

**Virginia Space Grant Consortium
Student Research Conference - April 19, 2010
Omni Hotel, Newport News, Virginia**

**Undergraduate Research Scholars
Poster Presentations – Ballroom C**

WIDE AREA AUGMENTATION SYSTEMS: THE W.A.A.S. OF THE FUTURE

Michael Clarke, Hampton University

Wide Area Augmentation System (WAAS) is a system of satellites and ground stations that gives the user of GPSs more accurate readings. Wide Area Augmentation System is a new navigational aid system being used by the Federal Aviation Administration (FAA) to provide aircraft the ability to use GPS satellites in all phases of flight; allowing for signal corrections and giving the user better position accuracy than any other current aerial navigation aid. WAAS is being implemented to enhance the National Airspace System (NAS) to make the congestion due to the demand within aviation more manageable.

SONIC BOOM MINIMIZATION OF AIRFOILS THROUGH COMPUTATIONAL FLUID DYNAMICS AND COMPUTATIONAL ACOUSTICS

Michael Creaven, Virginia Tech

This project analyzes 2-D, inviscid, steady supersonic flow over different airfoil designs at Mach 2.2 while at 60,000 ft. The airfoils tested have sharp leading and trailing edges. The shapes range from diamond to convex to a combination of the two. A hybridization of Computational Fluid Dynamics (CFD) and Computational Acoustic simulations are used to obtain values for the lift coefficient, drag coefficient, and maximum overpressure. The trends obtained from this very specialized case show that flat bottomed airfoils generate the smallest overpressures, and the highest lift to drag ratios. The reason for this is that the thinner shapes create smaller disturbances in the flow and thus generate smaller shock waves, which in turn reduce the drag and the overpressure. This study does not take into consideration structural issues, viscosity, differing angles of attack, or 3-D effects.

ASSISTED NECK MOVEMENT UNDER HIGH G+ SITUATIONS

Steven Day, Virginia Tech

The objective of this research is to investigate smart actuator technology for an adaptive neck brace to assist pilots during high g+ maneuvers. Analysis and experiments were conducted to develop a simplified analytical model of the neck, determine the effectiveness of using a brace to prevent neck injury under high acceleration loads, identify actuator technology capable of actuating the mechanism effectively and efficiently, and to experimentally validate the chosen mechanism and actuator. The experiment successfully demonstrated that an adaptive neck brace can successfully reduce the displacement experienced by acceleration forces. The physical

model utilized a scissor mechanism brace configuration using shape memory alloy (SMA) wire for actuation. The presence of the brace avoided high resonant peaks and introduced damping to the original model.

IMPACT MECHANICS AND ENERGY DISSIPATION IN CNT-BASED MATERIALS

William Jacobs, University of Virginia

An active experimental exploration of the use of carbon nanotube (CNT)-based materials in the design of multifunctional lightweight aerospace structures and thermal protection coatings calls for a better understanding of the nature of the collective behavior of CNTs under conditions of dynamic loading. Recent design of a novel mesoscopic model for CNTs opens up opportunities for computational investigation of the impact resistance of CNT materials. In this presentation, we report the results of a series of simulations of high-velocity impact of a spherical projectile on a free-standing thin film composed of a random network of (10,10) CNT bundles (buckypaper). Atomic-level simulations of individual CNTs and small CNT bundles are used for the investigation of energy dissipation rates from low frequency mechanical oscillations to high frequency thermal vibrations, providing information required for a reliable parameterization of the mesoscopic model.

USING AN iROBOT CREATE AS THE BASE FOR AN AUTONOMOUS MOBILE ROBOT

Jessica Jones, Hampton University

In this research, we will use an iRobot® Create™ to build an autonomous mobile robot. Using cameras and bumpers, the robot will be able to move in an unknown environment and create a map after it navigates. Based on its current map and localization, the robot will be able to recognize an area that it has previously visited. With the cameras, the robot will be able to recognize objects (colors) and relay messages specific to that object or color. This proposed robot would be similar to those sent to Mars or the Moon, but a smaller scale and inexpensive version. Because this robot will have the ability to explore and map unknown areas, this may help scientists improve their rover designs and aid in NASA getting a better understanding of Mars and other planets in the solar system. In addition, data collected by the robot during the navigation and mapping process would be viewed visually using available visualization tools. In my poster, I will discuss the design of the user interface and the movement of the robot. I will also discuss challenges that I have faced and how I plan to continue with this research.

DEVELOPMENT OF A TOMOGRAPHY TECHNIQUE FOR APPLICATION TO A SCRAMJET WIND TUNNEL

Elizabeth Martin, University of Virginia

A tunable diode laser absorption tomography (TDLAT) technique is being developed at the University of Virginia to determine the spatially-resolved distribution of temperature and water

vapor concentration in a scramjet combustor. In order to aid in the development of this technique, the present study simulates integrated line-of-sight projection measurements and reconstructs these projections to determine the effects of data collection geometry and ambient water vapor on reconstruction accuracy. Results show that reconstruction error is more dependent on the number of rays taken in each projection than on the number of projections taken around the periphery of the flow. Additionally, reconstruction error appears to be linearly dependent on the amount of ambient water vapor that is external to the region of interest in the spectroscopic measurements. Overall, these results show that TDLAT data collection time can be reduced by taking fewer projections with a high density of rays while maintaining reconstruction accuracy.

MOLECULAR MODELING OF PHOTOLUMINESCENT COPPER(I) CYANIDE MATERIALS

Jasprina Ming, Old Dominion University

Studies show that solid copper(I) cyanide has interesting photoluminescent properties. Recent work has shown that the UV spectrum of CuCN may be attributed to Laporte-allowed excitations from occupied to unoccupied π -type molecular orbitals (MOs). The emission spectrum is attributed to the relaxation from an excited state triplet with a bent structure due to distortions that remove degeneracies in the partially occupied MOs of the linear triplet. The addition of aliphatic and aromatic amines to CuCN chains lead to substantial changes in the structural and photophysical properties of the material including shifts in λ_{\max} for both the excitation and emission spectra and orbital mixing. The study of CuCN materials has been expanded to examine the affect of amines on substituted CuCN (zigzag and helical) chains that were optimized at the DFT (BLYP) level. Time- dependent DFT (TD-DFT) studies on the optimized structures of theses model compounds reveal that the excitations for the substituted chains are generally consistent with the unsubstituted chains; however, differences are attributed to type of ligand, structure, and stoichiometry.

INVESTIGATION OF THE DESIGN AND PERFORMANCE OF REPEATING SPACE TRACK CONSTELLATIONS

Michelle Perez, Virginia Tech

A constellation is a group of satellites that are coordinated to carry out a common mission. There are many ways to design satellite constellations, and this paper investigates and compares a popular method of design known as Flower Constellations, with a relatively newer approach known as Parametric Constellations. This paper also introduces tools that were developed in MATLAB and Satellite Tool Kit to aid in the design and display of Parametric Constellations. Following this tool presentation, the paper also discusses how the tools were used to show that a Parametric Constellation can be more effective than a Flower Constellation for a specific Geoscience Remote Sensing mission known as FLORAD (FLOWer constellation deploying RADiometers). From this investigation and tool development process, we conclude that the Parametric Constellations can be more effective because the design parameters of this system allow for the use of real numbers.

DETAILED CHARACTERIZATION OF MAGNETIC FIELDS SURROUNDING THE WHORL II SPACECRAFT SIMULATOR AND APPLICATION TO ATTITUDE DETERMINATION

Robert Robertson, Virginia Tech

The research presented in this report focuses on the Whorl II spacecraft simulator in Virginia Tech's Space Systems Simulation Laboratory (SSSL). The goal of this research is to improve the reliability and accuracy of the magnetometer aboard Whorl II that is used for attitude determination. Magnetic interference surrounding the simulator causes unacceptable margins of error its perceived attitude. The first step in solving this problem was to characterize the magnetic fields surrounding the simulator. With this information, it was determined that the primary cause of magnetic interference is the ferrous, steel pedestal that supports the simulator. The behavior of the magnetic interference and the role of the magnetometer in attitude determination led to the final solution: to re-design the method of magnetometer calibration. This new method calibrates the raw magnetometer data dynamically, meaning that the calibration method changes in response to the position of the simulator. This significantly improves the accuracy of the magnetometer in attitude determination.

ANALYTICAL AND COMPUTATIONAL MICROMECHANICS ANALYSIS OF THE EFFECTS OF INTERPHASE REGIONS ON THE EFFECTIVE COEFFICIENT OF THERMAL EXPANSION OF CARBON NANOTUBE-POLYMER NANOCOMPOSITES

Skylar Stephens, Virginia Tech

Analytical and computational micromechanics techniques based on the finite element method and composite cylinders method, respectively, have been used to determine the effective CTE of carbon nanotube-epoxy nanocomposites containing aligned nanotubes. Both techniques have been used in a parametric study of the influence of interphase stiffness and interphase CTE on the effective CTE of the nanocomposites. For both the axial and transverse CTE of aligned nanotube nanocomposites with and without interphase regions, the computational and analytic micromechanics techniques were shown to give similar results. The good agreement between computational and analytic results gives confidence that the computational micromechanics approach can be used to study the effects of clustering of nanotubes and clustering of nanotubes with interphase regions currently under study.

FORMATION OF HIGHLY ELECTRICALLY CONDUCTIVE SURFACE-SILVERED POLYIMIDE FILMS UNDER EXCEPTIONALLY MILD CONDITIONS

Tyler Stukenbroeker, College of William & Mary

This study attempted to improve upon a previously reported route to room-temperature metallization of a polyimide substrate. The silver(I)-triflate complex used to dope the polymer was replaced with a silver(I)-hexafluoroacetylacetonate complex to remove the possibility that residual triflic acid would compromise the structural integrity of the polymer film. The results were initially very promising, showing conductivity and reflectivity values comparable or

improved with the new complex versus the old. Furthermore, cracking observed with the triflate films did not occur. The conductivity was modeled as a function of several parameters allowing the entire metallization process to be optimized. Though macroscopic characterization suggested the two films were similar in nature, microscopy revealed significant differences between films from the two complexes. SEM showed a more textured surface for the Ag-HFA, suggesting more nucleation sites. TEM, however, showed that the Ag-HFA films have thin silver layers, indicating that some silver remains unreduced. Thus, it appears that there is a ligand effect in this process, and hence many new silver complexes and salts can now be studied.

DEVELOPMENT OF A WIRELESS SENSOR NETWORK FOR LIGHTNING STRIKE CURRENT FLOW DETECTION AND COMPOSITE STRUCTURAL HEALTH MONITORING

David Talaiver, Old Dominion University

The goal of this project was to investigate the feasibility and development of a wireless network of current sensors to characterize the electrical current flow of a lightning strike through composite structures. Carbon fiber reinforced plastics (CFRP) have found numerous applications in the aerospace industry and many others due to their extremely high stiffness to weight ratio. Due to the large volume fraction of carbon in the composite matrix, CFRPs are efficient electrical conductors. However, the conductivity of most CRFPs is much less than the metal structures that they are replacing thereby increasing the structure's vulnerability to lightning damage. The ability to analyze the nature of a lightning strike on a composite airframe in real-time could allow for advanced warning of risk to the airframe before a failure can occur. A Current Direction Sensor (CDS) was developed and found to accurately measure current magnitude and direction in two axes. To enable wireless communication, low power Zigbee Motes were initially used as a means of sensor data collection and transmission. Unfortunately, the low sample rate made the use of Zigbee protocol impractical for high frequency lightning waveform capture. To provide a faster sample rate the data was collected with a National Instruments USB Data Acquisition module. Utilizing standard 802.11 WiFi the sensors were successfully integrated into a wireless sensor network which measured current at each satellite location and transmitted it back to the base station. The system was capable of accurately measuring DC currents. In a simulated lightning test, the sensor output waveform was saturated and was unable to provide a faithful representation of the signal. Although the system was unable to capture a “real” lightning strike, the concept was proven to be successful and has generated enough interest from industry and academia to warrant further research.