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4th Annual
Dayton Engineering Sciences
Symposium
October 27, 2008
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WELCOME

On behalf of the Organizing Committee, we would like to welcome you to the 4th Annual Dayton Engineering Sciences Symposium (DESS). Sponsored by the Dayton Section of the American Society of Mechanical Engineers (ASME), the symposium is intended to facilitate communication between members of the regional technical community, and to provide a forum for students, engineers, and scientists to present their work and sharpen their technical presentation skills.

This year's symposium features 98 technical presentations spanning a broad range of engineering sciences. In addition to scientific research, this year's symposium includes special sessions on Undergraduate Projects & Engineering Education. This year's symposium has a special emphasis on "**Energy"**, and we've arranged for Mr. William (Bill) Harrison to deliver our keynote speech. Mr. Harrison is the Technical Advisor for Fuels and Energy for the Propulsion Directorate of the Air Force Research Laboratory. He is an Air Force Research Laboratory Fellow responsible for developing strategy and advising program managers on issues related to fuels and energy. He serves on several DoD, inter-agency and government/commercial working groups related to alternative energy, the environment, and propulsion. He has been a co-leader of the demonstration of Fischer-Tropsch Fuels on the B-52 aircraft and the co-leader of team that developed the military handbook for certifying fuels for use all Air Force systems.

To follow on this theme, we have also arranged a short panel session on "Energy: Present Challenges & Future Opportunities", which will be facilitated by handful of regional experts on the topic of energy in transportation and alternative energy technology. The panel session is intended to be a forum where these experts engage in discussion on this topical subject which serves to highlight various viewpoints, promote dissenting ideas, and to foster participation from you, the audience. The goal of a panel session is not for us all to reach some consensus, nor is it for the panel to convince us that they have all the answers. The aim is to cultivate a greater understanding of energy issues, present challenges, and future opportunities for the science & engineering community.

We hope that this symposium will serve to encourage increased participation and cooperation within the Dayton Region's professional and academic communities. Its success would not have been possible without all of your participation: speakers, session chairs, panelists, students, faculty, government and industry representatives, organizing committee, and the ASME Dayton Section Executive Board.

Carl Tilmann, Symposium Chair
John Leland, Symposium Co-Chair
Sivaram Gogineni, Executive Advisor

– KEYNOTE –

"Alternative Energy for Aerospace Applications"

William E. Harrison III
Technical Advisor for Fuels and Energy
Propulsion Directorate, Air Force Research Laboratory, Wright Patterson AFB OH

Mr. William (Bill) Harrison is the Technical Advisor for Fuels and Energy for the Propulsion Directorate of the Air Force Research Laboratory. He is an Air Force Research Laboratory Fellow responsible for developing strategy and advising program managers on issues related to fuels and energy. He serves on several DoD, inter-agency and government/commercial working groups related to alternative energy, the environment, and propulsion. He has been a co-leader of the demonstration of Fischer-Tropsch Fuels on the B-52 aircraft and the co-leader of team that developed the military handbook for certifying fuels for use all Air Force systems. In addition, he recently completed a MBA at the MIT Sloan School and is an MIT Sloan Fellow.

In November of 2004 until March of 2006, Mr. Harrison was detailed from the Air Force as a technical advisor to assist the staff of the Deputy Under Secretary of Defense for Advanced Systems and Concepts to help establish a new initiative in the Office of the Secretary of Defense (OSD) – the Assured Fuels Initiative. His prime focus was to support the Total Energy Development Program (TED) to catalyze the industry to produce clean fuels from domestic alternative and unconventional resources and determine which resources were technically mature and economically viable. He also served as a liaison to the Department of Energy (DOE) to establish joint programs for the Department of Defense to use fuels from alternative and unconventional resources that were supported by DOE programs. The outreach that was conducted as part of the TED program was used for planning the Joint Battlespace Use Fuel of the Future (J-BUFF) Program, which will evaluate, demonstrate, certify and implement clean fuels produced from secure, diverse, domestic resources for use in all military tactical vehicles, aircraft and ships.

Mr. Harrison has received many awards and decorations including the Exceptional Civilian Service Award, Meritorious Civilian Service Award, Exemplary Civilian Service Award, Military Reservist Supervisor of the Year, and the Dayton Affiliates Council Award for Outstanding Professional Achievement. In addition, as a team co-lead he has received the FAA Excellence in Aviation Award, Defense Standardization Program Achievement Award, Air Force Association Award, U.S. Air Force Outstanding Science Team Award, and the Ronald W. Yates Award. He is also a member of the National Scholars Honor Society.

– PANEL SESSION –

"Energy: Present Challenges & Future Opportunities"

William Harrison, *Technical Advisor for Fuels and Energy, AFRL Propulsion & Power*

Dieter Multhopp, *Sr. Principle Engineer, Energy Efficiency Initiative AFRL Air Vehicles*

Thomas Ramsay, *Senior Engineer, Vehicle Research Division, Honda R&D Americas*

Gary Walzer, *Senior Principle Engineer, Alternative Energy Technology, EMTEC*

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Session 1: Energy:	**8:40-10:40 AM**	**Room 156A**

Chair: Scott Stouffer, UDRI

DESS08-0074

Energy Concerns for the Aerospace Corporation

Scott Snelling
Goodrich Aircraft Wheels & Brakes

Rising fuel costs have only heightened the emphasis that aerospace corporations must place on energy. Airframe and airline customers want to reduce fuel burn more than ever, placing an even greater emphasis on weight than before, while still demanding increases in product reliability. These requirements are driving new technologies and the use of lightweight materials. Additionally, global green initiatives are filtering into product and manufacturing requirements. Transportation and shipping costs are becoming more significant for both the supplier and the customer. This presentation will discuss how such issues are impacting overall business decisions, as well as taking a more detailed look at product design considerations. A focus will be given to aircraft electric brakes and how this new technology meets the customer desires of lower weight and higher reliability.

DESS08-0054

Energy Requirements Planning for New Product Development: A Project Framework Approach

Adedeji Badiru
Air Force Institute of Technology - AFIT/ENV

This presentation will discuss energy design planning for new product development using a project framework approach. Energy is one of the biggest challenges facing mankind. Energy is an all-encompassing commodity that touches the life of everyone. Managing energy effectively is of paramount importance in every organization and every nation. It is mandatory to optimize decisions relating to energy exploration, production, distribution, and consumption. Product energy requirement is one viable avenue to control energy consumption. Decisions relating to energy management should be of interest at all levels ranging from personal, organizational, institutional, community, state, and national levels. According to the strategic plan of the US Department of Energy, reliable and affordable energy is central to our economic and national security. Indeed, energy helps drive the U.S. and global economy and has a significant impact on our quality of life and the health of citizens.

DESS08-0047

A Cost Benefit Analysis: Viability of Passive Solar Energy Systems for Large Facilities on Air Force Installations

Sang Lee

Air Force Institute of Technology

Passive solar technology has been an untapped potential for gains as a renewable energy source even though the large scale photovoltaic solar field that replace complete utility systems currently present the lowest cost per energy (KWH) ratio. Passive solar systems such as solar daylighting and solar heating present a viable solution for the Air Force and the commercial sector where the highest energy cost is in electricity generation through the load reduction strategy. Furthermore, passive solar technology is attractive solution since its implementation can be managed locally at the facility level and is less restrictive than the large investment and land space required to install a solar collection farm. The passive solar industry has made strides in its technology but further innovation and research development is needed to nurture growth in an area of solar technology whose potential has been largely unrealized.

DESS08-0029

An Evaluation of Solar Air Heating Technology at U.S. Air Force Installations

David Brown

Air Force Institute of Technology

Numerous legislative acts have been put in place to guide the Federal Government towards more efficient and environmentally responsible energy use. To reach the goals set forth in these acts, energy managers must analyze numerous alternative energy options. Transpired solar collectors, or SolarWalls, may be a viable option at many Air Force installations. These walls consist of perforated, metal cladding that use solar energy to pre-heat fresh air for ventilation systems. This research will provide energy managers with a brief summary of Air Force energy initiatives to date, as well as a description of how SolarWall technology works. Through the use of case studies, this research will attempt to uncover and consolidate lessons learned from previous SolarWall users in the DoD. Economic assessments will also be performed at various base locations to assist Air Force energy leaders in recognizing which bases may or may not be potential candidates for SolarWalls.

DESS08-0019

Efficiency Improvements for a Rural South American Community Electrical System

Thomas Wenning
University of Dayton

Peter Kleinhenz
University of Dayton / Go Sustainable Energy, LLC

In the developing South American country of Bolivia, citizens of the rural community of Tumupasa pay high electricity prices due to a small, isolated, and poorly controlled electrical generation system. Power generation for the community comes from a diesel generator and a small hydro-electric generator. Power quality issues and blackouts are common in the community. The community has limited technical resources and possesses little information about daily demand, power factor, load factor, customer usage, system generation efficiency or system distribution efficiency. Thus, the community is in need of technical assistance to analyze, diagnose and recommend improvements for the electric system. A team of three individuals went to the community and conducted an analysis of the electrical generation systems, the transmission and distribution system, and the end user habits. This paper summarizes key findings. These findings include optimal generator operation, identification of system losses, and end use categorization.

DESS08-0049

BIO GREEN WASTE TO ENERGY An old Technology with a New Future

John Norton
Owner, Norton Engineering LLC; Chairman, ASME Solid Waste Processing Division

After 15 years of quiet dormancy, modern incineration is headed for a big comeback here in America. Incineration releases the energy in waste material; it is used for steam and electric generation in 86 American cities already. It now has several new things going for it: 16 years of compliance with the most stringent air pollution control limits in the world, University advocacy, a new Supreme Court Ruling, ASME Solid Waste Processing Division's new "white paper" with the approval of the ASME Energy Division, the national energy crisis, and the inexorable growth of post recycled solid waste in America. Combined with readily available green bio fuels, it presents a truly homegrown energy source independent of outside influence. Side benefits include the preservation of "greenfield" land, diesel fuel conservation, and traffic and emission reductions.

Session 2: Materials: 8:40-10:40 AM Room 156B

Chair: Geoff Fair, AFRL/RX

DESS08-0041

Mechanical Testing to Determine Interface Properties of Fiber Reinforced Ceramics

Joy Davis
Wright State University

Dr. Geoff Fair
AFRL/RXLN

The need for high temperature materials has increased in aerospace applications. Fiber reinforced ceramics enable high temperature applications with improved performance. Tailored fiber-matrix interfaces are required in order to create a weak bond, which is necessary for damage tolerance. In this work, fiber coatings are used to fulfill the weak bond requirement. Rare earth phosphate coatings are being considered because of their oxidation properties and performance in high temperatures. Interface properties are characterized by using fiber push-out and crack deflection testing. Four different coatings are being investigated: lanthanum, dysprosium, gadolinium and terbium phosphate. Lanthanum phosphate is used as the control sample as it has been investigated previously. Results show that dysprosium phosphate behaves analogous to lanthanum phosphate. Current results also indicate that gadolinium and terbium phosphate appear to be strong interfaces and not suitable for this application.

DESS08-0086

Growth of Carbon Nanotubes on Porous Carbon Substrates

Ian Barney
Wright State University

S.M. Mukhopadhyay
Wright State University

This project focuses on the growth of carbon nanotubes on porous engineering structures to create multi-scale materials with increased surface area, where additional functionalities may be added. Thick layers on carbon nanotubes have been grafted on various carbon substrates (microcellular foams, fibers, and flat graphite) using chemical vapor deposition (CVD). Influence of surface functional groups on the growth of nanotubes was investigated by comparing pre-coated and uncoated samples. Analyses of chemical states have been preformed using x-ray photoelectron spectroscopy (XPS) and of nano-structure using scanning electron microscopy (SEM). Results indicate that silica-like nano-coatings improve the growth of carbon nanotubes, showing higher growth rate, purity, stronger adhesion to the surface, and improved homogeneity. A variety of applications benefiting from improved properties of CNT enhanced substrates will be discussed.

DESS08-0084

Characterization of Carbon Nanotubes in Epoxy

Gerard Simon
Wright State University

Carbon nanotubes (CNT) have been shown experimentally to increase the yield strength, Young's modulus, and strain to failure of epoxies when added as a reinforcing material. The performance of the reinforced epoxy may be maximized controlling the dispersal of the CNTs within the epoxy. However, the CNT strands have a tendency to bundle together instead of dispersing in a controllable fashion. To determine the dispersion of the CNT throughout an epoxy, many characterization methods are available. These include scanning-electron microscopy (SEM), transmission-electron microscopy (TEM), and x-ray diffraction (XRD). Characterization using TEM will be discussed. Proper preparation of the sample to be studied is essential, as the sample must be thin enough to allow penetration of the electron beam, yet robust enough to withstand the beam's energy. With the appropriate preliminary steps, TEM becomes on of the best methods of characterizing CNT in epoxy.

DESS08-0083

Geometrical Modeling, Microstructural Analysis, and Surface Modification of Microcellular Carbon Structures

Anil kumar Karumuri
Wright State University

S. M. Mukhopadhyay
Wright State University

Microcellular foams of graphitic carbon can form the core substrate for many advanced structures due to their high surface area, interconnected porosity, low density, and high thermal and electrical conductivity. This has potential applications in the areas of thermal, structural, electrical and biomedical devices, both for military and commercial applications. This talk will focus on geometrical modeling of the microcellular structure, and its correlation with actual microstructural data obtained in graphitic foam. In addition, most surface related properties of these can be enhanced by careful grafting and functionalization of carbon nanotubes. In this study, influence of nanotubes on surface area, composite formation, and mechanical behavior are being modeled and tested. Results obtained to date will be presented in light of current understanding in the literature.

DESS08-0072

The Use of a Polymer Based Composite System for Repair of High Temperature Pipeline

Thomas Spradlin
Wright State University

Dr. John Henshaw, Ph.D., P.E.
The University of Tulsa

Determination of the glass transition temperature for a graphite/polymer matrix material as implemented in a bi-directional carbon fiber composite was the main focus of this work. The necessity of this critical temperature comes from the current governing ASTM standard, PCC-2. The accuracy of this transition temperature is dependent upon the material having reached full cure, thus requiring the creation of a predictive percent cure model as a function of time. Through the use of this model the glass transition temperature of the material can be predicted. This research resulted in the development of two cure models, one for a catalyzed version of the system and one for the un-catalyzed version. The end glass transition temperatures of the un-catalyzed and catalyzed materials were determined to be 296˚C and 280˚C, respectively. The models predicting percentage conversions were determined to be sufficiently accurate thus requiring revision to the current governing standard, ASTM PCC-2.

DESS08-0093

Ultrasonic Characterization of Thermally Aged Epoxy

Shaun Freed
Univ. of Dayton Ph.D student in Materials Engineering

Some polymer matrix composite material researchers are interested in understanding better the aging process of polymers under elevated temperature environments. Polymers undergo physical and chemical changes over time when exposed to high temperatures, and often a thin surface layer of material degradation results. This research has sought to characterize the changes in mechanical properties within this surface layer (~ 250 microns thick) through the use of ultrasonic surface waves. These experiments were conducted on epoxy, but the technology should be extendable to more traditional high temperature use polymers. The results to date demonstrate that mechanical property changes within this aged layer cause the ultrasonic wave to increase in velocity, decrease in attenuation, and reduce its amplitude scatter. Future plans to correlate these measurements to specific aging mechanisms and specific mechanical properties will also be outlined.

Session 3: Fluid Dynamics / CFD: 8:40-10:40 AM Room 156C

Chair: BG Shiva Prasad, Emerson Climate Technologies, Inc.

DESS08-0004

Computational Fluid Dynamics Analyses for Supersonic Nozzle at Ohio State University

Barbara Rodriguez
AFRL/RBAC

The Air Force Research Laboratory has performed Computational Fluid Dynamics (CFD) for the Ohio State University to support the design of a supersonic nozzle and test section. The tunnel has a rectangular inlet, square outlet and length of 17.5cm. As the tunnel reached Mach 5, large boundary layers developed along the sides. Several CFD simulations have been run for the empty tunnel, different size cylinders and spheres and a 1cm wedge with a deflection angle of 10 degrees which was done to verify CFD and theory. Current simulations show an extensively large, malformed boundary layer developing which may adversely impact the aerodynamics of models placed in the test section. The results produced by the CFD code AVUS (Air Vehicles Unstructured Solver) will help OSU determine the type and size of the model that may be placed in the test section.

DESS08-0014

Flow Stability Analysis of Thermal Perturbation in Mach 1.5 Laminar Boundary Layer

Hong Yan
Wright State University

Datta Gaitonde
AFRL

A numerical study is performed to explore the effect of thermal perturbation in a Mach 1.5 flat plate laminar boundary layer. The flow stability characteristics are assessed by varying the initial disturbance amplitude, frequency, the spanwise width of the heating element and the bump shape. The thermal bump generates two pairs of counter-rotating streamwise vortices formed at the four edges of the element. When the heat source is pulsed, vortex shedding is observed. These vortices interact with each other, generating a complicated vortical field. The study of the different initial disturbance amplitudes demonstrates the existence of non-linear effects while the frequency variation highlights the importance of pulsing in determining the features of the downstream disturbance.

DESS08-0015

A Numerical Investigation on the Performance of a Low-flow Thermodenuder

Alejandro Briones
University of Dayton Research Institute

Jamie Ervin, Matthew Dewitt, Scott Stouffer, Christopher Klingshirn
University of Dayton Research Institute

Meng-Dawn Cheng
Oak Ridge National Laboratory

Edwin Corporan
AFRL Wright Patterson Air Force Base

Thermodenuders are used to remove volatiles from aerosols. An extensive numerical investigation is conducted to examine the performance of a low-flow thermodenuder. The laminar nitrogen flow inside the thermodenuder is modeled in three dimensions. A steady, one-way coupling Lagrangian approach is used to track the NaCl particles, whose trajectory depends on the balance between the particle inertia, flow drag, and thermophoretic forces. The thermodenuder operates horizontally and buoyancy acts vertically. Without buoyancy the flow is axisymmetric and the flow permeates the screen and the particle losses occur downstream along the screen. With buoyancy the flow becomes non-axisymmetric and two non-aligned counter-rotating vortices are formed on each side of the inlet flow. These vortices reduce particle losses by pushing particles towards the centerline. Although thermophoretic losses are increased by buoyancy the overall particle losses are reduced by the effect of buoyancy. The effect of temperature on particle losses is also examined.

DESS08-0061

Initial Characterization of Three-Dimensional Flow Separation in a Compressor Stator

Samuel Bailie
AFRL/RZTF

Grant Hile
AFRL/RZTF

Steven Puterbaugh
AFRL/RZTF

A research program is underway to effect a net decrease in aerodynamic loss of a moderately loaded axial compressor stator passage across varying operating conditions. Three dimensional boundary layer separation, typical at the suction surface corners, can differ greatly from classical 2D separation, and is the dominant loss and blockage generating feature in the diffusing flowfield of compressor stators. The initial research phase is presently described, wherein a relevant stator configuration has been designed, and numerical simulations have been used to characterize the aerodynamic performance and key flow features of the baseline configuration. The evaluation has been conducted at the high subsonic inlet Mach design condition as well as off-design conditions, including varying incidence angle and Mach number. Refinement and analysis of the baseline configuration is on-going, but the design's performance suggests it is a typical modern stator, providing a good benchmark for the planned competitive approaches towards performance improvement.

DESS08-0067

Direct, Real-time Measurement of Airfoil Lift and Moment Using Flow Bifurcation Points

Siva Mangalam

Tao Systems

Pressure distribution and load balance are commonly used in wind tunnel experiments to measure the aerodynamic forces generated by wings and bodies. These measurement techniques provide accurate estimates in steady flow but they have limited frequency response for real-time, in-flight determination of aerodynamic forces, especially in the presence of gusts, deformation of flexible structures, and control actuation. An unconventional method has been developed to measure aerodynamic forces and moments in real time by merely identifying the flow bifurcation points, such as the leading-edge stagnation and flow separation points, using surface signatures obtained with flush-mounted hot-film gages. The presentation will include some results from recent wind tunnel and flight experiments, a physical modeling of the measurement technique, and the mathematical basis for the approach.

DESS08-0010

Calibration Model for Low Speed CFD Analysis

Stephen Warrener

AFRL RBAC

Computational Fluid Dynamics (CFD) analyses for a blended wing aircraft were compared with wind tunnel data acquired through tests conducted at NASA/Langley Research Center's 14 x 22 Low Speed Wind Tunnel (LSWT). The comparison is for validation of the low velocity performance of the Air Vehicles Unstructured Solver (AVUS). The vehicle was tested at Mach .143 at angles of attack ranging from -6 to +24 degrees with various flap deflection conditions including 0, 30, 60 and 90 degrees. Computational simulations range from -5 to +10 degrees angles of attack for all flap deflections. All configurations included fixed leading edge slats. Coefficients of lift and drag for the various configurations are presented.

Session 4: Engineering Education: 8:40-10:40 AM Room 157A

Chair: Gary Dale, AFRL/RB

DESS08-0006

Exposing Inner City Students to Engineering: The Kiser PK-8 Robotics Program

Douglas Smith

Eric Ebbers

Gerica Brown

Colin Gorey

University of Dayton, Department of Mechanical and Aerospace Engineering Students

Four University of Dayton Students have developed their MEE 499: Engineering Service Learning course experience to partner with an inner city Dayton Public School to expose students to career fields in math, science and engineering. By using Lego Mindstorms robotics kits, this student-led program aims to demonstrate to urban youth that not only is engineering fun and necessary but that it is attainable for all students no matter their background. The students will discuss how they lead the way to seek project funding, developed engaging projects, and developed a model for sustaining this program beyond their December graduation. The presentation will also touch on ways the engineers enhanced their own academic learning in a non-traditional setting (a middle school classroom).

DESS08-0048

Engaging Student Learning with a Sustainability Initiative at Sinclair Community College

Robert Gilbert

University of Dayton/Sinclair Community College

Robert Woodruff

Sinclair Community College

Sinclair Community College has increased its sustainability initiative in two main areas of recycling to reduce waste stream and energy efficiency to reduce energy consumption. Sinclair has initiated a biodiesel production project, funded by the Ohio Department of Natural Resourses, to produce biodiesel with used kitchen oil. The biodiesel is then used in the lawn and facilities maintaince equipment. Sinclair students are producing and testing the biodiesel to ASTM biodiesel standards. Energy efficiency and energy code requirements are now incorporated into all architectural, civil, construction management, and construction technology courses. Sinclair students, as a part of course requirements, are performing energy audits for non-profit organizations in the surrounding community.

DESS08-0066

SCADA defense, a hands-on trainer to educate students on control system vulnerabilities.

David Olander
Air Force Institute of Technology, Center for Cyberspace Research

Juan Lopez
Air Force Institute of Technology, Center for Cyberspace Research

Dr. Richard Raines
Air Force Institute of Technology, Center for Cyberspace Research

In recent years critical infrastructure protection has become a key item of interest due to cyber vulnerabilities and the asymmetric target it presents to attackers. Current education and research in the area of infrastructure control system security is growing dramatically. This presentation focuses on a hands-on training system using commercial equipment to actively demonstrate an attack on an infrastructure device and then shows how various strategies can be employed to defend against those attacks. The presentation will introduce SCADA systems and their vulnerabilities, then focus on the details of the training system. This system discussion will describe the attack method and discuss potential defensive measures. It will conclude with the benefits of providing SCADA training.

Session 5: Design & Optimization I: 8:40-10:40 AM Room 157B

Chair: Tommy Baudendistel, P.C. Krause and Associates

DESS08-0077

Mechanization of Shape-Changing, Rigid-Body Linkages

David Myszka
University of Dayton

Dr. Andrew Murray
University of Dayton

A procedure to synthesize rigid-body linkages capable of shape change has been developed. In this process, open or closed chains of rigid links connected with revolute joints are created to approximate "morphing" curves. After optimizing links that match the design curves, additional binary links are added to achieve a single degree of freedom mechanism. This study explores details of designing the constraining links, including achieving proper order, understanding assembly circuits, and avoiding singularities.

DESS08-0046

Optimization of Spherical Four Bar Devices for Spatial Tasks

David Perkins
University of Dayton

Andrew Murray
University of Dayton

The use of spherical four bar mechanisms as a reorientation device for repetitive, high throughput spatial tasks has been proposed. Spherical four bar mechanisms are single degree of input devices and all points on the links move along the surface of a sphere. When coupled with a prismatic joint, the resulting mechanism is a two degree of freedom system capable of reaching two given spatial positions and orientations. This work has focused on optimizing the link angles of the spherical four bar to produce a mechanisms that will reach the desired orientations by reducing the input and internal loads. An alternative means of actuating the device by attaching a spherical-prismatic-spherical chain from ground to the coupler link is also presented. This actuation method decouples the actuation design from the kinematic synthesis and can allow more solutions to the two position synthesis task.

DESS08-0039

Kinematic Synthesis in Designing Shape-Changing Mechanisms for Varying Cross-Section Profiles

Shamsul Shamsudin
University of Dayton, Graduate Student

Professor Andrew P. Murray
University of Dayton

This study discusses a kinematic procedure to synthesize planar shape changing mechanisms consisting rigid links and revolute joints. Using Matlab®, the user will input the curves that make the design profiles. The design profiles are the morphing curves in the shape changing machine. The procedure ensures that each profile has the same least arc length and number of points. The new profiles become target profiles. Next, the target profiles are broken into segments that will best fit the shape in each of the target profiles. When that is done, the system will do the mechanization part. The ultimate goal is to produce a 1 degree-of-freedom (DOF) mechanism that will move the chain of rigid bodies from one target profile to another. This could be achieved by adding supplement binary links where needed. To further simplify the use of this system, a graphical user interface (GUI) is being developed using Matlab®.

DESS08-0075

Dynamometer Design for Vertical Axis Wind Turbine Model Testing

Thomas Mooney
University of Dayton Research Institute

Steve Fuchs
University of Dayton Research Institute

Testing vertical axis wind turbine scale models in a low speed wind tunnel (LSWT) presents unique challenges for design of a dynamometer system. Wind loads produced by a turbine model cantilevered into the wind stream exceed allowable bending moments for commercially available torque transducers, and thus dictate a design utilizing an intermediate shaft and bearing set. Due to non-linearity of the power produced by a turbine under changing wind velocities, very little torque is produced at low wind velocities. Therefore, the dynamometer system must have very low frictional losses. A successful design was achieved by using frictionless bearings and a non-contact frictionless torque transducer. The design incorporates features to protect integrity of the sensitive torque transducer and a current-programmable hysteresis brake for controlling load applied to the turbine. Varying brake loads allow characterization of turbine power verses scale wind speed ranging from 2 mph to 23 mph.

DESS08-0005

Low-Cost/High-Speed Bearing Tester Using Torque Ripple Sensors

Tommy Baudendistel
P.C. Krause and Associates

Steve Pekarek
Purdue University

Eric Walters
P.C. Krause and Associates

In the aviation industry, the ever increasing need for more power in addition to the need to reduce weight and size has driven the requirements for higher and higher rotating speeds in aircraft machinery. This in turn has put an increasing burden on the bearings used in these machines. In this presentation, a recently developed fixture was developed to test high-speed bearings in the range of 25,000 rpm. This low-cost test fixture was developed to test bearings to failure by applying an artificial axial load. This low-cost/high-speed bearing tester is instrumented with a low cost torque ripple sensors and temperature probes to aid in the development of a PHM algorithm as well as a suite of temperature probes to monitor bearing temperatures. As the bearings fail the torque ripple and temperature signatures created are recorded for future analysis.

DESS08-0064

Inflatable/Rigidizable Space Structures

Brett Cooper
Air Force Institute of Technology

Dr. Jonathan Black
Air Force Institute of Technology

Dr. Richard Cobb
Air Force Institute of Technology

The Air Force Institute of Technology (AFIT) recently completed spaceflight testing of the Rigidizable Inflatable Get-Away-Special EXperiment (RIGEX). Integrated and flown under the direction of DoD's Space Test Program, AFIT students designed, built, and space qualified the experiment, which flew on STS-123. RIGEX was designed to demonstrate the feasibility of using inflatable/rigidizable materials to create large lightweight space structures. RIGEX consisted of three inflatable tubes, manufactured by L'Garde, Inc., that transition from stiff to flexible at 125 degrees Celsius. On orbit, resistive heaters warmed each tube, the tube inflated, cooled, and vented, while sensors recorded process. The rigidized tubes modal responses were tested via embedded accelerometers and piezoelectric patches. Post-flight observations indicate all tubes deployed and all data was collected. Files containing images, pressure, temperature, and accelerations were recovered. Each tube's physical alignment was precisely mapped in 3-D, and post flight comparison to on-orbit data is ongoing.

Session 6: Undergraduate Projects: 8:40-10:40 AM Room 163A

Chair: Thomas Ramsay, Honda R&D Americas

DESS08-0037

A Hydrogen Storage and Generation System Utilizing Metal Hydrides for Varied Proton Exchange Membrane Fuel Cell Applications

Ian Fuller

WSU Undergraduate Student

This novel technology represents a huge leap forward in the ambitious idea of a hydrogen economy. By using a metal hydride, such as sodium borohydride as a hydrogen storage medium, as well as a proprietary solid acid technology, this system allows fuel cells to be safely, economically, and efficiently used in a wide range of applications. The metal hydride offers a high-energy density storage medium, eliminating the need for high-pressure tanks. Furthermore, storing the hydrogen in solid form until needed also eliminates the need for new infrastructure such as hydrogen pipelines and fueling stations. By utilizing metal hydrides and a solid acid, hydrogen is available on demand with the addition of water. This technology can be used widely throughout the "hydrogen economy" and offers several benefits over traditional hydrogen proposals.

DESS08-0012

Solar Autoclave for Rural Nicaraguan Medical Clinics

Matt Pittinger

University of Dayton Senior Mechanical Engineering Student

Chris Weiss

University of Dayton Senior Mechanical Engineering Student

Extreme poverty limits the availability of many energy sources. To many people of the world, including rural Nicaraguan clinics, electricity is scarce and expensive. The head nurse at the clinic of Sabana Grande in Nicaragua does not have on-site access to a medical device sterilizer. She must travel a significant distance to get contaminated equipment sterilized. This is a problem because it takes her away from patients and travel costs are not covered in clinic's budget. A team of five Senior Mechanical Engineering Students at the University of Dayton have taken on a project to conceptualize, develop, and build a solar autoclave for rural Nicaraguan Medical clinics. This presentation will focus on the need for sustainable development in rural Nicaragua through the solar autoclave design project.

DESS08-0088

Solar Updraft Tower

James Menart
Wright State

Chase Nessler
Wright State

Christopher Grote
Wright State

Ryan Jones
Wright State

Jon Holmes and Brian Selander
Wright State

Senior design students at Wright State University have designed and built a solar updraft tower. A solar updraft tower consists of a large tower connected to an inexpensive solar collector spread out over the ground. The idea is for the solar collector to heat the air causing it to rise up the tower. Located in the tower is a turbine that converts the energy of the moving air to electricity via a turbine. The solar tower built at Wright State consists of a 35 foot tall tower with a collector radius of 15 feet. The collector was made of inexpensive plastic and essentially makes use of the green house effect. A CFD analysis of the tower was performed with the software FLUENT. The built tower did produce electrical power, but it was not significant.

DESS08-0001

An Electric Auxilary Engine for a Sailboat Using Renewable Energy - A Capstone Project

Russell Marcks
Sinclair Community College

A 16-student team from Sinclair Community College performed a viability study to develop an electrified auxiliary sailboat drive with onboard renewable energy charging system. The project is intended to: 1) Introduce green technology to a mechanical curriculum, 2) Apply electrical systems in mechanical design, 3) Introduce students to an unfamiliar application using familiar principles, 4) Promote teamwork. The design criteria, based upon the instructors experiences, involves a 25 foot cruising sailboat. The auxilary drive is required to take the boat from dock to open water and propel it into the wind to raise sail. Once under sail, the auxilary is shut down to allow battery charging by any combination of wind generator, tow generator, and solar panels over a 10 hour sailing period. The result is a working prototype of a drive unit and a viable alternative energy charging. A follow-up project is planned to confirm viability.

DESS08-0081

Robotic Lawnmower

Joseph Mertz
Wright State

Jeff Baugher
Wright State

Kuldip S. Rattan
Wright State

The autonomous lawnmower needs the ability to mow and trim grass in an area in less than twenty minutes, while avoiding obstacles located within the area. The obstacles are a flower bed, fenced area, and a moving object that goes in front of the lawnmower for thirty seconds and then move off field. The main tasks are creating a frame, selecting the proper wheel motors, powering the system, integrating off the shelf sensors, implementing control algorithms, and designing navigational algorithm that efficient use data from the laser range finder (LRFS) and touch sensors. LRFS is the main sensor for detecting obstacles and is the main source of data to the computer. The touch sensor is utilized to get better turns in the fence area and prevents major collisions. The signals creates output of the algorithm controls the speed and direction of the mower through the use of encoders.

DESS08-0002

Appropriate Ram Pump Technology in Quetzaltenango

Gordon Schweitzer
University of Dayton

Purpose: The report highlights the research, development, installation of a ram pump water system within a coffee cooperative named Palmera Xolhuitz between May 14th, 2008 and July 23rd, 2008 through the nongovernmental organization Appropriate Infrastructure Development Group (AIDG). Scope: This test installation provides water for nearly two hundred residents who financed the project using community contracts. Furthermore, this installation was the first ram pump installation of AIDG. Findings: Test methods, ram pump installation techniques, and troubleshooting techniques created new information within the ram pump field. Conclusions: Through analyzing construction techniques, efficiency test rubrics, and design improvements, the ram pump system performed at high efficiency and delivered water through five hundred meters of pipeline to provide water for community. Recommendations: Even though the journey to commission a fully functional ram pump system was difficult, the process was documented to heighten success for future installations by utilizing experimental techniques and efficiency testing.

Session 7: Structures & Solid Mechanics I: 8:40-10:40 AM Room 163B

Chair: Larry Byrd, AFRL/RZ

DESS08-0044

Structural Health Monitoring of a Thermal Protection System for Fastener Failure

Randy Tobe
Wright State University

Dr. Ramana Grandhi
Wright State University

Thermal protection systems (TPS) are a critical component of hypersonic vehicles. Efficient structural health monitoring (SHM) of the TPS for structural integrity is an important aspect to ensuring the overall safety and availability of these vehicles. This research investigates detection and localization of fastener failure on a mechanically attached TPS. The structural dynamics of the TPS is analyzed to ensure that the damage states of interest are detected. Since extensive experimentation of physical structures is time-consuming and expensive, a finite element model has been created to capture the physics of a real world TPS prototype. This model analyzes resonant frequency and mode shape changes between the healthy state and damaged states of interest to detect and localize fastener failure.

DESS08-0031

Structural Vibration Measurements Using Hybrid Videogrammetry System

Chris Allen
Air Force Institute of Technology

Alan Jennings
Air Force Institute of Technology

Dr. Jonathan Black
Air Force Institute of Technology

This project developed a laser tracking system capable of taking vibration measurements of a moving object in real time. First steps involved uniting a videogrammetry system, which uses specialized cameras to output the 3D positional data in real time, with a Simulink model that uses the sampled coordinates to track a defined structure with a laser. Issues arose in the model's ability to accurately track the desired point on the structure. Calculations determined an error of up to 3 degrees at a distance of 5 meters from the origin. An in depth calibration method was employed that increased accuracy to within a degree at the same distance. Prediction filters were put in place to decrease the amount of lag between the laser and the structure when in motion. Currently, a laser vibrometer has been introduced into the system to begin obtaining and analyzing vibration data.

DESS08-0024

Calibration of Laser Steering for Vibration Measurements on Moving Objects

Alan Jennings
Air Force Institute of Technology, WPAFB, OH

Jonathan Simpkins, Ryan Sollars
Trinity University, San Antonio, TX

Chris Allen and Jonathan Black
Air Force Institute of Technology, WPAFB, OH

Lasers can be used for high speed, high accuracy, non-contact measurements. For the beam to be properly steered, the position and orientation of the laser system must be known in reference to the object or system. In this case, the laser system is referenced to a video motion capture system allowing steering to points on objects moving about the capture volume. Two methods of calibration are presented here for referencing the laser steering system. The basis of calibration lies on determining the location of the laser through the motion capture volume and using geometric properties of a two-mirror steering system. Results of the calibration are sufficient to have the laser track within half a degree for distances over 4m. This calibration enables measurements of vibrations of large magnitude such as those found in flexible space structures.

DESS08-0003

Fatigue Testing of Out-of-Plane Counterweights for a High Speed Application

David Myszka
University of Dayton

Counterweights are commonly used to balance machinery from excessive vibrations due to rotating components. When an in-plane counterweight is not feasible, a pair of counterweights on offset planes is necessary. The counterweights and their attachment hardware are loaded with centripetal force, proportional to their respective masses. Additionally, the counterweights experience zero to peak loading as the machine is cycled on and off. This presentation will highlight the approach behind fatigue testing a new pair of counterweights and their attachment hardware for a high speed application. A novel test fixture has been designed to be used in conjunction with a uni-axial MTS machine, and applies the proper stress distributions simultaneously to both counterweights.

DESS08-0027

Optimized Designer Aero-Servo-Controls and Engineered Viscoelastic Material Properties

Harry H. Hilton
University of Illinois at Urbana-Champaign (UIUC)

Daniel H. Lee
University of Illinois at Urbana-Champaign (UIUC)

Craig G. Merrett
University of Illinois at Urbana-Champaign (UIUC)

This paper presents the confluence of the designer theories of viscoelastic materials and of aero-servo-viscoelsticity as previously formulated. A wing is examined for flutter instabilities by simultaneously applying calculus of variation approaches to optimize both control and viscoelastic material property parameters in order to obtain the "best" flutter velocity. In this self-excited problem, it is noted that more control and/or stiffer materials do not necessarily lead to higher flutter speeds. This is due to the inherent dependence of the latter on phase relations, which will shift in an individual manner. While the analysis is given in general terms, these optimum solutions must, therefore, be applied on a case by case basis. These protocols are applicable to a variety of problems involving static or dynamic aero/hydro elastic or viscoelastic problems including responses to flow generated noise.

DESS08-0038

Experimental Challenges for Mechanical Characterization of Thermal Barrier Coatings Using a Free-free Beam Setup at Elevated Temperature

Oliver Easterday
Air Force Institute of Technology

Dr. Anthony Palazotto
Air Force Institute of Technology

Thermal barrier coatings have been found to have beneficial mechanical characteristics for suppression of high cycle fatigue. Characterization of these thin coatings has posed challenges due to inherent damping by experimental apparatus as well as ambient air. The current testing has evolved to using a free-free beam suspended in a vacuum. Great interest in elevated temperature characterization exists but adapting the current setup poses three major challenges: method of suspension (boundary conditions), method of loading (forcing function), and method of heating (maintaining homogeneity). A conceptual design to address these issues and adapt the ambient temperature apparatus to elevated temperature testing is presented.

Session 8: Aircraft Efficiency I **1:20-3:00 PM** **Room 156A**

Chair: Kevin Hallinan, University of Dayton

DESS08-0057

An overview of SensorCraft capabilities and key enabling technologies

Juan Martinez
AFRL/RBAA

Peter Flick
AFRL/RBSA

Gary Dale
AFRL/RBAA

The Air Force Research Laboratory has formulated a vision that holds high promise in providing revolutionary intelligence, surveillance, and reconnaissance (ISR) capabilities only dreamed of until now. This ingenious concept blends a wide spectrum of emerging technologies in an aircraft configured and optimized with advanced sensing capabilities integrated into an airframe that sustains a continued presence. This is achieved through extremely long endurance, thus giving the warfighter the needed edge in difficult targeting environments. It is the unique combination of advanced sensors and sustained presence that enables continuous and rapid reaction to the dynamic combat operations requirements confronting current and evolving military operations.

DESS08-0076

Key Aerodynamic Technologies for SensorCraft

Gary Dale
AFRL Air Vehicles Directorate (AFRL/RBAA)

Exploitation of laminar flow for increased SensorCraft time-on-station will result in more stringent manufacturing tolerances than would otherwise be required. A series of experiments has been undertaken, in a lowspeed wind tunnel and a novel propelled-model facility, to obtain data to determine manufacturing tolerances for laminar flow aircraft. Results from those experiments will be presented. Plans for a follow-on test, to include pressure gradient effects are described. Spanwise periodic, Discrete Roughness Elements (DRE) for swept wing laminar flow control (SWLFC) is a technology which shows promise for achieving the time-on-station (TOS) required for an affordable SensorCraft. Flight tests utilizing DRE for SWLFC on a model mounted to a hard-point on a Cessna O-2 are presented.

DESS08-0050

Endurance Limits of Unmanned Air Vehicles

Trenton White
AFRL

Current state of the art aerodynamic, structural and propulsion design and manufacturing methods allow air vehicles to be created with endurance capability on the order of one week aloft. The development of various alternative energy sources has opened the possibility for a revolutionary class of air vehicles that are no longer constrained in endurance by expendable energy sources. This revolutionary class of vehicles will be powered by renewable energy methods, such as solar energy collection or wind harvesting, and endurances will perhaps be limited by the reliability of the air vehicle's critical component systems. Although solar-powered UAVs have currently only flown through three or four day-night cycles, it is possible that they may eventually be able to fly for several weeks, months, or even years. Notional UAV concepts from both current and revolutionary classes will be described and compared.

DESS08-0094

Energy Efficiency: Past Trends, Future Needs

Ryan Plumley
AFRL/RBAA

The Air Force Research Laboratory has initiated a multi-year study of energy efficiency for future aircraft. Much has been made recently on future oil reserves and prices. This would suggest thoughtful use of this resource. The Air Vehicles directorate is investigating aerodynamic efficiency to allow fuel usage flexibility in the mobility area for completing the same and future missions. Past achievements such as supercritical airfoils, computation aerodynamic design, winglets, and manufacturing technologies have shown major increases in efficiency. Revolutionary advances are being investigated through new aircraft designs, changes to existing aircraft, and changes in how those aircraft fly. Blended wing configurations are being explored in partnership with NASA's Subsonic Fixed Wing program as well as formation flight. Also, viscous drag reduction techniques could further fuel usage reduction. Technologies evaluated that could create large fuel consumption savings will be developed for demonstration.

DESS08-0022

Efficiency of Large Transport Aircraft

William Blake
Air Force Research Laboratory - Air Vehicles Directorate

Cale Zeune
Air Force Research Laboratory - Air Vehicles Directorate

The presentation will discuss a metric for comparing efficiency of large transport aircraft, payload-range efficiency (PRE). PRE is defined as payload times range divided by fuel used. The parameters that impact PRE will be discussed. PRE values will be shown for various civil passenger, freighter and military aircraft. The progression in PRE with time will be discussed, along with current AFRL programs that will increase PRE for future vehicles. Finally, PRE of aircraft will be compared to other modes of transportation such as cars, trains, etc.

Session 9: Manufacturing **1:20-3:00 PM** **Room 156B**

Chair: Larry Dosser, Mound Laser & Photonics Center, Inc.

DESS08-0089

A Stochastic Production Planning Model Under Uncertain Demand

Meenakshi Prajapati
Wright State University

Dr. Xinhui Zhang
Wright State University

This study proposes a stochastic production planning model under uncertain demand for an international enclosure manufacturing company. The company purchases material from Asia and sub assembly from Europe and long lead times have been observed. As a result, purchasing decisions and production plans have to be made months in advance before the demand is realized. To make things more complicated, demand patterns are highly seasonally and market changes dramatically change future demand. To assist purchasing decisions and to build production plans, a two stage stochastic production planning model that explicitly includes uncertainty is developed with the goal of minimizing the overall production, inventory and overtime cost. The model is solved using real data from the company and results have shown the effectiveness of the model compared with various deterministic production models. The model has bee implemented and an annual saving of more than $400,000 in inventory cost has been achieved.

DESS08-0052

Accelerating Design-to-Manufacturing Transition in the Aerospace Industry

Dan Sokol
Renaissance Services

Many aerospace & defense organizations have placed an increased emphasis on reducing the time to transition products from engineering to manufacturing while simultaneously reducing the product technical risks. Unfortunately, most manufacturers still follow a serial process for creating the detailed design. In addition, producibility is often not formally addressed because it is treated as an additional step that requires extra engineering effort that delays completion of the product definition. This presentation will discuss a business process and software tool that captures manufacturing engineering expertise and provides real-time, quantitative information to link design requirements to the manufacturing processes. This practical approach to Six Sigma-enabled design has been created to help engineering create the detailed design documentation, while simultaneously addressing producibility analysis and characteristic accountability. The result is a reduction in the time and labor to complete detailed design.

DESS08-0087

High Speed Laser Welding of Fuel Cell Components

Scott Cornell
Mound Laser & Photonics Center, Inc.

Kevin Hartke
Mound Laser & Photonics Center, Inc.

A typical fuel cell stack requires hundreds of feet of weld in the metallic bipolar plates that deliver fuel and collect current from the device. This welding must be done with high precision and no defects. Mound Laser & Photonics Center, Inc. has combined the technological advances in both laser systems and beam movement to increase welding speeds by over 100 times that of conventional laser welding. The process uses the latest high average power fiber laser and a galvometric driven beam steering technology to achieve weld speeds near 1 meter/sec. High speed photography is used to monitor the process and understand the weld phenomena taking place at these high weld rates. An overview of experimental results and how this technology can be applied to the fuel cell industry with the possibility of lower costs and processing time will be discussed.

DESS08-0028

Free-Edge Effects on Solidification Microstructure in Beam-Based Solid Freeform Fabrication of Thin-Wall Geometries

Joy Davis
Wright State University

Dr. Nathan Klingbeil
Professor, Wright State University

In laser or electron beam deposited materials a consistent microstructure is required in order to produce certain mechanical properties. The Rosenthal solution for a moving point heat source has been used in previous work to determine the solidification cooling rates and thermal gradients governing microstructure (grain size and morphology) for semi-infinite, thin-wall deposits. In this work, the Rosenthal solution was modified to include the effects of free-edges. This was accomplished by superposition of two point heat sources symmetrically approaching one another, with the line of symmetry representing the free edge. Results for dimensionless solidification cooling rate and thermal gradient were determined numerically with MATLAB, and plotted as a function of depth within the melt pool. Results were further plotted on solidification maps to predict trends in grain size and morphology for Ti-6Al-4V. Results suggest that grain morphology is relatively insensitive to free-edges, while melt pool size is not.

DESS08-0021

Effect of Finite Geometry on Solidification Microstructure in Beam-Based Fabrication of Thin-Wall Structures

Satish Kuchi
Graduate Student , Wright State University

Dr. Nathan Klingbeil
Professor, Wright State University

New additive manufacturing processes are being developed which use the energy from a laser or an electron beam to build up structures layer-by-layer directly from powdered metal form. Previous work has considered the effects of process variables (beam power and velocity) on solidification cooling rate and thermal gradient (the key parameters controlling microstructure) in beam-based deposition of Ti-6Al-4V. However, this prior work was limited to semi-infinite deposit geometries and steady-state conditions in the melt pool. The goal of the current study is to investigate the effects of finite deposit geometry (finite length and height) and non steady-state changes in the process variables through parametric finite element modeling with ABAQUS. The aim of the current project is to come up with handbook-type results which would guide process engineers in the additive manufacturing of various thin-wall geometries.

Session 10: Design & Optimization II **1:20-3:00 PM** **Room 156C**

Chair: Rebecca Hoffman, SIMULIA

DESS08-0043

Laser Shock Process Optimization by Employing 2D, Symmetric 3D, and Parametric Plate Model

Gulshan Singh
Wright State University, Dayton, OH

Ramana V. Grandhi
Wright State University, Dayton, OH

Dr. David Stargel
Wright Patterson Air Force Base, OH

In the laser shock peening (LSP) process, favorable residual stresses are induced on a surface to improve fatigue and fretting properties of metals. For optimal utilization of this promising technology simulation-based optimization strategy is required. In this research, a parametric plate model, a three-step optimization approach, and suitable surrogate models are developed to address this requirement. The parametric plate model can consider most LSP parameters as compare to models available in literature. The optimization approach employs 2D, symmetric 3D, and the parametric plate model in a step-by-step procedure for efficient optimization. A sub-parametric surrogate model is introduced to manage the large computational cost (4 days). Particle swarm optimization (PSO) is used as the optimization algorithm. PSO is modified by latin hypercube sampling population generation and a strategy to handle integer variables. The developed modal and optimization approach are demonstrated on the plate model.

DESS08-0059

Optimization of a Hub Sleeve using PSO and meta-model

Jong-Bin Im
Wright State University

Helicopters operate in a complex aerodynamic environment with requirements of high maneuverability, high speed and multi-role capabilities. Hence the successful operation of a flight-worthy vibration control system depends on its ability to cope with uncertainties that may arise within the system and the environment. The sleeve attaches the rotor blade to the rotor hub. It also provides attachments for the pitch lever and flapping stops. The flapping stops limit the blade angles. The rotor torque is transmitted to the rotor drive system via the rotor mast (by bushings). The mast is hollow to allow for internal routing of the instrumentation cables. In this study, the hub sleeve of a helicopter is optimized. And Bayesian particle swarm optimization (BPSO) with sequential meta-model method is used to optimize the hub sleeve.

DESS08-0069

Risk Based Design of Cracked Stiffened Panels.

Venkateswaran Shanmugam
Wright State University, Dayton, OH

Dr. Ravi C. Penmetsa
Wright State University, Dayton, OH

Dr. Eric Tuegel
Air Force Research Laboratory, Wright Patterson Air Force Base, Dayton, OH

A new paradigm for determining the probability of fracture that enables faster decisions is demonstrated for stiffened panels. The probability of fracture as a function of crack size for a range of stiffened panel geometries under a particular loading distribution is presented in a nomograph. Using the nomograph, a stiffened panel can be designed to a specified probability of fracture for a given crack size, e.g., a 2-bay crack, or the probability of fracture assessed for a cracked panel in service. The nomograph, or a series of nomographs for different loadings, can be constructed by experts in probabilistic analysis prior to any need to calculate the probability of fracture. Later, a structural integrity engineer can rapidly determine the probability of fracture of a cracked stiffened panel using the appropriate nomograph. Many aerospace and naval structures are made of stiffened panels making this procedure widely applicable.

DESS08-0040

Reliability Based Design of a Supercavitating Projectile

Matthew Riley
Wright State University

Ramana V. Grandhi
Wright State University

William P. Krol
Naval Undersea Warfare Center, Division Newport

Due to increased technology in underwater stealth, surface ships are often vulnerable to attack from underwater sources such as submarines. The Adaptable High-Speed Underwater Munitions (AHSUM) project is a Navy initiative to develop high-speed projectiles to be fired from surface ships to serve as a final-tier torpedo defense system. These projectiles must be aerodynamically and hydrodynamically stable while also capable of entering the water at low entry angles. It is the goal of this research to investigate the supercavitating projectile through modeling in each of the three phases of operation—including uncertainties inherent to the problem—and to perform a multidisciplinary optimization to determine the projectile configuration that results in the highest probability of eliminating the target.

DESS08-0085

Quantification of model uncertainty for LSP simulation

Inseok Park
Wright State University, Dayton, OH

Hemanth Amarchinta
Wright State University, Dayton, OH

Ramana Grandhi
Wright State University, Dayton, OH

Dr. David Stargel
Wright Patterson Air Force Base, OH

Laser Shock Peening (LSP) is an advanced technique to increase the fatigue life by inducing compressive residual stresses into a structure. A FE model needs to be built to simulate the LSP process, and material model is demanded as a part of composing the FE model. The three material models are available for building the FE model; Elastic Perfectly Plastic, Johnson-Cook, and Zerilli-Armstrong models. Given the different models for a specific purpose, the conventional way is to choose a model which represents a physical system better than other models. However, to consider a model may lead to the considerable underestimation of uncertainty in an output when the uncertainty in model brings about a large uncertainty in the output. In this research, the uncertainty in the residual stress field due to the uncertainty in material model is quantified for an axi-symmetric model acted upon by LSP.

Session 11: Computer Sciences **1:20-2:40 PM** **Room 157A**

Chair: Bonnie Schwartz, AFRL/RB

DESS08-0025

Robust Learning of Robotic Motions and Their Effects

Alan Jennings
The University of Dayton, Dayton, OH

Raul Ordonez
The University of Dayton, Dayton, OH

A method is presented for developing and training a control law for robotic motion. The first goal is to characterize motions by their consistent effect on the environment. The second is to construct multiple motion primitives with similar effect to try if primary method fails. The motion is characterized via neural network and wavelet transforms and classified via k-means and particle swarm optimization clustering. Clusters constitute a motion primitive and the motion space is explored via alienation techniques to compile useful primitives. Eventually the output will involve fuzzy feedback from human sources to train which primitive to choose.

DESS08-0055

A Novel Methodology for Detecting and Tracking Contraband Digital Files Transmitted Via the BitTorrent Peer-to-Peer Protocol

Karl Schrader
Air Force Institute of Technology, Center for Cyberspace Research

Dr. Barry E. Mullins
Air Force Institute of Technology, Center for Cyberspace Research

This research considers the problem of identifying and tracking contraband digital files that are shared using the BitTorrent peer-to-peer protocol. We propose a methodology that uses payload analysis to inspect each packet on a network for BitTorrent handshake messages, extracts the unique identifier of the file being shared, and compares that identifier against a list of known contraband files. If the file identifier is on the list, the entire packet is added to a Wireshark-readable log file for later analysis. We implement this methodology using an FPGA-based embedded software application, and then add several optimizations to the system to improve processing speed and probability of packet intercept under high network utilization. Testing shows that the final design is able to successfully capture and process BitTorrent handshake messages with a probability of at least 98.9% under a traffic load of 88.1 Mbps on a 100 Mbps network.

DESS08-0053

Subjective Audio Quality over Secure IEEE 802.11 Wireless Local Area Networks

Benjamin Ramsey
Air Force Institute of Technology, Center for Cyberspace Research

Dr. Barry E. Mullins
Air Force Institute of Technology, Center for Cyberspace Research

Subjective G.711 audio quality resulting from wireless transmission over encrypted IEEE 802.11b, IEEE 802.11g, and IEEE 802.11n draft 2.0 wireless local area networks (WLANs) is evaluated. Following ITU-T P.800, forty-two human subjects rate audio recordings taken during 12 network conditions. WLAN encryption is alternated between WPA2 and WPA2 with transport mode 3DES IPsec, and simultaneous call volume is alternated between 6 or 10 simultaneous calls. Results indicate that a previous E-model calculation for 802.11b accurately predicts the subjective Mean Opinion Score (MOS). Upper bound for the decline in MOS due to 3DES IPsec is found to be less than 0.65 (90% CI) for all scenarios examined. Additionally, the subjective data suggests that the combination of G.711 encoding and 802.11 transmission decreases original audio file MOS by a minimum of 0.6 during six simultaneous calls, suggesting that toll quality (MOS > 4.0) calls over a WPA2 encrypted 802.11 WLAN is impractical.

DESS08-0056

VoIP over MANETS: A Performance Analysis of OLSR

Lady Noreen Santos
Air Force Institute of Technology, Center for Cyberspace Research

Dr. Barry E. Mullins
Air Force Institute of Technology, Center for Cyberspace Research

Voice over Internet Protocol (VoIP) in Mobile Ad hoc Networks (MANETs) takes advantage of the mobility and versatility of MANETs and the flexibility and interoperability that a digital voice format affords. Research has shown that VoIP-like traffic can be routed through an ad hoc network using the Ad hoc On-demand Distance Vector routing protocol. This research studies the suitability of the Optimized Link State Routing (OLSR) protocol for routing in MANETs running VoIP applications. Using the OPNET modeler, representative VoIP traffic is sent over a MANET and delay and packet loss are observed. Node density, number of data streams and mobility are varied, creating an experimental design consisting of 18 distinct scenarios. On average, delay was below 2 ms, which is significantly below the recommended 150 ms threshold for VoIP applications. Packet loss was also relatively low at less than 10%, which should result in acceptable VoIP application quality.

Session 12: Human Factors & Biomedical **1:20-3:00 PM** **Room 157B**

Chair: Tarun Goswami, Wright State University

DESS08-0068

Temporomandibular joint disorders: joint loading and biomechanical analysis

Shirish Ingawale
Wright State University

Tarun Goswami
Wright State University

Temporomandibular joint (TMJ) is a complex, sensitive, and highly mobile joint. Millions of people suffer from temporomandibular disorders (TMD) in USA alone. As reconstruction with either partial or total joint prosthesis is the only potential treatment option in certain TMD conditions, it is essential to study outcomes of the FDA approved TMJ implants. Evaluating the kinetics and kinematics of TMJ enables the understanding of structure and function of normal and diseased TMJ to predict changes due to alterations, and to propose more efficient methods of treatment. Although many researchers have conducted biomechanical analysis of TMJ, many of the methods have certain limitations. Therefore, a more comprehensive analysis is necessary for better understanding of different movements and resulting forces and stresses in the joint components. This presentation provides the results of a state-of-the-art investigation of the TMJ anatomy, TMDs, treatment options, FDA approved TMJ prosthetic devices, 3-D modeling, and biomechanical analysis.

DESS08-0090

Deep Brain Stimulation: Mechanisms of Design and Placement

Melissa Jones
Wright State Student BME

The implantation of deep brain stimulation electrodes results in significant lesioning due to condensed charge fields and chemical interactions. Investigations were aimed at the potential for a significant decrease in the electrode aspect ratio to reduce or eliminate the physiological effects of stimulation while increasing the volume of tissue affected. Studies were reviewed which showed the lesioning effect of both electrical stimulation and of electrode design on the volume of surrounding tissue affected by stimulation as the diameter of the electrodes reach the micro level. Lesions resulting from electrical stimulation are most typical in “full scale” electrodes and the effects are minimized as the diameter of the electrode decreases. As the diameter of the electrode tip decreases to the micro level, the aspect ratio decreases which results in exponentially more effective stimulation due to an increase in volume of tissue affected by the stimulation.

DESS08-0091

Dissociation of the Humeral Prosthesis – Retrieval, Load, and Torque Analysis

Alyssa George
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Michael Iossi, M.D.
Wright State University Boonshoft School of Medicine, Dept. of Orthopedic Surgery. Dayton, OH.

Tarun Goswami, D.Sc.
Wright State University, Dept. of Engineering and Boonshoft School of Medicine, Dept. of Orthopedic Surgery. Dayton, OH.

Ronald Markert, Ph.D.
Wright State University Boonshoft School of Medicine, Dept. of Internal Medicine. Dayton, OH.

Lynn A. Crosby, M.D.
Wright State University Boonshoft School of Medicine, Dept. of Orthopedic Surgery. Dayton, OH.

The goal of this research was to evaluate the forces across the glenohumeral joint that lead to dissociation of the humeral prosthesis. The pullout strength was tested for ten implants (5 Zimmer, 1 Depuy, 2 Exactech, and 2 Biomet). The mean across all implants (n=10) was 1513 N. The range for all trials (n=100) was 723-2730 N. These implants have also been tested under torsion to assess another possible method of dissociation. After 36 comparisons between individual implants, there were numerous differences, but these differences were not manufacturer dependent. Overall, our investigation supports the idea that likelihood of dissociation is independent of implant manufacturer selection. All implants tested had pullout strengths well above predicted joint forces for daily activity. Based on these findings, an adequate taper-lock is achievable for the implant brands tested. It is doubtful that dissociation in vivo is due solely to distractive force for these prostheses.

DESS08-0016

Growth of Biological Cells on Microcellular Carbon Foam

Elizabeth Maurer
Mechanical & Materials Engineering, WSU, Applied Biotechnology Branch, Human Effectiveness Directorate AFRL/RHPB

Sharmila M. Mukhopadhyay
Mechanical & Materials Engineering, Wright State University

Saber Hussain
Applied Biotechnology Branch, Human Effectiveness Directorate AFRL/RHPB

Carbon is available in many forms such as solid graphite, diamond, as well as nanotubes, nano-plates, buckyballs etc. in addition to amorphous carbon. A relatively new structure currently being studied is microcellular carbon foam. It can be used in an array of applications such as heat exchangers, radiators, composite cores, as well as in products that require controlled electrical and thermal properties in porous materials. Though, graphite is known to be a bio-compatible material, not much research has been done on the possibility of using microcellular foams as scaffolding for in-vitro tissue and cell growth. This study aims at investigating the influence of various surface treatments on osteoblast and neuroblastoma cell lines. Recent focus is on cell proliferation and viability on foam grafted with carbon nanotubes which may direct growth directions. This study will potentially lead to methods of speeding and controlling cell growth related to bio-sensing, tissue healing etc.

DESS08-0058

Streamlining the flight line: Preserving mental energy and temporal demand using hands free data collection methods

Nicole Arbuckle
University of Dayton Research Institute

Kristie Nemeth
University of Dayton Research Institute

Laurie Quill
University of Dayton Research Institute

An avatar called Autonomic Communication Exchange (ACE) has been developed by our research team. This job aid is designed for both hands-free and automatic collection of maintenance data. Through conversational communication, other auditory, visual and paralinguistic cues, and RFID technology, ACE collects maintenance data for the technician allowing them to continue performing hands-on maintenance tasks. Twelve participants were asked to complete a series of remove and replace tasks while interacting with the ACE prototype system and a K'NEX® motorized simple machine educational kit (simulating a maintenance task). In this case, the RFID and speech interaction was the only hands free condition significantly faster than other alternatives. Additionally, users rated the ease of use of the RFID with speech interaction higher than all of the other conditions. The presence of a visual model of a human head for the avatar also increased the participant's perceived quickness and accuracy of data entry.

Session 13: Structures &Solid Mechanics II **1:20-3:00 PM** **Room 163A**

Chair: Stephen Clay, AFRL/RB

DESS08-0018

Improving the Matrix Condition Number of Weakly-Enforced Boundary Value Systems

Douglas Wickert
Air Force Institute of Technology

Dr. Robert A. Canfield
Air Force Institute of Technology

Weak enforcement of boundary conditions--i.e., satisfaction of boundary conditions in an integral sense--arises naturally in many weighted residual methods for boundary value problems. Boundary conditions that are specified in terms of functions of primary variables can often only be enforced in a weak sense if expensive iterative solutions are to be avoided. Although weak boundary residuals are simple to state, they can lead to numerical difficulties. In particular, least-squares finite element solutions typically result in ill-conditioned matrices. In this paper, we introduce a method for improving matrix condition number of weakly-enforced least-squares finite element solutions based on condensation of the weak boundary variables. In addition to improving the numerical stability of the problem, the approach also improves the numerical efficiency of the solution as it reduces the number of variables that must be solved. Results for several examples from elasticity and fluid problems are presented and compared.

DESS08-0062

Effect of a Graded Layer on the Plastic Dissipation during Mixed-Mode Fatigue Crack Growth on Plastically Mismatched Interfaces

Craig Baudendistel
Wright State University

Nathan Klingbeil
Wright State University

Recent work has proposed a dissipated energy theory of fatigue crack growth in layered materials under mixed-mode loading. An assumption of this prior work is that a perfect crack exists along the interface joining the top and bottom layers. The current work incorporates a grading of plastic properties between the two layers through finite element modeling. An elastic-plastic 2D model using 8-node biquadratic elements was used to map the plastic dissipation of a two layer specimen with a grading of plastic properties. This property gradient allows for a more realistic representation of the plastic dissipation accumulated during a steady state cracking configuration. More accurate fatigue crack growth rates in layered material systems can be predicted. It was found that incorporation of a graded layer increased the amount of plastic dissipation. While this graded layer effect cannot be ignored, plastic dissipation is still dominated by the mode of loading.

DESS08-0051

Material Model Investigation of a High Strain Rate Process

Hemanth Amarchinta
Wright State University

Ramana Grandhi
Wright State University

Kristina Langer
Wright-Patterson Air Force Base

David Stargel
Wright-Patterson Air Force Base

Several processes are being used on aircrafts and other structures to increase the fatigue life. Laser Shock Peening (LSP) is one of them used now-a-days to increase the fatigue life by including compressive residual stresses into the material. LSP has the advantage of more depth penetration and covers wide range of geometries compared to other techniques. Simulating the LSP process is essential, due to the cost involved in performing the tests. The LSP process has many parameters that must be precisely determined for an accurate simulation. Among them are temporal pressure profile, spatial pressure profile, and material behavior. During the LSP process the component can experience strain rates up to . The material behavior at such high strain rates is significantly different than quasi static loading. This work involves investigation of material models such as Johson-Cook and Zerilli-Armstrong and comparison with available experiment results.

DESS08-0034

Consideration of Wear at High Velocities

Chad Hale
Air Force Institute of Technology

Dr. Anthony N. Palazotto
Air Force Institute of Technology

Dr. William P. Baker
Air Force Institute of Technology

The Holloman High Speed Test Track is a USAF rocket-powered sled track facility used for investigating aircraft munitions systems, hypersonic environments, and aerodynamic related effects. An important phenomenon is the amount of wear associated with the rocket sled's slipper/rail interaction at high velocities never investigated in the past. This wear prediction proof of concept model, made of a global analysis incorporated into a local submodel, has been carried out in ABAQUS. The end result is a wear function that can analytically predict the amount of material lost due to frictional interactions at velocities up to 1.5 km/s. An experimental effort will verify the formulation by comparison with the observed wear in actual experimental test track slippers. The comparisons will allow for further modification of the model and a better understanding of the high velocity wear phenomenon. Results from the initial proof of concept wear model are presented and discussed.

DESS08-0060

Simultaneously Coupled Least-Squares Finite Element Formulation for Fluid-Structure Interaction

Cody Rasmussen
Air Force Institute of Technology

Robert Canfield
Air Force Institute of Technology

Fluid-structure interaction problems prove difficult due to the coupling between fluid and solid behavior. Typically, different theoretical formulations and numerical methods are used to solve fluid and structural problems separately. The least-squares finite element method is capable of accurately solving both fluid and structural problems. This capability allows for a simultaneously coupled fluid structure interaction formulation using a single variational approach to solve complex and nonlinear aeroelasticity problems. The simultaneous solution method was applied to aeroelasticity problems with a known solution. Acheiving these exact results required unique iterative methods to balance each domain and/or equation weighting factor within the simultaneous solution scheme. This provided the first "hands-off" method to solve multi-domain and other unsolvable Least-Squares Finite Element problems.

Session 14: Sensors I **1:20-3:00 PM** **Room 163B**

Chair: James Gord, AFRL/RZ

DESS08-0096

30-kHz Thermometry and Species-Concentration Measurements with Time-Division-Multiplexed (TDM) Absorption Spectroscopy

James Gord
Air Force Research Laboratory

Scott T. Sanders
University of Wisconsin

Sukesh Roy
Spectral Energies, LLC

Two time-division multiplexed (TDM) sources based on fiber Bragg gratings were applied to monitor gas temperature, water mole fraction, and methane mole fraction in a practical high-pressure gas turbine combustor based on line-of-sight absorption spectroscopy. The water TDM sensor sweeps through ten discrete wavelengths in the 1350 nm range, while the methane sensor sweeps through four discrete wavelengths in the 1665 nm range. In combination, the sources cycle through fourteen wavelengths in the 1325-1666 nm range every 33 microseconds. Although absorption spectroscopy is employed to determine the temperature and species concentrations, this technology is fundamentally different from typical diode laser–based absorption sensors and has many advantages, specifically, the acquisition of many spectral features covering a wide spectral range to provide better temperature accuracy at 30 kHz. Measurements in high-pressure, turbulent reacting flows and for 2D tomographic reconstruction of the temperature and species-concentration fields is also discussed.

DESS08-0095

1-kHz Thermometry with Amplified Femtosecond Lasers

Sukesh Roy
Spectral Energies, LLC

Robert P. Lucht
Purdue University

James R. Gord
Air Force Research Laboratory

Time-resolved femtosecond coherent anti-Stokes Raman scattering (fs-CARS) spectroscopy of molecular nitrogen is used for the measurement of temperature in atmospheric-pressure, near-adiabatic, hydrogen-air diffusion flames. The initial dephasing rate of the Raman coherence induced by the ultrafast (~85 fs) pump and Stokes beams is used as a measure of gas-phase temperature. This initial frequency-spread dephasing rate of the Raman coherence is completely independent of collisions and depends only on the frequency spread of the transition bandwidth of Raman transitions at different temperatures. A simple theoretical model based on the assumption of impulsive excitation of Raman coherence, followed by decay of the signal because of differences in the frequencies of the excited Raman transitions, is used to extract temperatures from the time-resolved fs-CARS experimental signals. The extracted temperatures from fs-CARS signals are in excellent agreement with the theoretical temperatures calculated using an adiabatic reaction mechanism.

DESS08-0078

Performance Results for the Optical Turbulence Reduction Cavity

Ryan Schmit
AFRL/RBAI

Chris McGaha
AFRL/RBAI

John Tekell
AFRL/RBAI

Jim Grove
AFRL/RBAI

Michael Stanek
AFRL/RBAI

The testing of a new optical turbulence reduction cavity model for the Trisonic Gasdynamics Facility (TGF) has occurred. The current model has optical quality fused silica windows that will allow non-intrusive flow field measure to be made. The results presented in this abstract compare the current optical turbulence reduction cavity model with the historic data from the old turbulence reduction cavity model that was built in the mid 1970s.

DESS08-0035

Schlieren Based Seedless PIV in Large Scale Wind Tunnel Facilities

Chris McGaha
AFRL/RBAI

Sivaram Gogineni
Spectral Energies, LLC

Gary Settles, Mike Haragather, JD Miller, Lori Dodson
Penn State University

The analysis of highly unsteady aerodynamic flowfields requires a diagnostic approach that captures instantaneous flowfield data at rates of several kHz. Typical flowfield examples include three-dimensional cavity and turret flows. Large wind tunnel facilities suffer from the difficulty of particle seeding for techniques such as Particle Image Velocimetry (PIV). AFRL/RBAI, in collaboration with Spectral Energies, LLC and Penn State University, is developing a focused schlieren capability that minimizes the averaged distance imaged (depth-of-field) along the light source's optical path associated with schlieren optics and is compatible with PIV software. Tunnel floor boundary layer data was collected at WPAFB's Tri-sonic Gasdynamics Facility (TGF) for a Mach 2.3 flowfield using conventional schlieren optics and IDT Provision PIV software. The focused schileren capability was demonstrated for a two-dimensional Mach 2.3 wedge flow in the TGF.

DESS08-0097

High Bandwidth Plasma Sensor Suite for Flow Parameter and Vibration Measurement

Sivaram Gogineni
Spectral Energies, LLC

Eric Matlis
University of Notre Dame

Tom Corke
University of Notre Dame

We are developing a "suite" of miniature, ac-driven, weakly-ionized plasma devices that can be used to measure various quantities that are important to gas-turbine engine performance. Specifically, the sensors measure singly, or in combination, surface pressure, shear stress, gas temperature and gas species. The design of these devices is based on the "plasma anemometer" that was developed earlier for measurement of mean and dynamic mass-flux in high-enthalpy hypersonic flows. They use pairs of electrodes driven by ac-voltage waveforms to locally ionized the air (or gas). The design of the electrodes and electronic operation varies depending on gas property to be sensed. Our initial effort consists of designing and fabricating the plasma sensors and electronics for the different measured quantities. The overall objective is to replace standard laboratory sensors that adequately provide diagnostics in a lab environment, but are known to fail or have limitations when used on full-scale engines.

Session 15: Aircraft Efficiency II **3:20-4:40 PM** **Room 156A**

Chair: Lance Chenault, Aerospace Business Development Associates

DESS08-0063

Development and Flight Test of a Multi-Function Controller for Automated Cruise Flaps on an Aircraft Wing

Craig Cox
Air Force Research Laboratory

Cruise flaps are devices designed to minimize drag, and previous research has explored using a wing-based pressure differential to automate them. Different presentations of the pressure differential data tend to lead to the development of different types of controllers for automated cruise flaps. A presentation used by previous researchers led to an unstable drag-minimizing controller, while a presentation used in this research leads to a stable controller which implements multiple functions. Techniques previously used for high Reynolds number natural--laminar-flow airfoils are modified for use with the low Reynolds number SD7037 airfoil used in flight testing. The results of rigid-aircraft simulations are presented showing the effectiveness of the multi-function controller, which is able to simultaneously reduce drag and alleviate the effects of vertical gusts. Results are also presented for flight tests performed using the drag-reducing functions of the controller.

DESS08-0023

Formation Flight for Drag Reduction

William Blake
Air Force Research Laboratory - Air Vehicles Directorate

The idea of flying aircraft in bird-like formations will be discussed. Aircraft flown in close formation can benefit from upwash generated by aircraft upstream in the formation, reducing drag and increasing range. The underlying physics behind this phenomenon will be discussed. Results from drag reduction flight tests conducted by the USAF and NASA using T-38, F-16 and F-18 aircraft in two ship formations will be shown. Some problems with formation flight and strategies to overcome them will also be shown.

DESS08-0073

Measurement of Energy Exchange in Fluid-Structure Interactions

Arun Mangalam
Tao Systems

Recent developments in the ability to directly measure the aerodynamic forces generated by gusts, control actuation and structural deformation have made it possible to estimate the energy transfer between the fluid and the structure. In aerospace applications, aerodynamic damping plays a key role in the design of the vehicle for gust load alleviation and flutter suppression, requiring a minimization of the energy transfer from the flow to the structure. On the other hand, in energy harvesting there is a need to efficiently transfer as much energy as possible from the fluid to the structure. The method described in this presentation will help in developing effective control techniques to realize both objectives.

DESS08-0098

Oil Depletion Estimations

Ryan Plumley
AFRL/RBAA

John Byrnes
AFRL/RBAA

It seems that the more you read, the harder it is to reach a conclusion about how much oil (or coal or natural gas) is left in the ground. Or for that matter, how much is recoverable. Because each estimate is using different assumptions! Fortunately, there's a way for you to get clearer on the assumptions you believe... and that's through using the tools of Systems Thinking. Chris Soderquist of Pontifex Consulting has developed a System Dynamics simulation model; simply an R/P formula (Reserve/Production). It seems like a straightforward and useful calculation, but like all calculations it is based on key assumptions: (1) future production and consumption is exactly the same, (2) there is no growth in the economy driving fuel usage, (3) prices remain the same and/or they do not impact demand, and (4) no new technologies come online to change desired usage. These assumptions will be discussed, then tested by the model, and finally summarized.

Session 16: Flight Operations **3:20-4:40 PM** **Room 156B**

Chair: Carl Tilmann, AFRL/RB

DESS08-0026

Replicating the Bay of Biscay: Issues in Agent-Based Modeling Validation

Brian Heath
Wright State University

Ray Hill
Air Force Institute of Technology

Frank Ciarallo
Wright State University

During World War II, German U-boats, or submarines, crossed the Bay of Biscay to disrupt the logistical forces in the North Atlantic that were supporting the Allies. To combat this Allied planes were dispatched to search and destroy submarines in the Bay. Over the years attempts have been made to model this scenario because it can give insight into past, present, and even future military operations. One of the modeling paradigms used to analyze this scenario is the Agent-Based Modeling (ABM) paradigm. However, for these ABMS to be used effectively they must be validated. Although validation is not a new topic in simulation, ABM presents some unique challenges with respect to the conceptual model, properties of the simulation, and the simulation's intended purpose. We highlight these challenges in ABM validation and discuss our proposed solutions using a replication of the Bay of Biscay scenario as an initial test case.

DESS08-0036

Vision-Based Navigation for Airfield Surface Operation

Bonnie Schwartz
AFRL/RBCC

Eric W. Frew and Tristan Gerritsen
University of Colorado

Stephen Pledgie, Chris Brinton, and Shivang Patel
Mosaic ATM

Today's aircraft operations on the airport surface, including taxiing, airfield navigation, avoidance of runway incursions, and obstacle avoidance, all require significant human involvement and decision-making. For the operation of Unmanned Aircraft Systems (UAS), significant effort is required to survey each airfield at which the UAS will operate, and to specify detailed taxi path waypoints, which the UAS tracks using GPS guidance. A number of disadvantages exist in this approach, including the significant effort required to survey airfields, the manual human oversight required to monitor the operation of the UAS on the airfield, and the reliance on GPS. The UAS Ground Operations Management System (UGOMS) provides accurate, real-time position determination on the airfield through the fusion of multiple sensor inputs already available on the aircraft (specifically measurements from a computer vision system and inertial navigation sensors), without reliance on GPS, and without detailed a priori surveying of the airfield.

DESS08-0080

Support for Planning of Air Refueling Tasking and Allocation (SPARTA)

Gina Daniels
Air Force research Laboratory

Rob Wnek
Northrop Grummon

Randall Whitaker
Northrop Grummon

Christopher Weimer
Air Force Research Laboratory

Samuel Kuper
Air Force Research Laboratory

Air Mobility Command (AMC) Tanker Airlift Command Center (TACC) Tanker Barrel is responsible for allocating tanker assets that are assigned to various wings once a need has been determined, requested and validated. It is important that assets are allocated in an efficient manner so that a maximum number of requests can be supported and that allocations are efficient in order to decrease costs to the Air Force by maximizing fuel usage and crew time and minimizing delay in aircraft movements. AFRL has designed a tool to allow barrel users to rapidly check for ways to more efficiently allocate tanker resources by implementing a method of visualizing potential candidates for mission combination through a work flow that was suggested through many hours of knowledge acquisition with TACC personnel. A subjective evaluation was conducted by demonstrating the tool to tanker personnel and obtaining their opinions and suggestions for further refinement.

DESS08-0045

Autonomous Intelligent Systems Integration in Safety in Flight Test and Launch Operations

Jeff Hadhazy
Aerospace Research Systems, Inc.

Dr. Pamela Menges
Aerospace Research Systems, Inc.

Autonomous Intelligent Systems (AIS) have found their place in the engineering of machinery and vehicles. Engineering of operational systems may benefit from the use and integration of AIS. One area where AIS are proving highly productive is in the design of critical flight operations management systems. The development of an AIS-based systems security program for flight test and commercial launch operations has created an adaptive information environment capable of accessing vehicle, personnel, operations, range safety, security, medical, facility and engineering data. The unique network provides integrated communications for operations personnel including emergency responders. Database elements can be designed to provide mission analysis, risk assessment, incident reporting and may include PRP data. An intelligent network may also integrate training and simulation modules with incident-accident, operational security, range safety and mission scenarios. As a mobile mesh network, an AIS operational management system also supports real-time simulation.

Session 17: Aerospace Vehicle Design 3:20-4:40 PM Room 156C

Chair: Daniel Tejtel, AFRL/RB

Design & Optimization

DESS08-0007

Ramstar Orbital Spaceplane as a Model for Advanced Concepts Visualization

Pamela Menges
Aerospace Research Systems, Inc.

Advanced concepts visualization offers a set of programmable tools to analyze complex vehicles and systems. The Ramstar Orbital Spaceplane is being used as a virtual modeling platform for advanced vehicle and systems concepts development. The virtual laboratory uses neural technology and intelligent cross platform utilities to create a distributed laboratory environment. As a smart systems spaceplane it is a natural candidate for experimentation with open architectures and configurable systems modules. The "virtual spaceplane" provides opportunities to develop models utilizing parametric and multiphysics data as well as systems level experiments and simulations for components, crew modules, payloads, and "What ifs." The visualization system initially served as a tool for systems integration. Over its eight years of development, radiation, thermal, and vehicle dynamics have been integrated and provide simulation and analysis modules. The virtual spaceplane laboratory is now serving as an experimental environment and tool set for spacecraft engineers.

DESS08-0079

Exergy-Based Methods for Analysis and Design of Aerospace Vehicles

John Doty
University of Dayton

José Camberos
Air Force Research Lab

David Moorhouse
Air Force Research Lab

Designing aerospace vehicles for optimum system performance is a difficult task. Historically, design methods optimize individual components at their respective operating points and then assemble them into a combined vehicle. This methodology cannot really be envisioned as a design approach, but rather must be viewed as system assembly: It integrates components into a single system but is not a systems-level design. The ever-increasing performance required of future aerospace vehicles needs a new design paradigm that incorporates physical laws before the vehicle is assembled. Such an approach requires system-level analysis and trades to be performed in a consistent, intuitive, and quantitative manner. This integrated, physics-based design approach will provide the aerospace engineer a clear and consistent roadmap for performance and trade studies. A paradigm shift away from the off-the-shelf assemblage of hardware must necessarily include the ability to assess design impacts on performance and system integration before the components are available.

DESS08-0071

Optimal Re-entry Trajectory Terminal State Due to Variations in Waypoint Locations

William Karasz
Air Force Institute of Technology

The Air Force's Prompt Global Reach concept describes the desire to have a capability to reach any target within a 9000 nautical mile distance within two hours of launch. To meet this objective, much effort is being devoted to hypersonics and re-entry vehicles. Specifically, this research addresses how a re-entry vehicle can reach the target in minimum time and also investigates alternate paths, via waypoints, of the re-entry vehicle which still meet the mission objectives. The result of this research is a direct numerical solution technique for mapping the sensitivity of the terminal state as a function of waypoint location while satisfying vehicle dynamics, control limitations, and defined waypoint constraints.

DESS08-0009

Roughness Considerations for the HIFiRE-1 Vehicle

Roger Kimmel
AFRL/RBAA

The Hypersonic International Flight Research Experimentation (HIFiRE) program is a hypersonic flight test program executed by the Air Force Research Laboratories (AFRL) and Australian Defence Science and Technology Organization (DSTO). The emphasis of flight one is aerothermodynamics, and boundary layer transition is the primary experiment. This makes it critical to specify allowable roughnesses and trips. No theory is available for estimating allowable roughness heights, so correlations must be used. This presentation describes several correlations for distributed nose tip roughness and discrete frustum roughness. Generally, the correlations all give reasonable results about the same order of magnitude, but show considerable spread. When making roughness estimates, several correlations should be examined, and decisions on trips and roughness must be made using judgment based on how near one is to a specific criterion.

Session 18: Micro Air Vehicles **3:20-4:40 PM** **Room 157A**

Chair: David Allen, OAI

DESS08-0065

Tools for Conceptual Design and Engineering Analysis of Micro Air Vehicles

Mustafa Turan
Air Force Institute of Technology

Dr. Robert A. Canfield
Air Force Institute of Technology

Dr. Fred Harmon
Air Force Institute of Technology

Micro Air Vehicles are a subset of Unmanned Aerial Vehicles that are up to two orders of magnitude smaller than the manned systems. Near-Earth environments make specific missions difficult and dangerous to accomplish. Advances in material science, analytical tools have enabled highly effective small-sized aircraft like UAVs. Nevertheless, data using full size aircraft is inadequate to characterize miniature aircraft parameters. The main objectives of this research are: collect and systematize the available data; create a statistically integrated database of MAV designs for conceptual design trades; synthesize and model a prototype design using conceptual and empirical analysis; then highlight MAV-specific design criteria and identify gaps in existing data for later research. The following design tools constitute the starting point in the proposed effort for creating a demonstration tool-set for MAV design. Digital DATCOM (Aerodynamics, Stability), Matlab/Excel, Model Center as executive control program (Sizing and Trade Studies)

DESS08-0032

Simulation of Low Reynolds Number Airfoil in High Frequency Pitch and Plunge Motions using SC/Tetra

Sunil Vytla
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P. G. Huang
Wright State University, Dayton, OH

N. Watanabe
CRADLE, Japan

Combinations of Sinusoidal Pitching and Plunging motions of airfoil SD7003 was simulated using SC/Tetra. Reynolds number of 10,000 and 40,000 based on free stream flow velocity and the airfoil chord were considered in the study. The simulations were carried out using the moving boundary and stretching mesh techniques to achieve the desired motion of the airfoil using an unstructured mesh. The simulation results were compared with phase averaged values from the experiments. It is observed that the Reynolds number effect is not significant. We are planning to do the 3-D simulations using the dimensions of the water tunnel used for the experiments and compare the results with 2-D cases.

DESS08-0042

Aerodynamic Performance of Two-Dimensional Bio-Inspired Wing Sections in Micro-Air-Vehicle Applications

Charles Webb
Haibo Dong
WSU

Birds and Insects fly in what is known as an ultra-low Reynolds number regime. This has made the realization of a fully functioning Micro-Air-Vehicle or MAV very difficult as conventional aerodynamic theory and engineering struggles to match nature's ability. The current research specifically examines the aerodynamic response of profiled wing sections indicative of three insect species: dragonfly, cranefly, and hoverfly, to periodic kinematics with respect to cruising flight and hover. This study compares the performance of these "bio-inspired" wings to that of more conventional technical airfoils: GAW-1 and elliptical airfoil in an effort to aid in the design process of MAVs.

DESS08-0033

Verification of a Transpiration Aeroelastic Solver.

Ernest Thompson
University of Dayton

In an investigation, a velocity transpiration enabled inviscid fluid flow solver and a computational structural dynamics solver are loosely coupled to produce a static nonlinear aeroelastic code. The code is applied to different geometries. The results from code are verified against the results produced from a linear aeroelastic solver and grid deformation enabled non-linear aeroelastic solver. The study demonstrates the utility of the velocity transpiration enabled solver in the preliminary design environment introducing higher fidelity with moderate computational expense.

Session 19: Heat Transfer & Thermal Sciences 3:20-4:40 PM Room 163A

Chair: Kevin Klasing, GE

DESS08-0017

3D Thermal-Fluid and Stress Analysis for Single Chip SiC Power Sub-Modules

Bang Tsao
University of Dayton Reserach Institute

Katie Sondergelt
University of Dayton Reserach Institute

Jacob Lawson
University of Dayton Reserach Institute

James Scofield
AFRL

Levi Elston
AFRL

Three dimensional thermal-fluid and stress models of a single chip SiC power sub-module were generated using ANSYS in order to determine the maximum temperature and deformation under various conditions. The effects of heat flux, fluid temperature and differential pressure on temperature and thermal stress contours were of particular concern. For steady state cases, a simulated heat flux of 11.12x104 W/m2 with film coefficients of either 300 W/m2-K or 6 W/m2-K resulted in maximum device junction temperatures of 316 and 458 K respectively, and corresponding deformations of .0296% and .0436%. The transient response after 25,000 seconds also showed junction temperatures in the range of 316 K to 458 K. The time to reach steady state was determined to be about 15,000 seconds with a film coefficient of 6 W/m2-K. Experiments will be conducted in order to validate ANSYS results.

DESS08-0030

Implementation of Water Cooled Load Bank

Larry Burich
AFRL/RZPE, Wright State University

Jonathan Potter
AFRL/RZPE, Wright State University

The use of an air cooled load bank to test generators in AFRL's High Speed Drive Stand room has created numerous issues. To address these issues, a new load bank was developed. This new load bank is water cooled to transport heat out of the drive stand room by using 30 5KW water heater elements configured in three banks of 10. Each element is switched on or off by a controller built into the load bank to meet the loading requirements. Three of the elements are controlled by a Pulse Width Modulation (PWM) circuit to provide 20W steps in loading. The load bank is equipped with rectifiers and adaptor plates to accommodate various generator configurations including single phase AC, 3-phase AC, and DC voltages. In order to minimize floor space used, the load bank is wall mounted above the drive stand.

DESS08-0020

Numerical Analysis of Copper Coated Thickness in Carbon Foam

Mohammad Almajali
University of Dayton

Khalid Lafdi
University of Dayton

The high thermal conductivity, light density and high porosity make carbon foam an attractive material in a wide range of industrial applications. However, the high porosity carbon foams have certain limitations in relation to their strength and thermal performance. Coating carbon foam from inside is one of the best methods used to improve the thermo-mechanical properties. The main factor that controls the improved properties is the coated thickness. The major issue associated with coating carbon foam is determining the coated thickness. In this study a numerical model was developed to predict the coated thickness. Initially the model was built in two dimensions and compared with models from literature. Then samples of Graphite plates were coated experimentally to validate the theoretical model and a very good agreement was found between the predicted and experimental results. The numerical model was then modified to include the surface area of carbon foam.

DESS08-0092

Calculating Modulating Steam Boiler Efficiency and Quantifying Energy Savings for Preheating Combustion Air

Steve Mulqueen
University of Dayton

Steam boiler plants often consist of several fire-tube boilers. Staging boilers such that they operate at peak efficiency can result in energy savings. In addition, reducing excess air and preheating combustion air offer energy saving opportunities. The decision about whether to pursue these opportunities often depends on the expected savings. Thus, accurate estimates of savings are vital to efforts to improve energy efficiency. This presentation will discuss methods for estimating the expected savings from these measures in natural gas fire-tube boilers. The methods described here include both calculations of the combustion temperature and heat transfer effects within the boiler. In addition, combustion, shell, and blow-down losses will be calculated to determine boiler efficiency. As a consequence, these methods provide better estimates of savings than methods that ignore these effects.

Session 20: Sensors II **3:20-4:40 PM** **Room 163B**

Chair: Spectral Energies, LLC

DESS08-0082

Lucky Imaging of Low Earth Orbiting Satellites

Chris Carlton
Air Force Institute of Technology

Dr. Richard Cobb
Air Force Institute of Technology

Lucky imaging has reemerged as a viable technique to achieve diffraction-limited imagery from ground-based optics. On Earth, visible imaging of space is limited by two notable factors: telescope diffraction limit and atmospheric seeing limit. Lucky imaging minimizes effects from the seeing limit by capturing high-speed images (tens of milliseconds exposure time) and removing distortions through frame selection. The principle technologies enabling this technique are the advancements in CCD cameras, specifically in electron-multiplying CCDs. By reducing readout noise, the sensitivity of traditional CCDs has been greatly increased, allowing for low-light photography at the necessary frame rates. By coupling this photography with image selection and stacking, lucky imaging can potentially improve imagery resolution to the diffraction limit of the telescope. This research investigates the suitability of lucky imaging of low Earth orbiting satellites with small aperture telescopes. The processes of lucky imaging and the hardware and software employed will be presented.

DESS08-0011

Adaptive Control of Woofer-Tweeter Adaptive Optics

Jimmie Perez
Air Force Institute of Technology

Adaptive optics applies advanced sensing and control to improve the ability of optical systems to collect images through a turbulent atmosphere. The results of this research effort demonstrate the combination of two recent approaches to improve the performance of adaptive optics in directed energy weapon and laser communication scenarios. The first approach is adaptive control, which offers improved performance over fixed gain controllers in the presence of rapidly changing turbulence and wind velocities. The second approach incorporated into the study is a dual-mirror system. The two mirrors are a high bandwidth, low actuator stroke (tweeter) mirror and a low bandwidth, large stroke (woofer) mirror. The woofer-tweeter combination allows for better compensation of the large variance, high spatial frequency phase distortion generated by strong turbulence. The performance of an adaptive woofer-tweeter architecture is compared to both a traditional, fixed-gain, woofer-tweeter AO system and to an adaptive single mirror system.

DESS08-0070

A Frequency Agile Patch Antenna Using Ferroelectric Thin Film Varactor Technology

Mark Patterson
University of Dayton

Guru Subramanyam
University of Dayton

Hai Jiang
University of Dayton

Jiadong Wang
University of Dayton

A patch antenna was constructed on top of a Barium-Strontium-Titanate thin ferroelectric film. The feed line to the antenna consisted of a ferroelectric varactor shunt switch which acted as a variable attenuator and reactive load to the antenna. This interaction allowed the antenna to be tuned with an applied DC voltage so that the resonant frequency changed 200 MHz per volt. The natural frequency of the antenna was 7.7 GHz and would change up to 8.3 GHz with an applied DC potential of 3 volts. The antenna combination had a VSWR of 1.001 at a frequency of 7.7 GHz with a Bandwidth of 50 MHz. The high Q of the antenna reduces the need for high Q filters.

DESS08-0013

An Algorithm for Automated Feature Extraction from Flash LADAR

JN Markiel
The Ohio State University

C. Toth
Center for Mapping

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An algorithm is presented which extracts features from a time series of Flash LADAR images without a-priori knowledge of the surrounding environment. Flash LADAR utilizes laser ranging to acquire 3D information in the object space, which may be utilized to reconstruct the sensor environment. The extracted features are tested to identify motion artifacts and separate entities into static and non-static states. Static features can be utilized to provide a positional fix owing to the availability of range data, enabling navigation in environments where GPS is challenged or intermittent. The algorithm is linear based, robust to sensor noise, and utilizes image data to drive a series of heuristics on an autonomous basis. The algorithm can be utilized to extract static features without requiring manual input or adjustment. Location error from extracted features is examined on the basis of sequential frames.