

# Research Symposium I Ohio Aerospace Institute Wednesday, July 7, 2004

## OAI Forum Room

9:00 A.M. **Jennifer Buttler, Bowling Green State U, Sophomore**

“Low Emissions Alternative Power (LEAP) Project Office Business Team of the  
Aeropropulsion Research Program Office (ARPO) ”

0140/Barbara Mader, Aeropropulsion Research Program Office

9:15 **Jennifer Chin, John Carroll University, Junior**

“Office of Equal Opportunity Programs”

0180/Deborah Coteleur, Office of Equal Opportunity Programs

9:30 **Susan Pho, Case Western Reserve University, Junior**

“Integrated Financial Management Program”

0222/Joseph Kan, Employee and Commercial Payments Branch

9:45 **Odlanier Silva, U of Turabo, Senior**

“Investigation of Injector Slot Geometry on Curved-Diffuser Aerodynamic Performance”

0300/Gerard Welch, Vehicle Technology Directorate

10:00 **Kathryn Petro, Miami University, Junior**

“Records Management: Preserving the Past to Make the Future”

0620/Kevin Coleman, Logistics and Technical Information Division

10:15 **Session Break**

10:30 **Samuel Barker, Brigham Young U-Idaho, Senior**

“Making Space Travel to Jupiter Possible”

5120/Frank Ritzert, Advanced Metallics Branch

10:45 **Session Ending**

11:00 **LUNCH**

1:00 **Jean-Philippe Belieres, Arizona State University, PhD**

“Ionic Liquids and New Proton Exchange Membranes for Fuel Cells”

5150/James Kinder, Polymers Branch

1:15 **Katherine Peplowski, Ohio Northern University, Senior**

“High Temperature Polymers for use in Fuel Cells”

5150/James Kinder, Polymers Branch

1:30 **Plousia Vassilaras, Baldwin Wallace College, Senior**

“Nano-Casted Metal Oxide Aerogels as Dual Purpose Structural Components for Space Exploration”

5150/Nicholas Leventis, Polymers Branch

1:45 **Christina Inman, Spelman College, Sophomore**

"Photo-Curing: UV Radiation curing of polymers"

5160/Dennis Fox, Durability and Protective Coatings Branch

2:00 **John Holchin, University of Dayton, Sophomore**

"Durability of Environmental Barrier Coatings in a Water Vapor/Oxygen Environment"

5150/Dennis Fox, Polymers Branch

2:15 **John Dankovich, Case Western Reserve University, Senior**

"Thin Film Solar Cells: Organic, Inorganic and Hybrid"

5410/Sheila Bailey, Photovoltaic and Space Environments Effects Branch

2:30 **Michael Kasick, Carnegie Mellon University, Sophomore**

"Analysis of Electrical Characteristics of Thin Film Photovoltaic Cells"

5410/Aloysius Hepp, Photovoltaic and Space Environments Effects Branch

2:45 **Eren Turgay, University of Kentucky, Senior**

"Dust Accumulation and Solar Panel Array Performance on the Mars Exploration Rover (MER) Project"

5410/Geoffrey Landis, Photovoltaic and Space Environments Effects Branch

3:00 **Leigh Peters, Case Western Reserve University, Junior**

"Evaporator Development for an Evaporative Heat Pipe System"

5410/Kenneth Burke, Photovoltaic and Space Environments Effects Branch

3:15 **Robert Needham, Case Western Reserve University, Senior**

"Aircraft Fuel Cell Power Systems"

5410/Patricia Loyselle, Photovoltaic and Space Environments Effects Branch

3:30 **ADJOURN**

**Low Emissions Alternative Power (LEAP) Project Office Business Team of the  
Aeropulsion Research Program Office (ARPO) Org. 0140**

**Jennifer A. Buttler**  
Bowling Green State University  
Marketing  
Undergraduate, sophomore  
**Mentor: Barbara Mader**

The program for which I am working at this summer is Propulsion and Power/Low Emissions Alternative Power (P&P/LEAP). It invests in a fundamental TRL 1-6 research and technology portfolio that will enable the future of: Alternative fuels and/or alternative propulsion systems, non-combustion (electric) propulsion systems. P&P/LEAP will identify and capitalize on the highest potential concepts generated both internal and external to the Agency. During my 2004 summer at NASA Glenn Research Center, I worked with my mentor Barbara Mader, in the Project Office with the Business Team completing various tasks for the project and personnel.

The LEAP project is a highly matrixed organization. The Project Office is responsible for the goals advocacy and dollar (budget) of the LEAP project. The objectives of the LEAP Project are to discover new energy sources and develop unconventional engines and power systems directed towards greatly reduced emissions, enable new vehicle concepts for public mobility, new science missions and national security. The Propulsion and Power/Low Emissions Alternative Power directly supports the environmental, mobility, national security objectives of the Vehicle Systems Program and the Aeronautics Technology Theme. Technology deliverables include the demonstration through integrated ground tests, a constant volume combustor in an engine system, and UAV/small transport aircraft all electric power system. My mentor serves as a key member of the management team for the Aeropulsion Research Program Office (ARPO). She has represented the office on numerous occasions, and is a member of a number of center-wide panels/teams, such as the Space management Committee and is chair to the Business Process Consolidation Team. She is responsible for the overall coordination of resources for the Propulsion and Power Project- from advocacy to implementation.

The goal for my summer at NASA was to document processes and archive program documents from the past years. I used the computer and office machines, and also worked with personnel in setting up a Cost Estimation Plan. I gained office experience in Word, Excel, and Power Point, with the completion of a variety of tasks. I made spreadsheets that pertained to the budget plan for Journey to Tomorrow, to name a few I have supported the office by tracking resource information: including programmatic travel, project budget at the center level to budgets for individual research sub-projects and grants. I also assisted the Program Support Office in their duties including, representing the office on numerous occasions on center-wide teams/panels, such as the Space management committee, IFMP Budget Formulation, Journey to Tomorrow Committee, and the Vehicle Systems Program Business Process Team.

## Office of Equal Opportunity Programs

**Jennifer L. Chin**

John Carroll University  
Marketing and Logistics  
Senior

**Mentor: Deborah Cotleur**

### ABSTRACT

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The NASA Glenn Office of Equal Opportunity Programs works to provide quality service for all programs and/or to assist the Center in becoming a model workplace. During the summer of 2004, I worked with Deborah Cotleur along with other staff members to create and modify customer satisfaction surveys.

This office aims to assist in developing a model workplace by providing functions as a change agent to the center by serving as an advisor to management to ensure equity throughout the Center. In addition, the office serves as a mediator for the Center in addressing issues and concerns. Lastly, the office provides assistance to employees to enable attainment of personal and organizational goals.

The Office of Equal Opportunities is a staff office which reports and provides advice to the Center Director and Executive Leadership, implements laws, regulations, and presidential executive orders, and provides center wide leadership and assistance to NASA GRC employees.

Some of the major responsibilities of the office include working with the discrimination complaints program, special emphasis programs (advisory groups), management support, monitoring and evaluation, contract compliance, and community outreach.

During my internship in this office, my main objective was to create four customer satisfaction surveys based on EO retreats, EO observances, EO advisory boards, and EO mediation/counseling. I created these surveys after conducting research on past events and surveys as well as similar survey research created and conducted by other NASA centers.

I began the process by reviewing the past surveys created to obtain feedback from the EO program for EO Advisory group members, leadership training sessions for supervisors, preventing sexual harassment training sessions, and observance events. In addition, I also conducted research on the style and format from feedback surveys from the Marshall Equal Opportunity website, the Goddard website, and the main NASA website. Using the material from the Office of Equal Opportunity Programs at Glenn Research Center along with my previous research, I created four customer satisfaction surveys. These surveys were then forwarded to the Equal Opportunity staff for review. Feedback from the staff gave me a framework with which to work and to improve the surveys.

My goal in the Office of Equal Opportunity Programs was to create customer satisfaction surveys to get feedback about retreats, observances, advisory boards, and mediation/counseling sessions. With this feedback, the office would be able to serve its customers in a more efficient manner by working to make any improvements to future programs.

The method to obtain more feedback from these surveys was through the posting of these surveys electronically. In addition, we intended to have an automatic survey distribution to get a faster response through the internet. In doing so, we would be able to target all the attendees and to get their feedback about the events or sessions attended.

## **Integrated Financial Management Program**

**Susan Pho**

Case Western Reserve University

Accounting

Undergraduate, Junior

**Mentor: Joseph J. Kan**

### **ABSTRACT**

Having worked in the Employees and Commercial Payments Branch of the Financial Management Division for the past 3 summers, I have seen the many changes that have occurred within the NASA organization. As I return each summer, I find that new programs and systems have been adapted to better serve the needs of the Center and of the Agency. The NASA Agency has transformed itself the past couple years with the implementation of the Integrated Financial Management Program (IFMP). IFMP is designed to allow the Agency to improve its management of its Financial, Physical, and Human Resources through the use of multiple enterprise module applications.

With my mentor, Joseph Kan, being the branch chief of the Employees and Commercial Payments Branch, I have been exposed to several modules, such as Travel Manager, WebTads, and Core Financial/SAP, which were implemented in the last couple of years under the IFMP. The implementation of these agency-wide systems has sometimes proven to be troublesome. Prior to IFMP, each NASA Center utilizes their own systems for Payroll, Travel, Accounts Payable, etc. But with the implementation of the Integrated Financial Management Program, all the "legacy" systems had to be eliminated. As a result, a great deal of enhancement and preparation work is necessary to ease the transformation from the old systems to the new. All this work occurs simultaneously; for example, e-Payroll will "go live" in several months, but a system like Travel Manager will need to have information upgraded within the system to meet the requirements set by Headquarters.

My assignments this summer have given me the opportunity to become involved with such work. So far, I have been given the opportunity to participate in projects resulting from a congressional request, several bankcard reconciliations, updating routing lists for Travel Manager, updating the majordomo list for Travel Manager approvers and point of contacts, and a NASA Headquarters project involving improper payments on firm fixed price contracts.

Each of the projects that I have worked on this summer presents a different aspect of the work performed on a regular basis by members of this branch. Not only do I get to see the "big picture" of what occurs within the organization, but I also get to experience the "little stuff" that goes on here and throughout the NASA Agency.

# INVESTIGATION OF INJECTOR SLOT GEOMETRY ON CURVED-DIFFUSER AERODYNAMIC PERFORMANCE

Odlanier Silva  
University of Turabo  
Mechanical Engineering  
Undergraduate, Senior  
**Mentor: Gerard E. Welch**

## ABSTRACT

The Compressor Branch vision is to be recognized as world-class leaders in research for fluid mechanics of compressors. Its mission is to conduct research and develop technology to advance the state of the art of compressors and transfer new technology to U. S. industries. Maintain partnerships with U.S. industries, universities, and other government organizations. Maintain a balance between customers focused and long range research.

Flow control comprises enabling technologies to meet compression system performance requirements driven by emissions and fuel reduction goals (*e.g.*, in UEET), missions (*e.g.*, access-to-space), aerodynamically aggressive vehicle configurations (*e.g.*, UAV and future blended wing body configurations with highly distorted inlets), and cost goals (*e.g.*, in VAATE). The compression system requirements include increased efficiency, power-to-weight, and adaptability (*i.e.*, robustness in terms of wide operability, distortion tolerance, and engine system health and reliability). The compressor flow control task comprises efforts to develop, demonstrate, and transfer adaptive flow control technology to industry to increase aerodynamic loading at current blade row loss levels, to enable adaptively wide operability, and to develop plant models for adaptive compression systems. In this context, flow control is the controlled modification of a flow field by a deliberate means beyond the natural (uncontrolled) shaping of the solid surfaces that define the principal flow path. The objective of the compressor flow control task is to develop and apply techniques that control circulation, aerodynamic blockage, and entropy production in order to enhance the performance and operability of compression systems for advanced aero-propulsion applications.

This summer I would be working with a curved-diffuser because it simulates what happens with flow in the stator blades in the compressor. With this experiment I will be doing some data analysis and parametric study of the injector slot geometries to get the best aerodynamic performance of it. This includes some data reduction, redesign and fast prototyping of the injector nozzle.

**Kathryn Petro**  
Miami University  
Major: Marketing  
Mentor: Kevin Coleman

### **Records Management: Preserving the Past to Make the Future**

As an intern in the Records Management Office at NASA, I have learned the importance of records management and teamwork. I work in building 60 with Kevin Coleman, the Records and Forms Manager and History Officer, and Deborah Demaline, the senior records specialist. Prior to my internship, I had never paid attention to records and their role in operating a business. However, after my first assignment of identifying files and filling out a C-277 form, I realized the importance of preserving each file.

Since NASA is a government agency, keeping our records in a safe and easily accessible area is a major priority. As the records have accumulated over the years, and the destruction of records has been put on hold due to the fairly recent tobacco litigation; the amount of NASA's records has been quickly accumulating. Currently, our records are stored at Plum Brook in Sandusky, Ohio. Recently, rain has leaked through the bunkers and caused damage to some of our records boxes. Plum Brook has been experiencing difficulty in finding the funds to repair the damage. NASA Glenn is reluctant to give Plum Brook more money because the staff at the Sandusky site has not shown us a detailed summary of what they are doing with the funds we give them annually.

Even though storing our records at Plum Brook comes with little cost, there are plenty other companies that offer a records storage area and a special software database for easy record retrieval. My assignment is to do a feasibility study on these companies to see how they compare in providing the appropriate criteria for NASA Glenn's needs. Other research I am doing is on which companies will allow us to convert our physical records into an electronic database for quicker retrieval and to eliminate the cost of storing our records in a facility altogether.

The two studies have required me to not only work closely with the Records Management Department, but also the Information Technology staff. It has been important for me to thoroughly understand the criteria both departments here at NASA Glenn need in order to make the system effective for the entire organization. The interaction that I am experiencing with different organizations within NASA Glenn and the various companies we are looking at has enhanced my communication skills. Without proficient communication skills, it is difficult to seek how each company meets all of NASA's standards. This includes webx conferences, teleconferences, face-to-face meetings, knowing the appropriate time to ask questions, knowing what those appropriate questions are, and most importantly, being a good listener. During the meetings and conferences I attend, I ensure that I understand where each party is coming from and listen carefully to the points people make.

In addition to working with the feasibility study, I will later work on a marketing plan to encourage employees to take care in storing their records and learn the importance of the History Office. Also, the department is trying to develop a special presentation for new employees during their orientation. Assisting Deborah Demaline in taking inventory at Plum Brook is another task that must be done to ensure that the records have been properly placed.

## MAKING SPACE TRAVEL TO JUPITER POSSIBLE

**Samuel P. Barker**

Brigham Young University-Idaho

Senior

Frank Ritzert

### ABSTRACT

From man landing on the moon to a simple satellite being launched into orbit, many incredible space accomplishments have been witnessed by us all. However, what goes un-noticed to the common man is the extensive research and testing that lasts months, years, and even decades. Much of this required research just so happens to take place in the corridors of the Glen Research Center building number 49.

In the Advanced Materials division of G.R.C., a number of researchers have the responsibility of discovering which metal, ceramic, or polymer is best for a specific application. Under the guidance of mentor extraordinaire Frank Ritzert, I am involved in many critical projects dealing with refractory metals, two of which I will mention in this report.

The Jupiter Icy Moons Orbiter (JIMO) project actually was under full swing back in the 50's and early 60's. To enable the 14 year trek to the icy moons of Europa, Callisto, and Ganymede, nuclear propulsion methods were selected. Due to the extreme temperature of the reactor and the extended time period, a refractory metal would need to be implemented. After years of research and progress, the program was suddenly canceled.

About a decade ago, the JIMO project was re-instated and now has a goal for departure around 2014. However, a few obstacles lie in our way concerning the use of refractory metals. In certain areas of the orbiter a joint is required between the refractories and other less dense metals. Two of these joints are with nickel based super alloys. Being an intern for Frank Ritzert, the refractory metals expert, I have the opportunity to develop the best method to braze refractory metals to Nickel 201. This involves the actual brazing, electron microscopy and reporting the results. My second project involves a certain part of the orbiter where Niobium 1Zirconium, a refractory metal, is joined with Hastelloy-X a Ni based metal. Small quantities of oxygen, helium and other impurities in the Ni alloy could diffuse into the Nb1Zr causing embrittlement and possibly major failure. I will be testing the effects of Hast-X on Nb1Zr in a high temperature for 10, 50, 100, and 500 hours. After the samples are run through the heat treatment, strength and chemistry will be tested and reported.

My appreciation for the research that goes behind every project has and will continue to grow. By digging through old documents written in the 50's and 60's, scouring through forgotten closets, and learning from those with experience in the refractory metals, I am bound to have an incredible learning experience here at N.A.S.A.



# IONIC LIQUIDS AND NEW PROTON EXCHANGE MEMBRANES FOR FUEL CELLS

**Jean-Philippe Belières**  
Arizona State University  
Physical Chemistry  
PhD  
**Mentor: James Kinder**

## ABSTRACT

There is currently a great surge of activity in fuel cell research as laboratories across the world seek to take advantage of the high energy capacity provided by fuel cells relative to those of other portable electrochemical power systems. Much of this activity is aimed at high temperature fuel cells, and a vital component of such fuel cells must be the availability of a high temperature stable proton-permeable membrane. NASA Glenn Research Center is greatly involved in developing this technology.

Other approaches to the high temperature fuel cell involve the use of single-component or almost-single-component electrolytes that provide a path for protons through the cell. A heavily researched case is the phosphoric acid fuel cell, in which the electrolyte is almost pure phosphoric acid and the cathode reaction produces water directly. The phosphoric acid fuel cell delivers an open circuit voltage of 0.9 V falling to about 0.7 V under operating conditions at 170°C. The proton transport mechanism is mainly vehicular in character according to the viscosity /conductance relation.

Here we describe some Proton Transfer Ionic Liquids (PTILs) with low vapor pressure and high temperature stability that have conductivities of unprecedented magnitude for non-aqueous systems. The first requirement of an ionic liquid is that, contrary to experience with most liquids consisting of ions, it must have a melting point that is not much above room temperature. The limit commonly suggested is 100°C. PTILs constitute an interesting class of non-corrosive proton-exchange electrolyte, which can serve well in high temperature ( $T = 100 \sim 250^\circ\text{C}$ ) fuel cell applications.

We will present cell performance data showing that the open circuit voltage output, and the performance of a simple  $\text{H}_2(\text{g})/\text{Pt}/\text{PTIL}/\text{Pt}/\text{O}_2(\text{g})$  fuel cell may be superior to those of the equivalent phosphoric acid electrolyte fuel cell both at ambient temperature and temperatures up to and above 200°C.

My work at NASA Glenn Research Center during this summer is to develop and characterize proton exchange membranes doped with ionic liquids. The main techniques used to characterize these materials are: Impedance Spectroscopy, NMR, DSC, TGA, DMA, IR, and SEM ...

## High Temperature Polymers for use in Fuel Cells

**Katherine M. Peplowski**  
Ohio Northern University  
Chemistry  
Senior

**Mentor: James Kinder**

### ABSTRACT

NASA Glenn Research Center (GRC) is currently working on polymers for fuel cell and lithium battery applications. The desire for more efficient, higher power density, and a lower environmental impact power sources has led to interest in proton exchanges membrane fuels cells (PEMFC) and lithium batteries.

A PEMFC has many advantages as a power source. The fuel cell uses oxygen and hydrogen as reactants. The resulting products are electricity, heat, and water. The PEMFC consists of electrodes with a catalyst, and an electrolyte. The electrolyte is an ion-conducting polymer that transports protons from the anode to the cathode.

Typically, a PEMFC is operated at a temperature of about 80°C. There is intense interest in developing a fuel cell membrane that can operate at higher temperatures in the range of 80°C-120°C. Operating the fuel cell at higher temperatures increases the kinetics of the fuel cell reaction as well as decreasing the susceptibility of the catalyst to be poisoned by impurities. Currently, Nafion made by Dupont is the most widely used polymer membrane in PEMFC. Nafion does not function well above 80°C due to a significant decrease in the conductivity of the membrane from a loss of hydration. In addition to the loss of conductivity at high temperatures, the long term stability and relatively high cost of Nafion have stimulated many researches to find a substitute for Nafion.

Lithium ion batteries are popular for use in portable electronic devices, such as laptop computers and mobile phones. The high power density of lithium batteries makes them ideal for the high power demand of today's advanced electronics. NASA is developing a solid polymer electrolyte that can be used for lithium batteries. Solid polymer electrolytes have many advantages over the current gel or liquid based systems that are used currently. Among these advantages are the potential for increased power density and design flexibility.

Automobiles, computers, and cell phones require highly efficient power density for lowering emissions and meeting increasing consumer demands. Many of the solutions can be provided by proton exchange membrane fuel cells and lithium batteries. NASA Glenn Research Center has recognized this need, and is presently engaged in a solution. The goals for the summer include mastering synthesis techniques, understanding the reactions occurring during the synthesis, and characterizing the resulting polymer membranes using NMR, DSC, and TGA for the PEMFC and lithium batteries.

NANO-CASTED METAL OXIDE AEROGELS  
AS DUAL PURPOSE STRUCTURAL COMPONENTS FOR SPACE EXPLORATION

Plousia E. Vassilaras  
Baldwin-Wallace College  
Physics and Chemistry  
Undergraduate  
Mentor: Dr. Nicholas Leventis

NASA missions and space exploration rely on strong, ultra lightweight materials. Such materials are needed for building up past and present space vehicles such as the Sojourner Rover (1997) or the two MERs (2003), but also for a number of components and/or systems including thermal insulators, Solar Sails, Rigid Aeroshells, and Ballutes. The purpose of my internship here at Glenn Research Center is to make dual purpose materials; materials that in addition to being lightweight have electronic, photophysical and magnetic properties and, therefore, act as electronic components and sensors as well as structural components. One type of ultra lightweight material of great interest is aerogels, which have densities ranging from  $0.003 \text{ g/cm}^3$  to  $0.8 \text{ g/cm}^3$ . However, aerogels are extremely fragile and, as a result, have limited practical applications. Recently, Glenn Research Center has developed a process of nano-casting polymers onto the inorganic network of silica-based aerogels increasing the strength 300 fold while only increasing the density 3 fold. By combining the process of nano-casting polymers with inorganic oxide networks other than silica, we are actively pursuing lightweight dual purpose materials.

To date, thirty different inorganic oxide aerogels have been prepared using either standard sol-gel chemistry or a non-alkoxide method involving metal chloride precursors and an epoxide; epichlorohydrin, propylene oxide or trimethylene oxide, as proton scavengers. More importantly, preliminary investigations show that the residual surface hydroxyl groups on each of these inorganic oxide aerogels can be successfully crosslinked with urethane. In addition to characterizing physical and mechanical properties such as density, strength and flexibility, each of these metal oxide aerogels are being characterized for thermal and electronic conductivity and magnetic and optical properties.

## **Photo-Curing: UV Radiation curing of polymers**

**Christina A. Inman**

Spelman College

Major: Chemistry/ Industrial Engineering

Undergraduate Sophomore

**Mentor: Michael A. Meador**

### **ABSTRACT**

The Polymers Branch of the Materials Division is dedicated to the development of high-performance for a variety of applications. Areas of significant interest include high-temperature polymers, low density, and high strength insulating materials, conductive polymers, and high density polymer electrolytes. This summer our group is working diligently on a photo-curing project. There is interest in the medical community feel the need for a new and improved balloon that will be used for angioplasty (a form of heart surgery). This product should maintain flexibility but add many other properties. Like possibly further processability and resistance to infection. Our group intends on coming up with this product by using photo-enolization (or simply, photo-curing) by Diels-Alder trapping.

The main objective was to synthesize a series of new polymers by Diels-Alder cycloaddition of photoenols with more elastomeric properties. Our group was responsible for performing the proper photo-curing techniques of the polymers with diacrylates and bismaleimides, synthesizing novel monomers, and evaluating experimental results. We attempted to use a diacrylate to synthesize the polymer because of previous research done within the Polymers Branch here at NASA. Most acrylates are commercially available, have more elastometric properties than a typical rigid aromatic structure has and they contain ethylene oxides in the middle of their structure that create extensive flexibility. The problem we encountered with the acrylates is that they photo chemically and thermally self polymerize and create diradicals at low temperatures; these constraints caused a lot of unnecessary side reactions. We want to promote solely, diketone polymerization because this type of polymerization has the ability to cause very elastic polymers. We chose to direct our attention towards the usage of maleimides because they are known for eliminating these unnecessary side reactions.

We tried to synthesize several different compounds in order to combine the two techniques and properties of both the acrylates and the maleimides. The Jeffamine 600 maleimide was unsuccessful because it was too large (containing approximately 13 repeating groups). We synthesized another maleimide but because of their low molecular weights, the product appeared to be a very gooey and non useful substance. We synthesized yet another maleimide using the same concept but a different amine, but we could not purify it. We tried several purification options including, column chromatography, flash columns and vacuum distillation. We tried a different bismaleimide and ran it through our UV light chamber, but in the end it turned out to be a very brittle product because of its rigid structure.

Currently, our primary goal is to synthesize a maleimide similar to the Jeffamine 600, using other amines that have shorter chains. Our hypothesis is that these shorter chains will contain both acrylate and maleimide characteristics. Our product will hopefully be very flexible, very elastic and experience no side reactions.

## Durability of Environmental Barrier Coatings in a Water Vapor/Oxygen Environment

**John E. Holchin**  
University of Dayton  
Mechanical Engineering  
Sophomore  
**Dennis S. Fox**

### ABSTRACT

Silicon carbide (SiC) and silicon nitride (Si<sub>3</sub>N<sub>4</sub>) show potential for application in the hot sections of advanced jet engines. The oxidation behavior of these materials has been studied in great detail. In a pure oxygen environment, a silica (SiO<sub>2</sub>) layer forms on the surface and provides protection from further oxidation. Initial oxidation is rapid, but slows as silica layer grows; this is known as parabolic oxidation. When exposed to model fuel-lean combustion applications (standard in jet engines), wherein the partial pressure of water vapor is approximately 0.5 atm., these materials exhibit different characteristics. In such an environment, the primary oxidant to form silica is water vapor. At the same time, water vapor reacts with the surface oxide to form gaseous silicon hydroxide (Si(OH)<sub>4</sub>). The simultaneous formation of both silica and Si(OH)<sub>4</sub> -the latter which is lost to the atmosphere- the material continues to recede. Recession rates for uncoated SiC and Si<sub>3</sub>N<sub>4</sub> are unacceptably high, for use in jet engines, - on the order of 1mm/4000h.

External coatings have been developed that protect Si-based materials from water vapor attack. One such coating consists of a Ba<sub>0.75</sub>Sr<sub>0.25</sub>Al<sub>2</sub>Si<sub>2</sub>O<sub>8</sub> (BSAS) topcoat, a mullite/BSAS intermediate layer and a Si bond coat. The key function of the topcoat is to protect the Si-base material from water vapor; therefore it must be fairly stable in water vapor (recession rate of about 1mm/40,000h) and remain crack free. Although BSAS is much more resistant to water vapor attack than pure silica, it exhibits a linear weight loss in 50% H<sub>2</sub>O - 50% O<sub>2</sub> at 1500°C.

The objective of my research is to determine the oxidation behavior of a number of alternate hot-pressed monolithic top coat candidates. Potential coatings were exposed at 1500°C to a 50% H<sub>2</sub>O - 50% O<sub>2</sub> gas mixture flowing at 4.4 cm/s. These included rare-earth silicates, barium-strontium aluminosilicates. When weight changes were measured with a continuously recording microbalance, linear weight loss was observed. BSAS materials have a fairly high volatility at this temperature, but rare-earth mono-silicate compounds were significantly more stable.

# Thin Film Solar Cells: Organic, Inorganic and Hybrid

**John Dankovich**

Case Western Reserve University

Chemistry / Political Science

Senior Undergraduate

**Mentor: Sheila Bailey**

## ABSTRACT

Thin film solar cells are an important developing resource for hundreds of applications including space travel. In addition to being more cost effective than traditional single crystal silicon cells, thin film multi-crystalline cells are plastic and light weight. The plasticity of the cells allows for whole solar "panels" to be rolled out from reams. Organic layers are being investigated in order to increase the efficiency of the cells to create an organic / inorganic hybrid cell.

The main focus of the group is a thin film inorganic cell made with the absorber  $\text{CuInS}_2$ . So far the group has been successful in creating the layer from a single-source precursor. They also use a unique method of film deposition called chemical vapor deposition for this. The general makeup of the cell is a molybdenum back contact with the  $\text{CuInS}_2$  layer, then CdS, ZnO and aluminum top contacts. While working cells have been produced, the efficiency so far has been low.

Along with quantum dot fabrication the side project of this that is currently being studied is adding a polymer layer to increase efficiency. The polymer that we are using is P3OT (Poly(3-octylthiophene-2,5-diyl), retroregular). Before (and if) it is added to the cell, it must be understood in itself. To do this simple diodes are being constructed to begin to look at its behavior. The P3OT is spin coated onto indium tin oxide and silver or aluminum contacts are added. This method is being studied in order to find the optimal thickness of the layer as well as other important considerations that may later affect the composition of the finished solar cell.

Because the sun is the most abundant renewable, energy source that we have, it is important to learn how to harness that energy and begin to move away from our other depleted non-renewable energy sources. While traditional silicon cells currently create electricity at relatively high efficiencies, they have drawbacks such as weight and rigidity that make them unattractive especially for space applications. Thin film photovoltaics have the potential to alleviate these problems and create a cheap and efficient way to harness the power of the sun.

## **Analysis of Electrical Characteristics of Thin Film Photovoltaic Cells**

**Michael P. Kasick**

Carnegie Mellon University  
Electrical & Computer Engineering  
Undergraduate Sophomore  
**Mentor: Aloysius F. Hepp**

### **ABSTRACT**

Solar energy is the most abundant form of energy in many terrestrial and extraterrestrial environments. Often in extraterrestrial environments sunlight is the only readily available form of energy. Thus the ability to efficiently harness solar energy is one of the ultimate goals in the design of space power systems. The essential component that converts solar energy into electrical energy in a solar energy based power system is the photovoltaic cell.

Traditionally, photovoltaic cells are based on a single crystal silicon absorber. While silicon is a well understood technology and yields high efficiency, there are inherent disadvantages to using single crystal materials. The requirements of weight, large planar surfaces, and high manufacturing costs make large silicon cells prohibitively expensive for use in certain applications. Because of silicon's disadvantages, there is considerable ongoing research into alternative photovoltaic technologies. In particular, thin film photovoltaic technologies exhibit a promising future in space power systems. While they are less mature than silicon, the better radiation hardness, reduced weight, ease of manufacturing, low material cost, and the ability to use virtually any exposed surface as a substrate makes thin film technologies very attractive for space applications.

The research group lead by Dr. Hepp has spent several years researching copper indium disulfide as an absorber material for use in thin film photovoltaic cells. While the group has succeeded in developing a single source precursor for  $\text{CuInS}_2$  as well as a unique method of aerosol assisted chemical vapor deposition, the resulting cells have not achieved adequate efficiencies. While efficiencies of 11% have been demonstrated with  $\text{CuInS}_2$  based cells, the cells produced by this group have shown efficiencies of approximately 1%. Thus, current research efforts are turning towards the analysis of the individual layers of these cells, as well as the junctions between them, to determine the cause of the poor yields.

As a student of electrical engineering with some material science background, my role in this research is to develop techniques for analyzing the electrical characteristics of the  $\text{CuInS}_2$  cells. My first task was to design a shadow mask to be used to place molybdenum contacts under a layer of  $\text{CuInS}_2$  in order to analyze the contact resistance between the materials. In addition, I have also analyzed evaporated aluminum top contacts and have tested various methods of increasing their thicknesses in order to decrease series resistance. More recently I have worked with other members of the research group in reviving a vertical cold-wall reactor for experimentation with  $\text{CuInS}_2$  quantum dots. As part of that project, I have improved the design for a variable frequency and pulse width square wave generator to be used in driving the precursor injection process. My task throughout the remainder of my tenure is to continue to analyze and develop tools for the analysis of electrical properties of the  $\text{CuInS}_2$  cells with the ultimate goal of discovering ways to improve the efficiency of our photovoltaic cells.

# DUST ACCUMULATION AND SOLAR PANEL ARRAY PERFORMANCE ON THE MARS EXPLORATION ROVER (MER) PROJECT

**EREN H. TURGAY**  
University of Kentucky  
Computer Science and Electrical Engineering  
Undergraduate, Senior  
**Mentor: Geoffrey A. Landis**

## ABSTRACT

One of the most fundamental design considerations for any space vehicle is its power supply system. Many options exist, including batteries, fuel cells, nuclear reactors, radioisotopic thermal generators (RTGs), and solar panel arrays. Solar arrays have many advantages over other types of power generation. They are lightweight and relatively inexpensive, allowing more mass and funding to be allocated for other important devices, such as scientific instruments. For Mars applications, solar power is an excellent option, especially for long missions. One might think that dust storms would be a problem; however, while dust blocks some solar energy, it also scatters it, making it diffuse rather than beamed. Solar cells are still able to capture this diffuse energy and convert it into substantial electrical power. For these reasons, solar power was chosen to be used on the 1997 Mars Pathfinder mission. The success of this mission set a precedent, as NASA engineers have selected solar power as the energy system of choice for all future Mars missions, including the Mars Exploration Rover (MER) Project.

Solar cells have their drawbacks, however. They are difficult to manufacture and are relatively fragile. In addition, solar cells are highly sensitive to different parts of the solar spectrum, and finding the correct balance is crucial to the success of space missions. Another drawback is that the power generated is not a constant with respect to time, but rather changes with the relative angle to the sun. On Mars, dust accumulation also becomes a factor. Over time, dust settles out of the atmosphere and onto solar panels. This dust blocks and shifts the frequency of the incoming light, degrading solar cell performance.

My goal is to analyze solar panel telemetry data from the two MERs (Spirit and Opportunity) in an effort to accurately model the effect of dust accumulation on solar panels. This is no easy process due to the large number of factors involved. Changing solar flux (the amount of solar energy reaching the planet), solar spectrum, solar angle, rover tilt, and optical depth (the opacity of the atmosphere due to dust) were the most significant. Microsoft Excel and Visual Basic are used for data analysis. The results of this work will be used to improve the dust accumulation and atmosphere effects model that was first created after the Mars Pathfinder mission.

This model will be utilized and applied when considering the design of solar panel array systems on future Mars projects. Based on this data, and depending upon the tenure and application of the mission, designers may also elect to employ special tools to abate dust accumulation, or decide that the expected level of accumulation is acceptable.



## **Evaporator Development for an Evaporative Heat Pipe System**

Leigh C. Peters  
Case Western Reserve University  
Mechanical Engineering  
Junior Undergraduate  
Mentor: Kenneth A. Burke

### **ABSTRACT**

As fossil fuel resources continue to deplete, research for alternate power sources continues to develop. One of these alternate technologies is fuel cells. They are a practical fuel source able to provide significant amounts of power for applications from laptops to automobiles and their only byproduct is water. However, although this technology is over a century old and NASA has been working with it since the early 1960's there is still room for improvement.

The research I am involved in at NASA's Glenn Research Center is focusing on what is called a regenerative fuel cell system. The unique characteristic of this type of system is that it used an outside power source to create electrolysis of the water it produces and it then reuses the hydrogen and oxygen to continue producing power. The advantage of this type of system is that, for example, on space missions it can use solar power to recharge its gas supplies between periods when the object being orbited blocks out the sun.

This particular system however is far from completion. This is because of the many components that are required to make up a fuel cell that need to be tested individually. The specific part of the system that is being worked on this summer of 2004 is the cooling system. The fuel cell stack, that is the part that actually creates the power, also produces a lot of heat. When not properly cooled, it has been known to cause fires which, needless to say are not conducive to the type of power that is trying to be created. In order to cool the fuel cell stack in this system we are developing a heat pipe cooling system.

One of the main components of a heat pipe cooling system is what is known as the evaporator, and that is what happens to be the part of the system we are developing this summer. In most heat pipe systems the evaporator is a tube in which the working fluid is cooled and then re-circulated through the system to absorb more heat energy from the fuel cell stack. For this system, instead of a tube, the evaporator is made up of a stack-up of screen material and absorbent membranes inside a stainless steel shell and held together by a film adhesive and epoxy.

There is an initial design for this flat plate evaporator, however it has not yet been made. The components of the stack-up are known, so all testing is focused on how it will all go together. This includes finding an appropriate epoxy to make the evaporator conductive all the way through and finding a way to hold the required tight tolerances as the stainless steel outer shell is put together. By doing the tests on smaller samples of the stack-ups and then testing the full size component, the final flat plate evaporator will reach its final design so that research can continue on other parts of the regenerative fuel cell system, and another step in the improvement of fuel cell technology can be made.

# AIRCRAFT FUEL CELL POWER SYSTEMS

**Robert Needham**

Case Western Reserve University

Electrical Engineering

Senior

**Mentor: Patricia Loyselle**

## ABSTRACT

In recent years, fuel cells have been explored for use in aircraft. While the weight and size of fuel cells allows only the smallest of aircraft to use fuel cells for their primary engines, fuel cells have showed promise for use as auxiliary power units (APUs), which power aircraft accessories and serve as an electrical backup in case of an engine failure. Fuel cell APUs are both more efficient and emit fewer pollutants.

However, sea-level fuel cells need modifications to be properly used in aircraft applications. At high altitudes, the ambient air has a much lower pressure than at sea level, which makes it much more difficult to get air into the fuel cell to react and produce electricity. Compressors can be used to pressurize the air, but this leads to added weight, volume, and power usage, all of which are undesirable things.

Another problem is that fuel cells require hydrogen to create electricity, and ever since the Hindenburg burst into flames, aircraft carrying large quantities of hydrogen have not been in high demand. However, jet fuel is a hydrocarbon, so it is possible to reform it into hydrogen. Since jet fuel is already used to power conventional APUs, it is very convenient to use this to generate the hydrogen for fuel-cell-based APUs.

Fuel cells also tend to get large and heavy when used for applications that require a large amount of power. Reducing the size and weight becomes especially beneficial when it comes to fuel cells for aircraft.

My goal this summer is to work on several aspects of Aircraft Fuel Cell Power System project. My first goal is to perform checks on a newly built injector rig designed to test different catalysts to determine the best setup for reforming Jet-A fuel into hydrogen. These checks include testing various thermocouples, transmitters, and transducers, as well making sure that the rig was actually built to the design specifications. These checks will help to ensure that the rig will operate properly and give correct results when it is finally ready for testing.

Another of my goals is to test new membranes for use in proton-exchange membrane fuel cells, in the hope that these membranes can increase the electricity that is produced by fuel cells. Producing more electricity means that fewer fuel cells are needed, thus reducing the weight and volume of an APU based on fuel cells, making such an APU much more viable.

# Research Symposium I Ohio Aerospace Institute Wednesday, July 7, 2004

## OAI Federal Room

9:00 A.M. **Kevin Robb, Penn State University, Senior**

“Improved Nuclear Reactor and Shield Mass Model for Space Applications”

5490/Michael Barrett, Thermo-Mechanical Systems Branch

9:15 **Melissa Papa, Penn State University, Senior**

“Main Power Distribution Unit for the Jupiter Icy Moons Orbiter (JIMO)”

5490/Charles Castle, Thermo-Mechanical Systems Branch

9:30 **Gina Blaze, Cleveland State University, Senior**

“Stirling Engine Controller”

5490/Mary Ellen Roth, Thermo-Mechanical Systems Branch

9:45 **Christopher Nakis, Grove City College, Junior**

“Stirling Engine Dynamic System Modeling”

5490/Jeff Schreiber, Thermo-Mechanical Systems Branch

10:00 **Erin Burns, Michigan Tech University, Senior**

“Research Performed Within the Non-Destructive Evaluation Team at NASA Glenn Research Center”

5520/Laura Cosgriff, Optical Instrumentation Technology Branch

10:15 **Thomas Brinson, Florida A&M University, Masters**

“Thermodynamic Modeling of a Solid Oxide Fuel Cell to Couple with an Existing Gas Turbine Engine Model”

5530/George Kopasakis, Controls and Dynamics Technology Branch

10:30 **Gregory Savich, University of Rochester, Junior**

“Fabrication of a Novel Gigabit/Second Free-Space Optical Interconnect – Photodetector Characterization and Testing and System Development”

5620/Rainee Simons, Electron Device Technology Branch

10:45 **Eric Radke, University of California-Los Angeles, Masters**

“Application of Simulated Annealing and Related Algorithms to TWTA Design”

5620/Karl Vaden, Electron Device Technology Branch

11:00 **LUNCH**

1:00 **Richard Su, University of Maryland-College Park, Masters**

“Design of Amphoteric Refraction Models Using Wavica and Rayica”

5620/Jeffrey Wilson, Electron Device Technology Branch

1:15 **Christopher Subich, University of Central Florida, Senior**

“Model of Atmospheric Links on Optical Communications from High Altitude”

5640/Felix Miranda, Applied RF Technology Branch

- 1:30 **Nathan Yassine, Cleveland State University, Senior**  
“Digital Communication Constraints in Prior Space Missions”  
5640/Robert Romanofsky, Applied RF Technology Branch
- 1:45 **Mark Trapp, Carnegie Mellon University, Senior**  
“Eccentric Loading of Microtensile Specimens”  
5920/Noel Nemeth, Life Prediction Branch
- 2:00 **Matthew Smith, Penn State University, Masters**  
“Consideration of Alternate Working Fluid Properties in Gas Lubricated Foil Journal Bearings”  
5930/Samuel Howard, Structural Mechanics and Dynamics Branch
- 2:15 **Matthew Ellis, Purdue University, Masters**  
“Effect of Detonation through a Turbine Stage”  
5940/Edmane Envia, Acoustics Branch
- 2:30 **La'nita Ward, Spelman College, Junior**  
“Investigation of the Environmental Durability of a Powder Metallurgy Material”  
5960/Malcolm Stanford, Tribology and Surface Science Branch
- 2:45 **Rachel Laster, Kentucky State University, Senior**  
“The Monitoring System for Vibratory Disturbance Detection in Microgravity Environment Aboard the International Space Station”  
6727/Kenol Jules, Microgravity Environment and Telescience Branch
- 3:00 **Theresa Guo, Massachusetts Institute of Technology, Freshman**  
“Visualizing Ultrasound Through Computational Modeling”  
6728/Jerry Myers, Fluid Flights Projects Branch
- 3:15 **ADJOURN**

## **Improved Nuclear Reactor and Shield Mass Model for Space Applications**

**Kevin Robb**

Penn State University

Mechanical and Nuclear Engineering

Undergraduate, Senior

**Mentor: Michael Barrett**

### **ABSTRACT**

New technologies are being developed to explore the distant reaches of the solar system. Beyond Mars, solar energy is inadequate to power advanced scientific instruments. One technology that can meet the energy requirements is the space nuclear reactor. The nuclear reactor is used as a heat source for which a heat-to-electricity conversion system is needed. Examples of such conversion systems are the Brayton, Rankine, and Stirling cycles.

Since launch cost is proportional to the amount of mass to lift, mass is always a concern in designing spacecraft. Estimations of system masses are an important part in determining the feasibility of a design.

I worked under Michael Barrett in the Thermal Energy Conversion Branch of the Power & Electric Propulsion Division. An in-house Closed Cycle Engine Program (CCEP) is used for the design and performance analysis of closed-Brayton-cycle energy conversion systems for space applications. This program also calculates the system mass including the heat source. CCEP uses the subroutine RSMASS, which has been updated to RSMASS-D, to estimate the mass of the reactor.

RSMASS was developed in 1986 at Sandia National Laboratories to quickly estimate the mass of multi-megawatt nuclear reactors for space applications. In response to an emphasis for lower power reactors, RSMASS-D was developed in 1997 and is based off of the SP-100 liquid metal cooled reactor. The subroutine calculates the mass of reactor components such as the safety systems, instrumentation and control, radiation shield, structure, reflector, and core. The major improvements in RSMASS-D are that it uses higher fidelity calculations, is easier to use, and automatically optimizes the systems mass. RSMASS-D is accurate within 15% of actual data while RSMASS is only accurate within 50%.

My goal this summer was to learn FORTRAN 77 programming language and update the CCEP program with the RSMASS-D model.

# **MAIN POWER DISTRIBUTION UNIT FOR THE JUPITER ICY MOONS ORBITER (JIMO)**

**Melissa R. Papa**  
Pennsylvania State University  
Aerospace Engineering  
Undergraduate, Senior  
**Mentor: Charles H. Castle**

## **ABSTRACT**

Around the year 2011, the Jupiter Icy Moons Orbiter (JIMO) will be launched and on its way to orbit three of Jupiter's planet-sized moons. The mission goals for the JIMO project revolve heavily around gathering scientific data concerning ingredients we, as humans, consider essential: water, energy and necessary chemical elements. The JIMO is an ambitious mission which will implore propulsion from an ION thruster powered by a nuclear fission reactor. Glenn Research Center is responsible for the development of the dynamic power conversion, power management and distribution, heat rejection and ION thrusters.

The first test phase for the JIMO program concerns the High Power AC Power Management and Distribution (PMAD) Test Bed. The goal of this testing is to support electrical performance verification of the power systems. The test bed will incorporate a 2kW Brayton Rotating Unit (BRU) to simulate the nuclear reactor as well as two ION thrusters. The first module of the PMAD Test Bed to be designed is the Main Power Distribution Unit (MPDU) which relays the power input to the various propulsion systems and scientific instruments.

The MPDU involves circuitry design as well as mechanical design to determine the placement of the components. The MPDU consists of fourteen relays of four different variations used to convert the input power into the appropriate power output. The three phase system uses 400 Volts<sub>L-L</sub> rms at 1000 Hertz. The power is relayed through the circuit and distributed to the scientific instruments, the ION thrusters and other controlled systems. The mechanical design requires the components to be positioned for easy electrical wiring as well as allowing adequate room for the main buss bars, individual circuit boards connected to each component and power supplies.

To accomplish creating a suitable design, AutoCAD was used as a drafting tool. By showing a visual layout of the components, it is easy to see where there is extra room or where the components may interfere with one another. By working with the electrical engineer who is designing the circuit, the specific design requirements for the MPDU were determined and used as guidelines. Space is limited due to the size of the mounting plate therefore each component must be strategically placed. Since the MPDU is being designed to fit into a simulated model of the spacecraft systems on the JIMO, components must be positioned where they are easily accessible to be wired to the other onboard systems. Mechanical and electrical requirements provided equally important limits which are combined to produce the best possible design of the MPDU.

## **Stirling Engine Controller**

**Gina M. Blaze**

Cleveland State University

Electrical Engineering

Undergraduate, Junior

**Mentor: Mary Ellen Roth**

Stirling technology is being developed to replace RTG's (Radioisotope Thermoelectric Generators), more specifically a stirling convertor, which is a stirling engine coupled to a linear alternator. Over the past three decades, the stirling engine has been designed to perform different functions. Stirling convertors have been designed to decrease fuel consumption in automobiles. They have also been designed for terrestrial and space applications. Currently NASA Glenn is using the convertor for space based applications.

A stirling convertor is a better means of power for deep space missions and "dusty" missions, like the Mars Rovers, than solar panels because it is not affected by dust. Spirit and Opportunity, two Mars rovers currently navigating the planet, are losing their ability to generate electricity because dust is collecting on their solar panels. Opportunity is losing more energy because its robotic arm has a heater with a switch that can not be turned off. The heater is not needed at night, but yet still runs. This generates a greater loss of electricity and in turn diminishes the performance of the rover. The stirling cycle has the potential to provide very efficient conversion of heat energy to electric al energy, more so than RTG's. The stirling engine converts the thermal energy produced by the decaying radioisotope to mechanical energy; the linear alternator converts this into electricity.

Since the early 1990's, tests have been performed to maximize the efficiency of the stirling convertor. Many months, even years, are dedicated to preparing and performing tests. Currently, two stirling convertors #'s 13 and 14, which were developed by Stirling Technology Company, are on an extended operation test. As of June 7th, the two convertors reached 7,500 hours each of operation. Before the convertors could run unattended, many safety precautions had to be examined. So, special instrumentation and circuits were developed to detect off nominal conditions and also safely shutdown the engines. The test will last for a period of 8000 to 9000 hours. Other types of tests that have been performed are: performance mapping, controller development, launch environment, and vibration emissions testing.

Currently, the thermo-mechanical systems branch is housing a RG-350, a stirling convertor. The convertor was used in previous tests such as a Hall Thruster test, world's first integrated test of a dynamic power system with electric propulsion. Another test performed was to conclude if free piston stirling convertors can be synchronized for vibration balancing, with no thermodynamic or electrical connections and not cause both to shutdown if one failed. The ability to reduce vibration by synchronizing convertor operation but still be able to operate when one partner fails is pertinent in space and terrestrial applications. The convertor is now being brought back into operation and a controller is in the process of being developed. This convertor will be used as a testbed for new controllers.

I worked with Mary Ellen Roth on the electrical engineering aspects of the RG-350. My main goal was to enhance the data collection process. I worked on different aspects of the RG-350, with a main focus on the engine controller. I drew a schematic of the wire connections in the engine controller, using PCB Express, so that a plan could be devised to connect the power meter properly between the output of the engine and the engine controller. I measured the power using two different instruments: Valhalla Scientific power meter and Ohio Semitronics power measurement device. The convertor is connected to an Agilent 34970A Data Acquisition/Switch Unit, which allows the user to measure, record, and monitor voltage, current, frequency, and temperature. I assisted in preparing the Data Acquisition for general operation. I also helped test a panel of transducers, which will be placed in the rack that powers and monitors the convertor.

## Stirling Engine Dynamic System Modeling

Christopher G. Nakis  
Grove City College  
Mechanical Engineering  
Junior  
Mentor: Jeff Schreiber

### ABSTRACT

The Thermo-Mechanical systems branch at the Glenn Research Center focuses a large amount time on Stirling engines. These engines will be used on missions where solar power is inefficient, especially in deep space. I work with Tim Regan and Ed Lewandowski who are currently developing and validating a mathematical model for the Stirling engines. This model incorporates all aspects of the system including, mechanical, electrical and thermodynamic components. Modeling is done through Simplorer, a program capable of running simulations of the model. Once created and then proven to be accurate, a model is used for developing new ideas for engine design.

My largest specific project involves varying key parameters in the model and quantifying the results. This can all be done relatively trouble-free with the help of Simplorer. Once the model is complete, Simplorer will do all the necessary calculations. The more complicated part of this project is determining which parameters to vary. Finding key parameters depends on the potential for a value to be independently altered in the design. For example, a change in one dimension may lead to a proportional change to the rest of the model, and no real progress is made. Also, the ability for a changed value to have a substantial impact on the outputs of the system is important. Results will be condensed into graphs and tables with the purpose of better communication and understanding of the data.

With the changing of these parameters, a more optimal design can be created without having to purchase or build any models. Also, hours and hours of results can be simulated in minutes. In the long run, using mathematical models can save time and money. Along with this project, I have many other smaller assignments throughout the summer. My main goal is to assist in the processes of model development, validation and testing.



**RESEARCH PERFORMED WITHIN THE NON-DESTRUCTIVE EVALUATION  
TEAM AT NASA GLENN RESEARCH CENTER**

**Erin A. Burns**

Michigan Technological University

Mechanical Engineering

Masters, Candidate

**Mentors: Dr. Don Roth and Laura Cosgriff**

**ABSTRACT**

Non-destructive testing is essential in many fields of manufacturing and research in order to perform reliable examination of potentially damaged materials and parts without destroying the inherent structure of the materials. Thus, the Non-Destructive Evaluation (NDE) Team at NASA Glenn Research Center partakes in various projects to improve materials testing equipment as well as analyze materials, material defects, and material deficiencies.

Due to the array of projects within the NDE Team at this time, five research aims were supplemental to some current projects.

A literature survey of NDE and testing methodologies as related to rocks was performed. Also, Mars Expedition Rover technology was assessed to understand the requirements for instrumentation in harsh space environments (e.g. temperature). Potential instrumentation and technologies were also considered and documented. The literature survey provided background and potential sources for a proposal to acquire funding for ultrasonic instrumentation on board a future Mars expedition.

The laboratory uses a Santec Systems AcousticScope AS200 acoustography system. Labview code was written within the current program in order to improve the current performance of the acoustography system.

A sample of Reinforced Carbon/Carbon (RCC) material from the leading edge of the space shuttle underwent various non-destructive tests (guided wave scanning, thermography, computed tomography, real time x-ray, etc.) in order to characterize its structure and examine possible defects.

Guided wave scan data of a ceramic matrix composite (CMC) panel was reanalyzed utilizing image correlations and signal processing variables. Additional guided wave scans and thermography were also performed on the CMC panel. These reevaluated data and images will be used in future presentations and publications.

An additional axis for the guided wave scanner was designed, constructed, and implemented. This additional axis allowed incremental spacing of the previously fixed transducers for ultrasonic velocity measurements.

# **THERMODYNAMIC MODELING OF A SOLID OXIDE FUEL CELL TO COUPLE WITH AN EXISTING GAS TURBINE ENGINE MODEL**

**Thomas E. Brinson**

Florida Agricultural and Mechanical University

Mechanical Engineering

Graduate, 2<sup>nd</sup> year Master's

**Mentor: George Kopasakis**

## **ABSTRACT**

The Controls and Dynamics Technology Branch at NASA Glenn Research Center are interested in combining a solid oxide fuel cell (SOFC) to operate in conjunction with a gas turbine engine. A detailed engine model currently exists in the Matlab/Simulink environment. The idea is to incorporate a SOFC model within the turbine engine simulation and observe the hybrid system's performance. The fuel cell will be heated to its appropriate operating condition by the engine's combustor. Once the fuel cell is operating at its steady-state temperature, the gas burner will back down slowly until the engine is fully operating on the hot gases exhausted from the SOFC. The SOFC code is based on a steady-state model developed by The U.S. Department of Energy (DOE). In its current form, the DOE SOFC model exists in Microsoft Excel and uses Visual Basics to create an I-V (current-voltage) profile. For the project's application, the main issue with this model is that the gas path flow and fuel flow temperatures are used as input parameters instead of outputs. The objective is to create a SOFC model based on the DOE model that inputs the fuel cells flow rates and outputs temperature of the flow streams; therefore, creating a temperature profile as a function of fuel flow rate. This will be done by applying the First Law of Thermodynamics for a flow system to the fuel cell. Validation of this model will be done in two procedures. First, for a given flow rate the exit stream temperature will be calculated and compared to DOE SOFC temperature as a point comparison. Next, an I-V curve and temperature curve will be generated where the I-V curve will be compared with the DOE SOFC I-V curve. Matching I-V curves will suggest validation of the temperature curve because voltage is a function of temperature. Once the temperature profile is created and validated, the model will then be placed into the turbine engine simulation for system analysis.

# **FABRICATION OF A NOVEL GIGABIT/SECOND FREE-SPACE OPTICAL INTERCONNECT - PHOTODETECTOR CHARACTERIZATION AND TESTING AND SYSTEM DEVELOPMENT**

**Gregory R. Savich**  
University of Rochester  
Optics/Optical Engineering  
Undergraduate - Third Year  
**Mentor: Rainee N. Simons**

## **ABSTRACT**

The time when computing power is limited by the copper wire inherent in the computer system and not the speed of the microprocessor is rapidly approaching. With constant advances in computer technology, many researchers believe that in only a few years, optical interconnects will begin to replace copper wires in your Central Processing Unit (CPU). On a more macroscopic scale, the telecommunications industry has already made the switch to optical data transmission as, to date, fiber optic technology is the only reasonable method of reliable, long range data transmission. Within the span of a decade, we will see optical technologies move from the macroscopic world of the telecommunications industry to the microscopic world of the computer chip. Already, the communications industry is marketing commercially available optical links to connect two personal computers, thereby eliminating the need for standard and comparatively slow wired and wireless Ethernet transfers and greatly increasing the distance the computers can be separated. As processing demands continue to increase, the realm of optical communications will continue to move closer to the microprocessor and quite possibly onto the microprocessor itself. A day may come when copper connections are used only to supply power, not transfer data.

This summer's work marks some of the beginning stages of a 5 to 10 year, long-term research project to create and study a free-space, 1 Gigabit/sec optical interconnect. The research will result in a novel fabricated, chip-to-chip interconnect consisting of a Vertical Cavity Surface Emitting Laser (VCSEL) Diode linked through free space to a Metal-Semiconductor-Metal (MSM) Photodetector with the possible integration of microlenses for signal focusing and Micro-Electromechanical Systems (MEMS) devices for optical signal steering. The advantages, disadvantages, and practicality of incorporating flip-chip mounting technologies will also be addressed.

My work began with the design and construction of a test setup for the experiment and then appropriate characterization of the test system. Specifically, I am involved in the characterization of a commercially available 1550nm wavelength, 5mW diode laser and a study of its modulation bandwidth. Commercially produced photodetectors as well as the incorporation of microwave technology, in the form of RF input and output, are used in the characterization procedure. The next stage involves the use of a probe station and network analyzer to characterize and test a series of photodetectors fabricated on a 2 inch, Indium Gallium Arsenide (InGaAs) wafer in the Branch's microlithography lab. Other project responsibilities include, but are not limited to the incorporation of a transimpedance amplifier to the photodetector circuit; a study of VCSEL technology; bit error rate analysis of an optical interconnect system; and analysis of free space divergence of the VCSEL, optical path length of the interconnect; and any other pertinent optical properties of the one gigabit per second interconnect for fabrication and testing.

# Application of Simulated Annealing and Related Algorithms to TWTA Design

**Eric M. Radke**

University of California, Los Angeles

Mathematics

Graduate

**Mentor: Karl R. Vaden**

Simulated Annealing (SA) is a stochastic optimization algorithm used to search for global minima in complex design surfaces where exhaustive searches are not computationally feasible. The algorithm is derived by simulating the annealing process, whereby a solid is heated to a liquid state and then cooled slowly to reach thermodynamic equilibrium at each temperature. The idea is that atoms in the solid continually bond and re-bond at various quantum energy levels, and with sufficient cooling time they will rearrange at the minimum energy state to form a perfect crystal. The distribution of energy levels is given by the Boltzmann distribution: as temperature drops, the probability of the presence of high-energy bonds decreases.

In searching for an optimal design, local minima and discontinuities are often present in a design surface. SA presents a distinct advantage over other optimization algorithms in its ability to escape from these local minima. Just as high-energy atomic configurations are visited in the actual annealing process in order to eventually reach the minimum energy state, in SA highly non-optimal configurations are visited in order to find otherwise inaccessible global minima.

The SA algorithm produces a Markov chain of points in the design space at each temperature, with a monotonically decreasing temperature. A random point is started upon, and the objective function is evaluated at that point. A stochastic perturbation is then made to the parameters of the point to arrive at a proposed new point in the design space, at which the objection function is evaluated as well. If the change in objective function values  $\Delta E$  is negative, the proposed new point is accepted. If  $\Delta E$  is positive, the proposed new point is accepted according to the Metropolis criterion:  $p(\Delta f) = \exp(-\Delta E/T)$ , where  $T$  is the temperature for the current Markov chain. The process then repeats for the remainder of the Markov chain, after which the temperature is decremented and the process repeats. Eventually (and hopefully), a near-globally optimal solution is attained as  $T$  approaches zero.

Several exciting variants of SA have recently emerged, including Discrete-State Simulated Annealing (DSSA) and Simulated Tempering (ST). The DSSA algorithm takes the thermodynamic analogy one step further by categorizing objective function evaluations into discrete states. In doing so, many of the case-specific problems associated with fine-tuning the SA algorithm can be avoided; for example, theoretical approximations for the initial and final temperature can be derived independently of the case. In this manner, DSSA provides a scheme that is more robust with respect to widely differing design surfaces. ST differs from SA in that the temperature  $T$  becomes an additional random variable in the optimization. The system is also kept in equilibrium as the temperature changes, as opposed to the system being driven out of equilibrium as temperature changes in SA. ST is designed to overcome obstacles in design surfaces where numerous local minima are separated by high barriers.

These algorithms are incorporated into the optimal design of the traveling-wave tube amplifier (TWTA). The area under scrutiny is the collector, in which it would be ideal to use negative potential to decelerate the spent electron beam to zero kinetic energy just as it reaches the collector surface. In reality this is not plausible due to a number of physical limitations, including repulsion and differing levels of kinetic energy among individual electrons. Instead, the collector is designed with multiple stages depressed below ground potential. The design of this multiple-stage collector is the optimization problem of interest.

One remaining problem in SA and DSSA is the difficulty in determining when equilibrium has been reached so that the current Markov chain can be terminated. It has been suggested in recent literature that simulating the thermodynamic properties of specific heat, entropy, and internal energy from the Boltzmann distribution can provide good indicators of having reached equilibrium at a certain temperature. These properties are tested for their efficacy and implemented in SA and DSSA code with respect to TWTA collector optimization.

# **DESIGN OF AMPHOTERIC REFRACTION MODELS USING WAVICA AND RAYICA**

**Richard Su**

University of California, Berkeley

Electrical Engineering

Graduate

**Mentor: Jeffrey Wilson**

## **Abstract**

The phenomenon of refraction of light is due to refractive index mismatches in two different media. However, to achieve this effect, a finite reflection loss is inevitable. A recent finding presented a unique type of interface, ferroelastic materials, that enables refraction without any reflection for either an electron or a light beam. This property is called total refraction.

The same type of interface that yields total refraction can also yield amphoteric refraction, where the index of refraction can be either positive or negative depending on the incident angle. This interface could potentially be used to steer light without reflections which could have major applications in high power optics.

My goal this summer is to first familiarize myself with the Mathematica software, especially the Wavica and Rayica packages. I will then model the amphoteric refraction by either modifying the Wavica and Rayica packages or using the built-in functions in these packages.

# **MODEL OF ATMOSPHERIC LINKS ON OPTICAL COMMUNICATIONS FROM HIGH ALTITUDE**

**Christopher Subich**

University of Central Florida  
Mathematics & Computer Science  
Undergraduate, Senior

**Mentors: Grigory Adamovsky (RIO, 5520) and Félix Miranda (RCA, 5640)**

## **ABSTRACT**

Optical communication links have the potential to solve many of the problems of current radio and microwave links to satellites and high-altitude aircraft. The higher frequency involved in optical systems allows for significantly greater signal bandwidth, and thus information transfer rate, in excess of 10 Gbps, and the highly directional nature of laser-based signals eliminates the need for frequency-division multiplexing seen in radio and microwave links today.

The atmosphere, however, distorts an optical signal differently than a microwave signal. While the ionosphere is one of the most significant sources of noise and distortion in a microwave or radio signal, the lower atmosphere affects an optical signal more significantly. Refractive index fluctuations, primarily caused by changes in atmospheric temperature and density, distort the incoming signal in both deterministic and nondeterministic ways. Additionally, suspended particles, such as those in haze or rain, further corrupt the transmitted signal.

To model many of the atmospheric effects on the propagating beam, we use simulations based on the beam-propagation method. This method, developed both for simulation of signals in waveguides and propagation in atmospheric turbulence, separates the propagation into a diffraction and refraction problem. The diffraction step is an exact solution, within the limits of numerical precision, to the problem of propagation in free space, and the refraction step models the refractive index variances over a segment of the propagation path. By applying refraction for a segment of the propagation path, then diffracting over that same segment, this method forms a good approximation to true propagation through the atmospheric medium. Iterating over small segments of the total propagation path gives a good approximation to the problem of propagation over the entire path.

Parameters in this model, such as initial beam profile and atmospheric constants, are easily modified in a simulation such as this, which allows for the rapid analysis of different propagation scenarios. Therefore, this method allows the development of a near-optimal system design for a wide range of situations, typical of what would be seen in different atmospheric conditions over a receiving ground station.

A simulation framework based upon this model was developed in FORTRAN, and for moderate grid sizes and propagation distances these simulations are computable in reasonable time on a standard workstation. This presentation will discuss results thus far.

## **ACKNOWLEDGEMENTS**

Insight and input from Dr. Robert Manning of the Antenna, Microwave, and Optical Systems Branch (RCA, 5640) are deeply appreciated.

# DIGITAL COMMUNICATION CONSTRAINTS IN PRIOR SPACE MISSIONS

**Nathan K. Yassine**  
Cleveland State University  
Electrical Engineering  
Post-graduate  
**Mentor: Robert R. Romanofsky**

## ABSTRACT

Digital communication is crucial for space endeavors. It transmits scientific and command data between earth stations and the spacecraft crew. It facilitates communications between astronauts, and provides live coverage during all phases of the mission. Digital communications provide ground stations and spacecraft crew precise data on the spacecraft position throughout the entire mission.

Lessons learned from prior space missions are valuable for our new lunar and Mars missions set by our president's speech. These data will save our agency time and money, and set course our current developing technologies. Limitations on digital communications equipment pertaining mass, volume, data rate, frequency, antenna type and size, modulation, format, and power in the passed space missions are of particular interest. This activity is in support of ongoing communication architectural studies pertaining to robotic and human lunar exploration. The design capabilities and functionalities will depend on the space and power allocated for digital communication equipment. My contribution will be gathering these data, write a report, and present it to Communications Technology Division Staff.

Antenna design is very carefully studied for each mission scenario. Currently, Phased array antennas are being developed for the lunar mission. Phased array antennas use little power, and electronically steer a beam instead of DC motors. There are 615 patches in the phased array antenna. These patches have to be modified to have high yield. 50 patches were created for testing. My part is to assist in the characterization of these patch antennas, and determine whether or not certain modifications to quartz micro-strip patch radiators result in a significant yield to warrant proceeding with repairs to the prototype 19 GHz ferroelectric reflect-array antenna. This work requires learning how to calibrate an automatic network, and mounting and testing antennas in coaxial fixtures. The purpose of this activity is to assist in the set-up of phase noise instrumentation, assist in the process of automated wire bonding, assist in the design and optimization of tunable microwave components, especially phase shifters, based on thin ferroelectric films, and learn how to use commercial electromagnetic simulation software.

## **ECCENTRIC LOADING OF MICROTENSILE SPECIMENS**

**Mark A. Trapp**  
Carnegie Mellon University  
Mechanical Engineering  
Mentor: Noel Nemeth

### **ABSTRACT**

Ceramic materials have a lower density than most metals and are capable of performing at extremely high temperatures. The utility of these materials is obvious; however, the fracture strength of brittle materials is not easily predicted and often varies greatly. Characteristically, brittle materials lack ductility and do not yield as other materials. Ceramics materials are naturally populated with microscopic cracks due to fabrication techniques. Upon application of a load, stress concentration occurs at the root of these cracks and fracture will eventually occur at some not easily predicted strength. In order to use ceramics in any application some design methodology must exist from which a component can be placed into service.

This design methodology is CARES/LIFE (Ceramics Analysis and Reliability Evaluation of Structures) which has been developed and refined at NASA over the last several decades. The CARES/LIFE computer program predicts the probability of failure of a ceramic component over its service life. CARES combines finite element results from a commercial FE (finite element) package such as ANSYS and experimental results to compute the abovementioned probability of failure. Over the course of several tests CARES has had great success in predicting the life of various ceramic components and has been used throughout industry. The latest challenge is to verify that CARES is valid for MEMS (Micro-Electro Mechanical Systems). To investigate a series of microtensile specimens were fractured in the laboratory. From this data, material parameters were determined and used to predict a distribution of strength for other specimens that exhibit a known stress concentration. If the prediction matches the experimental results then these parameters can be applied to a desired component outside of the laboratory.

During testing nearly half of the tensile specimens fractured at a location that was not expected and hence not captured in the FE model. It has been my duty to investigate the nature of this phenomenon in hopes of finding a better correlation between theory and empirical results. To investigate I built complete FE models of all of the tensile specimens using ANSYS. It is suspected that some misalignment naturally occurs during testing and thus additional bending stresses are present in the specimens. I modeled this eccentric loading and ran several FE trials using ANSYS/PDS (a probabilistic design system in ANSYS).

My objective this summer has been to familiarize myself with the CARES/LIFE program in hopes of using it in conjunction with ANSYS to help verify that CARES is applicable to MEMS-scale (greater than 1 micron, less than 1 millimeter) components.



# CONSIDERATION OF ALTERNATE WORKING FLUID PROPERTIES IN GAS LUBRICATED FOIL JOURNAL BEARINGS

**Matthew J. Smith**  
Penn State University  
Mechanical Engineering  
Graduate, Masters  
**Mentor: Dr. Adam Howard**

## ABSTRACT

The Oil-Free Turbomachinery Program at the NASA Glenn Research center is committed to, revolutionary improvements in performance, efficiency and reliability of turbomachinery propulsion systems. One of the key breakthroughs by which this goal is being achieved is the maturation of air lubricated foil bearing technology. Through experimental testing, foil bearings have demonstrated a variety of exceptional qualities that show them to have an important role in the future of rotordynamic lubrication. Most of the work done with foil bearings thus far has considered ambient air at atmospheric pressure as the working fluid or lubricating fluid in the bearing. However, special applications of oil-free technology require the use of air at non-standard ambient conditions or completely different working fluids altogether.

The NASA Jupiter Icy Moon Orbiter program presents power generation needs far beyond that of any previous space exploration effort. The proposed spacecraft will require significant power generation to provide the propulsion necessary to reach the moons of Jupiter and navigate between them. Once there, extensive scientific research will be conducted that will also present significant power requirements. Such extreme needs require exploring a new method for power generation in space. A proposed solution involves a Brayton cycle nuclear fission reactor. The nature of this application requires reliable performance of all reactor components for many years of operation under demanding conditions. This includes the bearings which will be operating with an alternative working fluid that is a combination of Helium and Xenon gases commonly known as HeXe. This fluid has transport and thermal properties that vary significantly from that of air and the effect of these property differences on bearing performance must be considered.

One of the most promising applications of oil-free technology is in aircraft turbine engines. Eliminating the oil supply systems from aircraft engines will lead to significant weight and maintenance reduction. In such applications, the lubricating fluid will be high altitude air. This air will be at much lower pressure than that at sea level. Again this property change will result in a change in bearing performance, and analysis is required to quantify this effect.

The study of these alternate working fluid properties will be conducted in two ways: analytically and experimentally. Analytical research will include the use of a mathematical code that can predict film thickness profiles for various ambient conditions. Estimations of load capacity can be made based upon the film thickness trends. These values will then be compared to those obtained from classical rigid bearing analysis. Experimental Research will include testing a foil bearing at a variety of ambient air pressures. The analytical and experimental data will be compared to draw conclusions on bearing performance under alternate working fluid properties.

# Effect of Detonation through a Turbine Stage

Matthew T. Ellis  
Purdue University  
Aerospace Engineering  
Graduate Student  
Mentor: Dr. Dale E. Van Zante

## ABSTRACT

Pulse detonation engines (PDE) have been investigated as a more efficient means of propulsion due to its constant volume combustion rather than the more often used constant pressure combustion of other propulsion systems. It has been proposed that a hybrid PDE-gas turbine engine would be a feasible means of improving the efficiency of the typical constant pressure combustion gas turbine cycle. In this proposed system, multiple pulse detonation tubes would replace the conventional combustor. Also, some of the compressor stages may be removed due to the pressure rise gained across the detonation wave.

The benefits of higher thermal efficiency and reduced compressor size may come at a cost. The first question that arises is the unsteadiness in the flow created by the pulse detonation tubes. A constant pressure combustor has the advantage of supplying a steady and large mass flow rate. The use of the pulse detonation tubes will create an unsteady mass flow which will have currently unknown effects on the turbine located downstream of the combustor. Using multiple pulse detonation tubes will hopefully improve the unsteadiness. The interaction between the turbine and the shock waves exiting the tubes will also have an unknown effect. Noise levels are also a concern with this hybrid system.

These unknown effects are being investigated using TURBO, an unsteady turbomachinery flow simulation code developed at Mississippi State University. A baseline case corresponding to a system using a constant pressure combustor with the same mass flow rate achieved with the pulse detonation hybrid system will be investigated first.

## **Investigation of the Environmental Durability of a Powder Metallurgy Material**

**La'Nita D. Ward**  
Spelman College  
Chemistry/Mathematics  
Undergraduate, Junior  
**Mentor: Dr. Malcolm K. Stanford**

### **ABSTRACT**

PM304 is a NASA-developed composite powder metallurgy material that is being developed for high temperature applications such as bushings in high temperature industrial furnace conveyor systems. My goal this summer was to analyze and evaluate the effects that heat exposure had on the PM304 material at 500°C and 650°C. The material is composed of Ni-Cr, Ag, Cr<sub>2</sub>O<sub>3</sub>, and eutectic BaF<sub>2</sub>-CaF<sub>2</sub>. PM304 is designed to eliminate the need for oil based lubricants in high temperature applications, while reducing friction and wear. However, further investigation was needed to thoroughly examine the properties of PM304.

The effects of heat exposure on PM304 bushings were investigated. This investigation was necessary due to the high temperatures that the material would be exposed to in a typical application. Each bushing was cut into eight sections. The specimens were heated to 500°C or 650°C for time intervals from 1 hr to 5,000 hrs. Control specimens were kept at room temperature.

Weight and thickness measurements were taken before and after the bushing sections were exposed to heat. Then the heat treated specimens were mounted and polished side by side with the control specimens. This enabled optical examination of the material's microstructure using a metallograph. The specimens were also examined with a scanning electron microscope (SEM). The microstructures were compared to observe the effects of the heat exposure.

Chemical analysis was done to investigate the interactions between Ni-Cr and BaF<sub>2</sub>-CaF<sub>2</sub> and between Cr<sub>2</sub>O<sub>3</sub> and BaF<sub>2</sub>-CaF<sub>2</sub> at high temperature. To observe this, the two compounds that were being analyzed were mixed in a crucible in varied weight percentages and heated to 1100°C in a furnace for approximately two hours. Then the product was allowed to cool and was then analyzed by X-ray diffraction. Interpretation of the results is in progress.

**THE MONITORING SYSTEM FOR VIBRATORY DISTURBANCE DETECTION  
IN MICROGRAVITY ENVIRONMENT  
ABOARD THE INTERNATIONAL SPACE STATION**

**Rachel M. Laster**  
Kentucky State University  
Computer Science/ Liberal Studies  
Undergraduate Level, Senior  
**Mentor: Kenol Jules**

**ABSTRACT**

Scientists in the Office of Life and Microgravity Sciences and Applications within the Microgravity Research Division oversee studies in important physical, chemical, and biological processes in microgravity environment. Research is conducted in microgravity environment because of the beneficial results that come about for experiments. When research is done in normal gravity, scientists are limited to results that are affected by the gravity of Earth. Microgravity provides an environment where solid, liquid, and gas can be observed in a natural state of free fall and where many different variables are eliminated.

One challenge that NASA faces is that space flight opportunities need to be used effectively and efficiently in order to ensure that some of the most scientifically promising research is conducted. Different vibratory sources are continually active aboard the International Space Station (ISS). Some of the vibratory sources include crew exercise, experiment setup, machinery startup (life support fans, pumps, freezer/compressor, centrifuge), thruster firings, and some unknown events. The Space Acceleration Measurement System (SAMS), which acts as the hardware and carefully positioned aboard the ISS, along with the Microgravity Environment Monitoring System (MEMS), which acts as the software and is located here at NASA Glenn, are used to detect these vibratory sources aboard the ISS and recognize them as disturbances. The various vibratory disturbances can sometimes be harmful to the scientists' different research projects. Some vibratory disturbances are recognized by the MEMS's database and some are not. Mainly, the unknown events that occur aboard the International Space Station are the ones of major concern.

To better aid in the research experiments, the unknown events are identified and verified as unknown events. Features, such as frequency, acceleration level, time and date of recognition of the new patterns are stored in an Excel database. My task is to carefully synthesize frequency and acceleration patterns of unknown events within the Excel database into a new file to determine whether or not certain information that is received is considered a real vibratory source. Once considered as a vibratory source, further analysis is carried out. The resulting information is used to retrain the MEMS to recognize them as known patterns.

These different vibratory disturbances are being constantly monitored to observe if, in any way, the disturbances have an effect on the microgravity environment that research experiments are exposed to. If the disturbance has little or no effect on the experiments, then research is continued. However, if the disturbance is harmful to the experiment, scientists act accordingly by either minimizing the source or terminating the research and neither NASA's time nor money is wasted.

# VISUALIZING ULTRASOUND THROUGH COMPUTATIONAL MODELING

**Theresa W. Guo**

Massachusetts Institute of Technology

Mechanical Engineering

Undergraduate, Sophomore

**Mentor: Jerry G. Myers**

## ABSTRACT

The Doppler Ultrasound Hematocrit Project (DHP) hopes to find non-invasive methods of determining a person's blood characteristics. Because of the limits of microgravity and the space travel environment, it is important to find non-invasive methods of evaluating the health of persons in space. Presently, there is no well developed method of determining blood composition non-invasively. This projects hopes to use ultrasound and Doppler signals to evaluate the characteristic of hematocrit, the percentage by volume of red blood cells within whole blood. These non-invasive techniques may also be developed to be used on earth for trauma patients where invasive measure might be detrimental.

Computational modeling is a useful tool for collecting preliminary information and predictions for the laboratory research. We hope to find and develop a computer program that will be able to simulate the ultrasound signals the project will work with. Simulated models of test conditions will more easily show what might be expected from laboratory results thus help the research group make informed decisions before and during experimentation.

There are several existing Matlab based computer programs available, designed to interpret and simulate ultrasound signals. These programs will be evaluated to find which is best suited for the project needs. The criteria of evaluation that will be used are 1) the program must be able to specify transducer properties and specify transmitting and receiving signals, 2) the program must be able to simulate ultrasound signals through different attenuating mediums, 3) the program must be able to process moving targets in order to simulate the Doppler effects that are associated with blood flow, 4) the program should be user friendly and adaptable to various models. After a computer program is chosen, two simulation models will be constructed. These models will simulate and interpret an RF data signal and a Doppler signal.

**Research Symposium I  
Ohio Aerospace Institute  
Wednesday, July 7, 2004**

**OAI Industry Room**

9:00 A.M. **Daniel Thompson, Ohio Wesleyan University, Sophomore**

“Computing and Combustion”

5800/Dhanireddy Reddy, Turbomachinery and Propulsion Systems Division

9:15 **William Jordan, University of Kentucky, Senior**

“Certification of CFD Heat Transfer Software for Turbine Blade Analysis”

5820/Ali Ameri, Turbine Branch

9:30 **Michelle Moreno, University of Texas-Pan Am, Junior**

“Calibration, Data Acquisition, and Post Analysis of Turbulent Fluid Flow in a Calibration Jet Using Hot-Wire Anemometry”

5820/Robert Boyle, Turbine Branch

9:45 **Walter Kiefer, University of Akron, Senior**

“Validation of CFD/Heat Transfer Software for Turbine Blade Analysis”

5820/James Heidmann, Turbine Branch

10:00 **Eric Bishop, Ohio State University, PhD**

“Combustion Branch Website Development”

5830/Chi-Ming Lee, Combustion Branch

10:15 **Edward Summers, Massachusetts Institute of Technology, Freshman**

“Development of Message Passing Routines for High Performance Parallel Computations”

5830/Jinho Lee, Combustion Branch

10:30 **Brian Parma, Arizona State University, Senior**

“Numerical Modeling and Testing of an Inductively-Driven and High-Energy Pulsed Plasma Thrusters”

5430/Hani Kamhawi, On-Board Propulsion Branch

10:45 **Scott Trapp, University of Toledo, Senior**

“Jupiter Icy Moons Orbiter (JIMO) Electrical Systems Testbed”

5450/Ramon Lebron-Velilla, Electrical Systems Development Branch

11:00 **LUNCH**

1:00 **Rayna Rogers, University of Dayton, Junior**

“Computer Graphic Design using Auto-CAD and Plug Nozzle Research”

5860/Albert Johns, Nozzle Branch

1:15 **Jennifer Suder, University of Akron, Junior**

“Reformer Fuel Injector”

5870/Thomas Tomsik, Propellant Systems Technology Branch

**1:30 Ryan Foster, University of Michigan, Sophomore**

“Simplifying CEA through Excel, VBA, and Subeq”

5880/Russell Claus, Engine Systems Technology Branch

**1:45 Sampa Kundu, Cleveland State University, Senior**

“The Fluids and Combustion Facility”

6701/Janice Gassaway, Business Management Office

**2:00 Shauna Mintz, University of Akron, Junior**

“Safety Aboard the International Space Station”

6711/Michael Hicks, Microgravity Combustion Science Branch

**2:15 James King, Fayetteville State University, Junior**

“Soot Nanostructure: Using Fringe Analysis Software on High Resolution Transmission Electron Microscopy of Carbon Soot”

6711/Randall Vanderwal, Microgravity Combustion Science Branch

**2:30 Patrick Bozym, University of Illinois, Senior**

“Exploring Space on the Computer”

6711/Dennis Stocker, Microgravity Combustion Science Branch

**2:45 Idoreyin Montague, Shaw University, Junior**

“Regulation of Vascular Growth in the Chorioallantoic Membrane of Japanese Quail Eggs”

6712/Patricia Parsons-Wingerter, Microgravity Fluid Physics Branch

**3:00 Genee Smith, Fayetteville State University, Sophomore**

“The Fractal-based Analysis of the Regulation of Vascular Remodeling in the Quail Chorioallantoic Membrane”

6712/Patricia Parsons-Wingerter, Microgravity Fluid Physics Branch

**3:15 Julian Logan, Morehouse College, Sophomore**

“Practical Pocket PC Application w/ Biometric Security”

7140/Tammy Blaser, Flight Software Engineering Branch

**3:30 ADJOURN**

## COMPUTING AND COMBUSTION

**Daniel Thompson**  
Ohio Wesleyan University  
Computer Science  
Undergraduate Sophomore  
**Mentor: Dhanireddy Reddy**

### ABSTRACT

Coming into the Combustion Branch of the Turbomachinery and Propulsion Systems Division, there was not any set project planned out for me to work on. This was understandable, considering I am only at my sophomore year in college. Also, my mentor was a division chief and it was expected that I would be passed down the line. It took about a week for me to be placed with somebody who could use me.

My first project was to write a macro for TecPlot. Commonly, a person would have a 3D contour volume modeling something such as a combustion engine. This 3D volume needed to have slices extracted from it and made into 2D scientific plots with all of the appropriate axis and titles. This was very tedious to do by hand. My macro needed to automate the process.

There was some education I needed before I could start, however. First, TecPlot ran on Unix and Linux, like a growing majority of scientific applications. I knew a little about Linux, but I would need to know more to use the software at hand. I took two classes at the Learning Center on Unix and am now comfortable with Linux and Unix.

I already had taken Computer Science I and II, and had undergone the transformation from Computer Programmer to Procedural Epistemologist. I knew how to design efficient algorithms, I just needed to learn the macro language. After a little less than a week, I had learned the basics of the language. Like most languages, the best way to learn more of it was by using it.

It was decided that it was best that I do the macro in layers, starting simple and adding features as I went. The macro started out slicing with respect to only one axis, and did not make 2D plots out of the slices. Instead, it lined them up inside the solid. Next, I allowed for more than one axis and placed each slice in a separate frame. After this, I added code that transformed each individual slice-frame into a scientific plot. I also made frames for composite volumes, which showed all of the slices in the same XYZ space. I then designed an additional companion macro that exported each frame into its own image file. I then distributed the macros to a test group, and am awaiting feedback.

In the meantime, I am researching the possible applications of distributed computing on the National Combustor Code. Many of our Linux boxes were idle for most of the day. The department thinks that it would be wonderful if we could get all of these idle processors to work on a problem under the NCC code. The client software would have to be easily distributed, such as in screensaver format or as a program that only ran when the computer was not in use. This project proves to be an interesting challenge.



# CERTIFICATION OF CFD HEAT TRANSFER SOFTWARE FOR TURBINE BLADE ANALYSIS

**William A. Jordan**  
University of Kentucky  
Mechanical Engineering  
Senior  
**Mentor: Ali A. Ameri**

## ABSTRACT

Accurate modeling of heat transfer effects is a critical component of the Turbine Branch of the Turbomachinery and Propulsion Systems Division. Being able to adequately predict and model heat flux, coolant flows, and peak temperatures are necessary for the analysis of high pressure turbine blades. To that end, the primary goal of my internship this summer will be to certify the reliability of the CFD program *GlennHT* for the purpose of turbine blade heat transfer analysis.

*GlennHT* is currently in use by the engineers in the Turbine Branch who use the FORTRAN 77 version of the code for analysis. The program, however, has been updated to a FORTRAN 90 version which is more robust than the older code. In order for the new code to be distributed for use, its reliability must first be certified. Over the course of my internship I will create and run test cases using the FORTRAN 90 version of *GlennHT* and compare the results to older cases which are known to be accurate. If the results of the new code match those of the sample cases then the newer version will be one step closer to certification for distribution.

In order to complete these tests it will first be necessary to become familiar with operating a number of other programs. Among them are *GridPro*, which is used to create a grid mesh around a blade geometry, and *FieldView*, whose purpose is to graphically display the results from the *GlennHT* program. Once enough familiarity is established with these programs to render them useful, then the work of creating and running test scenarios will begin.

The work is additionally complicated by a transition in computer hardware. Most of the working computers in the Turbine Branch are Silicon Graphics machines, which will soon be replaced by LINUX PC's. My project is one of the first to make use the new PC's. The change in system architecture however, has created several software related issues which have greatly increased the time and effort investments required by the project.

Although complications with the project continue to arise, it is expected that the goal of my internship can still be achieved within the remaining time period. Critical steps have been achieved and test scenarios can now be designed and run. At the completion of my internship, the FORTRAN 90 version of *GlennHT* should be well on its way to certification.

# **Calibration, Data Acquisition, and Post Analysis of Turbulent Fluid Flow in a Calibration Jet Using Hot-Wire Anemometry**

**Michelle Moreno**

University of Texas Pan American

Mechanical Engineering

Undergraduate Junior

**Mentor: Robert Boyle**

## **ABSTRACT**

The Turbine Brach concentrates on the following areas: Computational Fluid Dynamics (CFD), and implementing experimental procedures to obtain physical modeling data. Hot-Wire Anemometry is a valuable tool for obtaining physical modeling data.

Hot-Wire Anemometry is likely to remain the principal research tool for most turbulent air/gas flow studies. The Hot-Wire anemometer consists of a fine wire heated by electric current. When placed in a fluid stream, the hot-wire loses heat to the fluid by forced convection. In forced convection, energy transfer is due to molecular motion imposed by an extraneous force moving fluid parcels. When the hot-wire is in "equilibrium", the rate of heat input to the wire is equal to the rate of heat loss at the wire ends. The equality between heat input and heat loss is the basis for King's equation, which relates the electrical parameters of the hot-wire to the flow parameters of the fluid.

Hot-Wire anemometry is based on convective heat transfer from a heated wire element placed in a fluid flow. Any change in the fluid flow condition that affects the heat transfer from the heated element will be detected virtually instantaneously by a constant-temperature Hot-Wire anemometry system. The system implemented for this research is the IFA 300. The system is a fully-integrated, thermal anemometer-based system that measures mean and fluctuating velocity components in air, water, and other fluids. It also measures turbulence and makes localized temperature measurements.

A constant-temperature anemometer is a bridge and amplifier circuit that controls a tiny wire at constant temperature. As a fluid flow passes over the heated sensor, the amplifier senses the bridge off-balance and adjusts the voltage to the top of the bridge, keeping the bridge in balance. The voltage on top of the bridge can then be related to the velocity of the flow. The bridge voltage is sensitive to temperature as well as velocity and so the built-in thermocouple circuit can be attached to a thermocouple that can measure the fluid temperature. This temperature reading can then be used by the software to correct the results to minimize the effect of temperature.

The working apparatus will contain the necessary components to run the system appropriately. A calibration jet will be used to create turbulent flow. A hot-wire will be placed 4 diameter distances from the exit, and data will be acquired using the IFA 300 software named Thermo Pro. Through Thermo Pro, one can calibrate the necessary hot-wire probes, acquire data, and analyze the collected data. The data will be compared to a similar test performed using Pitot - static tube measuring pressure changes. Using Bernoulli's equation, which relates pressure and velocity changes, both sets of data will be compared to see the exactness of the system.

The goal for summer 2004 is to be familiar with IFA 300, implement the software, acquire suitable data, and make relevant comparisons to similar models. Once the system runs accordingly, a training manual will be created for future use.

# VALIDATION OF CFD/HEAT TRANSFER SOFTWARE FOR TURBINE BLADE ANALYSIS

**Walter D. Kiefer**

The University of Akron  
Mechanical Engineering and Applied Math  
Undergraduate, Senior

**Mentor: James Heidmann**

## ABSTRACT

I am an intern in the Turbine Branch of the Turbomachinery and Propulsion Systems Division. The division is primarily concerned with experimental and computational methods of calculating heat transfer effects of turbine blades during operation in jet engines and land-based power systems. These include modeling flow in internal cooling passages and film cooling, as well as calculating heat flux and peak temperatures to ensure safe and efficient operation. The branch is research-oriented, emphasizing the development of tools that may be used by gas turbine designers in industry.

The branch has been developing a computational fluid dynamics (CFD) and heat transfer code called *GlennHT* to achieve the computational end of this analysis. The code was originally written in FORTRAN 77 and run on Silicon Graphics machines. However the code has been re-written and compiled in FORTRAN 90 to take advantage of more modern computer memory systems. In addition the branch has made a switch in system architectures from SGI's to Linux PC's. The newly modified code therefore needs to be tested and validated. This is the primary goal of my internship.

To validate the *GlennHT* code, it must be run using benchmark fluid mechanics and heat transfer test cases, for which there are either analytical solutions or widely accepted experimental data. From the solutions generated by the code, comparisons can be made to the correct solutions to establish the accuracy of the code. To design and create these test cases, there are many steps and programs that must be used.

Before a test case can be run, pre-processing steps must be accomplished. These include generating a grid to describe the geometry, using a software package called *GridPro*. Also various files required by the *GlennHT* code must be created including a boundary condition file, a file for multi-processor computing, and a file to describe problem and algorithm parameters. After the case is run to completion, post-processing must then be accomplished. The software package for this step is called *FieldView* which is used to view the solution graphically, as well as generate relevant data of the solution for analysis and comparison. A good deal of this internship will be to become familiar with these programs and the structure of the *GlennHT* code, as well as dealing with the problems associated with the change in system architecture.

The end goal of my internship will be to create and organize a collection of test cases to validate the *GlennHT* code. These will include various plots to demonstrate the accuracy of the code, as well as sufficient documentation to describe the procedures required to run these cases, and technical difficulties encountered and their solutions, so that future work may be done on the basis of this earlier experience. At this point the *GlennHT* code should be well on its way towards validation and certification for use in industry.

# **Combustion Branch Website Development**

**Eric Bishop**  
Boston University  
Bionformatics  
First Year Graduate Student  
**Mentor: Chi-Ming Lee**

The NASA combustion branch is a leader in developing and applying combustion science to focused aerospace propulsion systems concepts. It is widely recognized for unique facilities, analytical tools, and personnel. In order to better communicate the outstanding research being done in this Branch to the public and other research organization, a more substantial website was desired. The objective of this project was to build an up-to-date site that reflects current research in a usable and attractive manner.

In order to accomplish this, information was requested from all researchers in the Combustion branch, on their professional skills and on the current projects. This information was used to fill in the Personnel and Research sections of the website. A digital camera was used to photograph all personnel and these photographs were included in the personnel section as well.

The design of the site was implemented using the latest web standards: xhtml and external css stylesheets. This implementation conforms to the guidelines recommended by the w3c. It also helps to ensure that the web site is accessible by disabled users, and complies with Section 508 Federal legislation (which mandates that all Federal websites be accessible).

Graphics for the new site were generated using the gimp ([www.gimp.org](http://www.gimp.org)) an open-source graphics program similar to Adobe Photoshop. Also, all graphics on the site were of a reasonable size (less than 20k, most less than 2k) so that the page would load quickly.

Technologies such as Macromedia Flash and Javascript were avoided, as these only function on some clients which have the proper software installed or enabled.

The website was tested on different platforms with many different browsers to ensure there were no compatibility issues. The website was tested on windows with MS IE 6, MSIE 5, Netscape 7, Mozilla and Opera. On a Mac, the site was tested with MS IE 5, Netscape 7 and Safari.

# **DEVELOPMENT OF MESSAGE PASSING ROUTINES FOR HIGH PERFORMANCE PARALLEL COMPUTATIONS**

**Edward K. Summers**  
Massachusetts Institute of Technology  
Engineering  
Undergraduate, Freshman  
**Mentor: Jinho Lee, Ph.D.**

## **ABSTRACT**

Computational Fluid Dynamics (CFD) calculations require a great deal of computing power for completing the detailed computations involved. In an effort shorten the time it takes to complete such calculations they are implemented on a parallel computer.

In the case of a parallel computer some sort of message passing structure must be used to communicate between the computers because, unlike a single machine, each computer in a parallel computing cluster does not have access to all the data or run all the parts of the total program. Thus, message passing is used to divide up the data and send instructions to each machine.

The nature of my work this summer involves programming the "message passing" aspect of the parallel computer. I am working on modifying an existing program, which was written with OpenMP, and does not use a multi-machine parallel computing structure, to work with Message Passing Interface (MPI) routines. The actual code is being written in the FORTRAN 90 programming language.

My goal is to write a parameterized message passing structure that could be used for a variety of individual applications and implement it on Silicon Graphics Incorporated's (SGI) IRIX operating system.

With this new parameterized structure engineers would be able to speed up computations for a wide variety of purposes without having to use larger and more expensive computing equipment from another division or another NASA center.

# **Numerical Modeling and Testing of an Inductively-Driven and High-Energy Pulsed Plasma Thrusters**

**Brian Parma**

Arizona State University  
Aerospace Engineering  
Senior

**Mentor: Hani Kamhawi**

## **ABSTRACT**

Pulsed Plasma Thrusters (PPTs) are advanced electric space propulsion devices that are characterized by simplicity and robustness. They suffer, however, from low thrust efficiencies. This summer, two approaches to improve the thrust efficiency of PPTs will be investigated through both numerical modeling and experimental testing.

The first approach, an inductively-driven PPT, uses a double-ignition circuit to fire two PPTs in succession. This effectively changes the PPTs' configuration from an LRC circuit to an LR circuit. The LR circuit is expected to provide better impedance matching and improving the efficiency of the energy transfer to the plasma. An added benefit of the LR circuit is an exponential decay of the current, whereas a traditional PPT's under damped LRC circuit experiences the characteristic "ringing" of its current. The exponential decay may provide improved lifetime and sustained electromagnetic acceleration.

The second approach, a high-energy PPT, is a traditional PPT with a variable size capacitor bank. This PPT will be simulated and tested at energy levels between 100 and 450 joules in order to investigate the relationship between efficiency and energy level.

For the numerical modeling, a two-dimensional, axisymmetric Multi-Block Arbitrary Coordinate Hydromagnetic (MACH2) code is used. The MACH2 code, designed by the Center for Plasma Theory and Computation at the Air Force Research Laboratory, has been used to gain insight into a variety of plasma problems, including electric plasma thrusters. The goals for this summer include numerical predictions of performance for both the inductively-driven PPT and high-energy PPT, experimental validation of the numerical models, and numerical optimization of the designs. These goals will be met through numerical and experimental investigation of the PPTs' current waveforms, mass loss (or ablation), and impulse bit characteristics.

# JUPITER ICY MOONS ORBITER (JIMO) ELECTRICAL SYSTEMS TESTBED

**Scott J. Trapp**  
University of Toledo  
Electrical Engineering  
Undergraduate  
**Mentor: Ramon Lebron**

## ABSTRACT

The Jupiter Icy Moons Orbiter (JIMO) mission will send a spacecraft to explore three of Jupiter's moons (Callisto, Ganymede, and Europa), all of which show evidence of containing vast subterranean oceans beneath their icy surfaces. The evidence of these oceans was discovered by Galileo, and the moons are believed to have the three essential ingredients for life: water, energy, and the necessary chemical elements. Galileo has shown that melted water on Europa has been in contact with the surface of the moon in geologically recent times, and may still lie relatively close to the surface.

This project will also introduce a revolutionary new form of electric propulsion powered by a nuclear fission reactor. This electric propulsion is called ion propulsion. It was used on a previous mission called Deep Space 1, proving that ion propulsion works for interplanetary travel. Since JIMO will be traveling farther from the sun, solar power will be difficult to supply the electric energy demanded by the mission. Therefore a nuclear reactor and a thermo-electric converter system will be necessary.

Besides making the trip to three of Jupiter's moons – one after the other – a realistic possibility, this new form of power and propulsion opens up the rest of the outer solar system for future exploration. JIMO will fulfill its goals by exploring Europa first, with subsequent trips to the moons Callisto and Ganymede in order to provide comparisons key to understanding the evolution of all three.

In order to ensure the stability and proper preparation of the electrical system on JIMO, the High Power AC Power Management and Distribution (PMAD) Test Bed is being developed. The testing on this AC PMAD will consist of electrical performance verification of candidate power system components. Examples of these components are: high power AC switchgear, high power AC/DC converters, AC power distribution units, DC power distribution units, etc.

Throughout the course of the summer the over-current control circuit for the five different size relays will be constructed and tested. This circuit will sense the current input to the spacecraft loads and automatically switch off power if the current is too high. Once the circuit is verified to function properly and all necessary modifications have been made, a circuit schematic and board layout will have to be drawn using OrCAD, and the circuits will have to be built.

## **Computer Graphic design using Auto-CAD and Plug Nozzle Research**

**Rayna C. Rogers**  
University of Dayton  
Mechanical Engineering  
Undergraduate, Junior  
**Mentor: Albert L. Johns**

### **ABSTRACT**

The purpose of creating computer generated images varies widely. They can be use for computational fluid dynamics (CFD), or as a blueprint for designing parts. The schematic that I will be working on the summer will be used to create nozzles that are a part of a larger system. At this phase in the project, the nozzles needed for the systems have been fabricated. One part of my mission is to create both three dimensional and two dimensional models on Auto-CAD 2002 of the nozzles.

The research on plug nozzles will allow me to have a better understanding of how they assist in the thrust need for a missile to take off. NASA and the United States military are working together to develop a new design concept. On most missiles a convergent-divergent nozzle is used to create thrust. However, the two are looking into different concepts for the nozzle. The standard convergent-divergent nozzle forces a mixture of combustible fluids and air through a smaller area in comparison to where the combination was mixed. Once it passes through the smaller area known as A8 it comes out the end of the nozzle which is larger the first or area A9. This creates enough thrust for the mechanism whether it is an F-18 fighter jet or a missile. The A9 section of the convergent-divergent nozzle has a mechanism that controls how large A9 can be. This is needed because the pressure of the air coming out nozzle must be equal to that of the ambient pressure other wise there will be a loss of performance in the machine. The plug nozzle however does not need to have an A9 that can vary. When the air flow comes out it can automatically sense what the ambient pressure is and will adjust accordingly.

The objective of this design is to create a plug nozzle that is not as complicated mechanically as it counterpart the convergent-divergent nozzle.



## REFORMER FUEL INJECTOR

Jennifer L. Suder  
The University of Akron  
Chemical Engineering  
Undergraduate, Junior

Today's form of jet engine power comes from what is called a gas turbine engine. This engine is on average 14% efficient and emits great quantities of green house gas carbon dioxide and air pollutants, i.e. nitrogen oxides and sulfur oxides. The alternate method being researched involves a reformer and a solid oxide fuel cell (SOFC). Reformers are becoming a popular area of research within the industry scale. NASA Glenn Research Center's approach is based on modifying the large aspects of industry reforming processes into a smaller jet fuel reformer. This process must not only be scaled down in size, but also decrease in weight and increase in efficiency. In comparison to today's method, the Jet A fuel reformer will be more efficient as well as reduce the amount of air pollutants discharged.

The intent is to develop a 10kW process that can be used to satisfy the needs of commercial jet engines. Presently, commercial jets use Jet-A fuel, which is a kerosene based hydrocarbon fuel. Hydrocarbon fuels cannot be directly fed into a SOFC for the reason that the high temperature causes it to decompose into solid carbon and H<sub>2</sub>. A reforming process converts fuel into hydrogen and supplies it to a fuel cell for power, as well as eliminating sulfur compounds. The SOFC produces electricity by converting H<sub>2</sub> and CO<sub>2</sub>. The reformer contains a catalyst which is used to speed up the reaction rate and overall conversion. An outside company will perform a catalyst screening with our baseline Jet-A fuel to determine the most durable catalyst for this application.

Poor feed mixing within the reformer effects the distribution of temperature, which can cause a deposit of carbon residue resulting in poor reformer performance and conversion efficiency. The first phase of the project is dedicated to designing a steam, fuel, and air injector and testing several in order to prevent these carbon residue deposits. The injectors will have a separate test run with a quartz tube and laser diagnostics that will analyze the mixing properties of the designed injectors. These will then be used to inject various mixtures of steam, fuel and air into the reformers.

Our project team is focusing on the overall research of the reforming process. Eventually we will do a component evaluation on the different reformer designs and catalysts. The current status of the project is the completion of buildup in the test rig and check outs on all equipment and electronic signals to our data system. The objective is to test various reformer designs and catalysts in our test rig to determine the most efficient configuration to incorporate into the specific compact jet fuel reformer test rig.

## **Simplifying CEA through Excel, VBA, and Subeq**

**Ryan Foster**  
University of Michigan  
Computer Science  
Undergraduate, Sophomore  
**Mentor: Russ Claus**

### **ABSTRACT**

Many people use compound equilibrium programs for very different reasons, varying from refrigerators to light bulbs to rockets. A commonly used equilibrium program is CEA. CEA can take various inputs such as pressure, temperature, and volume along with numerous reactants and run them through equilibrium equations to obtain valuable output information, including products formed and their relative amounts.

A little over a year ago, Bonnie McBride created the program subeq with the goal to simplify the calling of CEA. Subeq was also designed to be called by other programs, including Excel, through the use of Visual Basic for Applications (VBA).

The largest advantage of using Excel is that it allows the user to input the information in a colorful and user-friendly environment while allowing VBA to run subeq, which is in the form of a FORTRAN DLL (Dynamic Link Library). Calling subeq in this form makes it much faster than if it was converted to VBA.

Since subeq requires such large lists of reactant and product names, all of which can't be passed in as an array, subeq had to be changed to accept very long strings of reactants and products. To pass this string and adjust the transfer of input and output parameters, the subeq DLL had to be changed. One program that does this is Compaq Visual FORTRAN, which allows DLLs to be edited, debugged, and compiled. Compaq Visual FORTRAN uses FORTRAN 90/95, which has additional features to that of FORTRAN 77.

My goals this summer include finishing up the excel spreadsheet of subeq, which I started last summer, and putting it on the internet so that others can use it without having to download my spreadsheet. To finish up the spreadsheet I will need to work on debugging current options and problems. I will also work on making it as robust as possible, so that all errors that may arise will be clearly communicated to the user. New features will be added old ones will be changed as I receive comments from people using the spreadsheet. To implement this onto the Internet, I will need to develop an XML input/output format and learn how to write HTML.

## THE FLUIDS AND COMBUSTION FACILITY

**Sampa Kundu**

Cleveland State University

Accounting

Undergraduate, Senior

**Mentor: Janice K. Gassaway**

### ABSTRACT

Microgravity is an environment with very weak gravitational effects. The Fluids and Combustion Facility (FCF) on the International Space Station (ISS) will support the study of fluid physics and combustion science in a long-duration microgravity environment.

The Fluid Combustion Facility's design will permit both independent and remote control operations from the Telescience Support Center. The crew of the International Space Station will continue to insert and remove the experiment module, store and reload removable data storage and media data tapes, and reconfigure diagnostics on either side of the optics benches. Upon completion of the Fluids Combustion Facility, about ten experiments will be conducted within a ten-year period.

Several different areas of fluid physics will be studied in the Fluids Combustion Facility. These areas include complex fluids, interfacial phenomena, dynamics and instabilities, and multiphase flows and phase change. Recently, emphasis has been placed in areas that relate directly to NASA missions including life support, power, propulsion, and thermal control systems. By 2006 or 2007, a Fluids Integrated Rack (FIR) and a Combustion Integrated Rack (CIR) will be installed inside the International Space Station.

The Fluids Integrated Rack will contain all the hardware and software necessary to perform experiments in fluid physics. A wide range of experiments that meet the requirements of the international space station, including research from other specialties, will be considered. Experiments will be contained in subsystems such as the international standard payload rack, the active rack isolation system, the optics bench, environmental subsystem, electrical power control unit, the gas interface subsystem, and the command and data management subsystem.

Just like the Fluids Integrated Rack, the Combustion Integrated Rack is composed of several subsystems. These subsystems are the international standard payload rack, the optics bench, the combustion chamber, the diagnostics measurements system, the fuel/oxidizer, management assembly, the electrical power system, the environmental control systems, and the command and data management system. Some of the areas that will likely be studied include fire prevention, detection, and suppression, incineration of solid waste, power generation, flame spread, soot and polycyclic aromatic hydrocarbons, and materials synthesis. Similar investigations will be flown together whenever possible. Multi-user chamber inserts will be used to support experiments in droplets, solids, and gaseous fluids.

In conclusion, the Fluids and Combustion Facility will allow researchers to study fluid physics and combustion science in a long-duration microgravity environment.

# **SAFETY ABOARD THE INTERNATIONAL SPACE STATION**

**Shauna M. Mintz**  
University of Akron  
Mechanical Engineering  
Undergraduate  
**Mentor: Mike Hicks**

## **ABSTRACT**

As with any task that NASA takes on, safety is of utmost importance. There are pages of safety codes and procedures that must be followed before any idea can be brought to life. Unfortunately, the International Space Station's (ISS) safety regulations and procedures are based on 1g standards rather than on 0g. To aide in making this space age "home away from home" a less hazardous environment, I worked on several projects revolving around the dangers of flammable items in microgravity.

The first task I was assigned was to track flames. This involves turning eight millimeter video recordings, of tests run in the five second drop tower, into avi format on the computer. The footage is then compressed and altered so that the flame can be seen more clearly. Using another program called Spotlight, line profiles were used to collect data describing the luminescence of the flame at different points. These raw data are saved as text files and run through a macro so that a Matlab program can analyze it. By fitting the data to a curve and determining the areas of brightest luminescence, the behavior of the flame can be recorded numerically. After entering the data into a database, researchers can come back later and easily get information on flames resulting from different gas and liquid mixtures in microgravity.

I also worked on phase two of the FATE project, which deals with safety aboard the ISS. This phase involves igniting projected droplets and determining how they react with secondary materials. Such simulations represent, on a small scale, the spread of onboard fires due to the effervescence of burning primary materials. I set up existing hardware to operate these experiments and ran tests with it, photographing the results. I also made CAD drawings of the apparatus and the area available on the (SF)<sup>2</sup> rig for it to fit into. Those drawings were then used to determine how the hardware could be made to fit into the small region allotted for it. The experiment will later be performed on the KC-135, and the results gathered will be used to reanalyze current safety standards for the ISS, including the distance of required separation for flammable materials.

My most exciting project dealt with the droplet generator used for FATE. The current apparatus is very large and bulky. It can, also, possibly produce slightly inaccurate results when droplets are dislodged from the needle, when projected. This is because the system is pressure based. When droplets are made in microgravity they form a ball around the tip of the needle. The droplets are then blown off using air pressure. A piezoelectric droplet generator was determined to be the best route for redesign. Rather than having to blow off the droplet, a quick pulse from the generator would provide enough force to produce a projectile. I spent days researching and networking to find the information needed to understand piezoceramics and make a suitable device. After determining the appropriate design, drawings were put together in AutoCAD and parts were made and ordered. The final product will be included in the experiments sent up on the KC-135.

**Soot Nanostructure: Using Fringe Analysis Software on High Resolution  
Transmission Electron Microscopy of Carbon Soot**

**James D. King**

Fayetteville State University

Double Major in Computer Science and Mathematics

Undergraduate, junior

**Mentor: Randy Vanderwall**

**Abstract**

Using high resolution transmission electron images of carbon nanotubes and carbon particles, we are able to use image analysis program to determine several carbon fringe properties, including length, separation, curvature and orientation. Results are shown in the form of histograms for each of those quantities. The combination of those measurements can give a better indication of the graphic structure within nanotubes and particles of carbon and can distinguish carbons based upon fringe properties. Carbon with longer, straighter and closer spaced fringes are considered graphitice, while amorphous carbon contain shorter, less structured fringes.

## Exploring Space on the Computer

Patrick Bozym  
University of Illinois  
Physics / Nuclear Engineering  
Senior  
**Mentor: Dennis P. Stocker**

For the past year Dennis Stocker has been in the process of developing pencil and paper games, which are fun, challenging, and educational for middle school and high school students. The latest version of these pencil and paper games is Spaceship Commander. The objective of the game is to earn points by plotting the flight path of a spaceship so astronauts can perform microgravity experiments, and make short-range measurements of other planets. During my ten weeks here at the GRC my goal is to create a computer based version of Spaceship commander.

During the development of this game the primary focus has been on making it as educational and fun for the student as possible. The main educational objective of this game is to give students an understanding of forces and motion, including gravity. This is done by incorporating Newton's laws into the game. For example a space craft in the video game experiences a gravitational force applied to it by planets.

The software I am using to create this game is a freeware application called Game Maker. Game Maker allows novice computer programmers like me to create arcade style games using a visual drag and drop interface. By using functions provided by Game Maker and a few I have written myself, I have been able to create a few simple computer games.

Currently the computer game allows the student to navigate a space ship around planets, and asteroids by using the arrow keys on the numeric keypad. Each time an arrow key is pressed by the student the corresponding acceleration of the space ship is seen on the screen. Points are earned by navigating the space ship close enough to planets to gather scientific data. However the game encourages the student to plan his or her course carefully, because if the student gets too close to a planet they may not be able to escape the planet's gravity, and crash into the planet.

The next step in the game development is to include a launch sequence which allows the student to launch from their home planet at a speed and direction determined by the student. In addition to that, I hope to include additional levels, and mission objectives for the student to carry out. When the game is completed it will be posted on the internet as a freeware application. It is hoped that young people who play this game will become more interested in NASA and pursuing careers in science, technology, engineering, and mathematics.

# Regulation of Vascular Growth in the Chorioallantoic Membrane of Japanese Quail Eggs

Idoreyin P. Montague

Shaw University

Physics

Undergraduate

Mentor: Dr. Patricia Parsons-Wingenter

The Microgravity Research Program is part of NASA's Office of Biological and Physical Research (OBPR). The mission of the Microgravity Fluid Physics research program is to facilitate and conduct the best possible fluid physics research using the space environment and make this knowledge available to the scientific community and the public at large.

During the summer of 2004, I worked in this division with Dr. Patricia Parsons-Wingenter. Dr. Parsons was working on several projects that used the chorioallantoic membrane (CAM) of Japanese quail eggs. The CAM develops in the eggs of birds and reptiles and is a very vascular fetal membrane composed of the fused chorion and adjacent wall of the allantois. The CAM is formed on day 4 of incubation and its primary job is to mediate gas exchanges with the extra embryonic environment. The CAM of our Japanese quail eggs is easily identifiable to us because it is transparent and it sits on top of the yolk with the embryo in the center.

The CAM is of interest because of its many applications in the field of medicine as it relates to vascular remodeling and angiogenesis. Angiogenesis is simply the growth or formation of new blood vessels and anti-angiogenesis is the inhibition of said vessels. Angiogenesis occurs naturally in a healthy body for healing wounds and for restoring blood flow to tissues after injury and in females during the monthly reproductive cycle. In many serious diseases, like several types of cancer and those that affect the heart and cardiovascular system, the body loses control over angiogenesis. These diseases, which are dependent on angiogenesis, result when new blood vessels either grow excessively or insufficiently.

The chorioallantoic membrane of our Japanese quail eggs gives a good model of angiogenesis. We used angiogenic regulators to inhibit or stimulate vascular growth in the CAM in a healthy manner and they induced distinct vascular patterns *in vivo*. Certain dominant regulators can be recognized by their unique vascular patterns and from these patterns; we can deduce specific alterations in vascular remodeling and angiogenesis. This will aid us in early-stage diagnosis and customized therapies for patients with angiogenic-dependent diseases.

This particular research is important to NASA because cardiovascular health issues are the second highest of ten categories that have been defined as risk factors in human space exploration. Also, cardiovascular-related diseases have been the leading cause of death in America since 1981. Therefore, this kind of research in the field of cardiovascular health is of great importance to humans on earth and in space.

# **The Fractal-based Analysis of the Regulation of Vascular Remodeling in the Quail Chorioallantoic Membrane**

**Geneé S. Smith**

Fayetteville State University

Biology

Undergraduate, Senior

**Mentor: Patricia Parsons-Wingenter**

## **ABSTRACT**

Critical to the advancement of space exploration is the safety and well being of astronauts while in space. This study focuses on the second highest of NASA-defined risk categories for human space exploration, cardiovascular alterations. Current research of this problem is being tackled by investigating angiogenesis through vascular remodeling. Angiogenesis is the growth and formation of new blood vessels. Angiogenesis is an important part of maintaining normal development and bodily functions. The loss of control of this process, either insufficient or excessive vascular growth, is considered a common denominator in many diseases, such as cancer, diabetes, and coronary artery disease.

Objectives are presently being met by observing the effects of various regulators, like thrombospondin 1 (TSP-1) and a novel vessel tortuosity factor (TF), through the use of the chorioallantoic membrane (CAM) of Japanese quail embryos, which enable the direct optical imaging of 2-dimensional vascular branching trees. Research within the CAM is being performed to deduce numerous methods of regulating vessel growth. This project centers on the ability of a novel vessel regulator to affect angiogenesis. For example, it is hypothesized that the TSP-1 will inhibit the growth of CAM vasculature.

Fractal/VESGEN-based techniques and PIV analysis are the methodologies used to investigate vascular differentiation. This tactic is used to quantify results and measure the growth patterns and morphology of blood vessels. The regulatory mechanisms posed by this vessel regulator can be deduced by alterations found within the vasculature patterns of quail embryos.



# Practical Pocket PC Application w/ Biometric Security

**Julian Logan**

Morehouse College

Computer Science

Undergraduate Junior

**Mentor: Tammy M. Blazer**

## Abstract

I work in the Flight Software Engineering Branch, where we provide design and development of embedded real-time software applications for flight and supporting ground systems to support the NASA Aeronautics and Space Programs. In addition, this branch evaluates, develops and implements new technologies for embedded real-time systems, and maintains a laboratory for applications of embedded technology.

The majority of microchips that are used in modern society have been programmed using embedded technology. These small chips can be found in microwaves, calculators, home security systems, cell phones and more. My assignment this summer entails working with an iPAQ HP 5500 Pocket PC. This top-of-the-line hand-held device is one of the first mobile PC's to introduce biometric security capabilities. Biometric security, in this case a fingerprint authentication system, is on the edge of technology as far as securing information. The benefits of fingerprint authentication are enormous. The most significant of them are that it is extremely difficult to reproduce someone else's fingerprint, and it is equally difficult to lose or forget your own fingerprint as opposed to a password or pin number. One of my goals for this summer is to integrate this technology with another Pocket PC application.

The second task for the summer is to develop a simple application that provides an Astronaut EVA (Extravehicular Activity) Log Book capability. The Astronaut EVA Log Book is what an astronaut would use to report the status of field missions, crew physical health, successes, future plans, etc. My goal is to develop a user interface into which these data fields can be entered and stored. The applications that I am developing are created using eMbedded Visual C++ 4.0 with the Pocket PC 2003 Software Development Kit provided by Microsoft.

**Research Symposium I  
Ohio Aerospace Institute  
Thursday, July 8, 2004**

**OAI Industry Room**

9:00 A.M. **Chante Hill, Tennessee State University, Junior**

“Space Communications Emulation Facility”

7160/Rafael Sanabria, Computational Environments Branch

9:15 **Brandy Hammond, Cleveland State University, Freshman**

“Surface Modeling and Grid Generation for Iced Airfoils (SMAGGICE)”

7170/Herbert Schilling, Computational Sciences Branch

9:30 **Session Break**

9:45 **Kristin Bigach, Lehigh University, Senior**

“The Center Master Plan for NASA Glenn Research Center”

7320/Joseph Morris, Systems Management and Maintenance Branch

10:00 **Ashlie Flegel, University of Toledo, Sophomore**

“The Multistage Compressor Facility”

7610/Hal Weaver, Aviation Environments Test Engineering Branch

10:15 **Grant Lugas, Lorain County Community College, Sophomore**

“Stator Blade Laser Window Research”

7700/John Taylor, Engineering Development Division

10:30 **Brandon Travis, University of Kentucky, Junior**

“Bolt Analysis Program”

7725/Kelly McEntire, Turbomachinery Branch

10:45 **Nathaniel Young III, Prairie View A&M University, Junior**

“Design of Timer Circuit for Dynamic Data System”

7660/Mark Sorrells, Electronic and Special Systems Branch

11:00 **LUNCH**

1:00 **Moline Prak, John Carroll University, Sophomore**

“The Investigation of Carbon Contamination and Sputtering Effects of Xenon Ion Thrusters”

5480/Bruce Banks, Electro-Physics Branch

1:15 **Amanda Opaluch, Wittenberg University, Senior**

“The Use of Pristine and Intercalated Graphite Fiber Composites as Buss Bars in Lead-Acid Batteries”

5480/James Gaier, Electro-Physics Branch

1:30 **Yazmin Gomez Cruz, University of Turabo, Junior**

“Manufacturing BMS/ISO System Review”

7720/Wilma Taylor, Electrical and Avionics Systems Branch

**1:45 Lisa Ritchie, Kent State University, Junior**

**“Flywheel Technology”**

7630/Vicki Crable, Space Power and Propulsion Test Engineering Branch

**2:00 Laura Burke, Case Western Reserve University, Junior**

**“Trajectory Analysis”**

7820/Robert Falck, Systems Analysis Branch

**2:15 Corinne Kellerman, University of Arizona, Sophomore**

**“Website of the Systems and Analysis Branch Supported Projects and Graph Analysis”**

7820/Melissa McGuire, Systems Analysis Branch

**2:30 Claudia Panait, George Washington U, Junior**

**“Book Out! An Inventory Story”**

0620/Susan Oberc, Logistics and Technical Information Division

**2:45 ADJOURN**

## SPACE COMMUNICATIONS EMULATION FACILITY

**Chante' A. Hill**

Tennessee State University  
Electrical, Computer Engineering  
Undergraduate, Senior

**Mentor: Frances Lawas-Grodek**

### ABSTRACT

Establishing space communication between ground facilities and other satellites is a painstaking task that requires many precise calculations dealing with relay time, atmospheric conditions, and satellite positions, to name a few. The Space Communications Emulation Facility (SCEF) team here at NASA is developing a facility that will approximately emulate the conditions in space that impact space communication. The emulation facility is comprised of a 32 node distributed cluster of computers; each node representing a satellite or ground station. The objective of the satellites is to observe the topography of the Earth (water, vegetation, land, and ice) and relay this information back to the ground stations. Software originally designed by the University of Kansas, labeled the Emulation Manager, controls the interaction of the satellites and ground stations, as well as handling the recording of data.

The Emulation Manager is installed on a Linux Operating System, employing both Java and C++ programming codes. The emulation scenarios are written in eXtensible Markup Language, XML. XML documents are designed to store, carry, and exchange data. With XML documents data can be exchanged between incompatible systems, which makes it ideal for this project because Linux, MAC and Windows Operating Systems are all used. Unfortunately, XML documents cannot display data like HTML documents. Therefore, the SCEF team uses XML Schema Definition (XSD) or just schema to describe the structure of an XML document. Schemas are very important because they have the capability to validate the correctness of data, define restrictions on data, define data formats, and convert data between different data types, among other things. At this time, in order for the Emulation Manager to open and run an XML emulation scenario file, the user must first establish a link between the schema file and the directory under which the XML scenario files are saved. This procedure takes place on the command line on the Linux Operating System. Once this link has been established the Emulation manager validates all the XML files in that directory against the schema file, before the actual scenario is run.

Using some very sophisticated commercial software called the Satellite Tool Kit (STK) installed on the Linux box, the Emulation Manager is able to display the data and graphics generated by the execution of a XML emulation scenario file. The Emulation Manager software is written in JAVA programming code. Since the SCEF project is in the developmental stage, the source code for this type of software is being modified to better fit the requirements of the SCEF project. Some parameters for the emulation are hard coded, set at fixed values. Members of the SCEF team are altering the code to allow the user to choose the values of these hard coded parameters by inserting a toolbar onto the preexisting GUI.

## **SURFACE MODELING AND GRID GENERATION FOR ICED AIRFOILS (SMAGGICE)**

**Brandy M. Hammond**  
Cleveland State University  
Computer Engineering  
Undergraduate, Sophomore  
**Mentor: Herbert W. Schilling**

### **ABSTRACT**

Many of the troubles associated with problem solving are alleviated when there is a model that can be used to represent the problem. Through the Advanced Graphics and Visualization (G-VIS) Laboratory and other facilities located within the Research Analysis Center, the Computer Services Division (CSD) is able to develop and maintain programs and software that allow for the modeling of various situations. For example, the Icing Research Branch is devoted to investigating the effect of ice that forms on the wings and other airfoils of airplanes while in flight.

While running tests that physically generate ice and wind on airfoils within the laboratories and wind tunnels on site are done, it would be beneficial if most of the preliminary work could be done outside of the lab. Therefore, individuals from within CSD have collaborated with Icing Research in order to create SmaggIce. This software allows users to create ice patterns on clean airfoils or open files containing a variety of icing situations, manipulate and measure these forms, generate, divide, and merge grids around these elements for more explicit analysis, and specify and discretize subcurves.

With the projected completion date of Summer 2005, the majority of the focus of the SmaggIce team is user-functionality and error handling. My primary responsibility is to test the Graphical User Interface (GUI) in SmaggIce in order to ensure the usability and verify the expected results of the events (buttons, menus, etc.) within the program. However, there is no standardized, systematic way in which to test all the possible combinations or permutations of events, not to mention unsolicited events such as errors. Moreover, scripting tests, if not done properly and with a view towards inevitable revision, can result in more apparent errors within the software and in effect become useless whenever the developers of the program make a slight change in the way a specific process is executed. My task therefore requires a brief yet intense study into GUI coverage criteria and creating algorithms for GUI implementation.

Nevertheless, there are still heavily graphical features of SmaggIce that must be either corrected or redesigned before its release. A particular feature of SmaggIce is the ability to smooth out curves created by control points that form an arbitrary shape into something more acquiescent to gridding (while maintaining the integrity of the data). This is done by a mathematical model known as Non-Uniform Rational B-Spline (NURBS) curves. Existing NURBS code is written in FORTRAN-77 with static arrays for holding information. My new assignment is to allow for dynamic memory allocation within the code and to make it possible for the developers to call out functions from the NURBS code using C.

GEOGRAPHIC INFORMATION SYSTEMS &  
WEB PAGE DEVELOPMENT

Justin Reynolds

Mentors: Ronald Zurawski & Karl Hagelin

The Facilities Engineering and Architectural Branch is responsible for the design and maintenance of buildings, laboratories, and civil structures. In order to improve efficiency and quality, the FEAB has dedicated itself to establishing a data infrastructure based on Geographic Information Systems, GIS. The value of GIS was explained in an article dating back to 1980 entitled "Need for a Multipurpose Cadastre" which stated,

*"There is a critical need for a better land-information system in the United States to improve land-conveyance procedures, furnish a basis for equitable taxation, and provide much-needed information for resource management and environmental planning."*

Scientists and engineers both point to GIS as the solution. What is GIS? According to most text books, Geographic Information Systems is a class of software that stores, manages, and analyzes mapable features on, above, or below the surface of the earth. GIS software is basically database management software to the management of spatial data and information. Simply put, Geographic Information Systems manage, analyze, chart, graph, and map spatial information.

At the outset, I was given goals and expectations from my branch and from my mentor with regards to the further implementation of GIS. Those goals are as follows: (1) Continue the development of GIS for the underground structures. (2) Extract and export annotated data from AutoCAD drawing files and construct a database (to serve as a prototype for future work). (3) Examine existing underground record drawings to determine existing and non-existing underground tanks. Once this data was collected and analyzed, I set out on the task of creating a user-friendly database that could be assessed by all members of the branch. It was important that the database be built using programs that most employees already possess, ruling out most AutoCAD-based viewers. Therefore, I set out to create an Access database that translated onto the web using Internet Explorer as the foundation. After some programming, it was possible to view AutoCAD files and other GIS-related applications on Internet Explorer, while providing the user with a variety of editing commands and setting options.

I was also given the task of launching a divisional website using Macromedia Flash and other web-development programs.

# THE CENTER MASTER PLAN FOR NASA GLENN RESEARCH CENTER

**Kristin M. Bigach**  
Lehigh University  
Industrial Engineering  
Undergraduate, Senior  
**Mentor: Joseph E. Morris**

## ABSTRACT

The Center Master Plan for NASA Glenn Research Center is a comprehensive survey of NASA Glenn's current facility assets and a vision of how we see the facilities will change over the next 20 years in order to support the changing NASA Mission. This Center Master Plan is a vital management tool used by all organizations for making near term decisions and in future planning. During the summer of 2004, I worked with Joseph Morris, the Chief Architect in the Facilities Division, on beginning this Center Master Planning Process.

The previous Master Plan was completed by the Center in 1985 and contained general information on the background of the facility as well as maps detailing environmental and historic records, land use, utilities, etc. The new Master Plan is required for the Center by NASA headquarters and will include similar types of information as used in the past. The new study will provide additional features including showing how individual buildings are linked to the programs and missions that they serve. The Master Plan will show practical future options for the facility's assets with a twenty year look ahead. The Plan will be electronically retrievable so that it becomes a communications tool for Center personnel.

A Center Master Plan, although required, is very beneficial to NASA Glenn Research Center in aiding management with the future direction of the campus. Keeping up-to-date information and future plans readily available to all of NASA Glenn will insure that future real property development efficiently and effectively supports the missions carried out and supported by the Center. A Center Master Plan will also facilitate coordination with Center supported programs, stakeholders, and customers. In addition, it will provide a basis for cooperative planning with local and other governmental organizations and ultimately ensure that future budgets include the Center program needs described in the plan. This will ensure that development plans are safe, practical, and cost effective.

To properly formulate any future plans, background information and research are required. Before bringing in a consultant to tackle the three year process anticipated to prepare a Center Master Plan, my job was to gather information on different organizations' contributions to the NASA mission, their facility needs, consistent trends they observe, etc. I conducted numerous interviews with personnel such as Directorate Representatives, Division Chiefs, Branch Chiefs, System Managers and Building Managers. I documented the information I received from them for future use. I used the information to create various color-coded maps layering the different data. This was done with the ending objective being to collect the information and place it in a database that will be linked with Aperture (a computer program that generates color-coded map layers from database information) and made electronically retrievable to the Planning Consultant, NASA personnel, program stakeholders, and other governmental agencies.

My goal this summer was to gather information and ideas appropriate for use in NASA Glenn Research Center's Master Plan and organize them for future application by the Planning Consultant. By the end of the summer, after completion of my goal, I will utilize my knowledge and create an array of "preliminary" future plans for the facility that can be passed along as a guidance tool.

# The Multistage Compressor Facility

**Ashlie Flegel**  
University of Toledo  
Mechanical Engineering  
Undergraduate, Sophomore  
**Mentor: Hal Weaver**

## ABSTRACT

Research and developments of new aerospace technologies is one of Glenn Research Center's specialties. One facility that deals with the research of aerospace technologies is the High-speed Multistage Compressor Facility. This facility will be testing the performance and efficiency of an Ultra Efficient Engine Technology (UEET) two-stage compressor.

There is a lot of preparation involved with testing something of this caliber. Before the test article can be installed into the test rig, the facility must be fully operational and ready to run. Meaning all the necessary instrumentation must be calibrated and installed in the facility. The test rig should also be in safe operating condition, and the proper safety permits obtained. In preparation for the test, the Multistage Compressor Facility went through a few changes. For instance the facility will now be utilizing slip rings, the gearbox went through some maintenance, new lubrications systems replaced the old ones, and special instrumentation needs to be fine tuned to achieve the maximum amount of accurate data.

Slips rings help gather information off of a rotating device- in this case from a shaft- onto stationary contacts. The contacts (or brushes) need to be cooled to reduce the amount of frictional heat produced between the slip ring and brushes. The coolant being run through the slip ring is AK-225, a material hazardous to the ozone. To abide by the safety regulations the coolant must be run through a closed chiller system. A new chiller system was purchased but the reservoir that holds the coolant was ventilated which doesn't make the system truly closed and sealed. My task was to design and have a new reservoir built for the chiller system that complies with the safety guidelines.

The gearbox had some safety issues also. Located in the back of the gearbox an inching drive was set up. When the inching drive is in use the gears and chain are bare and someone can easily get caught up in it. So to prevent anyone from getting hurt in the gears I designed a chain guard. The guard fully covers the whole sprocket gear and chain.

Some of the facility's systems were modified such as the lubrication system. This system is used to lubricate both the gearbox and compressor bearings, but now the system has been split into two separate systems; an independent system for the gearbox and another independent system for the compressor bearings. Since the lube system has been changed, the facility drawings became incorrect so it was my task to look over each system and update the drawings. There were a couple other systems that had minor changes so I updated those drawings as well.

When it comes time to test the compressor it is vital to get accurate data, one of the important pieces of data is to find out the compressor efficiency. Through calculations the efficiency can be found by getting the temperature. The facility uses thermocouples for temperature readings; they are very useful but not very accurate. A method has been found to improve the accuracy of these thermocouples by putting them through extreme temperature changes. The thermocouples will have to be heated up and cooled at a uniform temperature. The best way to achieve this is to put the thermocouples in an isothermal block. I was given a 10" diameter by 12" copper block and my assignment was to design the isothermal block for the thermocouple rakes.





Project Abstract

## Stator Blade Laser Window Research

Grant A. Lugas

Lorain County Community College

Mechanical Design

Undergraduate

Mentor: Vincent E. Satterwhite

### *Introduction:*

All turbofan engines used in modern aviation contain a series of fan blades and compressor blades which are all connected to one drive shaft. The drive shaft runs directly down the center of the engine. When looking at the front of a turbofan engine inlet the first visible set of blades are the fan blades which have the biggest diameter. The compressor stages are located from about the midpoint to the back of the engine. The compressor is a smaller bladed rotor that takes a percentage of the air from the intake and compresses it, while fuel is being added, to a high pressure; then it is ignited and combusted, while the exhaust trails out the back. The hot combusted fuel expands and exits out the rear of the engine rather quickly; this hot expansion of air turns the compressor wheels at a moderate rate which in return turns the shaft that the fan blades are connected to. Thus the fan blade tips are turning very fast creating almost all of the engines thrust needed for flight, which is mostly bypassed around the outside of the engine cowling. A commercial jet during flight as well as take-off is propelled by the front fan blades in the jet, while dark exhaust trails out the back from the compressor stages, which is the driving force that rotates the fan blades. Inside the jet engine between each set of blades are **stator blades**, which are pitched opposite of the fan and compressor blades, the stator blades are both rotational and axial fixed in place.

### *Project:*

The project that I was assigned to involves the QAT 22 fan test rig; which is currently under final design review and very soon will be fabricated. The purpose of this research facility is to better understand the effects of stator blades. Stator blades are used to straiten the air in a turbine. Although these blades are already being used in the aviation industry, there is still much information that is not yet fully known about them. The researcher's primary aim is to determine what the airflow is like at both the leading edge and the trailing edge of a stator blade.

My work focused on designing the windows usable for both a compressor rig and a test fan rig. The difference between the two is the test fan application will be looking into a stator blade array rather than just looking at the rotor. My discussion will include a detailed explanation of how the PIV laser window system functions from start to finish. I will also discuss how the information is gathered and organized. Further more I plan to talk about the purpose of this kind of research and the advantages to using this technology to determine the airflow characteristics of blade designs. Finally I will discuss the researcher's conclusion on the relationship between aerodynamics of a blade and how noise is produced. NASA's main goal with this particular facility is find ways to quiet engine noise by reducing the amount of cavitations that occurs around the blades of a turbofan engine.

## Bolt Analysis Program

Brandon E. Travis  
University of Kentucky  
Mechanical Engineering  
Junior  
Mentor: Kelly J. McEntire

### ABSTRACT

In designing and testing bolted joints there are multiple parameters to be considered and calculations that must be performed to predict the joint behavior. Each different set of parameters may call for a different set of equations. Determining every parameter in each bolted joint is impractical and in many cases impossible. On the other hand, it is much easier to reduce these calculations to a universal set that can be used for all bolted joints. This is the purpose of the Bolt Analysis Program.

My project under the Mechanical and Rotating Systems branch of the Engineering Development and Analysis Division was to take the Bolt Analysis Program Version 2.0 and update the program to a modern and user-friendly format. Version 2.0 of the Bolt Analysis Program is a useful program, but lacks the dynamic capabilities that are needed for current applications. Version 2.0 of the Bolt Analysis Program was written in 1993 using the Pascal programming language in a DOS format. This program allows you to input data in a step-by-step format, calculates the data, and then on a final screen displays the input and the output from the calculations.

Version 2.0 is still applicable for all bolted joint analysis, but has many updates that are desired. First, the program runs in DOS format. With the applications available today, my mentor decided it would be best to update the program into Microsoft Excel using Visual Basic for Applications (VBA). This would allow the program to have multiple Graphical User Interfaces (GUI's) while retaining all functions of the previous program. Version 2.0 only allows you to input data in a step-by-step process. If you make a mistake and need to go back, you must run through the entire program before you can return to fix your error. This becomes tedious when needing to change one parameter or test multiple sets of data. In Version 3.0, the program allows you to enter and change data at any time while displaying real-time output data. If you realize an error, it is as simple as scrolling back to your mistake and changing the data.

The second update for the program was to add capabilities not original to the program. Version 2.0 allows the user to input data and receive output data in an English unit format alone, restricting the user to units such as pound, inch, and psi. Version 3.0 will allow the user to use either Metric units or English units, giving the user the capability to use units such as the meter, Newton, and Mega-Pascal. Version 2.0 allowed the user to define the thread series on the bolt as either coarse threads or fine threads; Version 3.0 adds the extra-fine thread series. Also, graphing and printing capabilities were updated to allow the user to convert all documents to Microsoft Office compatible programs.

In conclusion, Bolt Analysis Program Version 3.0 upon completion will have achieved all desired goals.

## **Design of Timer Circuit for Dynamic Data System**

**Nathaniel Young III**  
Prairie View A&M University  
Electrical Engineering  
Undergraduate, Senior  
**Mentor: Mark Sorrells**

### **Abstract**

The Branch That I work in is in the Aero Electronic Test Branch, which is part of the Research and Testing Division. The Aero Electronic Test Branch deals with electronic control and instrumentation systems. This branch supports the research and test study of wind tunnels such as the 10x10, 9x15, and 8x6. Wind tunnels are used in research to test certain parts of a jet, plane, shuttle or any other flying object in certain test conditions.

My assignment is to design a programmable trigger circuit on a 19" standard rack mount that will allow the circuit to latch and hold for a predefined amount of time entered by the user when receiving a signal. It should then rearm itself within 0.25 seconds after the time is finished. The time should be able to be seen on a display showing the time entered. The time range has to be from 0-600 seconds in 0.01 second increments (600.00). From the information given, counters will be needed to design and build this circuit. A counter, in it's simplest form, is a group of flip flops that can temporarily store bits of information put into the circuit. They can be constructed in many different ways, such as in 4 flip flops (4-bit counter) or 8 flip flops and even higher. Counters are usually cascaded with other counters to reach higher bits, such as 16 or 24 bit counters. The application in which I will use the counters will be to count down from any programmable number that I input either by a keyboard or a thumbwheel. Also, I will use counters that will be used specifically as a frequency divider to divide the pulses that enter the circuit through an input signal from a crystal clock. The pulses will need to be divided so that it will function as a 100Hz clock putting out 100 pulses per second. A switch will be used to load my inputs in and more than likely a button also so that I can stop and hold the count at any point of time. I will use 5 BCD up/down programmable counters, and a certain amount (depending on what kind of "divide by N" counter I use) of frequency dividing counters for the assignment. After the design is carefully made, a task order will be written and then given to the manufacturer to create a rack mount circuit board that will match my specifications given.

The applications in which this design will be used for is in the use of the six-component balance signal conditioner for measurement and electronic system control. It can be used as a timer system for the balance signal conditioner in which it does numerous tests for the Wind tunnel research, in which a preset time can be set for how long it performs its tests. Specifically, my design should be applied to the balance signal conditioner used for the 8x6 wind tunnel research. Hopefully this design should aid in more efficient research for the 8x6 wind tunnel.

# THE INVESTIGATION OF CARBON CONTAMINATION AND SPUTTERING EFFECTS OF XENON ION THRUSTERS

**Moline K. Prak**  
John Carroll University  
Engineering  
Undergraduate, Sophomore  
**Mentor: Bruce A. Banks**

## ABSTRACT

The Electro-Physics Branch of the NASA Glenn Research Center investigates the effect of atomic oxygen, environmental durability of high performance power materials and surfaces, and low earth orbit. One of its current projects involves the analysis of ion thrusters.

Ion thrusters are devices that initiate a beam of ions to a target area. The type of ion thruster that I have been working with this Summer of 2004 emits positively charged Xenon ( $Xe^+$ ) atoms through two grids, the screen grid and the accelerator grid, after it enters an ionization chamber. Insulators are used to mechanically hold and separate these two grids. A propellant isolator, an instrument that closely resembles insulators, is placed in front of the ionization chamber. Both the insulator and isolator are made with a ceramic compound and filled with insulating beads. The main difference between the two devices is that the propellant isolator allows gas to flow through, in this case, the gas is  $Xe^+$ , and the insulators do not.

In order to avoid carbon deposits and other contaminating chemicals to settle on the insulators and propellant isolator, a metal shadow shield is placed around them. These shadow shields function as a protectant and can be shaped in numerous configurations. Part of my job responsibility this summer is to investigate the effectiveness of different shadow shields that are utilized on three different ion engines: the NSTAR (NASA Solar Electric Propulsion Technology Application Readiness), JIMO (Jupiter Icy Moons Orbiter), and NEXIS (Nuclear Electric Xenon Ion System). Using calculus and other mathematical tactics, I was asked to find the total flux of carbon contamination that was able to pass the protectant shadow shield. I familiarized myself with the software program, MathCad2004, to help perform some mathematical computations such as complex integration.

Another method of studying the probability of contamination is by experimental simulation. After attaining the precise parameters of the actual shadow shields, I created replicas of three types of shadow shielding to be used to undergo testing. It will be placed in a machine that produces carbon atoms at a high temperature of 200°C.

Carbon contamination is the effect of sputtering. Sputtering occurs when an ion particle or beam is aimed at a targeted material. As a result of this collision, atoms and other particles are ejected out of the target surface. Another part of my internship consisted of research on sputter ejection, or the angle distribution of sputtered material. This research entailed finding the past results of sputter ejection investigation as well as creating another type of mock simulation. Other minor projects include calculating the path of  $Xe^+$  gas through the insulating beads of the isolators and assisting my mentor in collecting data for his paper for the Joint Propulsion Conference & Exhibit to be held July 11-14, 2004 in Fort Lauderdale, Florida.

# **The Use of Pristine and Intercalated Graphite Fiber Composites as Buss Bars in Lead-Acid Batteries**

**Amanda M. Opaluch**  
Wittenberg University  
Biochemistry/Molecular Biology  
Undergraduate, Senior  
**Mentor: James R. Gaier**

## **ABSTRACT**

This study was conducted as a part of the Firefly Energy Space Act Agreement project to investigate the possible use of composite materials in lead acid batteries. Specifically, it examined the use of intercalated graphite composites as buss bars. Currently, buss bars of these batteries are made of lead, a material that is problematic for several reasons. Over time, the lead is subject to both corrosion at the positive plate and sulfation at the negative plate, resulting in decreased battery life. In addition, the weight and size of the lead buss bars make for a heavy and cumbersome battery that is undesirable. Functionality and practicality of lead buss bars is adequate at best; consequently, investigation of more efficient composite materials would be advantageous.

Practically speaking, graphite composites have a low density that is nearly one fourth that of its lead counterpart. A battery made of less dense materials would be more attractive to the consumer and the producer because it would be light and convenient. More importantly, low weight would be especially beneficial because it would result in greater overall power density of the battery. In addition to power density, use of graphite composite materials can also increase the life of the battery. From a functional standpoint, corrosion and sulfation at the positive and negative plates are major obstacles when considering how to extend battery life. Neither of these reactions are a factor when graphite composites replace lead parts because graphite is chemically non-reactive with the electrolyte within the battery. Without the problem of corrosion or sulfation, battery life expectancy can be almost doubled. The replacement of lead battery parts with composite materials is also more environmentally favorable because of easy disposal of organic materials.

For this study, both pristine and bromine intercalated single-ply graphite fiber composites were created. The composites were fabricated in such a way as to facilitate their use in a 3"x 1/2" buss bar test cell. The prime objective of this investigation was to examine the effectiveness of a variety of graphite composite materials to act as buss bars and carry the current to and from the positive and negative battery plates. This energy transfer can be maximized by use of materials with high conductivity to minimize the buss resistance. Electrical conductivity of composites was measured using both a contactless eddy current probe and a four point measurement. In addition, the stability of these materials at battery-use conditions was characterized.

## **MANUFACTURING BMS/ISO SYSTEM REVIEW**

**Yazmín Gómez**  
University of Turabo  
Industrial and Management Engineering  
Undergraduate, Senior  
**Mentor: Wilma J. Taylor**

### **ABSTRACT**

The Quality Management System (QMS) is one that recognizes the need to continuously change and improve an organization's products and services as determined by system feedback, and corresponding management decisions. The purpose of a Quality Management System is to minimize quality variability of an organization's products and services. The optimal Quality Management System balances the need for an organization to maintain flexibility in the products and services it provides with the need for providing the appropriate level of discipline and control over the processes used to provide them. The goal of a Quality Management System is to ensure the quality of the products and services while consistently (through minimizing quality variability) meeting or exceeding customer expectations.

The GRC Business Management System (BMS) is the foundation of the Center's ISO 9001:2000 registered quality system. ISO 9001 is a quality system model developed by the International Organization for Standardization. BMS supports and promote the Glenn Research Center Quality Policy and wants to ensure the customer satisfaction while also meeting quality standards.

My assignment during this summer is to examine the manufacturing processes used to develop research hardware, which in most cases are one of a kind hardware, made with non conventional equipment and materials. During this process of observation I will make a determination, based on my observations of the hardware development processes the best way to meet customer requirements and at the same time achieve the GRC quality standards.

The purpose of my task is to review the manufacturing processes identifying opportunities in which to optimize the efficiency of the processes and establish a plan for implementation and continuous improvement.

## FLYWHEEL TECHNOLOGY

**Lisa M. Ritchie**  
Kent State University  
Integrated Mathematics  
Undergraduate, Junior  
**Mentor: Vicki J. Crable**

### ABSTRACT

Throughout the summer of 2004, I am working on a number of different projects. While located in the Space Power and Propulsion Test Engineering branch, my main area of study is flywheel technology. I have been exposed to flywheels, their components, and their uses in today's society. I have been able to experience numerous flywheels here in the flywheel lab at NASA Glenn.

My first main project was to explore the attributes and physical characteristics of a flywheel. Our branch was constructing a flywheel demonstration to be presented at the public open house taking place in June. Our Flywheel Interactive Demo, or FIDO, represents a real life multi-flywheel system here at NASA. I was given the opportunity to learn about how these flywheels store energy and are able to position a satellite. With all of this new knowledge, I was able to create the posters that explained how our demonstration worked. I also composed a step-by-step process made up of four experiments that any visitor could follow and perform on FIDO. By stepping through these experiments, the individual learns how a flywheel works. They not only read the explanation of what is happening, but they are also able to see it happen. Creating these two posters not only taught me, but also helped teach the general public during the open house, how flywheel technology is a very important part of our future.

Through my research, I have learned that flywheels are able to store massive amounts of energy. They can be described as an electro-mechanical battery that stores kinetic energy while rotating. The faster it rotates, the more energy it stores. Their lifetime is about triple that of an ordinary battery. Flywheels also have the ability to combine energy storage with attitude control all in a single system. Attitude control is the ability to position a satellite as required. FIDO helps us to understand the rotational force (torque) that is applied upon a turntable or satellite during wheel acceleration/deceleration.

My other main project that I have just begun is to create a flywheel presentation, brochure, and video all explaining the history, applications, early attempts, and working processes of modern flywheels. These items are all useful tools for educating school children and even adults about flywheels. This task will require a large amount of research and skills in the use of multiple applications.

My goal this summer is to learn the dynamics and uses of a flywheel in today's society, and then inform and encourage the public about flywheels. I am able to express my knowledge by creating some effective as well as attractive posters, presentations, brochures, videos, etc. that are able to explain how a flywheel works along with how our FIDO demonstration simulates a real flywheel. My goal is underway, and should be successfully reached with the help of my mentor, other coworkers, and fellow interns.

# Trajectory Analysis

Laura M. Burke  
Case Western Reserve University  
Aerospace Engineering  
Undergraduate, Junior  
Mentor: Robert D. Falck

## ABSTRACT

The Systems Analysis Branch performs trajectory and systems analysis for next-generation launch vehicle and space transportation technologies. Currently the branch is supporting the Project Prometheus with analysis of nuclear electric and nuclear thermal propulsion missions to a variety of destinations. Within Project Prometheus a proposed mission to Jupiter and three of the planet sized icy moons that orbit it is developing. The Jupiter Icy Moons Orbiter (JIMO) as the project is being called will enable detailed scientific investigation of Jupiter's moons Callisto, Ganymede, and Europa. These moons were chosen to orbit for intensive study in particular because they are each believed to have water, energy, and organic material. The JIMO mission will utilize nuclear fission power and electric propulsion in order to allow the spacecraft to orbit the moons at close range for long durations of time.

My assignment this summer was to assist in developing a trajectory analysis for the spacecraft system the Jupiter Icy Moons Orbiter by rewriting an inefficient Excel file into a more efficient FORTRAN program. This program has been created for use planning the trajectory of the Jupiter Icy Moons Orbiter Mission. The program uses a database of thousands of data points representing flight time, burn time, thrust, mass of the propellant used, final mass of the spacecraft, ratio of final mass to initial mass, and change in velocity that a spacecraft experiences during each phase in the Jupiter Icy Moons Orbiter Mission. The trajectory program is capable of taking a specific user entered specific impulse (isp), final mass fraction, and thrust ( $P_f/m_0$ ) and through the use of cubic splines to fit specific data curves, the program can locate the exact flight time linked to the user specified values of specific impulse and final over initial mass fraction.

Currently, the database used by the program to calculate flight times for a given thrust is only for isps in the range of 2000 to 9000 seconds. Although the program is specific to the Jupiter Icy Moons Orbiter mission, it can be easily modified to fit any mission with a propulsion system expected isp range between 2000 and 9000 seconds.

This program performs the same tasks as the old Excel file but in a more timely fashion. Finally, this FORTRAN program will replace the Excel file as the tool used to calculate trajectory properties in missions and will provide valuable data to mission analysts for years to come.



## Website of the Systems and Analysis Branch Supported Projects and Graph Analysis

**Corinne Kellerman**  
University of Arizona  
Astronomy and Physics  
Undergraduate, Sophomore  
**Mentor: Melissa L. McGuire**

### ABSTRACT

Throughout the past few weeks I have learned a great amount of information about many interesting aspects that go on here at NASA Glenn Research Center Branch 7820. Branch 7820 is the Systems and Analysis Branch. The people involved in this Branch deal with in a nutshell the analysis of propulsion systems for Earth to orbit and space transportation systems.

The first project that I had worked on was helping my mentor learn more about lunar geography and the most recommended way to maintain communication for our future lunar missions. During this time I studied the craters of the moon, especially the South Pole, to provide her with information so that she can make decisions. I also researched to provide her with contact information on those people who are specialized in lunar geography so that she may talk to them to find out more in depth information.

Most of my time spent here has been helping to develop a comprehensive explanation and background of the different projects our Branch has supported. When I first came to NASA Glenn and started working with the 7820 Branch there website had many holes that needed to be filled in. I have spent numerous weeks researching information about topics such as Project Prometheus itself and one of its components Jupiter's Icy Moons Orbiter (JIMO). I have also done a large amount of research on propulsion systems and how different kinds work. I have learned many facts about Nuclear Electric Propulsion (NEP) all the way to Nuclear Thermal Propulsion (NTP) systems. I will continue to do this until all the holes are filled and find out about Global Integrated Design Environment (GLIDE) and Next Generation Launch technology (NGLT).

Since most of my job was providing information to go onto a website I had to learn how to put my information into a HTML format. I had no previous knowledge on how to do that kind of task and had to study how to do it and am now able to create a document in HTML format.

There has been reorganizing done here at NASA Glenn and our Branch was moved to another building. Therefore, our library had to be moved with us. I spent time helping to put together the boxes, pack the library, and label them accordingly. This was not an easy task but was an experience in itself. I was able to see old posters that NASA had produced about different space missions and look at Russian map of the US and books on space missions. I was also about to see what was in the library in terms of reference material helped because now I can make use of the information for my research on the website.

Throughout my internship my mentor will provide me with graphs to analyze and recreate so that she may use them to her advantage. I will learn from every piece of data that comes my way. Later, I will study and analysis gravity-loss for Earth departure trajectories. Since I haven't done that yet I cannot really describe what I will learn or what exactly the project entails. The whole experience has been great and I have no doubt that it will exceed every expectation previously thought.

## **Book Out! An Inventory Story.**

**Claudia M. Panait**  
George Washington University  
International Business  
Junior  
**Mentor: Susan Oberc**

### **Abstract**

The NASA Glenn Library is a science and engineering research library providing the most current books, journals, CD-ROM's and documents to support the study of aeronautics, space propulsion and power, communications technology, materials and structures and microgravity science. The GRC technical library also supports the research and development efforts of all scientists and engineers on site via full text electronic files, literature searching, technical reports, etc. As an intern in the NASA Glenn Library, I attempt to support these objectives through efficiently and effectively fulfilling the assignment that was given to me.

The assignment that was relegated to me was to catalog National Advisory Committee for Aeronautics, NASA Technical Documents into NASA Galaxie. This process consists of holdings being added to existing Galaxie records, upgrades and editing done to the bibliographic records when needed, adding URL's into Galaxie when they were missing from the record. NASA ASAP and Digidoc was used to locate URL's of PDF's that were not in Galaxie. A spreadsheet of documents with no URL's were maintained. Also, a subject channel of web, full-text, paid and free, journal and other subject specific pages were developed and expanded from current content of intranet pages.

To expand upon the second half of my assignment, I was given the project of taking inventory of the library's book collection. I kept record of the books that were not accounted for on a master list I was given to work from and submitted them for correction and addition. I also made sure the books were placed in the appropriate order and made corrections to any discrepancies that existed between the master list and what was on the shelf. Upon completion of this assignment, I will have verified that 21,113 books were in the correct location, order and have the correct corresponding serial number and barcode.

In conclusion, as of this date I have input around 750 documents into NASA Galaxie, inputting about half of the NASA Technical Documents into the system. The rest of my tenure in this program will consist of finishing the other half of the reports. In regard to the second assignment, I still have about three-quarters of the collection to record and correct.

# Research Symposium I

## Ohio Aerospace Institute

### Thursday, July 8, 2004

#### OAI Federal Room

9:00 A.M. **Kevin Speer, University of Arkansas, Masters**

“Quantification of 4H-to-3C-Polymorphism in Silicon Carbide (SiC) Epilayers and an Investigation of Recombination-Enhanced Dislocation Motion in SiC by Optical Emission Microscopy (OEM) Techniques”

5510/Philip Neudeck, Sensors and Electronics Technology Branch

9:15 **Jennifer Corrigan, University of Dayton, Senior**

“Finite Element Analysis of MEMS Devices”

5510/Robert Okojie, Sensors and Electronics Technology Branch

9:30 **Hilary Homenko, Stanford University, Freshman**

“Evaluation of Droplet Splashing Algorithm in LEWICE 3.0”

5840/Mark Potapczuk, Icing Branch

9:45 **Aaron Armstrong, Brigham Young University-Idaho, Senior**

“The Lewice Console”

5840/William Wright, Icing Branch

10:00 **Nicholas Mattei, University of Kentucky, Junior**

“Evaluation of Open-Source Hard Real Time Software Packages”

8100/Cynthia Calhoun, Risk Management Office

10:15 **Kalindra Mcrae, Fayetteville State University, Junior**

“Software Quality Assurance Metrics”

8100/Cynthia Calhoun, Risk Management Office

10:30 **Tracee Jordan, Tennessee State University, Freshman**

“Monitoring and Testing the Parts Cleaning Stations, Abrasive Blasting Cabinets, and Paint Booths”

8400/Danielle Griffin, Environmental Management Office

10:45 **Nathaniel Bewley, Cuyahoga Community College-West Campus, Sophomore**

“Security Management and Safeguards Office”

8500/Richard Soppet, Security Management and Safegaurds Office

11:00 **LUNCH**

1:00 **Nicole Epps, Spelman College, Sophomore**

“Constructing an Educational Mars Simulation”

9200/William Dedula, Educational Programs Office

1:15 **Stephen Henke, Lorain County Community College, Sophomore**

“Constructing an Educational Mars Simulation”

9200/William Dedula, Educational Programs Office

**1:30 Debra Goodenow, Ohio Northern University, Senior**

**“Model of a Piezoelectric Transducer”**

7715/Richard Oeftering, Instrumentation and Data Systems Branch

**1:45 Keith Blackwell, Cleveland State University, Junior**

**“Adaptive Clearance Control Systems for Turbine Engines”**

5530/Kevin Melcher, Controls and Dynamics Technology Branch

**2:00 ADJOURN**



**QUANTIFICATION OF 4H- TO 3C-POLYMORPHISM IN SILICON CARBIDE (SiC)  
EPILAYERS AND AN INVESTIGATION OF RECOMBINATION-  
ENHANCED DISLOCATION MOTION IN SiC BY OPTICAL  
EMISSION MICROSCOPY (OEM) TECHNIQUES**

**Kevin M. Speer**

Case Western Reserve University  
Materials Science & Engineering  
Ph.D. Student

**Mentor: Philip G. Neudeck, Ph.D.**

**ABSTRACT**

Environments that impose operational constraints on conventional silicon-(Si) based semiconductor devices frequently appear in military- and space-grade applications. These constraints include high temperature, high power, and high radiation environments. Silicon carbide (SiC), an alternative type of semiconductor material, has received abundant research attention in the past few years, owing to its radiation-hardened properties as well as its capability to withstand high temperatures and power levels. However, the growth and manufacture of SiC devices is still comparatively immature, and there are severe limitations in present crystal growth and device fabrication processes.

Among these limitations is a variety of crystal imperfections known as defects. These imperfections can be point defects (e.g., vacancies and interstitials), line defects (e.g., edge and screw dislocations), or planar defects (e.g., stacking faults and double-positioning boundaries). All of these defects have been experimentally shown to be detrimental to the performance of electron devices made from SiC. As such, it is imperative that these defects are significantly reduced in order for SiC devices to become a viable entity in the electronics world.

The NASA Glenn High Temperature Integrated Electronics & Sensors Team (HTIES) is working to identify and eliminate these defects in SiC by implementing improved epitaxial crystal growth procedures. HTIES takes two-inch SiC wafers and etches patterns, producing thousands of mesas into each wafer. Crystal growth is then carried out on top of these mesas in an effort to produce films of improved quality—resulting in electron devices that demonstrate superior performance—as well as fabrication processes that are cost-effective, reliable, and reproducible.

In this work, further steps are taken to automate HTIES' SiC wafer inspection system. National Instruments<sup>™</sup> LabVIEW<sup>©</sup> image processing and pattern recognition routines are developed that are capable of quantifying and mapping defects on both the substrate and mesa surfaces, and of quantifying polymorphic changes in the grown materials. In addition, an optical emission microscopy (OEM) system is developed that will facilitate comprehensive study of recombination-enhanced dislocation motion (REDM).

# Finite Element Analysis of MEMS Devices

Jennifer Corrigan

L.E.R.C.I.P. Summer 2004

Mentor: Dr. Robert Okojie

18 June 2004

A side-slide actuator and a corrugated diaphragm actuator will be analyzed and optimized this summer. Coupled electrostatic and fluid analyses will also be initiated. Both the side-slide actuator and the corrugated diaphragm actuator will be used to regulate the flow of fuel in a jet engine. Many of the side-slide actuators will be placed on top of a fuel injector that is still in the developmental stage as well. The corrugated diaphragm actuator will also be used to regulate the flow of fuel in fuel injectors. A comparative analysis of the performance matrix of both actuators will be conducted.

The side-slide actuator uses the concept of mechanical advantage to regulate the flow of fuel using electrostatic forces. It is made from Nickel, Silicon Carbide, and thin layers of Oxide. The slider will have a hole in the middle that will allow fuel to pass through the hole underneath it. The goal is to regulate the flow of fuel through the inlet. This means that the actuator needs to be designed so that when a voltage is applied to the push rod, the slider will deflect in the x-direction and be able to completely block the inlet and no fuel can pass through. Different voltage levels will be tested. The parameters that are being optimized are the thickness of the diaphragm, what kind of corrugation the diaphragm should have, the length, width, and thickness of the push rod, and what design should be used to return the slider. The current possibilities for a return rod are a built in spring on the slider, a return rod that acts like a spring, or a return rod that is identical to the push rod. The final actuator design should have a push rod that has rotational motion and no translation motion, a push rod thickness that prevents warping due to the slider, and a large ratio of the displacement on the bottom of the push rod to displacement on the top of the push rod.

The corrugated diaphragm actuator was optimized last winter and this summer will be spent completing the optimization of the coupled electrostatic and fluid flow parameters. It was found that Nickel is the best material to use for the diaphragm because it has a higher yield strength and allows for a larger stress, deflection and applied pressure. The parameters that were optimized were the wavelength and thickness of the diaphragm.

## **Evaluation of Droplet Splashing Algorithm in LEWICE 3.0**

**Hilary N. Homenko**  
Stanford University  
Science, Technology and Society  
Undergraduate, Freshman  
**Mentor: Mark Potapczuk**

### **ABSTRACT**

The Icing Branch at NASA Glenn Research has developed a computer program to simulate ice formation on the leading edge of an aircraft wing during flight through cold, moist air. As part of the branch's current research, members have developed software known as LEWICE. This program is capable of predicting the formation of ice under designated weather conditions. The success of LEWICE is an asset to airplane manufacturers, ice protection system manufacturers, and the airline industry. Simulations of ice formation conducted in the tunnel and in flight is costly and time consuming. However, the danger of in-flight icing continues to be a concern for both commercial and military pilots. The LEWICE software is a step towards inexpensive and time efficient prediction of ice collection.

In the most recent version of the program, LEWICE contains an algorithm for droplet splashing. Droplet splashing is a natural occurrence that causes accumulation of ice on aircraft surfaces. At impingement water droplets lose a portion of their mass to splashing. With part of each droplet joining the airflow and failing to freeze, early versions of LEWICE without the splashing algorithm over-predicted the collection of ice on the leading edge.

The objective of my project was to determine whether the revised version of LEWICE accurately reflected the ice collection data obtained from the Icing Research Tunnel (IRT). The experimental data from the IRT was collected by Mark Potapczuk in January, March and July of 2001 and April and December of 2002. Experimental data points were the result of ice tracings conducted shortly after testing in the tunnel. Run sheets, which included a record of velocity, temperature, liquid water content and droplet diameter, served as the input of the LEWICE computer program. Parameters identical to the tunnel conditions were used to run LEWICE 2.0 and LEWICE 3.0.

The results from IRT and versions of LEWICE were compared graphically. After entering the raw experimental data and computer output into a spread sheet, I mapped each ice formation onto a clean airfoil. The LEWICE output provided the data points to graphically depict ice formations developed by the program.

After comparing the collection efficiency, mass values and ice shapes produced by weather conditions of runs conducted in January 2001, it was evident that the splashing algorithm of LEWICE 3.0 predicts ice formations more accurately than LEWICE 2.0. Especially at conditions with droplet size between 80 and 160 microns, the splashing algorithm of the new LEWICE version compensated for the loss of droplet mass as a result of splashing. In contrast, LEWICE 2.0 consistently over-predicted the mass of the ice in conditions with droplet size exceeding 80 microns. This evidence confirms that changes made to algorithms of LEWICE 3.0 have increased the accuracy of predicting ice collection.

## **The Lewice Console**

**Aaron E. Armstrong**  
Brigham Young University-Idaho  
Computer Science  
Senior  
**Mentor: William B. Wright**

### **ABSTRACT**

Lewice (LEWIS ICE accretion program) is software used by literally hundreds of users in the aeronautics community for predicting ice shapes, collection efficiencies, and anti-icing heat requirements for aircraft. LEWICE performs its analysis in minutes on a desktop PC, allowing the user to run several parameter studies for design purposes. The ice shape predictions have been used to assess performance degradation both as an input to a CFD program or experimentally in flight or in a wind tunnel. This information is important to ensure an airplane's safe passage through an icing cloud.

Currently, Lewice runs as a DOS program that accepts many different inputs such as cloud conditions, wing shapes, and thermal deicing inputs. Usually, such experimental data is stored in spreadsheets. However, Lewice inputs are text files; therefore, they must be generated by the user. Lewice's outputs (collection efficiency, ice shapes and thicknesses) are also text files; to plot the data, users must generate a spreadsheet with this output. Because all Lewice I/O is in the form of text files, using Lewice can be tricky and time-consuming.

Our goal was to improve Lewice's usability by creating a user interface that would automatically generate Lewice input from a spreadsheet and automatically put Lewice output into spreadsheets with charts. Additionally, this user interface would automatically convert units (as Lewice only accepts input in certain units) and offer several output options. I call this program the "Lewice Console".

The Lewice Console is an easy to use interface for Lewice written in Visual Basic. It allows users to run Lewice given a spreadsheet listing experimental conditions. It automatically generates the input to Lewice, does necessary unit conversions, runs Lewice, and produces a spreadsheet with charts plotting the data. It allows users to import data from previously generated Lewice inputs into a spreadsheet. It also allows users to batch run Lewice on several different inputs to automatically generate multiple output spreadsheets. You can also generate plots of actual data vs. experimental data.

These capabilities are just the beginning for the Lewice Console. Lewice is capable of running a full deicing experiment given a geometry and heating apparatus information. However, users find it difficult to run such experiments due to the number of inputs and the difficult input file format. The Lewice Console would simplify experiment generation by allowing the user to interactively draw a geometry, place heating apparatus, and specify information about each part. The input to Lewice would be automatically generated from the experiment the user draws on the screen. The Lewice Console would simplify the experiment building process.



## **Evaluation of Open-Source Hard Real Time Software Packages**

**Nicholas S. Mattei**  
University of Kentucky  
Computer Science and Electrical Engineering  
Undergraduate, Junior  
**Mentor: Cynthia Calhoun**

### **ABSTRACT**

Reliable software is, at times, hard to find. No piece of software can be guaranteed to work in every situation that may arise during its use here at Glenn Research Center or in space. The job of the Software Assurance (SA) group in the Risk Management Office is to rigorously test the software in an effort to ensure it matches the contract specifications. In some cases the SA team also researches new alternatives for selected software packages. This testing and research is an integral part of the department of Safety and Mission Assurance.

Real Time operation in reference to a computer system is a particular style of handing the timing and manner with which inputs and outputs are handled. A real time system executes these commands and appropriate processing within a defined timing constraint. Within this definition there are two other classifications of real time systems: hard and soft. A soft real time system is one in which if the particular timing constraints are not rigidly met there will be no critical results. On the other hand, a hard real time system is one in which if the timing constraints are not met the results could be catastrophic. An example of a soft real time system is a DVD decoder. If the particular piece of data from the input is not decoded and displayed to the screen at exactly the correct moment nothing critical will become of it, the user may not even notice it. However, a hard real time system is needed to control the timing of fuel injections or steering on the Space Shuttle; a delay of even a fraction of a second could be catastrophic in such a complex system.

The current real time system employed by most NASA projects is Wind River's VxWorks operating system. This is a proprietary operating system that can be configured to work with many of NASA's needs and it provides very accurate and reliable hard real time performance. The down side is that since it is a proprietary operating system it is also costly to implement. The prospect of replacing this somewhat costly implementation is the focus of one of the SA group's current research projects. The explosion of open source software in the last ten years has led to the development of a multitude of software solutions which were once only produced by major corporations. The benefits of these open projects include faster release and bug patching cycles as well as inexpensive if not free software solutions. The main packages for hard real time solutions under Linux are Real Time Application Interface (RTAI) and two varieties of Real Time Linux (RTL), RTLFree and RTLPro.

During my time here at NASA I have been testing various hard real time solutions operating as layers on the Linux Operating System. All testing is being run on an Intel SBC 2590 which is a common embedded hardware platform. The test plan was provided to me by the Software Assurance group at the start of my internship and my job has been to test the systems by developing and executing the test cases on the hardware. These tests are constructed so that the Software Assurance group can get hard test data for a comparison between the open source and proprietary implementations of hard real time solutions.

## **Software Quality Assurance Metrics**

**Kalindra A. McRae**  
Fayetteville State University  
Computer Science  
Undergraduate Senior  
**Mentor: Cynthia Calhoun**

### **ABSTRACT**

Software Quality Assurance (SQA) is a planned and systematic set of activities that ensures conformance of software life cycle processes and products conform to requirements, standards and procedures. In software development, software quality means meeting requirements and a degree of excellence and refinement of a project or product. Software Quality is a set of attributes of a software product by which its quality is described and evaluated. The set of attributes includes functionality, reliability, usability, efficiency, maintainability, and portability. Software Metrics help us understand the technical process that is used to develop a product. The process is measured to improve it and the product is measured to increase quality throughout the life cycle of software. Software Metrics are measurements of the quality of software. Software is measured to indicate the quality of the product, to assess the productivity of the people who produce the product, to assess the benefits derived from new software engineering methods and tools, to form a baseline for estimation, and to help justify requests for new tools or additional training. Any part of the software development can be measured. If Software Metrics are implemented in software development, it can save time, money, and allow the organization to identify the caused of defects which have the greatest effect on software development.

The summer of 2004, I worked with Cynthia Calhoun and Frank Robinson in the Software Assurance/Risk Management department. My task was to research and collect, compile, and analyze SQA Metrics that have been used in other projects that are not currently being used by the SA team and report them to the Software Assurance team to see if any metrics can be implemented in their software assurance life cycle process.

**MONITORING AND TESTING THE PARTS CLEANING STATIONS,  
ABRASIVE BLASTING CABINETS, AND PAINT BOOTHS**

**Tracee M. Jordan**

Tennessee State University  
Civil and Environmental Engineering

Sophomore

**Mentor: Priscilla A. Mobley**

**ABSTRACT**

I have the opportunity to work in the Environmental Management Office (EMO) this summer. One of the EMO's tasks is to make sure the Environmental Management System is implemented to the entire Glenn Research Center (GRC). The Environmental Management System (EMS) is a policy or plan that is oriented toward minimizing an organization's impact to the environment. Our EMS includes the reduction of solid waste regeneration and the reduction of hazardous material use, waste, and pollution. With the Waste Management Team's (WMT) help, the EMS can be implemented throughout the NASA Glenn Research Center. The WMT is responsible for the disposal and managing of waste throughout the GRC. They are also responsible for the management of all chemical waste in the facility. My responsibility is to support the waste management team by performing an inventory on parts cleaning stations, abrasive cabinets, and paint booths through out the entire facility. These booths/stations are used throughout the center and they need to be monitored and tested for hazardous waste and material. My job is to visit each of these booths/stations, take samples of the waste, and analyze the samples.

## **Security Management and Safeguards Office**

**Nathaniel M. Bewley**  
Cuyahoga Community College  
Criminal Justice  
Undergraduate Sophomore  
**Mentor: Richard Soppet**

### **Abstract**

The Security Management and Safeguards Office at NASA is here to keep the people working in a safe environment. They also are here to protect the buildings and documents from sabotage, espionage, and theft. During the summer of 2004, I worked with Richard Soppet in Physical Security.

While I was working here I helped out with updating the map that we currently use at NASA Glenn Research Center, attended meetings for homeland security, worked with the security guards and the locksmith. The meetings that I attended for homeland security talked about how to protect ourselves before something happened, they told us to always be on the guard and look for anything suspicious, and the different ways that terrorist groups operate. When I was with the security guards I was taught how to check someone into the base, showed how to use a radar gun, observed a security guard make a traffic stop for training and was with them while they patrolled NASA Glenn Research Center to make sure things were running smooth and no one was in danger. When I was with the lock smith I was taught how to make keys and locks for the employees here at NASA. The lock smith also showed me that he had inventory cabinets of files that show how many keys were out to people and who currently has access to the rooms that they keys were made for.

I also helped out the open house at NASA Glenn Research Center. I helped out by showing the Army Reserves, and Brook Park's SWAT team where all the main events were going to take place a week before the open house was going to begin. Then during the open house I helped out by making sure people had there IDs, checked through there bags, and handed out a map to them that showed where the different activities were going to take place.

So the main job here at NASA Glenn Research Center for the Security Management and Safeguards Office is to make sure that nothing is stolen, sabotaged, and espionaged. Also most importantly make sure all the employees here at NASA are in a safe environment.

# CONSTRUCTING AN EDUCATIONAL MARS SIMULATION

**Nicole E. Epps**

Spelman College

Computer Science

Junior

Mentor: William T. Dedula

## ABSTRACT

Working in the Educational Programs Office, my task this summer is to model a 3D habitat that will be part of a future Mars base. With the President's charge to further explore Mars by way of robotic-led and human-led missions, there has been a surge in the activity regarding the "red planet". Since all present designs are merely conjecture, I have some creative freedom in deciding what the habitat will look like.

To get ideas for what a Mars habitat might be like, I looked at several references including websites and NASA documents. One of these was a NASA Technical Memorandum about Space Transportation Systems that I looked at to get insight on spaceship design. Information about the planet's environment, such as the gravity and the weather, is useful as well when designing the structure.

The main software that I am using is Lightwave 3D 7.5 and Modeler 7.5 that comes along with it. Lightwave is very complex in that it lets you model, surface, and animate so there was a lot to learn. To learn the software I watched a series of instructional videos, looked at online tutorials, and referenced several books. Modeling is like shaping clay with a computer. Every item modeled is made of smaller shapes called polygons. For example, each side of a box would be a different polygon. Modelers must be careful to design with users' systems in mind. Having a model made with too many polygons can slow down a walk-through, but it usually improves the small details on a model. Getting speed *and* quality proved tricky.

An important thing for me to remember when modeling the habitat was to save space. Also, I must consider that technology in the future will be much different than now, so I must be especially creative. My project will be used in an educational walk-through simulation in which users can interact with the environment. I worked closely with intern Stephen Henke who built a Mars Rover, terrain and programmed code for the simulation. This summer's project will help me with future aspirations in computer graphics. Modeling is a valuable skill that I appreciate having the chance to learn and practice.

# Constructing an Educational Mars Simulation

**Stephen A. Henke**

LCCC / University of Toledo Partnership

Computer Science Engineering (CSE)

Undergraduate

Mentor: **William Dedula**

Abstract

January 14<sup>th</sup> 2004, President George Bush announces his plans to catalyze the space program into a new era of space exploration and discovery. His vision encompasses a robotics program to explore our solar system, a return to the moon, the human exploration of Mars, and to promote international prosperity towards our endeavors. We at NASA now have the task of constructing this vision in a very real timeframe.

I have been chosen to begin phase 1 of making this vision a reality. I will be working on creating an Educational Mars Simulation of human exploration of Mars to stimulate interest and involvement with the project from investors and the community. GRC's Computer Services Division (CSD) in collaboration with the Office of Education Programs will be designing models, constructing terrain, and programming this simulation to create a realistic portrayal of human exploration on Mars.

With recent and past technological breakthroughs in computing, my primary goal can be accomplished with only the aid of 3-4 software packages. Lightwave 3D is the modeling package we have selected to use for the creation of our digital objects. This includes a Mars pressurized rover, rover cockpit, landscape/terrain, and habitat. Once we have the models completed they need to be textured so Photoshop and Macromedia Fireworks are handy for bringing these objects to life. Before directly importing all of this data into a simulation environment, it is necessary to first render a stunning animation of the desired final product. This animation will represent what we hope to capture out of the simulation and it will include all of the accessories like ray-tracing, fog effects, shadows, anti-aliasing, particle effects, volumetric lighting, and lens flares. Adobe Premier will more than likely be used for video editing and adding ambient noises and music.

Lastly, V-Tree is the real-time 3D graphics engine which will facilitate our realistic simulation. Using V-Tree template libraries and Microsoft Visual Studio 6, I hope to take all of our summer work and construct an interactive scene. The final program will be controlled from a flight box or computer joystick and run on the Vision Station (Vision Domes). The simulation testers will get a first hand feel for the system by trying to navigate the rover safely through the labyrinth of the Mars surface. The final program will be a great realistic success and discovery.

## **Model of a Piezoelectric Transducer**

Debra Goodenow  
Ohio Northern University  
Electrical Engineering  
Senior  
**Mentor: Rich Oeftering**

### **ABSTRACT**

It's difficult to control liquid and gas in propellant tanks in zero gravity. A possible design would utilize acoustic liquid manipulation (ALM) technology which uses ultrasonic beams conducted through a liquid and solid media, to push gas bubbles in the liquid to desirable locations. We can propel and control the bubble with acoustic radiation pressure by aiming the acoustic waves on the bubble's surface. This allows us to design a so called "smart tank" in which the ALM devices transfer the gas to the outer wall of the tank and isolating the liquid in the center. Because the heat transfer rate of a gas is lower of that of the liquid it would substantially decrease boil off and provide of for a longer storage life.

The ALM the beam is composed of little "wavelets" which are individual waves that constructively interfere with each other to produce a single, combined acoustic wave front. This is accomplished by using a set of synchronized ultrasound transducers arranged in an array. A slight phase offset of these elements allows us to focus and steer the beam.

The device that we are using to produce the acoustic beam is called the piezoelectric transducer. This device converts electrical energy to mechanical energy, which appears in the form of acoustic energy. Therefore the behavior of the device is dependent on both the mechanical characteristics, such as its density, cross-sectional area, and its electrical characteristics, such as, electric flux permittivity and coupling factor. These devices can also be set up in a number of modes which are determined by the way the piezoelectric device is arranged, and the shape of the transducer. For this application we are using the longitudinal or thickness mode for our operation. The transducer also vibrates in the lateral mode, and one of the goals of my project is to decrease the amount of energy lost to the lateral mode.

To model the behavior of the transducers I will be using Pspice, electric circuit modeling tool, to determine the transducer's electrical characteristics at the frequency of interest. This will also help me determine the characteristics of an impedance matching network to operate the transducer at its optimum efficiency. For this I will use ABMs (analog behavioral modeling) to model dependent current and voltage sources that represent the transducer. I have also been working on the Labview control software for the phased array used to control the bubbles, and will begin testing on that before the end of my internship.

## ADAPTIVE CLEARANCE CONTROL SYSTEMS FOR TURBINE ENGINES

**Keith M. Blackwell**  
Cleveland State University  
Electrical Engineering  
Undergraduate, Junior  
**Mentor: Kevin J Melcher**

The Controls and Dynamics Technology Branch at NASA Glenn Research Center primarily deals in developing controls, dynamic models, and health management technologies for air and space propulsion systems. During the summer of 2004 I was granted the privilege of working alongside professionals who were developing an active clearance control system for commercial jet engines. Clearance, the gap between the turbine blade tip and the encompassing shroud, increases as a result of wear mechanisms and rubbing of the turbine blades on shroud. Increases in clearance cause larger specific fuel consumption (SFC) and loss of efficient air flow. This occurs because, as clearances increase, the engine must run hotter and burn more fuel to achieve the same thrust. In order to maintain efficiency, reduce fuel burn, and reduce exhaust gas temperature (EGT), the clearance must be accurately controlled to gap sizes no greater than a few hundredths of an inch. To address this problem, NASA Glenn researchers have developed a basic control system with actuators and sensors on each section of the shroud. Instead of having a large uniform metal casing, there would be sections of the shroud with individual sensors attached internally that would move slightly to reform and maintain clearance. The proposed method would ultimately save the airline industry millions of dollars.

As part of this research, it was my task to assist in the preliminary testing by updating the programs to simulate and control actual test rig conditions. Using the latest version of Labview, I had to revise a time-based program that would accurately record the feedback from an actuator and the signal read by the position sensor in terms of displacement, velocity, and acceleration. Once the foundation for the program had been laid to precision with the initial variables to be defined under *user specified* conditions, I had to integrate additional factors such as the engine temperature and pressure in order to fully apply actual test conditions.

A couple engineers and I had to make subtle changes before we ran the preparatory test rig several times to ensure that both the program and the connected components were ready for the actual test. Accordingly, we used a capacitive sensor in place of an encoder which correlated well with my course studies in electrical engineering because sensors of this type can determine displacement based on the amount of voltage. With air as the dielectric, larger voltages would suggest a closer position of the two charged plates. Similarly we used a vertically positioned stepper motor in place of an actuator and loaded the motor with weights to simulate the pressure force on the turbine shroud.

Through this experience I learned that not all research has to be conducted with the actual experimental hardware, but that there are other ways (experimental and analytical) to simulate dynamic systems. Also, I was able to get a glimpse into the work of controls engineers which will help me decide my specific area of electrical engineering.