – make the need for high-resolution characterization of thunderstorms' electrical structure clear. In order to address this lack of resolution, many more simultaneous, synchronized vertical profiles must be collected, which is the goal of the Balloon Enabled Atmospheric Convection Observation Network (BEACON) program. In order to achieve the goal of a much higher sensor density in a convective weather system, the e-field detection equipment must be miniaturized dramatically, and paired with other detection technologies to accurately capture the e-field vector structure inside the thunderstorm. By combining the latest in COTS MEMS technology with new e-field detection approaches, the systems deployed in the BEACON sensor swarm are substantially lighter and more cost-effective than traditional balloon-borne e-field detection systems, enabling the use of smaller balloons and less lift gas per probe. Additionally, by simplifying the launch process and developing a well-defined CONOPS, a dense sensor swarm can be launched, managed, tracked and recovered by a relatively small team of volunteers. Moving forward, the BEACON system will provide an increasingly high-resolution view into the dynamics of convective weather. Additionally, the infrastructure and techniques developed to achieve initial success can be leveraged to other areas of interest both within the context of atmospheric convective systems (dark lightning, vertical lightning phenomenon, and correlation of lightning with ionizing radiation) and without (pollutant tracking, communications networks, and even art projects), further enabling and utilizing the cross-disciplinary approach to innovation that has produced the success of the effort to date.

A018: Lunar Organic Waste Reformer

Robert Zubrin (Pioneer Astronautics) ; Stacy Carrera (Pioneer Astronautics) ; Mark Berggren (Pioneer Astronautics) ; Peter Jonscher (Pioneer Astronautics)

mberggren@pioneerastro.com

The Lunar Organic Waste Reformer (LOWR) uses oxygenated steam to reform organic wastes from space exploration outposts into valuable methane and oxygen products. Predominately organic wastes consisting of food waste and packaging, urine brine, fecal matter, paper, wipes and towels, gloves, and maximum absorbency garments are fed to the waste reformer following minimal preparation. At temperatures above 700°C, the waste materials are converted to a gaseous mixture of hydrogen, carbon dioxide, carbon monoxide, and methane. Excess steam is used to push the reforming reaction to completion and to control the reforming temperature. After condensing water from the reformer exhaust, additional hydrogen is added prior to a catalytic methanation step performed via the Sabatier reaction. The methanation reaction converts virtually all of the carbon evolved from the waste material into methane while producing additional water. An electrolysis system converts water into hydrogen for the methanation reaction while co-producing oxygen. The LOWR is very energy efficient due to direct, non-electrolytic production of a significant portion of the required hydrogen in the reformer. In addition, integrated heat exchange in the reforming and Sabatier systems recover substantial amounts of process thermal energy. The LOWR is adaptable to microgravity environments, allowing its implementation for long-duration human spaceflight and orbiting outposts. Pioneer Astronautics has demonstrated the technology in an integrated prototype system operating at rates comparable to full-scale requirements.

A019: Solar Cube Heliogyro CubeSat

Richard Blomquist ()

rblomquist6@gmail.com

The Solar Cube heliogyro solar sail is a Cubesat that utilizes reflected solar pressure as its only means of propulsion and attitude control. Its 6 solar reflecting blades, each 200 m long and 20 cm wide, are constructed from ultrathin, highly reflective film and attach to a central spacecraft bus. Deployment is reliable and simple: the heliogyro core spins up and each blade slowly feeds out from its spool. Once deployed, Solar Cube employs sail control akin to a helicopter, using a collection of collective and cyclic blade pitch to steer the spacecraft. The continuous force generated by photons striking the windmill-like sail is sufficient to boost the craft out of Earth's gravity well, and, eventually, out of the solar system. With a 1000:1 aspect ratio, the blades on Solar Cube can scale up to provide the propulsion necessary for even the most aggressive solar sail missions on NASA's Technology Roadmap. Solar Cube also benefits the nascent open source space community, but in unique ways. The heliogyro will allow a CubeSat the same access to a large segment of space as a larger spacecraft. At the same time, it will dramatically reduce the cost of missions that otherwise would require a booster. The heliogyro also enables nanosatellites with ambitious delta V requirements to ride on launch vehicles that prohibit secondary payloads from carrying propellant. The successful deployment of Solar Cube will help open up solar system exploration to the masses.

A020: Experimental UAV Design

Brenda Shelley ()

bshelley@mymail.mines.edu

Unmanned Aerial Vehicles, or UAVs, are playing an increasing role in many fields. UAVs are already widely used for simple applications, but there are several other applications in which UAVs could emerge as a viable option. These applications include disaster monitoring, fire-fighting, search-and-rescue, homeland security, and entertainment. A lab-scale UAV which is suitable for novel scientific research, development, and experimentation purposes was designed and built. The UAV has swarm control capabilities as well as the ability to perform autonomous functions. Through an enormous amount of research, a design was implemented to make the UAV rugged and efficient. The UAV maintains the capacity to carry a heavy sensor payload. Sensors are attached and used to notify the system of its surrounding environment. Based on the sensor inputs, the UAV then makes decisions and performs various tasks. This design aims to show that a simple UAV is still capable of performing extremely complex tasks.

A021: Gas Flow Diagnostic and Modification at the CLEER High Energy Laser Lab

Jacob Graul (University of Colorado Colorado Springs) ; Taylor Lilly (University of Colorado Colorado Springs)

jsgraul@gmail.com

The Center for Laser Energy and Exploration Research's (CLEER) High Energy Laser Laboratory fulfills a unique interdisciplinary role the University of Colorado Colorado Springs; melding its expertise in laser physics and laser-gas interaction with applications of interest to the aerospace and related industries. The lab specializes in applying the distinctive properties of laser light to gain insight into the wide variety of laser-gas interaction, rarified gas dynamic and molecular absorption and manipulation experiments. These experiments will undoubtedly aid the future demands and technologies of the aerospace industry. From tunable diode laser absorption spectroscopy and optical scattering studies, to laser gas breakdown and heating experiments, the lab is equipped with several different types of lasers representing a diversity of powers and spectrums as well as the associated optical equipment required to analyze the performance and experimental impact of these lasers. Recently, the lab has conducted large-scale experimentation using high energy pulsed lasers to non-resonantly heat gases by directly modifying the gas on the kinetic level. This research stands as the first experimental report of its kind on the ability of such lasers to heat a gas in this manner; with the goal of advancing this technology to the point, where by arbitrary gases can be heated to a desired temperature, as high as 2000 K. Although this heating research is still ongoing, the lab is also focusing its efforts on time-resolved laser-based gas diagnostics; able to detect small changes in a gas's thermodynamic state over very small spatial and temporal scales. These examples of the laser gas interaction research conducted within the High Energy Laser Lab stand as just small sample of the high quality research taking place at UCCS's Center for Laser Energy and Exploration Research.

A022: Innovation at United Launch Alliance

Gregory J. Schiller (United Launch Alliance)

gregory.j.schiller@ulalaunch.com

Innovation can take many forms, from the way a company is organized, people that comprise the organization, processes that support business and product execution, and products that define the enterprise. United Launch Alliance origins stem from Lockheed Martin and Boeing when they revolutionized global space access with the introduction of their respective Atlas V and Delta IV rockets in the formulation of the Evolved Expendable Launch Vehicle Program. The long history of innovation that resulted in these vehicles continues today at ULA, ensuring that the Atlas and Delta families will continue to provide reliable, cost-effective space transportation for decades to come. ULA overcame a variety of challenges during the process of combining people, processes, and products from two disparate and competing companies into the world-class, "one-team", multiple product lines company that exists today. Innovation was required throughout while still leveraging 100 years of combined expertise between the two original teams. Organizational structure and extensive cross fertilization of employees evolved to fine-tune the one-team construct. Processes, analyses, and tools were evaluated, tested, and updated to ensure the final suite comprised the best-of-the-best. Continuous improvement labeled "Perfect Product Delivery" highlights ULA's focus on increasing efficiency throughout the enterprise through constant innovation. Finally, ULA continues to invest in product line innovation to provide increased performance, additional capability and flexibility, and open up new and exciting markets.

A023: Microwave Lens

Stephen Sloan ()

stephensloan25@gmail.com

Beamed energy propulsion methods are being investigated within the space industry for their potential to decrease fuel mass storage and usage and increase specific impulse values without the significant addition of equipment to microsatellites. One of the main concerns with this propulsion method is the efficiency at which energy can be beamed to the vehicle before utilization. It has been previously discovered that electromagnetic waves refract at a higher phase velocity when propagating between two conductive plates more than half a wavelength apart. Using this optical property for microwaves resonating from a 2.45 GHz Magnetron, a line-focus metal lens was designed and fabricated to collimate beamed microwaves from a predetermined focal point. The lens was tested within an anechoic chamber using the necessary measurement instrumentation to quantify improvements in the power successfully transferred over varying distances. Data shows an average increase in microwave beam preservation of about 66% along the center of the beam up to 1.25 meters of propagation, showing the successful focusing action of the microwave metal lens created. This method of microwave beam preservation is expected to increase the feasibility of beamed energy propulsion once microwave lens optimization is conducted.

A024: Modeling of Non-Equilibrium Hypersonic Flow

Ryan Bosworth ()

boz.wayne@gmail.com

In the modeling of non-equilibrium, hypersonic flow, great deals of different solution techniques are available. The aim of this work is to analyze and classify many of these techniques in terms of both their accuracy and required computational time. The accuracy of each method will be judged against a Direct Simulation Monte Carlo (DSMC) solution method which is known to be highly accurate but time intensive. Once differences in the solution methods are identified they will be assigned error values to coincide with the difference in results from the DSMC method. Finally, a 'best' solution method will be defined for each of a number of scenarios. This will be based on the fact that different methods will be better suited than others to accurately and expediently handle certain modeling situations.

A025: Orion Program EFT-1 Status

Scott Norris (Lockheed Martin Space Systems Company Orion Program) ; Lisa Holowinski (Lockheed Martin Space Systems Company Orion Program)

scott.d.norris@lmco.com

The Orion program, originally known as the Crew Exploration Vehicle (CEV) project, was awarded to Lockheed Martin in September 2006 for the Design, Development, Test and Evaluation (DDT&E) and production phases. The 2011 President's Budget Request, released in February 2010, called for the cancellation of the Constellation Program, including Orion, however, Orion was ultimately reformed as the Multi-Purpose Crew Vehicle (MPCV) program and, although the fundamental design requirements of the vehicle have remained stable since the reformulation, the vehicle's mission has significantly changed from ISS crew servicing to beyond earth orbit (BEO) exploration. Since the reestablishment of Orion as the BEO MPCV the design requirements have stabilized and the program will now focus more on test and evaluation. Following the reformulation of Orion MPCV in 2011 Lockheed Martin's contract was modified to focus on an Orion exploration flight test one, called EFT-1 to validate subsystems on Orion required for a high speed re-entry similar to a BEO return. This mission will be followed by an un-crewed Exploration Flight Test (EM-1) and then a crewed Exploration Flight Test (EM-2).This paper will describe the most recent progress of the Orion Project, current architecture and design concept, Orion flight test program, schedule overview, and will include discussion on how the recent architecture initiatives introduced by the administration will affect the Orion project.

A026: Disaggregation to Dematerialization: Evolving Toward the Second Space Age

Matt Bille, Bill Hojnowski, Tom Hunsaker, Paul Kolodziejski, Ray Schmotzer, Julia Vollmers (Booz Allen Hamilton)

bille_matt@bah.com

While microsatellites have made monumental advances, the greatest step toward maximizing their potential will be a conceptual one. Today, even large-satellite users are looking at disaggregating their payloads into smaller, more resilient, more flexible architectures. Dematerialization—the dramatic reduction in materiel achievable by replacing hardware with photons, electrons, and innovative operations—will be the next step beyond. Dematerialized Space Systems (DEMASS) will build on advances in micro- and nanospacecraft (e.g., SeeMe, F6, and Chipsat) and the emerging revolutions in nanotechnology, information clouds, and internet-based command and control. The resulting vision will guide microspace beyond niche solutions toward a broadly applicable paradigm as different from today's space efforts as space is from aviation, shrinking space and ground hardware by orders of magnitude while evolving resilient new capabilities based on networking, multipoint measurements, and virtual apertures. The First Wave of DEMASS efforts involves fostering discussion throughout the space community and increased cooperation between microspacecraft programs already in development. The Second Wave will apply DEMASS principles to missions now done with larger satellites in an interim era of disaggregated constellations where medium, small, and micro spacecraft will all be in the "tool kit" applied to mission requirements. The Third Wave, still decades away, is true dematerialization, where electrons/photons dominate the architecture and satellites continue to shrink in size and increase in numbers. Use of DEMASS in fields as diverse as intelligence, weather, missile warning, space surveillance, Earth science, and exploration offers advances in key metrics such as persistence and data latency as well as cost, manpower requirements, and responsiveness as we move toward the Second Space Age.

A028: Passive Turbulence Generating Grid Configurations in a Turbine Cascade Facility

Connor J. Wiese (USAF Academy Department of Aeronautics) ; Kurt P. Rouser (USAF Academy Department of Aeronautics)

Kurt.Rouser@usafa.edu

Increasing isentropic efficiency of low pressure turbines in high-altitude, low-speed aircraft is of principle concern to the United States Air Force. At these flight conditions, low pressure turbines operate at axial chord based Reynolds numbers of approximately 25k and are susceptible to boundary layer separation. Turbulence intensity levels at the turbine inlet have a significant effect on boundary layer separation. In order to simulate turbine operating conditions in the United States Air Force Academy cascade facility, the configuration of passive turbulence generating grids was studied to produce periodic flow through the turbine cascade. Three Reynolds numbers, 25k, 50k and 100k, and two grid orientations, one oriented perpendicular to inlet flow and one parallel to the cascade, were studied. Average inlet turbulence intensity and wake total pressure loss coefficient profile were dependent on Reynolds number, grid orientation and grid location. Periodic surface pressure coefficient profiles and periodic wake total pressure loss coefficient profiles were best achieved with the grid perpendicular to the cascade.

A029: Transonic Aerodynamics and Pitch Stability of Land Speed Record Contenders

C1C Benjamin Kramer (Department of Aeronautics, US Air Force Academy) ; Lt Col Andrew Lofthouse (Modeling & Simulation Research Center, US Air Force Academy) ; Eric Ahlstrom (Star Aerospace LLC)

andrew.lofthouse@usafa.edu

Several teams are seeking to break the current Absolute Land Speed Record, which stands at 763 mph, with the ultimate goal of more than 1000 mph. Safely achieving these speeds requires a thorough understanding of the transonic aerodynamics of the vehicle. The US Air Force Academy has teamed with the Avenger LSR team to conduct a detailed CFD study of the Avenger LSR rocket car. Specific attention will be paid to the drag and pitch stability during transonic conditions. As time allows, additional LSR contenders will be included in a comparative study. Conceptual analysis of the vehicles will be compared to the CFD to show the utility and limitations of first-order tools in unusual and unconventional vehicle evaluations. Finally, a full unsteady simulation of the complete record attempt will be completed.

A030: CFD Characterization of the USAFA Ludwieg Tube

Robert Decker (Modeling & Simulation Research Center, US Air Force Academy) ; C1C Joshua Rivey (Department of Aeronautics, US Air Force Academy) ; Lt Col Andrew Lofthouse (Modeling & Simulation Research Center, US Air Force Academy)

andrew.lofthouse@usafa.edu

A Ludwieg tube capable of flows up to Mach 6 was recently installed at the US Air Force Academy Department of Aeronautics. A Ludwieg tube is a high speed wind tunnel that does not rquire a total pressure control device or large settling chamber like a conventional blow-down tunnel. The facility allows the study of hypersonic flows, to include strong shocks and nonequilibrium gas chemistry as well as shockwave-boundary layer interaction. A previous CFD study was conducted of a portion of the tube to assist in understanding the operating envelope of flow conditions. Additional CFD simulations will be conducted by USAFA faculty and cadets in support of the Ludwieg tube operation. These simulations include a study of the diffuser section, to include the expansion wave patterns, to fully understand the operating characteristics of the tube. Additionally, simulations with different aerodynamic models will be conducted to understand aerodynamic model size and location effects on the expansion wave pattern and their effect on operation of the tube (similar to subsonic wind tunnel blockage effects).

A031: Cavity Resonance and Store Force and Moment Loading Using the Kestrel CFD Code

Capt Chris Coley (Modeling & Simulation Research Center, US Air Force Academy) ; Lt Col Andrew Lofthouse (Modeling & Simulation Research Center, US Air Force Academy)

andrew.lofthouse@usafa.edu

Many modern USAF aircraft, such as the F-22 and F-35, are designed with internal weapons bays due to the reduced radar signature from internal store carriage. A store released from such an internal bay is subjected to a highly unsteady flowfield that influences the release characteristics of the store. Depending on the store characteristics, such as mass and moment of inertia, the unsteady shear layer could negatively affect the repeatability of the store trajectory – in turn making it difficult or impossible to certify a store for release at certain flight conditions. Computational simulations have been performed of a generic weapons bay with a nominal store using a standard NASA CFD code, OVERFLOW 2. Recent versions of the DoD CFD code Kestrel now support the ability to simulate store separation events. USAFA faculty and cadets will be analyzing a generic store separating from an internal weapons bay using Kestrel and comparing the results to previous OVERFLOW and experimental results. The computational model will first be validated using an empty cavity to ensure that the pressure fluctuations are adequately captured. Static simulations of the cavity with the store will be completed, with the final goal of running a complete, unsteady 6DOF store separation simulation.

A032: Computational Investigation of Unsteady Aerodynamics of a Flapped Airfoil Using Response Functions

Lt Col Andrew Lofthouse (Modeling & Simulation Research Center, US Air Force Academy) ; Dr. Mehdi Ghoreyshi (Modeling & Simulation Research Center, US Air Force Academy)

andrew.lofthouse@usafa.edu

Computational Fluid Dynamics is an attractive method to generate aerodynamic tables of complex aircraft configurations for a variety of flight conditions. However, the computational expense required to simulate all flow conditions and aircraft attitudes is prohibitive. These same aerodynamic tables can be generated using reduced-order models with a small fraction of the computational resources. In this study, the unsteady nonlinear aerodynamic loads on a NACA 0012 airfoil due to arbitrary motion of a trailing-edge flap are investigated using indicial response functions. The reduced-order model considered is an indicial theory based on the convolution of step functions with the derivative of the input signal. The step functions are calculated using a computational model. The computational model will first be validated by comparing a clean (non-flapped) model with experimental data and previous computational results. The flapped model (with the flap undeflected) will also be compared with experiment and the clean model results. Finally, the response of the aerodynamic loads for arbitrary flap motion will be compared with previously published theoretical methods partly obtained from linear unsteady subsonic theory and the aerodynamic reverse flow theorems.

A033: Stability and Control Prediction of the X-31 and a Generic UCAV Model Using the Kestrel CFD Code

C1C Alexander Kim (Department of Aeronautics, US Air Force Academy) ; Dr. Mehdi Ghoreyshi (Modeling & Simulation Research Center, US Air Force Academy) ; Lt Col Andrew Lofthouse (Modeling & Simulation Research Center, US Air Force Academy)

andrew.lofthouse@usafa.edu

NATO STO Task Group AVT-201 on “Extended Assessment of Reliable Stability & Control Prediction Methods for NATO Air Vehicles” is studying various computational approaches to predict stability and control parameters for maneuvering aircraft. The objective of the Task Group is to determine an overall strategy for creating stability and control databases for vehicle simulation at full-scale conditions, including the deflection of control surfaces, throughout the operational envelope of the vehicle. Past assessments have been done on two vehicles: SACCON, a generic UCAV designed and tested for a previous task group, and the X-31 highly maneuverable aircraft previously flight tested by the US and Germany. Extensive wind tunnel data has been collected for these configurations, including static and dynamics cases, with and without control surfaces, and at low and high subsonic Mach numbers. In addition to the wind tunnel tests, the two configurations have been analyzed computationally by NATO researchers using several CFD codes. USAFA faculty and cadets will be analyzing these two configurations using the DoD CFD solver Kestrel and comparing their results with previously published CFD and wind tunnel results of the NATO task group.

A034: Re-Use Your CAD! Integrating Space Vehicle 3D Models with Heritage and Common Parts

Jennifer Herron (Action Engineering)

jennifer@action-engineering.com

The best advice I have ever received as an aerospace design engineer is that if a design isn’t working out quite right, flip it upside down. Over my career looking at things in the opposite order and inverted, usually lends a varied perspective, allowing the solution to become clear. Before a product is complete, designers must integrate multiple components together, much of this in aerospace is done with standard or common parts. Most of the time, we forget about the simple-yet crucial parts of our assemblies until the end of the design process. Depending on your level of completeness of your assembly model, depends on how well others will be able to collaborate with you and integrate your 3D assembly model with their system. As the design development process progresses, so should the completeness. Instead of modeling your own parts that source from a catalogue, what if you could seamlessly re-use those parts within your native 3D CAD environment?

A037: The Convergence of Hardware Reliability Analyses and Software Fault Management Design

Reinaldo Perez (Consultant, M. R. Research.)

reyjperez@msn.com

Aerospace programs require that as part of their mission assurance plan a hardware reliability engineering program must also be implemented. Multiple types of hardware reliability efforts accompany the mission assurance plan. The goal of the reliability efforts is to provide for a good design that is also reliable. Some of the most common reliability engineering tasks include Failure Modes Effects and Criticality Analysis (FMECA), Parts Derating Analysis, Probabilistic Risk Assessments (PRA), Worst Case Analyses (WCA), Fault Tree Analysis (FTA), and Single Event Effects (for space system). Obviously, the goal of these analyses is to provide documented evidence that the system and subsystems hardware are reliable per the present design specifications. During the processes involved in the development of reliability analyses the underlying premise is that all the engineering efforts, as described by the reliability analyses, are performed for the overall purpose of minimizing potential hardware faults in the system and subsystems. Hardware faults can be at the component level, interface level, circuit level, and assembly level. The design of software driven fault management system is also an essential component in the systems engineering of aerospace systems. The fault management software system (FMSS), also known in its compressed version as fault protection software, is an essential part of the flight software of aerospace platforms. FMSS is usually designed at a higher level of cognition. The FMSS most likely will capture only those faults that manifest themselves at the higher level of subsystem and system engineering (system effects) when in reality the fault actually originated deep in the hardware construct and has propagated upward through several levels of hardware interfaces to system effects. Because of these multipath propagations of faults it is often difficult to pinpoint the exact nature of the fault we are dealing with. It is not unusual for situations where the FMSS can capture a fault and implements a corrective action (often autonomous) without a true knowledge of the fault's origin and it will take flight operators a subsequent effort to finalize the true cause and origin of the fault. This work addresses a few design principles and a methodology for the capture and analysis of hardware faults at deep levels of hardware construct by a more cognizant FMSS. Therefore, this work also addresses the design of a more cognizant FMSS. Though there are many advantages in the design of a more knowledgeable FMSS, there are also some disadvantages that will also be addressed. The work will provide examples from one of the most commonly used hardware reliability analysis, the FMECA, to show how the convergence between hardware reliability analysis and FMSS can be accomplished for the purpose of capturing, diagnosis, and corrective action of faults that occur as deep as the component or circuit level. The principle however can also be used with other reliability analyses, but that will be addressed in future work. The work will consist of typical FMECA fault examples in aerospace systems and the development of the accompanying software algorithms in the FMSS.

A038: Understanding The Flight Test Discipline… Managing Risk and Adding Value to Unmanned Aerial System (UAS) Development

Greg Griffitt ()

greg.griffitt@avianeng.com

Many companies are presently working diligently on the development of UAS. Flight testing is a discipline. Sound test planning is critical to the development and flight test of these systems. However, many UAS manufacturers do not have trained and qualified workforces familiar with, or capable of, performing these tasks. This presentation will present an overview of the role and importance of flight testing in the development of UAS. As part of the discussion, the fundamentals of flight test planning will be discussed as they relate to UAS. This discussion will also include an overview of test planning methodology and the key elements of a comprehensive flight test plan, and will introduce the T&E “best practice” of test hazard analysis (THA). Detailed topics to be covered include:- Overview of the fundamentals of the flight test discipline UAS flight test requirementsUAS flight certification processRelevant FAA Airworthiness StandardsFlight test planningOverview of test planningTest plan development – Background and Purpose of TestTest plan development – Test Design (Scope and Method of Test) Test Planning - Test Hazard Analysis and Risk ManagementFlight test executionSafety Management Systems (SMS) Roles and ResponsibilitiesFlight test division of laborFlight test briefing and debriefingUse of Safety ChecklistsControl room disciplineData requirements (pre-flight / in-flight / post-flight) Critical parameter monitoringAbort criteria and use of the "no vote"ConclusionsCase studies and lessons learned regarding flight testing will be highlighted throughout the presentation, where appropriate.

A039: Unmanned Aircraft Systems (UAS) Missions, Business Value, and National Airspace Integration

Stan VanderWerf ()

s.vanderwerf@advanced-capitol.com

Mr. Stan VanderWerf (BSIE, MAIR, MSNSS), Executive Director of UAS Colorado, will provide an overview of UAS opportunities for both research and business. The FAA has been directed by Congress to integrate UASs into the national airspace thus prompting the initiation of a large nationwide research effort to develop the technology and procedures that will let manned and unmanned aviation systems share the same national airspace. Colorado has submitted an application to obtain one of these test sites. Not well known, is the extensive UAS activity, research, and differentiation already ongoing in Colorado that will permit our State to help the nation integrate UASs safely. Mr. VanderWerf will talk about Colorado's UAS activities, ongoing research, and encourage more research in Colorado. Mr. VanderWerf, a Colorado Springs resident, is leading the Colorado UAS Team in pursuing one of the six FAA UAS test sites for the nation. He is a retired Colonel, former Chief Scientist of NORAD/NORTHCOM, and former US Air Force Director for Electronic Warfare and Avionics.

A040: Orbital Drag Measurements in the ChAOSS Facility

Carlos Maldonado ()

cmaldona@uccs.edu

Gas-surface interactions in low Earth orbit (LEO) have been studied for years through a combination of on-orbit observations and laboratory experiments in an effort to measure momentum accommodation coefficients (MACs), as a function of both surface material and angle of incidence. These previous laboratory investigative attempts have been hindered by the limited availability of hyperthermal molecular beam sources capable of producing LEO conditions and accurate force measurement devices. This inability to accurately reproduce on-orbit conditions in ground-based facilities has been the primary limiting factor for decades and as a result, the research in gas-surface interactions in relation to MACs and subsequent drag effects has not progressed significantly since the mid to late 90's. Based on the previous lack of high fidelity hyperthermal sources some scientists hold that satellite drag coefficients should be calculated using accommodation coefficients measured in orbit rather than those measured in laboratory experiments. This line of thought will be challenged in the near future as hyperthermal molecular beam sources, more specifically atomic oxygen, have been developed which can accurately simulate LEO conditions. The ability to measure momentum accommodation coefficients in ground-based facilities will allow for the development of low drag materials. Careful selection of spacecraft materials with regard to drag will allow for the design of low drag spacecraft and the decrease of propulsion requirements. An increase in the understanding of gas-surface interactions will also lead to the improvement of computational methods. While many numerical models use a combination of specular and diffuse reflection modes, additional experimental measurements are required to increase the accuracy of numerical models in modeling gas-surface interactions in rarified flows.

A041: The Role of Low Temperature Fuel Chemistry on Turbulent Flame Propagation

Bret Windom (University of Colorado Colorado Springs) ; Sang Hee Won (Princeton University) ; Bo Jiang (Princeton University) ; Yiguang Ju (Princeton University)

bwindom@uccs.edu

Turbulent mixing of the fuel and air in jet propulsion engines occur at extreme conditions with regard to pressure and temperature. These extreme conditions create an environment which can lead to low temperature ignition of the reactants prior to their introduction into the high temperature turbulent flame. A high temperature, high Reynolds number, Reactor Assisted Turbulent Slot (RATS) burner has been developed to investigate the role of low temperature ignition of large hydrocarbon fuels on turbulent flame regimes and flame propagation. The turbulent flame structures and burning velocities of n-heptane/air mixtures are measured using planar laser induced fluorescence techniques with reactant temperatures spanning from 400 K - 700 K. It is found for the first time that for n-heptane/air mixtures there are two different turbulent flame regimes; a conventional chemically-frozen-flow regime and a low-temperature-ignition turbulent flame regime, which depend on the initial reactant temperature and flow residence time. In the latter case, large amount of CH_2O formation has been observed in the pre-flame zone, signaling a significant change in the reactant composition and chemistry resulting in accelerated turbulent burning velocities. The present results suggest that contrary to the previous studies, the turbulent flame regimes and burning velocities for fuels with prominent low temperature chemistry behavior cannot be uniquely defined at elevated temperatures.

A042: Vibration-Related Failures of Combustion and Steam Turbines

Alexi Rakow, Ph.D., P.E. (Exponent, Failure Analysis Associates; 2595 Canyon Boulevard, Suite 440, Boulder, CO 80302)

alexirakow@gmail.com

Turbine failures occur for multiple reasons, including fatigue, FOD, creep, corrosive attack, and improper maintenance. In nearly all cases, such failures result in changes in the turbine's vibration, which can be diagnosed to determine the cause of failure, before tearing down the machine. This presentation provides an overview of some of the more common failures occurring in combustion and steam turbines and their inter-relationship with vibration. Multiple case studies are discussed, including examples of failed blades, rotor bow, and rubs. Along with each case, examples of vibration data and vibration diagnostic techniques used to identify the responsible failure mode are discussed.

A043: TBD

Caroline Chouinard (Red Canyon)

caroline.chouinard@redcanyonsoftware.com

TBD

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