Engineers' Forum

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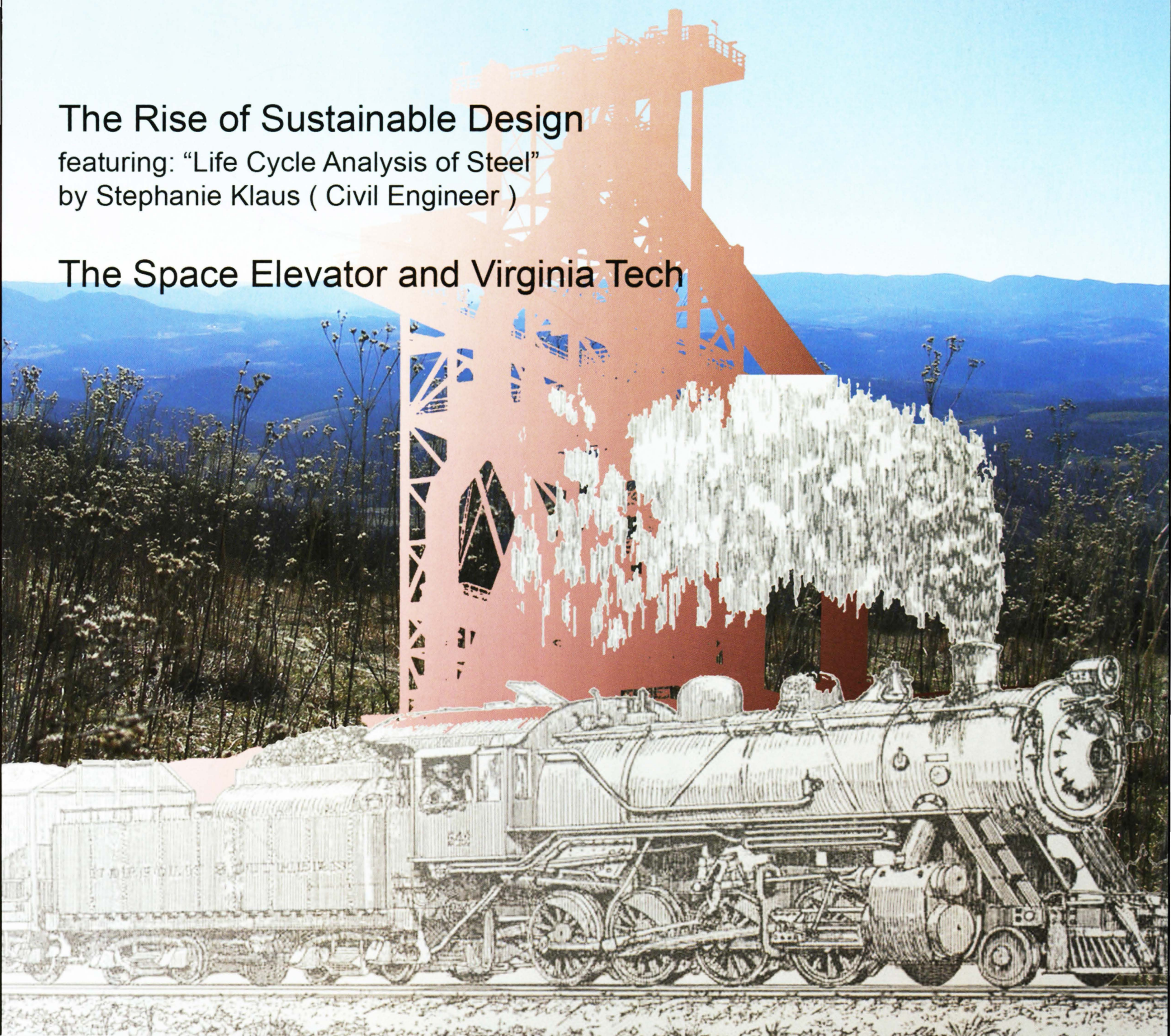
The Rise of Sustainable Design

featuring: "Life Cycle Analysis of Steel"
by Stephanie Klaus (Civil Engineer)

The Space Elevator and Virginia Tech



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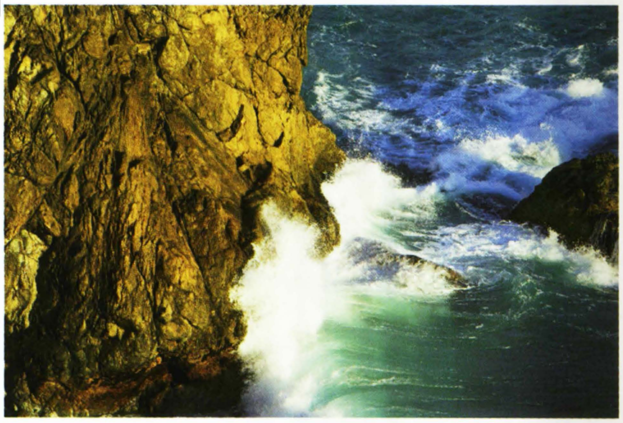

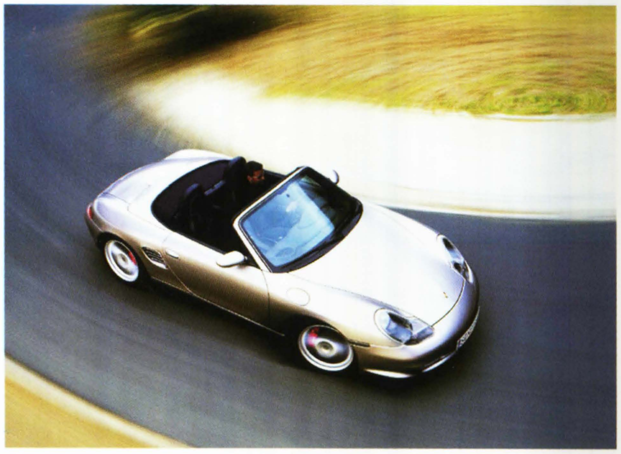

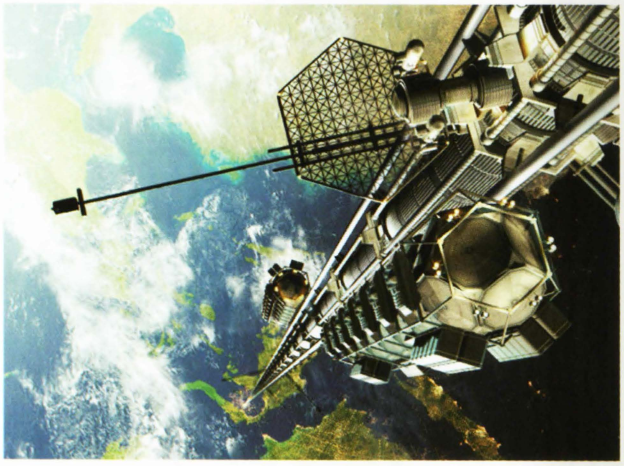

Inside

Engineers' Forum is Virginia Tech's student-run engineering magazine. Engineers' Forum is published four times during the academic year. The editorial and business office is located at:

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From The Editor

Dear Reader,

After this issue I will no longer be the editor. You'll be left with a talented group of younger students, all dedicated to continuing the Forum's goal of bringing relevant VT engineering news and stories to you.

As for me, I feel it was only a short time ago that I entered Tech. Now, with both Chemistry and ESM degrees almost complete, four internships and two solid years of various undergraduate research experiences under my belt, I've overstayed my welcome here. I'm sure these last years will end up being some of the best in my life, but although gruesome at times, I've chosen to further my education. So, the next four years of my life will be spent working towards a doctorate in mechanical engineering at USC (no, not in South Carolina). Don't worry though; when it comes to football, Tech will always come first.

I'm a firm believer in self-motivated work, a concept derived from internal goals and external pressures. The former source of motivation always yields the best performance, in school, athletics, relationships, anything. Unfortunately, the hardest part about being a college student is discovering a discipline you enjoy most. Find that, and you're set. I've just given you much more than two cents. Enjoy this issue, and take care.

Respectfully,

Enoch Dames
Editor-in-Chief

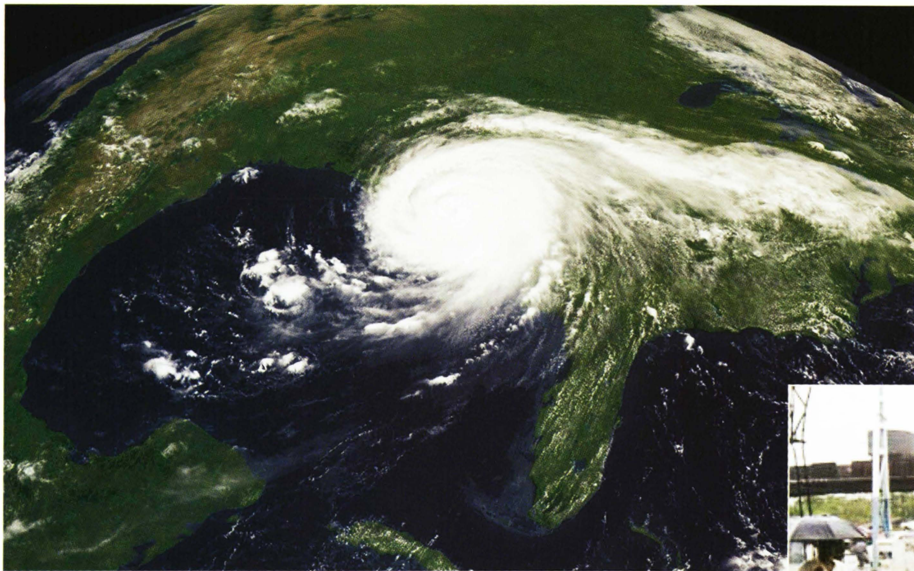
The Rise of Sustainable Design

DIVAKAR MEHTA

DOES LIFE exist on other planets? Although no one can answer this question with certainty, I like to believe the answer is yes. Inarguably true is that life on earth is possible only because of its unique environment. The perfect combination of oxygen, carbon dioxide, along with other gases works in unison with the protective ozone layer to make life possible.

Up until the industrial revolution, humankind has spent most of its existence living a fairly simple life. Inventions during the industrial revolution improved peoples' daily lives, but as one thing led to another, humankind employed innovation into every facet of life. The proverb, 'no pain, no gain', soon illustrated its relevance to humankind's perception of progress. As the human race applied innovation to their lives, they unfortunately started damaging the unique environment of our planet. As life got easier for those who embraced the revolution, the people of that day and age could not fathom that their actions were hurting themselves or future generations. The global danger of a small amount of smoke released into the atmosphere was hard to imagine, as scientists and engineers continued to invent novel ways to solve the different hardships faced by their fellow citizens.

As technology improved, Russia successfully launched the first satellite into space, Sputnik I, which eventually led to countless additional missions, including those motivated by Earth sciences. Such missions gave humankind an alarming picture of how much the atmosphere had deteriorated. Not until June 1974 did the world begin to understand the extent of damage on the ozone layer. Around this time, Nobel Laureate, Dr. F. Sherwood Rowland, publicized his findings concerning the deleterious effects chlorofluorocarbons (CFC's) have on the ozone layer. Simple subtraction shows that it took us nearly a century to realize that we were on the wrong path. During this period, we had gone from riding horses to flying on the Concorde, which could



An ariel view of the developing hurricane Katrina.

> *"In general, many scientists attribute these incidents to our disregard for the global environment."*

Mumbai monsoon, August 2005 killed more than 500 people. (rediff.com)

fly at a maximum operating cruising speed of 1350 miles per hour at a maximum altitude of 60,000 feet.

As Dr. Rowland publicized his findings, he met strong resistance from industries around the world as businesses and governments passed off his research as pessimistic and unreliable. With the discovery of the ozone hole over the Antarctic in 1985, Dr. Rowland's claims could no longer be dismissed as bogus. Two years later, nearly 200 world leaders joined the United States in ratifying the Montreal Protocol, which banned the use of ozone depleting chemicals and set the target of healing the ozone layer by the year 2050.

Despite many past rude awakenings, most people disregard environmental research as they feel the scientists involved present biased data and are simply overreacting. However, recent weather related tragedies around the world have swayed the opinions of many people. In August 2005, Hurricane Katrina struck the coastal United States and claimed the lives of approximately 1,400 people. Additionally in the year 2005, the city of Mumbai in India submerged under water for a few days after receiving the highest amount of rainfall recorded in history. Even the European continent was not spared by the abnormal weather spat as they recorded the first ever hurricane to approach them. In general, many scientists attribute the aforementioned incidents to our disregard for the global environment.

However, this is not the first time environmental concerns have entered the minds of the public. To generation Y (people born after the year 1976), this current wave seems to be the first, because environmental issues have again begun to spark attention from the media in recent years. As Dr. Steve Kampe, professor of Materials Science and Engineering (MSE), and a member of the steering committee for the Green Engineering Program at Virginia Tech (VT) says, "People respond to crises. People respond to them, they find solutions, they find ways to deal with it, and as people learn how to deal with it, then it is no longer in the headlines and it kind of goes away for a while until the next crisis," which is why there is never a constant level of environmental awareness in the minds of most people. Two major previous events that have stirred such awareness date back to the 1960's and the 1970's. In the early 1960's, Rachel Carson's Silent Spring elucidated upon the consequences of DDT use and, specifically, how this chemical entered the food chain with the potential to cause cancer and genetic disorders. Not surprisingly, an immediate outcry from chemical industry followed Ms. Carson's newly published book and some individuals went as far as questioning her integrity and sanity. As news headlines spread across the country, the focus of America's mind steered towards environmental awareness. The next eye-opening event took place in the 1970's, when The Organization of Petroleum Exporting Countries (OPEC) raised gasoline prices, leading to stagflation (an economic condition of elevated inflation and unemployment). Both of these events show that the media heavily influences how people think and what they consider as important or not. As a crisis hits, people scramble to fix the problem, but just as Dr. Kampe noted, once these problems are remedied, people tend to forget about them.

What does this have to do with engineering at Tech?

As freshmen, most engineering students are educated with the various elements of a good design such as safety, practicality etc., however, most engineering programs rarely mention the environments role as a finite raw material source. The environment is actually a very important, integral part of a good design as it is what sustains everything efficiently, and we as a race are on the verge of exceeding this capacity of the environment. Most engineers approach design without concern for environmental ramifications, focusing instead on whether products meet demand. Generally, industry portrays environmental considerations as an added cost and not an integral part of engineering. This mindset must change in order to improve global conditions. However, just as industry must do its part to change, equal contribution must come from its roots - the consumer population. As Dr. Sean McGinnis, Director of the Green Engineering Program at VT explains, "There is a general disconnect between most consumers and the environmental impact of products they buy because they rarely consider where the product materials come from, how much energy is consumed, how much waste is created, or what potential environmental and health issues may result", and therefore, because consumers do not ask for environmental responsibility, corporations typically do not focus on this area.

This is where VT steps in as a renowned engineering school offering a good education in various fields of engineering ranging from Aerospace Engineering to Systems Engineering. VT was one of the first universities in the United States that began including environment concerns into the curricula. The Green Engineering Program at VT began as early as 1995 and over the years, the program has been rejuvenated, as new faculty and staff take interest and help shape the program. Dr. Kampe explains, "what we want to do is give students the information, the data, and the tools to do your own analysis and to make your own informed decision, rather than telling students how they should think and what they should believe."

This idea is further cemented on the Green Engineering Program's website (www.eng.vt.edu/green/Mission.php) which states, "The mission of the Green Engineering Program is to promote dialogue and collaboration among Virginia Tech faculty, staff, students, administrators, and departments as well as with both local and global communities on issues related to green engineering and sustainability."

Left: Dr. Seam McGinnis, Right: Dr. Steve Kampe

The program at VT, in a way, just wants to get people's minds rolling.

The Green Engineering Program at VT consists of a steering committee with faculty and staff from most engineering departments directed by a daily program coordinator. It is essential to note that Green Engineering is not a department or division within the College of Engineering. Something is classified as a department at VT when it starts giving out degrees to students and a division is something that looks and feels like a department, however, does not hand out degrees. A program on the other hand is described as an "aggregation of faculty and staff with similar interests." One might imagine that the Green Engineering Program may eventually become it's own department, however, this is not the case. The program is highly interdisciplinary in that people of all engineering backgrounds can benefit from it without rigorously changing their plan of study. By becoming a department, there will be far more restrictions and Green Engineering will no longer remain an open school of thought where people can ponder about the consequences of their design and understand the environment better, while still practicing conventional engineering. This will happen because it is always difficult for different departments to collaborate towards a certain goal; however, a program is flexible enough to suit the needs of everybody effectively. According to Dr. McGinnis, "The real long term goal of the program is that you would not even have to have a green engineering concentration or program, because the concepts would be so fully incorporated into all the engineering degrees we already have that there would be no need for it." Through a variety of different courses, the Green Engineering Program strives to rid the notion among engineering students that the environment is but an afterthought, if thought of at all. The people responsible for the program also want future engineers to realize the importance of the environment and use their knowledge to help educate their world, one person at a time.

To give the reader an understanding of environmental considerations in product or process design, the Engineers' Forum, in partnership with the Green Engineering Program, the Materials Science and Engineering Department (MSE) and the Biological Systems Engineering Department (BSE) at VT, ran a small competition in "ENGR 3134 – Environmental Life Cycle Assessment". This class, one of the Green Engineering Program's core classes, gives students the opportunity to research environmental life cycle implications of a particular material from cradle to grave. Students investigated various phases of a product for environmental ramifications. The competition gave the students an opportunity to put their research together as one coherent life cycle assessment. A typical life cycle assessment is composed of four stages. The first stage involves material extraction or harvesting. Once the material is acquired, it is used to manufacture a product. After the product has been manufactured, it is used, retired, and must be properly disposed of. Life cycle assessments are essentially detailed analyses of how a particular material affects the environment from the date of extraction to the date it is disposed of.

For example, a life cycle assessment of a cotton T-shirt begins with an estimate of the amount of energy needed to remove cotton from its source and ready it for production. Next, the analysis quantifies various chemicals and other industrial products used to produce the T-shirt. Once made, energy used by the owner to wash the T-shirt is considered and finally an assessment is made describing how a typical cotton T-shirt is disposed of - how much landfill space it uses or how much incineration energy can be extracted from it. Although this example is very basic, it presents an overview of life cycle assessment. It is important to note the many other quantities are analyzed other than energy expenditure; these include measures of the formation of carbon dioxide (CO2), nitrogen oxides (NOX), and other pollutants. Once such analyses are complete, the engineer can pick a material for their product in a more educated manner, thus minimizing environmental impact as he/she helps humankind improve life. Now that you have an idea of what a life cycle assessment is, go ahead and read the award winning research paper written by Stephanie Klaus, and see for yourself how she goes through a life cycle assessment of Steel.

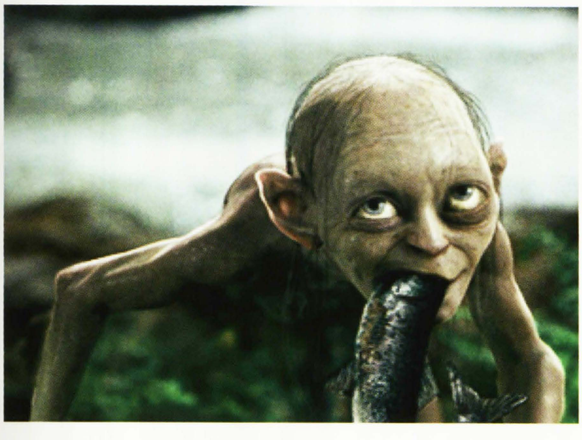
The Engineers' Forum *would like to thank Dr. McGinnis and Dr. Kampe for their help and support for the competition and article. Without their expertise and knowledge on this subject, this article would have been very hard to complete.*

What we have done so far...

loss of habitat, largely through the expansion of agriculture (BBC).

over-exploitation of wildlife, for example through overfishing and the build-up of nutrients through chemical fertilisers (BBC).

"On the island where I live our cabinet has been exploring the possiblility of buying land in a nearby country in case we become refugees of climate change." - Teleke Lauti, Minister for the Environment, Tuvalu



"I know the human being and fish can coexist peacefully." - George W. Bush

Life Cycle Analysis of Steel

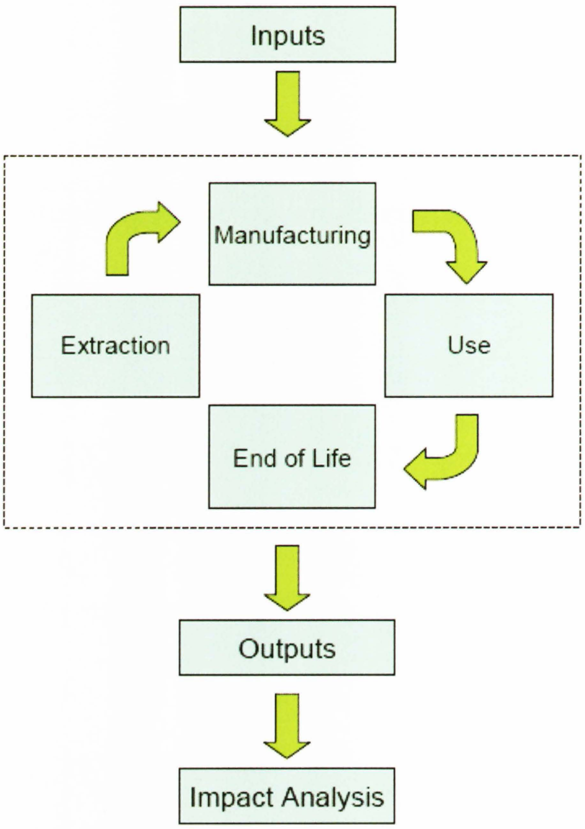
STEPHANIE KLAUS

LIFE Cycle Analysis is a formalized method of analyzing environmental, social, and economic impacts of a product, process or system in a quantified and consistent manner. Sometimes called a "cradle to grave" approach, Life Cycle Analysis considers these impacts over the entire lifetime of a product, process or system. While social and economic impacts are also important, this paper focuses solely on products' environmental impacts.

The life cycle of a product can be broken down into four phases: materials extraction, manufacturing, use, and end of life. Each phase of the product's life has inputs (such as materials, energy and water), outputs (such as products, air emissions, and solid waste), and impacts (such as acid rain, toxicity, and ecological damage). By researching inputs, outputs, and impacts for each phase of a product's life cycle we can assess which phase dominates and eventually decide how to minimize its environmental effect on the planet. The picture to the right examines the life cycle of a structural steel beam.

Low-carbon steel is the most commonly used material in the construction industry due to its low cost and high strength. Since low-carbon steel is over 99% iron (the remaining percentage being carbon), the following refers to the extraction of iron. Iron is the cheapest and most widely used metal in the world and almost all of it is used for steel production. Most of the world's iron ore comes from Brazil and Australia, while China is currently the number one iron ore and steel consumer.

Iron is one of the most common elements on earth, but pure iron is almost never found in nature (only from meteorites). The most common ores containing iron extracted for steel production are hematite and magnetite which are about 70% iron (1). Hematite is usually found deposited near bodies of water. Trace amounts of magnetite exist in almost all igneous and metamorphic rocks, or in sand, but its magnetic properties make it easily extractable. Within the United States, there are great deposits around the Lake Superior region, such as in Minnesota and Michigan.



The life cycle of a structural steel beam.

In the early days of mining, hematite was abundant enough to be mined and taken directly to steel furnaces. However, because of years of mining, those mines now harvest taconite, a low-grade ore that was at one time considered waste. Taconite contains only 25-30% iron and must be processed into pellets with an iron concentration of about 65% before it can be used in steel production (12). In the first step of extraction a large area of land is removed, exposing the ore beneath. Next is the beneficiation process which consists of the mined ore being crushed and sorted according to grade. Low grade ores such as taconite go through further refinement. Finally, refined ore is loaded onto trucks and transported to be processed into steel.

In 2005, 95% of the useable ore produced in the U.S. was shipped from ten mines in Michigan and Minnesota (12). All ten of these mines are open pit mines requiring a huge amount of land and waste. For example, the Republic Mine in Michigan is 600 feet deep with a pit surface area of 250 acres. Two types of waste are created from the mining of taconite: bedrock in the mine that isn't ore which is piled in waste dumps, and unwanted minerals in the ore itself which are separated into tailings. Tailings from taconite mining are mostly quartz - an inert waste stored in ponds.

Taconite mining, just like any other type of metal mining, can have negative environmental and public health impacts. Open pit mining disrupts the natural grade of land, potentially resulting in runoff and erosion. Additionally, due to the large amount of land associated with open pit mining, it can disrupt the existing ecosystem. Even though there is no toxic waste associated with the open-pit mines, the abandoned mines can be used as landfills with the potential to cause environmental problems. Furthermore, a problem commonly associated with abandoned mines is acid mine water which may pollute groundwater. Lastly, extraction of iron from ore produces toxic and corrosive gasses which may be harmful to workers and the environment (1).

Some major inputs of iron ore extraction and beneficiation are electricity and fuels, while some outputs are iron pellets, waste rods, acid mine water, engine fumes, dust and fines, and tailings (3). As illustrated in the tables above, extraction consumes more energy than primary ore processing (3). The tables also shows that although the process of ore mining consumes much energy, the most energy intensive process of extraction is hauling of the iron ore.

Energy Requirements for Extraction of Iron	
Process	**Btu/ton of Ore**
Drilling	1,710
Blasting	2,900
Loading	6,310
Haulage	50,860
Miscellaneous	6,490
Extraction Total	**68,270**

Energy Requirements for Beneficiation of Iron	
Process	**Btu/ton of Ore**
Ball Mill	3,870
Crushers	6,070
Rod Mill	1,550
Miscellaneous	340
Beneficiation Total	**11,830**

Table showing the energy consumed at different stages of mining for Iron Ore.

Once the iron ore is extracted from the ground and further purified, it is turned into steel and cast into useful objects. Steel is used for structural beams because no other material is at the same time so strong, tough, easily formed and cheap as steel (6). It is important for a structural beam to be strong in both tension and compression, to resist fracture, and perhaps most importantly, to be cheap and readily available.

There are two types of manufacturing processes for steel. The first is the reduction of iron ore using a basic oxygen furnace. The second is the melting of scrap steel in electric arc furnaces which, discussed as part of the end of life phase. Major steps in the basic oxygen furnace process are the blast furnace, the oxygen converter, secondary metallurgy and casting. Diagram A shows a flow chart of the basic oxygen furnace process to produce a 1000 kg steel beam.

Iron ore is first fed into a blast furnace along with fluxes, coke (a derivative of coal), blast (hot air) and other materials. The blast is heated to a temperature of 1200ºC and mixes with the coke to form carbon monoxide. The flux, coke and blast help facilitate reducing oxygen content in the steel and increasing carbon content. Inside the furnace, temperatures can reach 2200ºC (4) and the end product is reduced hot metal (pig iron). It takes a tremendous amount of energy to reach that temperature which means lots of input materials and wastes. The solid waste from the blast furnace is called slag. Although 275 kg of slag are produced per metric ton of steel, the construction industry recycles it as cement aggregate and asphalt (4). Another output of this process is blast furnace gas which can be reused for its energy content in boilers and power plants.

The next step in the process is transportation of the pig iron through an oxygen converter to further purify the hot metal. This process produces a lot of heat, so water and scrap steel are used as cooling agents (4). Crude steel is a result of this last process. However, high quality and specialized material properties required of steel necessitate secondary processing.

Ladle or vacuum treatments are two of these secondary metallurgy processes. The goal of this step is to reduce elements such as carbon, nitrogen, hydrogen and phosphorus to very low levels as well as maintaining a very precise temperature (4). The product of this process is liquid steel, which may be cast into specific shapes.

The manufacturing of steel currently employs two types of casting. One is the ingot casting method, while the other is the continuous casting method. In the ingot casting method, the liquid steel is poured into permanent molds. This method is on the decline and is typically used only for high-weight pieces that will be further processed. The more commonly used method is continuous casting, in which a water cooled copper mold is continuously fed with liquid steel which is quick cooled into short sections (4). This is the process most likely used for production of steel beams; the basic oxygen furnace process.

The manufacturing of steel consumes a lot of energy and materials while generating a lot of pollution. However, the good news is that steel is the most recycled material worldwide, with a rate of about 50% (6). Steel is a good material for recycling because it can be continuously melted and reformed with very little degradation of original ite electrodes and the scrap steel. Producing a metric ton of steel in an EAF requires 440 kW-hrs (11). Some environmental impacts from EAFs are: high sound levels, cooling water demand, dust and gas production, heavy truck traffic for scrap, and the effects of electricity generation. For every 1000 kg of steel that is recycled, 1,140 kg of iron ore and 450 kg of coal are saved (7).

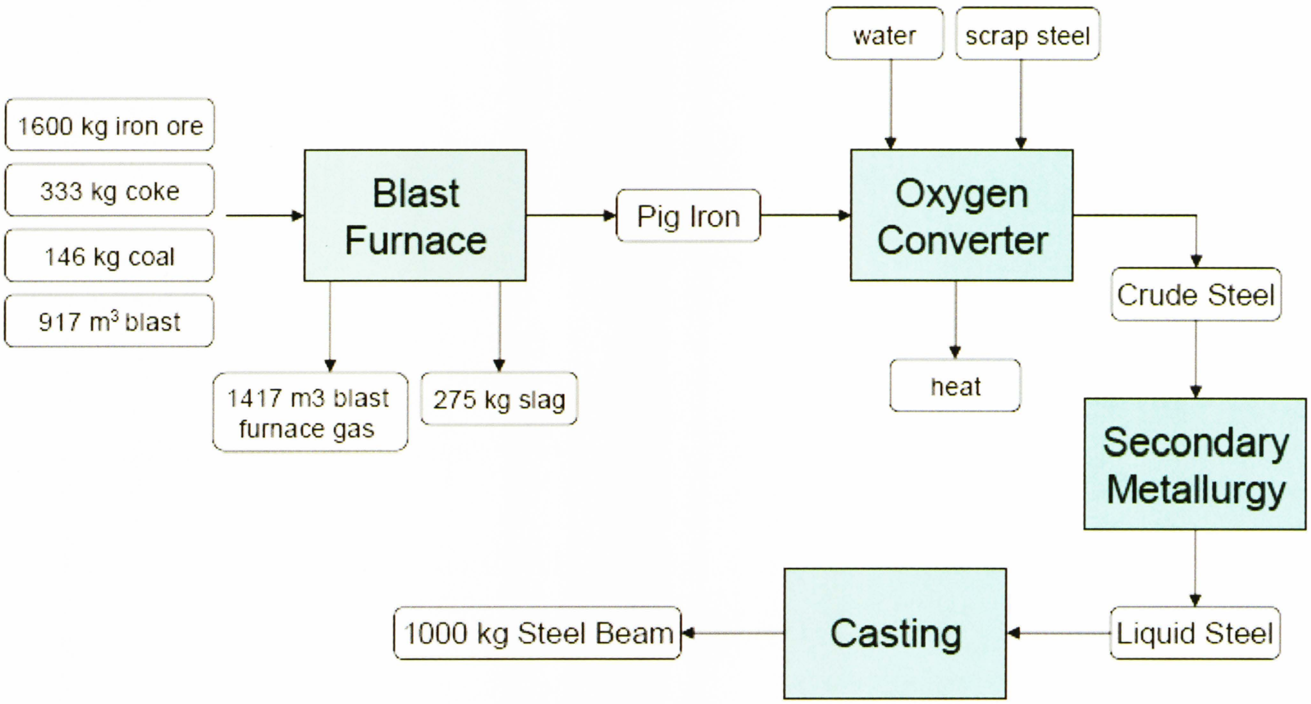


Diagram A: flow chart of the basic oxygen furnace process to produce a 1000 kg steel beam.

it is favored because it is cleaner, quicker, and more efficient (10-12% more efficient than ingot casting which is 85% efficient (4)).

Most environmental impacts from the steel manufacturing process come from blast furnace processes. As shown above, large amounts of materials burned everyday result in particulate matter emissions ranging from less than 10-40 kg/metric ton of steel (5). Also, waste water with high temperatures and suspended solids are discharged from properties. In fact, the two methods of producing steel both use some percentage of scrap metal. The basic oxygen furnace (BOF) process uses 25-35% of old steel, while the electric arc furnace (EAF) uses 95-100% of old steel. The BOF is usually used to make products such as steel cans and automotive fenders, while EAFs primarily produce structural beams and reinforcement bars requiring high strength (9).

An EAF melts scrap steel by passing an electric arc between graph- Because using scrap material over mining virgin ore is much cheaper, companies have a great incentive to recycle. However, the major limitation on steel recycling is scarce availability of scrap. Because steel is so durable and long-lasting there is not enough scrap to meet demands so virgin ore must be continuously mined (9). The steel composing a structural beam in a building could be used a hundred years before ever recovered.

The reuse of structural steel is desirable since the only energy input is deconstruction and transportation. However, compared to demolition, deconstruction currently isn't a practical option. After being demolished, the steel within most structures is unsalvageable for reuse. When time is taken to salvage steel from wreckage, the material properties must be confirmed and the amount of deterioration evaluated (7). There exists a large infrastructure for recycling associated processes, but not for reuse. However, as price of materials and energy increases, and landfill space decreases, there is a growing interest in designing buildings for disassembly (7).

Recycling rates for structural steel beams are extremely high, at almost 100% (10). The recycling rate for steel rebar is lower, at around 60%, because it is difficult to separate rebar from concrete (10). By comparison, the recycling rate for steel cans is also about 60% (10). Although efforts have been made within the last decade, recycling rates for cans could never be as high as steel beam recycling rates. People just don't have the incentive to recycle steel cans as they do to recycle steel beams in industry. The overall recycle rate for North America was about 70% in 2004 (10). Any steel that is not recycled is discarded in a land fill.

After examining the three most important phases of a steel beam's life cycle (the use phase has little impact), virgin ore manufacturing is clearly the most energy intensive phase. This phase uses the most material and has the most impact on the environment. For steel beams, the recycling rate is already maximized and virgin ore must be continuously mined to meet growing demand. Some possibilities to improve future environmental impacts are increased incentives to recycle other steel, and to design building and products for disassembly.

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BOSE® Suspension

DAN CIRULNIK

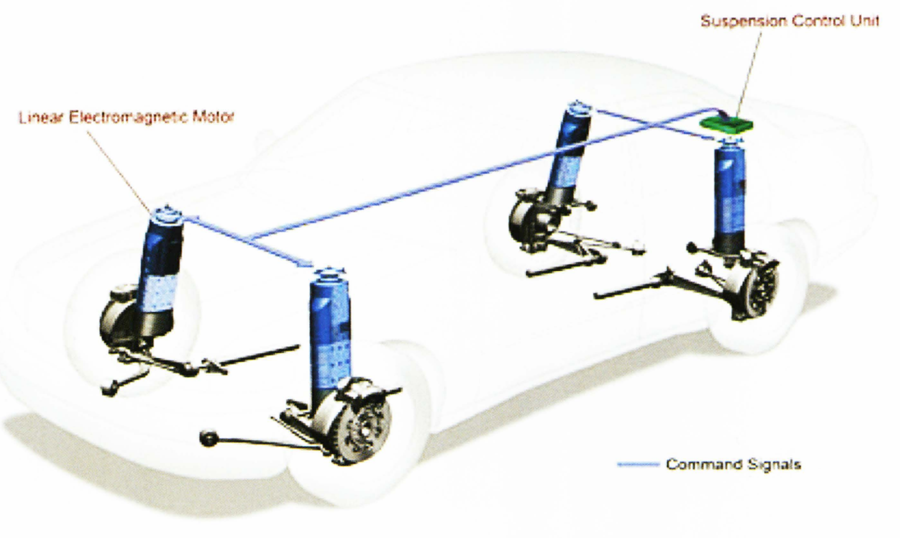
SUSPENSION design has been based on similar technology since its inception. A conventional suspension system is composed of a mechanical spring allowing the wheels to travel independent of the chassis, and a damping element to prevent the body of the car from bouncing as travels over rough terrain. Using these two basic elements, engineers have devised a solid axle suspension, and independent suspensions such as the McPherson Strut, the Swing Axle, the Trailing Arm, and the SLA front suspension. These all make use of a basic concept that has been around for many years. However, the Bose Suspension system, which does not use the conventional mechanical spring and damper, is an entirely new approach to suspension design.

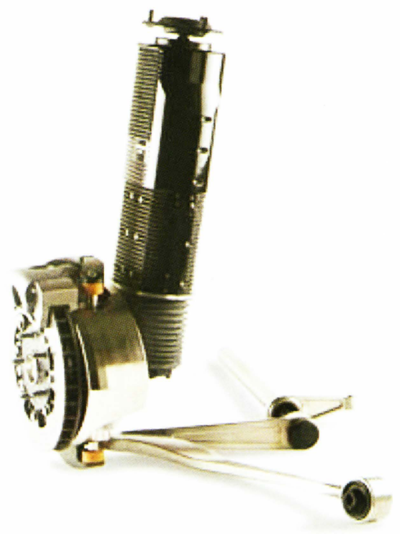
The two major functions of the suspension are: keeping the driver comfortable by preventing ground-induced vibrations from being directly transmitted to the driver, and allowing him to maintain greatest control by maximizing wheel-to-road contact. The Bose Suspension System is a novel design providing both better comfort and control than the current mechanical suspension design. This new suspension uses electromagnetism as the physical principle on which it behaves. The three major components of this system that govern its behavior are the Linear Electromagnetic Motor, a Power Amplifier, and Control algorithms.

In order to de-mystify the Linear Electromagnetic Motor, an elementary understanding of rotary motors is needed. Electrical current flows around a loop of wire. In the middle of the loop rests a magnet, which, by definition, creates a constant magnetic field. A force acts upon a current carrying wire within a magnetic field. In the case of a linear motor, its unwound stator, instead of producing a torque, produces linear force acting along its length. This is the heart of any linear electromagnetic motor, and the force and speed with which a motor can operate depends largely on the characteristics of the wire, current, and magnet. Particle accelerators and Maglev trains use this technology as their source of acceleration. In the case of the Bose design, a motor such as this is installed at each wheel.

The Bose system utilizes linear motors to adjust wheel position. A car with the Bose suspension traveling over a pothole, for example, can extend the wheel down into the recess much faster than an ordinary spring. This would keep the car from jouncing or rolling when

Bottom Left: The bose suspension modules installed. (www.bose.com)
Bottom Right: The Bose Suspension Front Corner Module.





passing over potholes or bumps; this would also keep the car in greater control over different road surfaces. A lack of disturbances would also provide a more comfortable ride for the driver. The same can be said of passing over bumps. The ride and stability would benefit greatly if the linear motor can move the wheel into the well while passing over the bump, but just how would the car know when the roadway was changing? Without an accurate model to predict undulations in the path of the car, this suspension would be nothing more than a glorified spring and damper system. If the suspension could predict the road variations, this system then becomes much more useful.

In order to anticipate bumps and potholes, a sensing and prediction algorithm is required. Bose refers to this as the 'Control Algorithm' for their suspension system. According to Bose, this algorithm is the culmination of 24 years of research. A long time by any means, but it seems to have paid off based on the results. The algorithm uses a number of sensors placed about the car to 'guess' what the motors should do with the wheels. A story ran by the Associated Press last November chronicled a test run during which a Bose Suspension system equipped car drives over a two-by-six board. According to the reports, the car seemed to retract its wheels while going over, and re-extended them at the right time to enable a rather reflexive looking reaction. This is the work of the control algorithm predicting when the wheels must be moved, and how far.

Between the algorithm and the linear motors lies a very clever and power amplifying system. The control algorithm compose the eyes and brain of the system, the motors the extremities, and the amplifying system the spinal chord. The algorithm sends the signal of how and when to move the wheels to the amplifier, which then sends the motors the power needed to adjust. The novel part is the regenerative process when the suspension absorbs a bump or undulation. Much like regenerative braking, the energy used when the suspension goes into jounce (or under braking as in the analogy just mentioned), the power amplifier can this energy to retract or extend the wheels next time. In this respect, the power required to operate the Bose Suspension is reportedly one-third of that used for normal air conditioning. The system dreamed up and designed by Amar Bose seems to be just what suspension design needs to take the next leap forward. The advantages of such a system have been chronicled extensively. Its ability to seemingly "leap" over obstacles in its way, or thrust a wheel down into a hole in the road is breathtaking. When accelerating or turning, the suspension can use the motors to prevent pitching or rolling of the car. Doing so combines the two most important facets of suspension: comfort and performance. By absorbing road disturbances, the system has a leg up on its competition in terms of comfort. The fact that it is also designed to greatly reduce pitch, roll, and vibration in the vehicle chassis makes this a performance boost as well. By reducing pitch, roll and vibration, the contact patch of the tire is kept at a maximum. There are some who think that contact patch dynamics and the interactions between the tire and road surface among the most important for vehicle behavior. Could it be that Amar Bose and company have found a suspension design worthy of being fitted, for a small fee and gain in weight, to your brand new Corvette or BMW? As for me - I'd be happy putting that suspension system in my 1984 Dodge Colt.

Athleticism, Engineering and Efficiency

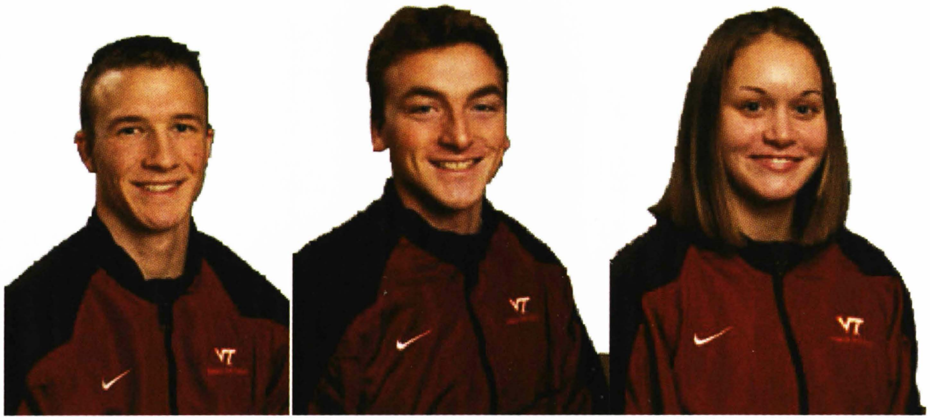
ENOCH DAMES

MOST non-engineers tend to have pity on us when we tell them our major. The ideas of long homework sets, large workloads, and difficult tests usually evoke a sense of sympathy. However, our typical responses fall somewhere along the lines of, "Yes, I guess it's tough, but I do it anyway." Most of us even find time for extracurricular activities or involvement in student organizations, all of which necessitate expertise in time management. Some of the most consistently productive engineering students at Tech are athletes, who work most efficiently under the pressures they experience.

Erin Mahony is one example of a student who leads seemingly double lives. As a junior Industrial Systems Engineer, Erin recently broke the women's university record in the pole vault and set a personal best with a jump of over 13' (4.01m) at the 2006 ACC championships. Although she admits to having somewhat of a natural talent for the sport, Erin and other vaulters must practice almost constantly.

"We run two or three times per week. We weight lift and go to the gymnastics room as well. Off-season, we pole-vault two times per week. In-season, we practice once a week and compete pretty much every weekend. You don't get any work done on the weekend, and you basically have to miss all your Friday classes," says Mahony.

Even with all her practice, Erin still finds time to get her work done and perform well in school. Asked whether or not it is difficult to keep up with both the academic and athletic portions of her life, Erin replied, "Group assignments can be hard because sometimes I can't meet because of practice. I've done sports my entire life, and I don't think my grades would be any better if I wasn't doing it."



Left to Right: Adam Bingaman, Joe Samaniuk, Erin Mahony

Another talented pole vaulter, Joe Samaniuk, is a senior in Chemical Engineering – he follows a similar belief: "I think the balance is difficult, but I know that every engineer balances their time between school and some other extra curricular activity. I like to think that whatever doesn't kill you makes you stronger. Being an athlete, an engineer and participating in other clubs or jobs is just a challenge - a challenge that has made me better at being all of those things. At the end of the 'work day' it's unbelievably satisfying to look back at how much you've accomplished because of the skills you've developed in managing your time."

Both Erin and Joe stressed to me that more work and activity force you to stay in constant check, leaving you more productive than otherwise. However, Adam Bingaman, a junior in Electrical Engineering, admits that it's no walk in the park, "Making up exams, doing work on the road, copying missed notes, and staying up to date with class information is very tough. It is worth it though," said Adam.

Evident in each athlete's mind is a level of confidence ready and willing to tackle the challenges they set. Why, it's no different at their track meets. This same approach to schoolwork and life in general is embraced by countless other students - it is a hallmark quality of every successful student and future leader.

"You really have no idea how efficient you can be and how much you can learn from that kind of pressure. It seems backwards, but the more extracurricular activities you get yourself into, the more efficient that few hours allotted homework time will be..."
- Joe Samaniuk, Junior, Chemical Engineering

" . . . the more time you have to do something, the longer it will take you,"
- Erin Mahony, Junior, Industrial

The Space Elevator and Virginia Tech

KARI ADKINS

WHAT if, by the year 2020, there exists a relatively cheap way to transport astronauts and cargo into space that was safer than sending a shuttle into orbit? The Spaceward Foundation hopes to spark such interest in a design with goals such as those listed above with the Elevator 2010 competition. The major goal of the competition is to show the world that a space elevator is a feasible and cost effective way of maintaining a presence in space while expanding our research to the Moon and eventually to Mars.

A space elevator is a climber that is capable of sending cargo into geosynchronous orbit. The climber reaches orbit via a ribbon that will be approximately 62,000 miles long (roughly one-fourth the distance to the moon) and thinner than a pencil. Such a ribbon would be made of carbon-nanotubes, a form of carbon discovered in the early 1990s. Carbon nanotubes are very strong - more than strong enough to ensure that a space elevator program in the United States would have several successful launches with little risk of failure. Launched by rockets 62,000 miles about the Earth, the ribbon will be attached to a floating base of approximately 1500 tons in weight. A combination of the forces exerted by the floating base and rotation of Earth will stablize the orbital position of the elevator.

Once the ribbon is in place, a climber can be attached. One of the more interesting aspects of the climber is that it collects the power it needs to ascend through photovoltaic (solar) cells. These cells do not collect sunlight however; they collect energy from a surface based source, such as a mirror reflecting light from the sun or Earth's atmosphere. With this innovative source of energy a climber may ascend into orbit with a constant rate of 120 miles per hour. Building a relatively shock- and vibration-resistant climber will ensure the safety of expensive cargo during its ascent into geosynchronous orbit.

After learning about basic space elevator concepts, one begins to wonder how a tiny ribbon with a cross section less than that of a pencil could possibly withstand the harsh conditions associated with both our atmosphere and outer space. Moreover, questions arise concerning the outrageous amounts of space debris constantly floating around our planet. What would happen if a portion of an old satellite were to hit the ribbon? Would it tear, or could such a collision be avoided entirely? Well, similarly to how the International Space Station is moved periodically to adjust for the debris fields, the ribbon could also be adjusted, by moving the floating base stationed on the Earth. Another question posed by many people concerns what would happen if a ribbon were to break. Would a large strand of ribbon embrace Earth? According to the Spaceward Foundation the answer to this question is no. The ribbon is so small that it wouldn't make a big impact on the Earth. The concept is very innovative, seemingly resilient to the harsh environment associated with space, and hopefully by 2010 we will know exactly how send a climber into space safely using a carbon nanotube ribbon.

The Viginia Tech Spave Elevator team.

As mentioned above, the goal of the Spaceward Foundation is to spark interest in the space elevator concept, not just from the public, but also from both companies and investors, much like the effect air shows in the 1910s and 20s had on society's interest in aviation. This goal is being accomplished through the Elevator 2010 competition. Teams from around the country and world are designing climbers that someday could carry payloads into orbit. These teams will come together August 2006 in San Jose, California during the second annual competition for best design and design-implementation.

This is where Virginia Tech comes in. The Engineering Science and Mechanics (ESM) Department is sponsoring a Space Elevator Team (VTSET) who will compete in this year's competition. The team is composed undergraduate students, seven of whom are seniors focusing on this project as their senior design project, and one of whom is a freshman general engineering student. The team members are: David Gillespie, Meghan Gloyd, Clay Myatt, Ryan Steele, Chris Sturgill, Samantha Vaillant, Elliotte Want, and John Helveston.

For a project of this size and caliber, there exists much funding. The ESM department initially allocates 250 dollars per student. Additionally, Dr. Pat Artis, an ESM alumnus, and his wife, Nancy Artis, donated 18,000 dollars to the team. Part of the money donated by Dr. Artis has been used to send the team to the 2005 Space Elevator competition, where they learned much about the process of building a space elevator as well as making several connections with teams and companies who competed. One of those teams, Team SPECO, based in Chicago, Illinois, is unable to compete this year due to time constraints and work schedules and has donated their space elevator to VTSET.

Elliotte Want, one of the senior team members, related to me goals for this year's competition. "Our main goal is to build a competitive prototype of a space elevator by April 2006 within the constraints of the competition . . . The prototype will be built and tested on the strong-floor at Tech in order to maximize the power to weight ratio of the climber's systems," said Want. He also stressed the importance of the competition's criteria – stating that the winning climber should maximize the payload carrying capability and the climbing speed. By August, the team plans to be very well prepared and ready to succeed in this innovative competition.

Space elevators are ambitious designs of how to send humans and payloads into space in the 21st century. With the Elevator 2010 competition and the combined work of several teams, each trying different approaches, they will bring the concept out of science fiction and into reality.

| opinion |

Name:	John Doe
Interested in:	Women
Relationship Status:	It's complicated with Engineering
Favorite Quote:	"Life is hard, stupidity is harder."

ANDREW GOAD

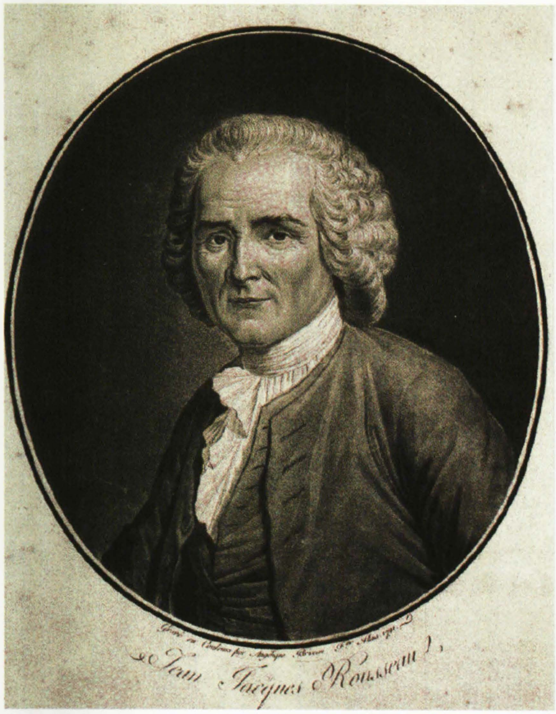
AS both engineers and Hokies, we strive to fulfill the motto Ut Prosim – that I may serve. This principle, although short in length, ultimately speaks volumes about what our relationship should be to the engineering profession. In order to have the best possible relationship with our future careers, we must not treat it unlike our other relationships in life. We must be both passionate and responsible, and remember our limitations. If we engineers cannot hold these ideals near, we cannot fulfill our pledge to society.

Generally, things in life we care for inevitably receive most of our attention. Almost a self-imposed rule, this approach to life can obviously have a major impact on your future career. Over the next several years, there are many questions that we will have to ask ourselves concerning our future. If we are dishonest with ourselves in answering these questions, we may end up traveling down an undesired path. Worse yet is the possibility that it might not be easy to climb out of one of these situations.

Only you can only choose your ideal career. Each of us is unique; our different interests in life make us such. It is in these interests that you may find hidden the first key to becoming a successful engineer. That key is passion. Without it you will find life to be mundane, and thus it will reflect on your work. However, with passion, your possibilities are infinite. The late 1700's philosopher, Georg Wilhelm Friedrich Hegel, once said, "Nothing great in the world has been accomplished without passion." It is important that we remember this as we move on to be great leaders in our future professions.

With passion, great ideas can be easily formed. However, it must be noted that these accomplishments do not always benefit society; take the atomic bomb and its consequences for example. As engineers we have pledged our lives to help design tools and processes to enhance the present and future state of being for all mankind. That is why we must always claim a certain responsibility over our passions. The Institute of Electrical and Electronics Engineers (IEEE) states this goal best in the first statement of their code of ethics:

"We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world…agree to accept responsibility in making decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment."



"The world of reality has its limits; the world of imagination is boundless."
- Jean-Jaccques Rousseau

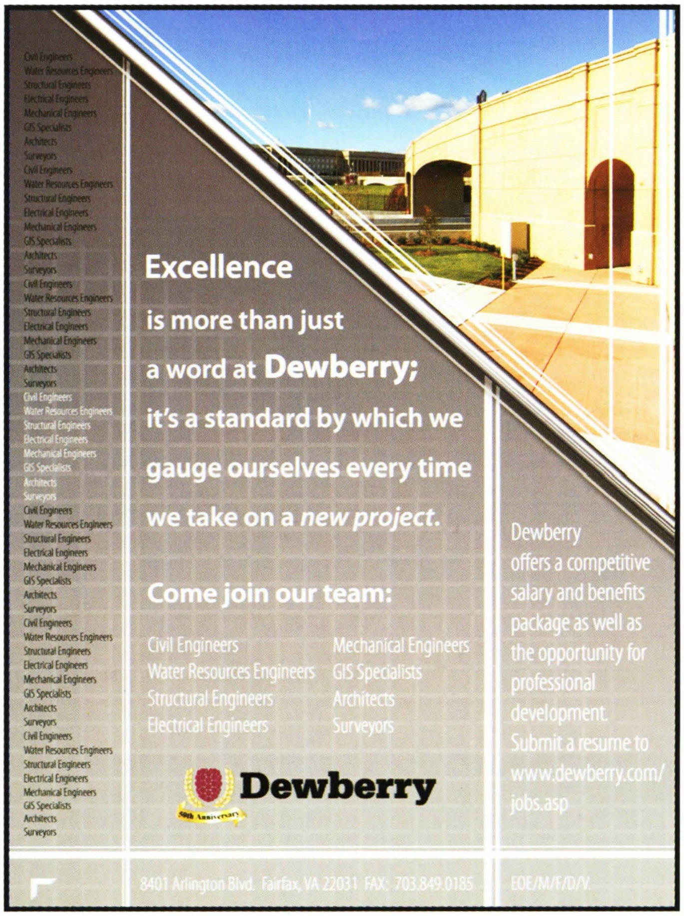
This goal is relevant to all engineers. External influences such as money, favors, or promotions must not override our morals and ethics. By allowing such temptations influence our decisions, our responsibility and pledge to society is lost, sometimes resulting in irreparable damage. Therefore, I ask, "What good can come of your creations if morals and ethics are left out of the decision-making process?" Does the end justify the means? It is important that we do not let the temptations of this world lead us astray in our engineering professions, and in life as a whole.

Nobody can argue me when I state that we are all humans – yet, we often forget this. As engineers we must take this lesson to heart. There is only so much we can accomplish. By saying that however, I have created a fine line between what we can accomplish and what we can't. The world is not really like that, and it shouldn't

"Nothing great in the world has been accomplished without passion."
- Georg Wilhelm Friedrich Hegel

be. As engineers, we must not limit ourselves. Yet we must realize that we are not gods; we cannot move mountains. There are some things that just are not possible. The early 1700's philosopher, Jean-Jacques Rousseau, from Switzerland put it best when he said, "The world of reality has its limits; the world of imagination is boundless." To examine this quote from the engineer's perspective we should look at the last part of the quote first. Engineers must have two qualities to succeed. The first and obvious one is the knowledge needed to do the job. Another equally important quality is creativity. Without a "boundless imagination", an engineer will find it very difficult to devise the clever solutions needed to solve the world's problems. Moving back to the first part of the quote however, we are able to take this knowledge and put it in perspective. Our world does have its limits.

The world is ready to welcome us as the next generation of problem solvers. Will we be ready to take that position? With the right passion and mindset, we will be more than ready. Evaluate your position now and prepare for where you would like to be in the coming years. If each of us does that, and is honest with ourselves, then we can look forward to all the success that the world has in store for us.



JOHN DOE, JR.

Blacksburg, VA 24060

OBJECTIVE

I am looking for a company driven to excellent.

EDUCATION

2002- Present Virginia Tech Blacksburg, VA 24060
B.S. in Engineering, expected in the future

AWARDS RECEIVED

• Most deadly player, Halo 2 on Xbox
• 'Last one standing' award, Aye Eta Pi field-party day
• Almost made deans list one semester
• NRA member of the year

WORK EXPERIENCE

June 5 - June 13, 2003 Widget Engineering Townsville, XY
Intern
• Almost passed production-line safety training
• Ensured that all widgets were hexagonal in shape

Summer 2002 Wild Willy's Travelling Circus
Cycling Instructor
• Personally trained mice for cycling races in local circus

INTEREST AND ACTIVITIES

Near-death experiences, video games, beer pong, frisby golf, and prolly some other stuff.