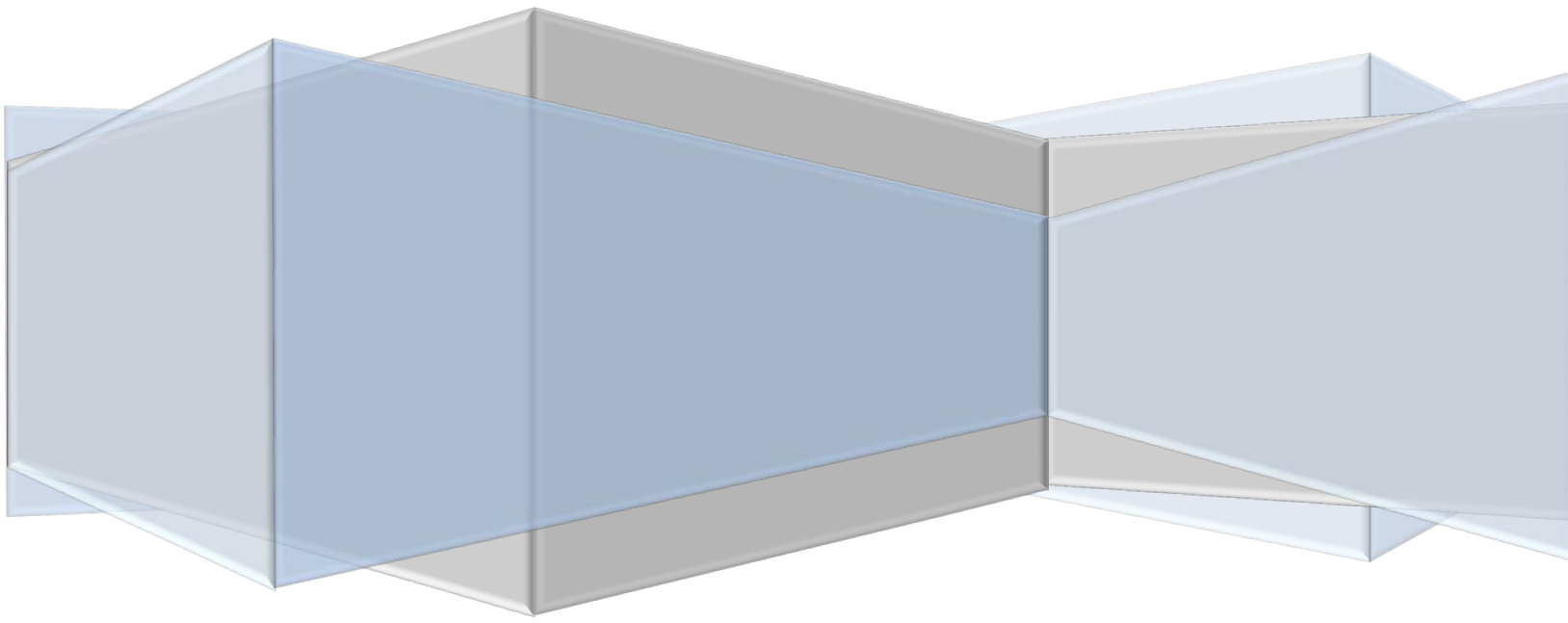
AIAA-RM Annual
TECHNICAL
SYMPOSIUM

AIAA Rocky Mountain Section Annual Technical Symposium 2016

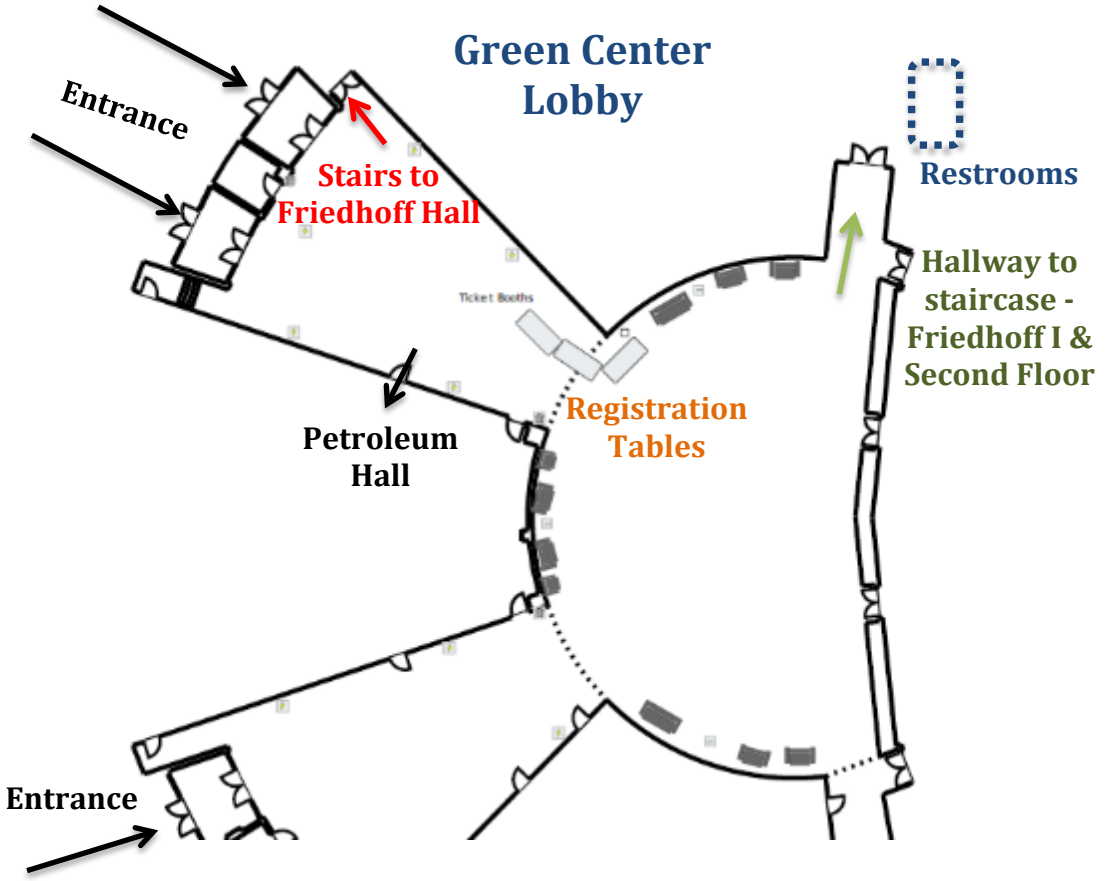


More information at the AIAA Rocky Mountain website: http://www.aiaa-rm.org/

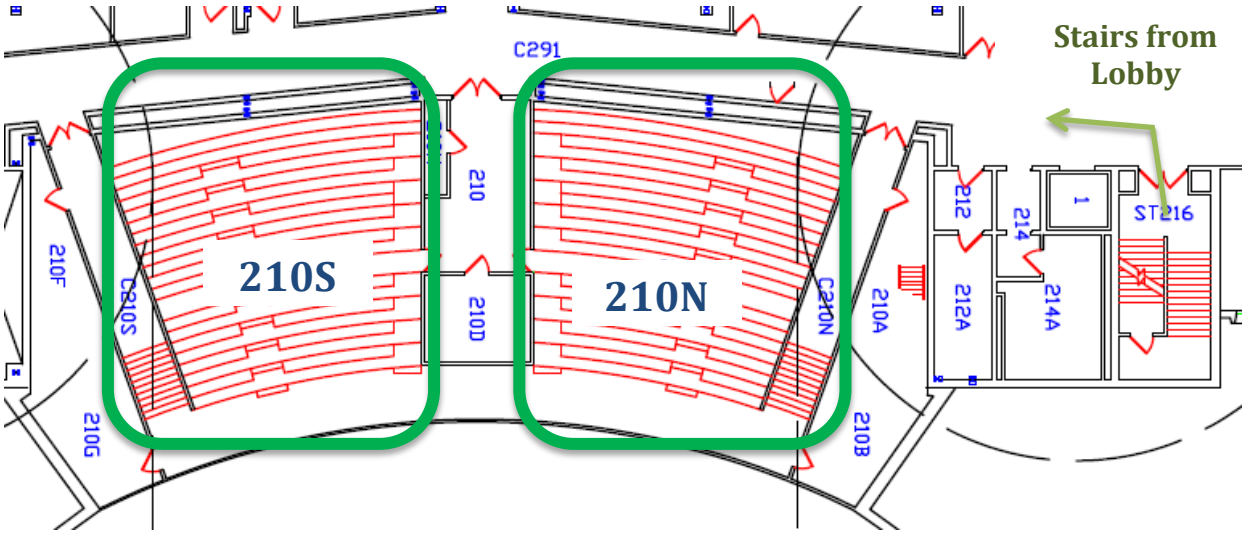
AIAA
Shaping the Future of Aerospace

AIAA Rocky Mountain Section
5th Annual Technical Symposium
October 21st, 2016

Conference Layout | Registration at 7:30am

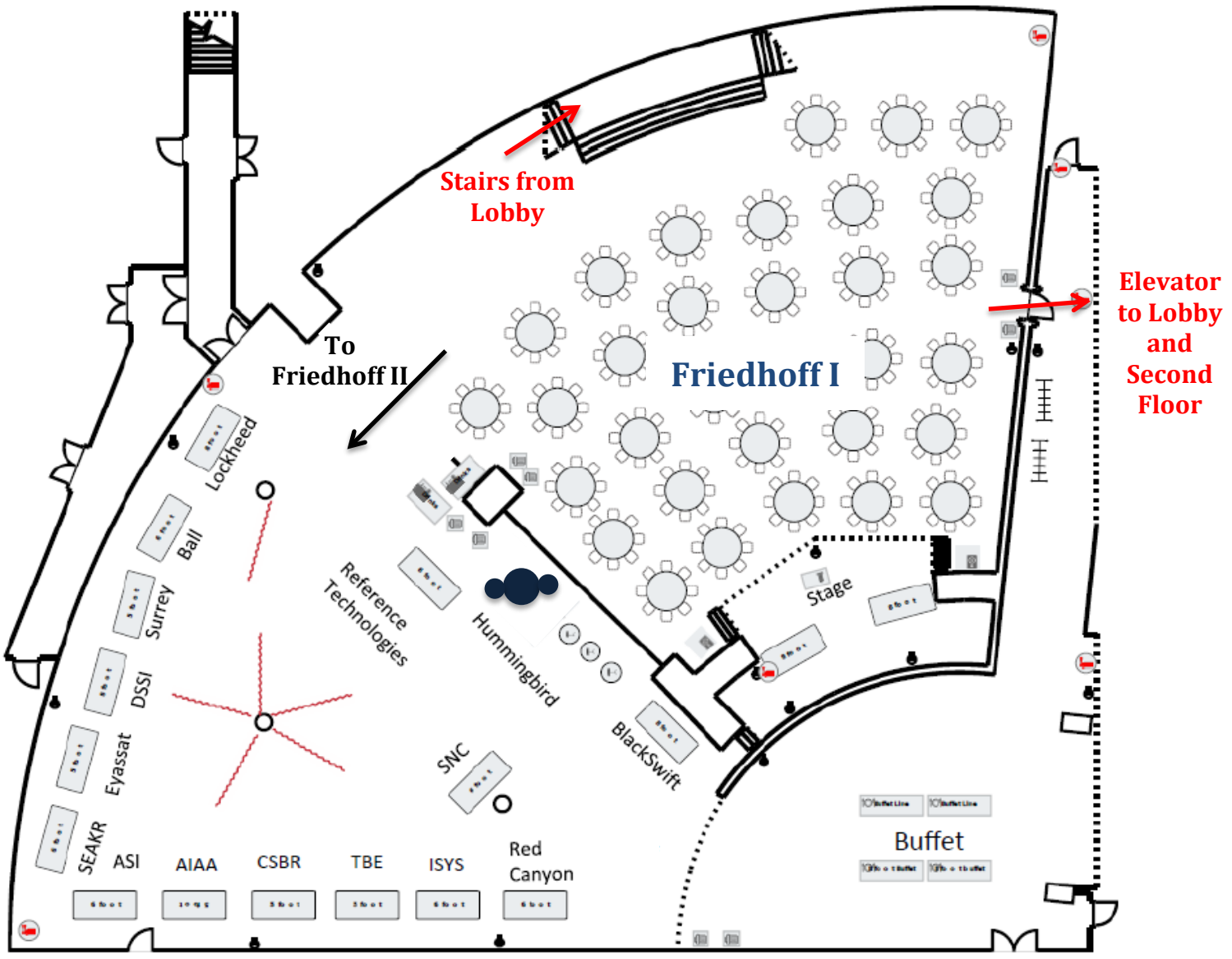


Green Center 2nd Floor "Tech-Talk Rooms"



COLORADOSCHOOLOFMINES EARTH • ENERGY • ENVIRONMENT

Main Hall & Exhibition Room



Message from the AIAA-RM ATS 2016 Chair

Ladies and Gentlemen,

The AIAA Rocky Mountain Section is proud to welcome you to the 2016 AIAA-RM Annual Technical Symposium (ATS). Now in its 5th year, ATS continues to distinguish itself as the Rocky Mountain region's event for aerospace industry, academia, and government to highlight new ideas, methodologies, concepts, and technical innovations. Colorado is home to the 2nd largest aerospace industry sector in the United States. As such, it is important that we continue to promote local growth and foster partnerships throughout our region in order to facilitate our future success. The purpose of this event is to shine a spotlight on the outstanding talent of our local personnel, companies, and institutions and to initiate collaboration between these groups in hopes of yielding solutions to tomorrow's challenges. We are honored and encouraged by the continued partnerships established through ATS and privileged to have expanded those partnerships in 2016.

We would like to take this opportunity to extend our appreciation to those who have made this event possible. As ATS returns to the Colorado School of Mines for the second consecutive year we thank the university, its students, and the faculty including Dr. Paul Johnson, Dr. Kevin Moore, and Dr. Angel-Abbud Madrid for hosting and sponsoring this year's event. In addition we offer our gratitude to all of our AIAA-RM volunteers that have worked so hard to make this such a huge success including Tyler Franklin, Tracy Copp, Taylor Lilly, John Grace, Erik Eliasen, John Marcantonio, Wes Kenison, and many others that have helped along the way. A symposium like this is difficult without the help of sponsors and affiliated organizations. Please be sure to take a moment to view the list of sponsors and to express your thanks in person by engaging with them throughout the day. Specifically, we would like to recognize this year's Diamond Sponsors Lockheed Martin Space Systems Company and Deep Space Systems. These organizations have shown their dedication to investing in the community and developing valuable partnerships through their substantial sponsorship of this event. Through their leadership, the section has an established platform for each of us to exchange concepts, promote ideas, and network solutions.

Finally, we would like to personally thank each and every one of you for taking the time and effort to attend this year's event, which will help each of us to create an engaging opportunity for every facet of the community, from young professionals to seasoned managers, from startups to Fortune 500s, and from educators to executers. We look forward to seeing you all at the AIAA-RM Annual Technical Symposium 2016.

Scott Tuttle
AIAA-RM ATS 2016 Chair
Lockheed Martin Space Systems Company
Systems Engineer

Brian Gulliver
AIAA-Rocky Mountain President 2016-17
Kimley-Horn
Aerospace and Spaceport Practice Leader

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SE

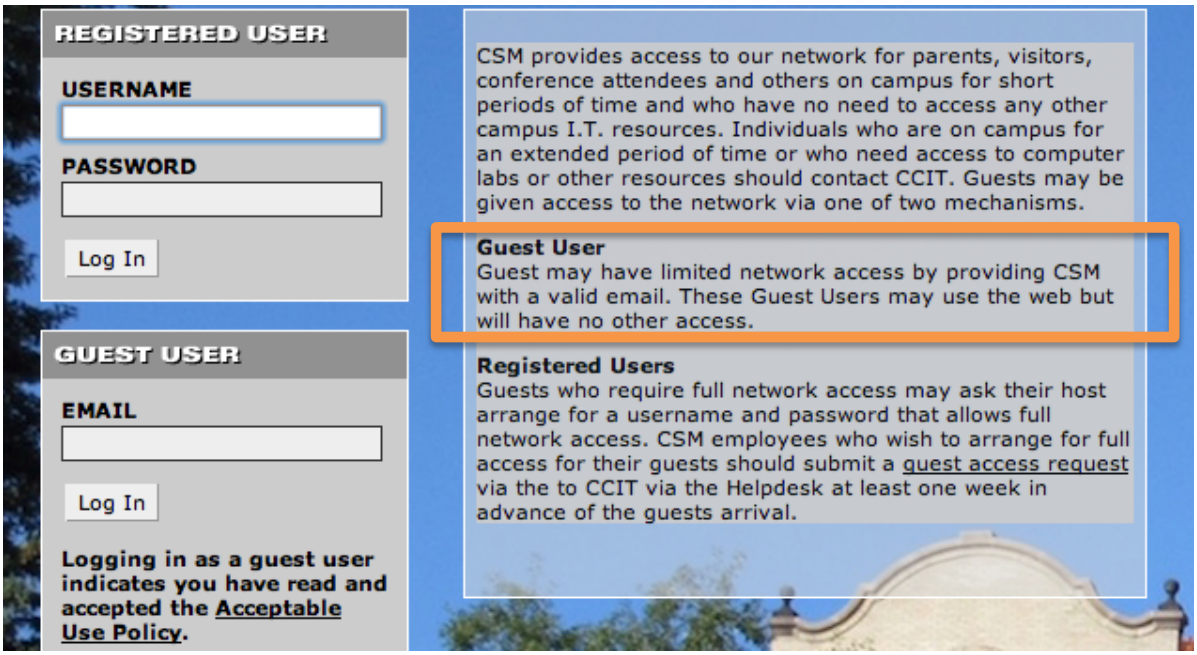
CSBR COLORADO space business roundtable

BRISTOL BREWING COMPANY

ATS 2016 Agenda

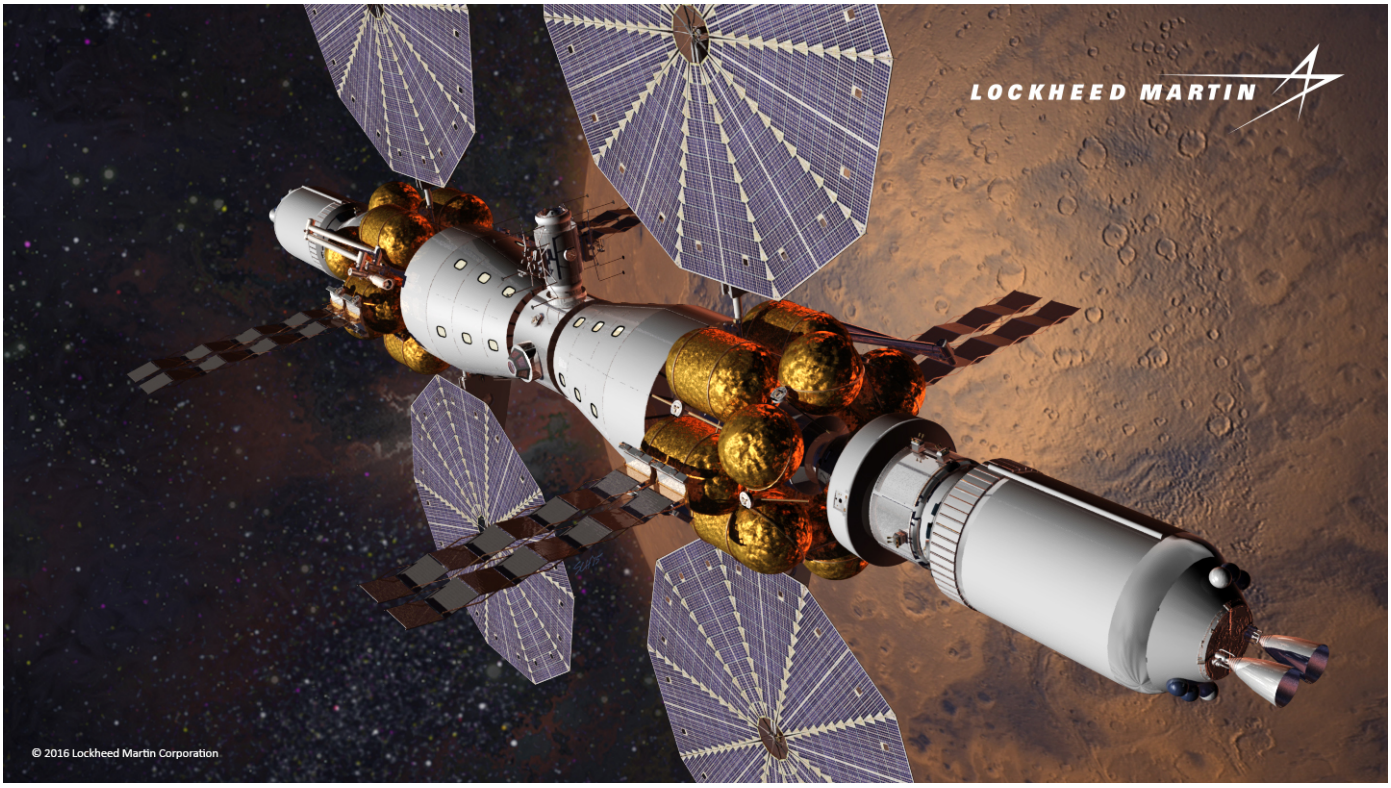
Time	Event
7:30-8:30am	**Registration and Breakfast**
8:30-8:45am	**Symposium Welcome** Friedhoff I
8:45-9:15am	**Lockheed Martin Sponsor Presentation** Mars Base Camp by Rob Chambers | Friedhoff I
9:20-10:15am	**PANEL Political Influences on the Colorado Aerospace Economy** Moderator Tracy Copp | Friedhoff I
10:20-11:10am	**Morning abstract presentations** See pages 11-12 | Friedhoff I, Petroleum Hall, GC210N, GC210S
11:10am-12:05pm	**KEYNOTE** The Once and Future Mars by Jim Crocker, VP Lockheed Martin Space Systems Company International
12:10 pm	Lunch served
12:30-12:55pm	**Deep Space Systems Inc. Sponsor Presentation** The Case for Mars Base Camp by Steve Bailey
1:00-1:55pm	**PANEL The Future of UAS** Moderator Allen Bishop | Friedhoff I **PANEL Big Value of Small Sats** Moderator Erik Eliasen | Petroleum Hall
1:55-2:10pm	**Poster Presentations & UAV Display**
2:10-3:50pm	**Afternoon abstract presentations** See pages 19-22 | Friedhoff I, Petroleum Hall, GC210N, GC210S
4:00-4:55pm	**PANEL International Collaboration in Aerospace** Moderator Kay Sears | Friedhoff I
4:55-5:10pm	**Closing Remarks** Friedhoff I
5:30-7:00pm	**Post-Symposium Networking Social** Miner's Saloon

Internet Access – Colorado School of Mines Wifi



Platinum Sponsor: Advanced Solutions Inc.

Diamond Sponsor: Lockheed Martin Space Systems Company 8:45am



Lockheed Martin Sponsor Presentation

Mars Base Camp

At Lockheed Martin, our job is to challenge ourselves and our industry teammates to drive the innovation that helps make grand achievements possible.

Mars Base Camp is Lockheed Martin's vision for sending humans to Mars by 2028. The concept is simple: transport astronauts from Earth to a Mars-orbiting science laboratory where they can perform real-time scientific exploration, analyze Martian samples, and confirm the ideal place to land humans on the surface in the 2030s. ♦

Rob Chambers has been with Lockheed Martin since 1993 and has worked on a variety of Space Systems Company programs including Earth remote sensing satellites, the Space Shuttle, and Orion. Rob has bachelor's and master's degrees in Aeronautical and Astronautical Engineering from Purdue University, and over the years has led the development of guidance and controls subsystems, avionics, and flight software. Rob has been with Orion since 2006 and is currently the program strategy lead for Orion production, focused on defining the capabilities and timelines for Orion's future exploration missions.

PANEL Political Influences on the Colorado Aerospace Economy 9:20am

This panel will delve into the challenges and opportunities that exist for the aerospace industry in an ever-changing political landscape. The panel will also explore how political leaders, local and national, state government, industry and academia can influence and change the conversation to affect positive outcomes for Colorado Aerospace Economy.

Panel Moderator

Tracy Copp
Ball Aerospace &
AIAA-RMS Public Policy Chair

Stacey DeFore
Teledyne Brown Engineering

Jay Lindell
Colorado Aerospace Champion

Joe Rice
Lockheed Martin Space Systems

David Ruppel
Front Range Airport

Scott Palo
University of Colorado, Boulder

Technical Speaker Session — 10:20am – 10:45am

Dream Chaser Space Utility Vehicle	**Friedhoff I**
Presenter	John Roth of Sierra Nevada Corporation
Authors	John Roth

In January 2016, Sierra Nevada Corporation's Dream Chaser space vehicle was selected by NASA to provide cargo services to the International Space Station under NASA's Commercial Resupply Services 2 contract. In June of 2016, SNC announced the signing of a Memorandum of Understanding with the United Nations Office of Outer Space Affairs to cooperate on development of a dedicated Dream Chaser mission to carry payloads of UN member countries to low Earth orbit. This presentation will provide an overview of these two programs as well as describe other missions being envisioned with the Dream Chaser vehicle.

UC2AV: Unmanned Circulation Control Aerial Vehicle for Short Takeoff and Enhanced Payload	**Petroleum Hall**
Presenter	Konstantinos Kanistras of the University of Denver
Authors	Konstantinos Kanistras, Pranith Chander Saka, Kimon P. Valavanis and Matthew J. Rutherford

Class I UAVs (<55lbs) will be the first allowed to fly in civilian airspace according to the new FAA regulations. The current state-of-the-art of conventional and commercially available small-scale UAVs limits considerably their utilization, flexibility and applicability to only executing specific short-duration missions because of major limitations due to size, payload, power supply, endurance, etc. Such UAVs can only perform missions they have been designed for. The proposed project aims to overcome conventional unmanned aircraft limitations and develop Unmanned Circulation Control Aerial Vehicles (UC2AVs) endowed with improved aerodynamic efficiency, increased useful payload during cruise flight, delayed stall, and reduced runway during take-off and landing. These advantages will be achieved by using and implementing the concept of Circulation Control (CC) that is proven to be the most effective active flow control method for lift enhancement purposes.

TEMPO GEO-Hosted Imaging Spectrometer	**GC 210N**
Presenter	Dennis Nicks of Ball Aerospace
Authors	Dennis Nicks

The Tropospheric Emissions, Monitoring of Pollution (TEMPO) program was selected by NASA for the Earth Venture Instruments 2012 Announcement of Opportunity. TEMPO is an innovative use of a well-proven remote sensing technique for air quality measurements and Ball Aerospace is the instrument developer. Low Earth Orbit remote sensing techniques have made measurements of photochemical species, precursors and oxidation products relative to air quality. These include NO2, O3, SO2, C2H2O2, CH2O and atmospheric aerosol. The TEMPO instrument combines a high spatial resolution spectrometer with a geostationary orbit to achieve unprecedented spatial and temporal measurement resolution. These new measurements will allow for hourly observations of air quality of Greater North America with urban-regional spatial scales (<60 km2). Hourly daytime observations will allow for measurements of the complex diurnal cycle of pollution driven by photochemistry. These measurements will contribute to better understanding of regional air quality and improved air quality forecasts.

Green Propellant Infusion Mission (GPIM), Advancing the State of Propulsion System Safety and Performance	**GC 210S**
Presenter	Christopher H. McLean of Ball Aerospace
Authors	Christopher H. McLean

Ball Aerospace is leading a NASA/DoD/Industry team developing, qualifying, integrating, and will be flying a demonstration mission of an ESPA-class propulsion subsystem using AF-M315E green propellant and a BCP-100 spacecraft. The project, called the Green Propellant Infusion Mission, is in NASA's Technology Demonstration Mission program office with Space Technology Mission Directorate's programmatic and technology oversight being provided by NASA Marshall Space Flight Center. This presentation provides an overview of the development of the thruster and thruster sub-system technology, the development of new methods for implementation of the AF-M315E propellant, and a review of the mission planning activities. The on-orbit demonstration will occur over a 13 month flight, with three major demonstration activities specific to the AF-M315E propulsion subsystem. At the completion this demonstration, sufficient data will be developed to allow for infusion of AF-M315E as a hydrazine replacement for spacecraft attitude control and primary propulsion.

Technical Speaker Session — 10:45am – 11:10am

Design and Assembly of an Engineering Design Unit (EDU) Portable Fire Extinguisher for the Orion MPCV	Friedhoff I
Presenter	Dr. Thierry Carriere of ADA Technologies, Inc.
Authors	Thierry Carriere, Benjamin Collins, Sarah Bernier
ADA Technologies has developed and deployed in space a fine water mist based fire extinguisher. The ISS astronauts now rely on these portable extinguishers for day to day fire protection. The successful deployment in space of the extinguishers in 2015 has positioned ADA well for developing a similar system for the Orion vehicle. The manned Orion spacecraft is vastly different from an ISS module, in particular from a volume and dimensions standpoint. As a result, this extinguisher will be smaller than its predecessor but still needs to achieve exceptional fire suppression performance in space. ADA started to design the Orion extinguisher and a preliminary design has been established, followed by the fabrication of an Engineering Design Unit in September 2016. The design includes a bladder system containing 3 pounds of water under 1200 psi nitrogen housed in a custom titanium tank. The extinguisher weighs 11.2 lb.	

An Inter-comparison of UAS for Survey Applications	Petroleum Hall
Presenter	Jack Elston, CEO of Black Swift Technologies
Authors	Jack Elston, Maciej Stachura, Cory Dixon
The recent flood of Unmanned Aircraft Systems (UAS) into the GIS industry, although exciting, has provided as many questions as platform options. Increased improvement in reliability and post-processing capabilities promises to provide a greatly simplified and reduced price option for producing orthomosaic and 3D datasets. Unfortunately the true value of any particular UAS remains difficult to determine as there exists a distinct lack of information when it comes to aircraft inter-comparisons. Paramount to collection of accurate data is the understanding of not only the limitations of the processing software but the relative errors and their sources introduced by the aircraft and sensor. This presentation will provide a direct comparison of three of the leading platforms, with data sets obtained over the same area of interest and within a day of each other.	

PFISR GPS Tracking Mode for Researching High-Latitude Ionospheric Electron Density Gradients Associated with GPS Scintillation	GC 210N
Presenter	Diana Loucks of University of Colorado, Boulder
Authors	Diana Loucks, Scott Palo, Marcin Pilinski, Geoff Crowley, Irfan Azeem
Ionospheric behavior in the high-latitudes can significantly impact UHF signals, resulting in degradation of GPS position solutions and satellite communications interruptions. To address these operational concerns, a need arises to identify and understand the ionospheric structure that leads to disturbed conditions in the Arctic. High-latitude ionospheric structures are known to change on the order of seconds or less, can be decameters to kilometers in scale, and elongate across magnetic field lines. Nominal operations at PFISR yield temporal resolution of minutes, and range resolution of tens of kilometers; specialized GPS receivers available for ionospheric sensing have up to a 100Hz observation sampling rate. ASTRA's CASES reciever is used for this study. We have developed a new GPS scintillation tracking mode for PFISR to address open scientific questions regarding temporal and spatial electron density gradients. The mode will be described, experimental campaigns analyzed, and results and lessons learned presented.	

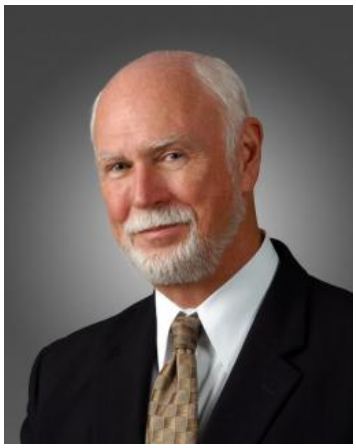
CubeSat Thermal Management	GC 210S
Presenter	Steven Isaacs of Roccor
Authors	Steven Isaacs, Greg Shoukas, Diego Arias
CubeSats and small satellites face thermal management challenges due to the limited available surface area for radiative cooling and their small heat capacity. Compared to typical terrestrial operating environments, these factors can lead to components running at higher average temperatures than would be preferred and experiencing a relatively wide range of temperatures due to cycling orbital boundary conditions.	

KEYNOTE

11:10am

Jim Crocker

Former Vice President and General Manager of Lockheed Martin Space Systems Company International



Over a career spanning 45 years, Jim Crocker has led some of the world's most exciting and important projects in astronomy, astrophysics and space exploration. Jim began his career as a junior engineer at NASA's Marshall Space Flight Center working on Apollo 17 and designing electronics for the three crewed Skylab Space Station missions. Before joining Lockheed Martin in 2002 he led the architecture development and the successful capture of the James Webb Space Telescope at Ball Aerospace and Technologies. At the European Southern Observatory, he led the design and construction of the VLT, the world's largest array of telescopes. At the Johns Hopkins University Center for Astrophysical Sciences he was the PM for the development of the renowned Sloan Digital Sky Survey which measured the distance to 1,000,000 galaxies, 100,000 quasars and determined the structure of the near universe. As head of Programs at the Space Telescope Science Institute he conceived the idea for and led the team that developed the system to correct the flawed optics on the Hubble Space Telescope. Jim was the systems architect for the Advanced Camera for Surveys which was the Hubble science instrument that recorded the Hubble Ultra Deep Field, perhaps the most profound astronomical image ever taken by mankind. Prior to leading SSC International at Lockheed Martin Space Systems Company, Jim was the VP and GM of the Civil Space line of business. Our knowledge of the universe was expanded with his leadership of the Spitzer Space Telescope and the operation and in orbit repair of the iconic Hubble Space Telescope. Jim is a Fellow in the AIAA and AAS and an elected member of the International Academy of Astronautics. He is the Current Chairman of the Board of the Universities Space Research Association and past Board Chair of the Denver Museum of Nature and Science.

The Once and Future Mars

The history of Mars Exploration Past, Present, and Future

The early observations of Mars with the newly invented telescope in the 1600s catapulted our understanding of Mars. In 1659 Christian Huygens tracked a spot on the surface (Syrtis Major) and deduced that the rotational period of Mars, its day, was about 24 hours, the same as the earths. He also reported the bright spots at the poles which we now know are the polar ice caps. Galileo, Kepler and Huygens showed us that Mars was new world. In a letter Kepler wrote to Galileo in 1610 saying "that as soon as we have ships or sales adapted to the heavenly breeze there will be some who will not fear even that void space in that soon settlers from our species of man will not be lacking on those worlds."

The exploration of Mars has been a dream of mankind for over 400 years. Now with Orion and SLS we have the opportunity to explore this strange new world. But how has our understanding of Mars changed throughout the centuries and how will the latest discoveries change our understanding of the Red Planet and our plans for exploration? ♦

Symposium Menu

Breakfast:

- Fresh Fruit
- Assorted Breakfast Breads and Danishes
- Freshly Brewed Coffee / Freshly Brewed Decaffeinated Coffee
- Numi Herbal and Non Herbal Teas to include Decaffeinated Numi Tea with Hot Water
- Bottled Orange Juice, Apple Juice, & Iced Water

Lunch:

- Tomato Basil Bisque
- House Salad with Balsamic Dressing
- Fresh Fruit Salad
- Spicy Italian Baguette, Grilled Tuscan Chicken Sandwich, Smoked Turkey and Brie and Greek Vegetable Wrap
- Pub Chips
- Assorted cookies & brownies
- Ice Tea & ice Water

Platinum Sponsor: Ball Aerospace

Platinum Sponsor: Red Canyon Engineering and Software

AIAA Student Membership

Diamond Sponsor: Deep Space Systems Inc. (DSSI) 12:30am

Steve Bailey is the founder and President of Deep Space Systems. Since its beginning in 2001, DSSI has been involved with planetary exploration efforts including MRO, GRAIL, Juno, MAVEN, OSIRIS-Rex, and Orion. In 2009 DSSI received the NASA Small Business of the Year award. Steve Bailey has worked exclusively on human and robotic space exploration systems since 1983. His extensive career has included work in industry, in civil service, at JPL, and in entrepreneurial space efforts. Steve has worked on human explorations projects including the Space Shuttle and Orion, and on robotic exploration systems including Artemis Lunar Lander, Mars Pathfinder, MCO, Blastoff! Lander, and Mars Odyssey. Steve served as spacecraft system design lead for the Mars Polar Lander and Mars Reconnaissance Orbiter.

Deep Space Systems Inc. Sponsor Presentation

The Case for Lockheed Martin's Mars Base Camp

NASA's ARRM and NextSTEP missions establish a path that can lead to a Mars Base Camp in 2028, a Mars orbital mission that places humans on the two alien worlds of Phobos and Deimos, and returns samples from the surface of Mars. But where does Mars Base Camp lead? And what are some of the possible paths for getting there? Steve Bailey will expand on Lockheed Martin's vision of a 2028 Mars Base Camp and a 2033 human expedition that employs a reusable single stage vehicle that provides global access for human exploration of the surface of Mars. Steve will discuss the potential role of water in a LOX/Hydrogen economy and the potential for ISRU to enable an expanding sphere of commercially led space utilization and government led exploration. ♦

PANEL The Future of Unmanned Aerial Systems (UAS) 1:00pm

Unmanned Aerial Systems (UAS) is quickly becoming one of the largest technical and commercially viable industries in the modern world. The assembled panelists represent leading experts in the UAS field including Academia, FAA, Industry, airborne applications, Legal and public safety. "Civil Unmanned Aerial Systems (UAS) promise to be the most dynamic growth sector of the world aerospace industry this decade, report Teal analysts in their latest market analysis".

Panel Moderator

Allen Bishop
President, CEO
Reference Technologies

Constantin Diehl
UAS Colorado

Emanuel Anton Esq.
Polsinelli LLC

Stephen Meer
Boulder County Sheriff's Office

Tom McKinnon
Agribotix

Brian Argrow
Prof Aerospace Engineering, CU Boulder

Bill Dunn
FAA Flight Standards District Office

PANEL The Big Value of SmallSats 1:00pm

The panel will explore the value of SmallSats from the perspectives of business value (business case analysis), educational (STEM) value, and operational value (CYGNSS Mission). Each panelist will share their unique insights and discuss why and how SmallSats can bring relevance into our daily lives, support innovative mission solutions, and provide an opportunity to grow the next generation of engineers and scientists.

Panel Moderator

Erik Eliasen
VP, National Security Space Programs at SSC Space US & AIAA Montana Chair

Mike Gazarik
VP of Engineering
Ball Aerospace

Rick Sanford
Senior Space/Cyber Business Leader
Surrey Satellite Technology US LLC

Rick Kohnert
Professional Research Assistant
University of Colorado / LASP

Debi Rose
Senior Program Manager
Southwest Research Institute (SwRI)

Data-Driven Fault Detection via Sparse Multisensory Learning	Friedhoff I
Presenter	Hao Zhang
Authors	Fei Han, Christopher Dreyer, Thomas Jones, Rob Kelso, James Thomas, and Hao Zhang

NASA plans to explore space using more sophisticated spacecraft at greater distances from earth. As spacecraft capabilities advance and space missions become more complex, faults are more likely to happen, while at the same time astronauts aboard will be experience longer communication delays to and from mission control, which will limit the support that mission control can provide to detect faults on deep space missions. Such operations illustrate the need for autonomous onboard fault detection in deep space. We will present work to support onboard Fault Detection, Isolation and Recovery (FDIR) strategies for future deep space missions. We are developing automated data-driven approaches that integrate multisensory measurements using sparse optimization for fault recognition. The approach will enable more accurate, robust, and realtime fault detection, and computationally identify informative sensors for subsequent fault diagnosis and response. Our approach will also aid future sensor design and integration.

Energy vs. Thrust	Petroleum Hall
Presenter	Allen Bishop of Reference Technologies
Authors	Allen Bishop

Three years ago electric based propulsion technologies with moderate efficiencies were just entering the Unmanned Aircraft Systems market, driven principally by advancements in; neodymium magnets, brushless motors, composites based propellers, complex blade designs, ducted fans, contra-rotation, axial mountings, high density batteries all served to enhance the efficiency relationship between energy vs. thrust. This presentation takes the audience on the journey of the Hummingbird® UAV which began 5 years ago. What began as an elegant design, quickly demonstrated that elegance is not a substitute for physics. It wasn't until an efficient propulsion system was designed and then coupled to an equally efficient hybrid power source that the Hummingbird would be able to leave the ground with a significant payload. In early 2016, the performance requirements were finally met allowing the Hummingbird to transition from an earth-bound vehicle to that of an efficient and useful VTOL aircraft.

Technical Opportunities for High Temperature "Smart" P3 Sensors and Electronics for Distributed Engine Control	GC 210N
Presenter	Laurel Frediani of Sporian Microsystems, Inc.
Authors	Laurel Frediani, Dr. Michael Usrey, Oran A. Watts

Current engine control architectures impose limitations on the insertion of new control capabilities due to weight penalties, reliability issues related to complex wiring harnesses, and costs associated with recertification. Therefore, there is a need for a high-temperature, smart P3 sensor as a key building block for distributed engine controls. Traditional gas turbine engine controls employ a centralized Full Authority Digital Engine Control structure where the bulk of the control functionality is housed within a single electronic control "box". The "Smart" P3 sensor will contain the signal conditioning and communication functions (digitizing and interface) within the sensor relieving the FADEC from unique power and signal conditioning as well as the digitizing of the analog source. This report focuses on the potential technical advantages of replacing the engine compressor discharge pressure (P3) sensor with a "Smart" sensor communicating via a digital interface to a Distributed Engine Control.

Rapid Assembly Lightweight Modular Structure	GC 210S
Presenter	Wayne White of SpaceBooster LLC
Authors	Wayne White

SpaceBooster LLC has patented and is developing a lightweight modular structure for the Moon and Mars. The structure can be transported to the surface of a celestial body, and assembled by two robots prior to the arrival of humans. The structure is airtight, thermally insulated, resistant to micro-meteoroid penetration, provides radiation shielding, includes an airlock, and is capable of being pressurized and equipped with life support systems. When assembled on celestial bodies with gravity up to 40% of Earth's gravity, the structure can be buried under two meters of extraterrestrial material to provide additional thermal insulation, radiation protection, and protection against micrometeoroid penetration. The structure can be assembled in different configurations, and may include windows, modular walkways to connect a number of structures, and hangar-style doors to accommodate passage of heavy equipment. The structure can also be configured for use on Earth in areas of chemical, biological, radiological, or nuclear contamination, and in areas subject to extreme temperatures.

A Martian Orbit Human Exploration Architecture	Friedhoff I
Presenter	Joshua Ehrlich of Lockheed Martin
Authors	Timothy Cichan, Stephen A. Bailey, Scott D. Norris, Robert P. Chambers, Steven D. Jolly, Joshua W. Ehrlich

Lockheed Martin Space Systems, headquartered in Littleton, Colorado, was awarded the contracts for the design, development, test, and production for Orion, the Multi-Purpose Crew Vehicle that is a key technology for NASA's human exploration architecture for beyond earth orbit (BEO) missions. Lockheed Martin has recently proposed Mars Base Camp (MBC) as a science-driven human orbital mission to Mars. As the name suggests, MBC is not just a single mission concept that leaves humans in Mars orbit, but an evolvable architecture in the spirit of NASA's "Journey to Mars", leading to human surface landing and exploration. This presentation will provide a Mars mission architecture that shows the prospect for sending astronauts to the Martian Moons by 2028. Human exploration within this architecture will involve crewed sortie missions to both of the planet's moons and Mars surface investigations using low latency tele-operated assets.

ATHENA: The Airborne Thermal Navigation Assistant	Petroleum Hall
Presenter	Dr. Lynnane George of Colorado Technical University
Authors	Dr. Lynnane George

Today's glider pilots rely on experience and knowledge of the land to successfully navigate through the air to reach thermals that provide lift. Students in the Electrical and Computer Engineering department at CTU are developing a sensing unit that displays near real-time data on thermals. We adapted a thermal sensor to a glider that wirelessly communicates with a tablet and displays the surrounding temperature. The sensor gathers data from the surrounding area in an underdetermined field of vision and wirelessly transmits that data collected to a tablet in the cockpit. An android based app overlays the temperature of the surrounding area on a topographical map for viewing by the pilot. This allows the pilot to see near real-world data and adjust the glider's course to the most efficient route. ATHENA will allow pilots to increase their flight times as well as help instructor pilots provide better feedback to their students.

Mathematical Modeling and Experimental Analysis of a Rubens' Tube	GC 210N
Presenter	C1C Kyra Schmidt of United States Air Force Academy
Authors	C1C Hunter Stephens , Dr. Lubov Andrusiv

The purpose of this project was to build and analyze a Rubens' Tube to compare its characteristics to those derived from a mathematical model. The Rubens' Tube was developed in 1905 by Heinrich Rubens and Otto Krigar-Menzel as a visual representation of the propagation of standing waves in a tube. The experimental Rubens' Tube was modeled using the wave equation to theoretically calculate natural frequencies and corresponding mode shapes. The vibrational response was calculated for the different boundary conditions used in the experimental measurements. The theoretical results showed that the wave equation model was valid for sound waves traversing the tube; however, there were differences between the predicted and actual frequencies at which standing waves would occur due to the effects of interference. In addition, this project presents an analysis of the experiment for a broad range of frequencies and the resultant effect on the standing waves.

QB50 Challenger: Integration, Testing and Technical Challenges	GC 210S
Presenter	Andrew Dahir of the University of Colorado Boulder
Authors	Andrew Dahir and Scott Palo

The University of Colorado Boulder has a rich history of successful cubesats through the Aerospace Engineering Department. The most recent cubesat to be completed is part of a multi-university project titled QB50, led by the Von Karman Institute of Fluid Dynamics. The purpose of this mission is a constellation of cubesats flying specified scientific sensors which include an ion-neutral mass spectrometer, a Langmuir probe or a FIPEX oxygen sensor to take measurements in the lower thermosphere. The University's QB50 cubesat, named Challenger, builds upon the satellite heritage from the Colorado Student Space Weather Experiment and Miniature X-Ray Spectrometer cubesats. The satellite system for QB50 Challenger was designed, built, integrated and tested by students in the Space Technology Integration lab through a graduate projects course. This presentation will provide an overview of the technical challenges and focus on the Integration and Testing Challenger.

Colorado Leads The Way In Interplanetary Space	Friedhoff I
Presenter	Andrew H. Grimes of Lockheed Martin Space Systems Company
Authors	Andrew H. Grimes

Lockheed Martin Space Systems Company in Littleton, Colorado actively supports several operational interplanetary science missions for NASA. These missions include Spitzer, Mars Odyssey, MRO, MAVEN, Juno, and OSIRIS-Rex. Lockheed Martin Space Systems Company also has one mission in development, InSight. This presentation will give an overview of the status of these missions, discuss some of the important scientific discoveries each mission has enabled, and update the audience on our newest missions.

Reconfigurable Weapons Rack for Fighter Aircraft	Petroleum Hall
Presenter	Lt Col Mike Anderson & Captain Kaz Teope of United States Air Force Academy
Authors	Kaz I. Teope , Daniel L. Jensen , Evan M. Fortney , and Michael L. Anderson

The characteristically small weapons bays on small fighter sized aircraft along with the last in, first out method for employing air to ground munitions provides an opportunity for innovative weapon rack designs to maximize efficiency of munition employment. Two novel designs were developed to maximize the effectiveness of current and future weapons systems. Mathematical models were developed and simulation analyses in Solidworks were accomplished to determine feasibility of the designs. Analysis showed that the designs were able to meet a factor of safety of 1.3 or greater for all cases analyzed and a functional model was built to test critical functions. Pivoting and raise/lower rate were tested on the functional model and the designs met the 5 second completion time requirement. Future work would entail aerodynamic computational fluid dynamics analysis and full scale prototype testing.

Mechanics of 3D Printed Materials and Structures	GC 210N
Presenter	Dhruv Bhate of Phoenix Analysis & Design Technologies, Inc. (PADT)
Authors	Dhruv Bhate

One of the key challenges in the implementation of 3D Printing or Additive Manufacturing (AM) for functional part production is being able to reliably predict the performance of parts made with these technologies. From the mechanics perspective, there are three main aspects of building this predictive capability: theoretical models that describe how these materials and structures behave, material parameters derived through characterization and finally, the coupled use of the models and parameters in predictive models, be they analytical or numerical. In this presentation, we review the different models available today and make the case for a non-empirical, physics-based approach to developing constitutive and failure models for AM processes. Our approach involves the use of established analytical theory along with experimental characterization and numerical simulation - we show how using all three approaches in a complementary nature allows us to resolve problems with this level of complexity.

Environmental and Engineering Applications Using Unmanned Aerial Vehicles	GC 210S
Presenter	Arthur Hirsch of TerraLogic
Authors	Arthur Hirsch

Unmanned Aerial Vehicles (UAVs) are now being recognized as a new and innovative way to manage environmental resources and infrastructure within right of way areas and areas of roadway expansion. UAVs provide a new civil engineering tool for transportation operations such as bridge inspections and asset management. The integration of GIS based mapping, spectral sensors and flight platforms has provided a new way to identify, map and manage risk areas. Right of way applications can range from vegetation and noxious weed mapping, wetland mitigation monitoring, impact assessments, revegetation and erosion control management to stormwater Best Management Practices (BMP) maintenance. Art Hirsch from TerraLogic, LLC (Boulder, Colorado) a transportation environmental engineering consultant will provide a presentation entitled “Environmental and Engineering Applications for UAVs”. Environmental and engineering applications that are being used internationally and in the United States will be discussed with an emphasis on roadway systems.

Mechanical properties of lunar simulants in vacuum	Friedhoff I
Presenter	Christopher B. Dreyer of Colorado School of Mines
Authors	Christopher B. Dreyer, Angel Abbud-Madrid, Alex Lampe, Tasha Markley, Travis Canney, Joseph Haines
The Colorado School of Mines has developed an experimental apparatus, called the In-situ Resource Utilization Experimental Probe (IEP) for the study of mechanical properties of planetary surface material in vacuum and at cryogenic temperatures as part of the IMPACT SSERVI, PI M. Horanyi, CU LASP. The mechanical properties of planetary surface material are of great importance for the development of systems that would interact with theses surfaces and to advance our understanding of planetary surfaces. The effect of different vacuum pumping speeds on the strength of JSC1-a (a lunar regolith simulant) and differences in-air versus in-vacuum as measured with a cone penetrometer with different levels of compaction will be discussed.	

Open Source Standards for Flight Rated Software	Petroleum Hall
Presenter	Jay David (JD) Marks of Red Canyon
Authors	JD Marks
Historically, aerospace flight software has been developed on a program-by-program basis without regard to any industry standard architectures. The cost of this customized approach has been absorbed into the overall cost associated with providing unique, specialized hardware. Limited budgets, small satellites, and unmanned aerial vehicles make this approach to FSW development impractical. In response to these issues, NASA has developed open source software as solution. The Core FSW Executive & Operating System Abstraction Layer are two examples of their advances. These products were used to demonstrate the feasibility of providing functionality for UAV flight applications. Providing common hardware interfaces and a standardized software infrastructure will drastically reduce delivery costs especially in the areas of development, integration, verification & validation. This methodology will also provide the ability to create new businesses, especially small specialized providers.	

Structural Mechanics of High Precision Slit-Tube Boom Deployer	GC 210N
Presenter	TJ Rose of Roccor LLC, Longmont Colorado
Authors	TJ Rose
Roccor LLC, based in Longmont, Colorado has developed several composite-based slit tube deployment mechanisms that have demonstrated precision deployment capabilities. Using a composite boom provides several advantages including thermal stability, improved strength, geometric design flexibility and the opportunity to embed electrical conductors. The Roccor team has recently developed a deployment mechanism that not only demonstrates precision deployment but also the capability to support column compression loading. Higher load capacities give this deployer the capability of deploying and supporting tensegrity structures as well as pushing out large instruments that require relative isolation from the spacecraft, or even push-off applications. This talk will provide an overview of the fundamental theory Roccor has developed to support and deploy composite slit-tube booms. Topics covered will include support requirements, thin shell slit-tube column degrees-of-freedom, and axial support methodology used during and after deployment	

Standard Lithium Ion Cell for Space Applications	GC 210S
Presenter	Jim Lee of Lockheed Martin
Authors	Jim Lee
In the last decade, lithium-ion batteries have become the standard energy storage solution for satellite applications. There is currently no industry standard for large lithium-ion cells for space applications. In order to reduce the industrial base risk and also provide cost reductions from supplier competition, we are in the process of releasing an AIAA specification for a large format lithium-ion space cell. The heritage of this cell stems from an effort originated by the US Government to in early 2000s to create a standard cell. The first generation cells (using an LCO chemistry) have been under life test for many years and are preforming well in the different orbital regimes (low earth orbit, medium earth orbit and the geosynchronous orbit). Lockheed Martin will begin life testing the second generation cells (using an NCA chemistry) in 2016 joining two other government agencies who started testing earlier this year.	

PANEL International Collaboration in Aerospace 4:00pm

International partnerships are an increasingly important aspect of today's aerospace business. These partnerships offer economic and technical advantages but also invite a number of challenges especially with respect to security, regulation, and cultural dynamics. In this panel our moderator, Kay Sears, will lead the panelists through a discussion of their experiences in international collaboration.

Panel Moderator

Kay Sears
VP of Strategy & Business Development
Lockheed Martin Space Systems

Paul Marshall
Assistant Program Manager, Orion
NASA Johnson Space Center

John Roth
VP Business Development
Sierra Nevada Corporation Space Systems

Scott Alexander
VP Business Development
Teledyne Brown Engineering

Michael McGrath
Director of Engineering
Laboratory for Atmospheric & Space Physics

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