Poster Perfect

“The attractiveness of a poster is highly correlated with the quality of the science,”

Graphic design and scientific inquiry require different skills,

but oddly enough, it appeared that the **PEOPLE WHO UNDERSTOOD THE BEAUTY OF FONTS** had a **SENSE OF PITCHING THEIR SCIENCE**.”

~ Colin Purrington, Swarthmore College

PIGS IN SPACE: EFFECT OF ZERO GRAVITY AND AD LIBITUM FEEDING ON WEIGHT GAIN IN CAVIA PORCELLUS

Colin B. Purrington
6673 College Avenue, Swarthmore, PA 19081 USA

ABSTRACT:

One ignored benefit of space travel is a potential elimination of obesity, a chronic problem for a growing majority in many parts of the world. In theory, when an individual is in a condition of zero gravity, weight is eliminated. Indeed, in space one could conceivably follow ad libitum feeding and never even gain an gram, and the only side effect would be the need to upgrade one's stretchy pants("exercise pants"). But because many diet schemes start as very good theories only to be found to be rather harmful, we tested our predictions with a long-term experiment in a colony of Guinea pigs (Cavia porcellus) maintained on the International Space Station. Individuals were housed separately and given unlimited amounts of high-calorie food pellets. Fresh fruits and vegetables were not available in space so were not offered. Every 30 days, each Guinea pig was weighed. After 5 years, we found that individuals, on average, weighed nothing. In addition to weighing nothing, no weight appeared to be gained over the duration of the protocol. If space continues to be gravity-free, and we believe that assumption is sound, we believe that sending the overweight — and those at risk for overweight — to space would be a lasting cure.

INTRODUCTION:

The current obesity epidemic started in the early 1960s with the invention and proliferation of elastane and related stretchy fibers, which released wearers from the rigid constraints of clothes and permitted monthly weight gain without the need to buy new outfits. Indeed, exercise today for hundreds of million people involve only the act of wearing stretchy pants in public, presumably because the constrictive pressure forces fat molecules to adopt a more compact tertiary structure (Xavier 1965).

Luckily, at the same time that fabrics became stretchy, the race to the moon between the United States and Russia yielded a useful fact: gravity in outer space is minimal to nonexistent. When gravity is zero, objects cease to have weight. Indeed, early astronauts and cosmonauts had to secure themselves to their ships with seat belts and sticky boots. The potential application to weight loss was noted immediately, but at the time travel to space was prohibitively expensive and thus the issue was not seriously pursued. Now, however, multiple companies are developing cheap extra-orbital travel options for normal consumers, and potential travelers are also creating news ways to pay for products and services that they cannot actually afford. Together, these factors open the possibility that moving to space could cure overweight syndrome quickly and permanently for a large number of humans.

We studied this potential by following weight gain in Guinea pigs, known on Earth as fond of ad libitum feeding. Guinea pigs were long envisioned to be the "Guinea pigs" of space research, too, so they seemed like the obvious choice. Studies on humans are of course desirable, but we feel this current study will be critical in acquiring the attention of granting agencies.

MATERIALS AND METHODS:

One hundred male and one hundred female Guinea pigs (Cavia porcellus) were transported to the International Space Laboratory in 2010. Each pig was housed separately and deprived of exercise wheels and fresh fruits and vegetables for 48 months. Each month, pigs were individually weighed by duct-taping them to an electronic balance sensitive to 0.0001 grams. Back on Earth, an identical cohort was similarly maintained and weighed. Data was analyzed by statistics.

RESULTS:

Mean weight of pigs in space was 0.0000 +/- 0.0002 g. Some individuals weighed less than zero, some more, but these variations were due to reaction to the duct tape, we believe, which caused them to be alarmed push briefly against the force plate in the balance. Individuals on the Earth, the control cohort, gained about 240 g/month ($p = 0.0002$). Males and females gained a similar amount of weight on Earth (no main of effect of sex), and size at any point during the study was related to starting size (which was used as a covariate in the ANCOVA). Both Earth and space pigs developed substantial dewlaps (double chins) and were lethargic at the conclusion of the study.

CONCLUSIONS:

Our view that weight and weight gain would be zero in space was confirmed. Although we have not replicated this experiment on larger animals or primates, we are confident that our result would be mirrored in other model organisms. We are currently in the process of obtaining necessary human trial permissions, and should have our planned experiment initiated within 80 years, pending expedited review by local and Federal IRBs.

ACKNOWLEDGEMENTS:

I am grateful for generous support from the National Research Foundation, Black Hole Diet Plans, and the High Fructose Sugar Association. Transport flights were funded by SPACE-EXES, the consortium of wives divorced from insanely wealthy space-flight startups. I am also grateful for comments on early drafts by Mañana Athletic Club, Corpus Christi, USA. Finally, sincere thanks to the Cuy Foundation for generously donating animal care after the conclusion of the study.

LITERATURE CITED:

NASA. 1982. Project STS-XX: Guinea Pigs. Leaked internal memo.

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Xavier, M. 1965. Elastane Purchases Accelerate Weight Gain In Case-control Study. Journal of Obesity. 2:23-40.

Cooling Effects of Dirt Purge Holes on the Tips of Gas Turbine Blades

Eric Couch, Jesse Christophel, Erik Hohlfeld, and Karen Thole

Gas turbine engines run better at higher combustion temperatures

At higher combustion temperatures, these engines generate more power and use less fuel. However, these temperatures are restricted by melting temperatures of the turbine blades downstream of the combustor (see Figure 1).

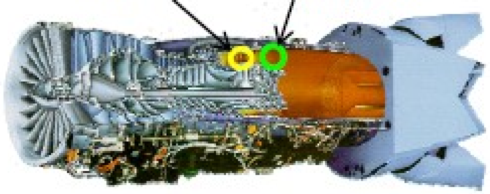


Figure 1. Pratt & Whitney F119 gas turbine engine.

Dirt purge holes on turbine blade tips allow for higher combustion temperatures

Harmful hot gases from the combustor leak across the gap between the blade tip and the shroud (see Figure 2). Dirt purge holes expel foreign particles from the blade tip so that film cooling holes are not blocked.

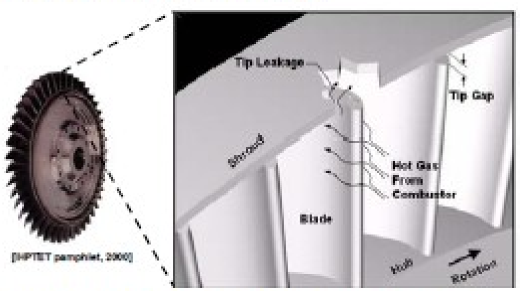


Figure 2. Flow at the tip region of a turbine blade.

The project goal was to find the film cooling effects of these dirt purge holes

To find the effects, we performed wind tunnel experiments with scaled turbine blades. The wind tunnel was low speed and low temperature, and the blades, shown in Figure 3, were scaled at 12 times their normal size. To measure temperatures on the blade tip, we used an infrared camera. Tip gap sizes and amount of coolant flow from the dirt purge holes were both varied.

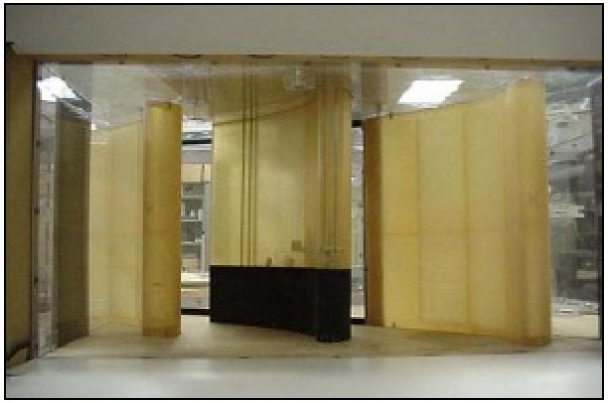


Figure 3. Large-scale turbine blade in wind tunnel.

Temperature measurements were converted to dimensionless cooling effectiveness

$$\text{Effectiveness} \quad \boxed{\eta = \frac{T_\infty - T_{aw}}{T_\infty - T_c}} \quad \text{where}$$

T_∞ = mainstream temperature
T_c = coolant temperature
T_{aw} = adiabatic wall temperature (on tip surface)

Cooling increased with blowing ratio

The effectiveness contours of Figure 4 show that cooling increased with blowing ratio.

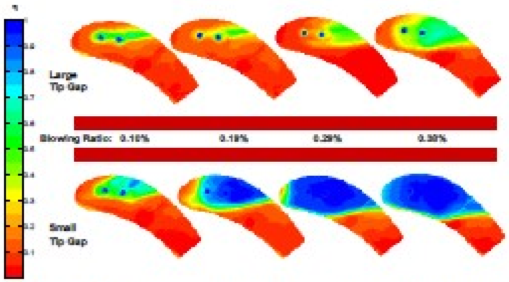


Figure 4. Measurements of film cooling effectiveness.

Tip size dramatically affected cooling

In Figure 5, the lateral averages of effectiveness plotted against the axial chord length show that tip size dramatically affected the cooling.

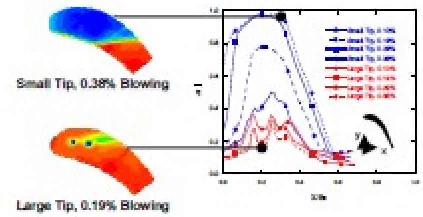


Figure 5. Laterally averaged effectiveness plotted against normalized axial chord.

In summary, dirt purge holes provide cooling to the tip surface

While intended to remove dirt from the blade, dirt purge holes also provide cooling to the tip surface. This cooling is enhanced with a small tip gap as the dirt purge floods the tip region near the leading edge with cool air.

Acknowledgments

The sponsor for this project was Pratt & Whitney.

An effective poster will help you ...

... engage faculty/peers/staff in conversation…

... get your main point(s) across to as many people as possible…

Source: Hess et al.

An effective poster is…

Focused	**Focused on a single message.**
Ordered	**Keeps the sequence well-ordered and obvious.**
Graphic	**Lets graphs and images tell the story; uses text sparingly.**

Source: Hess et al.

Many ineffective posters suffer from easy-to-fix problems, including…

- objective(s) and main point(s) hard to find
- text too small
- poor graphics
- poor organization

Source: Hess et al.

An effective poster operates on multiple levels ...

- source of information
- conversation starter
- advertisement of your work
- summary of your work

Source: Hess et al.

We suggest creating a storyboard for your project BEFORE you start designing your poster!!!

Building Sustainability into Control Systems Courses

Melody Baglione

Student Researchers: Julien Caubel, Kim Meehan, Mike Sanfelice, Mike Sterman, Eric Ringold, Jon Rodriguez, Sara Carlson

THE COOPER UNION

Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics
Grant No. DUE 1044830

Goal

The project aims to improve student learning of control systems by:

1) Creating new learning experiences leveraging a new energy efficient, LEED-certified academic building; and
2) Developing hands-on process control laboratory scenarios connecting traditional classroom theory to a building systems theme.

LEED-Platinum 41 Cooper Square Academic Building

Expected Outcomes

As a result of these new teaching strategies and learning materials students should be able to:

1) Describe the basic operational principles of central HVAC systems;
2) Identify the control goals, process variables, controller inputs/outputs, sensors and actuators; and
3) Consider the energy consumption and environmental impact during system, component, or process design.

Publications

Baglione, M., Caubel, J., "Developing Undergraduate Engineering Curriculum Material using the Heating, Ventilation, and Air Conditioning and Building Management Systems of a High Performance Academic Building," Proc. of the 2012 ASME International Mechanical Engineering Congress and Exposition, Nov. 9-12, Houston, TX.

Sterman, M., Baglione, M., "Design of Artificial Neural Network Using Solar Inputs for Assessing Energy Consumption in a High Performance Academic Building," Proc. of the 2012 ASME International Mechanical Engineering Congress and Exposition, Nov. 9-12, Houston, TX.

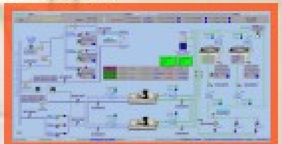
Baglione, M., "Incorporating Practical Laboratory Experiments to Reinforce Dynamic Systems and Control Concepts," Proc. of the 2009 ASME International Mechanical Engineering Congress and Exposition, Nov. 13-19, 2009, Lake Buena Vista, FL.

Methods & Strategies

The project exposes mechanical engineering students to real-world control systems applications while weaving in sustainable design principles by:

1) Creating a website with system descriptions, photos, and diagrams to accompany mechanical room and Building Management System tours; and
2) Designing new experimental scenarios using bench top process control rigs and configurable software interface from Feedback, Inc.

Website Learning Material Excerpt



Building Management System

Temperature Process Control Rig

Evaluation Methods

The assessment plan consists of both direct and indirect measures. Students describe the systems in a short **writing assignment**; the assignment is evaluated using a **cognitive skills rubric** based on Bloom's Taxonomy (both shown below). Customized pre- and post- Student Assessment of Learning Gains (SALG) surveys assess perceived learning gains and affective outcomes.

Writing Assignment

Part I: Consider the three subsystems on the tours:

1. Chillers
2. Plate and Frame Heat Exchanger
3. Air Handling Units

From a high-level describe the plants, the process variables, the controller inputs and outputs, and the actuators.

Part II: Briefly describe at least two energy saving design or control features in 41 Cooper Square and how these features save energy.

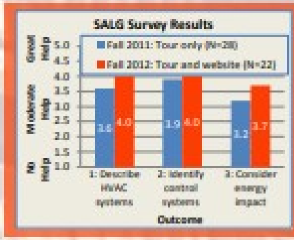
	Sophisticated 4	Satisfactory 3	Developing 2	Unsatisfactory 1
Cognitive Skills Rubric for Grading Writing Assignment	**Describes** basic principles of systems and **identifies** control goals; **Applies** control systems concepts to **analyze** process in terms of inputs/outputs; **Distinguishes** how system level components, e.g., actuators and sensors, achieve these goals.	**Describes** basic principles of systems and **identifies** control goals; **Identifies** the components yet fails to fully analyze the interaction of the components and process inputs/outputs.	**Describes** basic principles of systems and high level control goals; Attempts to identify components but may incorrectly describe their function or interaction.	Inaccurately describes operational principles and control goals.

Preliminary Findings

Preliminary faculty observations and student survey results suggest exposing students to real-world applications of classroom theory positively impacts learning and engages students in the learning process.

Providing students with background learning material about the systems on a website before the tour increases their conceptual understanding.

Survey results generally reveal students view building systems tours as an opportunity to appreciate the real-world applicability of control systems theory.



Open-Ended Survey Comments

"The HVAC mechanical rooms/BMS tour brought some of the concepts taught in class to reality and solidified the purpose of learning the material. By making the material concrete and seeing it in action in a building the course information was reinforced."

"The tour was a great example of control systems engineering in action, and I wish we had more tours of how the NAB [New Academic Building, i.e., 41 Cooper Square] works."

SALG Survey Results: Class impact on attitudes (affective outcomes)

As a result of your work in this class, what gains did you make in the following? (1: no gain, 2: some gain, 3: moderate gain, 4: good gain, 5: great gain)	Fall 2011 (N=28)	Fall 2012 (N=22)
Enthusiasm for systems and control	3.7	4.3
Interest in asking questions about the material or discussing the subject	3.4	3.9
Interest in taking additional classes or working on projects related to control systems	3.5	4.1
Confidence that you understand the material and can work in this area	3.9	4.3
Your comfort level in working with complex systems	3.6	4.3

Future Work

- Integrate building energy usage and automation data on website
- Design new experimental scenarios using upgraded controller and configurable software interface for liquid-level and temperature process control rigs
- Create problem solving assignments that mirror building systems (e.g., rain water harvesting system, radiant panel heat exchangers)
- Further assess impact on student learning and motivation (e.g., focus groups or interviews, observations of student behavior, and/or concept inventories)
- Continue to encourage and advise advanced building modeling, energy analysis, and building controls undergraduate and Master's research projects
- Disseminate results via publications, a symposium hosted by Cooper Union, and the Engineering Pathway CSE electronic library

Acknowledgements

Special thanks to Gerardo del Cerro, George Sidebotham, and the Cooper Union Facilities staff, especially Julio Santillana and Jody Grapes.

Building Sustainability into Control Systems Courses

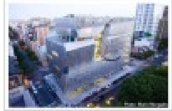
Melody Baglione
The Cooper Union for the Advancement of Science and Art
Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics (TUES) Grant No. DUE 1044830

Objectives

Improve student learning of control systems by:

1) Creating new learning experiences leveraging a new **L**eadership in **E**nergy & **E**nvironmental **D**esign (**LEED**) Platinum-certified academic building, and
2) Developing hands-on process control laboratories connecting classroom theory to a building systems theme.

41 Cooper Square



41 Cooper Square is a 175,000 square feet, LEED Platinum-certified academic and laboratory building. The building has two 500-ton chillers, natural gas fired boilers, heat exchangers for radiant ceiling panels, water- and air-side economizers, and a 250 kW cogeneration plant. A state-of-the-art **B**uilding **M**anagement **S**ystem (**BMS**) operates the building's **h**eating, **v**entilation, and **a**ir **c**onditioning (**HVAC**) systems.

Methodology

Expose mechanical engineering students to real-world control systems applications while weaving in sustainable design principles by:

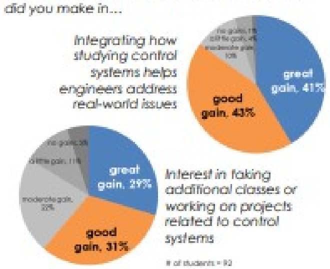
1) Integrating new experiments that mirror actual building systems using bench top process control rigs and configurable software interface, and
2) Facilitating synthesis of control systems theory using building content management website, real-time data, and mechanical room tours.

Evaluation

Assessment plan measured student learning outcomes, the project's impact on student motivation, as well as the efficacy of the project beyond its initial implementation and consisted of:

1) Pre- and post- **S**tudent **A**ssessment of **L**earning **G**ains (**SALG**) surveys

As a result of your work in this class, what gains did you make in…

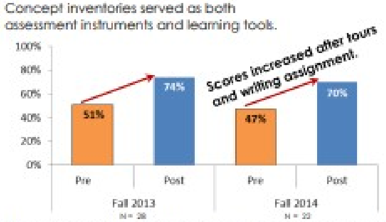


2) Writing assignment grading rubric

	Sophisticated 4	Satisfactory 3	Developing 2	Unsatisfactory 1
Cognitive Skills Rubric for Grading Writing Assignment	**Describes** basic principles of systems and **identifies** control goals; **Applies** control systems concepts to **analyze** process in terms of inputs/outputs; **Synthesizes** how system level components, e.g., sensors and actuators, interact to achieve goals.	**Describes** basic principles of systems and **identifies** control goals; **identifies** the components yet fails to fully analyze the interaction of the components and process inputs/outputs.	**Describes** basic principles of systems and high level control goals; Attempts to identify components but may incorrectly describe their function or interaction.	Inaccurately describes operational principles and control goals.

3) Pre- and post- concept inventories

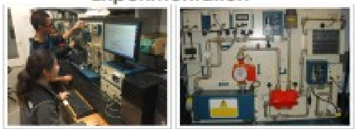
Concept inventories served as both assessment instruments and learning tools.



4) External evaluator/instructor observations and student interviews

- External evaluator assessed the project impact by observing lectures, labs, and tours and by interviewing key informants.
- To evaluate the efficacy, in Fall 2014, an instructor unaffiliated with project implemented the new course interventions.

1. Hands-On Process Control Experimentation



Students begin experimenting with level-flow and temperature process control rigs in three 2-hour lab modules.

2. Content Management Website

Students are assigned building-related background reading with system descriptions, photos & schematics.

New dashboard shows real-time power consumption, cogen production & rainwater collection.

Content also made available on lobby kiosk.

New course interventions revolve around building systems theme

3. Mechanical Room and Building Automation Tours

Students are taken on tours of the building's mechanical rooms and are shown the Building Management System (BMS).

4. Writing Assignment

Part I: Consider the three subsystems on the tours:

- Chillers
- Plate and Frame Heat Exchanger
- Air Handling Units

From a high-level describe the plants, the process variables, the controller inputs and outputs, and the actuators.

Part II: Briefly describe at least two energy saving design or control features in 41 Cooper Square and how these features save energy.

Excerpt of student writing:

"The plant in the ***Chillers*** *system is the combination of evaporator, compressor, condenser, and expansion valve. This system takes heat from one flow of water and, by means of a standard vapor compression cycle, moves it through a refrigerant loop to another flow of water… The controller input is the temperature of the water flowing out of the chiller… The actuator is the variable frequency drive which controls the current flowing to the AC motor in the compressor…"*

A writing assignment challenges students to synthesize the building's systems using control systems terminology. Finally, students return to the lab to implement the tuning methods learned in class.

Student Interviews

"The HVAC mechanical rooms/BMS tours helped by providing a common real-world application of the course materials. It also strengthened my interest in controls, maybe even leading to interest in a controls engineering profession in the future ."– Fall 2012 Student

"I tend to be a 'big picture' type of person…if I know exactly why I'm learning something, it is easier for me to learn…After seeing the building's systems and sensors, I was able to make the connection between theory and reality, so learning in class became easier."– Fall 2012 Student

"A hands-on approach proved valuable in emphasizing non-obvious characteristics of systems. For example, it is easier to control the level of the tank than the flow rate in a pipe because the capacitance of the tank causes slow response times."– Fall 2014 Student

"I think having labs really helps in learning the material. The things we do in class are theoretical and sometimes it's hard to see what actually happens in reality. Labs help visualize what really occurs as we change the different values."– Fall 2014 Student

"[The HVAC mechanical rooms/BMS tour] allowed me to see how controls is being used in the real world. Plus, the HVAC system in the building is something that directly affects me, which made it more interesting ."– Fall 2013 Student

"The valuable thing learned from the project is vocabulary. You can learn about all sorts of systems and models in the classroom, but to get an idea of industry standards and terminology is very valuable."– Fall 2014 Student

Outcomes

New course components help students appreciate the real-world applicability of control systems.

- Measurable gains in three new learning outcomes:
  1) identifying control systems,
  2) describing basic HVAC operational principles, and
  3) considering the environment and energy consumption during design.
- Affective outcomes include:
  1) Increased interest in projects related to building systems (Students are working with faculty and facilities staff to improve building operations)
  2) Students pursuing building systems & sustainability advanced degrees
  3) Acquired vocabulary and knowledge help students get industry jobs

Broader Impacts

Students learn industry relevant skills so graduates are better prepared.

- Professional organizations have asked to use content for training manuals & webinars
- Graduates refer back to website on the job

Learning content is scalable and adaptable.

- Content and professional training adaptable as undergraduate course modules or boot camps
- Community college interested in adopting process control labs into Energy Services & Technology program

Project resulted in 6 peer-reviewed conference proceedings, 7 Master's thesis projects, 11 poster presentations at 6 regional and national conferences, 4 Senior Capstone Design projects, and 45,665 website hits!

Future Work

Build on established academic, industry, and government partnerships to disseminate, evaluate, adapt, and scale-up project.

1) Incorporate feedback from Center for Sustainable Engineering (CSE) Electronic Library peer-review and other colleges
2) Continue to develop adaptable and scalable curricular modules
3) Continue work with CUNY Building Performance Lab to apply Building Re-Tuning
4) Share energy saving strategies with NYC Carbon Challenge University partners
5) Continue engaging students in building projects & implementing energy savings

ASEE Annual Conference NSF Grantees' Poster Session
Seattle, Washington, June 14 - 17, 2015

The PI acknowledges the assessment role of Gerardo del Cerro and Prof. Luchtenburg. The PI thanks the Cooper Union Buildings and Grounds staff, faculty, and students that contributed to this project.

Tips for Design and Formatting

- **Shorten your text lines**
  - Long lines of text are difficult to read
- **Justify the right way: to the left**
  - Studies show left justifying makes for easier read
- **Consider your font**
  - Some font variety is good (2-3)
  - Use non-serif fonts like Helvetica for the title and headings and serif like Palatino for body
- **Don’t put conclusions on the floor**
  - Use rightmost column—or, if you feel daring, start the body of the poster with it

Source: Zielinska

Tips for Design and Formatting

- **Text: Bigger is better**
  - Use font size of 85pt for the title, 36–44 for the headers, and 24–34 for the body text
  - Check for readability at 6 feet
- **Dump PowerPoint’s color palette**
  - Deep blues and fluorescent greens are too dark and difficult to read
  - Stay away from primary colors on primary colors (no reds on blues, or reds on yellows)
  - Background should be a muted color—one that is closer to white on the color spectrum

Source: Zielinska

How to make data easy on the eyes

- **Always title your graphs & banish legend**
  - Titles & labels are the best way to quickly tell readers what they are supposed to take away from your data.
- **Make your findings obvious**
  - Highlight the peak, minimum, or other comparison of interest with an arrow containing the data point value.
- **Include the method**
  - Consider a simple description of how you got the data you're presenting near the graph
- **Temporarily dump your text**
  - If you removed everything but the graphics, the poster should still be pretty good

Source: Zielinska

How to write and <u>not</u> write a title

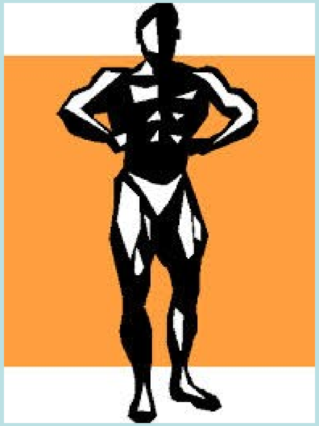
“A Portable Hardware Framework for Manual Encoding of Human Hand and Finger Dynamics”

“Can Robots Feel?”

“The MES mess, a good buffer gone bad”

“Bicycle + Flywheel: Engineering a Faster Commuter Bicycle”

Improve your body



- **Link images and text**
  - The words must be near the visual aid
- **Cut your text**
  - Keep about a 50/50 ratio of graphics to text
  - Pretend you're writing a telegram, and paying for every word
- **Avoid clutter**
  - Use graphs rather than tables
  - Only include data that tells your story…
- **<u>Arrange content to tell a story</u>!**

Source: Zielinska

What to do before you print

- **Give it a test run**
  - You find mistakes when you’re standing in front of your poster
  - You ensure your poster effectively helps you tell your story
  - Project your poster on the wall and run through your presentation
- **Get feedback**
  - From your advisors and peers
  - Consider “Pimp My Poster” (yes, really!) or online forums

Poster Presentation Evaluation

- **Poster aesthetics: focused, ordered, graphic**
  - Does your poster focus on the main point, keep the sequence well-ordered and obvious, use visuals to effectively tell the story, use text sparingly & convey main point effectively to a range of audiences?
- **Engineering Design**
  - Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- **Individual Oral Presentation Delivery**

Source

Zielinska, E., “**Poster Perfect:** How to drive home your science with a visually pleasing poster,” *The Scientist, 25(9), Sept. 2011,* http://www.the-scientist.com/?articles.view/articleNo/31071/title/Poster-Perfect/

Additional Sources/References

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- Purrington, C.B. Designing conference posters. Retrieved 3/6/2013, http://colinpurrington.com/tips/academic/posterdesign

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A Real Solution for Wave Energy Extraction

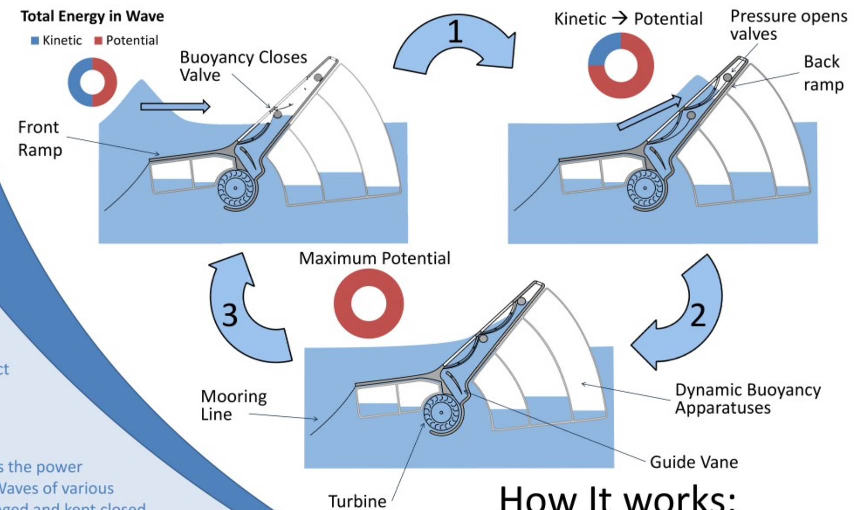
A. Blinken ME ‘00, D. Tox BSE ’00, B. Sting ME ‘00

The Challenge

Earth’s oceans contain an enormous amount of energy. Extracting the energy cost efficiently, however, poses a substantial challenge. The greatest potential for wave energy exploitation is well offshore, which necessitates a floating design that can withstand the open ocean and a robust underwater electrical infrastructure to relay the energy home. The most developed solutions are cost-inefficient, and as a result, there has yet to be a successful, large-scale, commercially-deployed wave energy converter (WEC). Our patent-pending device aims to resolve the inefficiencies in other technologies, making this immense source of power viable in select locations around the world.

Experimental Methods

A scale model has been prototyped for testing. The aim of this prototype is to understand how the geometry affects the power output and the efficiency. The prototype was fixed in place in a wave tank via wires to eliminate buoyancy effects. Waves of various amplitudes and periods were sent at the WEC. Instead of using a turbine to generate electricity, an acrylic flap is hinged and kept closed over an opening on the bottom of the WEC by a spring. When water is accumulated within the WEC, the flap opens and its position is read by a potentiometer. Each resistance value corresponds to a singular output power, requiring a calibration curve to translate resistance values to power and efficiency.

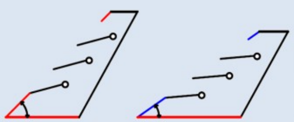


How It works:

1. Wave opens valves and climbs up the back ramp
2. Wave achieves maximum height and valves close, capturing maximum potential energy
3. Water drains through turbine and the next wave approaches

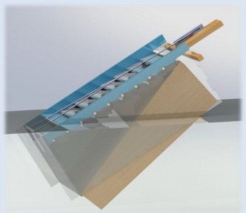
Optimization Parameters

Frontal Angle



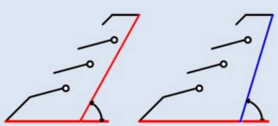
The Frontal Angle changes how the waves interact with the one-way valves.

1:40 Scale Model



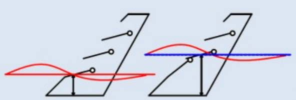
CAD model rendering

Back Ramp Angle

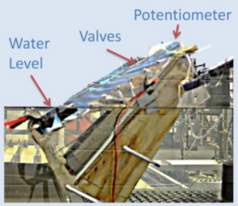


The Back Ramp Angle changes how the wave converts the kinetic energy into potential energy.

Water Level

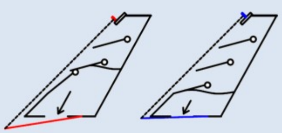


The Water Level changes the volume of the WEC that is filled as a wave enters the WEC



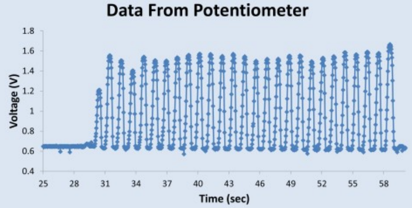
Prototype in Wave Tank

Instrumentation

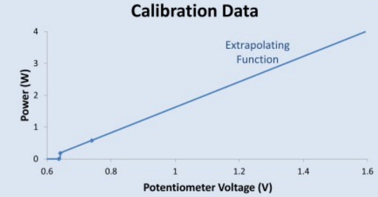


The angular position of the acrylic flap is converted into a linear translation of a slide potentiometer, which is later read by a computer.

Preliminary Data



Above is a sample of the data we obtained. The change in resistance manifests as a change in voltage. The measured oscillations show that the instrument tracks the periodic nature of the flow within the WEC. With a calibration, the output power can be obtained.



A controlled volume flow rate was input into the WEC and the voltage across the potentiometer was read. The largest producible volume flow rate was not enough to yield voltage readings seen in testing conditions. Linear extrapolation was used to estimate the energy efficiency of the WEC.

70% Estimated WEC Efficiency From Experimental Data*

*Wave Dragon claims 20% efficiency with turbine.

Acknowledgements:

We would like to thank Professor Lima for his guidance, Professor Cataldo and Luis Vega for their support, Professor Risbud, and all others who contributed to our effort. And Yev, for his sincere tone and immaculate disposition.

WAVEX

CUAL
Cooper Union
Acoustics Laboratory

Acoustic Characterization of 41 Cooper Square Academic Spaces

Harry Elephante (ME '99)
Advisors: Professor Baglione, Professor Wei

THECOOPERUNION

Problem Statement

Building acoustics play an important role in design of an academic space. Inappropriate acoustics can have a negative impact on student performance; therefore, it is important to be able to quantify the acoustic properties of the various labs, classrooms, and study spaces. This project has three primary goals:

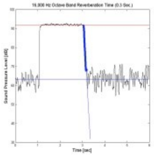
1. **Calculate the reverberation times of various rooms in the new academic building.**
2. **Quantify background noise levels.**
3. **Determine frequency response of rooms.**

Additionally, the new Cooper Union Anechoic Chamber was recently completed. A preliminary analysis of the acoustic properties of the chamber was performed.

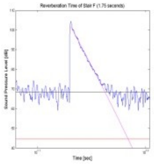
Reverberation Time Measurement Techniques

Two measurement techniques can be used to determine reverberation time of a room:

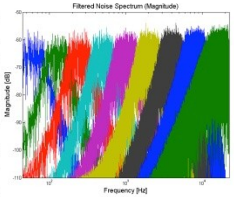
1. **Interrupted Noise Method:** Steady state white or pink noise is played, and the sound pressure level is measured. The sound is interrupted, and the time to decay by 60dB is measured (or extrapolated). Allows greater control over frequency content of signal, and is the preferred method if equipment exists.



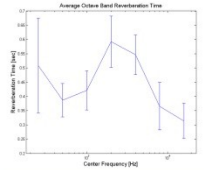
2. **Impulse Response Method:** A loud, nearly instantaneous sound source is used as an "impulse" source, and the decay time is measured. Common sources include gun shots, discharge of large capacitors, and balloon pops. Less control over frequency content of impulse, which generally lacks low frequencies, but is quicker and easier.

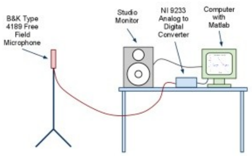


Octave Band Reverberation Time



White noise was filtered into octave bands (seen at right), and played over loudspeakers into a room. A measurement microphone recorded the instantaneous sound pressure level. Custom Matlab scripts were used to automatically calculate the reverberation time at each band level. Ten trials were recorded for each band level, and the mean and standard deviation were calculated (shown below). Reverberation time measurements were consistent with recommended levels for laboratory and classroom spaces [1,4]. A schematic of the setup is shown on the bottom right.





Results

ANSI standard S12.60-2002 recommends that classroom spaces should not have reverberation times exceeding 0.6 - 0.7 seconds. The following table shows the results of reverberation testing in various spaces in the building [5].

Table 1: Reverberation Time (seconds)

Room	Narrow Band (≈250 – 2000 Hz)	Broad Band (≈125 – 4000 Hz)
Anechoic Chamber	< 0.01	< 0.01
Grand Staircase	–	1.20
Stairwell D (Orange)	–	1.54
Stairwell F (Yellow)	–	1.75
4th Floor Study Lounge	0.53	0.54
Rose Auditorium	0.65	0.65
LL210 (classroom)	0.75	0.88
101 (classroom)	0.53	0.53

Reverberation times were generally acceptable, with the exception of LL210, which falls beyond the acceptable time of 0.7 seconds. The reverberation time of the anechoic chamber was less than the precision of the measurement system, which was expected, since the purpose of the chamber is to eliminate all reverberation.

Acknowledgements

I would like to thank the following people for their help during the preliminary phase of this project:

- Professor Wei
- Professor Baglione
- Jody Grapes and the staff at Buildings and Grounds

The following resources were used for preliminary research into the design and testing of anechoic chambers, and background acoustic testing information:

[1] "Acoustical Performance Criteria, Design Requirements and Guidelines for Schools." ANSI S12.60-2002

[2] Ressl, Marc S; Wundes, Pablo E. "Design of an Acoustic Anechoic Chamber for Application in Hearing Aid Research." *Recent Advances in Acoustics and Music.*

[3] Everest, F. Alton; Pohlmann, Ken C. *Master Handbook of Acoustics.* 5th ed. McGraw-Hill, 2009.

[4] Lord, Gatley, and Evensen. *Noise Control for Engineers.* McGraw-Hill, 1980

[5] Patynen, Katz, and Lokki. "Investigations on the Balloon as an Impulse Source." *J. Acoust. Soc. Am.* **129**(1), January 2011.

Impact Testing on a Plate with Closely Spaced Modes

PHIL A. MIGNON

PROFESSOR BAGLIONE

Purpose

- Learn Modal Analysis
- Develop procedures for using Test.Lab and LMS SCADAS
- Find natural frequencies of a plate with closely spaced mode shapes

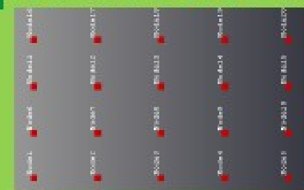
Motivation

- Refine our experimental modal techniques so that we can detect closely spaced natural frequencies. Closely spaced mode shapes are a problem faced in vibrations testing. Such a problem arose in the Titan II rocket.

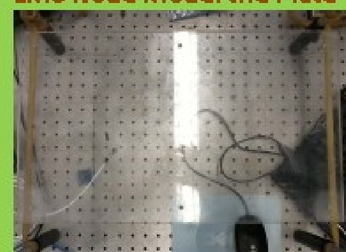
Titan II Rocket : Gemini Program

- Pogo Effect –
- Engineering Analysis:
- *Both oxidizer and fuel had natural frequencies* close to the natural frequency of the structure.

Experimental Setup

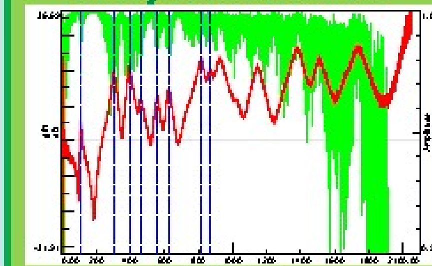


LMS Node Model the Plate



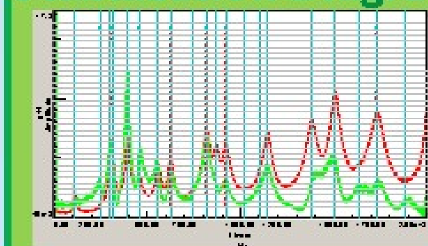
Simulate Free Free Boundary Conditions

FRF/Coherence

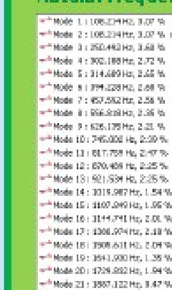


Drive Point – Node 7

Stabilization Diagram



Natural Frequencies



4th Mode Shape

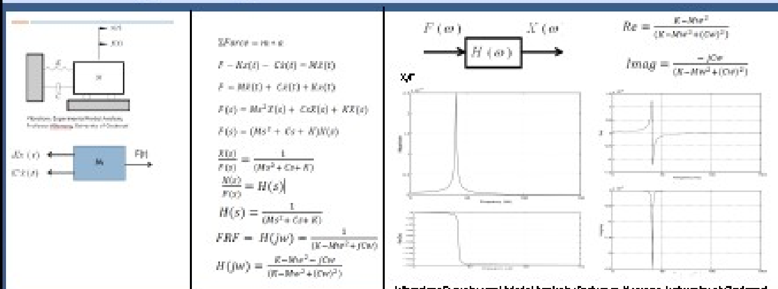
5th Mode Shape

Future Works

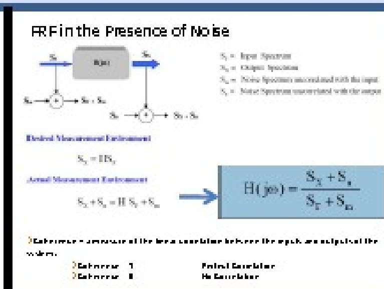
- Investigate the Curve-fitting method used by LMS
- Compare Impact Data to Shaker Data
- Integrate methods of animating mode shapes into undergraduate curriculum

Vibrations & Modal Analysis Theory

Single Degree of Freedom



Effect of Noise



MICROBIAL FUEL CELLS: APPLICATION THROUGH EDUCATION

Manchu Picchu (ME '49), Inca Minca (EE '49)
ME163 Mechanical Engineering Projects, ECE Electrical & Computer Engineering Projects, Advisors: Prof. Lima, Prof. Cumberbatch

INTRODUCTION

BACKGROUND

MFCs use biological processes to generate power by converting chemical energy in organic compounds into electrical energy.

Benefits of MFCs:

- Capable of deriving energy from many different fuels, and mixtures of fuels
- Do not produce harmful byproducts.
- Operate at neutral pH and room temperature, unlike different types of fuel cells

Limitations of MFCs:

- Scientists have a limited understanding of the biological mechanisms.
- MFC research lacks uniform methods standards.
- Materials can be costly.
- Power densities are currently too low for most applications.

Applications:

- Off-grid power
- Wastewater treatment
- Biofuel-powered robots
- Remote sensors

HOW MFCS WORK

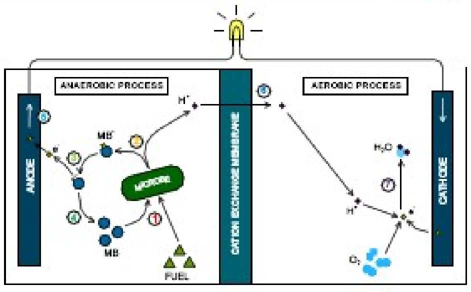


Figure 1: Diagram of Processes in a Two-Chamber MFC

1. The microbe takes in fuel (i.e. glucose) and the mediator molecule methylene blue (MB), and digests the glucose. During this process, an electron (e^-) binds to MB.
2. The microbe excretes the negatively-charged MB^- and a proton (H^+) into the surrounding fluid.
3. e^- is transferred from MB^- to the anode.
4. MB is recycled.
5. e^- travels from the anode to the cathode across a load.
6. Meanwhile, H^+ diffuses across the cation exchange membrane (CEM) to the cathode chamber
7. H^+, O_2, and e^-, react at the cathode to form water (H_2O).

OBJECTIVES

1. **Design an educational MFC kit** for high school students to help teach chemistry, biology, physics and scientific measurement. The kit will engage students by featuring multiple operational configurations.

2. **Design a μMFC power source** based on the same principles as the educational kit, to motivate and inform the educational MFC experience.

EDUCATIONAL MFC KIT

Using developing technologies in the classroom can inspire learning and curiosity in future engineers and scientists. MFCs, in particular, can be **multidisciplinary, hands-on tools** for high school education.

Our First Prototype:

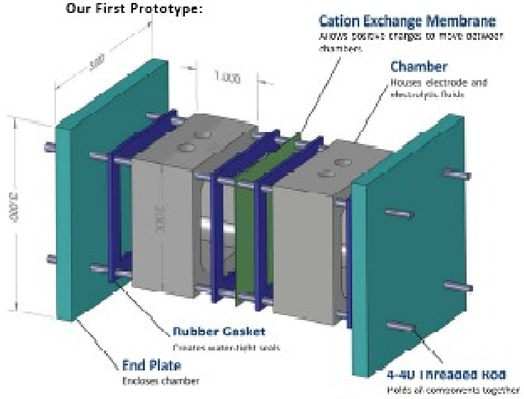


Figure 2: Exploded SolidWorks Assembly of MFC. Dimensions are in inches.

Design Requirements:

- Proper **safety** precautions must be implemented.
- **Cost** must be minimized. We project the material cost for one MFC to be **$25-45**.
- To engage students, the **different configurations** are incorporated into the design. Controllable degrees of freedom include types of electrodes, choice of ion exchange membrane, microbe source of microbes, and concentrations of solution reagents.

IMPLANTABLE μMFC POWER SOURCE

μMFCs could potentially be used to power implantable medical devices by using glucose in blood as a fuel. In order to maximize power density, the surface area of the electrode must be maximized. Siu and Chiao have designed a gold-plated PDMS electrode for a μMFC using an 8 step manufacturing process.

We propose to build a similar μMFC, but simplify the mold manufacturing process to a single step.

Manufacturing a PDMS-Gold Electrode:

The electrodes have micro-pilli structures, which increase the surface area by up to 80%. **We laser-cut microstructures into an acrylic mold instead of using traditional silicon-based μ-manufacturing techniques.**

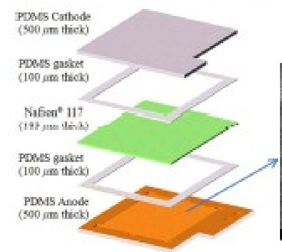


Figure 3: Exploded view of uMFC assembly (Siu, et al. 2008).

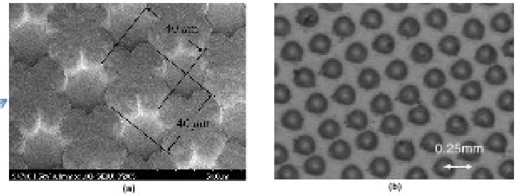


Figure 4: Microstructures. (a) Scanning electron microscope image of gold-plated PDMS electrode microstructures from Siu, et al. 2008. (b) Optical microscope image of laser-cut acrylic mold. Recesses are 0.12 mm deep and 0.2 mm wide.

ACKNOWLEDGEMENTS

We'd like to thank our advisors, Prof. Cumberbatch and Prof. Lima for their guidance, Prof. Kymissis for opening his lab up to us and for his suggestions for the μMFC, David Tan for assistance with the laser cutter, and Dionne Lutz for her expertise in the Kanbar Lab. Finally we'd like to thank our peers for their comments and suggestions.

REFERENCES

[1] R. A. Bullen, T. C. Arnot, J. B. Lakeman, and F. C. Walsh, "Biofuel cells and their development." Biosens. Bioelectron., vol. 21, pp. 2015–2045, 2006.
[2] B. E. Logan, *Microbial Fuel Cells*, 2008.
[3] C.-P.-B. Siu and M. Chiao, "A microfabricated pdms microbial fuel cell," Journal of Microelectromechanical Systems, vol. 17, no. 6, pp. 1329–1341, 2008.

CLOSING THE G A P
IN MIDFOOT INJURY DIAGNOSIS

A commonly misdiagnosed injury gets a leg up from a device that combines a doctor's hand exam with an MRI scan. The combined test reveals the scope of the injury so that patients get the care they need.

The Injury

Gaps between bones and tears in ligaments result in significant pain and an inability to bear loads

Treatment typically includes an invasive surgery to fuse bones together until the injury heals

One in five patients are initially misdiagnosed and do not receive the treatment they need

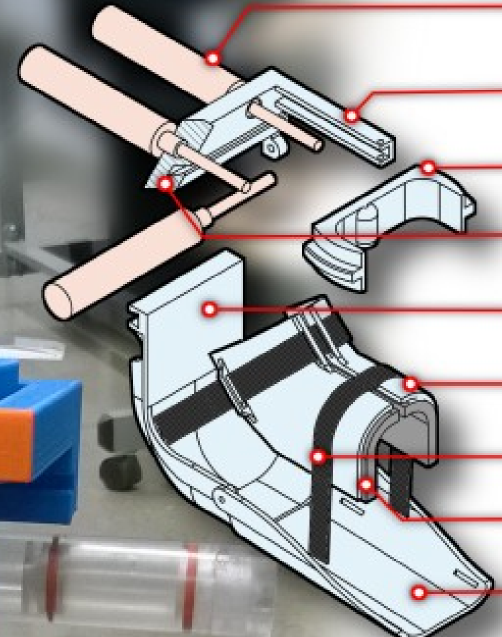
Rob Abdallah, Caleb Lear, Jason Potter
Senior Design Spring 2016
Advisor: Dr. Eric Lima

This project is Patent Pending

COMPUTATION DESIGN & INNOVATION: THE MAKERSPACE

Icahn School of Medicine at Mount Sinai

The Device



Pneumatic Pistons
Apply forces up to 40psi to the ball of the foot in 3 degrees of freedom

Columns
Supports combinations of axial and rotational motion, without losing stability

Saddle
Distributes loads on the ball of the foot

Dovetail Slider
Supports lateral motion and connects the base to the forcing mechanisms

Base
Supports the bottom of the foot

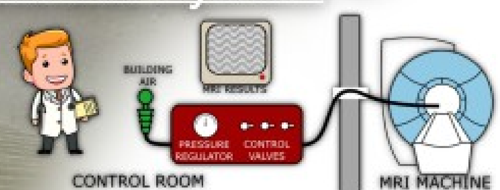
Clamp
Prevents motion of the bottom half of the joint, ankle, and heel

Straps
Hold the foot stably during an MRI exam

Foam Padding
Adds comfort and grip to the device

Leg Brace
Holds the leg in place during an exam and takes the weight of the device off the foot.

Control System



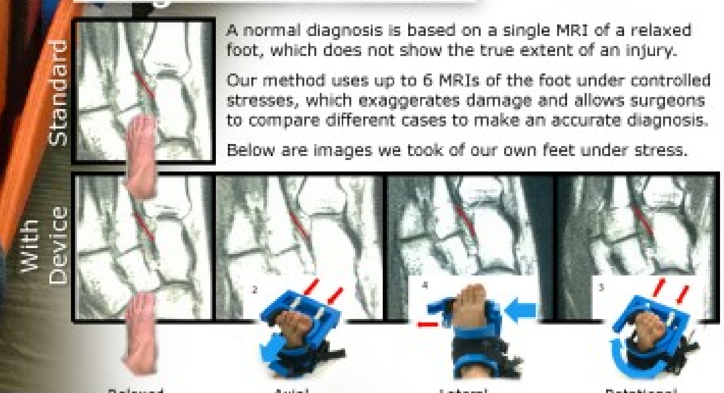
Our device uses a building air supply to actuate pneumatic pistons. A surgeon in the control room uses a set of simple valves to choose the direction of forces and slowly raises the pressure until the patient in the MRI machine can feel it. Remote actuation saves time during the exam, allowing the surgeon to take more tests during a single appointment.

Diagnosis Process

A normal diagnosis is based on a single MRI of a relaxed foot, which does not show the true extent of an injury.

Our method uses up to 6 MRIs of the foot under controlled stresses, which exaggerates damage and allows surgeons to compare different cases to make an accurate diagnosis.

Below are images we took of our own feet under stress.



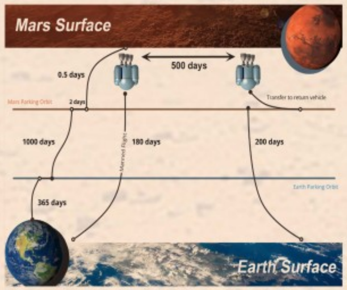
Fabrication

Plastic parts were used to make the device, including many 3D printed parts, because no metals can be used in an MRI machine.

Lightweight Mars Ascent Vehicle Design

Harris Paspuleti
Alexander Seligson
Hannah Quirk
Andrew Huh
Advisor: Professor Sven Haverkamp

It is NASA's goal to send humans to Mars by the end of the 2030's. To accomplish this, a Mars Ascent Vehicle (MAV) is needed to take astronauts from the surface of Mars back to outer space. The Cooper Union MAV offers a practical, lightweight, and cost-effective solution that fulfills NASA's requirements for entry, descent, and landing.



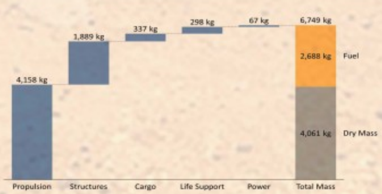
The Mars mission timeline is as follows:

1. MAV departs from Earth on the most energy efficient path, which takes 1000 days. The long flight is not an issue since vehicle is unmanned.
2. For the manned flight, a 180-day conjunction class trajectory provides the best balance of flight time, required delta-V, risk, and readiness.
3. The rocket enters a 250 km x 33,900 km elliptical (1-sol) orbit. The astronauts land on Mars and perform their mission.
4. The astronauts board the MAV and begin the 24-hour trip back to a 1-sol orbit. They rendezvous with the vehicle that brings them back to Earth. The 24-hour ascent was the fastest option with launch opportunities that occur multiple times per month.

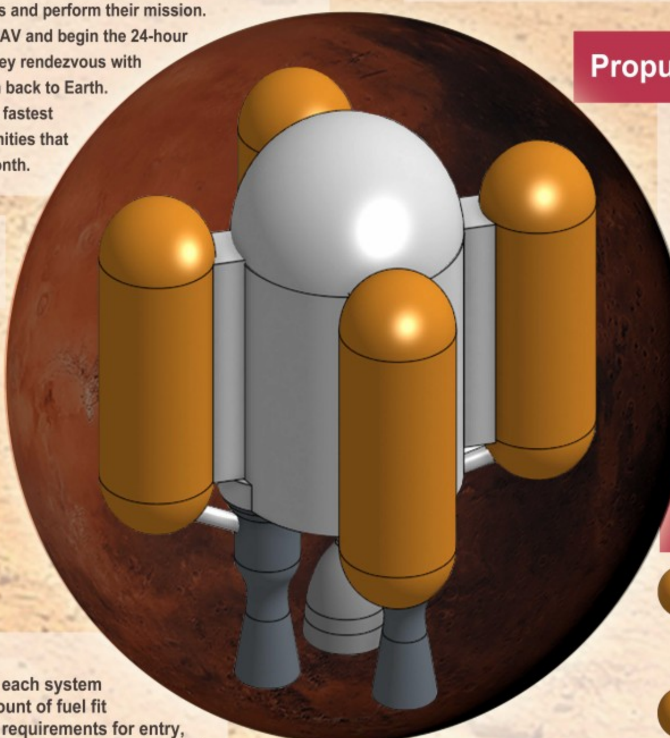
2025	2026	2029	2031	2033
Phase A: Concept Development	Phase B: Preliminary Design and Fabrication	Phase C: Final Design and Fabrication	Phase D: System Assembly and Integration	Phase E: Launch Operation

Subsystem:	Subsystem DDT&E Cost ($M)	Flight Unit Cost ($M)	Total Subsystem Cost ($M)
Crew Capsule	1872.40	272.89	2145.28
Ascent Stage (Storable)	2060.82	222.56	2283.38
In-space Habitat	2750.07	228.94	2979.01
Propulsive Stage	1111.28	85.39	1196.67
Propellant Depot	958.90	110.42	1069.32
		Total Cost ($M)	9673.67

The budget was estimated to fit NASA's goal of less than 2 billion USD per year until the launch year of 2035. A standard NASA cost spread of 60:40 for technically challenging designs was used. Simple Cost analysis estimation and Design Develop Test and Evaluation techniques were used. The projected cost for our MAV resulted in **9.7 billion USD spread over the length of the project.**

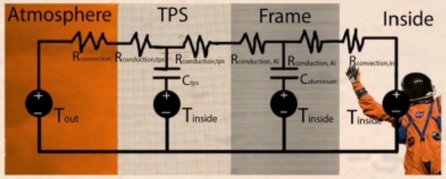


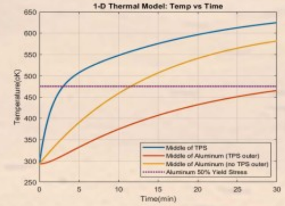
The final masses for each system and the required amount of fuel fit within NASA's mass requirements for entry, descent, and landing. The timeline and budget also fit within NASA-set parameters of a 2035 launch date and 2 billion dollars per year.



Thermal

Compression of the Mars atmosphere under supersonic speeds causes the MAV to heat up. A Thermal Protective System (TPS) is needed to prevent damage to the MAV structure.

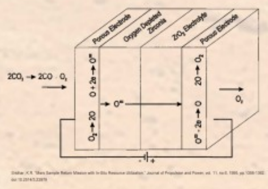




A 1D heat transfer model was used to model the thermal system. Without the TPS, the MAV reaches 475 K - where the frame is not structurally sound. With the TPS, it is below that point as shown in the figure above.

Propulsion

This MAV has a hybrid propulsion system that uses a solid paraffin-based wax as the fuel and liquid oxygen produced on Mars as the oxidizer



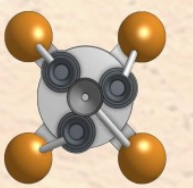
A zirconia membrane solid oxide electrolysis cell is used to convert collected CO2 into liquid oxygen. CO2 is decomposed near the membrane. A voltage is passed through the membrane so it can extract oxygen ions and recombine them into dioxygen. The in-situ system is sent before astronaut arrival, saving crewed takeoff mass.

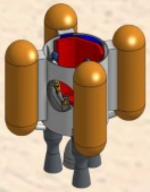
	kg
ZrO_2 system	19.8
Sorption comp.	21.7
Cryocooler	20.2
Dust filter	1.2
Heat exchanger	0.8
Other	39.0
ASRG	266.8
Total	369.5

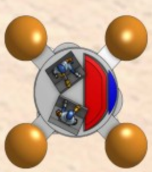
Sizing of the in-situ system to meet oxidizer requirements for a mission aiming for a delta-V of 5274 m/s

Structures

Structures were designed to minimize volume and weight to lower fuel demands and reduce risks in entry, descent, and landing.







The liquid fuel tank uses Teflon as its inner material and surface foam insulation (SOFI) as its surface material. Teflon withstands high internal pressures from the oxidized fuel tanks and does not require a large thickness. Multiple layers of SOFI are applied, resulting in a thickness about 12 times that of Teflon. The external SOFI layer ensures protection from environmental conditions on Mars along with ascent.

The frame of the MAV must withstand high pressures from ascent and prolonged stay on Mars. **Aluminum 7075** was used as the material for the frame for its structural integrity and thermal resistance.This allows for thin walls without losing rigidity in the Mars environment, and is convenient for manufacturing purposes.

THE COOPER UNION
COOPER UNION MOTORSPORTS S20

CARBON FIBER COMPRESSION MOLDING

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Raymond Choi
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Advisors:
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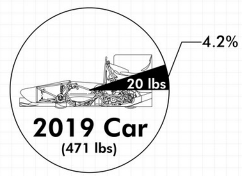
David Wootton

A LIGHTER CAR FOR THE 2020 SEASON

Cooper Union Motorsports is a student-run design team tasked with designing, building, and testing an open-wheeled racecar every year. A main goal this year is to **reduce the weight of the car by 20 lbs**. Weight reduction is currently limited by the physical properties of the materials the team uses. Thus, a new material and method of manufacturing is required.

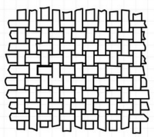


NEW MANUFACTURING METHODS

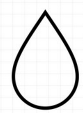
We plan to have Carbon Fiber Bulk Molding Composite (CFBMC) replace most aluminum components on the car. A low-cost CFBMC manufacturing process was designed in-house (see below) to avoid the high price of the commercial counterpart.

Compared to 7075 Aluminum, CFBMC is:

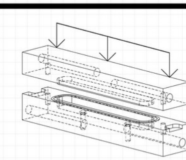
- 200% as Stiff
- 50% as Strong
- 45% Lighter



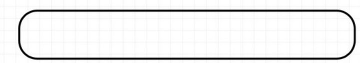
Carbon fiber is cut into short strands



The strands are mixed with epoxy resin



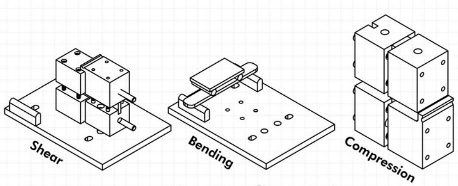
The mixture is compressed in a heated mold under high pressure



The part is removed from the mold and excess material is removed

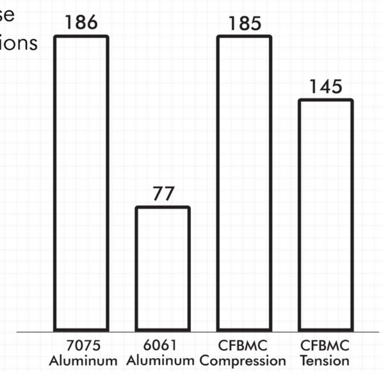
STRENGTH & STIFFNESS CHARACTERIZATION

Standardized samples were tested to identify the strength and stiffness properties of in-house CFBMC. A testing rig with multiple configurations was developed to test in shear, bending, and compression. Tension, impact, and fatigue were able to be tested with existing rigs.



Test Rig Configurations

Specific Strength [kN·m/kg]

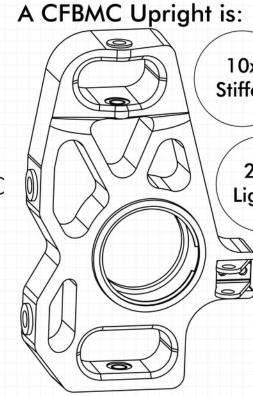


5 POUNDS OF WEIGHT REDUCTION

To validate the manufacturing process, a suspension upright, which acts as the connection point between the wheel and the rest of the car, was designed to be made of in-house CFBMC. The next steps are to produce a CFBMC upright and test it on the racecar.

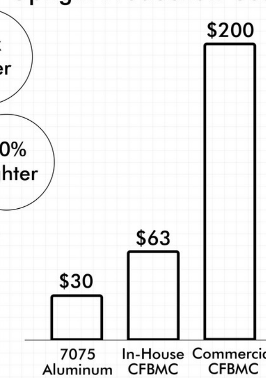
Replacing all aluminum with CFBMC should save at least 5 lbs overall while maintaining reasonable production costs for the team.

A CFBMC Upright is:



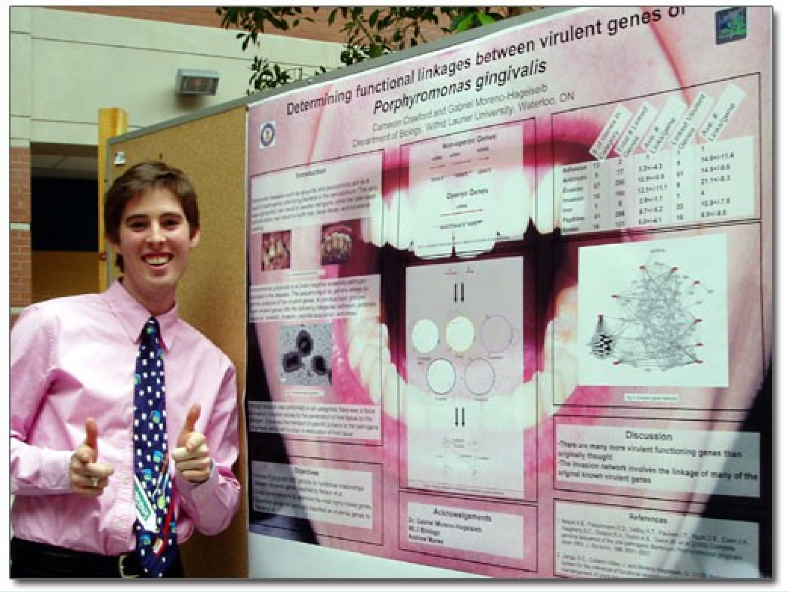
- 10x Stiffer
- 20% Lighter

Upright Production Cost



Some Tips from Colin's Website

- If you are obsessive compulsive and have a large wardrobe, try to choose your clothes to match your poster color.



Poster "Pitch"

- **Get your visitor hooked with a 2-sentence overview of why your project is interesting and relevant.**

For a research example, you might point to the illustration of the submerged hamster in your "Materials and methods" and say:

> "*I was interested in whether hamsters can mate underwater, which would be adaptive the ice caps melt away*."

Then point to the graph in Results section and say:

> "*I found that pairs of male and female hamsters didn't mate underwater, but instead drowned within 25 seconds.*"

Source: Purrington

Example: "A Novel Forced-Convection Baby Spoon"

For an engineering example, you might point to the illustration of a working mom preparing dinner for her family and say,

> *"As a working mom, I wanted to make family dinners safer and more efficient."*

Then while pointing to a schematic of a spoon design, say:

> *"We are designing a novel, self-cooling baby spoon based on forced convection that takes away a mom's need to blow on baby's food."*

Image: http://www.ohsweetbabies.com

Source: Baglione

Storyboarding and Mock Poster Session:

Prepare a poster storyboard and a 2- to 3-sentence “pitch”

Make sure your poster storyboard helps you tell your project story