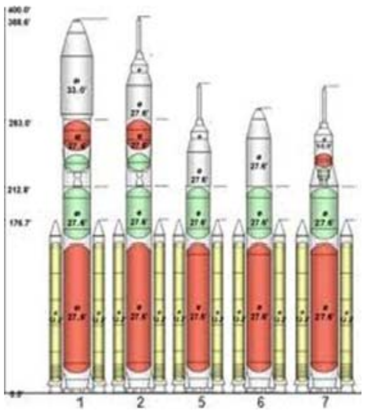

American Institute of Aeronautics and Astronautics Houston Section In Collaboration with INCOSE Presents

Annual Technical Symposium 2013

NASA/JSC Gilruth Center
Houston, Texas
Friday, May 17, 2013

General Chair

Ellen Gillespie

Organizing Committee

Douglas Yazell
Dr. Al Jackson/JSC
Dr. Steven Everett/Boeing
Rafael Munoz/JSC
BeBe Kelly-Serrato/A-SCC

CONTENTS

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PROGRAM SUMMARY

7:45 AM – 4:30 PM	**Registration Desk on First Floor**	**Next to Alamo Room**
8:00 AM - 9:00 AM	**Anousheh Ansari** **Alires Almon**	**Alamo Ballroom**
Session A **9:00 AM – 10:15 AM**	1. Aero/Astrodynamics 2. Propulsion 3. GN&C 4. INCOSE	San Jacinto Coronado Longhorn Lone Star
Session B **10:30 AM – 11:45 AM**	1. Aeroscience 2. EVA 3. GN&C 4. INCOSE	San Jacinto Coronado Longhorn Lone Star

12:00 NOON – 1:30 PM	**Lunch**	**Alamo Ballroom**

12:00 PM – 1:30 PM	Scott Kelly, Mike Fossum, Anousheh Ansari, Art Dula Richard Phillips, Jack Bacon, Franklin Chang Diaz, Paul Spudis, Beth Fischer	Alamo Ballroom
Session C **1:45 PM – 3:00 PM**	1. Automation & Robotics 2. Skylab Anniversary 3. Climate Change 4. INCOSE	San Jacinto Coronado Longhorn Lone Star
Session D **3:15 PM – 4:30 PM**	1. Automation 2. Space History and Education 3. Risk Analysis 4. INCOSE	San Jacinto Coronado Longhorn Lone Star

5:00 PM – 7:00 PM	Post-Conference Social / Mixer	NASA Hilton

Detail Programs Morning

Morning Program – Session A

8:00 - 9:00	Morning Key Note Speakers – Anousheh Ansari & 100 Year Starship – Alires Almon			
	San Jacinto (1)	Coronado (2)	Longhorn (3)	Lone Star (4)
	Session A-1: Theme – Aero/Astro Chair: Dr. Al Jackson	Session A-2: Theme – Propulsion Chair: Sheikh Ahsan	Session A-3: Theme – GN&C Chair: Dr. Steve Everett	Session A-4: Theme – Systems Eng (INCOSE)
9:00 - 9:25	**A-1.1** Analysis of Voyages Charting the Course for Sustainable Human Space Exploration **Kumar Krishen**	**A-2.1** Combustion Instability in the Project Morpheus Liquid Oxygen / Liquid Methane Main Engine **John. C. Melcher**	**A-3.1** Enhanced Optimal Control For Uncertain Spacecraft Tracking Problem **Ahmad Bani Younes**	**INCOSE-1** Model-Based Systems Engineering with SysML: An Approach for Reducing Cost and Improving Quality **Lenny Delligatti**
9:25 – 9:50	**A-1.2** Meteor Entry Trajectory Dispersion Analysis **Yvonne Vigue-Rodi**	**A-2.2** ISS Optimal Propellant Maneuvers **Sagar Bhatt**	**A-3.2** Launch Vehicle Gimbal Control Allocation **Abran Alaniz**	
9:50 - 10:15	**A-1.3** Planetary Defense 2013: Report on Flagstaff Conference **Al Jackson**	**A-2.3** On-Orbit Propulsion System Performance of ISS Visiting Vehicles **Mary Regina M. Martin**	**A-3.3** Angles-Only Navigation for Orbital Rendezvous **David Woffinden**	
10:15 – 10:30	15 Minute Break			

Morning Program – Session B

	San Jacinto (1)	Coronado (2)	Longhorn (3)	Lone Star (4)
	Session B-1: Theme – Aerosciences Chair: Benedicte Stewart	Session B-2: Theme – EVA Chair: Daryl Schuck	Session B-3: Theme – GN&C Chair: Douglas Yazell	Session B-4: Theme – Systems Eng (INCOSE)
10:30 – 10:55	B-1.1 The Latest Developments in the X51A and X37B John M. Dilorio	B-2.1 Technology Development Efforts for an Exploration Spacesuit Michelle Stein	B-3.1 Attitude Error Kinematics: Application in Optimal Control of Dynamical Systems Ahmad Bani Younes	INCOSE-2 How to Fail at Model-Based Systems Engineering Matthew Hause
10:55 - 11:20	B-1.2 Orion Program EFT-1 Status Blaine Brown	B-2.2 Development of a Spacesuit Helmet Mounted Display Testbed System Daryl Schuck	B-3.2 New Approach for Real-Time Inertia Estimation Donghoon Kim	
11:20 – 11:45	B-1.3 Economics of Asteroid Mining Shen Ge	B-2.3 Pressure Suit Design Considerations for Extreme High-Altitude Barry McCarter	B-3.3 Innovations for ISS Plug-In Plan (IPiP) Operations Kevin Moore	
12:00 - 1:30	***Lunch Key Note Panel Speakers:*** **Scott Kelly, Mike Fossum, Richard Phillips, Jack Bacon, Art Dula, Paul Spudis, Beth Fischer, Franklin Chang Diaz, Anousheh Ansari**			

Detail Programs Afternoon

Afternoon program – Session C

	San Jacinto (1)	Coronado (2)	Longhorn (3)	Lone Star (4)
	Session C-1: Theme – C&T Chair: Dr. Zafar Taqvi	Session C-2: Theme – Skylab Chair: Dr. Al Jackson	Session C-3: Theme – Climate Change Chair: Douglas Yazell	Session C-4 Theme – Systems Eng (INCOSE)
1:45 - 2:10	C-1.1 GRANNIE 4: Helping Astronauts in Deep Space Paul Frenger M.D.	C-2.1 Skylab 40th Anniversary Panel *Invited Speakers:* Ken Young Gary Johnson	C-3.1 The Essential Story of Climate Change Gerald R. North	INCOSE-3 MBSE without a Process-Based Data Architecture is just a set of random characters Robert Crain
2:10 - 2:35	C-1.2 Implementation of a Six Degree-Of-Freedom Robotic Arm Carol Fairchild		C-3.2 Climate Change, Climate Variability, and Extreme Events John W. Nielsen-Gammon	
2:35 - 3:00	C-1.3 Towards Low-Cost Power-Aware Wireless Transfer of Human Body Movements to Robotics Environments Faith Karabacak			
3:00 - 3:15	15 Minute Break			

Afternoon Program – Session D

	San Jacinto (1)	Coronado (2)	Longhorn (3)	Lone Star (4)
	Session D-1: Theme - Automation Chair: Daniel Nobles	Session D-2: Theme – Space History & Education Chair: Ted Kenny	Session D-3: Theme – Risk Analysis Chair: Roger Kleinhammer	Session D-4 Theme – Systems Eng (INCOSE)
3:15 – 3:40	D-1.1 Demonstration of Advanced Exploration and Robotics *Technologies in the Alamo Ballroom* Amy Ross	D-2.1 Eleven Things That Saved Apollo 11 Jared Woodfill	D-3.1 PRA and Conceptual Design Bryan Fuqua	INCOSE-4 NASA Integrated Model-centric Architecture Team Linda Bromley
3:40 - 4:05	D-1.2 An Optimized Neural Network Approach for Rapid Aircraft and Spacecraft Venting Predictions Patrick E. Rodi	D-2.2 Horizons and the Collier's Series, Man Will Conquer Space Soon! Al Jackson	D-3.2 PRA: Participation versus Validation Rick Banke	INCOSE-5 What's Happening with the new SysML User's Group Bill Othon
4:05 – 4:30	D-1.3 13 Aircraft/Spacecraft Mass Distribution Optimization Using Genetic Algorithms Patrick E. Rodi	D-2.3 Space Educational Module Shen Ge	D-3.3 HRA Aerospace Challenges Diana DeMott	

Symposium Location

The American Institute of Aeronautics and Astronautics (AIAA), Houston Section, welcomes you to the 2013 Annual Technical Symposium at NASA/JSC Gilruth Center on May 17, 2013.

Enter Gilruth Center using JSC Public Access Gate 5 on Space Center Boulevard if you do not have a JSC badge. The morning and afternoon technical presentations are in the Lone Star, Longhorn, and Coronado rooms on the second floor. The morning keynote speech and the luncheon are on the first floor in the Alamo Ballroom.

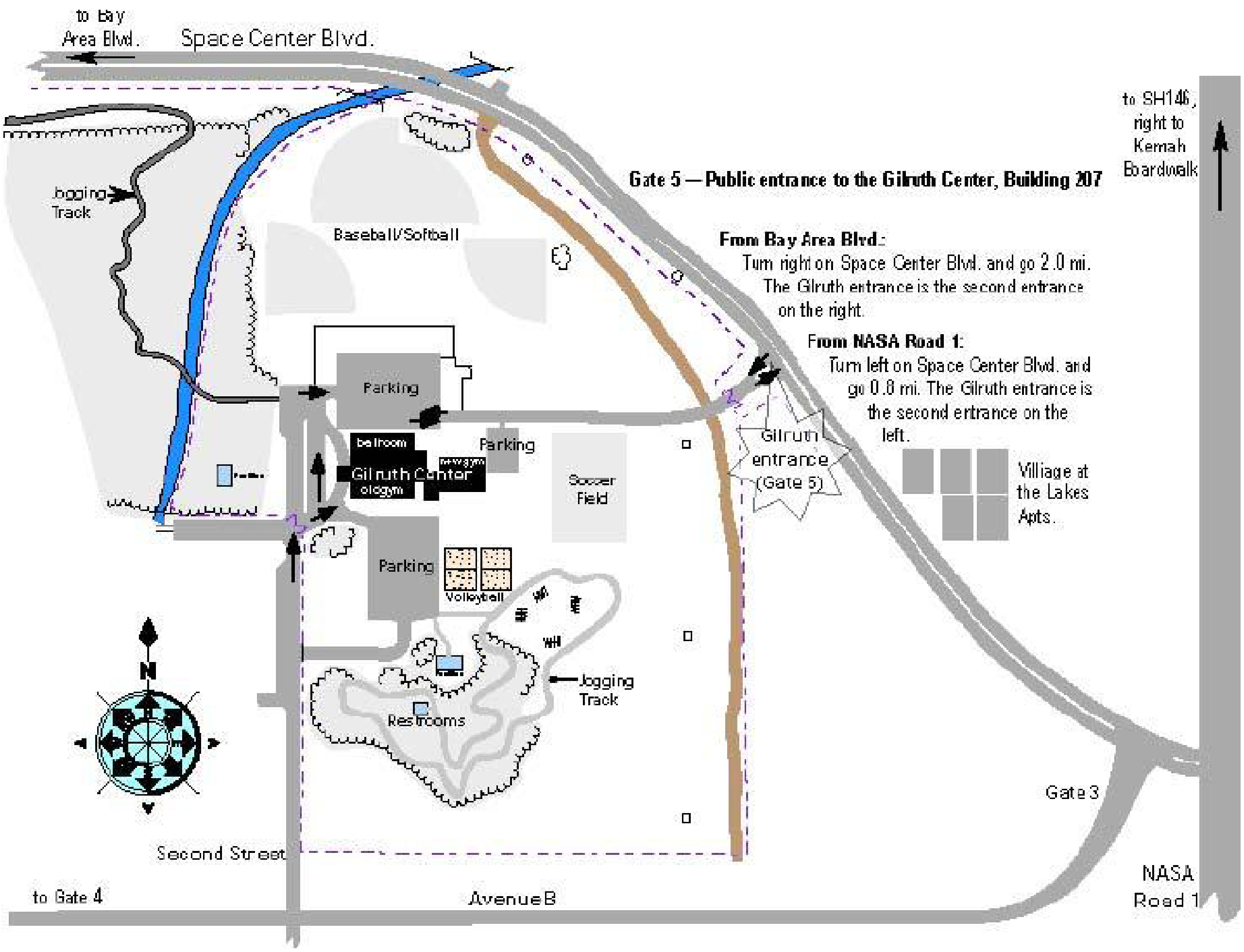

Figure 1. JSC Gate 5 Public Entrance Map

Symposium Information

Figure 2. Gilruth Center First Floor

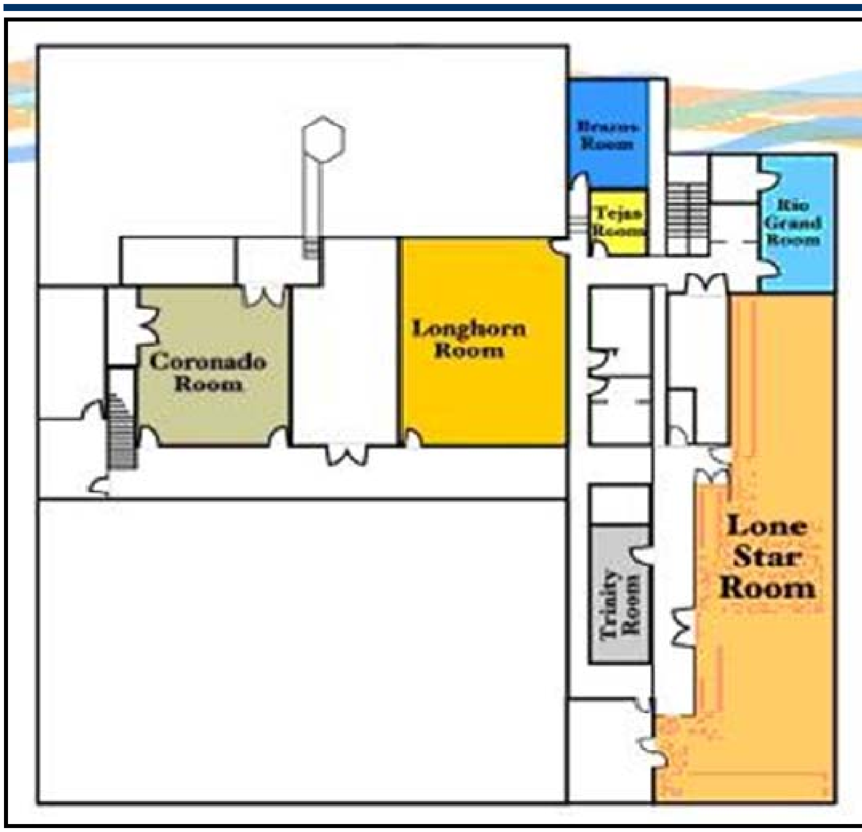

Figure 3. Gilruth Center Second Floor

Registration

Registration is free for presenters and $15 for attendees and is open all day beginning at 7:45 AM. Advance reservations are recommended but not required. Advance registration is easy to do on the web at www.aiaahouston.org. The registration desk is located in the hallway leading to the Alamo Ballroom. Registration is paid at the event and not online. There is no additional fee for the buffet lunch – the cost is included in the registration fee.

Special Events

Morning, 8:00-9:00 AM, Alamo Ballroom

***Keynote Speakers*: Anousheh Ansari & Alires Almon**

Assorted breakfast pastries and bagels with fresh cut fruit. Served with regular and low-fat cream cheese, butter, and assorted jellies. Includes Starbucks coffee (regular & decaf), a variety of fruit juices and hot tea.

Lunch | Noon–1:30 PM, Alamo Ballroom

Panel Topic: Future Space Exploration "Flight" Beyond LEO
Moderators: Beatriz Kelly-Serrato & Shirley Brandt

Keynote Speakers: Scott Kelly, Mike Fossum, Jack Bacon, Anousheh Ansari, Richard Phillips, Paul Spudis, Beth Fischer, Franklin Chang Diaz, Art Dula

Choose Italian meat lasagna or cheese manicotti. Served with sautéed green beans, tossed garden salad, fresh baked garlic bread and chocolate cake. Includes iced tea, water, and assorted soda

TECHNICAL SESSIONS

Three sessions will run in parallel in the morning and afternoon. Morning sessions start at 9:00 AM and end by noon. Lunch program begins at 12 noon and lasts for about an hour and fifteen minutes. Afternoon sessions start at 1:30 PM and end by 4:30 PM.

The sessions are held in the three meeting rooms on the second floor of the Gilruth Center.

PRESENTATIONS

Each presentation is allocated 30 minutes total time, including questions and any initial setup. Session chairs will maintain this pace to ensure that attendees can see presentations according to the posted schedule. Each room will be equipped with a laptop computer and a computer projector.

A-1.1
San Jacinto Room

ANALYSIS OF **VOYAGES** CHARTING THE COURSE FOR SUSTAINABLE HUMAN SPACE EXPLORATION*

Kumar Krishen, Ph.D. Fellow, SDPS, Assoc. Fellow, AIAA,
Fellow, IETE

The future of human presence in space beyond Earth orbit has been the focus of NASA strategic planning efforts for more than four decades. In the recent past, a report titled "Voyages, Charting the Course for Sustainable Human Space Exploration" was issued by NASA. This report identifies cis-lunar space, near-Earth Asteroids (NEAs), the Moon, and Mars and its moons as the destinations for future human exploration. The strategy for this exploration is based on capability-driven approach. This approach is used to identify capabilities that need to be developed to enable multiple human missions. This presentation will summarize the highlights of the NASA report. It will critically examine the implications of the destinations on technology development and capability enhancement. The objective is to show what developments should receive priority in the future to enable safe and affordable human space missions. It will identify a set of questions that can lead to a successful prioritization of the technology development. In this context each destination and technology identified in this report will be discussed and rationale for the technology prioritization provided.

* Views expressed in this presentation are not necessarily those of NASA

METEOR ENTRY TRAJECTORY DISPERSION ANALYSIS

Yvonne Vigue-Rodi Adelante Sciences Corp., Houston, TX 77586

Recent events regarding Near Earth Objects (NEOs) present vivid astronomical examples of asteroids fly-bys and meteors that enter the earth's atmosphere with no detection or very little early warning. Many NEOs are detected, tracked and their trajectories predicted as some of these objects fly-by within the Earth-Moon system, even within the orbits of our geostationary satellites, as with Asteroid 2012-DA14, which passed at a distance of 17,000 miles. The recent meteor event in the skies over Russia in February 2013 damaged buildings and injured over 1,000 people. This unexpected meteor was estimated to be 15 meters in diameter, and had not been previously detected or tracked. The Tunguska event of June 1908 presents another vivid example of the vast surface damage that can be caused even when meteors do not impact the surface (exploding above ground).

To study this challenging phenomenon, simulations have been performed to quantify variations in flight path trajectory dispersions for meteors that enter the Earth's atmosphere under diverse conditions. Results will be presented which consider meteor size, shape (round sphere or lumpy asymmetry), composition (stony asteroid or icy comet), flight path angle (steepness of atmosphere entry angle), and tumbling rate. These examples of trajectory dispersions will be presented, demonstrating the capabilities of this approach, and as preliminary efforts to demonstrate predictive capabilities that can, someday, become part of a much-needed early warning system for emergency preparedness procedures.

A-1.3
San Jacinto Room

PLANETARY DEFENSE 2013: REPORT ON FLAGSTAFF CONFERENCE

A. A. Jackson, Ph.D
Lunar and Planetary Institute

- Report on the International Academy of Astronautics conference on planetary defense conference April 2013.
- Current state of knowledge on Near Earth Objects (how many, physical characteristics, orbits, current limitations, current risk.
- Consequences of an impact (tsunami, NEO size vs. consequence, economic impact, past events).
- Techniques for deflecting or mitigating a threatening NEO (kinetic impact, gravity tractor, explosive devices, others).
- NEO deflection mission and campaign design (launch requirements, cost, timelines, new tools).
- Political, policy, legal framework for planetary defense creasing public awareness.
- Current national and international activities supporting planetary defense.

COMBUSTION INSTABILITY IN THE PROJECT MORPHEUS LIQUID OXYGEN / LIQUID METHANE MAIN ENGINE

John. C. Melcher, Ph.D., AIAA Senior Member
Robert L. Morehead, AIAA Member
Christopher D. Radke, AIAA Member
Eric A. Hurlbert, AIAA Member NASA Johnson Space Center, Houston, TX

The Project Morpheus liquid oxygen (LOX) / liquid methane rocket engines "HD4" and "HD5" demonstrated acoustic-coupled combustion instabilities during sea-level ground-based testing at the NASA Stennis Space Center (SSC). The instability characteristics are similar for the two engines and appear to have two triggers. First, high-amplitude, 1T, 1R, 1T1R (and higher order R harmonics) modes appear to be triggered by methane injector conditions. This instability usually manifests during low-throttle startup conditions and can propagate through main stage throttle-up but is never initiated after throttle-up. Second, transient self-limiting instabilities that appear as 1T-1L or 1R (with harmonics) seem to be triggered by LOX injector conditions. These instabilities typically happen at ignition, or shortly thereafter, and dampen out once the LOX injector chills in. Morpheus vehicle-HD4 tests at the NASA Johnson Space Center (JSC) only demonstrated low-amplitude 1T transient tones near ignition that always dampen, which are probably due to LOX conditions. The 1T/1R/1T1R instability signature has not been observed on the vehicle. The explanation for the lack of vehicle-test instabilities are theories in development. The most significant measured differences between the vehicle configuration and SSC configuration are the methane start surge frequency and damping as seen at the injector inlet. The surge occurs at 10 times higher frequency and dampens notably faster on the Morpheus vehicle even though the surge amplitudes are in family with the SSC data. To protect for the possibility of instability occurrence on the Morpheus vehicle, a new high-speed redline cutoff system has been designed, tested, and installed.

ISS OPTIMAL PROPELLANT MANEUVERS

Sagar Bhatt
The Charles Stark Draper Laboratory, Inc., Houston TX 77058

On August 1, 2012, the International Space Station (ISS) performed two docking maneuvers using a new technique that resulted in 93% propellant savings. These Optimal Propellant Maneuvers (OPMs) are achieved by commanding the ISS to follow a pre-planned attitude trajectory which was optimized to take advantage of naturally occurring environmental torques and available control authority from the jets. The trajectory was obtained by solving an optimal control problem. Flight implementation issues and operational constraints will be presented. OPM did not require any modifications to ISS flight software; thus this approach is applicable to any spacecraft controlled using thrusters. To date, 6 OPMs have been performed, resulting in nearly a full Progress supply tank worth of prop savings (860kg). Moreover, the reduced ISS structural loads of OPMs are an additional long-term benefit.

ON-ORBIT PROPULSION SYSTEM PERFORMANCE OF ISS VISITING VEHICLES

Mary Regina M. Martin[1], Robert A. Swanson[2], and Ulhas P. Kamath[3]

The Boeing Company, Houston, TX 77059

and

Francisco J. Hernandez[4] and Victor Spencer[5]

NASA Lyndon B. Johnson Space Center, Houston, TX 77058

The International Space Station (ISS) represents the culmination of over two decades of unprecedented global human endeavors to conceive, design, build and operate a research laboratory in space. Uninterrupted human presence in space since the inception of the ISS has been made possible by an international fleet of space vehicles facilitating crew rotation, delivery of science experiments and replenishment of propellants and supplies. On-orbit propulsion systems on both ISS and Visiting Vehicles are essential to the continuous operation of the ISS. This paper compares the ISS visiting vehicle propulsion systems by providing an overview of key design drivers, operational considerations and performance characteristics. Despite their differences in design, functionality, and purpose, all visiting vehicles must adhere to a common set of interface requirements along with safety and operational requirements. This paper addresses a wide variety of methods for satisfying these requirements and mitigating credible hazards anticipated during the on-orbit life of propulsion systems, as well as the seamless integration necessary for the continued operation of the ISS.

1 Propulsion System Engineer, Anadarko Industries, Houston, TX 77059
2 Propulsion/VIPeR Systems Engineer, Boeing Defense, Space & Security, MC HB5-30
3 Lead, ISS Propulsion Systems Integration, Boeing Defense, Space & Security, MC HB5-30
4 ISS Propulsion System Engineer, NASA Johnson Space Center, Propulsion and Power Division, EP4. AIAA Member.
5 ISS Propulsion System Manager, Propulsion and Power Division, EP4. AIAA Member.

ENHANCED OPTIMAL CONTROL FOR UNCERTAIN SPACECRAFT TRACKING PROBLEM

Ahmad Bani Younes1 and James D. Turner2

An optimal tracking control is developed where the optimal control is calculated by optimizing a universal penalty. The optimal tracking problem formulation is generalized by modeling the control gains as a Taylor series in the parameter uncertainty. The generalized control formulation is computed as an off-line calculation for the sensitivity gains. The goal of the generalized control formulation is to eliminate the need for gain scheduling for handling model parameter variations. An estimator is assumed to be available for predicting the model parameter changes. Higher-Order control sensitivity calculations are applied on the full nonlinear model using computational differentiation tool. Several attitude error representations are presented for describing the tracking orientation error kinematics. Compact forms of attitude error equation are derived for each case. The attitude error is initially defined as the quaternion (rotation) error between the current and the reference orientation. Transformation equations are presented that enable the development of nonlinear kinematic models that are valid for arbitrarily large relative rotations and rotation rates. The nonlinear error dynamics for kinematics and the equation of motion is retained, yielding a tensor-based series solution for the Co-State as a function of error dynamics. Control sensitivity calculations are performed to handle model and parameter uncertainty in the real system. The OCEA (Object Oriented Coordinate Embedding) computational differentiation toolbox is used for automatically generating the first- through fourth-order partial derivatives required for the generalized control sensitivity differential equation. Several numerical examples are presented that demonstrate the effectiveness of the proposed approach. The methods presented are expected to be broadly useful for control applications in science and engineering.

1 PhD Candidate, Aerospace Engineering, Texas A&M University, College Station, Texas, olalahmad@gmail.com.
2 Research Professor, Aerospace Engineering, Texas A&M University, College Station, Texas, turner@aero.tamu.edu, Fellow AAS, Associate Fellow AIAA

A-3.2
Longhorn Room

LAUNCH VEHICLE GIMBAL CONTROL ALLOCATION

Abran Alaniz

Two gimbal control allocation algorithms are reviewed, a Space Shuttle based algorithm and a pseudo inverse algorithm. The pseudo inverse algorithm is based on weighted least squares. The choice of weighting in not unique, but an optimal weighting for pitch and yaw control can be derived. A set of weighting candidates for 3 -axis gimbal control will be discussed. Both algorithms are applied to a multi-gimbal launch vehicle and evaluated for robustness. Nominal and perturbed thrust profiles are considered.

ANGLES-ONLY NAVIGATION FOR ORBITAL RENDEZVOUS

David Woffinden
The Charles Stark Draper Laboratory, Houston, TX 77058

Angles-only navigation for orbital rendezvous has been utilized on a variety of programs for various durations. This unique approach of determining the relative motion between two orbiting vehicles by measuring the relative line-of-sight angles has attracted significant attention. Although it has been widely accepted, there are several subtleties with this navigation strategy that make it difficult to understand its limitations and capabilities for rendezvous and docking applications. This presentation highlights the fundamental concepts with angles-only navigation, illustrates its potential and shortcomings, and provides an analytical solution that dispels the myths and uncertainties associated with this methodology. An intuitive graphical interpretation is also provided along with several examples related to orbital rendezvous.

B-1.1
San Jacinto Room

THE LATEST DEVELOPMENTS IN THE X51A AND X37B

John M. DiIorio

Mr. John M. DiIorio will discuss the latest developments in the X51A autonomous Mach 6 test flight Wa-verider dropped from a B-52 wing. The first flight was successful, but the second and third flights failed. Four units were built. The X37B is a robotic autonomous space plane, launched by a (Atlas) rocket, a fleet of two units each having a successful first flight. These flights were sub-orbital lasting more than a year each. A third flight is underway. Mr. DiIorio will list some practical ‘endgames’ for each type. One of them leads to NASA returning to (four) manned missions in 2016, one of which will carry up to six astronauts to E1, E2, or L1 to construct a deep space station. Mr. DiIorio will explain how this may be accomplished. This portion of the presentation is an extension of Mr. DiIorio ATS 2012 speech on deriving a stability collinear Lagrangian point equation for the placement of deep space stations.

ORION PROGRAM EFT-1 STATUS

Blaine Brown
Lockheed Martin Space Systems Company, Houston Texas 77058

The Orion program, originally known as the Crew Exploration Vehicle (CEV) project, was awarded to Lockheed Martin in September 2006 for the Design, Development, Test and Evaluation (DDT&E) and production phases. The 2011 President's Budget Request, released in February 2010, called for the cancellation of the Constellation Program, including Orion, however, Orion was ultimately reformed as the Multi-Purpose Crew Vehicle (MPCV) program and, although the fundamental design requirements of the vehicle have remained stable since the reformulation, the vehicle's mission has significantly changed from ISS crew servicing to beyond earth orbit (BEO) exploration. Since the reestablishment of Orion as the BEO MPCV the design requirements have stabilized and the program will now focus more on test and evaluation.

Following the reformulation of Orion MPCV in 2011 Lockheed Martin's contract was modified to focus on an Orion exploration flight test one, called EFT-1 to validate subsystems on Orion required for a high speed reentry similar to a BEO return. This mission will be followed by an un-crewed Exploration Flight Test (EM-1) and then a crewed Exploration Flight Test (EM-2).

This paper will describe the most recent progress of the Orion EFT-1 Project, including affordability initiatives, current test architecture, risk reduction initiatives, vehicle design, and production status.

THE ECONOMICS OF ASTEROID MINING

Shen Ge, SPACE, sge@spaceacad.org
Neha Satak, SPACE, nsatak@spaceacad.org

Asteroid mining is drawing increasing interest in the last year with the establishment of two space companies publicly declaring their common intention of mining asteroids. However, the economics of asteroid mining is barely developed which raises questions on how these companies and future startups will attract enough investment for such a mammoth project. In economics, a net present value that is positive indicates a positive return on a project. No significant additions have been made to Mark Sonter's net present value equation for asteroid mining since he wrote his thesis in 1997. This paper serves to address both the technical and economic factors required to determine a future asteroid mining mission's feasibility. Building upon Sonter's equation, it introduces new variables to cover the gaps and resolves uncertainties in the previous equation.

B-2.1
Coronado Room

TECHNOLOGY DEVELOPMENT EFFORTS FOR AN EXPLORATION SPACESUIT

Michelle Stein/Oceaneering

NASA proposes to fly a new Exploration Space Suit within the next decade that will:

- Enable safe and efficient EVA operations at multiple destinations for human space exploration supported by multiple spacecraft;
- Affordably support incorporation of new technologies;
- Increase crew safety for training and flight operations;
- Improve reliability to enable multi-year missions with limited hardware and spares;
- Increase operational efficiency by reducing crew time for EVA preparation and maintenance;
- Reduce the mass of the spacesuit, supporting systems, and consumables.

In 2012, the Oceaneering-led CSAFE team worked to develop key technologies needed for such a suit. These technologies were identified because they could benefit from early, focused development, and because they were not being addressed by other NASA development efforts. Some of these efforts are summarized below and will be presented in greater detail at the symposium.

- PLSS – Developed robust Positive Pressure Relief Valve (PPRV) and novel Feedwater Supply Assembly (FSA) that supplies water for cooling.
- Thermal Control – Evaluated thermal performance of CSAFE LCG Engineering Evaluation Unit (EEU) and current Space Suit Assembly (SSA) LCVG in series of manned tests with varying metabolic rates.
- Avionics – Developed cold plate to remove heat from advanced PLSS avionics.
- Spacesuit Gloves – Developed prototype Phase VII Gloves that incorporated enhanced-mobility hand joints, improvements to the glove adjustment, and enhancements to the TMG features over those of the current Phase VI gloves. Also developed Link Net Glove prototypes that utilize link net construction for the fingers and thumb and a dippable, breathable bladder assembly.

B-2.2
Coronado Room

DEVELOPMENT OF A SPACESUIT HELMET MOUNTED DISPLAY TESTBED SYSTEM

Honeywell/Daryl Schuck

The next generation spacesuit, currently under development by NASA, is anticipated to incorporate Helmet or Head Mounted Display (HMD) technologies in order to make the crew more autonomous through a robust informatics system. In anticipation of this, NASA and Honeywell produced an HMD testbed system that provides the capability to explore display designs and operational concepts in analogous field environments. The system was designed as an extension of an established spacesuit informatics system that included a variety of data including procedures, photo, video, and navigational parameters. Using a Near To Eye optical solution, the device was housed in a military style dust goggle. The system also implemented a spacesuit glove compatible user interface device and intuitive user interface hosted on a fanless, small form factor, low power PC. The purpose of this presentation is to provide an overview of the various parts of this system, describe the software architecture, and describe its initial testing that was conducted prior to delivery. The paper will also address field testing that occurred post delivery. Challenges for integrating this technology in a spacesuit platform are also discussed.

PRESSURE SUIT DESIGN CONSIDERATIONS FOR EXTREME HIGH-ALTITUDE

David Clark Company/ Shawn Macleod

Co-authors: David Clark Company: Shane Jacobs, Dan Barry, Dan McCarter, and Mike Todd

Introduction: David Clark Company – the pioneer and world leader in aerospace crew protective equipment – supported Red Bull Stratos by developing the state-of-the-art pressure suit ensemble required to protect the balloon pilot during all mission phases, including supersonic free-fall from extreme altitudes. A team of subject matter experts encompassing virtually all disciplines related to aeronautical/aerospace crew survivability/ escape developed this suit and related equipment. This presentation will outline the pressure suit ensemble design requirements, suit design considerations and the iterative design process, suit testing, operational use, and lessons learned as they apply to crew survivability and high-altitude bailout for future (government and commercial) aerospace vehicles.

Methods: The Red Bull Stratos pressure suit ensemble needed to address many requirements, some of which represented a significant departure from traditional aeronautical/aerospace programs. These included wide-ranging temperature and pressure profiles, mobility/range-of-motion requirements, and factors unique to extreme altitude supersonic free-fall. Three suits were fabricated for use in the testing and development program. Each suit was subjected to a series of acceptance tests prior to use including leak tests, structural tests, and fit checks.

Results: The suits were utilized during a series of ground-based and low altitude tests including vertical wind-tunnel tests, unpressurized skydiving, thermal vacuum chamber testing, and two jumps from high altitude manned balloon flights at 71,615 ft (21,828m) and 97,145 ft (29,610m). The project culminated in October 2012, when balloon pilot Felix Baumgartner successfully free-fell from 127,852 ft (38,969m), reaching maximum velocity of Mach 1.25.

Discussion: Red Bull Stratos expanded the performance envelope for aerospace crew protective equipment, validating the equipment design and procedures related to free-fall from extreme altitude. This project has provided valuable data pertaining to pressure suit design, crew survivability and high-altitude bailout, both for future government vehicles and those being developed as part of the nascent commercial spaceflight industry.

ATTITUDE ERROR KINEMATICS: APPLICATION IN OPTIMAL CONTROL OF DYNAMICAL SYSTEMS

Ahmad Bani Younes[1] and James D. Turner [2]

Several attitude error representations are presented for describing the tracking orientation error kinematics. Compact forms of attitude error equation are derived for each case. The attitude error is initially defined as the quaternion (rotation) error between the current and the reference orientation. Transformation equations are presented that enable the development of nonlinear kinematic models that are valid for arbitrarily large relative rotations and rotation rates. Nonlinear optimal tracking control formulations have been considered where the state equation consists of the nonlinear state variables. A reference trajectory is obtained by solving optimal open-loop spacecraft maneuvers control. The feedback control strategy seeks to drive the terminal state values to zero. The state variable for the control problem is the error state relative to a reference trajectory. A generalized Riccati matrix and disturbance rejection control formulation is presented that accounts for the state nonlinearity through second order. The developed attitude error kinematics is used to describing the tracking orientation error dynamics. The optimal feedback Spacecraft tracking control is solved and presented.

The goal is to develop an efficient, compact form of the attitude error kinematics that still retains the full nonlinear behavior. The development is approached in two different approaches based on the coordinate choice of the inertial and body frames. The performance is tested by solving optimal control spacecraft tracking problem. The benefits of each approach are discussed.

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2 Research Professor, Aerospace Engineering, Texas A&M University, College Station, Texas, turner@aero.tamu.edu, Fellow AAS, Associate Fellow AIAA

B-3.2
Longhorn Room

NEW APPROACH FOR REAL-TIME INERTIA ESTIMATION

Donghoon Kim[1], Sanghyun Lee[2], and James D. Turner[3]

In general, mass properties of spacecraft should be measured before launch and used for attitude control of the spacecraft. In orbit, the change of the mass properties depends on consumption of propellant or any events which substantially influence the inertia tensor. The variation of the mass properties affects the performance of the attitude control. The accurate information of the properties is required for reliable and efficient attitude control.

The accuracy of the estimation of the mass properties might be deteriorated when the gyro-based data with noise is directly used. There have been a lot of filters to reduce the effects of the noise, such as the butterworth, the zero-phase shift, the extended Kalman filter (EKF), etc.

The authors propose a combined filter for estimating the inertia for the spacecraft in real-time. The measured angular velocity is filtered through the EKF and the angular acceleration is calculated through Savitzky-Golay filter (SGF). Then, recursive least squares (RLS) method is applied to estimate the inertia.

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INNOVATIONS FOR ISS PLUG-IN PLAN (IPIP) OPERATIONS

Kevin Moore

Limited resources and increasing requirements will continue to influence decisions on ISS. The ISS Plug-In Plan (IPiP) supports power and data for science, vehicle systems, and daily operations through the Electrical Power System (EPS) Secondary Power/Data Subsystem. Given the fluid launch schedule, the focus of the Plug-In Plan has evolved to anticipate future requirements by judicious development and delivery of power supplies, power strips, Alternating Current (AC) power inverters, along with innovative deployment strategies. This paper describes the innovative collaboration of the ISS Program Office, Engineering Directorate, Mission Operations, and International Partners and how it develops and enhances unique solutions with existing on-board equipment and resources.

GRANNIE 4: HELPING ASTRONAUTS IN DEEP SPACE

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Sending Astronauts beyond low Earth orbit will entail significant dangers [1]. "Human spaceflight risks include physiological effects from radiation, hypogravity, and terrestrial environments, as well as unique challenges in medical support, human factors, and behavioral health support" [2]. Over 50 years, from Mercury-Gemini-Apollo and Skylab to the ISS, with 3 orbital and 6 manned moon landings, NASA has accumulated considerable data on the detrimental physiological and psychological effects of spaceflight.

Deep space missions demand special care for the well-being of Astronauts, who after all are merely Human. The author suggests an artificial intelligence protector which he calls *GRANNIE 4* ("Guardian Robotic Agent with Neural Networks, Intellect and Emotions"). *GRANNIE 4* (*GRANNIE* for short) is an offshoot of the author's 40 year robot / AI research which ranges from smart robots to intelligent medical devices, more specifically the *ANNIE* Robot ("Android with Neural Networks, Intellect and Emotions"). GRANNIE would possess a large knowledge base and act semi-autonomously with little Earth guidance.

GRANNIE would be tied into all other spacecraft systems, so that in the event of some incapacitation of the Human crew, she could complete the mission on her own and return the Astronauts to Earth [3]. But her main responsibility would be their physical and mental well-being. With a Human-like personality, intellectual and emotional traits, *GRANNIE* would interact with the people on board, chatting in an informal, cheerful way, in a natural voice [4], or playing interactive games such as poker-chess-mahjongg, but always making correlations which turn medical data into immediately useful information. In addition, with a compact folding robotic avatar body and artificial vision, complex hands and facial expressivity, *GRANNIE* could perform a variety of tasks: from menial ones such as serving meals, to important ones such as suturing a laceration, medicating a patient or helping to handle a surgical emergency.

Besides the shared *GRANNIE*, each Astronaut would also have a non-robotic "shadow AI" of their own. The author called this his *Doppelgänger Project*, in which he entered his personal knowledge, preferences and emotions into the artificial brain of his own *ANNIE* human nervous system function emulator [5]. This AI can be tuned for cognitive function and memory support, to help if a crew member develops an Alzheimer's-like mental decline. By thus supporting these brain functions on a deep space journey, the AI would help *GRANNIE* keep an Astronaut on-mission safely as long as possible [6]. The result of adding *GRANNIE* to the Astronaut crew: the safest possible manned deep space missions.

IMPLEMENTATION OF A SIX DEGREE-OF-FREEDOM ROBOTIC ARM

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A robotic arm is a blend of mechanical, electrical and computer parts integrated together to resemble the form and function of a human arm. The important factor in designing a robot arm is to understand the required form and function of the robotic arm for its target application. This Robotic Arm is designed as the first subsystem of a fully autonomous robot to be designed and built sometime in the future. The robot will be mobile and approximately 39 inches (1 meter) tall. In order to achieve the widest spectrum of useful application, the Robotic Arm has six degrees-of-freedom (DOF) and a "gripper" end-effector. Six DOF theoretically provides accessibility to movement in 3-dimensional space with the ability to move forward/backward, up/down, and left/right. For the Robot Arm, the movement is the combined rotation and translation about three perpendicular axes. Computer-based control of shoulder, elbow and wrist joint motors provide smooth movement and accurate positioning for the Arm.

Design requirements for the Arm specify an ability to reach up to 30 inches and have a lift capability of 2 pounds. Joint motors for the Robot Arm were chosen to be brushless direct current (DC) servo motors with built-in gearing and feedback control loop circuitry. DC servo motors provide precise position and velocity control. Cost is also a factor and DC servo motors are typically an affordable way to realize the necessary position accuracy for the Robot Arm. Just like a human arm, this Robot Arm has a wrist, elbow and shoulder joints each with two motors, one for rotational movement and one for translational movement. Careful analysis of torque requirements was performed to guarantee the ability to execute the lift and manipulation tasks envisioned for the Arm. The analysis entailed calculating the amount of force that rotates around individual arm joints. The motors must not only support the weight of the arm itself, but the two-pound payload that is required to lift.

Robot Arm Control Software directs the trajectory path of the Robotic Arm based on user-defined arm positions. Currently, Lynxmotion's SSC-32 Visual Sequencer software is used to calibrate and control the Robot Arm. The software is configured for the screen servo controls to match the operation of individual servo motors. The user interface depicts the position of servo motors control boxes to reflect the design of the Robot Arm on the computer screen. The user can move the individual joint servos then save the desired arm position. A series of arm positions can be saved as a sequence to be reused. Additional software packages are being considered to provide increased capability of commanding the Arm position based on the user defined end-effector position (inverse kinematics).

TOWARDS LOW-COST POWER-AWARE WIRELESS TRANSFER OF HUMAN BODY MOVEMENTS TO ROBOTICS ENVIRONMENTS*

Faith Karabacak, Arif Ceber and Hakduran Koc
University of Houston – Clear Lake

Robots were first utilized in the industry for various purposes as programmable machines to perform a set of pre-specified tasks without interacting with humans in the course of operation. However, in recent years, significant efforts have been reported in the literature for human-robot interactions. In systems where humans and robots interact during the execution of a task, robots do not perform preprogrammed tasks, but execute different sets of actions depending on the commands sent by humans.

In this work, our goal is to investigate various ways to transfer human body movements to robotics environments without any physical connection; and then, to design a prototype robot architecture that imitates those movements in real-time. The prototype consists of electrical and mechanical components such as microcontrollers, motors, mechanical structures, etc. In the target system, the signals representing body movements are either detected by sensors attached to body (in case of arm movements) or generated by a human (in case of leg movements). In the final prototype, energy consumption, speed and implementation cost are important optimization metrics to consider during the design process.

Considering the power consumption, we build a small size (around 5-inch-tall) robot. The weight of the robot primarily depends on material used. Also, mechanical complexity plays a key role in our design. Besides robot body, there are two controllers (that are attached to hands) to detect and transfer the signals representing the arm movements from human to robot. In addition, the signals representing leg movements are generated by pressing physical buttons on the controllers. The movements include going forward and backward, turning right and left, moving arms individually and together.

As wireless communication plays a key role in this project, we consider various ways of using wireless radio frequency (RF) communication such as using a standard protocol or not and using different operating frequencies. Most devices fulfill a standard protocol working at 2.4 GHz ISM Band such as Wi-Fi, Bluetooth, Zigbee, etc. The proprietary RF networks make use of their own protocols to get a reliable communication link. They are computationally light weight and optimized for power consumption and packet overhead. Given these advantages, our system operates Nordic's Gazell 2.4GHz protocol with the nRF24LE1 chip from Nordic Semiconductors. The nRF24LE1 integrates an nRF24L01 core operating in 2.4GHz license-free ISM band using an enhanced 8-bit 8051-compatible CPU. As RF can provide low-cost, power-efficient and reliable communication, we design a communication board composed by a nRF24LE1 radio chip and a PCB antenna, implement a communication architecture, and analyze different scenarios to find a suitable module configuration.

The controllers and robot are connected in a star network using proprietary nRF24L01 transceiver core. In addition, transceivers in close proximity need to co-exist in harmony to be able to transmit and receive without any interference from their neighbors and other wireless devices operating in the same frequency.

THE ESSENTIAL STORY OF CLIMATE CHANGE

Dr. Gerald R. North, Texas A&M University
Distinguished Professor of Atmospheric Sciences and Oceanography

My talk will focus on the main reasons for accepting the greenhouse gas theory of forced climate change.

The **paleoclimate*** record puts modern climate change into perspective. Radiation balance of the earth-atmosphere system is a process wherein the radiation heating from the sun is matched with the outgoing radiation fluxes. This leads to a very cold planet. Balance can only be achieved by a significant absorption of infrared radiation by greenhouse gases such as water vapor, carbon dioxide and methane. (The main gases, oxygen, nitrogen and argon do not absorb.) We can bring these gases on board one at a time to see how the planet warms to its present state. This simple procedure explains our present climate.

If carbon dioxide concentrations are increased (doubled, for example), the outgoing radiation from the top of the atmosphere decreases slightly. This means more sunlight is being absorbed than infrared is being shed to space. This heating causes Earth's temperature to increase. That is the essence of the greenhouse theory. Feedback mechanisms can cause the warming to be amplified.

To get quantitative about climate change as forced by greenhouse gases, we turn to more detailed models simulating the circulation of the atmosphere and the oceans. We are in the primitive stages of this very ambitious undertaking, but I can give a progress report on where we stand, based on assessments from various sources such as the US National Academy of Sciences (NAS) and the UN Intergovernmental Panel on Climate Change (IPCC).

* **Paleoclimate** (from the Meteorology & Weather Dictionary)
A climate of the geologic past, as opposed to a climate of the historical past for which instrumental records are available.
http://meteorology.geography-dictionary.org/Meteorology-and-Weather-Dictionary/paleoclimate

CLIMATE CHANGE, CLIMATE VARIABILITY, AND EXTREME EVENTS

Dr. John W. Nielsen-Gammon, Texas A&M University
Regents Professor of Atmospheric Sciences and Texas State Climatologist

The latest international report on climate change states: “The type, frequency and intensity of extreme events are expected to change as Earth’s climate changes.” (source: IPCC AR4 WG1, 2007) However, after passing from source to source, the summary statement often ends up being something like, “In other words, a warmer atmosphere from climate change likely yields greater extremes in weather.” (source: Philip Bump, TheAtlanticWire, April 25, 2013)

This talk will explore whether and to what extent an increase in extreme events is an expected or required aspect of climate change. The resolution to this issue hinges on precisely what one means by an increase in extreme events, a concept that seems simple but in fact has three different but commonsense meanings. After discussing idealized examples, I will turn to the question of whether any particular extreme event can be attributed to climate change, and if not, whether and in what sense climate change can be held partially responsible.

Finally, I will apply these concepts to an in-depth study of a particular extreme event: the extreme Texas/Oklahoma heat wave of 2011. I will show results from numerical experiments that attempt to isolate the role played by various climatic factors in causing this particular event. I conclude that the two most important climatic players were a decaying La Niña pattern in the tropical Pacific Ocean and atmospheric chaos (which I prefer to call bad luck). Global warming made a small contribution to the increase in temperatures above the 1981-2010 mean.

D-1.1
Alamo Ballroom

DEMOSTRATION OF ADVANCED EXPLORATION AND ROBOTICS TECHNOLOGIES

Amy Ross

Demo Only

AN OPTIMIZED NEURAL NETWORK APPROACH FOR RAPID AIRCRAFT AND SPACECRAFT VENTING PREDICTIONS

Dr. Patrick E. Rodi1
Lockheed Martin, Houston, TX 77258-8487

Vehicle venting analysis is the prediction of the pressure time histories for unpressurized internal compartments of aircraft and spacecraft. One or more interconnected compartments may exist within a vehicle and are usually connected to the ambient air by a surface-mounted vent. These compartment pressures can induce structural loads to vehicle components due to the pressure differential that may develop across solid faces. Aircraft maneuvers can quickly induce a large change in pressures on the Outer Mold Line of the vehicle. Consequently, any surface vents can experience significant pressure changes that impact the internal compartment pressures. For spacecraft, ascent and re-entry are the two main venting events.

In this presentation, results from an examination of using artificial Neural Networks (NN) to predict the internal compartment pressure time history for a space capsule reentering the Earth's atmosphere will be shown. A Neural Network-based approach was selected for their ability to mimic the compartment pressure time histories from a very small number of high fidelity venting solutions. The NN uses a simple 9/10/1 feed-forward network architecture with inputs based on the freestream static pressure and Mach time histories, their time derivatives and moving averages. The time periods of the moving averages were optimized using a Genetic Algorithm. The resulting NN predictions were within 1.3% and 0.25 seconds the peak of the delta-pressure value and time-at-peak-pressure, respectively. This tool runs in the Matlab environment very quickly, and can predict the compartment pressure time history for a new re-entry trajectory within a few seconds.

1LM Fellow, 2100 Space Park dr., Houston TX, 77258-8487, AIAA Associate Fellow

D-1.3
San Jacinto Room

AIRCRAFT/SPACECRAFT MASS DISTRIBUTION OPTIMIZATION USING GENETIC ALGORITHMS

Dr. Patrick E. Rodi1
Lockheed Martin, Houston, TX 77258-8487

Locating components and payloads in aircraft and spacecraft is critically important. For aircraft, the viable center-of-mass range can be small and excursions outside of this range can have serious impacts to performance and, stability and control. For orbiting spacecraft, the center-of-mass location dictates the center about which objects will rotate. For re-entry capsules the center-of-mass influences the angle-of-attack for trim, which sets the lift-to-drag ratio. Historical methods used to analyze hardware locations can be tedious and resource intensive, and often evaluate all the possible permutations. By employing a Genetic Algorithm (GA) a nearly optimal distribution can be identified using significantly less resources.

In this work, a Genetic Algorithm has been employed to optimize the distribution of mass in aircraft and spacecraft. This approach was selected due to its historical success on similar problems, ease of implementing cost functions, and versatility for incorporating a wide variety of constraints. To illustrate this approach, a GA has been employed to optimize the position of a set of payloads with a spacecraft capsule for re-entry. A prescribed center-ofmass volume is the primary constraint imposed while a number of cost functions are optimized including: maximization of the capsule’s moment-of-inertia, minimization of the moment-of-inertia, optimizing for late on-load and/or early off-load payloads. Also, constraints for payload-to-payload proximity associations (both favorable and unfavorable) are demonstrated. The new method is an innovative and efficient approach to locating components within vehicles, and is useful from conceptual to final design.

1LM Fellow, 2100 Space Park dr., Houston TX, 77258-8487, AIAA Associate Fellow

ELEVEN THINGS THAT SAVED APOLLO 11

Jared Woodfill

Scripture states: " Forget not the ancient landmarks thy fathers have set." To that end, a father of the Apollo Program's Spacecraft's Caution and Warning System will remind attendees of little known threats to the first manned lunar landing. After 47+ years, Jerry continues as a NASA JSC employee in the Engineering Directorate. He will explain incidents that might have ended in tragic disaster. . As the mission's spacecraft warning system engineer, Jerry Woodfill witnessed them, first hand, in the Mission Evaluation Room (MER). His presentation will detail each from a technical perspective. All provide a valuable lesson for planners of future manned missions. Apollo 11's threats to the crew were every bit as ominous as those faced by Apollo 13's astronauts.

D-2.2
Coronado Room

HORIZONS AND THE COLLIER'S SERIES, *MAN WILL CONQUER SPACE SOON!*

Dr. A. A. Jackson, Technical Committee Chair, Astrodynamics, AIAA Houston Section and Douglas Yazell, AIAA Houston Section Horizons newsletter Editor

AIAA Houston Section's Horizons newsletter team gathered a few new partners for a special project starting in 2012: reprinting the eight installments of the Collier's spaceflight series *Man Will Conquer Space Soon!* The original articles appeared in the weekly magazine Collier's from 1952 to 1954. Wernher von Braun led a creative team including Collier's editor Cornelius Ryan, writers Willy Ley, Fred Whipple, Heinz Haber and Oscar Schacter, and artists Chesley Bonestell, Fred Freeman and Rolf Klep. The Collier's series had a huge worldwide cultural effcet leading up to Sputnik (1957), the first person in space (Gagarin, 1961) and the first people on the Moon (Armstrong and Aldrin, 1969). Horizons is first to reprint the entire Collier's series page by page in high resolution, about 89 pages in all. Horizons, a free PDF publication at www.aiaahouston.org, is using eight consecutive bimonthly issues to complete the project, from August 2012 to October 2013. Wernher von Braun assembled this subset of the V2 rocket team to create the technical background for a 1948 science fiction novel which would fire the public's imagination for human spaceflight. The novel was not published until 2006 but von Braun's team captured the public's imagination with the Collier's spaceflight series.

SPACE EDUCATIONAL MODULE

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The Scientific Preparatory Academy for Cosmic Explorers (SPACE) plans to build its reputation and support through modular programs called SPACE Educational Modules. These are to be in three variations of different lengths which can be hosted at any university in any country in the world: 20 hour, two week, and one semester. These educational modules are not merely classroom projects but are rather self-contained courses solving a real-world problem with multi-year implications that has the ultimate goal of becoming a funded project. We discuss how this module will work and the institutions which we hope to collaborate with in hosting our efforts.

D-3.1
Longhorn Room

PRA AND CONCEPTUAL DESIGN

Diana DeMott, Bryan Fuqua, Paul Wilson

Once a project obtains approval, decision makers have to consider a variety of alternative paths for completing the project and meeting the project objectives. How decisions are made involves a variety of elements including: cost, experience, current technology, ideologies, politics, future needs and desires, capabilities, manpower, timing, available information, and for many ventures management needs to assess the elements of risk versus reward.

The use of high level Probabilistic Risk Assessment (PRA) Models during conceptual design phases provides management with additional information during the decision making process regarding the risk potential for proposed operations and design prototypes. The methodology can be used as a tool to: 1) allow trade studies to compare alternatives based on risk, 2) determine which elements (equipment, process or operational parameters) drives the risk, and 3) provide information to mitigate or eliminate risks early in the conceptual design to lower costs. Creating system models using conceptual design proposals and generic key systems based on what is known today can provide an understanding of the magnitudes of proposed systems and operational risks and facilitates trade study comparisons early in the decision making process.

Identifying the "best" way to achieve the desired results is difficult, and generally occurs based on limited information. PRA provides a tool for decision makers to explore how some decisions will affect risk before the project is committed to that path, which can ultimately save time and money.

PRA: PARTICIPATION VERSUS VALIDATION

Diana DeMott, Richard Banke

Probabilistic Risk Assessments (PRAs) are performed for projects or programs where the consequences of failure are highly undesirable. PRAs primarily address the level of risk those projects or programs posed during operations. PRAs are often developed after the design has been completed. Design and operational details used to develop models include approved and accepted design information regarding equipment, components, systems and failure data. This methodology basically validates the risk parameters of the project or system design.

For high risk or high dollar projects, using PRA methodologies during the design process provides new opportunities to influence the design early in the project life cycle to identify, eliminate or mitigate potential risks. Identifying risk drivers before the design has been set allows the design engineers to understand the inherent risk of their current design and consider potential risk mitigation changes. This can become an iterative process where the PRA model can be used to determine if the mitigation technique is effective in reducing risk. This can result in more efficient and cost effective design changes.

PRA methodology can be used to assess the risk of design alternatives and can demonstrate how major design changes or program modifications impact the overall program or project risk. PRA has been used for the last two decades to validate risk predictions and acceptability. Providing risk information which can positively influence final system and equipment design the PRA tool can also participate in design development, providing a safe and cost effective product.

D-3.3
Longhorn Room

HRA AEROSPACE CHALLENGES

Diana DeMott

Compared to equipment designed to perform the same function over and over, humans are just not as reliable. Computers and machines perform the same action in the same way repeatedly getting the same result, unless equipment fails or a human interferes. Humans who are supposed to perform the same actions repeatedly often perform them incorrectly due to a variety of issues including: stress, fatigue, illness, lack of training, distraction, acting at the wrong time, not acting when they should, not following procedures, misinterpreting information or inattention to detail.

Why not use robots and automatic controls exclusively if human error is so common? In an emergency or off normal situation that the computer, robotic element, or automatic control system is not designed to respond to, the result is failure unless a human can intervene. The human in the loop may be more likely to cause an error, but is also more likely to catch the error and correct it. When it comes to unexpected situations, or performing multiple tasks outside the defined mission parameters, humans are the only viable alternative. Human Reliability Assessments (HRA) identifies ways to improve human performance and reliability and can lead to improvements in systems designed to interact with humans. Understanding the context of the situation that can lead to human errors, which include taking the wrong action, no action or making bad decisions provides additional information to mitigate risks. With improved human reliability comes reduced risk for the overall operation or project.

MODEL-BASED SYSTEMS ENGINEERING WITH SYSML: AN APPROACH FOR REDUCING COST AND IMPROVING QUALITY

Lenny Delligatti

Affordability is driving change in both organizations and the systems they deliver. Reducing cost is the pre-eminent goal. And the traditional document-based approach to systems engineering is expensive. A significant percentage of total lifecycle cost is incurred in the maintenance of a disjoint set of engineering artifacts that are the outputs of lifecycle activities. And when that cost isn't paid, that disjoint set of artifacts becomes inconsistent and obsolete.

Model-Based Systems Engineering (MBSE) is an alternative to the traditional document-based approach to systems engineering that can solve these problems. With MBSE, systems engineers perform the same lifecycle activities they always performed, but the results of those activities are captured in a single, integrated system model, created with a dedicated modeling tool. The system model serves as the primary engineering artifact—a central repository for design decisions—from which all other artifacts can be autogenerated: requirement specifications, interface definition documents, system design specifications, engineering analyses, test case specifications, and even production-quality source code for software systems. Designers make changes in a single place within the model, and the modeling tool automatically propagates those changes to all diagrams and autogenerated artifacts, which significantly reduces the time required to maintain those artifacts and eliminates the risk of inconsistency between them.

The Systems Modeling Language (SysML) is the de facto standard language for systems modeling. SysML is a graphical modeling language, which provides systems engineers the capability to visually represent the structure, behavior, and constraints of a system-of-interest and capture traceability to requirements. MBSE practitioners commonly create a system model in SysML, and then evolve that model over time when new design decisions are made and when requirements change. The system model remains at all times the central repository for design decisions as the design evolves.

HOW TO FAIL AT MBSE

Matthew Hause

Adopting Model-Based Systems Engineering (MBSE) techniques can be difficult. As with all things, there are far more ways to do things wrong than right. There can also be a perception that MBSE is a passing fad that will soon go the way of iPhones, the internet and other flash in the pan technologies. Add to that the lack of publicized evidence on Return on Investment (ROI) and the natural resistance to MBSE can become insurmountable. This presentation will start with a presentation of papers and reports on MBSE that have demonstrated a true ROI. It will then highlight a list of practical Do's and Don'ts when adopting MBSE listed below.

- Don't Neglect Training and Mentoring
- Encourage Collaboration
- Engage with Professional and Standards Organizations
- Don't Adopt an External Process Wholesale
- Don't Approach MBSE as Duplicate Work
- Integrate MBSE with Configuration Management
- Stay Informed of Best Practice
- Integrate Metrics into your Process
- Don't Conduct Paper-Based Reviews
- Don't Abuse Lean and Agile Development
- Optimize Your Process
- Don't Model Too Much, Too Early
- Build Documentation and Code Templates Early
- Don't Use Incompatible Modelling Tools
- Don't Adopt a Custom Notation
- Don't Duplicate Paper-based Processes With Tools
- Don't Start by Buying a Tool (Any tool)

The presentation will demonstrate that evidence-based research as well as practical tips will help systems engineers make the case for MBSE in their own organizations and implement MBSE successfully

MBSE WITHOUT A PROCESS-BASED DATA ARCHITECTURE IS JUST A SET OF RANDOM CHARACTERS

Robert Crain

A Process-based Data Architecture provides an understanding of what information is needed to effectively execute the enterprise's business processes and provides a framework for effectively managing the enterprise's information environment. It provides a representation of data artifacts and data assets that classifies and defines all data entities, their attributes, and associations to facilitate knowledge of how data is produced, managed, and shared in different contexts of use. The Data Architecture provides identification, management, interoperability, and integration of information across business or organizational elements needed to support Product Data Life-cycle Management goals. It also ensure that data needed by programs and projects (e.g., for milestones, reviews, mission operations, and anomalies or investigations, decisions, and outcomes) are identified and managed to provide traceability of data used in decision making.

The Data Architecture is the foundation for a solid Model-Based Systems Engineering (MBSE) approach. A well-defined process-based data architecture will facilitate:

- Standardization (definitions, concern viewpoints, etc.)
- Document based process flaws
- Process compliance audits
- Interoperability and data exchange
- Data Integration
- Application (Tool) Schema and Methodology development
- Definition of IT requirements

NASA INTEGRATED MODEL-CENTRIC ARCHITECTURE TEAM

Linda Bromley

As the complexity of typical aerospace systems increases, systems engineers are looking for better ways to gain an understanding of the overall system and all its interactions. In a time of tight resources, they are additionally looking for ways to reduce cost, improve product quality and to reduce the overall time to design and deliver a product. As a result there is an increasing use of Model-Based Systems Engineering (MBSE) techniques and tools. Moving from a document-based to a model-based enterprise system has been shown through benchmarking of numerous commercial companies to provide an improved ability for complexity management, improved quality and completeness of designs, reduced time to manufacturing, reduction of overall costs and an ability for other programs/projects to share designs. Additional benefits include the ability to identify and correct design or integration problems early in the lifecycle, better, more thorough design reviews, reduced or more focused testing, and the ability to track how a change in a requirement or one part of the system will affect other systems. Given this potential, the NASA Agency has formed a team to help move the Agency from a document-centric to a model-based enterprise system. This presentation describes the progress and findings of the NASA Integrated Model-centric Architecture (NIMA) team.

TECHNOLOGY DEVELOPMENT ENVIRONMENT FOR EXPLORATION

Bill Othon

NASA will develop new and innovative capabilities to enhance performance as well as to reduce the risk and cost of future human spaceflight. This *capabilities-driven* approach will identify the engineering and operational technologies that must be developed in order to advance human spaceflight beyond Earth orbit. These new technologies must be demonstrated *within a mission context* that will allow future project managers to accept the risk of applying these innovative products to meet mission objectives more completely and for lower cost. The Integrated Power Avionics and Software (iPAS) environment is designed to evaluate and mature technologies quickly, using a path-to-flight approach. iPAS focuses on early hardware-software integration, leveraging off code libraries and off-the-shelf hardware and avionics to quantitatively evaluate the impact of technologies on systems. iPAS leverages off both Engineering and Operations teams at JSC and across NASA Centers to maximize innovation.

Lunch Program
Key Note Panelists
Biographies & Moderators

Future Space Exploration “Flight” Beyond LEO

Anousheh Ansari

"First Female Private Space Explorer & First Space Ambassador" Morning Keynote Speaker

Anousheh Ansari is a Co-Founder and Chief Executive Officer of Prodea Systems. As she launched her company, on September 18, 2006, she also blasted off for an eight-day expedition aboard the International Space Station and captured headlines around the world as the first female private space explorer. She also earned a place in history as and the first astronaut of Iranian descent, the first Muslim woman, and the fourth private explorer to visit space. This was the accomplishment of a lifelong dream for her. As a successful serial entrepreneur and active proponent of world-changing technologies and social entrepreneurship she along with her family provided the title sponsorship for the Ansari X Prize, a $10 million cash award for the first non-governmental organization to launch a reusable manned spacecraft into space twice within two weeks. This feat was accomplished in 2004 by legendary aerospace designer Burt Rutan in 2004. With the success of the X Prize competition, Ansaris had helped launch a new era in private space exploration. Prior to her Space ventures, Anousheh served as co-founder, chief executive officer, and chairwoman for Telecom Technologies, Inc.; subsequently earning three key U.S. patents and growing 100% sequentially yearly since inception, her company successfully merged with Sonus Networks, where she served as General Manager and Vice President of the Softswitch division. Anousheh is a member of the X Prize Foundation's Vision Circle, as well as its Board of Trustees. She is a life member in the Association of Space Explorers and on the advisory board of the Teacher's in Space project. She has received multiple honors, including the World Economic Forum Young Global Leader, Ellis Island Medal of Honor, Horatio Alger Award for Distinguished American, DFW International Community Alliance Hall of Fame award, the Working Woman's National Entrepreneurial Excellence Award, George Mason University's Entrepreneurial Excellence Award, George Washington University's Distinguished Alumni Achievement Award, and the Ernst & Young Entrepreneur of the Year Award for Southwest Region. While under her leadership, Telecom Technologies earned recognition as one of Inc. magazine's 500 fastest-growing companies and Deloitte & Touche's Fast 500 technology companies. Anousheh serves on the boards of several not-for-profit organizations focused on STEM education and youth empowerment. She currently works to enable social entrepreneurs to bring about radical change globally, with organizations such as ASHOKA, which supports social entrepreneurship around the world, including the Middle East and Central Asia. She runs an annual competition called the "What If?" competition for middle school student to promote free thinking and STEM education. Anousheh earned a bachelor's degree in electronics and computer engineering from George Mason University, followed by a master's degree in electrical engineering from George Washington University. She received an honorary doctorate from International Space University and recently an honorary doctorate from George Mason University. She is currently working toward a master's degree in astronomy from Swinburne University.

Michael E. Fossum
Astronaut

Michael E. Fossum is a retired colonel in the U.S. Air Force. He received his commission from Texas A&M University in May 1980. After completing his graduate work at the Air Force Institute of Technology, he was detailed to NASA-Johnson Space Center, where he supported Space Shuttle flight operations. He resigned from active duty in 1992. In 1998, Fossum was selected as an Astronaut Candidate. The veteran of three space flights currently serves as the Assistant Director for the International Space Station. Fossum has logged more than 194 days in space, including more than 48 hours during seven spacewalks.

Dr. PAUL D. SPUDIS

Dr. PAUL D. SPUDIS is a Senior Staff Scientist at the Lunar and Planetary Institute in Houston, Texas. His research focuses on impact and volcanic processes on the planets and requirements for sustainable human presence on the Moon. He was Deputy Leader of the Science Team for the *Clementine* mission to the Moon in 1994, the Principal Investigator of the Mini-SAR radar experiment on India's Chandrayaan-1 mission in 2008-2009, and a team member of the Mini-RF radar on NASA's Lunar Reconnaissance Orbiter mission (2009 present). He was a member of two White House commissions on U. S. Space Policy. He is the author or co-author of over 100 scientific papers and six books, including *The Once and Future Moon* and *The Clementine Atlas of the Moon*.

Scott J Kelly
Astronaut

Scott J. Kelly (Captain, USN, Ret.) is a graduate of the State University of New York Maritime College and the University of Tennessee at Knoxville. In 1996, Kelly was selected by NASA as an Astronaut Candidate. The veteran of three spaceflights has logged more than 180 days in space, including one long duration spaceflight. Most recently, he and cosmonaut Mikhail Kornienko were selected to serve a one-year mission aboard the International Space Station. The goal of the 2015 mission is to understand how the human body reacts and adapts to the harsh environment of space.

Chairman and CEO, Ad Astra Rocket Company
Dr. Franklin R. Chang Díaz

Dr. Franklin R. Chang Díaz www.franklinchangdiaz.com is founder and current Chairman and CEO of Ad Astra Rocket Company, www.adastrarocket.com, a US firm developing advanced plasma rocket technology with operations in Houston, Texas and Guanacaste, Costa Rica. In 2005 Dr. Chang Díaz completed a 25 year career as a NASA astronaut where he became a veteran of 7 space missions. He has logged over 1,600 hours in space, including 19 hours in three space walks. In 1994, in conjunction with astronaut training at NASA, he founded and directed the Advanced Space Propulsion Laboratory (ASPL) at the Johnson Space Center where he managed a multi-center research team developing advanced plasma rocket propulsion concepts. Dr. Chang Díaz is the inventor of the VASIMR® engine, a high power plasma rocket currently under development by Ad Astra for in-space applications. He has over 30 years of experience in experimental plasma physics, engineering and high power electric propulsion and 25 years of experience in space operation and the management and implementation of research and development programs at NASA. Dr. Chang Díaz holds a PhD degree in Applied Plasma Physics from the Massachusetts Institute of Technology and a Bachelor of Science degree in Mechanical Engineering from the University of Connecticut.

Prior to his work at NASA, Dr. Chang Díaz was involved in magnetic and inertial confinement fusion research at MIT and the Charles Stark Draper Laboratory. He is an Adjunct Professor of Physics at Rice University and the University of Houston. He is married to the former Peggy Marguerite Stafford of Alexandria, Louisiana and has four daughters: Jean Elizabeth (38) Sonia Rosa (33), Lidia Aurora (23) and Miranda Karina (16). He enjoys music, flying and scuba-diving. His mother, brothers and sisters still reside in Costa Rica

EXCALIBUR • ALMAZ

Art Dula

Art has over 30 years experience as an attorney specializing in aerospace, export control and intellectual property law. He was a consultant to NASA on the Space Shuttle payload contract and an advisor to the U.S. Congress on legal issues concerning space stations. He is a past Chairman of the American Bar Association's Section on Science & Technology and is a corresponding member of the IAA and an associate fellow of the AIAA. Mr. Dula teaches space law at the University of Houston. He holds a J.D. degree from Tulane University. Prior to founding Excalibur Almaz in 2005, Mr. Dula served as Director and General Counsel to companies including Eagle Aerospace, Inc.; Space Services, Inc., which launched the first private U.S. space vehicle; and Spacehab, Inc., which built and flew Spacehab modules in the U.S. Space Shuttle. He also founded Space Commerce Corporation, the first U.S.-Russian aerospace joint venture. Mr. Dula is a former Director and current member of the Board of Governors of the National Space Society and twice received society's Space Pioneer Award. In addition, he is literary executor for the writer Robert A. Heinlein and serves as Trustee of the Robert A. and Virginia Heinlein Prize Trust, which offers annual awards to individuals for significant commercial accomplishments in aerospace, and to aerospace students in international contests.

Dr. John (Jack) Bacon
Futurist

Jack Bacon has often been called "A New Carl Sagan." He is an internationally-known motivational speaker, a distinguished lecturer (emeritus) of the American Institute of Aeronautics and Astronautics (AIAA), and one of the most requested speakers in the world for topics concerning technology and the factors that shape human society. A noted futurist and a technological historian, he has written three popular books entitled "My Grandfathers' Clock," "My Stepdaughter's Watch," and “The Parallel Bang,” with many thousands of copies sold of each. A fourth: *“Killer Apps for the Green Global Village”* is in the works. His lectures have captivated tens of thousands of all ages in thirty-two countries on six continents, and he has appeared on numerous radio and television broadcasts. In his daily work, he is on the management team overseeing the construction and operation of the most complicated technical project in history: the International Space Station. A graduate of Caltech (B.S. '76) and the University of Rochester (Ph.D. '84) his extensive career includes roles in the development of many cutting edge technologies, including controlled thermonuclear fusion, the development of the electronic office, factory automation, and the globalization of business. He pioneered the deployment of several artificial intelligence systems, learning his craft at the famed Xerox Palo Alto Research Center. He was the United States' lead systems integrator of the Zarya-the jointly-built spacecraft that forms the central bridge and adapter between all US and Russian technologies on the Space Station. This landmark in technological history was built in Moscow by American and Russian engineers and launched from the Baikonur Cosmodrome in November 1998. Jack is a fellow of the Explorer's Club, a member of the AIAA, the National Speakers Association, the International Federation of Professional Speakers, Engineers without Borders, and Rotary International. He was a founding member of the board of directors of the Science National Honor Society (www.ScienceNHS.org). Among his numerous awards, he is a recipient of NASA’s Exceptional Achievement Medal, the Director’s Special Commendation, and the coveted Silver Snoopy award-the only award to fly in space. He routinely advises numerous academic programs and institutions, and he is a champion of education throughout the world. When he's not on the road, Jack cherishes his time together with Kathleen: his lifelong love since high school, found five states away after 27 years apart. (You’ve gotta love the Internet!)

Ms. Beth Fischer
Honeywell

Ms. Beth A. Fischer is the Director, Engineering Center of Excellence for Honeywell Technology Solutions, Inc (HTSI).   She has an extensive 20+ year aerospace experience base developed through a career with NASA and Honeywell including positions in human spaceflight program management, associate and deputy director positions for NASA Johnson Space Center (JSC) Engineering and Center Operations, aerospace engineering product development and delivery, project management, contract management, business development, business management, payload processing and launch operations, and infrastructure management. She excels in leading and integrating diverse teams, managing day to day operations and executing challenging new initiatives such as the recently formed Engineering Center of Excellence for HTSI. She has received numerous awards throughout her career including highlights of a NASA Outstanding Leadership Medal for her work in JSC Engineering, a NASA Exceptional Achievement Medal for her work on the International Space Station and Certificates of Commendation from the Johnson Space Center Director and Kennedy Space Center Director. Ms. Fischer has a Bachelor's Degree in Industrial Engineering from Kettering University and a Masters Degree in Engineering Management from the University of Central Florida.   She resides in Houston, TX with her two children.

Richard Phillips
Founder and President Phillips & Company

For more than 22 years, Rich has helped companies and organizations build leadership momentum for products, services and ideas. Rich is the Founder and President of Phillips & Company, a global communications firm focused on creating, defending and sustaining leadership positions through public relations and business development. Phillips & Company is currently the number one PR agency in the world serving the aerospace and emerging commercial space market, and the company is recognized for its issues advocacy and corporate public relations work in homeland security, mobile computing, education, healthcare and energy. Rich has helped create several coalitions to support issues and goals of member companies including the Family Services Technology Council, Next Step in Space Coalition, Healthcare Mobile Innovation Alliance and the Healthcare Delivery Innovation Alliance. Rich is also managing partner of Telepoint Global Hosting Services, a trading platform for wholesale voice with a focus on telecom carriers in Asia, Africa, Latin America and the Middle East and Blackpool Application Hosting, a Dublin-based telecom firm focused on managing voice traffic between Europe and the world. Rich also serves on the Board of Directors of Explore Mars, a non-profit committed to advancing the U.S. leadership role in space exploration. Rich earned a B.A. in Economics with Distinction from Boston University and a Master's in Public Policy from Georgetown University.

Panel Moderator ~ AIAA Technical Operations Chair ~IT Strategic Consultant
Aerospace – Science Consulting Consortia & Pro Life Coaching
Beatriz Kelly-Serrato (BeBe)

BeBe Kelly-Serrato has a degree in Geological Sciences and has worked as an IT Security Specialist, a Scientist, and an Aerospace Engineer; she currently pursues additional activities in music, executive coaching, professional speaking, vocal coaching, and business development. She's held positions in corporate and government sectors, supporting security network infrastructures for the past 25 years. She has developed relationships with scientists, engineers, and individuals from diverse backgrounds, including the arts. She's utilized these connections in creative and diplomatic ways to help create useful business connections. She's utilized her experience and background from her knowledge of science, engineering, and aerospace, but her creativity provided much more than her employers or clients anticipated. In her career, she's worked within the NASA contractor community in the Engineering Directorate as a system engineering manager and outside the NASA environment for fortune 500 companies as a project manager and IT Security Specialist. BeBe is comfortable transitioning between the government sector, Oil-Gas and Corporate Business environments; she is supportive to individuals and teams in structured and relaxed settings. She's currently the developing Aerospace – Science Consulting Consortia, LLC, Pro Life Coaching, and Glass of Class Jazz Vocals in a difficult economy. She is searching for full-time work and volunteers for the AIAA and Teachers in Space for the Space Foundation. Her present goal is to locate a career or contracts and transition to commercial aerospace for IT security systems or within another corporate area before settling into professional speaking, branding, product development, and coaching full time either on her own or as an internal integrator for a company who could utilize her skill set. Her core values include Independence, Risk-taking, and Integrity, and are key in driving her towards attaining her goals. She is a speaker and facilitator for think tanks and keynote panels for the aerospace community and IT Security Summits. She was invited to facilitate a think tank for IT cloud security recently during the Texas Technology Summit. Coaching and moderating the AIAA panel will be an interesting challenge. She has raised three children and is a care giver to her Mom.

Shirley Brandt
AIAA Houston Section Chair
Toast Master Sergeant of Arms (Co– Moderator)

Shirley Brandt has provided support in dynamics on commercial aircraft, and loads and dynamics on military aircraft for many years. She transitioned into the Space program, and worked in Structural Dynamics on the Space Shuttle. For 12 years, she worked on the interface of the Canadian Robotic Arm with the International Space Station. She's been a member of AIAA for about 35 years, where she's held several offices, including Houston Section Chairman. Currently, she is the Secretary of the National Systems Engineering Technical Committee and is Honors & Awards Deputy Director for AIAA Region IV. She holds several offices in Toastmasters International.

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