INTERN SUMMARY REPORTS

Probe Station Antenna Range

By: Phil Barr
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Date: July 23, 2004

This summer I was given the task of programming a Probe Station to collect near field antenna patterns and convert them to far field patterns. The purpose of this project is to provide NASA with another means of antenna characterizing. Currently, NASA Glenn can measure near field and far field patterns of many different types of antennas. The antennas targeted for this lab are small patch antennas at high frequencies that require probe biasing. The Probe Station contains two probes for RF signals and another two for DC Biasing. The way this lab works is as follows: A patch antenna is placed on the probe station and biased properly for testing. This antenna is known as the Antenna Under Test (AUT). The AUT is supplied with an RF signal from a probe that is connected to a network analyzer. Above the AUT hangs a probe for measuring the electric field emitted by the AUT. The probe is controlled by four axis. The axis of movements for this probe are back and forth, left and right, up and down, and rotation. The network analyzer and axis controllers are tied into a computer for reading commands and recording data. The probe scans a rectangular pattern above the AUT to measure the electric field emitted by the AUT. This data is then recorded and analyzed back at the computer.

When I arrived here most of the hardware for the lab was already installed. I was given a complete overview of how everything runs and asked to integrate everything in LabVIEW.

From my work this summer a user is now capable of taking a near field antenna scans of many types of patch antennas and converting this to the more important far field pattern in LabVIEW. This program was designed to measure both linear and circularly polarized antennas. My goal for this project was to automate and prevent the user from seeing everything done behind the scenes. This goal proved harder than I had originally thought because I came to learn that to accomplish everything I would need to make use of several applications. LabVIEW is important for hardware control and data acquisition, but when it comes to analysis and display I had to look elsewhere. The conversion of the near field data to far field data is done in Matlab. I was able to integrate Matlab into LabVIEW so that the user wouldn't need to do this them self. Another important feature not capable from LabVIEW was providing the user with an unlimited

number of graph displays. I wanted the user to be able to conduct a scan and be able to choose from a collection of different graphs to display relative to the scan. For a typical scan on a linear patch antenna the user has 24 different types of graphs they can view. In LabVIEW you can only display as many graphs as you code into the program. With 24 different graphs you would either need to exclude some or take up much needed panel space in LabVIEW. To solve this problem I knew I would need to come up with a method to allow the user to open multiple graphs each in their own window. This was accomplished by creating a graphing program in Visual Basic and executing it from LabVIEW. To keep everything uniform I needed to integrate the graphing features of LabVIEW into Visual Basic which took some time to figure out.

This Probe Station antenna range is almost complete. Currently I'm working on safe guards such as making sure a scan isn't attempted when equipment may be off. This antenna range has been tested using predictable horns and observing that the results are what was expected.

The remaining time here I'll finish tweaking and improving the antenna range. A technical memorandum will be written to give exposure to the new capabilities NASA has from this range. I've been given flyers for different conferences that my mentors think would be good for me to apply a paper towards. I've also been asked to search the US Patent and Trademarks office to find out how unique this project is compared to what already exists.
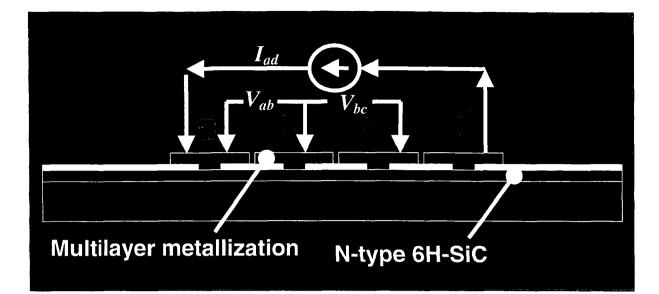
In conclusion, my work this summer has been very beneficial to NASA and myself. NASA has gained the capability of further antenna testing through the use of a new lab and I've been exposed to a number of different programs. I was told what the antenna range should be able to do and was free to implement it however I chose. This allowed me to think creatively without being limited to certain specs. It also forced me to think as a designer. I needed to put myself in the position of the user and make certain my program was the easiest to use along with being robust enough to allow meaningful and useful data analysis and presentation.

David DeAngelis
7/16/2004

LERCIP 2004 Summary

This summer I am continuing my project from the previous two summers. My work involves ohmic contacts to N-type silicon carbide (SiC) devices. My mentor, Dr. Robert Okojie, is developing the technology behind high performance sensors and actuators for harsh environments. SiC is useful because it is able to operate at temperatures up to 600 °C and it is resistant to radiation damage. This allows sensors and electronics to be placed in new locations, such as inside a jet engine or in space application without using heavy shielding. Ultimately this results in more efficient, smarter engine technology, reduced launch weights for spacecraft, and high power and high temperature electronics.

A fundamental part of SiC devices is the ohmic contact. The contact is the interface between the semiconductor (SiC) and external circuitry. The current flowing in and out the devices is through the contact. Ensuring that these contacts remain ohmic (linear I-V behavior) allows us to fabricate devices that do not waste power at the metallurgical junction. Another key part is maintaining a low contact resistance. It is desired to maintain minimum energy loss by avoiding a rectifying electrical characteristic.

My project is to develop and implement a testing procedure for measuring the contact resistance while the device is operating at high temperature. It is important to measure the contacts while simulating the true operating environment as closely as possible. For this reason, measurements are taken while the device is heated at intervals up to 600 C in air. To test the long term reliability of the devices, the high temperature measurements are repeated after heating the sample for long intervals in air. A new set of data is gathered after heating for a total of 100, 200 and then 400 hours. The current as a function of voltage and the contact resistance was measured using the four point probe technique. The four point probe method is chosen because it measures contact resistance while eliminating error due to wire resistance and calibration issues.

Multilayer metallization   **N-type 6H-SiC**

The diagram above shows a cross section of the four point probe test structure, where the letters a, b, c, and d indicate where probe tips are placed. The current supplied, I_{ad}, is 1 mA. Voltages V_{ab} and V_{bc} along with the center to center contact distance 's' and the contact diameter 'd' are then used in a modified Kuphal's formula to find the contact resistance.

$$Rc = \frac{A}{I}\left[V_{AB} - V_{BC}\frac{\ln\left(3\frac{S}{D} - \frac{1}{2}\right)}{2\ln(2)}\right]$$

These measurements are performed through a microscope on a hot chuck system using probe points that are attached to micromanipulators. Collecting this data is difficult because we must place four probe points simultaneously and make sure we have a strong connection. Also, the outermost layers of the contacts and the probes tend to oxidize, forming a thin barrier that we must penetrate.

Some early results of this work were presented at the 2004 Electronic Materials Conference at the University of Notre Dame. I had the opportunity to attend this conference and gain exposure to the latest news in semiconductor research. I gave a 20 minute presentation to fellow conference attendees and was generally well received. The abstract of this talk is as follows:

In-situ High Temperature and Current Characterization of Ohmic Contacts to N-type SiC

We report the results of the in-situ characterization of Ti/TaSi$_2$/Pt ohmic contacts to 6H-SiC during high temperature and current accelerated stressing. Several 6H-SiC four-point probe test structures are exposed to a constant current of 1 mA and temperature up to 600 °C in air ambient at intervals of 100 hrs up to 400 hrs. The insertion of SiC devices into the critical sections of the propulsion systems and on-board electronics and sensors for planetary missions to harsh planets (i.e.,

Venus) and other cosmic bodies will require that these devices survive and operate reliably during the entire mission. The temperature in these environments is sometimes greater than 500 °C and with high radiation values. Thus, the goal of this work is to evaluate the long term stability and reliability of Ti/TaSi$_2$/Pt ohmic contact metallization to 6H-SiC under simulated constant operating conditions at high temperature. The current-voltage (I-V) characteristics, the series resistance, and the specific contact resistance (SCR) of the test structures are measured in-situ under the above environmental conditions. After every 100 hrs of heating at 600 °C in air and at 1 mA, the samples are cooled and similar measurements are repeated. The results are then compared to determine deviations from the initial values. Unstable voltage offsets that precede the eventual failure of SiC devices have been largely attributed to the electrical instability at the semiconductor metallurgical junction. Another marker of premature failure is associated with the irreversible drift of the device reading during operation. One source of drift is likely due to microstructural changes in the material after extended current stressing. Before the contact resistance is measured, the ohmic behavior of the test structure is verified. The device is heated in the atmosphere from room temperature to 600 °C. The temperature effect on the resistance shows a non-linear behavior, starting with a high resistance at room temperature and gradually decreasing. From about 250 °C, the resistance begins an upward swing and continues to 600 °C. This behavior is explained by the dominance of impurity and phonon scattering mechanisms on current transport at temperature below 250 °C and above, respectively. The plots of the resistance versus temperature during the various 100 hr cyclic soaking period do not track perfectly as is expected under ideal conditions, thus suggesting that microstructural changes are occurring either within the metal contact (e.g., phase transformation), at the metallurgical junction (e.g., chemical reaction), or within the crystal. With regard to the SCR, it is initially measured to be 4 x 10$<^{-4}$ cm^2 and remains constant over the temperature range after the first 100 hrs. However, a factor of two increase is observed after 400 hrs of soak at 600 °C in air, even as the SCR remain relatively constant at the new values. At the talk scanning electron microscopy and auger analyses will be used in conjunction with the I-V characteristics to discuss the failure mechanisms.

Since the conference, I have been working on preparing and testing new samples to add to our collection of data. Our first high temperature tests support our theory of the chemical mechanism behind our ohmic contacts. We are now measuring the contact resistance of samples that have varying doping levels and epilayer thicknesses to find the optimum combination. We also plan to implement a passivation scheme to prevent edge encroachment, or oxidation of the contact caused by oxygen leaking in from the side. This work should give us a more clear picture of how to create a thermally stable, low resistance ohmic contact to N-type silicon carbide.

L.E.R.C.I.P. Internship Summary

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Mentor: Al Downey, Electron and Optical Devices Branch (5620)

I am currently working towards a double major in Computer Science and Electrical and Computer Engineering. My summer internship at NASA Glenn Research Center has allowed me to apply and further my knowledge of both of these fields. This summer is my second L.E.R.C.I.P. experience, and has worked out equally well as the first. I haven't been working on one single project this year, but instead have had a good variety of things to work on. Thus far I have spent time on the following tasks: antenna measurements, high-temperature reliability testing, and left-handed metamaterials.

The first two weeks of my summer were put toward testing planar antennas that operate at either 14 GHz or 35 GHz. It is hoped that after some fine-tuning, these two types of antennas can be combined, producing a single antenna that operates at both frequencies. The antennas are tested in an antenna range, which is essentially a Plexiglas box lined with foam absorber. A signal at a specific frequency enters the range via a horn mounted on one side of the Plexiglas box. The antenna under test is mounted on a rotating stage directly in the path of the input signal. During testing, the antenna is rotated from a -90° position to a 90° position, relative to the input signal. Effectively, this measures the antenna's ability to receive waves coming from any practical angle. Meanwhile, the power of the signal received by the antenna is monitored. This entire testing procedure is performed automatically by software written in a graphical programming language called LabVIEW. In addition to using this software to measure a number of antennas, I was able to tweak the program, allowing it to run three times faster.

Reliability testing has consumed more of my time this summer than any other topic. Reliability

testing occurs over an extended period of time, up to 1000 hours in this case. The devices to be tested are simple, on-wafer circuit components such as resistors, transmission lines, and capacitors. During the entire test, the devices must be kept at a temperature of 500° C. In addition, the devices must be biased to a certain current/voltage level throughout the testing period. I am currently working on the software and hardware for this reliability test setup. The software is again written in LabVIEW. This software will periodically measure the current through and voltage across each device, making it possible to determine when the devices fail, and how their parameters change over time. Due to the extremely high temperatures required by the test, the software will also routinely perform safety checks.

The subject that has filled my spare moments this summer is left-handed metamaterials (LHM's). A metamaterial is a block constructed from more than one type of material. The block is composed in such a way that artificial "cells" are created. The composite behaves like a continuous material because its elements are much smaller than the wavelength of the electromagnetic radiation incident upon it. One way to create a LHM is to start with dielectric sheets that have a thin layer of metal on each side. The sheets are etched so that there are straight, parallel copper lines on one side and split-ring resonators on the other side. Numerous such sheets are interlaced to form a rectangular grid.

Prior to this summer, engineers in my branch had already built one such LHM (See Figure 1 below), using a 20x20 grid.
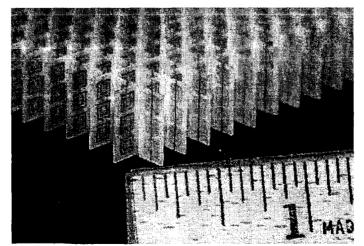

Figure 1: Left-handed metamaterial

My job was to help devise a way to measure the signal inside each cell of the LHM. The signal transmitted through the LHM had previously been measured by sandwiching the material between 2 solid sheets of metal, placing a signal source on one side of the block, and measuring the signal on the opposite side. I worked with another engineer to determine how to test each cell without adding too many additional variables. We built a new fixture to detect the signal. First, we mounted a coaxial connector on the corner of a thin metal sheet. The center conductor of the coax cable was extended out from the metal sheet so that it could be inserted in each cell of the LHM. We chose to attach the connector near the corner of the sheet so that it would be more visible, and hence easier to move quickly from one LHM cell to another. This was especially important because there are hundreds of cells, each of which is relatively small (5mm x 5mm). We used spare metal sheets to cover the parts of the LHM that were left exposed by our new test fixture. With the hardware setup finished, we wrote a simple LabVIEW program to read the power traveling into the block and out through the coax connector. The test setup is now complete and measurements are in progress.

Overall, I have been very pleased with both of my summers at NASA. For me, the experience has been interesting as well as practical. I learned how to use LabVIEW last summer, and was able to apply that skill in a year-long independent study during the past school year. In fact, I would not have been accepted for that position, had it not been for the experience I gained at NASA. Furthermore, the proficiency I gained during my independent study has made me a better programmer back at NASA this summer.

Hubble Space Telescope Bi-Stem Thermal Shield Analyses

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7-27-04

The Hubble Space Telescope (HST) was launched April 24, 1990, and was deployed April 25 into low Earth orbit (LEO). It was soon discovered that the metal poles holding the solar arrays were expanding and contracting as the telescope orbited the Earth passing between the sunlight and the Earth's shadow. The expansion and contraction, although very small, was enough to cause the telescope to shake because of thermal-induced jitters, a detrimental effect when trying to take pictures millions of miles away. Therefore, the European Space Agency (ESA, the provider of the solar arrays) built new solar arrays (SA-II) that contained bi-stem thermal shields which insulated the solar array metal poles. These thermal shields were made of 2 mil thick aluminized-Teflon fluorinated ethylene propylene (FEP) rings fused together into a circular bellows shape. The new solar arrays were put on the HST during an extravehicular activity (EVA), also called an astronaut space walk, during the first servicing mission (SM1) in December 1993. An on-orbit photograph of the HST with the SA-II, and a close up of the bellows-like structure of the thermal shields is provided in Figure 1.

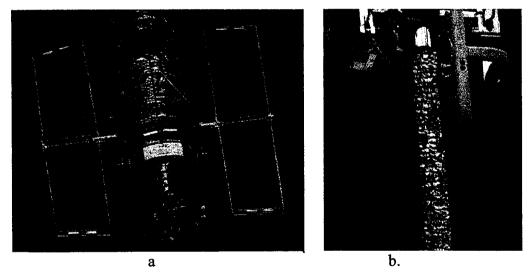a   b.

Figure 1. On-orbit photograph of the Hubble Space Telescope during SM1, a). HST with Solar Array II attached, and b). Close-up of a section of thermal shields.

While in space the bi-stem thermal shields were exposed to space phenomena such as atomic oxygen, ultraviolet (UV) radiation and electron and proton radiation (Van Allen Belt trapped particle radiation), in additional to thermal cycling and vacuum. On Earth, oxygen is a diatomic molecule, but in LEO short wavelength UV radiation breaks the diatomic bonds and forms monatomic oxygen, which is highly reactive. Therefore, when it collides with the FEP in space it will react, and can chemically erode it away, while the UV and particle radiation embrittles it. This is problematic when using the material as a long-term insulator, because it

turns the FEP from a flexible and stretchy substance into a hard brittle substance, causing it to crack and break apart, losing its effectiveness as an insulator, affecting the durability of satellite systems.

After 8.25 years in space, during the fourth servicing mission (SM3B) in March 2002, the second set of solar arrays were retrieved and replaced with a third set of arrays (SA-III). A section of the bi-stem thermal shields was provided to the NASA Glenn Research Center from ESA, so that the environmental durability of the thermal shields could be studied and compared to previously retrieved and studied insulation materials from HST. Figure 2 shows images of the as-retrieved bi-stem sample.
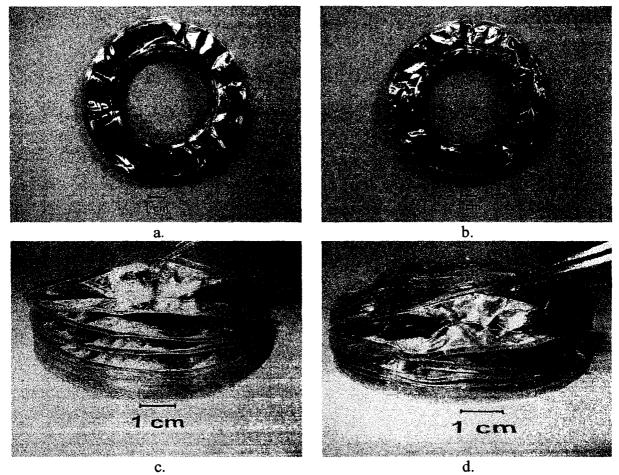

a.   b.

c.   d.

Figure 2. Post-retrieval images of the thermal shield sample provided to Glenn: a). Side A, b). Side B, c). Anti-solar side lifted to show individual welds with no cracks, and d). Solar facing side lifted to show individual welds with through-thickness cracks.

As can be seen in the pictures, the retrieved sample is severely damaged on the solar exposed side (image 2d and right side of images in 2a and 2b). It was more severely damaged than it was originally thought to be, compromising the original plans of how some tests were to be performed. Instead of laying flat as well as being reflective, the bi-stem thermal shield puckers on the solar-facing side and contains through-thickness cracks and has pieces flaking off. Between the fused rings, or welds, the solar-facing side is no longer continuously connected, and

large holes and cracks reaching from the inner weld to the outer weld exist. Images at low magnification of cracks and holes taken with an Olympus Stereo Zoom microscope are provided in Figure 3.

Figure 3. Optical microscopy images of the thermal shield sample section "Weld 3": a). Hole in weld, and b). Through-thickness cracks.

Four tests are to be completed on both pristine material, to provide a control and reference to how degraded the material is, and the space-exposed material. The first of these are tensile tests. A 38.5 cm long dog-bone shaped piece of material, with 2.5 cm in the narrowest area, is cut and then stretched by a machine until the piece breaks. Results between the pristine and space-exposed materials can then be compared as to whether changes in the mechanical properties have occurred. Large differences between the pristine and space-exposed material are expected in the ultimate tensile strength and elongation at failure. Unfortunately due to the extensive damage on the solar-facing side of the space exposed material, a dog-bone sample appears to be impossible to cut, and so a tensile test will not be completed on the solar facing side. An attempt at getting a piece as close to the solar-facing side as possible will be done, to try to get an idea of the decrease in elongation at failure.

The optical properties of the bi-stem thermal shield will also be examined. The solar absorptance and thermal emittance are to be measured on both the pristine and space-exposed material and it is not expected that the optical properties will be greatly changed. To test these properties, a keystone shape will be cut out around a ring of both the pristine and solar-exposed material and using a Lambda-19 UV/VIS/NIR Spectrophotometer the reflectance will be measured. In the damaged area of the solar exposed material, a piece as close to the size needed will be cut.

Density and hardness tests will also be completed. To measure the nano-hardness of the material, a small, approximately 0.8 x 0.8 cm square is mounted on three Atomic Force Microscope holders. It is then placed inside of a nanomechanical system that is operated in conjunction with an Atomic Force Microscope and is able to provide ultra light load indentations and can continuously measure force and displacement as an indent is made. Hardness vs. contact depth measurements are made and graphed. Preliminary tests on pristine FEP have been conducted to evaluate creep during the indentation process. It is important to unload the indenter after creep has stopped. The tests conducted indicated that a 15 second hold period is needed to minimize creep. Figure 4 shows the creep tests conducted at 500 µN loading for 5 mil pristine

Al-FEP. The deeper the indent the softer the material; and so by comparing the indent depths and computing the hardness from the indentation area the amount of embrittlement due to UV radiation can be quantified.
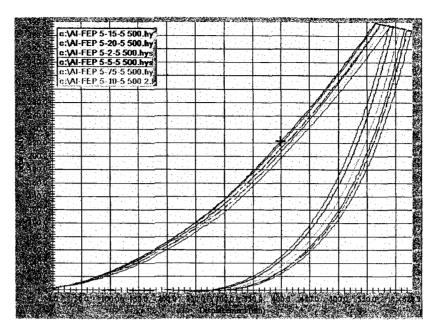

Figure 4. Nanomechanical indentation creep test data for pristine 5 mil thick Al-FEP.

Initial sample sectioning and documentation has been initiated, along with preliminary hardness testing. Tensile, optical, hardness & density tests are all planned. I hope to show the severe degradation of the space exposed Al-FEP bi-stem thermal shield throughout the testing process, and contribute to the continued research to improve materials used for space flight insulation. This information is crucial to the space community.

GRABER – the Duct Tape of Space
and JIMO Heat Conducting Foam

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Crack formation in the space shuttle's heat shield during flight poses a major safety concern to everyone on board. Cracking weakens the structure of the shield and lessens the protection it offers against the high temperatures and forces encountered during re-entry. Astronauts need a way to mend these cracks while in space. This is GRABER's function; it can be 'spackled' into the cracks by an astronaut. The material then hardens, or cures, due to being in a vacuum and the heat encountered when it faces the sun.

A great deal of work and testing is necessary to create a material that will be workable in a vacuum over a wide range of temperatures, will cure without cracking, will adhere to the sides of the crack, and that can withstand the extreme temperatures of re-entry. A Brookfield PVS Rheometer is being used to characterize GRABER's viscosity at various temperatures and stirring rates. Various compositions of GRABER are being heat treated in a vacuum to determine probably curing times in space. The microstructures of cured samples of each composition are being examined using both optical and electron microscopy.

Jupiter's Icy Moon Orbiter (JIMO) will be lifting off sometime around 2013. JIMO will have more power than its predecessor, Galileo, allowing it to change orbits to circle three of Jupiter's moons. Both of the engine types being considered require large heat dissipation systems. These systems will be comprised of heat conductive tubing and plates with a liquid flowing through them. In order to maximize the speed of heat transfer between the tubes and the panels, the in-between areas will be filled with heat conductive silicon carbide foam.

Two different foam systems are being considered for this foam. Currently, experimentation is underway with adding SiC, carbon, and carbon fibers to a two part fire retardant foam. The foam is them pyrolized and its mass and dimensional changes are measured. The structure of the foam will be examined using optical and electron microscopy as well. Work is also planned with a foam system developed by an Italian team.

CDF and PDF Comparison Between Humacao, Puerto Rico and Florida

Rosana González-Rodríguez

INTRODUCTION

The knowledge of the atmospherics phenomenon is an important part in the communication system. The principal factor that contributes to the attenuation in a Ka band communication system is the rain attenuation. We have four years of tropical region observations. The data in the tropical region was taken in Humacao, Puerto Rico. Previous data had been collected at various climate regions such as desserts, template area and sub-tropical regions. Figure 1 shows the ITU-R rain zone map for North America.

Rain rates are important to the rain attenuation prediction models. The models that predict attenuation generally are of two different kinds. The first one is the regression models. By using a data set these models provide an idea of the observed attenuation and rain rates distribution in the present, past and future. The second kinds of models are physical models which use the probability density functions (PDF).
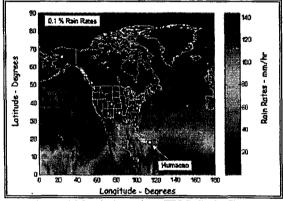

Figure 1.North America ITU-R Rain Zones

This paper presents the analysis of Humacao, Puerto Rico and Boca Ratón, Florida rain data through the development of the Probability Density Function (PDF) and the Cumulative Distribution Function (CDF). The PDF is a function of a continuous variable such that the integral of the function over a specific region yields the probability that its value will fall within the region. The CDF describes a statistical distribution. It has the value, at each possible outcome, of the probability of receiving that outcome or a lower one. The Humacao and Florida data sets are use to obtain the corresponding PDF and CDF. Humacao has 35 months of data, from July 2001 to May 2004. Florida has 46 months of data, from March 1995 to December 1998.

EXPERIMENT DESCRIPTION

A Ka band Propagation Terminal is deploy in the roof of a building. The terminal is a 1.8 meter offset reflector antenna and weather instruments. These instruments take data for weather statistic like barometric pressure, outside temperature and relative humidity. The rain accumulation is a measure with a tipping bucket rain gauge. A "tip" is a measurement of 0.01 millimeter of rain accumulation. Every time a tip occur the instrument send a signal to the computer data logging system which store it in a file. The amount of rain collected form a gauge located on the roof of a building is usually lower than the amount collected from the gauge located on the ground. The difference in the catch of the gauge is cost by the air flow across the gauge [14]. Humacao rain data logging began on July 2001.
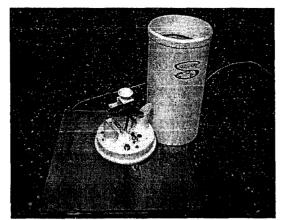
Figure 5.Tipping Bucket

Latitude Deg.	Longitude Deg.	Azimuth Deg.	Elevation Deg.	Site Altitude
18.1487	-65.8385	108	37	70 m

Table 1.Humacao Terminal Description

DATA FILE DESCRIPTION

Humacao rain data file is a text archive that has seven columns and an indeterminate numbers of rows. The number of rows is indeterminate because they depend on the amount of tips recorded. The rain data file contains the following variables:

- Column 1: GMT DAY
- Column 2: Hours
- Column 3: Minutes
- Column 4: Seconds
- Column 5: Fractions of seconds.
- Column 6: Tips
- Column 7: Cumulative rain

An example of Humacao rain data file is:

```
5   22  40  13  40  .01  .0004
5   23  43  58  43  .02  .0092
6   00  02  06  02  .03  -.0008
```

The Florida rain data file is a text archive that has six columns containing the followings variables:

- Column 1: Year
- Column 2: Month
- Column 3: Day
- Column 4: Hours
- Column 5: Minutes
- Column 6: Seconds

An example of a Florida rain data file is shown below:

```
98  01  06  15  42  02.80
98  01  06  15  42  05.03
98  01  06  20  07  40.60
```

RAIN RATE ANALYSIS

The data files need to be pos-process for example, the time is change from the hours, minutes, seconds format to fraction of days as a define in equation 1 and 2. Equation 1 corresponds to the Humacao data files and equation 2 corresponds to the Florida data files.

$$t_k = A_{k,0} + \frac{A_{k,1} + \frac{A_{k,2}}{60} + \frac{A_{k,3} + A_{k,4}}{3600}}{24} \qquad (1)$$

$$t_k = E_{k,2} + \frac{E_{k,3} + \frac{E_{k,4}}{60} + \frac{E_{k,5}}{3600}}{24} \qquad (2)$$

The terms in equation 1 and 2 are defined as follow. $A_{k,0}$ and $A_{kE,2}$ correspond to the day of the year. $A_{k,1}$ and $A_{k,3}$ correspond to the hours. $A_{k,2}$ and $A_{k,4}$ correspond to the minutes. $A_{k,3}$ and $A_{k,5}$ correspond to the seconds and $A_{k,4}$ is the fraction of a seconds.

To obtain the total rain fall we need to perform the sum of all tips. As previously mention the amount of water per tip is 0.01 inches. Total rainfall is defined in equation 3, where the variable Amp represents the amount of water in one tip.

$$Cum_k = \sum_{n=0}^{k} Amp_n \qquad (3)$$

Equation 3 is redefined as equation 4 to account for the index definition used in the MathCAD software.

$$Rain\_Fall = Cum_{NP-1} \qquad (4)$$

Equation 5 defines the time different of two consecutives tips. Subscript k represents the number of rows in data file.

$$\Delta 0_k = \left(t_{k+1} - t_k \right) \qquad (5)$$

For eliminates two consecutive time values that are not on the same day in the data set we need to do a statement for $\Delta 0_k$. This statement establishes that when $\Delta 0_k$ more than 1 the value that we need to use for $\Delta 0_k$ will be 0.000001. In the other case ($\Delta 0_k$ less than 1), $\Delta 0_k$ will be $\Delta 0_k$.

For obtain the total time that the rain rate was between 1 mm/hr to 300 mm/hr we use a sum of all differences between the numbers of point between zero to number of point in the data file.

For calculate the rain rate in millimeters per hours we use the equation 6 that have the conversion of the rain rate in mm/hr units. If the increment in seconds and limit the max rain rate to 300 mm/hr rain rates and the min rain rate to 1 mm/hr is more than three we use that data point and we convert it in mm/hr. In the other hand, if that increment in second is less than 3 we do not use the data point for analysis purpose.

For calculate the Probability Density Function (PDF) we use the following range:

0<rr<10
10<rr<20

20<rr<30
30<rr<40
.....
150<rr<160

To obtain the percent of the time the indeterminate rain rate can happen (PDF), first we add all samples that fall in a specific rain rate range, then it is divided by the total number of raw data points and the results is then multiply by 100.

$$PP_m = \frac{P_m}{P\_total} \times 100 \qquad (6)$$

In equation 7 we have the add of all samples that fall in a specific rain rate range

$$P_m = \sum_{k=0}^{rows(A)-2} if(m \cdot 10 < RR_k < m \cdot 10 + 10, 1, 0) \qquad (7)$$

In equation 8, we have the total of number of raw data points.

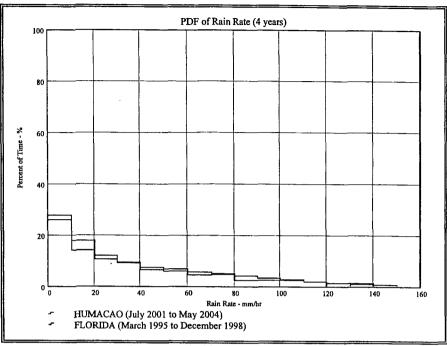$$P\_total = \sum_{m=0}^{15} P_m \qquad (8)$$

In the other hand, to obtain the Cumulative Distribution Function (CDF), first we add of all samples in a specific rain rate, then it is divided by the total number of points and the results is then multiply by 100.

$$CUM_m = \frac{CUM1_m}{CUM1_0} \times 100 \qquad (9)$$

In equation 10 we have add of all samples in a specific rain rate where m is a number between zero to fifth teen.

$$CUM1_m = \sum_{k=m}^{15} P_k \qquad (10)$$

The Probability Density Function (PDF) for four years of data in Humacao and Florida is show in figure 2.

PDF of Rain Rate (4 years)

HUMACAO (July 2001 to May 2004)
FLORIDA (March 1995 to December 1998)

Figure 2.Probability Density Function

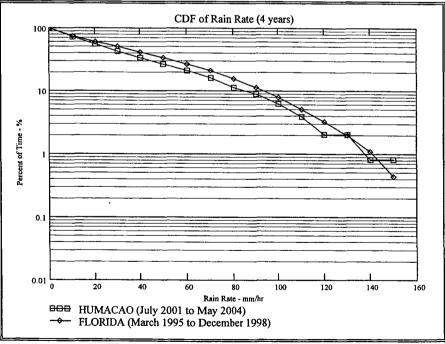The Cumulative Distribution Function (CDF) for four years of data in Humacao and Florida Data is show in figure 3.

CDF of Rain Rate (4 years)

HUMACAO (July 2001 to May 2004)
FLORIDA (March 1995 to December 1998)

Figure 3.Cumulative Distribution Function

CONCLUSION

The probability of rain rate between Humacao and Florida are basically the same. Humacao was bigger percent of probability than Florida in the smaller rain rates (0 to 30 mm/hr), but later it gets almost the same. In the larger rain rates (100 to 160 mm/hr) Humacao and Florida has the same percent probability for obtain that quantity of rain. The cumulative distribution function (CDF) shows that Florida has more percent of time to have a determinate rain rate in mm/hr than Humacao. Humacao has more percent of time to have the larger rain rate (between 140 to 160 mm/hr) than Florida. Humacao and Florida has the same percent of time to have a smaller rain rate (0 to 10 mm/hr). Florida has more percent of time to have a rain rate between 20 to 140 mm/hr than Humacao. Florida rain rate data shows larger rain probabilities in the range of 20 to 140 mm/hr than Humacao. The conclusions will be summary in that Florida is a worst case of rain rate than Humacao, Puerto Rico. Now the next step that we need to do is investigate is an atmospheric event occur by analyzed Florida data by month.
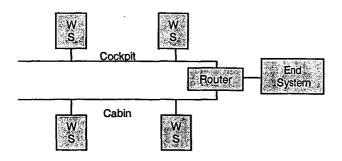
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Phase II – Development of the On-board Aircraft Network
Mentor: Richard A. Slywczak
Written By: Bryan D. W. Green and Okechuckwu A. Mezu

Description of Work

Phase II will focus on the development of the on-board aircraft networking portion of the testbed which includes the subnet and router configuration and investigation of QoS issues. The tesbed configuration will look like the following:

This implementation of the testbed will consist of a workstation, which functions as the end system, connected to a router. The router will service two subnets that provide data to the cockpit and the passenger cabin. During the testing, data will be transferred between the end systems and those on both subnets. QoS issues will be identified and a preliminary scheme will be developed. The router will be configured for the testbed network and initial security studies will be initiated. In addition, architecture studies of both the SITA and Immarsat networks will be conducted.

Testing Objectives

The phase II testing will accomplish the following objectives:
1. Configure the testbed for the aircraft on board configuration.
2. Perform QoS analysis based on the configuration settings in the router and IOS operating system.
3. Perform architectural studies on the SITA and Immarsat Networks to understand the configuration and operation of both systems.

Quality of Service Defined:

Quality of Service is defined as a network's ability to provide consistent performance for a specified service. The purpose of the Weather Information Communications (WINCOMM) Project is to develop advance communications and information for aircraft. This involves improving the time and manner in which weather data is sent to aircraft from the ground. Since the cockpit's communication method will now work on the packet switch network, several Quality of Service issues arise. Data destined for the cockpit needs to have priority over data destined to the cabin. Data priority is an issue where specified network traffic receives preferred treatment over other traffic while traveling to its destination. The goals of Quality of Service include:

1. Dedicated bandwidth
2. Controlled jitter and latency
3. Improved loss characteristics

The testbed for the cockpit/cabin scenario consists of two workstations running both Linux Red Hat 9 and Microsoft Windows Server 2000. One machine emulates the cabin and the other machine emulates the cockpit. Both workstations are connected to a Cisco router through an eight port hub. A front end system is connected to another router through a switch. The two routers are connected for emulation through the serial interfaces. The QoS features on the first router will be used to improve service.

The Cisco's IOS has four aspects of QoS which include classification, marking, policing and shaping, and queuing. Classification is basically separating network traffic into a specified class of service. The separation of classes can be based on an incoming interface, source or destination address, or applications. Marking consists of putting some type of mark on packets that enter or leave the router according to the classification scheme. Policing and shaping is a reaction to the marked packets. This aspect of QoS controls the traffic entering or leaving the router, so that the network conditions are predictable. Finally, queuing controls how and in what order packets are allowed to enter and leave the network.

Cisco IOS offers different types of QoS tools and below are the tools relevant to our application with examples:

Classification – this tool is used to identify and mark flows such as Policy-Based Routing (PBR).
Congestion Management – Examples of these are Priority Queuing (PQ), Weighted Fair Queuing (WFQ), and Class Based Weighted Fair Queuing (CB/WFQ). The manage the network upon congestion
Congestion Avoidance - Congestion avoidance techniques monitor the network traffic loads in order to prevent network congestions. Some examples are Weighted Random Early Detection (WRED), and Committed Access Rate (CAR).

Policy-Based Routing - It was first implemented on Cisco IOS Software Release 11.1. This mechanism forwards/routes data packets based on predefined polices according to

Access Control Lists. Thus classification and marking are the QoS features provided by Policy-Based Routing.

Access Control Lists are used to classify particular traffic by implementing a sequential list of permit and deny conditions. These lists are applied to an interface on the router and can be used to filter data based on applications, protocols, port numbers, and/or IP addresses.

Policy-Based Routing also allows for the marking of the IP precedence bits located in the type of service field of the IP header. The first three bits of the TOS field represent the IP precedence field. Although there are eight possible combinations, only six classes are available.

Priority queuing (PQ): It is implemented in Cisco IOS Software Release 11.1 and above. It ensures that important traffic gets precedence over others. PQ can be prioritized by network protocol, incoming interface, packet size, source/destination address, etc. Packets are categorized in one of four queues – high, medium, normal, or low – based on assigned priority.

Weighted Fair Queuing:
Weighted Fair Queuing is implemented to overcome the limitations of the first in first out (FIFO) queuing. WFQ is implemented in Cisco IOS Software Release 11.1.
Weighted Fair Queuing separates traffic based on source and destination network or MAC address, protocol, source and destination port, and socket numbers of a particular session. The classification scheme allows network traffic to be distributed in conversation like schemes based on fair queues. Data is placed in queues based the time it takes for the last bit of each packet to arrive.

Class Based Weighted Fair Queuing improves WFQ by allowing user defined classes of traffic. Traffic can be classified based on matching protocols, access control lists, and/or input interfaces. Bandwidth, weight, and maximum packet limit are administered to class during congestion periods.

Weighted Random Early Detection
WRED algorithm is designed to avoid congestion before it becomes a problem. It combines the RED algorithm with IP precedence to provide preferential traffic handling for high priority packets. WRED can be configured to discard lower priority traffic when the interface begins to get congested.

Committed Access Rate:
Committed Access Rate is available in Cisco IOS Software Release 12.1. CAR performs two QoS functions.
Packet classification is accomplished by separating traffic based on physical ports, source or destination IP or MAC address, application port, or the IP protocol type as specified in the Access Control List. After the data is classified, it is marked using the IP precedence bits.
CAR also has the ability to police and shape data. This is accomplished by managing the bandwidth for a given class of traffic through rate limiting. Traffic that falls between

specified rates is transmitted. While the other data is either dropped or placed in a different priority category.

Implementation and Architectures:

The current architecture for the aircraft IP network testbed is shown in the following diagram.

The routers used in this diagram are 2500 series routers with one Ethernet port each. The two routers are connected via the serial interfaces.

All of the tools available for QoS will work with this existing architecture. However, some of the features in these tools will only work under different configurations and architectures.

Priority Queueing:

Implementing the priority queueing tool in the existing architecture can be accomplished via an access list and a priority list. Creating the appropriate access list and matching it with a priority list will classify the network traffic into the necessary priority queue. Only one priority list can be assigned to a specified interface.

Priority queueing also has the ability to assign priorities based on the interface packets are entering. If the cockpit and cabin have a dedicated interface for incoming traffic, the data entering the router can be classified into one priority queues. This means explicitly declaring that packets entering the interface assigned to the cockpit be place into the high priority queue. This also means using a router with more than one Ethernet interface.

Committed Access Rate:

Implementing the committed access rate tool in the existing architecture can be accomplished by using the appropriate access list and by specifying a rate limit. Once the policy is matched with an access list the transmission rate for cockpit or cabin data can be specified.

CAR also has the ability to identify packets based on the IP precedence bits in the IP header. However, this requires QoS implementation on the source end of this scenario.

Once the bits are marked and sent through the network, the aircraft's router can use CAR to specify a rate limit for the cockpit and/or cabin.

Policy-Based Routing:
Policy-Based Routing allows for the setting of IP precedence, IP next-hop, and interface after matching the appropriate access list. The IP precedence bits can be used to declare priority and this tool can be used on the current architecture.

Weighted Fair Queuing:
Weighted Fair Queuing along with Class Based WFQ are IP precedence aware. Using this feature within this tool is the best implementation for QoS. However, configurations must be implemented on the source end of this scenario as well. Thi tool will work with the current architecture.

Notes / Reccomendations:
Using routers with more than one Ethernet interface would be very beneficial to this scenario. The schemes and configurations will be more intricate allowing for the best implementation of QoS.
Access Control Lists are normally used as security features. Therefore, when using this tool to implement QoS the list must be configured carefully. If the list permits only one class of traffic all other traffic will be implicitly denied.
IP precedence and Differentiated Services Code Point both take advantage of the QoS solutions within the IP header. Both use the type of service field to mark precedence bits. These tools often times require cooperation throughout all of the networks in which the data packets are traveling.

Development of the Planar Inlet Design and Analysis Process (PINDAP)

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Undergraduate, Junior
Mentor: Dr. John W. Slater

PROJECT SUMMARY

The aerodynamic development of an engine inlet requires a comprehensive program of both wind tunnel testing and Computational Fluid Dynamics (CFD) simulations. To save time and resources, much "testing" is done using CFD before any design ever enters a wind tunnel.

The focus of my project this summer is on CFD analysis tool development. In particular, I am working to further develop the capabilities of the Planar Inlet Design and Analysis Process (PINDAP). "PINDAP is a collection of computational tools that allow for efficient and accurate design and analysis of the aerodynamics about and through inlets that can make use of a planar (two-dimensional or axisymmetric) geometric and flow assumption."[1] PINDAP utilizes the WIND CFD flow solver, which is capable of simulating the turbulent, compressible flow field.

My project this summer is a continuation of work that I performed for two previous summers. Two years ago, I used basic features of the PINDAP to design a Mach 5 hypersonic scramjet engine inlet and to demonstrate the feasibility of the PINDAP. The following summer, I worked to develop its geometry and grid generation capabilities to include subsonic and supersonic inlets, complete bodies and cowls, conic leading and trailing edges, as well as airfoils. These additions allowed for much more design flexibility when using the program. This summer, I am working with Dr. Slater to add

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[1]"Planar Inlet Design and Analysis Process (PINDAP)" John W. Slater

additional automation capabilities to PINDAP in order to make it more user-friendly so that a non-CFD expert could use PINDAP to design and analyze an inlet, duct, airfoil, etc.

The development focus for this summer is to add several "design modules" to PINDAP which would allow a designer to model an aerodynamic object without the numerous and tedious design inputs previously required. For example, a NACA 4-Digit Series airfoil design module is currently under development. This would allow a designer to inut minimal geometry information such as chord length and 4-digit airfoil number in addition to other grid spacing parameters and then using that information, PINDAP would generate the airfoil geometry and grid for use with CFD simulations. Previously, a designer would have had to individually input all of the curve entities making up the airfoil shape in addition to many other grid and zone parameters. Concurrently with the airfoil design module, a supersonic inlet design module is also being developed. This module will significantly simplify the rather complex task of designing the appropriate inlet geometry as well as simplify the grid generation process for supersonic inlets. This design module could potentially be applied to current design concepts of the Supersonic Business Jet.

Following the addition of several design modules to PINDAP, I will be using the software to run through the design and analysis of an inlet (or airfoil, etc) utilizing all PINDAP components. This will be used as an example case (tutorial) for a PINDAP user's manual that is being written as the software is developed.

Dr. Slater has set the goal of an alpha release of the software to several branch members during the summer, and if all goes according to plan, the months of work on this project will culminate with a beta release to the Inlet Branch sometime in August

2004. These pre-releases will allow branch members to evaluate the software and provide

additional input and suggestions prior to the release of version 1.0. A timetable has not

been set for that release. Dr. Slater has also begun work on an AIAA (American Institute

of Aeronautics and Astronautics) paper on PINDAP which he is planning to submit to

one of the upcoming AIAA conferences.

Lucien Hertert
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An Overview of My 2004 Summer Internship

This summer I have been working with the Non-destructive evaluation (NDE)

group and NASA Glenn Research Center. As this is my second summer with the group, I

was able to begin working as soon as I arrived. My first task was to develop a system to

acquire an impedance analyzer. The basic setup of the system is as follows: a piezo-

electric patch is attached to a sample, and a lead is attached to that patch. Another lead is

attached directly to the sample, and the leads are connected to the impedance analyzer.

The system then puts a voltage through the material over a range of frequencies, and the

corresponding impedances are measured for each frequency. After data is collected, it

can be compared to another data set, and through a series of calculations a damage

parameter is produced. For the time being, we are using a correlation calculation to find

the damage parameter. The hope for this project is that a baseline measurement can be

taken, and then sometime later another measurement could be taken, and the damage

parameter would determine how much damage had been done to the sample. To test this

hypothesis, we took baseline data from a sample, and then sent it out to have a notch cut

into it. When it was returned, we again took measurements on the sample, and the

damage parameter was significantly lower (this signifies more damage, because a perfect

correlation is 1).

Another project that I have been working on pertains to the group's newly

acquired acoustography system. This system creates a full field ultrasonic signal on one

side of a sample, and an acousto-optic sensor is placed on the other side of the sample.

The acousto-optic sample changes colors based on the intensity of the ultrasonic field that passes through the sample, and a camera captures pictures of the acousto-optic sensor. This system was developed by a commercial group working in conjunction with our group. Since the system was delivered, we have ported the control and analysis software from C to LabVIEW, and are currently working on optimization and improvements in both areas of the software. I worked heavily on optimizing the internal representation of images (16-bit, RGB, etc.) as well as overall program structure optimization. In the near future, I will be working on converting this system over to a real-time processing environment.

A third project I have worked on was mostly a continuation of a system I developed last summer. This system uses our thermography setup to measure the reflectance of a sample. Thermography is conceptually fairly simple: flash lamps heat up a sample and an infrared camera captures the heat profile of the sample as it cools. The idea is that the cooling rate will differ in areas that there is a structural inconsistency, such as a flaw. Measuring reflectance is a bit more complicated, but it consists of taking four sets of images: light on/no sample; light off/no sample; light on/with sample; light off/no sample. Each set of images is averaged to obtain a representative image, and calculations are done on a pixel-by-pixel basis to calculate the reflectance for each pixel. This summer, I have been adding functionality to the program that I created last year in order to better suit the needs of my mentor in the research he is currently doing.

For the rest of the summer, I will be working on various other projects, such as the real-time implementation of the acoustography system, as well as updating the data acquisition software for our groups' guided wave scanner.

My Summer Experience as an Administrative Officer Assistant

Janelle C. Jones
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Junior
Mentor: Sandra Hardy

The motto of the Safety and Assurance Directorate (SAAD) at NASA Glenn Research Center is "mission success starts with safety." SAAD has the functions of providing reliability, quality assurance, and system safety management to all GRC projects, programs and offices. Product assurance personnel within SAAD supervise the product assurance efforts by contractors on major contracts within GRC. The directorate includes five division offices and the Plum brook Decommissioning Office. SAAD oversees Glenn's Emergency Preparedness Program which handles security, hazmat, and disaster response and supervision.

The Safety and Assurance Directorate Office (8000), headed by Vernon Wessel, offers direct support to the entire directorate. It ensures the implementation of Headquarters and GRC administrative, fiscal, and human resource policies. The office sustains the Directorate managers in providing resources and expertise. During my internship, I worked in this directorate office under the administrative officer.

The administrative officer has a number of responsibilities within the directorate. She reviews and initiates action on task orders involving a full range of scientific and engineering disciplines. She evaluates the contractor task plans including statement of work, funding, and schedule requirements. She manages purchase requests for required funding, while providing fiscal year and contract funding status. She also directs and coordinates programs and projects that support the directorate, while acting as the liaison between her directorate and other within Glenn Research Center.

My main objective was to work with the financial and budgetary side of the directorate office. This included working with the entire budgets of the five divisional offices in the directorate, including risk management, Glenn safety, environmental management, quality management, and Plumbrook decommissioning office. My tasks included updating and inputting transaction data in numerous excel spreadsheets that tracked the finances of the different offices. I monitored and analyzed the travel, training, overtime, awards, and labor budgets for each of the offices. I also ran monthly reports in each of the areas to give to the division managers and the director of the Safety and Assurance Directorate. These reports would include the amount of money budgeted, the amount of money spent, the percentage through the fiscal year, and the amount of money remaining, along with other information requested from chiefs and managers. Based on my analysis of the reports and conclusions I drew from the data, division chiefs would make decisions about their office for the upcoming

weeks and months regarding the use of their budget balance. Also, there would be an itemized list giving the details of how exactly money had been spent within the office. As required by NASA headquarters our directorate is responsible for updating certain metrics that can be seen on the NASA website. I was given the job of bringing all of these metrics up to date to be approved by appropriate personnel at headquarters. To aid in the completion of my tasks I attended all relevant meeting, including staff meeting and teleconferences. Moreover, I played a big part in managing the budget of the NASA Engineering and Safety Center (NESC) Program. This program was created my Administrator O'Keefe to provide a central location to coordinate independent engineering and safety assessments across the agency. To supervise the money I met with the chief engineer and attended weekly teleconferences with individuals from all of the other centers.

These tasks were completed using a number of different software applications. One of those was the Integrated Financial Management Program. Within this program are the Core Financial and Core Financial Business Warehouse Programs. These two programs allow me to see all charges that have been made inside the entire directorate that meet the specifications that I input. They were instrumental in giving reports to division office chiefs and other managers within the directorate. Another necessary skill to complete my objectives was an in depth knowledge of Microsoft Excel spreadsheets. I often needed to create mathematical formulas and do extensive formatting to the worksheets. I had to arrange data so that it was easy for the reader to see exactly how much money remained in each budget while including enough information for the reader to see how that money had been spent. This part of my objective allowed me to work on my relationship skills because I had to interact with various personalities.

I made sure that my internship experience included more than tasks delegated to me by my mentor. I also participated in a number of different projects. One was is the GRC Adopt-a-Highway Program. Glenn, as a participant in this program, is responsible for maintaining the cleanliness of a stretch of highway a short distance from the GRC facilities. A couple hours a month other volunteers and myself would venture out to the highway and pick up trash and other things left beside the road. Another project was chaperoning a group of middle school aged children in the NASA project program to the COSI museum in Toledo, Ohio. The NASA Project program is designed to motivate students to pursue higher education in the fields of math, science, and engineering. I also walked along side the NASA float in the Lorain International Parade. I was dressed in an astronaut outfit and passed out literature pertaining to NASA and educational program offered at Glenn to those attending the parade.

Programming an Experiment Control System

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Mentor: Donald Chubb

Paper in lieu of Research Symposium II presentation

July 16, 2004

NASA Glenn Research Center
Photovoltaic and Space Environments Branch

As NASA develops plans for more and more ambitious missions into space, it is the job of NASA's researchers to develop the technologies that will make those planed missions feasible. One such technology is energy conversion. Energy is all around us; it is in the light that we see, in the chemical bonds that hold compounds together, and in mass itself. Energy is the fundamental building block of our universe, yet it has always been a struggle for humans to convert this energy into useable forms, like electricity. For space-based applications, NASA requires efficient energy conversion methods that require little or no fuel.

Here at the NASA Glenn Research Center, the Photovoltaic and Space Environments branch has spent years researching one such method, solar cell (photovoltaic) arrays. This summer, I worked as an intern in this branch under Dr. Donald Chubb, who is currently researching a novel application of solar cell technology, Thermophotovoltaics (TPV). A TPV system at its core contains three parts: a heater, an emitting material, and a photovoltaic array. The heater brings the emitter material up to a high temperature. The heated emitter releases electromagnetic radiation in the infrared range. This radiation is then absorbed by the photovoltaic cells, which convert the radiation energy into electricity. In order to make the TPV system as efficient as possible, the emitter and the photovoltaic array must be synchronized, that is, the emitter must emit a large amount of radiation at wavelengths that the photovoltaic cells absorb well. The system's heater can be anything that produces heat – a traditional combustion source, a nuclear reaction, or something else. This flexibility makes the TPV system adaptable to many different applications, both space-based and terrestrial.

This summer in Dr. Chubb's lab, we have been preparing an experiment that will help determine the expected usable life of a TPV system. A major limiting factor on the life of the system is the evaporation of the emitter material and its deposition on the photovoltaic cells. As the emitter material deposits on the cells, the cells become less and less efficient. Our experiment will measure the vapor pressure of some candidate TPV emitter materials, allowing us to determine how much lifespan we can expect out of a TPV system utilizing each different material.

The experiment itself takes place inside a vacuum chamber. A sample of the emitter material is heated by a filament, which carries a current delivered by a power supply. Due to the extreme heat, emitter material will evaporate and deposit onto a detector called a quartz crystal monitor (QCM). This detector determines the rate of deposition and the thickness of the deposited material based on changes in the oscillation frequency of the crystals. The rig also contains several thermocouples to monitor the temperature and a residual gas analyzer (RGA), which analyzes the composition of the extremely low-pressure atmosphere inside the rig.

My work this summer has focused on creating the computer program that will communicate with all the experimental equipment, and therefore serve as the monitor, control, and recording system for the experiment. I have done all my programming in Microsoft's Visual Basic design environment. To create the program, I first adapted some existing programs and created some new programs that talk to each piece of equipment individually. The different components communicate with the computer through three different hardware systems: the computer's COM ports, a GPIB (General Purpose Interface Bus), and a PCI (Peripheral Component Interconnect) card. In order to

communicate with the devices, I had to become familiar with the programming protocols for all three.

Right now, I am nearing completion of the first version of the experiment control program, which will display and record data from the QCM, thermocouples, power supply, and pressure gauge simultaneously. In addition, the program will allow the user to control each device. This will allow the user to set such things as the measurement units of the pressure gauge, the QCM's parameters, and the current delivered by the power supply. The program will also calculate the vapor pressure of the material being evaporated. This program will be used to monitor the initial run of the experiment, in which we will test the vapor pressure of silver. Since the vapor pressure of silver is already well known, we can compare our results to the accepted value to test the accuracy of our rig.

For subsequent runs of the experiment, in which we will be testing the unknown vapor pressures of our TPV emitter materials, I will expand the program to automatically change the current delivered by the power supply to regulate the temperature of the material. This will allow the experiment to run for days to weeks with absolutely no user input.

The data from this experiment will help us learn important information as we develop a new technology, and my program will be responsible for gathering and recording that data.

Reducing the Cation Exchange Capacity of Lithium Clay to Form Better Dispersed Polymer-Clay Nanocomposites

Maggie Liang

The Ohio State University

Major: Biochemistry

Undergraduate, Sophomore

Mentor: Sandi Campbell

Abstract

Polymer-clay nanocomposites have exhibited superior strength and thermo-oxidative properties as compared to pure polymers for use in air and space craft; however, there has often been difficulty completely dispersing the clay within the matrices of the polymer. In order to improve this process, the cation exchange capacity of lithium clay is first lowered using twenty-four hour heat treatments of no heat, 130°C, 150°C, or 170°C to fixate the lithium ions within the clay layers so that they are unexchangeable. Generally, higher temperatures have generated lower cation exchange capacities. An ion exchange involving dodecylamine, octadecylamine, or dimethyl benzidine (DMBZ) is then employed to actually expand the clay galleries. X-ray diffraction and transmission electron microscopy can be used to determine whether the clay has been successfully exfoliated. Finally, resins of DMBZ with clay are then pressed into disks for characterization using dynamic mechanical analyzer and oven-aging techniques in order to evaluate their glass transition, modulus strength, and thermal-oxidative stability in comparison to neat DMBZ. In the future, they may also be tested as composites for flexural and laminar shear strength.

Improving the lifetime and overall performance of its high-temperature polymer materials is of constant interest to the Polymers Branch at NASA Glenn Research Center. One technique that is currently being studied is the dispersal of clay within composites in order to reinforce various polymers. Researchers have noted improvements in strength, heat stability, and gas barrier properties of polymer-clay nanocomposites in comparison to neat polymers. Moreover, all of these improvements can be attained at a relatively low clay loading of two to ten weight percent and without alteration to the polymer's basic properties or loss of clarity in the polymer.

Not only is clay a naturally very stable substance, its structure lends itself well as an even more promising means of fortification. Natural clay is composed of impermeable clay layers stacked very closely together, approximately 1 nanometer apart. Upon dispersal, however, the layers are separated and become aligned in random directions. The result is that these exfoliated clay layers create a treacherous pathway for any permeant to penetrate through the nanocomposite. This proves to be a significant advantage since one of the major concerns when dealing with polymers is the threat of degradation, particularly due to oxidation.

X-ray diffraction and transmission electron microscopy (TEM) are typically used to analyze the extent of clay dispersal. X-ray diffraction techniques can quantitatively determine the distance of separation between the clay layers. Using the Bragg equation, $n\lambda = 2d\sin\theta$, the d-spacing of the clay gallery for both the unmodified and dispersed clay can be calculated and then compared. The TEM also confirms dispersal by providing a qualitative picture of the separated clay layers. Characteristics of a successful dispersal image include clearly defined, thin clay layers that are spaced far apart and lie in many different directions.

However, due to strong electrostatic forces between the layers, clay generally disperses poorly in the matrices of the polymer. In order to make the inorganic clay more compatible with the organic polymer, an ion exchange is used to displace the cations present in the clay, such as sodium or lithium, with protonated diamines and protonated alkyl amines. The diamines are added to react with the ester/acid monomers used in polymer synthesis, while the long carbon chains are inserted between the clay layers to expand the gallery; thus, the clay becomes somewhat organophilic. Also, as the clay layers are separated, the surface area of the clay layers increases and the polymer chains are better able to integrate with the clay sheets. A series of three ion exchanged clays were prepared for each heat treatment using dodecylamine, octadecylamine, or dimethyl benzidine (DMBZ) for a total of twelve samples.

This summer I am particularly interested in lowering the cation exchange capacity (CEC) of the clay so that it will disperse better within the polymer matrices. In order to accomplish this, the clay is heat treated at various temperatures. These include unheated, 130°C, 150°C, and 170°C treatments for 24 hours each. During heating the cations

migrate from exchange sites throughout the gallery space into the actual clay layers, thus becoming unexchangeable. With fewer cations present, the electrostatic forces in the clay are even further weakened. The clay initially arrives, though, containing interlayer sodium ions which are too large to facilitate this process. For that reason, the first step is to exchange the sodium ions in the clay with smaller lithium ions using lithium chloride, even before the clay is heat treated. Thus, it is the fixation of lithium after modification rather than the naturally occurring sodium cations that result in a decreased CEC.

Afterward, the CEC is determined by repeated saturation of the samples with 0.10N aqueous ammonium acetate, added drop-wise. After centrifuging the sample, the supernatant is analyzed for lithium using inductively coupled plasma (ICP). The sample is placed into a high-temperature plasma or gas. When the atoms relax, they give off light which can be separated into wavelengths by spectroscopy. This makes it possible to analyze the chemical makeup of a substance as well as quantify these values by comparing the sample to a known standard sample. Repeating this procedure a total of three times, the CEC is calculated as the total number of milliequivalents of lithium extracted in the three washings divided by the mass of the clay used. Increasing the heat treatment temperature has been observed to cause a reduction in CEC values.

All of the clay samples are dispersed in the polyimide DMBZ. The resins are then prepared for testing by pressing them into small disks. They are tested using the dynamic mechanical analyzer (DMA) for modulus strength and glass transition temperature. The glass transition generally indicates the upper limit usage temperature. Also, the thermo-oxidative stability of the samples is monitored through oven-aging at 550°F for 1000 hours. The samples may be tested as composites for other mechanical properties such as flexural and laminar shear strength. Results of these tests are in the process of being compiled, but it is the hope that certain properties will greatly improve without losing the integrity of other properties.

Already used in other industries such as automobile manufacture, polymer-clay nanocomposites show great promise for aerospace application. The polymers currently used by NASA for air and spacecraft have the potential to be reinforced with a relatively small amount of clay to enhance their performance and durability.

FEASIBILITY OF EB WELDED HASTELLOY X AND COMBINATION OF REFRACTORY METALS

Diana A. Martinez
University of Texas- El Paso
Metallurgical and Materials Engineering
Undergraduate, Senior
Mentor: Frank J. Ritzert

PROJECT DESCRIPTION AND ASSIGNMENT

As NASA continues to expand its horizon, exploration and discovery creates the need of advancement in technology. The Jupiter Icy Moon Orbiter's (JIMO) mission to explore and document the outer surfaces, rate the possibility of holding potential life forms, etc. within the three moons (Callisto, Ganymede, and Europa) proves to be challenging.

The orbiter itself consists of many sections including: the nuclear reactor and the power conversion system, the radiator panels, and the thrusters and antenna. The nuclear reactor serves as a power source, and if successfully developed, can operate for extended periods.

During the duration of my tenure at NASA Glenn Research Center's (NASA GRC) Advanced Metallics Branch, I was assigned to assist Frank J. Ritzert on analyzing the feasibility of the Electron Beam Welded Hastelloy X (HX), a nickel-based superalloy, to Niobium- 1%Zirconium (Nb-1Zr) and other refractory metals/alloys including Tantalum, Molybdenum, Tungsten, and Rhenium alloys. This welding technique is going to be used for the nuclear reactor within JIMO.

As my assignment, I was responsible for researching and optimizing the EB weld joint for this and other combinations of refractory metals to the HX alloy. In order to achieve this, interfacing with other engineers from GRC was a critical step in accomplishing personal goals and others set forth by my mentor Frank.

Beginning my summer here at GRC, the initial step was to educate myself on the JIMO project and what its goals were. A further understanding of the overall goals helped to direct me in the right direction for my individual goals. After discussing a strategy for my portion, initial analyses began.

Given a NASA GRC draft work plan for the project, seen below, I was able to begin to formulate my test matrix with the help of my mentor.

NASA GRC DRAFT WORK PLAN (F.J. Ritzert)

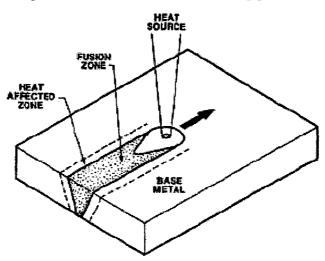| Refractory metal	Alloy*	Superalloy	Welding process
Nb alloys	Nb-1Zr	Hastelloy X	electron beam
	C103	Hastelloy X	electron beam
Ta alloys	T-111	Hastelloy X	electron beam
	ASTAR 811C	Hastelloy X	electron beam
Mo alloys	Mo-47.5Re	Hastelloy X	electron beam
	TZM**	Hastelloy X	electron beam
W alloys	W-25Re**	Hastelloy X	electron beam
Re alloys	Re***	Hastelloy X	electron beam

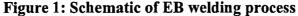*All alloys listed are currently on-hand at NASA GRC
**TZM and W-25Re are not considered as promising candidates due to post-weld behavior. They may be included for reference because the material is on-hand.
***Re is not considered as a top tier candidate due to the lack of historical information. It may have considerable potential plus the material is on-hand.

To begin, an evaluation of the cleanliness of the EB welding process was to be conducted. To do so, a beam was run over the surface of a material, in this case Nb-1Zr, sectioned off and analyzed for the oxygen pickup within the weld. If within the suitable range, the project was permitted to press forward.

In determining the feasibility of the EB welded HX to any of the combination of refractory metals, test coupons were developed and sent to Walt Wozniak. Test coupons (1 sq. in) were EB welded together, sectioned off around the welded region, mounted, and prepped for optical analysis. The as-received weld joint was characterized based on a number of set parameters. Interest in intermetallic formation within the welded region and oxygen pickup, along with basic structure characterization, and chemical analysis of diffusion of elements into refractory alloy was conducted.

Again, Walt Wozniak helped in the optimization of the weld beam. This was done for each individual material due to the fact that each metal reacts differently to the welding process. Discussed in our meeting July 7 of 2004, Walt explained the significance to the beam width; the tighter the beam, the faster the process can be conducted as well as the lower the heat produced. The material will experience a small area of heat affected zone. Therefore, the optimization of the electron beam will be different for HX to Nb-1Zr and HX to C103. Seen below is a schematic of what and where the heat affected zone is seen:

Figure 1: Schematic of EB welding process

It was to be determined if having a wider electron beam would be more suitable for our overall goal, thus the optimization of the beam was key to this project.

In the case of the materials welded together, a cleaning process was done to remove any contaminates which might have caused such things as embrittlement within the welded region (oxygen pickup, etc). This was done with the help of those located in the ChemLab in Building 105.

Due to the timely process, there are no photographs to display the current analyses that have been preformed to date. This is still an on-going project.

Further work to be completed in this portion of the project consists of encapsulation and aging of welded coupons at varying times. Metallographic examination and SEM analysis will be preformed. Alternative joining techniques will be investigated including the bi-metal tubing concept.

My Work in the NASA Glenn History Office and Records Management Office

Robert C. Mate
Marquette University
Political Science and English
Undergraduate Senior
Mentor: Kevin P. Coleman

This is my fourth summer working with my mentor, Kevin P. Coleman, who is the Center History Coordinator, Center Records Manager, and Center Forms Manager. I am working in the GRC History Office with some overlap in the Records Management Office. I have three major projects this summer. First, I am assisting in the documentation of historic facilities. Second, I am involved in a project to organize files and create an archives at Plum Brook Station. Third, I have helped the records management office with its inventory of stored records at Plum Brook. Also, I received an award this summer for research work I had done for NASA in the past.

First, my primary project is to help assemble documentation for historic facilities at Glenn. This is somewhat of an extension of my project from last summer. Last summer, I worked to compile a complete list of all of NASA's historic sites and landmarks (as designated by the National Park Service, as well as several private organizations) throughout the country. Then, I briefly researched the significance of historic designation under federal law. Finally, I put my findings into a report which was submitted to NASA Headquarters. Upon review by the NASA History Office and several center-level history officials, it was decided that NASA should work to update its documentation of its historic sites and landmarks since some of the documentation was outdated or unavailable. Until recently, many project managers and facility managers working at historic facilities were not even aware that their surroundings had been designated as historic under federal law (most specifically, the National Historic Preservation Act of 1966 and its amendments). Therefore, they were unaware of the legal obligations for historic preservation.

This summer, my project is to research some of Glenn's historic sites and landmarks in more detail. The goal is to put together a template for documenting historic NASA facilities. The hope is that this template of requirements for historic documentation of facilities (which may include records, drawings, photos, film, interviews, and a Web site) can be used agency-wide to assist center history offices in documenting historic sites and landmarks. To this end, I am working with Bob Arrighi, an archivist from InDyne, Inc., and Anne Burke, a NASA co-op, to gather and assess the historic value of records from several facilities at Glenn and Plum Brook Station. We will also work to determine the costs of each part of the template.

This project began with a meeting between Kevin Coleman, Glenn's Chief Architect Joe Morris, Bob Arrighi, and me. Joe Morris indicated that in addition to Glenn's current historic sites and landmarks, a significant section of the Center may one day be nominated as a "historic district." This possibility is not without consequence, as it would mean that all the facilities within the historic district will automatically fall under the federal laws applying to the preservation and documentation of historic

buildings. My project, which includes research of some of the buildings within this potential historic district, will impact how smooth the transition to historic status will be.

Bob Arrighi and I started off by researching and documenting the history of Building 4, the Flight Research Building (also known as the Hangar). We have taken an inventory of the photos and drawings that have been stored in the Hangar's records room. Then, we interviewed the Chief of Aircraft Operations, William Rieke, to get a sense of the significant projects and accomplishments that had occurred at the Hangar. I have also reviewed flight log books going back as far as 1943 and documenting historic material. Soon, Bob Arrighi, Anne Burke, and I will begin setting up oral interviews with retirees who worked at the Hangar. From these interviews, we will attain a complete and accurate record of the many projects that went on at the Hangar.

Other buildings at Glenn which are scheduled to be documented as part of this project include the Altitude Wind Tunnel, the Zero Gravity Research Facility, Buildings 24 and 16, and Propulsion Systems Labs 1 & 2. Bob Arrighi, Anne Burke, and I will soon begin researching the historic sites and landmarks at Plum Brook Station. The facility at Plum Brook that will be the focus of our research is the Spacecraft Propulsion Facility (B-2). B-2 is the only National Historic Landmark located at Plum Brook Station. Although it is doubtful all of these facilities will be documented before my summer internship ends, these projects will be continued by the History Office after I am gone.

Second, I am also working with Bob Arrighi and Anne Burke on a project to inventory and organize the records of Plum Brook Station. Currently, the files in Plum Brook's engineering building are unorganized. This can have serious consequences, as important records cannot always be readily accessed by researchers, NASA officials, or historians. Our job is to organize Plum Brook's files according to facility and project, put them into a logical finding system, and create a sign-out procedure for people who wish to view the records. The records will then be appropriately stored in climate-controlled rooms in order to preserve their integrity. This endeavor will require us to make weekly trips to Plum Brook. Galen Wilson of the National Archives and Records Administration will be assisting us in the project by helping to identify historically significant records among the general facility and project records.

Third, I am assisting the Glenn Records Management Office in completing its inventory of records that are stored in the bunkers at Plum Brook Station. Over the course of this summer (and the past two summers), I have worked with Suzanne Kelley and Debbie Demaline of InDyne, Inc. to complete this inventory. As there are many bunkers at Plum Brook – each of which contains thousands of boxes of files – this is a huge undertaking. This inventory is important because it will ensure the integrity of Glenn's record-keeping process. We checked to make sure that all boxes that are listed as being in a specific location at Plum Brook are in their proper storage locations. In addition to being important so that records are easily retrievable, this inventory may also have great significance in the near future as Glenn looks at moving its records from Plum Brook to another location.

Another item of interest that did not comprise a huge amount of my time this summer – yet was still significant – was my mentor's coordination of the June 9 premiere/award ceremony for the book Taming Liquid Hydrogen: The Centaur Upper-Stage Rocket 1958-2002 by Dr. Virginia Dawson and Dr. Mark Bowles. My role in the logistics of the ceremony was small, and included helping with the decorations and with

people who required assistance in the parking lot. However, after the ceremony was over, I was presented with a special award from the History Office at NASA Headquarters for my work last summer on my research of NASA's historic sites and landmarks. The award was totally unexpected, but I was happy that I had been a small part of the extraordinary NASA History Office team that is working to preserve the history of America's space program.

In conclusion, my projects this summer will be significant to the History Office and the Records Management Office in the long term. The documentation of historic buildings – and in light of the potential historic district at Glenn – is important so that NASA can stay up to date with its historic preservation obligations. The project to organize Plum Brook's records will ensure that the records will be readily accessible. Also, the inventory of Glenn's records at Plum Brook will ensure the reliability of Glenn's record storage procedures. For all these reasons, I consider this summer at NASA Glenn to have been very productive.

EDUCATION, TECHNOLOGY, AND MEDIA:
A PEAK INTO MY SUMMER INTERNSHIP AT
NASA GLENN RESEARCH CENTER
IN CLEVELAND, OHIO

Giovanna E. Mignosa
2004 NASA's Abstract

Mentor: Susan F. Gott

Senior at Ohio University, Athens, Ohio
Major: Video Production & French
Minor: Art & TEFL Certificate
(Teaching English as a Foreign or Second Language)

Presented on: August 20th, 2004

"Ad aspra per aspera" derives from Latin and it translates "to the stars through difficult places." When I was little I used to dream of reaching the stars, "of running away to sea, of curing cancer, of playing for the Pirates, of painting in Paris, of tramping through the Himalayas" (Dancing School by Annie Dillard). I always wanted to explore space and to be on a mission out of the Earth. I didn't get to fly into space on the shuttle, but I have had the opportunity to participate in the Lewis Educational and Research Collaborative Internship Program (LERCIP) through the Ohio Aerospace Institute (OAI) and the Educational Programs Office (EPO) at NASA John H. Glenn Research Center (GRC) at Lewis Field in Cleveland, Ohio.

Many were the reasons for me wanting to participate in the LERCIP College Program such as continued development of my professional abilities, and the fact that the employees at NASA GRC treat me like a family member. I have come to NASA not knowing exactly what is that I wanted to do with my life, but through the years NASA has helped me to discover areas of interest to me. I am still in the process of figuring out more about myself, but I believe that I am on my chosen path thanks to my successful college (academic and personal success) and NASA.

For the last three years (2002-2004) I have worked in the Educational Programs Office (EPO) as the assistant of the LERCIP Program Manager, Susan F. Gott. While working in the EPO I have provided webcast support (December 17th, 2003), for a NASA webcast and videoconference entitled "12 Seconds that Changed the World." In 2003 one of my duties involved working with a group of students, organizing, coordinating and preparing a NASA GRC Educational Video for the Annual Student/Mentor Recognition Banquet. I contributed for NASA GRC in helping out at the Cleveland 2003 Air Show, as well as in the NASA GRC 2002, 2003 and 2004 Annual Honor Awards Ceremony.

This summer I have had the honor to represent NASA GRC at the first ever International Children's Games hosted in the USA, downtown Cleveland sponsoring some of the educational programs both for students and teachers, as well as the visitor center and NASA's upcoming events for the year. I provided assistance to my mentor in compiling program reports; I interacted with mentors to follow-up on tracking and student evaluation forms. I coordinated various cultural and educational events such as the Annual Student/Mentor Recognition Banquet, Picnic, tours, conferences, etc., and I assisted the Program Manager in daily routines.

My internship this summer as the assistant of the LERCIP Program Manager involved some of the following:

1) organizing/planning activities, such as the Research Symposium I and II (college participants present the research they have been working on to NASA employees),
2) attending staff, program meetings,
3) drafting communication to staff, interns, and customers,
4) participating in videoconferences and webcasts,
5) compiling, gathering, and creating charts,
6) serving as a liason to the program manager/my mentor with students and mentors.

I loved what I did because I was treated not only as a staff member, but a valued part of the team. I was encouraged to participate in activites, provide input, and listened

James Moon
Senior
Tennessee State University
Aeronautical and Industrial Technology

My name is James Moon and I am a senor at Tennessee State University where my major

is Aeronautical and Industrial Technology with a concentration in industrial electronics. I am

currently serving my internship in the Engineering and Technical Services Directorate at the

Glenn Research Center (GRC). The Engineering and Technical Service Directorate provides the

services and infrastructure for the Glenn Research Center to take research concepts to reality.

They provide a full range of integrated services including engineering, advanced prototyping and

testing, facility management, and information technology for NASA, industry, and academia.

Engineering and Technical Services contains the core knowledge in Information

Technology (IT). This includes data systems and analysis, inter and intranet based systems

design and data security. Including the design and development of embedded real-time software

applications for flight and supporting ground systems, Engineering and Technical Services

provide a wide range of IT services and products specific to the Glenn Research Center research

and engineering community.

In the 7000 Directorate I work directly in the 7611 organization. This organization is

known as the Aviation Environments Technical Branch. My mentor is Vincent Satterwhite who

is also the Branch Chief of the Aviation Environments Technical Branch. In this branch, I serve

as the Assistant program manager of the Engineering Technology Program.

The Engineering Technology Program (ETP) is one of three components of the High

School L.E.R.C.I.P. This is an Agency-sponsored, eight-week research-based apprenticeship

program designed to attract traditionally underrepresented high school students that demonstrate

an aptitude for and interest in mathematics, science, engineering, and technology. This program

offers hands-on work experience to develop practical and theoretical knowledge, skills, and abilities in Electrical, Electronic, and Mechanical Engineering Technology. Program activities include a design project, fabrication, classroom instruction, oral presentations, and a variety of enrichment activities, such as career counseling and facility tours under the careful supervision of the High School L.E.R.C.I.P. staff.

As the Assistant Program Manager, I am responsible for managing 11 Engineering Technology Students across GRC. Inherent in my responsibilities is to communicate with management, engineering, and the technician workforce to develop student work assignments in the areas of electrical, electronic, and mechanical engineering technology. I also provided resume training, cover letter development, and the interviewing skills techniques.

I am responsible for the ordering of materials and accessories for the ETP which include: Robots, Boe-Bots, Sumo Bots, 130-in-1 labs, and soldering kits and tool kits. I coordinate weekly meetings in which the students of ETP and I analyze resumes and cover letters. We also run practice presentations to prepare each student for their final presentation in August. I am also responsible for ensuring computer access of each student prior to arrival. I participated in the Professional Development workshop. I also performed follow-up sessions with the students of the High School L.E.R.C.I.P.

My assignments have been very beneficial. I am gaining great experience in both management and education. These assignments have turned me into a more responsible and dedicated employee. I am self-starting, self-motivated, and very team oriented. I have developed professional work beliefs which are punctuality, timeliness, efficiency, and a respect for others. I am confident that where ever I shall go I will demonstrate a strong commitment to excellence in producing quality goods, services, and most importantly customer satisfaction.

Drinking Water Database
ShaTerea R. Murray
Graduate Student
University of Alabama of Birmingham
Mentor: Danielle M. Griffin

This summer I had the opportunity to work in the Environmental Management

Office (EMO) under the Chemical Sampling and Analysis Team or CS&AT. This team's

mission is to support Glenn Research Center (GRC) and EMO by providing chemical

sampling and analysis services and expert consulting. Services include sampling and

chemical analysis of water, soil, fuels, oils, paint, insulation materials, etc. One of this

team's major projects is the Drinking Water Project. This is a project that is done on

Glenn's water coolers and ten percent of its sink every two years.

For the past two summers an intern had been putting together a database for this

team to record the test they had perform. She had successfully created a database but

hadn't worked out all the quirks. So this summer William Wilder (an intern from

Cleveland State University) and I worked together to perfect her database. We began be

finding out exactly what every member of the team thought about the database and what

they would change if any. After collecting this data we both had to take some courses in

Microsoft Access in order to fix the problems. Next we began looking at what exactly

how the database worked from the outside inward. Then we began trying to change the

database but we quickly found out that this would be virtually impossible.

Which lead to the beginning of our own version of the database. William's strong

background in computers automatically made him the leader in the computer program

aspects of the database, thus leaving me the input aspect of the database. Will would create and design different forms, tables, and reports that were needed for the database. In turn I would input the date into the database. Finally we allowed the analysis to critique the database for operational problems and clarity. We were able to finish a great amount of the database yet there are still some quirks that need to be worked out.

Sonca Nguyen
Project Summary
Summer 2004

Design of an EXB Probe

Introduction

Current chemical propulsion technology cannot address the needs of some deep space missions. The amount of chemical propellant required to accomplish certain NASA's planned missions is too immense such that the spacecraft will never be able to lift off. To address this concern, electric propulsion systems have been chosen as the primary propulsion systems for some NASA's future missions, including DAWN and JIMO.

The HiPEP (High Power Electric Propulsion) engine being developed at NASA Glenn Research Center is a proposed engine for the JIMO mission, which will visit three of Jupiter's icy moons. Optimizing thruster's lifetime and efficiency are the two foci for the engineers on the Ion Team. One qualitative study of the engine's efficiency can be accomplished by examining the ratio of doubly- to singly-charged ions in the ion beam of the engine. Thrust efficiency directly relates to this ratio. The bulk of this project is to redesign and build an EXB probe to obtain this qualitative measurement. Once this probe is built, it can be installed in a vacuum tank (VF 65 in building 301) behind the exit plane of the HiPEP engine to collect data.

Background on Ion Thruster

In order to understand the usefulness of an ExB probe, one must understand how an ion thruster works. Figure 1a shows an ion thruster built at NASA Glenn and Figure 1b below shows a schematic of an ion thruster.

Some of the main features of an ion thruster include the hollow cathode, discharge chamber, grids, and the neutralizer. Gas such as Xenon or Argon is injected into the discharge chamber. The electrons produced by the hollow cathode bombard with the neutral gas atoms, ionizing the gas in the chamber into plasma. In this plasma, two species of electrons and ions coexist. At the end of the discharge chamber is a screen grid and accelerating grid, which are at a very low potential. The ions accelerate towards the grids and create an ion beam at the exit plane of the engine, thus thrust is obtained.
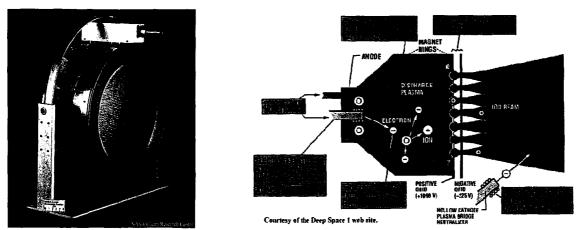

Figure 1 (a) Ion engine built at NASA GRC (b)Schematic of ion engine. *Courtesy of NASA-GRC*

ExB Probe Theory

The ExB probe is one application of the Lorentz force. When a particle is in both an electric field and a magnetic field, it experiences a force known as Lorentz force,

$$F = eq(E + uXB)$$

Equation 1

where F is the force
        E is the electric field
        u is the velocity of the particles
        B is the magnetic field
        e is charge of an electron
        q is the charge.

This relationship implies that a particle with a certain velocity in a magnetic field will deflect in a direction perpendicular to both. An electric field can be applied such that it can re-deflect the particle back to its original path. Alternately, the electric and magnetic fields can be adjusted in an ExB probe such that the particles entering the collimator must stay in a predicted manner, un-deflected from its original path. Figure 2 below is a schematic of the ExB probe.
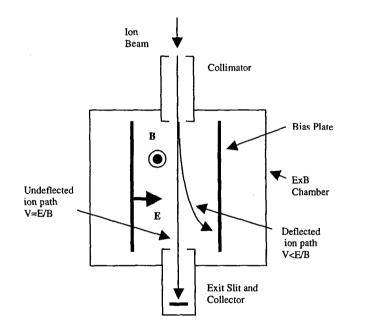

Figure 2. ExB Probe. *Courtesy of Aaron Snyder, NASA-GRC*

The main components of an ExB probe are the collimator, electrodes, magnets, and the collector. An electric field is obtained when a bias voltage is applied to the two electrodes. The main function of the collimator is to focus the beam of the ion and the collector's function is to measure the current of ions which have not been deflected.

By varying the bias voltage, thus electric field, the ion currents can be measured from the collector. Plot such as the one in Figure 4 can be obtained from the ExB probe. It is a curve of relative ion currents versus the bias plate potential. Typically, two peaks appear on the graph

and it is known that the first peak is from low energy ions and the second peak is from high energy ions based on the relation in Equation 1.
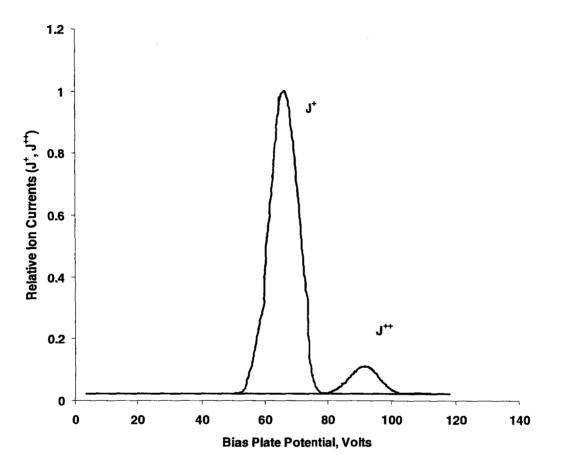

Figure 4. An example of a data collected from an ExB probe. *Courtesy of Aaron Snyder, NASA GRC*
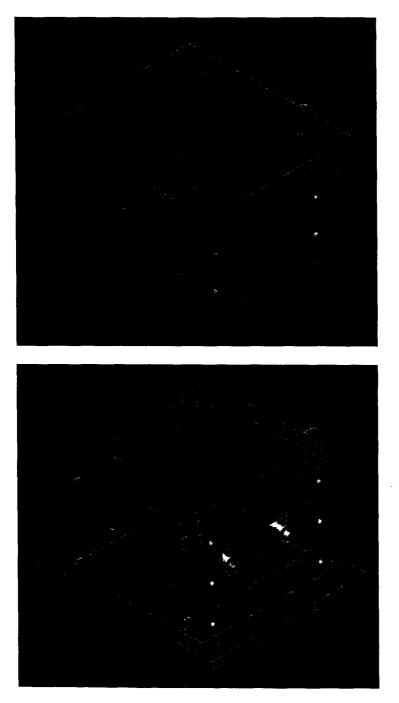
Design Considerations

For the particles to remain on its original path, the net force exerted on it must be zero. Thus, the main design is based on this relationship:
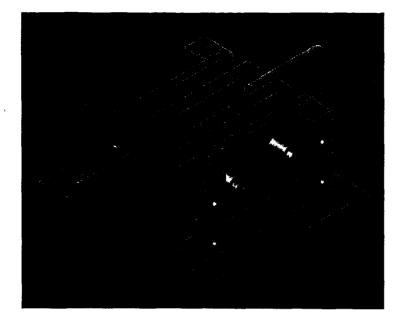
$$E=uB$$

A few key parameters were being considered before the design of the probe including the magnetic field strength, the electric field, and the distance between the electrodes. The magnetic field strength of 0.09 Tesla is obtained from an available set of magnets. With 0.09 Tesla and a given ion energy of 6700 eV, the required range of electric field is 400-500V, and this is for a gap of 2 cm. The magnitude of the electric field and the distance between the electrodes are directly related. It is desirable to separate the electrodes at 2 cm because the electric field required is within the range of the available power supplies.

Design

The design work was done through SolidEdge. Following are some pictures illustrating the design. I have made several modifications to the existing probe to ensure proper alignment and short circuiting of the electrodes.

Conclusions

I have modified the existing ExB probe, which will be used as part of the diagnostic tools for HiPEP engine testing. The parts are currently being machined while I am setting up the test experiment using LabVIEW. Data to be obtained from this probe will be able to qualitatively characterize the thrust efficiency of the HiPEP engine.

TEXURING CARBON-CARBON COMPOSITE RADIATOR SURFACES
UTILIZING ATOMIC OXYGEN

Taylor Raack
Northwestern University
Integrated Science / Computing and Information Systems
Undergraduate Senior
Mentor: Donald A. Jaworske

Future space nuclear power systems will require radiator technology to dissipate excess heat created by a nuclear reactor. Large radiator fins with circulating coolant are in development for this purpose and an investigation of how to make them most efficient is underway. Maximizing the surface area while minimizing the mass of such radiator fins is critical for obtaining the highest efficiency in dissipating heat. Processes to develop surface roughness are under investigation to maximize the effective surface area of a radiator fin.

Surface roughness is created through several methods including oxidation and texturing. The effects of atomic oxygen impingement on carbon-carbon surfaces are currently being investigated for texturing a radiator surface. Early studies of atomic oxygen impingement in low Earth orbit indicate significant texturing due to ram atomic oxygen. The surface morphology of the affected surfaces shows many microscopic cones and valleys which have been experimentally shown to increase radiation emittance. Further study of this morphology proceeded in the Long Duration Exposure Facility (LDEF). Atomic oxygen experiments on the LDEF successfully duplicated the results obtained from materials in spaceflight by subjecting samples to 4.5 eV atomic oxygen from a fixed ram angle. These experiments replicated the conical valley morphology that was seen on samples subjected to low Earth orbit.

Previous Monte Carlo computer simulations of atomic oxygen impingement on such surfaces predict the conical morphology of experimentally derived surfaces. A particular two-dimensional computer model developed at NASA Glenn simulates the arrival of atomic oxygen onto a polymer substrate through a defect zone in a protective coating. This model is analogous to a Kapton substrate covered by a glass-fiber matrix with microscopic defect zones. The model is completely adjustable to simulate any kind of substrate geometry, physical behavior, and atomic oxygen impingement characteristics that the operator desires. Arrival of atomic oxygen can be from a fixed ram angle, isotropic to simulate an oxygen plasma environment, or sweeping to simulate arrival on a solar oriented surface. Energies of the incoming atoms can be selected to match low Earth orbit conditions, any other fixed energy, or energy based on a Maxwellian distribution for thermospheric atoms with respect to the orbital velocity and angular inclination. Impingement surface characteristics allow the modeler to change the reactivity and recombination probabilities for atomic oxygen on that particular surface, be it polymer or protective coating.

Modeling parameters that lead to simulated surface textures obtained experimentally in the LDEF were identified when the Monte Carlo simulator was first used. Optimal vales for these parameters were obtained and simulations using these values continue to agree with the surface morphology obtained experimentally on the LDEF. Simulations show that impingement on a flat surface with fixed angle arrival of atomic oxygen increases surface roughness continuously during impingement but at a decreasing rate (non-linear.) Isotropic impingement leads to a negligible surface roughness due to the breakdown of tall cones by atomic oxygen arriving from all angles.

The model is currently being updated with a statistics package to analyze the morphology of the surface during its growth. Measurements of the cones on the eroded

surface allow the operator to identify an "aspect ratio" for the cones, which may be a good indicator of surface roughness. The cone statistics algorithm looks for cones across the entire surface of the erosion area and attempts to identify cones that have a similar aspect ratio and overall size, since experimentally the overall size of the cones and valleys of a particular morphology are relatively constant at any given time. The total surface area of the eroded polymer is also calculated. These statistics are then graphed and can be visualized immediately following the simulation, or saved for later use. Another addition to the model includes an automation feature to allow the operator to input parameters for many different simulations and let them proceed without operator intervention. Through the cone analysis and automation package developed it is hoped to identify which parameters in the model to adjust to increase and decrease cone aspect ratio, surface roughness, and surface area.

Experimental study of carbon-carbon surface texturing is continuing through operation of an end Hall thruster to impinge atomic oxygen on carbon-carbon composites. By varying the operational parameters, it is hoped that a procedure for texturing surfaces optimal for radiators can be achieved. While the Monte Carlo simulation allows for variation in many different parameters for atomic oxygen introduction, surface characteristics, and atom / surface interactions, the variables most likely to be of parametric importance are initial atomic oxygen energy and impingement time. The Monte Carlo model will be used to mimic the workings of the end Hall thruster and allow researchers to determine how best to operate it to achieve maximum surface roughness. Through computer modeling and experiment the goal is to find an optimum surface roughness for heat dissipation in future space power systems.

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 lnad-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 Informations Systems manage, analyze, chart, graph, and map spatial information.

GIS can be broken down into two main categories, urban GIS and natural resource GIS. Further still, natural resource GIS can be broken down into six sub-categories, agriculture, forestry, wildlife, catchment management, archaeology, and geology/mining.

Agriculture GIS has several applications, such as agricultural capability analysis, land conservation, market analysis, or whole farming planning.

Forestry GIS can be used for timber assessment and management, harvest scheduling and planning, environmental impact assessment, and pest management.

GIS when used in wildlife applications enables the user to assess and manage habitats, identify and track endangered and rare species, and monitor impact assessment.

GIS can be used in catchment management operations also. It can display runoff and erosion modeling. It can aid in sedimentation and water quality studies and can help to evaluate alternative management methods.

GIS can even be beneficial in archaeology, helping to facilitate the mapping and prediction of prehistoric sites, establish site vandalism studies, and create site management studies.

Another way that Geographic Information Systems can be utilized is through the field of geology and mining. It can aid in oil, gas, and minerals exploration. It can also be activated for the purposes of geologic mapping and terrain analysis, open pit mine design and redamation, and geologic hazard mapping.

However, at NASA Glenn, Urban GIS is primarily used. But what are its applications? Urban GIS applications include the provision of utilities, management of storm water, location and allocation of critical resources such as hospitals, schools or fire stations, study of disease outbreak patterns, crime analysis, waste collection routing or hazardous waste transportation. An urban geographic information system must be capable of processing a variety of attribute information from many different sources in order to satisfy the data needs of the service delivery, management, and policy levels of government. My project, using GIS, involved underground management.

What are the advantages of GIS? Computerized information allows improvement in the efficiency of the process as well as improvement in the effectiveness of the organization as long as the computer is able to produce and process the needed information. Thus, by improving both efficiency and effectiveness, computer processing technology continues to add value to the computerized and stored information.

Another reason why computerized information is so valuable is because it can be shared with other functions within an organization if it is properly stored within a server, mainframe, or centralized computer system.

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.

In addition I had the privilege of working on various intern committees, including serving as a layout-editor for the LERCIP Newsletter. All of these experiences have added to the enjoyment of my work and have provided me with a solid foundation on which to build my future professional career.

Brandi Robinson
Susan F. Gott
LERCIP
July 9, 2004

N.A.S.A. Project 2004 Assignment for Internship

This summer I have been working with the N.A.S.A. Project at Cuyahoga Community College (Tri-C) under the title of Exploring Aeronautics Project Leader. The class that I have worked with is comprised of students that will enter the eighth grade in the fall of 2004. The program primarily focuses upon math proficiency and individualized class projects. My duties have encompassed both realms.

During the first 2-3 weeks of my internship, I worked at NASA Glenn Research Center (GRC) researching, organizing, and compiling information for weekly Scholastic Challenges and the Super Scholastic Challenge. I was able to complete an overview of Scholastic Challenge and staff responsibilities regarding the competition; a proposal for an interactive learning system, Quizdom; a schedule for challenge equipment, as well as a schedule listing submission deadlines for the staff.

Also included in my tasks, during these first 2-3 weeks, were assisting Tammy Allen and Candice Thomas with the student application review and interview processes for student applicants. For the student and parent orientation, I was assigned publications and other varying tasks to complete before the start of the program.

Upon the commencement of the program, I changed location from NASA GRC to Tri-C Metro Campus, where student classes for the Cleveland site are held. During the duration of the program, I work with the instructor for the Exploring Aeronautics class, kkkk, assisting in classroom management, daily attendance, curriculum, project building, and other tasks as needed. These tasks include the conducting of the weekly competition, known as Scholastic Challenge.

As a Project Leader, I am also responsible for one subject area of the Scholastic Challenge aspect of the N.A.S.A. Project curriculum. Each week I have to prepare a mission that the participants will take home the following Monday and at least 10 questions that will be included in the pool of questions used for the Scholastic Challenge competition on Thursdays. For at least one of these competitions, I must compile all mission and question information submitted by the staff, distribute missions to the students, and enter questions into Jeopardy formatted PowerPoint presentation.

Unique the N.A.S.A. Project are its Saturday sessions and opportunities for field trips. As a Project Leader, I am required to attend all field trips and Saturday sessions held for participants and their parent(s)/guardian(s). The Saturday sessions do not require my assistance because they are facilitated by a contracting company, Imhotep. This leaves my duties to observation unless instructed otherwise.

2D ANAYLSIS OF IN-FLIGHT PARTICLES

Jonathan Shearer
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Icing Branch, 5840

One of the primary uses of the in-flight icing research performed aboard NASA Glenn's DHC-6 Twin Otter is for Icing Research Tunnel (IRT) and icing prediction code (Lewice) validation. Using the in-flight data to establish the IRT and Lewice as accurate simulators of actual icing conditions is crucial for supporting the research done in the Icing Branch. During test flights during the 2003 and 2004 flight season, a Natural Ice Shape Database was collected. For flights where conditions were appropriate, the aircraft is flown in an icing cloud with all ice protection systems deactivated. The duration of this period is usually determined by the pilot's ability to safely control the aircraft. When safe flight is no longer possible, the aircraft is maneuvered into clear air above the cloud layer. At this point several photographs are taken of the ice shape that was accreted on the wing test section during this icing encounter using a stereo photograph system (Figure 1). The stereo photograph system utilizes two cameras located at different locations on the fuselage that are both pointed at the same location on the wing. When both cameras take photographs of the same location at the same time, the negatives can be combined digitally to generate a two dimensional plot describing the cross-section of the ice shape. After these photographs are taken, the wing de-icing boots are activated and the ice shape is removed.

In addition to the stereo photographs documenting the ice shape, many different channels of data are recorded by the aircrafts data acquisition system. Many probes and sensors record airspeed, temperature, ice presence, liquid water content, and droplet size. During post-flight data processing, the start and end times each icing encounter are identified from the flight notes. At this point, the pertinent data collected during the icing encounter can be used to generate the necessary settings for re-creating this flight using the IRT or Lewice. In the IRT, an actual Twin Otter wing section will be used with the determined conditions to accrete an ice shape which should be similar in shape to the in-flight shape documented by the stereo photographs. The accuracy and likelihood for

success of these wind tunnel tests relies heavily on the accuracy of the input data. If the data acquired in-flight is not processed correctly, these input conditions will not produce a duplicate ice shape.

Temperature, airspeed, liquid water content, and drop size are all critical inputs for any IRT test. Each of these parameters is collected by probes on the aircraft, and can be analyzed after the normal post-flight processing. Droplet size, however, is especially important for ice cloud simulation, and requires extra post-flight analysis to correctly report. Nearly all meteorological testing agencies in the United States and elsewhere use Particle Measuring System (PMS) probes to acquire the size of cloud droplets. The Twin Otter primarily uses two PMS probes drop size acquisition. For sensing drops between roughly 0-50 microns, a Forward Scattering Spectrometer Probe (FSSP) is used (Figure 2). This probe measures drop diameter from the forward scattering of laser light by the droplets passing through the probe. Larger drops, up to over a millimeter in diameter, require a different type of probe called a PMS Optical Array Probe (OAP) 2D-C Grey (Figure 3). This probe finds drop size using an array of diodes that are shadowed when droplets interrupt a laser beam exposed to the cloud. When it is determined by the flight test researchers that drops greater than 50 microns were present during an icing encounter, analysis of the 2D data from the 2D-C Grey is necessary to accurately determine the average drop size in the cloud.

This analysis process was one of my multiple tasks during this summer work session. While the data collected by the FSSP probe directly reports a distribution of drop sizes present in a cloud, the 2D Grey instead stores thousands of two-dimensional images recorded during flight. When a particle passes through the laser beam and shadows the diodes, the 2D image is presented real-time to the flight researchers, and stored for later 2D analysis. This processing requires specially authored software to interpret the 2D images and convert them into a distribution of drop sizes. Although the software is capable of analyzing the images in an automated fashion, the errors associated with such processing are very undesirable. It is important to remember that the probe records images of all particles passing through the air, and not just water droplets. Ice plates, rods, and snowflakes are all common particles that skew the droplet distribution if processed automatically due to the inability of the software to distinguish between them

and droplets. These particles do not pose a problem for the FSSP probe because in general they are much greater in size than 50 microns. In order to minimize the error for these cases, the software must be used interactively with human judgment to discern between particle types.

Each icing encounter is analyzed in one minute increments, and the distribution of drop sizes over that period is averaged to report one Median Volumetric Diameter (MVD) representing that minute. The software can be configured to aid in the interactive process by eliminating some particles automatically (Figure 4). Different calculations are made on each 2D image to determine how close to circular it is, as well as how focused. Some particles are automatically filtered by cut-offs input for these parameters. Before any particle is accepted and added to the distribution, the user is asked to verify that it is in fact a water droplet (Figure 5). Depending on probe resolution, there is still a certain amount of error in the user judgment of particles. After all particles for a particular minute increment are counted, an output file is written for later use.

Because the FSSP and 2D Grey have a certain amount of overlap in their effective size ranges, the newly processed 2D data must be blended with the FSSP to generate a representative MVD for the entire droplet spectra. A complicated series of formulas is used in Microsoft Excel to accomplish this task. Since FSSP MVD is recorded every second, a block of sixty seconds must be combined for use with the 2D data. Both probes count the number of droplets and sort them according to size in different bins. An imaginary bin is interpolated between the size ranges of each probe, with the bins closest to this interpolated bin being discarded. With the droplet distribution of each probe effectively blended together, the spectra MVD value can be reported for the one minute segment. When all one minute periods in a specific icing encounter are processed, the conditions are now ready for IRT testing.

Accurate droplet size is essential for re-creating the in-flight ice shape and validating the IRT testing conditions. Drop size has an enormous impact on the shape and size of accreted ice shapes, and ignoring drops larger then 50 microns would certainly cause differences to arise between ice shapes. With the properly processed spectra MVD data, valuable IRT testing time will not be wasted. The conditions input into the tunnel will be an accurate representation of in-flight icing.
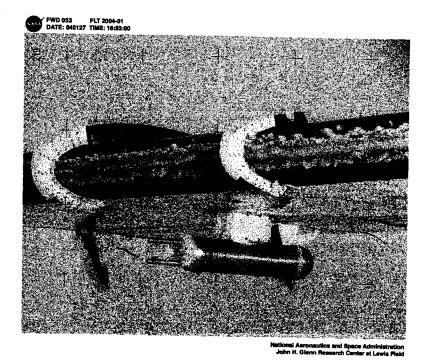
APPENDIX

Figure 1: Stereo photograph of wing test section

Figure 2: FSSP Probe mounted on wing hardpoint
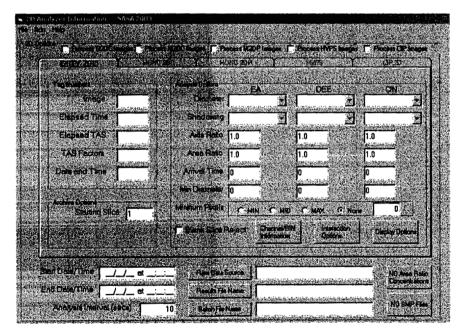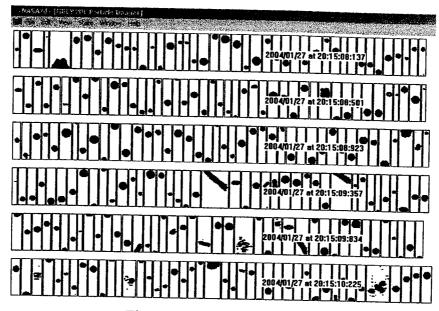
Figure 3: 2D Grey probe mounted on wing hardpoint

Figure 4: 2D Analyzer configuration screen

Figure 5: 2D particle images

Working at the Ohio Aerospace Institute

Hortenzia Szabo
Baldwin Wallace College
Undergraduate, Freshman
Mentor: Mary E. Auzenne

Abstract

The Ohio Aerospace Institute is a wonderful place to work. I enjoy coming to work everyday knowing that I will be surrounded by smiling faces. My mentor, Mary Auzenne, is the Program Manager of the LERCIP College Internship Program, however, I spend most of my time working with Akua Soadwa, the Assistant Program Manager. She is in charge of planning, coordinating, and managing every event that is involved with the college internship program such as the socials, picnic, banquet, workshops, and research symposium. My job is to make her job easier. I help out with the planning, coordinating, and managing of these events. When I first got on board Akua was in the process of planning the second social for the interns. The social is a way for the interns to interact with one another as well as to find out more about where the other interns are working at NASA. We ordered the food, went shopping, and set up the Guerin House for the party. I made sign-in sheets, which helped us get a rough count of the attendees. The next event was the Technical Presentation Workshop and the Professional Development Workshop. These workshops are designed to enhance skills of the interns. We were there to sign people in and direct them to the room where the presentation was to take place. I also took pictures of the workshop and provided copies for the presenters, as well as our files.

The next order of events was Research Symposium I and the Picnic, which took up all of my time. As the abstracts where turned in by the students my job was to keep track of them, type the titles in the schedule, type up the evaluations, make badges, and create the evaluator's folders. I made arrangements for refreshments and helped Akua put up signs of the schedule, and signs directing the people to the designated rooms. The picnic was a lot of fun to plan. I was in charge of keeping track of the replies for the picnic and there were days when I would receive hundreds of e-mails throughout the

day, making feel very popular. I made arrangements for renting a cotton-candy machine and a frozen drink machine, I also made arrangements with the DJ, kept track of when people where volunteering for each activity, corresponded with game leaders to find volunteers, helped Akua buy decorations, took pictures, and caught thieves trying to steal frozen drinks. The weather was not the best and it started raining towards the end, but I never had so much fun getting drenched!

The next event was the banquet. I did not have a lot of responsibilities with this event. I would like to however, give myself credit for coming up the color combination: red and gold. I helped buy decorations and ordered the balloons. I picked up the balloons, took pictures, and worked the registration table. I would also like to give myself credit for getting a backdrop, which gave a completely different dimension to the main cafeteria.

The final event is Research Symposium II for which I have the same responsibilities as for the first one. And while doing all of this I was also helping out with the newsletter. Another assistant program manager, Giovanna Mignosa and I were responsible for three articles each week: Meet the Staff, Meet the GRC Staff, and Quote of the Week. I took the pictures of the staff and organized it in Microsoft Word, I conducted an interview with NASA GRC's Center Director, Dr. Julian Earls, and the Deputy Director, Rich S. Christiansen, and looked for inspirational quotes online. In between all of this, I was also working on the workshop summary reports, organizing the evaluations and abstracts from the first Research Symposium, sending out the evaluations to the interns, contacting interns for their follow-up sessions, helping Akua distribute paychecks, and reading all of my e-mails and answering questions that students may have had about upcoming events, etc.

This has been a wonderful experience for me. Prior to this internship I was not a very friendly person, however, this position allowed me to meet all of the interns and this has enhanced my communication skills. I learned to work with people and in return learned to listen more, and I even became much more patient and understanding. I learned that a key to success is wanting perfection. I also learned multitasking, which is very hard if you are not used to it at first. The important thing to remember is to write everything down and to prioritize!

Now I would like to take this opportunity and thank some people without whom this internship would not have been as successful. I would like to thank Beth, Catherine, Ila, Joyce, Kelly, Dave, and Mark for making my tenure at the OAI such a wonderful experience! I would also like to thank Mary for being a great mentor, and finally, Akua, with whom I have worked most closely with and who is just really fun! Never once did she get frustrated with all of the questions that I asked her and never once did she make me feel like I was not doing a good job. Thank you Akua for making me feel special!

The New Approach to Self-Achievement (N.A.S.A.) Project 2004

Candace J. Thomas
Hampton University
Sociology/Psychology
Undergraduate Senior
Mentor: Tammy Allen

The New Approach to Self-Achievement Program is designed to target rising seventh, eighth, and ninth grade students who require assistance in refining their mathematical skills, science awareness and knowledge, and test taking strategies. During the six week duration of the program, students are challenged in these areas through the application of robotic and aeronautic projects which encourage the students to practically apply their mathematical and science awareness accordingly.

The first three weeks of my tenure were designated to assisting Mrs. Tammy Allen in the preparation of the 2004 NASA Project. As her assistant, I was held accountable for organizing, filing, preparing, analyzing, and completing the applications for the NASA Project. Additionally, I constructed the apposite databases which contained imperative information which aided in the selection of our participants. During the latter portion of those three weeks, Mrs. Allen, various staff members, and I, interviewed the numerous first-time applicants of the NASA Project. Furthermore, I was assigned to contact the accepted applicants of the program and provide all necessary information for the initiation of the child into the NASA Project.

During the six week duration of the program, I will be working as a Project Leader at the Lorain Middle School site located in Lorain, Oh, with Mr. Fondriest

Fountain. Mr. Fountain and I will work with the eighth and ninth grade students in constructing robots, in which the students are told are made for NASA research which is being conducted on the surface of planet Mars. The robots, which are built from LEGOS and programmed through RoboLab computer software, are prepared to complete assigned Missions such as running obstacle courses; plowing and retrieving LEGOS; and scanning surfaces for intense regions of light.

As a Project Leader, I am responsible for assisting Mr. Fountain in the classroom; preparing lessons and developing curriculum conducive to the students' comprehension level; taking attendance; providing support during field trips; and maintaining an orderly and positive learning atmosphere for the students. I also assist in preparing weekly Missions in the form of a packet, which are assembled by the Project Leaders from the Cleveland and Lorain sites, that containing age and grade level appropriate information on mathematics, science, logic, NASA and NASA Glenn Research Center facts, and test taking strategies and techniques.

Throughout the week I am responsible for introducing and tutoring this information to the students. Every Thursday, the students are tested on their retention of this information by competing in a Scholastic Challenge in the form of Jeopardy PowerPoint Presentation. Upon completion of this competition, although every student is rewarded in some way, the winning team is rewarded with NASA prizes and paraphernalia.

Mr. Fountain, the Lorain, staff and myself have worked together diligently in preparing exercises; class work; and games that will strengthen the scholastic the bases of these students. The students have been rigorously been working on fractions, decimals,

geometry, multiplication, and division during these first two weeks of the program. Fortunately, there have been numerous signs of an improvement in the students' confidence and ability to execute mathematical problems that once intimidated them. Their psychological improvements, can be partial contributed to the Saturday sessions in which the student's parent's must attend, with IMHOTEP, a contracting company that focuses on reducing test anxiety and the psychological progression of students and parents in the areas of mathematics, science and test taking skills.

The NASA Project is a new and innovative way to ensure that no is left behind within the school system. Too often, many students are overlooked and not given the proper vessels and guidance to excel and compete with students who are doing well in the same course. This program is a pledge to provide every student with an equal chance to become the astronauts, engineers, technology programmer, and mathematicians of NASA near future.

Information Technology Support in the 8000 Directorate

William D. Wilder
Cleveland State University
Computer Engineering
Junior
Eli Abumeri

My summer internship was spent supporting various projects within the Environmental Management Office and Glenn Safety Office. Mentored by Eli Abumeri, I was trained in areas of Information Technology such as: Servers, printers, scanners, CAD systems, Web, Programming, and Database Management, ODIN (networking, computers, and phones).

I worked closely with the Chemical Sampling and Analysis Team (CSAT) to redesign a database to more efficiently manage and maintain data collected for the Drinking Water Program. This Program has been established for over fifteen years here at the Glenn Research Center. It involves the continued testing and retesting of all drinking water dispensers. The quality of the drinking water is of great importance and is determined by comparing the concentration of contaminants in the water with specifications set forth by the Environmental Protection Agency (EPA) in the Safe Drinking Water Act (SDWA) and its 1986 and 1991 amendments.

The Drinking Water Program consists of periodic testing of all drinking water fountains and sinks. Each is tested at least once every 2 years for contaminants and naturally occurring species. The EPA's protocol is to collect an initial and a 5 minute

draw from each dispenser. The 5 minute draw is what is used for the maximum contaminant level. However, the CS&AT has added a 30 second draw since most individuals do not run the water 5 minutes prior to drinking. This data is then entered into a relational Microsoft Access database. The database allows for the quick retrieval of any test(s) done on any dispenser. The data can be queried by building number, date or test type, and test results are documented in an analytical report for employees to read.

To aid with the tracking of recycled materials within the lab, my help was enlisted to create a database that could make this process less cumbersome and more efficient. The date of pickup, type of material, weight received, and unit cost per recyclable. This information could then calculate the dollar amount generated by the recycling of certain materials. This database will ultimately prove useful in determining the amounts of materials consumed by the lab and will help serve as an indicator potential overuse.

Working with the Glenn Safety Office (GSO), I created a database to track all handicap parking permits (temporary and permanent) lab-wide. Information stored in the database can be queried to check for available and expired parking locations.

Two weeks were spent in July archiving over 2000 paper documents to an electronic filing format. Each individual document was filed based on content and can be searched by key words. Also during July, the GSO underwent a modular furniture upgrade which required certain offices to be emptied. In order to maintain the efficiency of employees affected by this upgrade, network connections were rerouted to available offices and conference rooms allowing work to be continued during this time.

I created fact sheets detailing and documenting some key processes that I have been responsible for over the summer. This will allow other employees to continue using

the same practices and procedures taught to me by my mentor well after my internship is complete.

This summer has been a great experience. The staff of the EMO and GSO made sure that I felt like part of the team as my opinion was sought on numerous occasions. I was given the opportunity to work with minimal supervision and my efforts were always greatly appreciated.

THE MORRISON BEARINGLESS SWITCHED RELUCTANCE MOTOR

David S. Wong
University of Michigan
Computer Science Engineering
Senior
Mentor: Carlos R. Morrison

About the Motor:

Switched reluctance motors typically consist of pairs of poles protruding outward from a central rotor, surrounded by pairs of coils protruding inward from a stator. The pairs of coils, positioned a short distance from opposing sides of the rotor, are connected in series. A current runs through the coils, generating a magnetic flux between the coils. This attracts the protruding poles on the rotor, and just as the poles on the rotor approach the coils, the current to the coils is inverted, repelling the rotor's poles as they pass the coils. This current switching, back and forth, provides a continuous rotational torque to the rotor.

Traditional switched reluctance motors possess many positive traits, including reliability, durability, low cost, and operation in adverse environments such as high temperatures, extreme temperature variations, and high rotational speeds. However, because rotors are often manufactured with minute flaws due to imperfections in the machining process, traditional switched reluctance motors often suffer from substantial amounts of vibration. In addition, the current in the coils imparts a strong radial magnetic force on the rotor; the continuous alternating of the direction of this force also causes vibration. As a result, switched reluctance motors require bearings that, run at high speeds, can require lubrication apparatus and are subject to problems with heat and wear.

My mentor's recent invention, the "Bearingless" Switched Reluctance Motor, actually uses magnetic bearings instead of traditional physical bearings. Sensors are used to continuously determine the position of the rotor. A computer reads the position sensor input, performs calculations, and outputs a current to a set of extra coils (in addition to the coils rotating the rotor). This current provides a magnetic force that counters and damps the vibration.

The sense-calculate-update loop iterates more than thirty thousand times per second. For now, our goal is to have the rotor rotate at about 6000 rpm, and at that speed, the magnetic bearing is adjusting the rotor's position more than 300 times per rotation.

It is hoped that this new invention will increase load-carrying capacity, stiffness, and vibration-suppression capacity for the switched reluctance motor.

My Work:

While my mentor's invention has been patented, it has not yet been fully, successfully implemented. I have been working closely with my mentor to help get his motor operating. In the lab, I have been providing my input on various general troubleshooting tasks.

At the beginning of the summer, our focus was on the motor alone; the magnetic bearing part of the code in the computer was deactivated entirely. After making some changes in the code and tweaking the positions of some of the sensors, along with a variety of other hardware adjustments, the motor successfully ran, but, at this point, only on mechanical bearings.

Next, we activated the magnetic bearings, and attempted to levitate the rotor between the bearings, without the motor running. For a time, this was completely unsuccessful. We delved into the code, looking for some sort of error that could be causing our problems, but no error could be found. We finally brought in a hardware analyzer, which created a simulated sensor signal that was inputted into the control system. The analyzer also accepted the output, and this was compared with the known input to determine whether the output was reasonable. We ultimately determined that our problem was something related to the hardware input. This was quickly solved. A few tweaks to the control program's settings later, and the motor was both levitated and running.

Up to this point, the motor has run, levitated, as fast as 4000 rpm. We continue to make both hardware and software adjustments in an effort to push that number higher. Also, we plan to take various measurements, including torque measurements, to help determine more clearly the full capabilities of the motor.

Additionally, throughout the summer, I have been working on converting my mentor's code and control system, written in a fairly old DOS format, to a more professional and modern dSpace/MATLAB/Simulink solution. If successful, this would likely allow substantially more robust control of both the motor and the magnetic bearings, lowering the control program's loop time by as much as two-thirds. It would also allow us to design a cleaner user interface for adjusting the control program's settings.

References:

Morrison, Carlos R. 2004, *Bearingless Switched Reluctance Motor,* US Patent 6,727,618 B1.

Acknowledgements:

Modification of Bushing Test Rig and Research of Variable Inlet Guide Vane Bushings For Further Development of PM304 Bushings

Anne Yanke
Masters Candidate
Case Western Reserve University
L.E.R.C.I.P. Summer 2004

PS304 is a high temperature solid lubricant coating comprised of a nickel-chrome binder, chrome oxide hardener, barium-calcium fluoride high temperature lubricant, and silver as the low temperature lubricant. This coating is used to lubricate Oil-Free Foil Air Bearings as they experience friction and wear during start up and shut down. The coating deposition process begins with undercutting the shaft. This area is then sandblasted to provide a rough surface for the coating to adhere to. The coating powder is then sent through the plasma spray gun and a reasonably thick layer is applied to the undercut area of the shaft. The coating is then ground down even with the surface of the shaft and gets a nice polished finish.

The foil air bearings use the solid lubricant, as mentioned above, during start up and shut down. During normal operating conditions, generally above 2000RPM, the bearings utilize air as their lubricant. Foil air bearings are comprised of a thin top foil and a corrugated bump foil. They have an interference fit with the shaft before operation. As the air gets "trapped" between the top foil and the shaft, it presses the top foil against the bump foil, in turn compressing the bumps. As the bumps compress, it allows for the air to separate the top foil from the shaft, therefore, utilizing the trapped air as its lubricant.

The coating has proven to sustain over 100,000 start/stop cycles at temperatures ranging from ambient to 650°C.

Since PS304 comes initially in powder form, we are able to use it for other applications as well. For example, PM304 bushings can be made from the material through conventional powder metallurgy methods. The powder is fed into the die, and is then cold pressed. Finally, the pressed piece is hydrogen sintered at 1100°C for 20 minutes.

A test rig has been developed to determine the sliding characteristics of the PM304 bushings, such as friction and wear. During the preliminary testing, it was discovered that the bushings require a break in period at high temperatures to obtain a lubricating glaze on the surface of the shaft. Without this break in period, the bushings would disintegrate not far into the test. After the break in period, the PM304 bushings, just like the PS304 coating, not only are able to withstand temperatures up to 540°C but also perform better with increasing temperature.

These bushings are currently being used in industrial furnace conveyors, and they have been working very well compared to the previously used bronze bushings. Another application the bushings should perform well in is variable inlet guide vanes (IGVs) and variable stator blades. The bushing test rig is under modification to simulate the appropriate operating conditions of variable IGVs and variable stator blades to begin testing and analysis. This will ensure the bushings are in fact capable of operating in such conditions.

The maximum temperature for the furnace being used is 1000°C, which will allow very high temperature testing to be done, potentially opening the door for use of these bushings in the hotter areas of the engine. With the modifications, the tests performed can include full rotation of the shaft at speeds up to 400RPM or an oscillatory motion up to 45°, which could be easily modified for a larger angle of rotation, if desired.

The PM304 bushing test rig modifications and the resulting data will be the focal point of my master's thesis. I will be studying the bushings under conditions similar to current variable IGV and variable stator blade conditions. My goal is to determine if the PM304 bushings are an alternative to the bushings currently in use and have the data to backup my conclusion.

Changes in Hardware in Order to Accommodate Compliant Foil Air Bearings of a Larger Size

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Compliant foil air bearings are at the forefront of the Oil-Free turbomachinery revolution of supporting gas turbine engines with air lubricated hydrodynamic bearings. Foil air bearings have existed for almost fifty years, yet their commercialization has been confined to relatively small, high-speed systems characterized by low temperatures and loads, such as in air cycle machines, turbocompressors and microturbines. Recent breakthroughs in foil air bearing design and solid lubricant coating technology, have caused a resurgence of research towards applying Oil-Free technology to more demanding applications on the scale of small and mid range aircraft gas turbine engines.

In order to foster the transition of Oil-Free technology into gas turbine engines, in-house experiments need to be performed on foil air bearings to further the understanding of their complex operating principles. During my internship at NASA Glenn in the summer of 2003, a series of tests were performed to determine the internal temperature profile in a compliant bump-type foil journal air bearing operating at room temperature under various speeds and load conditions. From these tests, a temperature profile was compiled, indicating that the circumferential thermal gradients were negligible. The tests further indicated that both journal rotational speed and radial load are responsible for heat generation with speed playing a more significant role in the magnitude of the temperatures.

As a result of the findings from the tests done during the summer of 2003, it was decided that further testing would need to be done, but with a bearing of a larger diameter. The bearing diameter would now be increased from two inches to three inches. All of the currently used testing apparatus was designed specifically for a bearing that was two inches in diameter. Thus, my project for the summer of 2004 was to focus specifically on the scatter shield put around the testing rig while running the bearings. Essentially I was to design a scatter shield that would be able to accommodate the three inch bearing and that would also meet all safety requirements. Furthermore, the new scatter shield also had to house a heater, used for high-speed and temperature testing. Using Solidworks, a computer aided modeling program, I was able to

accomplish the task set out for me and designed the new scatter shield. Furthermore, I also guided the fabrication process.

As a result of this containment shield being designed, the Oil-Free turbomachinery team now has the ability to test bearings of larger diameters. Finally, it is expected that these tests will provide information useful for the validation of future analytical modeling codes.