HIGH PERFORMANCE FLEXIBLE MATRIX COMPOSITE ACTUATORS FOR TRAILING EDGE FLAP CONTROL
Amanda Chou, Virginia Tech

Novel smart material and actuator technology will ultimately lead to the development of aerodynamically efficient, air vehicles capable of radical shape change that can accomplish various mission types with superior performance. In this research, active skins based upon pressurized flexible matrix composites (FMCs) are investigated for trailing edge flap control of a glider wing. The new active flexible FMC skins consist of embedded pressurized composite tubes in an elastomeric resin. A mathematical model for a single pressurized FMC composite tube is developed and presented. Using the single tube model, a Rule of Mixtures (ROM) is employed to find the effective properties of the multi-tube active skin. Modeling the top and bottom skins of the trailing edge as active FMC skins, the effective parameters are used to derive the equations for bending and axial extension of the active material using Hamilton's Principle. The 2-D vortex panel method is utilized for estimating the aerodynamic loading on the trailing edge flaps. From the mathematical representation of the FMC trailing edge flaps with aerodynamic loading, analysis is performed for insight and design.

CHARACTERIZATION OF THE PHASE SEPARATION OF POLYVINYLPYRROLDONE/TRISILANOLPHENYL-POSS POLYMER BLENDS
Jonathan Conyers, Virginia Tech

Polyvinylpyrrolidone (PVP) is a polymer that has shown promise in aerospace sealant applications. Trisilanol-POSS (TPP) integration into polymers as blends has shown increased stability, structural integrity, and thermal resistance. PVP/TPP blends might increase the properties of the PVP to create better aerospace sealants. Optical microscopy temperature ramps of low molecular weight PVP/TPP blends revealed morphological changes occurring for all blend compositions that could be de-etting or phase separation. X-ray photoelectron spectroscopy (XPS) was used to further explore the morphological changes. All low molecular weight PVP/TPP films revealed elemental nitrogen and silicon on the surface before thermal annealing due to PVP and TPP being at the surface of the sample. After annealing, all samples lacked the original nitrogen peak, and the silicon peak is more intense. The lack of a nitrogen peak after annealing confirms that PVP is not present at the surface. The increased silicon peak reveals that TPP rises to the surface, and the polymers are phase separating. Even at 80% PVP and 20% TPP blends, TPP covered the entire surface of the substrate. Due to the simple process of phase separation, aerospace applications based on tool less manufacturing seem quite feasible with TPP/PVP blends.

CONCEPTUAL DESIGN OF AN AERODYNAMIC BRAKE FOR HYPersonic RECOVERY
Jesse Quinlan, University of Virginia

Supersonic combustible ramjet (scramjet) engines have become a prominent field of research in the area of hypersonic technology. Capable of reaching speeds in excess of Mach 10 without the necessity of any moving parts, scramjets may prove to be a viable solution to the problem of dependable hypersonic transport. However, further research into a scramjet’s operation is required and therefore provides an impetus for further flight tests. The Hy-V Scramjet Experiment has been established in order to verify scramjet research done at the University of Virginia and elsewhere. Furthermore, a first-ever scramjet recovery is being investigated by the Hy-V researchers at the University. A conceptual design of an aerodynamic brake that may provide a reliable means of recovery at hypersonic flight conditions has been completed. The brake area required to slow the scramjet payload from Mach 5 to Mach 1 was shown to be conducive to a manageable and symmetric 4-brake system. Several brake designs were analyzed using Finite Element Analysis software, and a candidate brake design was decided upon based on its analysis and design feasibility. A solid model was developed illustrating the placement and operation of the aerodynamic brakes and the opening load-reducing dampers.
HYPERSONIC GLIDER FOR WAVE-RIDER VEHICLE
Alicia Saringer, Old Dominion University

It is in the interest of NASA to investigate if a deployable glider can be utilized for a six-foot hypersonic wave-rider vehicle. This glider should function to stabilize the vehicle when the vehicle decelerates to transonic and subsonic speeds. The design specifications require the glider to be seventy-five percent of the vehicle's length and that the glider is stowed during the hypersonic regime. The design of the glider was inspired from the research done by R.T. Jones of NASA Ames who has shown that oblique wings promise more aerodynamic efficiency for aircrafts flying at transonic and low supersonic speeds (known as the wing sweep theory). From this theory, a prototype of an oblique glider was modeled in Inventor 2008 Professional along with a scaled model of the six-foot wave-rider. It was assembled and placed in a tube at varying angles of attack and sweep. The model was imported into CFDesign were fluid analysis was done to analyze the forces on the wing. The analysis was set for atmospheric conditions at 50 km and local Mach number of 1.2.
The CFD analysis illustrated that the optimal angle of attack was between five and ten degrees. Therefore the analysis was run for angles of attack from five to ten degrees in one degree increments for all the sweep angles. The analysis also showed that the vehicle stalls when it reaches an angle of attack of thirty-five degrees. The pressure distribution from CFDesign analysis showed that the glider can handled the forces the glider experiences. A limitation for this analysis is that it does not account for thermal effects and stresses that the glider experiences when it is stowed.

TRAJECTORY ANALYSIS FOR THE HY-V SCRAMJET FLIGHT EXPERIMENT AND THE EFFECTS OF A RECOVERY SYSTEM
Amanda Smith, University of Virginia

With the retirement of the space shuttle near and rising fuel prices driving a demand for more efficient travel, alternative engine technology is being heavily researched. The scramjet, or supersonic combustion ramjet, has proven to be a promising development in reusable hypersonic transportation. Flight testing these engines, however, is very expensive and no scramjet flight has yet been recovered in reusable condition. To decrease costs, ground testing and simulations are being conducted to better model scramjet flight characteristics. In this project, NASA Wallops' GEM software was used to simulate the trajectory of a scramjet flight experiment and analyze the effects of varying flight parameters on the trajectory to increase accuracy of ground simulations. The results were compared to wind tunnel data gathered from ground tests. Sensitivity of the trajectory to each input parameter was noted so corrections could be applied in flight tests to achieve desired flight conditions. Integration of a recovery system was included in the simulation and potential landing sites were found.

TIME OF FLIGHT AS A BIOPHYSICAL TECHNIQUE TO INVESTIGATE THE PROTIEN AND LIPID CONTENT
Benjamin Winer, College of William and Mary

Time of flight second ion mass spectroscopy or TOF-SIMS has been used extensively in the semiconductor industry for many years. TOF-SIMS was used primarily as a tool to test for semiconductor quality. Only recently have scientists started to try and develop TOF-SIMS as a biophysical technique to investigate the protein and lipid content of biological tissue. TOF-SIMS is a powerful technique that allows scientists to collect chemical along with morphological information. The importance of TOF-SIMS being able to be developed into a technique that can investigate biological tissue is that it would provide scientists with the location of proteins and lipids in a tissue sample. This could help scientists to gain a better understanding of what roles certain proteins and lipids play in the development of an organism. TOF-SIMS can also help scientists to gain a better understanding of the protein signals that cause the development of a cancerous teratoma. Our hope is to prove that TOF-SIMS is a viable biophysical technique that can investigate biological tissue. We plan to show that from the investigation of drosophila melanogaster embryo's that we have been able to attain some biologically relevant data from the chemical spectra that we have been able to correlate to the secondary ion image. This is a good proof of principle that TOF-SIMS can be used to investigate biological samples.
Virginia Space Grant Consortium  
Student Research Conference - April 21, 2008  
Old Dominion University, Norfolk, Virginia  

Aerospace Graduate Research Fellows  
Oral Presentations –Potomac/York Room

Applied Physics

8:45 a.m.  DOUBLE ELECTRIC LAYER IN THE STATIONARY SHOCK WAVE STRUCTURES OF A SUPersonic FLOW  
D. Janette Drake, Old Dominion University

One of the most challenging issues facing NASA’s Mars exploration probes is the interaction between the acoustic shock waves formed during entry and the plasma created due to the friction between the probe and the atmosphere. This interaction can manifest itself in the form of a localized increase of electron temperature, plasma induced shock dispersion and acceleration, optical emission enhancement, or double electric layers. We are performing experimental and gas kinetic modeling on simulated Martian entry plasma. Special emphasis is given to the in situ utilization of Martian entry plasma. Formation and structure of a double electric layer produced by a spherically blunt object in these plasmas is discussed.

9:00 a.m.  DESIGN MODIFICATIONS TO ACHIEVE LOW-BOOM AND LOW-DRAG SUPersonic CONCEPTUAL DESIGNS  
Daniel. B. Le, University of Virginia

A new methodology for designing the wings of a low-boom low-drag conceptual aircraft is proposed. The primary objective of this work is to develop an automated integrated framework to design the wing of a supersonic commercial jet. The work focuses on the design of the aircraft wing geometry, specifically the wing planform, camber, and twist. The wing is designed to achieve a lift distribution which supports low boom performance while maintaining high aerodynamic performance. The wing planform is parameterized to maintain design flexibility while limiting the number of design variables. It is necessary for the designer to be able to inject knowledge-based design decisions into the process. To allow this, the parameterization scheme maintains a level of flexibility for the designer to inject knowledge-based design decisions into to the design process.

This methodology addresses two important issues during the conceptual design phase: maintenance of high aerodynamic performance and design for low sonic boom impact. This research successfully shows that optimization techniques can be applied which emulate the designer’s manual process. The preliminary results indicate that small meaningful changes to the wing planform yield significant modifications to the equivalent area due to lift which is beneficial to low-boom performance.

9:15 a.m.  CHARACTERIZATION OF PRECAMBRIAN ORGANIC-WALLED MICROFOSSIL ULTRASTRUCTURE USING FOCUSED ION BEAM ELECTRON MICROSCOPY  
James D. Schiffbauer, Virginia Tech

Examination of microfossil ultrastructures using electron microscopy (EM) frequently involves tedious and painstaking mechanical preparation and presents only restricted viewing perspectives. Even so, field emission scanning electron microscopy (FE-SEM) is able to provide detailed, nanometer-scale surficial analyses and, in conjunction with transmission electron microscopy (TEM), allows for simulated three-dimensional views of surface and subsurface structures. However, this combination of EM techniques offers little control over orientation and selection of cross-sectioning sites, and therefore provides sub-optimum three-dimensional ultrastructural information. On the other hand, integrated sub-nanometer resolution FE-SEM, focused ion beam (FIB) sectioning capabilities, and energy dispersive x-ray spectroscopy (EDS) available in dual beam FIB systems allow for real-time, three-dimensional ultrastructural analysis and compositional mapping with precision site-selectivity and little to no mechanical sample preparation requirements.

The capabilities and methodologies for using a FEI DualBeam Helios NanoLab field-emission scanning electron/field-emission ion beam system constitute the majority of this presentation, utilizing multiple Precambrian organic-walled microfossils as subjects for ultrastructural analysis. While FIB techniques have been utilized in in-situ examination of microfossils (Kempe et al. 2005, Precambrian Res., 140, 36–54; Cavalazzi 2007, Astrobiology, 7, 402–415), this study focuses on analyzing palynologically extracted microfossils for thorough
investigation of both surface and subsurface microstructures. The microfossils highlighted here include sphaeromorphic and acanthomorphic acritarchs from the Mesoproterozoic Ruyang Group of North China, including *Dictyosphaera delicata* and *Shuiyousphaeridium macroreticulatum*; large sphaeromorphic acritarchs from the Paleoproterozoic Chuanlinggou Formation of the Changcheng Group in North China; and possible graphitized sphaeromorphic vesicles from the late Archean–early Paleoproterozoic Jingangku Formation of the Wutai Group in North China (Schiffbauer et al. 2007, Astrobiology, 7, 684-704).

9:30 a.m. **SYNTHESIS AND PROCESSING OF MnAlC PERMANENT MAGNETIC ALLOYS**
Elizabeth Cantando, University of Virginia

Mn_{54}Al_{44}C_{2} forms the metastable L10 intermetallic compound, and exhibits ferromagnetic behavior after appropriate heat treatment. This material offers a low-cost, light-weight alternative to rare earth, alnico and ferrite magnets currently in use. Characterization techniques include vibrating sample magnetometry (VSM), X-Ray diffraction (XRD), optical microscopy and transmission electron microscopy (TEM), while mechanical milling, melt spinning and vacuum induction melting are routinely employed for alloy formation. Finally, we explore heat treatments under magnetic fields as a new technique to tailor and enhance magnetic properties of interest.

9:45 a.m. **A DESIGN OF EXPERIMENTS APPROACH TO OPTIMIZATION OF NASA LANGLEY 12 FOOT WIND TUNNEL DYNAMIC RIG FOR NONLINEAR AND UNSTEADY AERODYNAMIC MODELING**
Brianne Williams, Old Dominion University

NASA Langley Research Center (LaRC) and Old Dominion University (ODU) Department of Aerospace Engineering are collaborating to develop a methodology for dynamic modeling of aircraft using wind tunnel measurements. Aircraft experience unsteady and nonlinear aerodynamics that are currently misunderstood and difficult to model mathematically. NASA LaRC has developed the hardware for a dynamic test rig for using the NASA Langley 12-foot Wind Tunnel (LaRC 12-FT WT). However, software development has been fraught with difficulty. Currently the software is being worked on by a NASA engineer. The software will be uploaded, bench tested, and implemented on the larger scale dynamic rig (DR) in the LaRC 12-FT WT. Concurrently ODU is working on a model simulation of the DR in order to determine possible sources of error in the rig. The second objective is to leverage the power of Design of Experiments (DOE) and Response Surface Methodology (RSM) to exercise, validate, and examine the sources of error on the DR. These methods will also allow for optimization of the rig to be conducted. The final objective is develop a general dynamic test modeling method for an aircraft using the DR and ultimately using a DOE/RSM approach to develop the necessary empirical models of aircraft unsteady aerodynamics.

10:35 a.m. **DEVELOPMENT OF AN ARTIFICIAL EXCITABLE MEMBRANE FOR USE AS A TUBE PUMP**
Christina Haden, University of Virginia

A polymer based artificial cell that mimics the excitability and refractoriness of cardiac myocytes is in the first stages of development. The ultimate goal of this project is to connect many of these excitable cells together to produce a medium exhibiting contraction similar to those of a real heart. This contracting medium will be used for the development of a tube pump capable of propelling fluids along its entire length. The conceptual design of the individual cell has been completed, and a series of experiments needed to test the components has been developed. Experimental results to date include the incorporation of tracer postassium ions into the foundation of the cell, which is a PVDF-HFP based ionic fluid polymer gel. A method for the measurement of the conductivity of these gels using electron impedance spectroscopy (EIS) has been established. Furthermore, carbon nanotubes have been successfully incorporated into the PVDF-HFP material, creating the basis for an electrode in the cell. Finally, the production of PPy membranes, an electroactive polymer, has begun and their electrochemical properties established using cyclic voltammetry.
Periodontal disease, commonly known as gum disease, affects millions of Americans. The current method of detecting periodontal disease is painful, invasive, and inaccurate. As an alternative to manual probing, the ultrasonographic periodontal probe is being developed to use RF ultrasound waveforms to measure periodontal pocket depth, which is the main measure of periodontal disease. The methods employed use wavelet transforms and pattern recognition techniques to develop artificial intelligence routines that can automatically detect pocket depth. Applying ultrasound to dentistry in this way is useful for long-term flight situations in the space industry.

In an effort to obtain a precision landing for Mars landers, it is important to use reaction control system (RCS) jets in order to control the trajectory of an entry vehicle traveling through atmospheric regions where aerodynamic control surfaces are ineffective. Experimental work involving RCS interactions is highly requisite in order to validate computational code and give greater physical understanding. In this paper, a parametric study conducted to assist in gaining data on the interactions of RCS is outlined. In this parametric study, two models of the Mars Science Lander (MSL) are placed in a wind tunnel at different Mach numbers at different angles of attack. The flow field around the model is illuminated using a Tesla coil. Pictures were taken of the different setups and are compared here to determine the robustness of the model design under the different conditions. The comparison is used to determine the model and set up for the experiments that will be used in conjunction with PLIIF in order to gain better physical and quantitative understanding of the RCS jet interactions. The pictures obtained show the interactions of the bow shock off the model with the barrel shock created in the free expansion jet.

Developing software that meets the requirements for which it is needed is a difficult task, and it is near impossible to ensure that the software correctly performs its intended function in all situations without any errors. Fixing these errors, or bugs, is a part of software maintenance. Often times, the person who is trying to fix the software (the maintainer) is not the same person who originally wrote the code for the software. The maintainer's job is hard because he/she first has to gain enough understanding of the code to know where to look for the problem, then he/she has to actually fix it. One way to make the maintainer's job easier is to automatically identify the parts of the code that correspond to a specific feature of the software, a process known as feature location. In my research, I am developing a technique for feature location that employs both static and dynamic analysis. The approach uses dynamic analysis to gain an initial mapping of features to source code and then expands and refines the mapping statically according to a set of rules. These rules help identify features for source code not included in the dynamic analysis. Evaluation of the approach is ongoing, but preliminary results indicate that the technique can locate feature code with good accuracy and completeness.

The Magellanic Stream is a 100 degree long gaseous stream trailing behind the Large and Small Magellanic Clouds, the two largest satellite galaxies of our Milky Way. I have used a new all-sky radio survey to explore the structure and origin of the Magellanic Stream. Contrary to previous assertions that the Stream originates in the Small Cloud, I have found that the Stream can be traced back to the southeastern region of the Large Cloud. I have also uncovered evidence that star formation in this region of the Large Magellanic Cloud is responsible for blowing out the gas that forms the Stream. This new formation mechanism for the Stream naturally explains its apparent lack of stars that has long puzzled Astronomers.
2:25 p.m.  KINEMATICS OF DWARF GALAXIES AND THEIR REMNANTS IN THE MILKY WAY HALO
Jeffrey L. Carlin, University of Virginia

Dwarf spheroidal (dSph) galaxies represent the low-mass end of the dark matter halo distribution, making them key discriminators between models of cosmological structure formation in the universe. Recent efforts have uncovered a few low-luminosity dSphs, as well as numerous stellar tidal streams (remnants of accreted, tidally disrupted dwarf galaxies) in the Milky Way halo, helping to explain the perceived deficit of observed dSphs relative to model predictions. To explore the reasons some halos survive intact, while others are tidally disrupted, orbital information is needed. To date, most kinematic studies of the dwarfs themselves, as well as known tidal features, have been limited to radial velocity programs, providing only one dimension of the full space motions. In the work described here, we measure tangential velocities (via “proper motions”) of individual stars in these systems, which can be combined with the radial component to derive orbits. The dynamical information of the dSphs and known tidal streams can then be used to look for orbital associations, as well as to constrain the shape of the Milky Way dark matter halo. We report here work in progress on the absolute proper motion of the Carina dSph, as well as a proper motion survey of, among others, the Sagittarius and Monoceros tidal streams.

2:40 p.m.  OUR DUSTY MILKY WAY: CONSTRAINING THE DUST DISTRIBUTION IN THE DISK OF OUR GALAXY
Gail Zasowski, University of Virginia

The interstellar dust permeating our home galaxy, the Milky Way, strongly affects astronomical observations and creates difficulties for studies of the Galaxy on both large and small scales. Our ability to accurately characterize both the large-scale structure of the Galaxy, and the smaller regions embedded in it, relies on our knowledge of the intrinsic nature and distribution of the intervening dust. We have developed a technique to obtain simultaneous distance and extinction information towards individual stars, using the fact that the majority of stars in the Galactic disk share a common intrinsic spectral energy distribution (SED) in the infrared. Deviations of the observed SEDs are then attributed to wavelength-dependent extinction along the line of sight. We apply this technique to stars contained in several large infrared catalogs; the enormous quantity of data points produces two- and three-dimensional Galactic extinction maps with high angular and spatial resolution and good signal-to-noise ratios. These maps will facilitate large-scale Galactic structure studies as well as provide better corrections of observational studies of stellar clusters, star-forming regions, and other elements crucial to a full understanding of the composition and history of our Galaxy and astronomical neighborhood.

3:30 p.m.  THE BIRTH OF SUPER STAR CLUSTERS
Amy E. Reines, University of Virginia

A multi-wavelength study of embedded massive clusters in the nearby (3.9 Mpc) starburst galaxy NGC 4449 is presented in an effort to uncover the earliest phases of massive star cluster evolution. By combining high resolution imaging from the radio to the ultraviolet, newborn star clusters in the process of emerging from their gaseous and dusty birth cocoons are revealed. Very Large Array observations at centimeter wavelengths are used to identify young clusters surrounded by ultra-dense HII regions, detectable via their production of thermal free-free radio continuum. Ultraviolet, optical and infrared observations are obtained from the Hubble and Spitzer Space Telescope archives for comparison. Thermal radio sources are identified within the galaxy and their physical properties are derived using both nebular emission from the HII regions and SED fitting to the stellar continuum. By combining results from the nebular and stellar emission, an I-band excess is found that is anti-correlated with cluster age. A photoluminescent process known as Extended Red Emission provides a favorable hypothesis for the observed I-band excess. Additionally, there is evidence indicating local processes such as supernovae and stellar winds are likely playing an important role in triggering the current bursts of star formation within NGC 4449.
Jupiter’s moon Europa has a tenuous atmosphere produced by Jupiter’s intense radiation environment, a plasma that erodes Europa’s surface. In the last year I have continued modeling this atmosphere, which began with models of the dominant component of the atmosphere, O₂, and the sparse but easily detectable Na. I have recently focused on modeling components of the atmosphere that have not been detected, but are expected to be present in the atmosphere due to their presence in the surface (as inferred by reflectance spectroscopy). This work is in preparation of an orbiter that could easily detect such atmospheric components. Such in-situ measurements of the atmosphere could resolve questions about surface composition, which has, as yet, only been detected remotely.

The impact of clouds on the incoming solar and outgoing terrestrial radiation is one of the largest uncertainties in global climate models. This research focuses on the determination of the effect that high altitude optically thin “subvisual” cirrus clouds (SVC) have on the spectrum of the Earth’s infrared radiation to space. In this study, Aqua-train satellite AIRS, CALIPSO, and MODIS observations, provide infrared radiance spectra, cloud height, and cloud coverage data, respectively. CALIPSO Lidar and MODIS multispectral radiance observations are used to identify clear versus cloudy fields of view for the time and space coincident with AIRS infrared radiance observations. The AIRS cloud-free and cloudy radiance to space spectra, together with atmospheric temperature profiles provided by global weather analyses, are used to determine the infrared spectrum of cloud emissivity and optical depth. The optical depth spectra are used to assess the potential contribution of increases in subvisual cirrus clouds on the global warming process.

Galaxy clusters, the largest gravitationally bound objects in the universe, form over time from collisions and mergers between clusters and between clusters and smaller galaxy groups. The results of these collisions can be detected in a variety of ways. In one case, I have found that clusters which have recently undergone a merger will have an enhanced Sunyaev-Zel’dovich (SZ) Effect. The SZ signal from thousands of clusters will soon be measured in order to constrain the dark matter and dark energy content of the universe. However, I have shown that while observations of the central SZ effect, which is more sensitive to merger enhancements, will hopefully bias these estimates, the integrated SZ signal will not and should be the quantity extracted from SZ surveys. Another result of cluster mergers is the acceleration of relativistic particles, which produce non-thermal emission that should be observable in X-rays. In the Coma cluster, the brightest merging cluster in the sky, detections of this emission have been claimed, though these findings are controversial. Using observations of Coma with the Hard X-ray Detector onboard Suzaku, I find no conclusive non-thermal emission and derive an upper limit on the emission that excludes the most recent previous detection.

The epoch of reionization is the period in the universe’s history when the first stars and galaxies were forming. During this process, these objects ionized the neutral hydrogen medium that pervaded the universe. By measuring the strength and power spectrum of this signal, we will be able to determine some fundamental properties of the early universe. We are building a low frequency radio interferometer called PAPER: The Precision Array to Probe the Epoch of Reionization. This array of 128 dipoles, located in the radio quiet zone of Western Australia, will be able to detect the power spectrum of this signal, as well as make maps of the entire sky at frequencies of 100-200 MHz. We are using a test array of eight dipoles in Green Bank, West Virginia, to study the gain and stability of our instrument and to develop new techniques for imaging with an interferometer over wide fields of view. We will complete our Green Bank array for a total of 16 antennas this spring, and begin deployment of a 32-elements array in Australia in the fall.
The Saharan Air Layer (SAL) is a layer of warm, dry, dusty air which normally overlays the cooler more humid surface air of the Atlantic Ocean. Forming over the Sahara Desert from late spring to early fall, air mixing across the desert becomes warm and dry forming a deep mixed layer in the troposphere. This layer can extend from 1,500 – 6,000 m in the atmosphere, be traced as far west as the Gulf of Mexico, and is characterized by mineral dust, dry air, and strong winds. The Saharan Air Layer has been shown to help increase vertical wind shear and allow for the entrainment of dry air into a tropical wave, which aids in weakening tropical disturbances. The dry air aloft forbids the moist air along the ocean’s surface from rising and condensing to form thunderstorm squalls. My research involves using CALIPSO satellite data, which will play a vital role in obtaining better information on the altitude and thickness of clouds and aerosol layers, and field research data to explore how the structure and intensity of hurricanes are affected when they interact with the SAL.
8:45 a.m. SOLVABILITY OF THE RADIOSITY EQUATION ON UNOCCLUDED CURVES
Katharine A. Ott, University of Virginia

The radiosity equation is a mathematical equation modeling the radiosity, or brightness, at points on a surface in terms of the reactivity and emissivity at these points. We study the mapping and spectral properties of the radiosity operator on $L^p(\partial \Omega)$ spaces, $p \in (1, \infty)$, where $\partial \Omega$ is a unoccluded curve. Specifically, we consider the case where $\partial \Omega$ is an infinite sector of aperture $\theta \in (0; 2\pi)$ in $\mathbb{R}^2$ and the reactivity function is piecewise constant. We show that the solvability of the radiosity equation hinges on whether or not the point 1 lies in the spectrum of the naturally associated integral operator.

9:00 a.m. MODELING AND VIBRATION SUPPRESSION OF A PRESSURIZED
Pablo A. Tarazaga, Virginia Tech

Optical membranes are being pursued for their ability to replace the conventional mirrors that are used to correct wave front aberration. Among some of the many benefits of using optical membranes, is their ability to considerably reduce the weight of the structure. As a secondary effect, the cost of transportation, which is of great interest in space applications, is reduced as well. Another interesting advantage is the ability to have a continuous surface for the attenuation of wave front aberrations, instead of a discrete grid of rigid mirrors that have to be individually controlled. The effect of adding a pressurized cavity behind an optical membrane are examined in this paper by coupling an acoustic cylindrical cavity to a cylindrical membrane at its boundaries. This paper also looks at using a positive position feedback controller for vibration suppression of the membrane. This is done by using a centralized acoustic source in the cavity as the method of actuation. The acoustic actuation is of great interest since it does not mass load the membrane, as most method of actuation would, and the model takes into account the acoustic structure interaction.

9:15 a.m. COMPACT OZONE LIDAR FOR ATMOSPHERIC OZONE AND AEROSOL MEASUREMENTS
Joel Marcia, Old Dominion University

A small compact ozone differential absorption lidar capable of being deployed on a small aircraft or unpiloted atmospheric vehicle (UAV) has been tested. The Ce:LiCAF tunable UV laser is pumped by a quadrupled Nd:YLF laser. Test results on the laser transmitter demonstrated 1.4 mJ in the IR and 240 μJ in the green at 1000 Hz. The receiver consists of three photon-counting channels, which are a far field PMT, a near field UV PMT, and a green PMT. Each channel was tested for their saturation characteristics.

9:30 a.m. DEVELOPMENT OF AN INFRARED LASER ABSORPTION TOMOGRAPHY TECHNIQUE
Meghan Colleen Snyder, University of Virginia

The non-intrusive, laser-based technique of Tunable Diode Laser Absorption Tomography (TDLAT) is a combination of tomographic image reconstruction and infrared laser absorption spectroscopy. The tomographic experimental design, setup and reconstruction algorithm is discussed, as well as the line-of-sight water vapor absorption measurements. This research will produce spatially resolved measurements of water vapor concentration and temperature of the flow at the exit of a dual-mode scramjet combustor. Water absorption measurements in room air are compared to the latest HITRAN spectroscopic data and found to be in good agreement.
Structures and Materials

9:45 a.m.  BENDING OF STRAIN-STIFFENING RUBBER-LIKE BEAMS
Landon M. Kanner, University of Virginia

This paper is concerned with investigation of the effects of strain-stiffening for the classical problem of plane strain bending by an end moment of a rectangular beam composed of an incompressible isotropic nonlinearly elastic material. For a variety of specific strain-energy densities that give rise to strain-stiffening in the stress-stretch response, the stresses and resultant moments are obtained explicitly. While such results are well known for classical constitutive models such as the Mooney-Rivlin and neo-Hookean models, our primary focus is on materials that undergo severe strain-stiffening in the stress-stretch response. In particular, we consider in detail two phenomenological constitutive models that reflect limiting chain extensibility at the molecular level and involve constraints on the deformation. The amount of bending that beams composed of such materials can sustain is limited by the constraint. Aerospace applications include bending of vehicle tires, rubber seals, deployable space structures, and vibration absorbers.

10:35 a.m.  CPG CONTROL OF TENSEGRITY STRUCTURES FOR BIOMEMTIC APPLICATIONS
Thomas K. Bliss, University of Virginia

The manta ray, *Manta birostris*, is an amazing creature, propelling itself through the water with the elegant and complex flapping of its wings. This animal is of interest for morphing structures applications, achieving outstanding efficiency and speed even with the enormous span of over five meters. This project aims at integrating biomimetic control systems with morphing structures to harness what years of evolution have created. Synthetic central pattern generators (CPG), the fundamental neural control mechanisms for rhythmic motion in animals, are applied to actuation control of tensegrity morphing structures. Current results illustrate successful integration of biomimetic control and structures to achieve efficient resonant control of a tensegrity structure.

10:50 a.m.  THE EFFECT OF ATMOSPHERIC CORROSION ON ENVIRONMENTAL FATIGUE CRACK PROPAGATION AND ITS INHIBITION
Jenifer S. Warner, University of Virginia

Age-hardenable aluminum alloys used in aerospace structures are susceptible to environment assisted fatigue crack propagation (EFCP). The majority of research has been performed in full immersion, moist air, or pure water vapor and does not capture atmospheric conditions that include contaminants which cause thin film electrolyte formation on the metal surface. There has been no controlled examination of a thin film electrolyte effect on EFCP or inhibition of such cracking. The goal of this research is to understand EFCP and inhibition for atmospheric conditions and important aerospace alloys: 7075-T651 (Al-Zn- Mg-Cu) and C47A-T8 (Al-Cu-Li). A candidate chromate (CrO4 2-) replacement inhibitor, molybdate (MoO4 2-), is examined. MoO4 2- effectively inhibits EFCP in 7075-T651 stressed during full immersion in chloride solution; as understood by hydrogen environment embrittlement and film stability where MoO4 2- promotes crack tip passivity, thus reducing H uptake. MoO4 2- inhibition is promoted by reduced loading frequency and stress intensity range and potentials at or anodic to free corrosion. The inhibiting effect of MoO4 2- parallels that of CrO4 2-, but is shifted to lower frequencies suggesting the Mo-bearing passive film is less stable under crack tip deformation than the Cr-bearing. For high mean stress loading, MoO4 2- fully inhibits EFCP as quantified by reduced crack growth rate to that of ultra-high vacuum and a changing crack surface morphology. For slightly anodic potentials, full crack arrest occurs. This research aims to improve fatigue life prediction for safe and economic operations of aircraft.
High performance piezoelectric materials are expected to play an important role in the next generation of sensors and actuators, used for example, in aircraft for active vibration and noise control. Piezoelectric materials can transform mechanical to electrical energy (and vice versa). The goal of this study is to understand how the local atomic structure is related to piezoelectric properties. For example, B-site alloys with the perovskite structure ABO3 such as Pb(Zr,Ti)O3 and Pb(Mg,Nb)O3 have extremely different piezoelectric characteristics. Nuclear magnetic resonance (NMR) has been shown to be a sensitive experimental probe of the local structure, but it is difficult to interpret the measurements without theoretical modeling. I show here that first-principles quantum mechanical calculations of chemical shielding can accurately predict oxygen NMR isotropic chemical shifts $\delta$iso(O) in Pb based perovskites. Calculations of $\delta$iso(O) are presented for the end point compounds PbTiO3 (PT) and PbZrO3 (PZ), and for the 50/50 alloy Pb(Zr1/2Ti1/2)O3 (PZT). The $\delta$iso(O) values are related to variations in the Ti-O and Zr-O bond lengths and used to interpret recent experimental measurements.

Ion conduction in materials enables active functions including actuation, sensing, and transport. Work at Virginia Tech has found that bio-inspired materials, relying on ion conduction, can be used to develop fluidic pumps and power sources using biological molecules such as phospholipids and proteins. In the past, these studies have involved the formation of a planar bilayer lipid membrane (BLM) formed across the pore(s) of a synthetic substrate. However, a new technique for BLM formation has been adopted that eliminates the need for a supporting substrate. Self-contained aqueous droplets are injected into a bath of organic solvent with dissolved lipid molecules and result in the formation of lipid monolayer-encased water droplets. When two like droplets are brought into contact with each other, the hydrophobic tails of the lipid molecules zip together creating a bilayer lipid membrane at the droplet interface. This technique creates individual aqueous compartments, similar to living cells, separated by phospholipid membranes. The incorporation of proteins into this lipid membrane interface makes it possible to tailor the ionic conductivity of the membrane and control transport of species from one “cell” to another. Preliminary results indicate the successful insertion of $\alpha$-Hemolysin ($\alpha$HL), a self-inserting protein that creates ion conductive pathways across the membrane. Controlling the transport of species from one compartment to another could also be achieved using feedback control. Our work investigates in parallel using classical control techniques to better understand and manipulate systems based on biological molecules.

At hypersonic flight velocities (Mach 5 and higher), vehicle leading edges are subjected to intense heat fluxes at their tip on the order of several MW/m^2. Extremely high temperatures and thermal gradients (and accompanying thermal stresses) are then developed, requiring a thermal protection system (TPS) for the underlying airframe. To date, various ceramic fiber, coatings, and ablative systems have been widely explored as a TPS for hypersonic flight vehicles. Here, we present an alternative metallic leading edge which combines efficient structural load support and the fortuitous fluid flow paths of open-cell periodic structures with heat pipe science, which transfers heat using the evaporation, transport, and condensation of a fluid. An overview of the operating mechanisms is discussed, and some preliminary experimental results are presented for a low-temperature, proof-of-concept leading edge prototype. The results indicate effective thermal spreading of a localized heat input.
2:10 p.m.  MEASUREMENTS AND MODELING OF THE FAILURE PRESSURE OF 1-STEAROYL-2-OLEOYL-SN-GLYCERO-3-PHOSPHOCHOLINE BILAYER LIPID MEMBRANES FORMED OVER A SINGLE PORE
David Hopkinson, Virginia Tech

Numerous methods have been developed for measuring mechanical properties of bilayer lipid membranes (BLMs) such as the Young's modulus, strength, bending modulus, and others. This paper introduces a new method for measuring the maximum pressure that can be withstood by BLMs formed over a porous substrate. This quantity, referred to as the failure pressure, has not been reported in the literature previously. In this series of experiments a BLM is formed across a single pore and is then pressurized until failure. This experiment is performed on 1-Stearoyl-2-Oleoyl-sn-Glycero-3-Phosphocholine (SOPC) lipid bilayers formed over a polycarbonate substrate with a single pore ranging from 5 to 20 μm in diameter. A trend of increasing failure pressure with decreasing pore size is observed, with failure pressures falling between 67 and 19 kPa, respectively. The same set of experiments is repeated for BLMs that are formed from a mixture of SOPC and 50 mol% cholesterol (CHOL) and this is found to increase the failure pressure by 56% on average. A plate model, a planar membrane model, and a spherical membrane model are used to show that the behavior of the BLMs is more membrane-like than plate-like, with a relationship between failure pressure \( P_f \) and pore size \( a \) of \( P_f \sim 1/a \). Also a quantitative model of the characteristic pressure curve from this experiment is developed based on the pressurization and flow of fluid in the test fixture. This model accurately reproduces the pressure curve of a BLM which includes an initial increase in pressure when the BLM is well formed across a pore, followed by a sharp drop in pressure after the BLM fails. Electrical impedance is also measured before and after pressurization of the BLM. It is found that the magnitude of electrical impedance drops by three orders of magnitude after pressurization, indicating that the BLM has failed and has opened a conductive pathway through the pore.

2:25 p.m.  THERMAL ENERGY HARVESTED TO POWER DIGITAL SHM HARDWARE
Benjamin L. Grisso, Virginia Tech

A digital signal processor based evaluation board has been utilized in the development of hardware for the impedance-based structural health monitoring technique. This hardware employs digital output to generate a rectangular excitation pulse train for structural excitation, and receives a digital input to sense the structural response. The DC power supply to this hardware is now replaced with standard nickel metal hydride and lithium ion batteries. Power required to perform all the autonomous impedance-based SHM operations is supplied from a battery. The battery is recharged using only a thermoelectric generator across a temperature gradient, with the appropriate harvesting circuitry, to make the system completely autonomous. Both the battery discharge and recharging characteristics are described. The time available for SHM operation with the battery, along with the system duty cycle are also disclosed.

2:40 p.m.  GUIDED WAVE INTERPRETATION FOR INTEGRATED VEHICLE HEALTH MANAGEMENT SENSORS
Jill Bingham, The College of William and Mary

Integrated Vehicle Health Management (IVHM) combines the use of onboard sensors with artificial intelligence algorithms to automatically identify and monitor structural health issues. A fully integrated approach to IVHM systems demands an understanding of the sensor output relative to the structure, along with sophisticated prognostic systems that automatically draw conclusions about structural integrity issues. Ultrasonic guided wave methods allow us to examine the interaction of multiphysics signals within key structural components. Since they propagate relatively long distances within plate- and shell-like structures, guided waves allow inspection of greater areas with fewer sensors. We have developed parallel processing, 3D elastic wave simulations using the finite integration technique in order to systematically examine the wave propagation in structures. Interpreting the simulated and experimental signals that we receive from transducers we look not only at the wave mechanics but also the signal processing using the dynamic wavelet fingerprinting technique to deliver the information in a form that does not require extensive knowledge of the guided wave physics.
3:30 p.m.  ENERGY HARVESTING FOR UNMANNED AERIAL VEHICLES
Steven R. Anton, Virginia Tech

Unmanned aerial vehicles (UAVs) are a critical component of many military operations. Over the last few decades, the evolution of UAVs has given rise to increasingly smaller aircraft. Along with the development of smaller UAVs, termed mini UAVs, has come issues involving the endurance of the aircraft. Endurance in mini UAVs is problematic because of the limited size of the fuel systems that can be incorporated into the aircraft. A large portion of the total mass of many electric powered mini UAVs, for example, is the rechargeable battery power source. Energy harvesting is an attractive technology for mini UAVs because it offers the potential to increase their endurance without adding significant mass or the need to increase the size of the fuel system. This paper investigates the possibility of harvesting vibration and solar energy in a mini UAV. Experimentation has been carried out on a remote controlled (RC) glider aircraft with a 1.8 m wing span. This aircraft was chosen to replicate the current electric mini UAVs used by the military today. The RC glider was modified to include two piezoelectric patches placed at the roots of the wings and a cantilevered piezoelectric beam installed in the fuselage to harvest energy from wing vibrations and rigid body motions of the aircraft, as well as two thin film photovoltaic panels attached to the top of the wings to harvest energy from sunlight. Flight testing has been performed and the power output of the piezoelectric and photovoltaic devices has been examined.

3:45 p.m.  MYLIOBATOID-INSPIRED FLAPPING FIN: QUALITATIVE FLOW STRUCTURE
Keith Moored, University of Virginia

Myliobatidae is a family of large pelagic rays including cownose, eagle and manta rays. They are extremely efficient swimmers, can cruise at high speeds and can perform turn-on-a-dime maneuvering, making these fishes excellent inspiration for an autonomous underwater vehicle. Myliobatoids have been studied extensively from a biological perspective; however the fluid mechanisms that produce thrust for their large-amplitude oscillatory-style pectoral fin flapping are unknown. An experimental robotic flapping wing has been developed that closely matches the camber and planform shapes of myliobatoids. The wing can produce significant spanwise curvature, phase delays down the span, and oscillating frequencies of up to 1 Hz, capturing the dominant kinematic modes of flapping for myliobatoids. This work uses dye flow visualization to qualitatively characterize the fluid flow structures during steady-state oscillation. Parametric boundaries are investigated for the activation points of different fluid mechanisms. Also, lessons are distilled from studying the fluid dynamics of myliobatoids that can be applied to the design of biomimetic underwater vehicles. Finally, the use of tensegrity structures as a structural foundation for an artificial pectoral fin is discussed.

4:00 p.m.  SYNTHESIS, CHARACTERIZATION AND APPLICATIONS OF CARBON NANOSHEETS
Ronald Quinlan, College of William and Mary

A radio frequency (RF) plasma enhanced chemical vapor deposition (PECVD) chamber is used to grow 2D carbon nanosheets. Our setup allows us to control gas composition, substrate temperature, and growth time which allows for some tailoring of the nanosheets. Here we report the ability to grow carbon nanosheets at temperatures ~700°C and then transfer the film to a non-growth, zero thermal budget substrate. The functionalization of the carbon nanosheets via an acid-treatment is also presented with the outline of on-going research and preliminary results from the functionalization of the carbon nanosheets.
First principles quantum mechanical methods have shown increasing promise over the past decade in the ability to rationalize the results of well-defined surface science experiments in terms of the electronic structure of surfaces [1]. Success has been achieved in establishing the molecular structure of adsorbed and absorbed intermediates, identifying the spectroscopic signatures of adsorbed and reactive species, following catalytic surface transformations, and predicting solid-state properties that occur at the gas/solid interface [2]. First principles simulations have very recently expanded to condensed matter interfaces, such as that between a metal surface and an aqueous environment [3, 4]. Although the method is confined to well-defined environments on nanoscopic size-scales, quantitative information regarding the thermodynamics and kinetics of fundamental atomic transformations can be derived and then applied to a tiered system of mesoscale and macroscale modeling techniques [5]. In the present work, ab initio calculations are being performed in order to elucidate the elementary adsorption, surface diffusion, and surface reaction processes that occur at the interface between aluminum and moist air. During exposure to moist air, two competing processes complement the oxidation of an aluminum surface — the reduction of molecular oxygen and of water. The reduction of water creates atomic hydrogen, which can be absorbed into the lattice and lead to hydrogen embrittlement in the presence of an applied stress. Important in the dynamics of hydrogen embrittlement are the uptake and transport of hydrogen from the donation site to the crack tip. These parameters are not easily experimentally examined, suggesting that theoretical and computational studies may provide insight. Periodic spin-polarized density functional theory (DFT) predictions regarding the thermodynamics and kinetics of important processes such as the adsorption, diffusion, and dissociation of water, oxygen, and hydroxide as well as the adsorption diffusion, uptake, and transport of hydrogen will be discussed. The effect of selected surface features such as step edges, vacancies, and other defects will also be discussed.

Two novel methodologies for the surface metallization of polyimide membranes are considered herein. In the first approach, we attach metal nanoparticles to a glass or polyimide substrate by means of a binder whose surface free energy and surface area allow for high adhesion to both the metal and the substrate—that is, through a ternary ‘metal-binder-substrate’ composite structure. Sintering at low temperatures allows for high conductivity and facile pattern resolution as low as 30 microns. This process is well-described for silver, with resistivities consistently within an order of magnitude of bulk polycrystalline silver; the only known hurdle for extension to copper or palladium lies in the fabrication of nanoparticles of those metals. In the second approach, we form an electrically conductive and specularly reflective metal surface on a special class of fluorinated polyimides that possesses a dangling hydrophilic group. This method requires the dissolution of a metal salt or complex in the polyimide matrix. After drying off solvent, application of a chemical reducing agent reduces the metal ion to native metal, and diffusion allows the formation of a continuous surface layer. This process is also well-described for silver, with resistivities within an order of magnitude of bulk polycrystalline silver and reflectivities approaching 90%. Attempts to extend this protocol to copper, palladium, and gold have been unsuccessful.
Aerospace Systems Concepts and Analysis

2:10 p.m.  FLOW AND THERMAL PERFORMANCE OF AN AIRFOIL-ENDWALL FILLET FOR A GAS TURBINE NOZZLE GUIDE VANE
Stephen Lynch, Virginia Tech

Gas turbine engines are used in a variety of power generation applications, including providing thrust for the F-35 Lightning II Joint Strike Fighter, turning electrical generators in combined-cycle power plants, and powering the M1 Abrams Main Battle Tank of the US Army. The efficiency and power output of a turbine engine can be increased by raising the combustion temperature. However, a complex swirling flow present near the junction of the nozzle guide vane airfoil and its casing (endwall) tends to decrease aerodynamic efficiency and increase metal temperatures. Past research indicates a large fillet at the endwall-airfoil junction can reduce aerodynamic losses and endwall heat transfer. Also, leakage flow through inherent gaps between individually manufactured turbine components can interfere with the endwall vortical flow.

This research discusses the combined effect of a leading edge endwall-airfoil fillet and leakage flow from a two-dimensional slot simulating the combustor-turbine gap. Measurements of total pressure loss for matched engine Reynolds number conditions were obtained at the exit of a nozzle guide vane cascade with and without two types of large leading-edge fillets installed. The effect of leakage flow from the two-dimensional slot was also determined. The aerodynamic loss results are compared to the previously presented results for adiabatic cooling effectiveness of gap leakage flow. Results showed that the fillets result in a slight decrease in total pressure loss for a standard turbulent boundary layer entering the cascade. The addition of realistic leakage flow from a combustor-turbine interface gap dramatically increased losses by 17% for the linear-profile fillet but did not increase losses for the elliptical-profile fillet, indicating that a thorough understanding of the inlet flow conditions is critical in the design of a fillet.

2:25 p.m.  CS-XML AND MODEL UNDERSTANDING
Kara A. Olson, Old Dominion University

The automated analysis of model specifications is an area that historically receives little attention in the simulation research community but which can offer significant benefits. A common objective in simulation is enhanced understanding of a system; model specification analysis can provide insights not otherwise available as well as time and cost savings in model development. The Condition Specification (CS) 1 is a model specification form that is amenable to analysis; CS-XML is an XML-based representation of such. This paper discusses the motivations for CS-XML and presents some results from analysis efforts using CodeSurfer 2, a software static analysis tool. CS-XML also provides an essential foundation for Web Services that support the analysis of discrete-event simulation models.
Human urine represents a major problem with respect to ammonia vapors in the crew cabin and the amount of water necessary for human hydration (2 kg/person/day). Bacterial nitrification represents an important element of the solution to water resource limitations in extended space flight missions. Nitrifiers convert potentially volatile NH$_3$ to NO$_3^-$ eliminating the problem of volatile ammonia in the cabin, and the NO$_3^-$ is potentially removable by another biological process, denitrification, leaving water that can be easily finished by physical-chemical means for reuse by the crew. Nitrifiers form biofilms on reactor surfaces, and the distribution of nitrifiers in biofilms (which can affect the efficiency of the process) is controlled by gradients of O$_2$ and NH$_3$. Changes in organism distribution can impact the rates at which the two genera of nitrifiers (i.e. ammonia oxidizing and nitrite oxidizing bacteria, AOB and NOB, respectively) function. Fluorescent in situ Hybridization (FISH) and microscale electrodes are used to study the distribution of these organisms, precursors, and products within the biofilms. Current results in planktonic cultures show growth and oxidation rates where uniform distribution of microorganisms and nutrient resources are maintained. Cell doubling time for AOB and NOB combined is 1.4 days. Data from these studies will be compared to rates found in biofilms to determine how these biofilms will benefit advanced life support systems.

3:30 p.m.  ASSESSMENT OF FREE STREAM SEEDER PERFORMANCE FOR VELOCIMETRY IN A SCRAMJET COMBUSTOR
Joseph H. Howison, University of Virginia

A free stream seeder designed to produce particles to conduct particle image velocimetry (PIV) in a scramjet combustor was studied. Using a probe and filter paper coupled to a vacuum pump, samples were collected from the output of the seeder in conditions near to those that are encountered in PIV studies. The filter paper samples were imaged using a scanning electron microscope (SEM) to obtain qualitative and quantitative data about the particles being generated. The seeder was able to produce particles near the target size of 0.3 μm. The light scattering and flow tracking abilities of the particles were also examined with the results indicating that the particles will perform well in scramjet combustor PIV research.

3:45 p.m.  REGIONAL AEROSOL TRANSPORT STUDY USING A COMPACT AEROSOL LIDAR
Jasper Lewis, Hampton University

A Compact Aerosol Lidar (CAL) was built in the Science Directorate at NASA Langley for the purposes of aerosol and cloud profiling. The aircraft lidar system uses a Nd:YAG pulsed laser operating at 1064-nm and 532-nm wavelengths, with an additional photon counting channel at 532-nm. Measurements made in the Norfolk-Virginia Beach region showed complex regional aerosol distributions. Comparisons with MODIS aerosol optical depth and in situ ground measurements of PM2.5 show good agreement.

4:00 p.m.  AN INVESTIGATION OF THE PHYSICAL MECHANISM OF HEAT TRANSFER AUGEMENTATION IN BOUNDARY LAYER FLOWS SUBJECT TO FREESTREAM TURBULENCE
David O. Hubble, Virginia Tech

Water tunnel experiments have been performed to examine how large scale, high intensity freestream turbulence affects heat transfer through a laminar boundary layer. Time-Resolved Digital Particle Image Velocimetry (TRDPIV) was used to examine the flow field along with time-resolved heat transfer from the wall. The surface heat flux was measured with a newly developed thin-film sensor called the Heat Flux Array (HFA) capable of measuring heat flux at 10 locations at frequencies to 35 Hz. Freestream conditions were controlled using passive grids producing turbulence intensities of 5.5% with integral length scales of 2 and 3.5cm. This was shown to increase in mean convective heat transfer coefficients by up to 15% with fluctuations to 40% above cases of very low freestream turbulence. It was also shown that fluctuations in heat flux traveled at approximately half the freestream velocity.
The Hy-V Sounding Rocket Project aims to launch a Terrier-Improved Orion from the NASA flight facility on Wallops Island and test a scramjet engine at an altitude of 80,000 ft at a speed over Mach 5. Much of the progress made during the past year stems from greater cooperation between Virginia Tech and the University of Virginia, greater involvement of faculty, and increased funding. The design of the four components of the scramjet flowpath, the inlet, isolator, combustion chamber, and nozzle, is reaching completion. Several concepts of what will go into the payload and how the payload will be configured have been developed. The target trajectory for the rocket is also being finalized. An overall work plan is presented with the tentative launch date set for Summer 2009.