AIAA Rocky Mountain Section
4th Annual Technical Symposium

November 6th, 2015

Contents

Diamond Sponsor: Lockheed Martin Space Systems Company

Message from the 2015 AIAA-RM ATS Chair

Ladies and Gentlemen,

The AIAA Rocky Mountain Section is proud to offer you a section-wide event to call your own. The 2015 AIAA-RM Annual Technical Symposium aims to highlight new ideas, methodologies, concepts, and technical innovations developed within the aerospace industry and academia in the Rocky Mountain Region. 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 especially proud to have such a large number of our local area college students and young professionals in attendance this year, who together represent the future of our industry.

We would like to take this opportunity to extend our appreciation those who have made this event possible. First, we would like to thank the Colorado School of Mines, including Dr. Paul Johnson, Dr. Kevin Moore, and Dr. Angel-Abbud Madrid for hosting and co-sponsoring this year's event. Next, we would like to offer our gratitude all of our AIAA-RM volunteers that have worked so hard to make this such a huge success. A big thank-you to Heather McKay, Tracy Copp, Taylor Lilly, John Grace, Scott Tuttle, and many others that have helped along the way. We would also like to thank all of our sponsors and affiliated organizations. Please be sure to take a moment to view the list of sponsors and to express your thanks in person. Specifically, we would like to recognize this year's Diamond Sponsors including Lockheed Martin Space Systems Company, Advanced Solutions Inc., 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 2015 AIAA-RM Annual Technical Symposium.

Tyler Franklin
AIAA-RM 2015 ATS Chair
Lockheed Martin Space Systems Company
Orion APW Manufacturing Engineer

Paul Anderson
AIAA-RM President 2015-16
Lockheed Martin Space Systems Company
Orion Program Avionics Director

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AGENDA

Time	Friedhoff Hall	Petroleum Hall	GC 210S	GC 215
7:30am - 8:30am	Registration and Breakfast			
8:30am - 9:15am	Kickoff Welcome by CSM President, Dr. Johnson and Lockheed Sponsor Presentation by Roger McNamara			
9:20am - 9:45am	CubeSat CU + Multiple Groups Pre-launch Calibration and Performance Study of the POLARCUBE 3U Temperature Sounding Radiometer Mission	Unmanned Systems CSM Prognostics Informed Rover Mission Control	Satellite Propulsion CU Boulder Volumetrically Efficient Cold Gas Cubesat Propulsion	CFD University of Wyoming Transported PDF modeling of turbulent flames using the flamelet generated manifold chemistry model
9:45am - 10:10am	Solar Array Analysis ATA Engineering Design and Analysis Tools for Deployable Space-Based Structures	Industry Standards Space Infrastructure Foundation Freedom from Government Oversight: Open standards and Compliance Assessment Impact on the Front Range	Science/Modeling Other Development of 3-D Background Error Covariance Model for PATH	CFD UCCS Derived Measurement of the Enthalpy of Vaporization of Complex Fuels Using a Reduced Pressure Distillation Curve Approach
10:10am - 10:35am	Radar Science CU Boulder & Stone Aerospace An Autonomous Cryobot Synthetic Aperture Radar for Subsurface Exploration of Europa	Manned Spaceflight Sierra Nevada Dream Chaser Space Utility Vehicle	Space Imaging Ball Aerospace Control of Sparse Aperture Formations	CFD CU Boulder Non-Inertial Frame Simulations of Rigid Body Dynamics in a Discrete Gas
10:40am-11:35am	**PANEL** - Aerospace Initiatives in the Rocky Mountain Region	**PANEL** - Higher Education and Industry: Partners in Flight?		
11:40am	Lunch Start			
12:00pm-12:25pm	Sponsor presentation by Advanced Solutions Inc. (ASI) - John Cuseo			
12:25pm - 12:55pm	Keynote Speaker- Dr. Al Romig, Jr.			
12:55pm - 1:10pm	Sponsor/Poster Presentation Viewing			
	Friedhoff Hall	**Petroleum Hall**	**GC 210S**	**GC 210N**
1:10pm - 1:35pm	RocketSat CU Boulder Induction Heating in Microgravity	Manned Spaceflight Deep Space Engineering Camera System for Orion	Manned Spaceflight Webster University Mars Crew Selection: An Operations Research Approach	CFD University of Wyoming Elliptic Blending Reynolds Stress Model in Hybrid LES-RANS Methods for Application in Attached and
1:35pm - 2:00pm	Balloon Science Fort Lewis College Gamma Radiation and Vertical Electric Field Measurements During a Summer Balloon Flight	Manned Spaceflight Paragon Space Development Corp. StratEx Program Overview	Unmanned Systems CSM Using Weighted-Parameter Models in Autonomous Decision Making	Biology CSM Melanin as an Independent Barrier against Ionizing Radiation
2:00pm - 2:25pm	Materials Science Lockheed Martin Application of Uncoated Phosphoric Acid Anodize in Aerospace	Materials Science CEM-Tek 3-D Printing for Aerospace, Awesome But With Challenges	Unmanned Systems CU Boulder Feature Recognition and Matching in Light Detection Ranging (LIDAR) Images for Relative Position and Attitude Estimation	Biology CU Boulder Collection and Experimentation of Earth's Stratospheric Microbial Life
2:25pm - 2:40pm	Afternoon Snack/Break and Sponsor/Poster Presentation Viewing			
2:40pm - 3:05pm	Unmanned Systems USAFA User Defined Object Tracking for Automated Net Recovery of RPA	Special Test Equipment Red Canyon & Lockheed Martin Orion Power and Data Unit Avionics Special Test Equipment	Climate Science CU Boulder & JPL The Impact of Atmospheric Modeling Errors on GRACE Estimates of Antarctic Ice Mass Loss	Aero Science CU Boulder Spanwise Variation of Stall Flutter on a Flexible NACA 0018 Finite Span Wing
3:05pm - 3:30pm	Unmanned Systems Red Canyon A Case Study of Autonomous Mission Operations Using the Integrated Scheduler-Planner And Reactive Executive (I-SPAREX): Mars Reconnaissance Orbiter (MRO)	Electronics & Radiation JPL and CalTech Analysis and Simulations of Space Radiation Induced Single Event Transients (SET)	Atmospheric Science University of Northern Colorado POPACS Atmospheric Density Estimates	Propulsion UCCS Combustion and flame behaviors of endothermic fuels
3:35pm - 4:30pm	**PANEL** - Aerospace Leadership: Navigating a Successful Career	**PANEL** - The Next Frontier: New Aerospace Technologies		
4:35pm - 5:05pm	Sponsor presentation by Deep Space Systems Inc. (DSSI) - Steve Bailey and Closing Remarks			
5:30pm - 7:00pm	Post Conference Networking at Blue Canyon Bar & Grill (1224 Washington Ave, Golden; Walkable distance from the Green Center)			

Diamond Sponsor: Advanced Solutions Inc. (ASI)

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A Growing Company Building the Foundation for Next Generation Space

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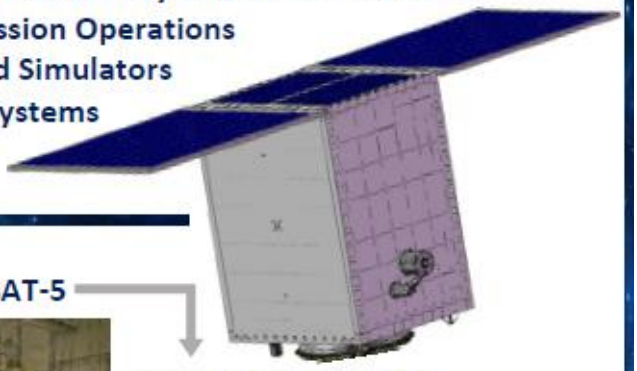
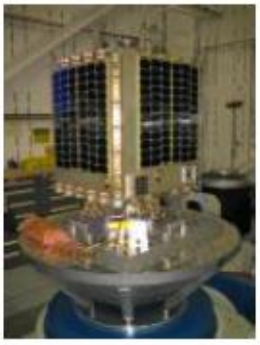


Leveraging Research to Reduce Barriers to Low-Cost Spaceflight

- *ASI supports the United States Air Force Academy (USAFA) on the FalconSAT program through an AFRL Phase III small business innovative research (SBIR) program*

FalconSAT-5



ASI-150 Satellite Bus
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- Low-Cost and Flight Proven
- ESPA Compliant up to 180 kg
- Flexible Payload Accommodation
- ΔV up to 1200 m/s (ASI-150EP)
- Designed for Efficient AI&T and Mission Operations

STK SOLIS Satellite Simulator

- One of many ASI products changing the way space missions are executed

Keep Your Mission, Spacecraft & Operations Teams on the Same Page from Mission Conception to Operations.

20 years of helping our customers succeed on the most challenging space missions

Recipient of Lockheed Martin's 2014 Rigel Award as the Orion Program's small business of the year

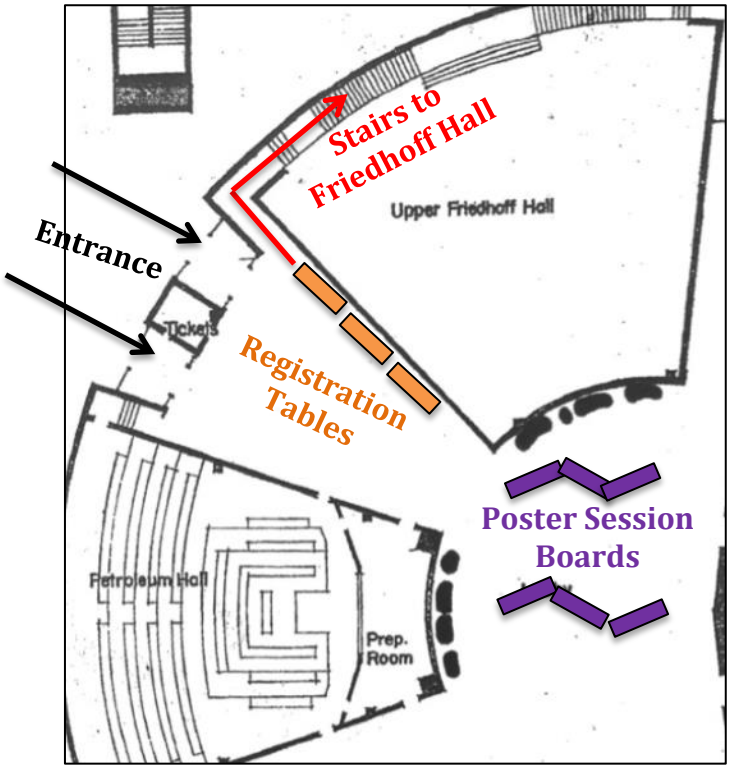
Diamond Sponsor: Deep Space Systems Inc. (DSSI)

Sponsors and Exhibitors

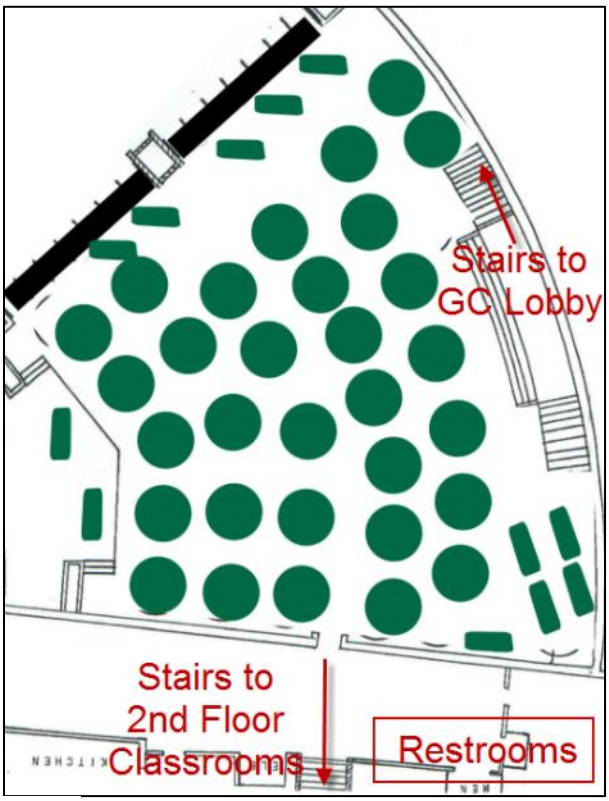
Conference Layout

REGISTRATION STARTS AT 7:30am

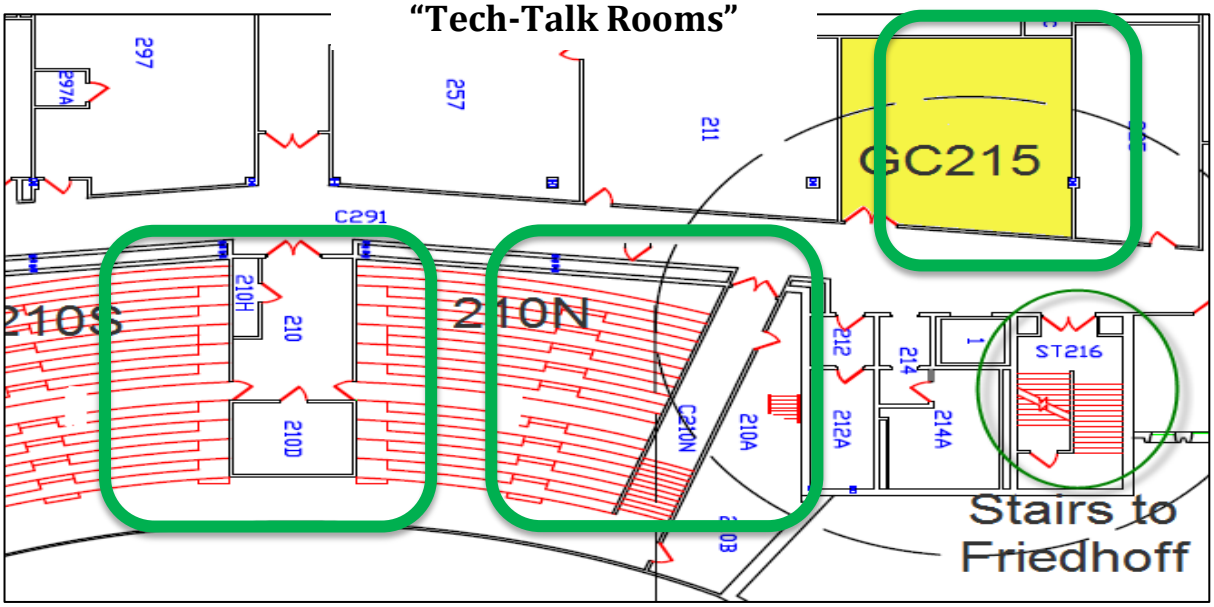
Green Center Lobby



Friedhoff Hall 1



Green Center 2nd Floor "Tech-Talk Rooms"



Morning Session Agenda

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9:45am - 10:10am	Solar Array Analysis ATA Engineering Design and Analysis Tools for Deployable Space-Based Structures	Industry Standards Space Infrastructure Foundation Freedom from Government Oversight: Open standards and Compliance Assessment Impact on the Front Range	Science/Modeling Other Development of 3-D Background Error Covariance Model for PATH	CFD UCCS Derived Measurement of the Enthalpy of Vaporization of Complex Fuels Using a Reduced Pressure Distillation Curve Approach
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9:20am-9:45am Technical Speaker Sessions

Friedhoff Hall	Petroleum Hall	GC 210S	GC 215
CubeSat	Unmanned Systems	Satellite Propulsion	CFD
CU + Multiple Groups	CSM	CU Boulder	University of Wyoming
Pre-launch Calibration and Performance Study of the POLARCUBE 3U Temperature Sounding Radiometer Mission	Prognostics Informed Rover Mission Control	Volumetrically Efficient Cold Gas Cubesat Propulsion	Transported PDF modeling of turbulent flames using the flamelet generated manifold chemistry model

Friedhoff Hall	**Title:**	Pre-launch Calibration and Performance Study of the POLARCUBE 3U Temperature Sounding Radiometer Mission
	Category:	CubeSat
	Affiliation:	CU + Multiple Groups
	Author(s):	Lavanya Periasamy, Albin J. Gasiewski, Brian Sanders, David Gallaher, Glenda Alvarenga, and Joshua Gordon
	Abstract:	The positive impact of passive microwave observations of tropospheric temperature, water vapor and surface variables on short-term weather forecasts has been clearly demonstrated in recent forecast anomaly growth studies. The development of a fleet of such passive microwave sensors especially at V-band and higher frequencies in low earth orbit using 3U/ 6U CubeSats could help accomplish the aforementioned objectives at low system cost and risk as well as provide for regularly updated radiometer technology. PolarCube, a 3U CubeSat that supports a 118.7503 GHz passive microwave sounder intends to serve as a demonstrator for such a fleet. The mission will focus on the study of Arctic vertical temperature structure and its relation to sea ice coverage, but include secondary goals of assessing potential for cloud mapping, cloud top altitude measurement, mesoscale convection and hurricane rain band mapping. The status of the instrument and spacecraft along with pre-launch testing will be presented.
Petroleum Hall	**Title:**	Prognostics Informed Rover Mission Control
	Category:	Unmanned Systems
	Affiliation:	CSM
	Author(s):	Adam R. Short and Douglas L. Van Bossuyt Ph.D.
	Abstract:	Robots are increasingly part of humanity's presence in space and vital to our exploration efforts. Problematically, the deeper humanity goes into space, the more unknowns must be faced and the longer the signal delays become. The question therefore arises of how can a system function for an extended period of time in an unknown, dangerous, and isolated environment. To address this problem, it must be broken into smaller parts, such as navigating a rover through with detectable hazards, navigating when hazards can only be detected after they affect the rover, effects of varying risk attitudes on the system, and combining these techniques to make a system that is optimized for survival. In our work, Prognostic and Health Management (PHM) based techniques were developed and evaluated for navigation of a simulated planetary rover through a hazardous environment. The tested techniques have been shown to be effective at increasing projected mission life.
GC 210S	**Title:**	Volumetrically Efficient Cold Gas Cubesat Propulsion
	Category:	Satellite Propulsion
	Affiliation:	CU Boulder
	Author(s):	Pulido Gerardo, Tyler Joy, Diego Gomes, Paige Arthur, and Peter Merrick
	Abstract:	Recent interest in cube satellites over the last few years has created interest in propulsion for small satellites. CubeSats, more than other satellites, are volume and power constrained, which pose challenges for implementation of CubeSat propulsion systems. R-134a propellant systems can provide low cost and efficient propulsion for impulse maneuvers, orbital maintenance, and attitude control for a CubeSat. The PROPSAT module is a cold-gas thruster for the COSGC ALLSTAR cube satellite, it is an all-aluminum structure that includes an internal propellant "tank" which stores liquid-phase R134a, a gas-phase cold-gas plenum, and the necessary valves, and sensors. The module is designed to extend the mission duration for cube satellites through orbital maintenance. The current design produces a ΔV of about 15 m/s over the mission life time. There is a large scope for expanding the utility of the PROPSAT module to other platforms.
GC 215	**Title:**	Transported PDF modeling of turbulent flames using the flamelet generated manifold chemistry model
	Category:	CFD
	Affiliation:	University of Wyoming
	Author(s):	Devalkumar Gajjar, Vasu Jaganath, Michael Stoellinger
	Abstract:	Numerical simulations of turbulent combustion using detailed reaction mechanism is computationally expensive. To reduce the computational cost, tabulated chemistry methods such as the flamelet generated manifold (FGM) method have been developed. In the FGM method the chemistry is reduced to the mixture fraction (a non-reacting scalar) and progress variable (a reacting scalar). For turbulent flames the FGM method is commonly combined with a presumed-shape PDF approach in which mixture fraction and progress variable are assumed to be independent. In this work we will detail the methodology to account for turbulence-chemistry interaction by solving the composition probability density function (PDF) transport equation with a Lagrangian Monte Carlo method. The proposed FGM/PDF method is implemented in open source CFD library OpenFOAM and the first results are shown. FGghFGM/FGM/PDF method is implemented in the open source CFD library Open-FOAM and first results will be shown.

9:45am-10:10am Technical Speaker Sessions

Friedhoff Hall	Petroleum Hall	GC 210S	GC 215
Solar Array Analysis	Industry Standards	Science/Modeling	CFD
ATA Engineering	Space Infrastructure Foundation	Other	UCCS
Design and Analysis Tools for Deployable Space-Based Structures	Freedom from Government Oversight: Open standards and Compliance Assessment Impact on the Front Range	Development of 3-D Background Error Covariance Model for PATH	Derived Measurement of the Enthalpy of Vaporization of Complex Fuels Using a Reduced Pressure Distillation Curve Approach

Friedhoff Hall	**Title:**	Design and Analysis Tools for Deployable Space-Based Structures
	Category:	Solar Array Analysis
	Affiliation:	ATA Engineering
	Author(s):	Laura Schweizer and Cory Rupp
	Abstract:	Solar electric propulsion (SEP) has been highlighted by NASA as a key technology for enabling future exploration missions across our solar system. Design of stronger SEP systems is highly dependent on development of larger spacecraft power sources, such as lightweight, deployable solar arrays. It is anticipated that future missions will require arrays with an order of magnitude larger deployed area than existing designs. Conflicting power and structural requirements for these arrays present a design task that is challenging to complete in a timely or cost-effective manner. To address this, ATA Engineering is developing a design and analysis toolset for rapid modeling and evaluation of solar array design spaces. The toolset enables engineers to extract valuable engineering data and insight at the early and intermediate design stages of deployable systems by enabling rapid parametric analysis and design optimization of entire classes of designs using only a single model.
Petroleum Hall	**Title:**	Freedom from Government Oversight: Open standards and Compliance Assessment Impact on the Front Range
	Category:	Industry Standards
	Affiliation:	Space Infrastructure Foundation
	Author(s):	Frederick A. Slane
	Abstract:	With a decline in federal funding for space and a growing commercial space industry the role of open standards is paramount to success. The major components of standards in an industry, judging from almost every other industry on the planet, consist of standards development and standards compliance. In the first, directly and materially interested parties collaborate to define the standards. In the second, self assessment, customer assessment and third party assessment (e.g., an Underwriter's Laboratory for space) are used. This paper explores the divergence from current government driven practices to a future of industry driven compliance assessment practices. For example, without FFRDC involvement industry will self assess on performance and act in response to that self assessment. Today third party government technical experts, paid for through project funds, assess performance. The change to an open standards basis will disrupt this conventional (for space, at least) technical power base. The Colorado region is in a prime position to exploit this change and be a catalyst for the space industry of the future.
GC 210S	**Title:**	Development of 3-D Background Error Covariance Model for PATH
	Category:	Science/Modeling
	Affiliation:	CU Boulder, EDE Dept.
	Author(s):	Kun Zhang
	Abstract:	The Precipitation and All-weather Temperature and Humidity (PATH) mission identified by the NRC decadal survey in 2007 will provide the potential for "hydrometric tracking" of Numerical Weather Prediction (NWP) models to large individual precipitation cells under conditions of rapidly evolving mesoscale convection. Under development to explore this potential is a real-time all-weather hydrometric tracking system based on iterative extended Kalman filtering and fast forward radiative transfer modeling. Realization of hydrometric tracking requires the development of a state-dependent local background error covariance model with practical computability and local inversion capability. Such a model is being developed, in part, using LEO passive microwave data from AMSU, ATMS and airborne radar, passive microwave data from GRIP. The resulting error covariance model will specifically provide both horizontal and vertical correlation products suitable for ~50 x 50 km local 3DVar assimilation of up to a nominal 25 channel PATH data cube.
GC 215	**Title:**	Derived Measurement of the Enthalpy of Vaporization of Complex Fuels Using a Reduced Pressure Distillation Curve Approach
	Category:	CFD
	Affiliation:	UCCS
	Author(s):	Stephen Burke, Janel Owens, and Bret Windom
	Abstract:	During the vaporization process of a fuel droplet, the composition changes as the fluid is being distilled. This results in transitioning thermo-physical and chemical properties, yet typical vaporization models assume constant properties, primarily because of the lack of data available for complex fuels as a function of fluid distilled. One particular property of interest is the enthalpy of vaporization (Hfg). The Clausius-Clapeyron equation can be rewritten to provide an expression for Hfg. Based on this expression, Hfg can be determined with the knowledge of the fluid's vapor liquid equilibrium (VLE) at varying pressures. A variable pressure distillation apparatus is used in concert with thermodynamic principles to evaluate the enthalpy of vaporization as function of volume distilled. This technique is applied to determine the varying Hfg of diesel fuel, Jet A, and a mixture of reference alkanes, and is validated by comparing values determined using a previously published composition-based technique.

10:10am-10:35am Technical Speaker Sessions

Friedhoff Hall	Petroleum Hall	GC 210S	GC 215
Radar Science	Manned Spaceflight	Space Imaging	CFD
CU Boulder & Stone Aerospace	Sierra Nevada	Ball Aerospace	CU Boulder
An Autonomous Cryobot Synthetic Aperture Radar for Subsurface Exploration of Europa	Dream Chaser Space Utility Vehicle	Control of Sparse Aperture Formations	Non-Inertial Frame Simulations of Rigid Body Dynamics in a Discrete Gas

Friedhoff Hall	**Title:**	An Autonomous Cryobot Synthetic Aperture Radar for Subsurface Exploration of Europa
	Category:	Radar Science
	Affiliation:	CU Boulder & Stone Aerospace
	Author(s):	Omkar Pradhan, Albin Gasiewski, Bill Stone, and Vickie Siegel
	Abstract:	We present the design and field testing results of a forward-looking endfire synthetic aperture radar (SAR) for the 'Very deep Autonomous Laser-powered Kilowattclass Yoyoing Robotic Ice Explorer' (VALKYRIE) ice-penetrating cryobot. This design demonstrates critical technologies that will support an eventual landing and ice penetrating mission to Jupiter's icy moon, Europa. Results proving the feasibility of an endfire SAR system for vehicle guidance, obstacle avoidance and mapping in a subsurface ice environment will be presented. The project consists of two parts, (i) design and testing of an array of four conformal cavity-backed log-periodic folded slot dipole array antennas that form agile radiating elements, (ii) design and testing of of a radar system that includes RF signal generation, 4x4 transmit receive antenna switching and isolation and digital SAR data processing. Testing and validation was carried out at CET, Stone Aerospace facility in Austin and Matanuska glacier in Alaska.
Petroleum Hall	**Title:**	Dream Chaser Space Utility Vehicle
	Category:	Manned Spaceflight
	Affiliation:	Sierra Nevada
	Author(s):	John Roth
	Abstract:	Dream Chaser is an autonomous, lifting body, crewed or uncrewed space vehicle developed under a public-private partnership between Sierra Nevada Corporation (SNC) and NASA. The vehicle is under consideration for the Commercial Resupply Services 2 contract for NASA to ferry cargo to the International Space Station and return science payloads to a gentle runway landing. SNC has also signed cooperative agreements with the European Space Agency (ESA), German Aerospace Center (DLR), and Japanese Space Agency (JAXA) to evaluate using Dream Chaser for international science and servicing missions. The presentation will provide an overview of Dream Chaser and a discussion of the various space missions it can support.
GC 210S	**Title:**	Control of Sparse Aperture Formations
	Category:	Space Imaging
	Affiliation:	Ball Aerospace
	Author(s):	Ian J. Gravseth, Scott Acton, and Scott Knight
	Abstract:	Sparse apertures deployed on-orbit have many distinct advantages over traditional monolithic observation platforms: larger apertures, individually replaceable components within the system, observational flexibility, and individual component maneuverability. Although there are additional technical hurdles to overcome versus a traditional observational platform approach, recent advances in relative position sensing, precise mirror control and formation flying indicate that a sparse aperture system can be developed and demonstrated on-orbit. This presentation will discuss a notional architecture for a sparse aperture and methods for controlling it.
GC 215	**Title:**	Non-Inertial Frame Simulations of Rigid Body Dynamics in a Discrete Gas
	Category:	CFD
	Affiliation:	CU Boulder
	Author(s):	Nicholas S. Campbell and Brian Argrow
	Abstract:	The state of DSMC methods and computational performance enable the realization of complex real-gas simulations. These are essential for the design and analysis of space and atmospheric flight vehicles operating in the rarefied to near continuum flow regimes. The superiority of using a discrete method to capture non-equilibrium flow phenomena could make the DSMC technique an important asset in understanding the nonlinear motion of flight vehicles high in an atmosphere. The current work considers the feasibility of simulating rigid body flight through a discrete-gas in a non-inertial reference frame. Non-inertial frame mechanics have been employed for simulating internal flows in past applications of the DSMC method. The current talk will discuss the intricacies and benefits of taking a non-inertial frame approach to a discrete-forces in-loop, flight dynamics solver. Results from verification studies in the collisionless flow limit will be presented and potential limitations of the method will be considered.

PANEL – Aerospace Initiatives in the Rocky Mountain Region (10:40am)

This panel aims to explore the interaction between the current public policy environment, the creation/maintenance of aerospace jobs, and a healthy, robust aerospace economy here in Colorado. The panel will discuss ongoing efforts to shape public policy that will continue to promote Colorado's blossoming aerospace industry (The 2nd Largest in the Nation!).

	**Congressman Ed Perlmutter** *US Representative (D - CO 7th District) since 2007*
	**Joe Rice** *Director of Government Relations for Lockheed Martin Space Systems and Former Colorado State Representative*
	**Dr. Michael Gazarik, Ph.D.** *Technology Director at Ball Aerospace, Former NASA Associate Administrator for the Space Technology Mission Directorate*
	**Art Maples** *Director of Strategic Partnerships – Colorado Space Technology Mission Directorate*
	**Edgar Johannsen** *Colorado Space Business Round Table*

PANEL - Higher Education and Industry: Partners in Flight? (10:40am)

This panel will host a productive discussion between university representatives and industry leaders on the needs and aspirations from both academia and industry. We will explore what efforts to prepare the future engineers are effective, which are not, and discuss potential areas of future collaboration between Colorado universities and aerospace industry leaders.

	**Stan Kennedy** *Oakman Aerospace President and Chief Systems Engineer*
	**Prof. Scott Palo** *University of Colorado, Boulder Associate Dean of Research in the College of Engineering*
	**Jim Paradise** *Senior Engineer at LMSSC, Engineering Initiatives Lead: ELDP, NEROP, Staffing, Employee Engagement, and STEM Outreach*
	**Jeffrey Forrest** *Chair & Professor, Aviation & Aerospace Science, Metropolitan State University*
	**Robert Belcher** *Business Development Executive at Jeppesen-Boeing*
	**Taylor Lilly** *UCCS Mechanical & Aerospace Engineering Assistant Professor*

Keynote Speaker Bio

Dr. Al D. Romig, Jr.
Executive Officer
National Academy of Engineering

Alton D, Romig, Jr. is the Executive Officer of the National Academy of Engineering. Under Congressional charter, the Academy provides advice to the federal government, when requested, on matters of engineering and technology. As Executive Officer, Dr. Romig is the Chief Operating Officer responsible for the program, financial and membership operations of the Academy, reporting to the President. Prior to joining the Academy, he served as Vice President and General Manager of Lockheed Martin Aeronautics Company Advanced Development Programs, better known as the Skunk Works ®. Dr. Romig spent the majority of his career at Sandia National Laboratories, operated by the Lockheed Martin Corporation. He joined Sandia as a Member of the Technical Staff in 1979 and moved through a succession of R&D management positions leading to appointment as Executive Vice President in 2005. He served as the Deputy Laboratories Director and Chief Operating Officer until 2010 when he transferred to the Skunk Works.

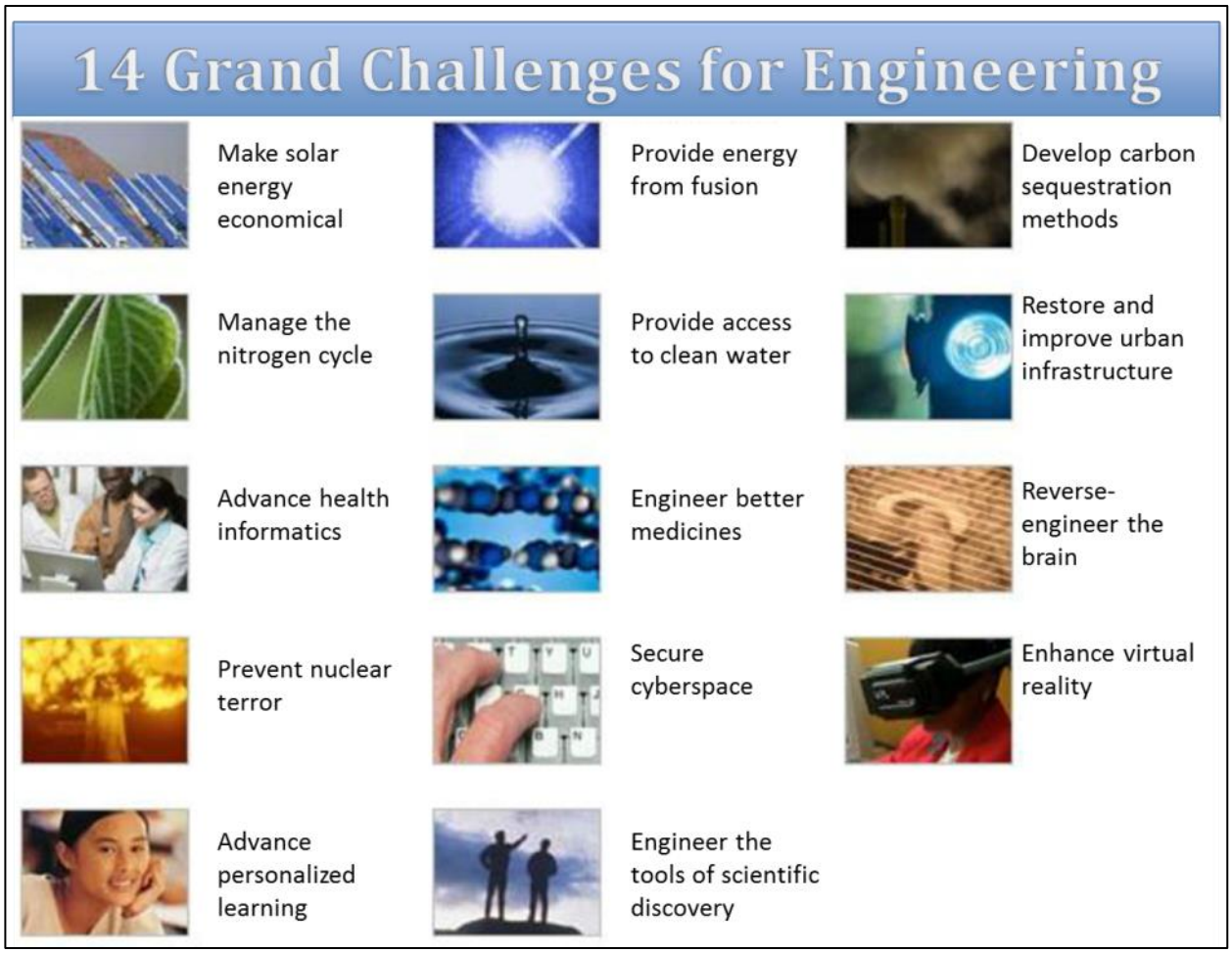
Dr. Romig graduated from Lehigh University in 1975 with a BS in Materials Science and Engineering. He received his MS and PhD in Materials Science and Engineering from Lehigh University in 1977 and 1979, respectively. Dr. Romig is a Fellow of ASM International, TMS, IEEE, AIAA and AAAS. Dr. Romig was elected to the National Academy of Engineering in 2003 and the Council of Foreign Relations in 2008. He was awarded the ASM Silver Medal for Materials Research in 1988.

Keynote Speaker (11:35 am): Dr. Al D. Romig, Jr.

The National Academies and the Nation's Aerospace Program

Established by an Act of Congress signed by President Abraham Lincoln in 1863, the National Academy of Sciences is a private, non-profit institution providing independent scientific and technical advice to the nation whenever called upon. Since its founding, the Academy, including the National Research Council (established 1916), National Academy of Engineering (established 1964) and National Academy of Medicine (established 1970), has undertaken thousands of studies in a variety of areas. Although founded during wartime, the Academy has performed valuable and important work for the nation over a wide range of topics in both peacetime and wartime. Aviation and space have been a focus of the academies for almost the past 100 years.

We will explore the highlights of the work, starting with the first involvement in 1916 with the establishment of the National Advisory Committee on Aeronautics to very recent studies on topics such as "3D Manufacturing in Space". Many great engineering trials remain. It is our duty as engineers to enhance lives of humans around the world by seeking solutions to these global challenges.



Afternoon Session Agenda

	Friedhoff Hall	Petroleum Hall	GC 210S	GC 210N
1:10pm - 1:35pm	RocketSat CU Boulder Induction Heating in Microgravity	Manned Spaceflight Deep Space Engineering Camera System for Orion	Manned Spaceflight Webster University Mars Crew Selection: An Operations Research Approach	CFD University of Wyoming Elliptic Blending Reynolds Stress Model in Hybrid LES-RANS Methods for Application in Attached and Separated Flows
1:35pm - 2:00pm	Balloon Science Fort Lewis College Gamma Radiation and Vertical Electric Field Measurements During a Summer Balloon Flight	Manned Spaceflight Paragon Space Development Corp. StratEx Program Overview	Unmanned Systems CSM Using Weighted-Parameter Models in Autonomous Decision Making	Biology CSM Melanin as an Independent Barrier against Ionizing Radiation
2:00pm - 2:25pm	Materials Science Lockheed Martin Application of Uncoated Phosphoric Acid Anodize in Aerospace	Materials Science CEM-Tek 3-D Printing for Aerospace, Awesome But With Challenges	Unmanned Systems CU Boulder Feature Recognition and Matching in Light Detection Ranging (LIDAR) Images for Relative Position and Attitude Estimation	Biology CU Boulder Collection and Experimentation of Earth's Stratospheric Microbial Life
2:25pm - 2:40pm	Afternoon Snack/Break and Sponsor/Poster Presentation Viewing			
2:40pm - 3:05pm	Unmanned Systems USAFA User Defined Object Tracking for Automated Net Recovery of RPA	Special Test Equipment Red Canyon & Lockheed Martin Orion Power and Data Unit Avionics Special Test Equipment	Climate Science CU Boulder & JPL The Impact of Atmospheric Modeling Errors on GRACE Estimates of Antarctic Ice Mass Loss	Aero Science CU Boulder Spanwise Variation of Stall Flutter on a Flexible NACA 0018 Finite Span Wing
3:05pm - 3:30pm	Unmanned Systems Red Canyon A Case Study of Autonomous Mission Operations Using the Integrated Scheduler-Planner And Reactive Executive (I-SPAREX): Mars Reconnaissance Orbiter (MRO)	Electronics & Radiation JPL and CalTech Analysis and Simulations of Space Radiation Induced Single Event Transients (SET)	Atmospheric Science University of Northern Colorado POPACS Atmospheric Density Estimates	Propulsion UCCS Combustion and flame behaviors of endothermic fuels
3:35pm - 4:30pm	**PANEL -** Aerospace Leadership: Navigating a Successful Career	**PANEL -** The Next Frontier: New Aerospace Technologies		
4:35pm - 5:05pm	Sponsor presentation by Deep Space Systems Inc. (DSSI) - Steve Bailey and Closing Remarks			
5:30pm - 7:00pm	Post Conference Networking at Blue Canyon Bar & Grill (1224 Washington Ave, Golden; Walkable distance from the Green Center)			

1:10pm - 1:35pm Technical Speaker Sessions

Friedhoff Hall	Petroleum Hall	GC 210S	GC 210N
RocketSat	Manned Spaceflight	Manned Spaceflight	CFD
CU Boulder	Deep Space	Webster University	University of Wyoming
Induction Heating in Microgravity	Engineering Camera System for Orion	Mars Crew Selection: An Operations Research Approach	Elliptic Blending Reynolds Stress Model in Hybrid LES-RANS Methods for Application in Attached and Separated Flows

Friedhoff Hall	**Title:**	Induction Heating in Microgravity
	Category:	RocketSat
	Affiliation:	CU Boulder
	Author(s):	Kristian Kates, Tyler Joy, April Olson, and Ashley Zimmerer
	Abstract:	The Colorado Space Grant Consortium's RocketSat-10 team at the University of Colorado at Boulder, with guidance from the Air Force Research Laboratory, is researching material science in a microgravity environment. The experiment was conducted at an altitude of 150 km on a Terrier Improved Malemute sounding rocket from NASA's Wallops Flight Facility. The objective was to melt and resolidify a sample of aluminum and indium in microgravity within three minutes. To accomplish this, the team designed a small-scale induction heating system. Induction heating in space broadens the applications for not only material science research but could lead to innovations in space-based additive manufacturing, annealing, and heat treatments.
Petroleum Hall	**Title:**	Engineering Camera System for Orion
	Category:	Manned Spaceflight
	Affiliation:	Deep Space
	Author(s):	Stephen A Bailey, Giuseppe R Pasqualino, John K Evanyo, and Katherine S Beseda
	Abstract:	Deep Space Systems (DSS) is supporting Lockheed Martin Space Systems Company in the development of an engineering camera systems for the Orion Multipurpose Crew Vehicle (MPCV). This high performance camera system is derived from commercial hardware that has been screened and modified for compatibility with the radiation, shock, vibration, thermal, and electromagnetic environments and requirements of the Orion system. The engineering camera flight system system includes: 1) four USB3.0 cameras derived from a PixeLINK machine vision camera, 2) seven 802.11n wireless cameras derived from a GoPro Hero4 action camera, and 3) two central Camera Controller units that incorporate an Intel NUC i5 computer. We will summarize: the progress to date on the Proton and Heavy Ion Radiation, Thermal Vacuum, Shock, and Vibration Testing, the modifications required for space flight qualification, and the challenges that remain.
GC 210S	**Title:**	Mars Crew Selection: An Operations Research Approach
	Category:	Manned Spaceflight
	Affiliation:	Webster University
	Author(s):	Dr. Lynnane George and William Eastburn
	Abstract:	This presentation will show how Operations Research using binary programming techniques provides an objective means to select a crew for an estimated 36 month-long manned mission to Mars. Our results are applicable to any number of other situations, where an objective and effective selection process is required to balance the mission objectives with the constraints and distinguish between large numbers of outstanding candidates. In the sample case of a manned mission to Mars, we took our scientific objectives and derived constraints from NASA Standard 3001, NASA Spaceflight Human System Standard. Other factors considered were biomedical data showing the effects on astronauts during long-term space missions. We began with a sample pool of 20 US and international astronauts and used our program to identify a crew and crew positions. This binary programming tool is easily adapted to new requirements and constraints and will be relevant to future NASA Mars mission planners.
GC 210N	**Title:**	Elliptic Blending Reynolds Stress Model in Hybrid
	Category:	CFD
	Affiliation:	University of Wyoming
	Author(s):	Rajib Roy and Michael Stoellinger
	Abstract:	The performance of elliptic blending Reynolds stress model (RSMeb) used in hybrid PITM-RSMeb method is investigated. The RSMeb model directly solves the modeled transport equation. It is integrated upto the wall though an elliptic blending function and utilizes a novel formulation of homogeneous dissipation rate. It does not uses geometrical wall distance information which makes it suitable for complex ow simulation. The RSMeb model parameters are calibrated by using DNS results for a plane channel ow with friction Reynolds number Re = 2000. Then, the hybrid model is applied in three external aerodynamic cases: periodic hill ow at several Reynolds number, 2D NACA 4412 airfoil with trailing edge separation and FAITH Hill. Each of the test cases exhibits ow separation, recirculation and reattachment. The RSMeb model has been found very robust and the hybrid PITM-SMeb model demonstrates a signi cant quantitative improvement compared to pure RANS simulations.

1:35pm - 2:00pm Technical Speaker Sessions

Friedhoff Hall	Petroleum Hall	GC 210S	GC 210N
Balloon Science	Manned Spaceflight	Unmanned Systems	Biology
Fort Lewis College	Paragon Space Development Corp.	CSM	CSM
Gamma Radiation and Vertical Electric Field Measurements During a Summer Balloon Flight	StratEx Program Overview	Using Weighted-Parameter Models in Autonomous Decision Making	Melanin as an Independent Barrier against Ionizing Radiation

Friedhoff Hall	**Title:**	Gamma Radiation and Vertical Electric Field Measurements During a Summer Balloon Flight
	Category:	Balloon Science
	Affiliation:	Fort Lewis College
	Author(s):	Eric Hicks, Robert Rothschild, Megan Chambellan, and Charles Hakes
	Abstract:	Details of the Fort Lewis College payloads on two Colorado Space Grant Consortium balloon flights are presented. Two primary and two supporting payloads are discussed. One primary experiment uses a Geiger-Muller tube to record gamma radiation as a function of altitude. The second primary experiment records the magnitude of the vertical electric field by means of a homemade electric field mill. An additional goal of this experiment is to explore the feasibility of constructing an inexpensive, sensitive, and durable field mill from low-cost, easily obtainable components. The design and calibration of the electric field mill is discussed. One supporting payload provides temperature measurements and regulation to the other payloads. The second supporting payload functions as a power monitoring system and records the voltage and current draw from separate batteries going to each payload. Results from a completed summer flight and plans for a fall re-flight are presented.
Petroleum Hall	**Title:**	StratEx Program Overview
	Category:	Manned Spaceflight
	Affiliation:	Paragon Space Development Corp.
	Author(s):	Norman Hahn
	Abstract:	On October 24, 2014 Alan Eustace and the StratEx program established a new world record for the highest altitude sky dive at 135,890 ft. This presentation will first talk about the new record holder and the StratEx team. Then the key hardware components will be described along with the extensive testing done to ensure the systems would work in the highly variable environment of the mission profile. The workings of the different operations teams will then be described to show how the small team was able to pull off such a complex mission. Finally, the manned flight campaign will be reviewed along with the records set and innovations developed.
GC 210S	**Title:**	Using Weighted-Parameter Models in Autonomous Decision Making
	Category:	Unmanned Systems
	Affiliation:	CSM
	Author(s):	Zac Mimlitz
	Abstract:	Remotely operated research vehicles, such as NASA's rovers on Mars, face many challenges in operating efficiently and autonomously. Hazard response and damage mitigation both require rapid responses in order to maintain vehicle operations and when limited on-board processing power making complex processing algorithms impractical to use, weighted-parameter models provide a light-weight solution for on-board risk-based, prognostic-enabled decision making. They allow the vehicles to autonomously consider large numbers of situational parameters, weighted with predetermined significance, and determine the best possible response, using only simple mathematical operations. By varying the parameters, their weights, and by using different interpretation techniques, this method can provide a wide range of possible decision making mentalities suiting any situation. This presentation outlines several parameter selection models, methods for tuning the weights to optimize performance and efficiency using simulations, and techniques for interpreting the results and applying them to vehicle behavior.
GC 210N	**Title:**	Melanin as an Independent Barrier against Ionizing Radiation
	Category:	Biology
	Affiliation:	CSM
	Author(s):	Carroll Olson
	Abstract:	The experiment Melanin as a Barrier against Ionizing Radiation, used melanin in human skin cells as a barrier against ionizing radiation. Because of the chemical composition of melanin, it reflects and absorbs UV radiation well, and was effective in lessoning the damage to skin cells from this type of radiation on tissue samples sent to 97,000 feet. Synthetic eumelanin was then used to create a barrier around a microorganism that traveled to 91,000 feet. There were more viable cells in the protected samples than in the unprotected samples, upon their return. Next, a transgenic yeast that expresses UV screening pigmentation genes of Micrococcus luteus will be developed. A single yeast can then be created that would express multiple pigmentation genes (including those responding to wavelengths of radiation outside of UV), and used as an artificial barrier in space against a large spectrum of radiation.

2:00pm - 2:25pm Technical Speaker Sessions

Friedhoff Hall	Petroleum Hall	GC 210S	GC 210N
Materials Science	Materials Science	Unmanned Systems	Biology
Lockheed Martin	CEM-Tek	CU Boulder	CU Boulder
Application of Uncoated Phosphoric Acid Anodize in Aerospace	3-D Printing for Aerospace, Awesome But With Challenges	Feature Recognition and Matching in Light Detection Ranging (LIDAR) Images for Relative Position and Attitude Estimation	Collection and Experimentation of Earth's Stratospheric Microbial Life

Friedhoff Hall	**Title:**	Application of Uncoated Phosphoric Acid Anodize in Aerospace
	Category:	Materials Science
	Affiliation:	Lockheed Martin
	Author(s):	Aaron Anderson and Brent Zimmerman
	Abstract:	This presentation will examine uncoated Phosphoric Acid Anodize (PAA) as a possible alternative for coated FPL etch in fabricating satellites. PAA has a higher initial bond strength than FPL etch and may not require priming since oxidation and UV radiation are not as much of a concern. This would allow for cost and schedule benefits in fabricating satellite structures. The presentation includes a rough outline of a test plan to validate uncoated PAA's shelf life.
Petroleum Hall	**Title:**	3-D Printing for Aerospace, Awesome But With Challenges
	Category:	Materials Science
	Affiliation:	CEM-Tek
	Author(s):	Stan L. VanderWerf
	Abstract:	3-D printing is the next wave in advanced manufacturing and will change the landscape of all industries including the aerospace industry. This presentation will describe how 3-D printing is affecting R&D and production within the industrial sectors supported by AIAA. Today small airplanes can be manufactured in a single print. Tomorrow we will enable interplanetary missions as the printer will replace parts and tools used to maintain spaceships while on mission by reducing the need for a large parts and tool inventory. 3-D printing is also a fantastic technology for rapid prototyping and permits the production of components for fit and design checks before large sums are spent on injection molds or castings. If you are in the aerospace industry, you need to be familiar with this emerging technology and how you can use it in your company.
GC 210S	**Title:**	Feature Recognition and Matching in Light Detection Ranging (LIDAR) Images for Relative Position and Attitude Estimation
	Category:	Unmanned Systems
	Affiliation:	CU Boulder
	Author(s):	Caleb Lipscomb, Penina Axelrad, and Jay McMahon
	Abstract:	Autonomous satellite rendezvous and docking (ARD) is a challenging function required to support on-orbit satellite servicing. ARD relies on accurate knowledge of the relative position and orientation of the target satellite relative to the chaser vehicle. OLTAE1,4 is an estimation method that uses range data from a LIDAR sensor to estimate the orientation and position of a target relative to the chaser. OLTAE requires target satellite features in the LIDAR range data to be matched to the corresponding features of a model of the target. This work focused on automating the identification and matching of features in a range image to features on a model of the target satellite using the SURF-Corner Method (SCM). SCM uses a combination of two image processing techniques, corner identification2 and Speed Up Robust Features (SURF)3, to identify and match features in a target image to features on a model or reference image.
GC 210N	**Title:**	Collection and Experimentation of Earth's Stratospheric Microbial Life
	Category:	Biology
	Affiliation:	CU Boulder
	Author(s):	Melody Blackis and Haleigh Flaherty
	Abstract:	Few experiments have examined the activity of microorganisms between 25 and 40 kilometers; therefore there is little ability to fully explore the applications that can be gained through understanding these organisms. The Stratospheric Microbe and Bacteria Accumulator (SIMBA) was designed to collect microorganisms near 36 kilometers and house them until they are cultured, examined, and tested in variable environmental conditions. This payload from the Colorado Space Grant Consortium flew on the High Altitude Student Platform this last September and returned with notable data that might assist in understanding these microorganisms from Earth's stratosphere further. Post mission conclusion, the design, testing, and experimental procedures will be re-assed and revised to ensure repeatability and improvement in the next revision of the design.

2:40pm - 3:05pm Technical Speaker Sessions

Friedhoff Hall	Petroleum Hall	GC 210S	GC 210N
Unmanned Systems	Special Test Equipment	Climate Science	Aero Science
USAFA	Red Canyon & Lockheed Martin	CU Boulder & JPL	CU Boulder
User Defined Object Tracking for Automated Net Recovery of RPA	Orion Power and Data Unit Avionics Special Test Equipment	The Impact of Atmospheric Modeling Errors on GRACE Estimates of Antarctic Ice Mass Loss	Spanwise Variation of Stall Flutter on a Flexible NACA 0018 Finite Span Wing

Friedhoff Hall	**Title:**	User Defined Object Tracking for Automated Net Recovery of RPA
	Category:	Unmanned Systems
	Affiliation:	USAFA
	Author(s):	Charles B. Wilson , Michael L. Anderson and Michael A. Hyde
	Abstract:	Automated recovery of Remotely Piloted Aircraft (RPA) has been fielded for over a decade on land. Automated recovery at sea has proven more difficult due to the increased number of variables. One proven solution is to deliberately fly the RPA into a shipboard net, however, this method requires a skilled RPA pilot. In order to increase fielding of RPA in commercial applications, new methods must be employed which do not require specialist pilots. Several concepts were analyzed for feasibility, but due to cost, simplicity, and designability, machine vision was selected for prototyping. The machine vision algorithm that was developed tracks an object according to the hue and luminance values of a user-selected pixel. The algorithm provides coordinates of the object's centroid to the RPA's autopilot so that it can guide the RPA into the net for recovery.
Petroleum Hall	**Title:**	Orion Power and Data Unit Avionics Special Test Equipment
	Category:	Special Test Equipment
	Affiliation:	Red Canyon & Lockheed Martin
	Author(s):	Donelson Lawry and Jason Burch
	Abstract:	The Orion Crew Vehicle Avionics system uses multiple boxes for redundancy and division of subsystem functions. The Power and Data Unit (PDU) is one of these avionics boxes. The PDU functions to route electrical power and data to various elements in the Orion Electrical System Avionics. This paper describes the Special Test Equipment or "STE" used in the Electrical Test of the PDU. Highlights of the PDU STE include Time Triggered Gigabit Ethernet "TTGbE" and 120 Vdc distribution at power levels approaching 10,000 Watts. The combination of high speed Ethernet, high voltage DC, and low level DC electronics presents a unique Electrical test challenge. The STE development at Lockheed Martin addressed these challenges.
GC 210S	**Title:**	The Impact of Atmospheric Modeling Errors on GRACE Estimates of Antarctic Ice Mass Loss
	Category:	Climate Science
	Affiliation:	CU Boulder & JPL
	Author(s):	Ryan A. Hardy, R. Steven Nerem, and David N. Wiese
	Abstract:	The Gravity Recovery and Climate Experiment (GRACE) has produced over 140 monthly global gravity models since 2002, enabling long-term monitoring of the changing distribution of mass on Earth's surface. In particular, GRACE has shown that Antarctica lost ~70 billion metric tons of ice per year between 2002 and 2014, raising sea level by 0.2 mm each year. Whether this mass loss is accelerating remains a critical question. Because GRACE is sensitive to gravity signals from land, oceans and the atmosphere, atmospheric signals must be removed from GRACE data using operational numerical forecast models to obtain land mass. This makes them a limiting factor in the accuracy of GRACE estimates of land mass. We assess the accuracy of the GRACE background atmospheric model over Antarctica using in situ pressure data and robust alternative models. These comparisons show significant biases in the trend and and acceleration of Antarctica's mass loss.
GC 210N	**Title:**	Spanwise Variation of Stall Flutter on a Flexible NACA 0018 Finite Span Wing
	Category:	Aero Science
	Affiliation:	CU Boulder
	Author(s):	Ethan C. E. Culler and John A. N. Farnsworth
	Abstract:	In order to increase aerodynamic efficiency, designers are progressing towards flexible, high aspect ratio wings. Unfortunately, these designs can sacrifice structural performance, allowing for increased wing oscillation, shorter fatigue life and lower divergence speeds. In an effort to mitigate these effects, a novel research program has been undertaken to investigate the viability of aerodynamic flow control as a method for controlling flutter. This work is focused on experimentally studying the spanwise variation and temporal evolution of the unsteady flow field around a finite span NACA 0018 wing undergoing stall flutter. Stereo Vision data was collected to track the wing kinematics and SPIV data was collected to isolate the flow field development. The stereo vision data suggests the flutter motion is predominantly composed of a pitching mode with a linear dependence on spanwise location. Preliminary analysis of the SPIV data shows spanwise variation in the size and location of flow separation.

3:05pm - 3:30pm Technical Speaker Sessions

Friedhoff Hall	Petroleum Hall	GC 210S	GC 210N
Unmanned Systems	Electronics & Radiation	Atmospheric Science	Propulsion
Red Canyon	JPL and CalTech	University of Northern Colorado	UCCS
A Case Study of Autonomous Mission Operations Using the Integrated Scheduler-Planner And Reactive Executive (I-SPAREX): Mars Reconnaissance Orbiter (MRO)	Analysis and Simulations of Space Radiation Induced Single Event Transients (SET)	POPACS Atmospheric Density Estimates	Combustion and flame behaviors of endothermic fuels

Friedhoff Hall	**Title:**	A Case Study of Autonomous Mission Operations Using the Integrated Scheduler-Planner And Reactive Executive (I-SPAREX): MRO
	Category:	Unmanned Systems
	Affiliation:	Red Canyon
	Author(s):	Caroline Chouinard
	Abstract:	Spacecraft operations demand a high level of responsiveness in dynamic environments. Estimating expected events is required by the mission operations team, as they attempt to both protect the spacecraft while also trying to make most efficient use of its time and resources. I-SPAREX is a layered autonomous flight system employing continuous, model-based planning and reactive sequencing engines. I-SPAREX builds on proven, existing components, specifically, NASA JPL's autonomous planner (CASPER), BSE's executive and FSW (VML 3.0), and TRACLabs' ontology tools. Developed under the direction of NASA's SBIR program, I-SPAREX is in its second year of Phase II. The MRO mission was chosen as the sample spacecraft system to model. An overview of planning and scheduling is presented, and the I-SPAREX system is described using a visual demonstration of the MRO
Petroleum Hall	**Title:**	Analysis and Simulations of Space Radiation Induced Single Event Transients (SET)
	Category:	Electronics & Radiation
	Affiliation:	JPL and CalTech
	Author(s):	Ray Perez
	Abstract:	Spacecraft electronic are affected by the space radiation environment. The space environment is responsible for many of the current transient events that occur in electronic which can upset the performance of the avionics hardware. As electronic components have become smaller in device geometry, lower in operating voltage, and higher in complexity, their immunity to the space radiation environment has suffered. The effect on electronic hardware has become a major concern for spacecraft avionics designers. The spacecraft avionics must be designed such that no SET shall cause an unrecoverable failure to the spacecraft. When a charged particle strikes at a sensitive node such as the drain node, electron-hole pairs are created along an ionization track. A transient current pulse is generated following the drift and diffusion mechanisms. The current pulse results in an SET voltage generation at the particle hit node. Under favorable conditions, the pulse may propagate and cause soft errors. We explore simulations of SET propagations in circuits.
GC 210S	**Title:**	POPACS Atmospheric Density Estimates
	Category:	Atmospheric Science
	Affiliation:	University of Northern Colorado
	Author(s):	Caleb Dahlke and Scott Dahlke
	Abstract:	Earth's upper atmospheric density is difficult to model due to many factors, but solar activity is the main driving force in temporal changes. The density can be estimated by observing satellite motion, but it is difficult to get accurate data using most satellites in orbit due to changes in their drag coefficients as their orientation changes. To improve estimates, Project POPACS (Polar Orbiting Passive Atmospheric Calibration Spheres) launched three identical 10 cm diameter aluminum spheres with different masses, 1 kg, 1.5 kg, and 2 kg, from a Space X Falcon 9 vehicle. Due to the spheres' identical and constant drag coefficients, we can collect accurate data on the density of the atmosphere that they traverse. Observations are obtained from Space Command's two line element sets (TLE's,) starting on the launch date, September 29, 2013, to the present. These observations are used to build a more accurate model of the atmospheric density.
GC 210N	**Title:**	Combustion and flame behaviors of endothermic fuels
	Category:	Propulsion
	Affiliation:	UCCS
	Author(s):	Colin Curtis, Brandon Patz, and Bret Windom
	Abstract:	Liquid propelled propulsion systems, which range from rocket systems to hypersonic scramjet and ramjet engines, require active cooling in order to prevent additional payload requirements. In these systems, the liquid fuel is used as a coolant in order to extract heat from the affected areas of the propulsion system. During this process, heat exchange occurs through phase change, sensible heat extraction, and endothermic reactions experienced by the liquid fuel. Previous research has demonstrated the significant modifications in fuel composition and changes to the fuel's physical properties can result from these endothermic reactions. In continuation, we are investigating the role of the endothermic reactions on the combustion and the subsequent heat release. To achieve this goal, we have developed a counterflow flame burner that will be coupled with a high pressure reactor to measure the effect of the endothermic reactions on flame extinction phenomenon and flame propagation.

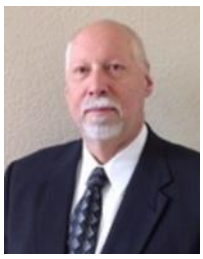
PANEL - Aerospace Leadership: Navigating a Successful Career (3:35pm)

This panel aims to provide valuable career development advice to both younger and experienced professionals from individuals that have "done it all". This panel will focus on the career highlights, key decision points, and lessons learned from veterans in the aerospace industry in order to promote the success of the next generation of engineers.

	**Adm. Richard Truly** *Former NASA Administrator / Navy Admiral / Astronaut / CSM Board of Trustees Member*
	**Dr. Al Romig** *Former EVP of Sandia National Labs, Former VP of LM Skunk Works, Current COO at the National Academy of Engineering*
	**Dr. Mike Hawes** *Lockheed Martin VP and Orion Program Manager*
	**Eric Anderson** *SEAKR Engineering President*
	**Teresa Porter** *ISYS Chief Executive Officer and President*
	**Col Martin France, USAF** *USAFA Aero Department Head*

PANEL - The Next Frontier: New Aerospace Technologies (3:35 pm)

In this panel, we will delve into the next wave of aerospace technologies and discuss key industry differentiators that will become relevant in the next 5-10 years and beyond. This diverse group of leaders will pass on their insights on tech advancements in the aerospace industry that are right over the horizon.

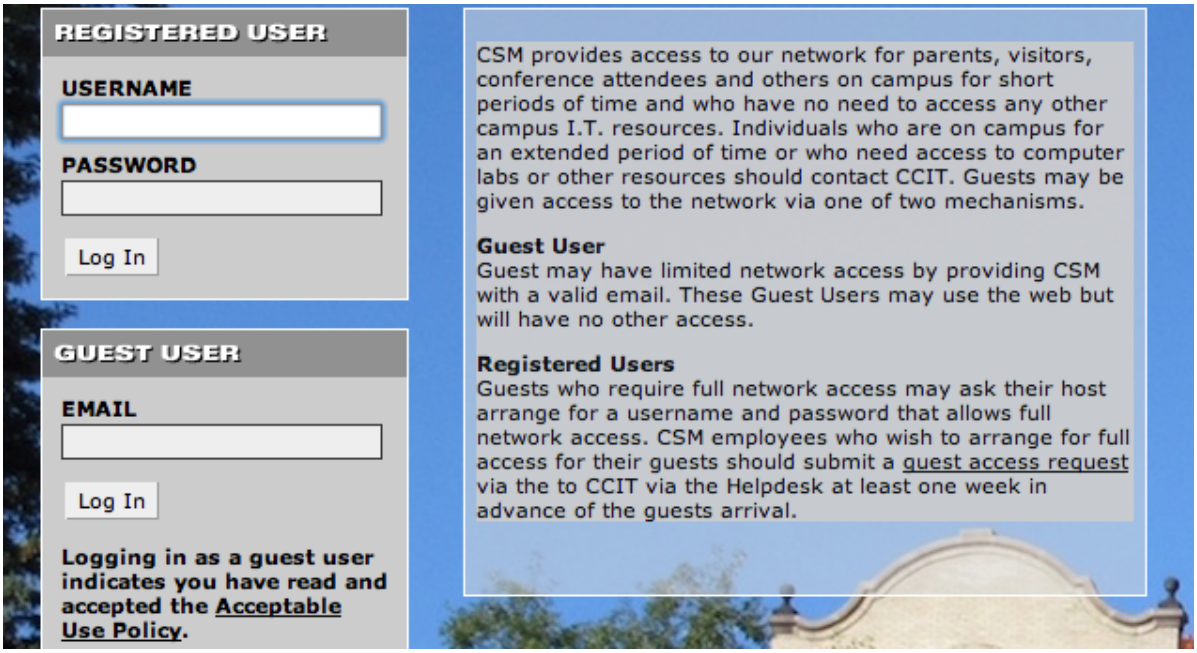
	**Dr. Merri Sanchez, Ph.D.** *Senior Executive and Chief Science and Technical Advisor, Headquarters Air Force Space Command, Peterson Air Force Base*
	**Dr. Michael Gazarik, Ph.D.** *Technology Director at Ball Aerospace and former NASA Associate Administrator for the Space Technology Mission Directorate*
	**Allen Bishop** *President of the Rocky Mountain Chapter of AUVSI*
	**Jon Goff** *Altius Senior Engineer (R&D Small Business with a focus in Space Robotics)*

AIAA Membership

Symposium Menu & Internet Access

Breakfast: The Classical Continental	**Morning Snacks:**
Fresh Fruit Trays Danish, Coffee Cake, and Bagels Fair Trade Aspretto Coffee Fair Trade Aspretto Decaf Coffee Hot Tea Options Orange Juice + Apple Juice Water Bottles	Assorted Granola Bars Fair Trade Aspretto Coffee Fair Trade Aspretto Decaf Coffee Hot Tea Options
Lunch: Italian Buffet	**Afternoon Break:**
Lasagna with Ground Beef Vegetable Lasagna House Salad + Other Sides Dessert Bars Iced Tea, Iced Water, Coffee	Gourmet Cookies and Snack Bars Carrots & celery served with Ranch dip Iced Water Coffee

Colorado School of Mines Wifi Information



Post Symposium Event (5:30 pm)

Wait out the traffic, relax, and grab some dinner and drinks at the nearby Blue Canyon Bar and Grille! **Located 3 blocks away** at 1224 Washington Ave, Golden

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