Engineers' Forum

Volume 31 No. 2 April 2011

Why Tubas are Awesome

Bridges to Prosperity in Haiti

Engineering in an Odd Place

APRIL 2011

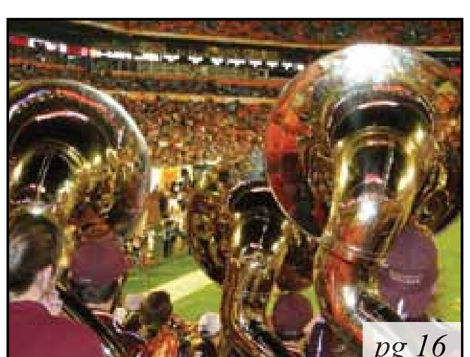
Engineers' Forum

VOLUME 31 NO. 2

INSIDE

Google Earth image of Ti Peligre

Dashboard of the VT-Rex



A few of the 24 VTubas which used their Yamaha horns at the Orange Bowl this past January.

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:

223 Femoyer Hall Virginia Tech
Blacksburg, VA 24061
Phone: 540-231-7738
Email: forum@vt.edu

URL: http://www.ef.org.vt.edu/

FROM THE EDITOR

Dear Readers,

As the spring semester of 2011 winds down, I'd like you to take a minute to think about your passions and how they relate to your major. It's easy to get bogged down in homework and grades and forget about why you chose your major in the first place.

The theme for this, the last issue of the 2010-2011 school year, is the passions that students have relating to engineering. Engineering can be found in unlikely places, like an equestrian track or the inner workings of a tuba. Applications of engineering can reach as far as Haiti, lay the track for a train, or move by way of a hybrid vehicle.

All of these passions and pursuits are connected with Virginia Tech, as well as many other passions students show every day. Engineering is not simply a set of problems to solve on yellow-green engineering paper. It is a way of looking at the world, and there is no better way to explore the world than through the programs here at Virginia Tech.

The Engineers' Forum magazine is one such program. The magazine is completely student-run, so if you think you'd like to get involved, we'd be happy to find a place for you! Maybe you want to see your name in print. Or maybe you'd like to see one of your photographs printed. If you're interested in graphics and design, our layout team is for you! And if you have talent in business, we need a good businessperson. We welcome anyone and everyone; you don't have to be an engineer. The best part? You are paid for your contributions. Send us an email at engineersforumvt@gmail.com. We'd love to work with you.

Our magazine is constantly changing and improving, and we welcome your input. If you have any feedback you'd like to share, changes you'd like to see, or topics you'd like to see covered in the Forum, please email us at forum@vt.edu.

Good luck on exams and have a great summer,

Christina Kazmer

Editor-in-Chief

Bridges to Prosperity *in Haiti*

What were you doing during spring break?

Eating mom's food? Celebrating Mardi Gras in New Orleans? Chilling out with old friends? How about building and inaugurating a bridge in Ti Peligre, Haiti?

Six students from Bridges to Prosperity (B2P), an engineering organization at Virginia Tech, spent their spring breaks inaugurating a bridge that they have been working on for more than a year. Composed of mainly civil engineers, B2P aims to "empower third world communities through foot bridge building, thereby advancing community public works, economic prosperity, and community access to schools, medicine, jobs, and markets."

The bridge project was started by Virginia Tech professor Dr. Bryan Cloyd, who is a sponsor of the elementary school in the village of Ti Peligre. The group of engineers working on this project successfully built a suspended footbridge on the Thomonde River. The inhabitants of Ti Peligre rely on the bridge to cross the Thomonde River to sell their crops in neighboring towns and for access to medical care and higher education.

The project began in 2009 with a feasibility study for the bridge, but the construction of the bridge was postponed until late 2010 after the Haiti earthquake earlier that year. The majority of the bridge construction occurred during Thanksgiving Break 2010 and now the bridge is fully functional and open for public use.

"Our first trip [to Ti Peligre] was during Thanksgiving break 2010," said B2P President Chris Cooke. "It was very engineering-driven. We started by surveying the land with the help of a few graduate students. After excavation, we added column arrangements and concrete sections. We had also worked on several designs and CAD drawings to plan this bridge, so we put those to use. Basically we got a majority of the actual building done."

During their trip to Ti Peligre this spring, the group inaugurated and dedicated the finished bridge, then handed over control and maintenance to the locals.

B2P trips take a very hands-on approach to applying engineering concepts learned in the classroom out in the real world. "Since we're all civil engineers, we put a lot of what we learned in classes like measurements, CAD, and materials to use… we would not have been able to build the bridge if not for our training in all our engineering classes," said Project Manager Nick Mason.

These engineers were not exempt from the challenges of building a bridge in a developing country. "There were several variables we didn't see coming while on the ground," said Mason. "As students, we had never mixed concrete on the ground. But we used the same ratio as we had planned, and we had already tested our mixture in the structures lab. We had four Haitian men helping us, and logistics coordination was also a little challenging. During Thanksgiving break, we ended up staying an extra week in Haiti to finish up our goals for the project."

"The thing that hit me when I got there was their lack of development, and how it affects their everyday lives," said Vice President Tyler Welsh. "[Ti Peligre] was not affected by the Haiti earthquake, but they still have refugees from around the country seeking shelter there."

"But despite all the obstacles, going to Haiti was more fun than we expected," concluded Mason.

During this trip, the group took several measures to make the bridge sustainable. "After the dedication we took a couple days to set up sustainable measures that will help the bridge last up to the designed life-span of 30 years," said Mason. "[We] set up a local bridge committee that will perform maintenance checks and annual bridge inspections after every rainy season. We also performed a socioeconomic survey where we gathered data about the community for a future bridge database."

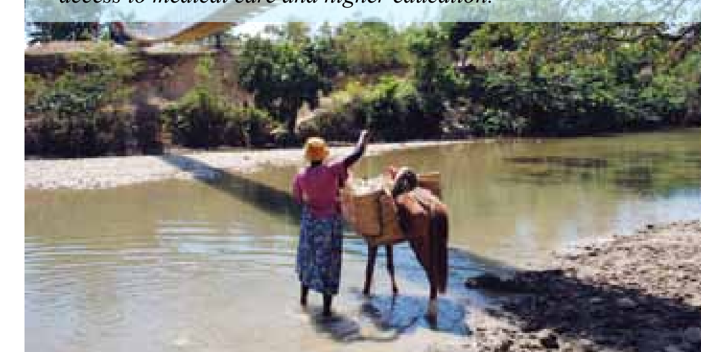
Aside from a truly unique engineering experience, the students also experienced a wonderful and welcoming Haitian community. "The part that most amazed me was the simplicity of their culture," said Cooke. "They're a very tight-knit, relationship-based community. Everyone knows everyone, everyone shakes each other's hand, and they look right into your eye while they are speaking to you. It was wonderful being with people like them."

International trips like this also serve as training for upcoming leaders of B2P. "I was not really involved with B2P until after the design phase was over, but I'm really excited to become more involved, especially with the actual construction of the project," said sophomore Kelsey Brandt, one of the six students that traveled to Ti Peligre. "I look forward to leading this effort in the future."

Building a bridge was not the sole goal of B2P in Ti Peligre. "We also want to build a partnership with another organization, Partners for Health," said Mason. "They helped us ship the cables down for our current bridge, and they will be a good organization to know in the future, since we'll be working in

Most of the construction of the bridge was done during Bridges to Prosperity's trip to Ti Peligre over Thanksgiving break last year.

The inhabitants of Ti Peligre rely on the bridge to cross the Thomonde River to sell their crops in neighboring towns, and for access to medical care and higher education.



This trip was future club leader Kelsey Brandt's first trip with Bridges to Prosperity. "I look forward to leading this effort in the future", she said.

Surveying the site before starting construction.

the same country. We are also hoping to build partnerships within Virginia Tech, especially the Architecture Department, and the Department for Outreach and International Affairs."

Now that the Ti Peligre bridge is finished, B2P is looking for other projects in and around Haiti to work on. "We've been talking with Partners In Health (PIH), one of the largest health care organization in Haiti's central Plateau, and a University Kiskeya in Port-Au-Prince to help us set up this program," said Mason. "PIH has given us some feedback that there is a large need for footbridges in the lower Artibonite region of Haiti. This is a challenging and exciting time for us as we figure out the future of our student chapter and where the next project will be. Whatever happens, we hope to continue with our momentum to make something that will not only bridge rural communities together, but hopefully bridge students from our university to Haiti for a long time."

Aishwarya Venkat is a freshman studying Biological Systems Engineering, and would love to travel to Haiti someday.

Expanding Research to the Nation's Capital

Virginia Tech is expanding its research program to the nation's Capital with the construction of the Virginia Tech Research Center – Arlington, located in Ballston, Virginia. It is scheduled to open this June. This state-of-the-art facility will give Virginia Tech the opportunity to foster corporate research partnerships with the private sector and to be in close proximity with government agencies and various public and private organizations in the Washington, D.C. metropolitan area.

"This new research center plays a significant role in our continuing efforts to establish a major presence in the region for Virginia Tech," said President Steger. "While a broad range of research programs will be housed in the facility, our primary focus is on technology, particularly computational technologies and network systems."

President Steger continued, "As we continue our work as one of the nation's leading research universities, we would be hard pressed to find a better location to consolidate and grow Virginia Tech's local research activities."

Located on 900 North Glebe Road, the Virginia Tech Research Center – Arlington will occupy five floors of the seven-story 144,000 square foot building. The building will consolidate the five Virginia Tech research centers and institutes already established throughout the Northern Virginia area into one building.

The interior of the building, designed by the architectural firm Gensler, will include offices, computational laboratories, and a conference center that is open for use to both Virginia Tech and the Washington, D.C. science and technology community for conducting meetings, symposiums, and other events.

One of the main features of the conference center is a demonstration/visualization room with a 20-foot ultra-high-resolution screen able to present a myriad of information in extensive size and detail. The conference center will also feature a tiered-style executive lecture hall, break-out session rooms, business center, and a divisible multipurpose room.

Saifur Rahman, Director of the Advanced Research, and Joseph Loring, Professor of Electrical and Computer Engineering, believe the new research facility is central to pursuing cutting-edge research initiatives and strengthening Virginia Tech's reputation as a major player in research for the Federal government in the nation's capital.

"A signature research building for Virginia Tech in the National Capital Region builds credibility among our sponsors, showing that we provide a local resource where we can demonstrate advanced applications of our research and discovery," said Saifur Rahman. "In relocating to the new building, the institute expects to continue and expand its core research activities in the areas of energy and the environment, bio-informatics, critical infrastructure protection, information security assurance and cyber physical systems."

Fred Hussain is a Senior in Electrical Engineering.

Engineering in an Odd Place:

A Brief Overview of Horseback Riding

I am fairly certain that when someone mentions "horseback riding," many people automatically picture either a fancy show, with riders decked out in formal, old-fashioned outfits or a high-stakes race somewhere in Kentucky. At first glance, the sport of horseback riding, or more formally equestrianism, has virtually no factors relating to engineering in any way, shape, or form. However, in taking a riding class through the Department of Animal and Poultry Science and riding for the Equestrian team, I can tell firsthand of the many ways equestrianism relates to physics and engineering, both in the show and in the classroom.

Before we get into any of the aspects of design and engineering involved in horse racing, let's first discuss how a horse runs, or its gait. There are multiple gaits which are analogous to walking, jogging, or a full-out sprint. The slowest gait is known as a walk, which is a perfect analogue to its human counterpart. This is a four-beat gait, with all four of the animal's legs moving independently in a specific pattern, landing each foot on the ground one foot at a time. This gait averages a speed of roughly 4 miles per hour.

One speed higher is the trot, similar to a brisk walk and can vary considerably in speed. The average trot, however, has a speed of about 8 miles per hour. A bouncier movement, this follows a two-beat rhythm. The horse's legs will in what is known as a diagonal pair. As the horse's left foreleg moves forward, his right hind leg will likewise move forward, and this rhythm will correspond to the other side on the second beat.

As we move a bit faster, we arrive at what is known as a canter, analogous to a swift jog. This gait ranges in speed from 10 to 17 miles per hour, and we will discuss later how this speed varies from horse to horse. The canter is a bit more complicated to explain as a three-beat gait. For instance, the horse will use the right hind leg to propel himself forward, leaving the left hind and right front leg to catch him after a moment of suspension. He will then stabilize himself on the left front leg before repeating the cycle. If executed properly, this will sound like a drum beating three times in rapid succession.

The gallop, a flat-out sprint, is also a four-beat gait. The fastest gait of all, the gallop averages between 25 and 30 miles per hour, though there have been few racehorses on a quarter-mile stretch that have been clocked at speeds as high as 55 miles per hour! The footfalls of this particular gait form a z-shape, with the left hind leg providing thrust, and then the right hind leg takes off, leaving the horse airborne for a fraction of a second before the left foreleg touches down, followed by the right foreleg.

Note that the speed of each gait is generally referred to by an interval. Horses, like most animals, come in a variety of shapes and sizes. Longer legs, for instance, could lead to a faster trot due to an extended stride. A horse that is more sensitive to his surroundings may be more willing to give his movements a bit more speed, while a more calm one may have a bit of a slower gait. Furthermore, the rider may also have a part in this; a more experienced rider can get a faster trot in more control than could someone who has never been in the saddle before.

The physics of the interaction between the horse and rider play a huge role in 'posting,' or rising up out of the saddle and sitting back down in a regular rhythm while at the trot. There is a certain way in which to time posting such that the rider sits back down in the saddle just as the horse's inside hind leg touches the ground. Known as 'posting on the diagonal,' this provides weight against the leg and, as such, increases forward momentum. Besides improving efficiency, this is one of the factors judges look for when watching a rider during a show.

In addition to the horse-rider pair, some of the more interesting engineering aspects of horseback riding can be found in the show ring or racetrack itself. The Alphin-Stuart Livestock Arena here on campus, for instance, is a $3.02 million state-of-the-art facility (funded largely through donations) featuring two holding areas for horses and other livestock. The facility also includes a 125' by 250' earthen arena and seating for up to 450. This area is utilized not just for the Equestrian Team, but for classes taught by the Department of Animal Science and is also used by the Virginia-Maryland Regional College of Veterinary Medicine.

The dirt arena is designed to best interact with the horses' hooves during any given gait. Given the consistency of the horses' hoof, combined with the metal shoe, dirt provides an ideal surface upon which traction can be maximized, in addition to forward momentum. This makes it much easier for both horse and rider to maintain a consistent speed and good form.

It should also be noted that the rider is just as involved in this partnership as the horse. The rider must work his or her legs constantly in order to generate impulsion, or forward momentum, in addition to assistance with steering. Furthermore, there is a certain posture that must be kept, or else control cannot be properly administered, and an improperly positioned rider can suffer damage to the spine in the long run due to the constant up-and-down motion of the horse.

The equipment used for riding must also be designed to fit a specific purpose. Saddles used in one riding discipline may differ widely from another. English-styled disciplines originally descend directly from the cavalry divisions of old and are designed with less comfort in mind and more of the ability for the horse-rider pair to quickly get from point A to point B. Western saddles, on the other hand, descend from those used out in the Old West and with jobs relating to cattle-herding. This was an endurance saddle, maximized for comfort and durability during long hours spent riding and bringing cattle slowly into the next town for sale. Bridles, the leather assembly worn over the horse's face, provide control in various ways. Some use direct contact with the inside of the horse's mouth, linking directly to the rider's hands, while others use a leverage system to provide maximum response with less pull strength.

At first glance, one may not immediately see a correlation between engineering and horseback riding. However, as an eyewitness to the sport, I can personally attest to using some quick calculations in my head while on horseback to determine forces applied. I will even look and see at the bridle or saddle and piece together how exactly pressure is applied to various areas of the horse. Equestrianism owes much to design and engineering work through the ages.

Travis Roth is a freshman planning to study Mechanical Engineering. He rides for the Hunter Equestrian Team, and has seen both Secretariat *and* Seabiscuit.

Freight and Passenger Rail: Tracks to the Future

After many years of speculation and contemplation, large-scale high-speed rail is finally about to arrive here in the United States. Though Amtrak's current Acela service claims to be the only high-speed rail service in the country, it only reaches its top speed of 150 miles per hour on some stretches of track where specific upgrades are currently in place. The condition of most of the track between Washington, DC and Boston restricts the Acela to a relatively slow average speed of about 70 miles per hour. However, recent developments have revealed that high-speed rail may well be coming to Virginia.

Freight rail has been making enormous profit since deregulation in the early 1980s brought the dead industry back to life. But what killed the great American railroad industry in the first place? Contrary to popular belief, it was not solely the arrival of the interstate and the arrival of affordable airline travel, but over-regulation. Up until the passage of the Staggers Rail Act in 1980, the Interstate Commerce Commission, a leftover from the days of the railroad monopoly, had a stranglehold on how American railroads operated. The railroad companies could not abandon a line without permission or even change service along a particular route without explicit permission from the government.

Continued use of lines made unprofitable by road and air traffic was the primary factor that led to the temporary demise of the American railroad industry. In the late 1960s, railroad companies responded to the crisis of over-regulation by merging amongst themselves. The two largest railroads of the Northeast, the New York Central and the Pennsylvania Railroad, merged into the Penn Central Transportation Company. Although the idea was sound, the implementation was a disaster. Clashing corporate cultures, coupled with incompatible computer systems, led to Penn Central operating essentially as two separate railroads under one name.

The current vision for high-speed rail will bring upgrades to a series of corridors across the nation.

Poorly-maintained track due to lack of maintenance funds led to frequent derailments and wreck. Conditions were so terrible that "standing derailment" became common; the track was so badly maintained railcars would simply fall over while sitting in yards. Penn Central would go bankrupt in the early 1970s, the largest corporate bankruptcy of its time. This lead to the formation of the government-run corporations Conrail and Amtrak. Amtrak continues to operate, overseeing all inter-city passenger rail travel in the United States outside of Alaska. Conrail became privately owned in the late 1980s, bought out by CSX and Norfolk Southern in 1997.

As the situation grew worse and worse, Congress had to act or the American railroads would forever disappear into the history books. The Staggers Rail Act of 1980 largely removed the old ICC regulations, returning the freight rail industry to profitability. Short lines merged into larger companies, forming the current rail giants of Union Pacific (which had already existed since the Civil War), CSX, Norfolk Southern, and the Burlington Northern/Santa Fe. Today the rail industry contributes billions to the economy. Norfolk Southern in particular has particularly ambitious expansion projects to remove trucks from the roads and lessen fuel consumption through rail in the planned Crescent Corridor, providing a more efficient link between the Midwest and the Deep South. The project is predicted to generate thousands of jobs in construction, engineering, management, and other labor. Passenger rail, however, still remains operated under Amtrak, whose only route to report a profit is the busy Northeast Corridor.

Japan virtually invented high-speed rail, with the famous 'bullet trains' beginning operation in 1964. Since then, high-speed rail has become prevalent in Western Europe. The French TGV (*Train a Grande Vitesse* or "High-Speed Train") is one of the fastest trains ever developed. Trains have been demonstrated to run at speeds up to 186 miles per hour, with a tested maximum of 275 miles per hour on long stretches of straight track. New magnetically powered trains that float above their track have been tested up to speeds of 361 miles per hour. Implementation of mass-scale high-speed rail technology in other countries has led to increased mobility and a lessened carbon footprint.

There is currently very real potential for high-speed rail to make an appearance of its own here in the United States. In the stimulus package passed last year, one clause under infrastructural improvement appropriated $8 billion for "intercity rail projects, with priority given to high-speed rail projects" across ten "corridors" that range from California to northern New England. Grants have already been awarded to states for start-up projects, with more money pledged on the way. The Chicago Hub area (Illinois, Michigan, Wisconsin, and Ohio) received the largest portion of the Federal grants, about $2.61 billion for their extensive project plans.

Some lines are expected to be ready for full service by the year 2015, with limited service beginning as soon as 2012. In addition, a private firm known as Desert XPress plans to link Southern California with Las Vegas. The ground-breaking ceremony is scheduled for later this year, with a projected completion date around mid-2014. Here in Virginia, Amtrak has signed an agreement with Norfolk Southern that will bring passenger rail service back to Norfolk, alleviating traffic congestion and providing a swift transportation option running at speeds up to 90 miles per hour between Norfolk and Washington, DC.

Implementing a nation-wide network of high-speed trains would require billions of dollars worth of upgrades and equipment and require cooperation between the public and private sectors. Although the freight rail infrastructure is solid and well-maintained (one of the best in the world), the current setup is inadequate for bringing about the American Bullet Train. Single-line track is in heavy use across the nation, and is efficiently used by the freight rail industry. As such, an entirely new electrified track system is required for service to begin. In addition, only new trains can run on these high-speed tracks.

Though many would argue that the train is a thing of the past, America's population continues to grow, resulting in a corresponding increase in transportation needs. In recent years, the Interstate Highway System and even the many airports across the nation are rapidly becoming overcrowded. In addition, though the price of oil has fallen since its high in 2008, there seem to be few signs, if any, that the price of oil will stabilize in the foreseeable future. High-speed rail systems, working in concert with slower local services, have huge potential to alleviate congestion and provide an environmentally friendly alternative for transportation.

Pair of trains at South Station Boston. Acela Express trains in Boston, on the Northeast Corridor, currently the only line used for high-speed rail in the U.S. Courtesy of Wikipedia.

Imagine the year 2025. The high-speed rail system started by 2009's stimulus package has long since been completed, with additional lines being constructed to connect suburban areas and to directly follow Interstate Highway corridors. A businessman in Washington, DC boards a Japanese-designed, American-built bullet train bound for a meeting in Boston. Traveling at an average speed of about 150 miles per hour, excluding a few short station stops, he reaches Boston in a little more than two hours. His meeting is then just a short walk away from Boston's newly renovated station, and he has avoided every minute of road traffic. He will be home by the late afternoon.

In addition to the benefit of time, the construction of a high-speed rail system would have enormous beneficial impacts on the economy and the environment. The construction itself will generate thousands of jobs in labor and engineering. The use of high-speed rail networks will alleviate congestion on the highways and airlines, resulting in a smaller carbon footprint. It seems now, more so than ever, that the iron horse is no longer a thing of the past. They're coming back faster, cleaner, and stronger than ever before.

Travis Roth is a self-proclaimed train freak planning to study Mechanical Engineering to work with the railroads. Yes, he has seen Unstoppable.

An overview of HEVT

Virginia Tech's Hybrid Electric Vehicle Team (HEVT) is competing in a nationwide competition called EcoCAR: The NeXt Challenge Advanced Vehicle Technology Competition. Composed of 16 engineering schools across the country, the goal is to maximize the fuel economy of a vehicle by adopting advanced battery technologies.

The Virginia Tech vehicle, nicknamed VT-REX, is a Saturn Vue hybrid sport-utility vehicle. It was donated by General Motors and operates on E85 ethanol gasoline. A centralized battery allows the vehicle for to travel for an extended range on electricity in order to maximize fuel economy.

The team is led by Dr. Doug Nelson, a Professor in the Department of Mechanical Engineering, who has been the faculty advisor for the HEVT program since 1995. Graduate students and Team Leaders Jesse Alley, Lynn Gantt, and Patrick Walsh also play an integral role in HEVT leadership.

Based on his three years of experience with the EcoCAR Challenge, Team Leader Gantt stressed the importance of having a successful design strategy executed by the team leaders within the first year. Laying a solid foundation is important competiveness within the remaining years of a multi-year competition, Gantt believes.

"The selections that the team makes is absolutely critical to the teams in the future finishing out whatever challenges [they face in future competitions]. All the work has to be done up front, if they make bad selections in year one, it just trickles down through [subsequent] years of competition solely putting you [and your entire team] in a disadvantage," Gantt said.

The HEVT team will continue to work on VT-Rex up until June, when full-scale testing alongside the 15 other competing schools will be conducted. The team will continue to make any repairs and improvements to the vehicle to ensure the vehicle is prepared.

Any undergraduate students interested in working with HEVT, either as a volunteer or as an independent study, can visit the HEVT website at: www.me.vt.edu/hevt/ for more information.

Fred Hussain is a senior in Electrical Engineering and wishes the car was auctioned to him for personal use.

Illustration by Wei Hann


The VTubas performing at the Virginia Tech Homecoming Parade this past Football season

Why Tubas Are Awesome

Instruments come in many shapes and sizes, from a piccolo that you could fit in your pocket to an organ the size of a house. They can be blown into, banged on, strummed, bowed, and programmed. Generally there are four types of instruments: winds, stings, percussion, and electronic. Winds can be broken down into two kinds, woodwinds and brass. Brass can then be broken down into upper and lower brass, depending on how high or low pitched the notes of the instrument are. Low brass can be broken down into several instruments including trombones, baritones, and tubas. Tubas then can then be either marching sousaphones, or the standard concert design. They might be in different keys, be made of different materials, have different designs and mechanics. There are countless types of tubas, just as with every kind of instrument. Only a few things remain consistent: they're big, heavy, loud, and really fun to play!

Tubas first appeared around the 19th century, and have been awesome ever since. John Phillip Sousa, a famous marching band composer, commissioned the creation of the sousaphone in the 1890s. Sousaphones are much easier to carry, and allow their users to march, play, and most importantly dance the Hokie Pokie. All tubas were originally made out of sheet metal, usually yellow or silver, but recently sousaphones have been being made out of fiberglass: a material far more light and durable, though at the cost of sound quality.

The Marching Virginians tuba section, the VTubas, use two sorts of horns, practice horns and show horns. The practice horns, now about 20% tape, strings, and rust, were made by a variety of manufacturers, but the shiny new show horns the 24 VTubas get to take to football games were made by Yamaha, a popular manufacturer for many kinds of Instruments (as well as motorcycles).

The manufacturing of tubas and sousaphones is the same as for most brass instruments. The basic concepts are the same for those of any object created out of sheet metal. There are three important steps to creating the tuba: Making the bell, the body, and the protective coating.

The Bell:

The bell is the most important part of a tuba. Whether you see it in the back of a stage in an auditorium or pointed at you from the 50 yard line on a football field, it's easily the coolest looking part of this amazing instrument.

It's formed first by bending a piece of sheet metal into what's called a "preliminary bell." It starts as a brass disk with a hole in the center, which is then formed around a bell shaped object to give it the proper shape- this part is called "the bell flare". Then the rest of the bell, the larger conical section leading to the flair, is formed by folding over a piece of sheet metal into a tube which is then put through a process called "brazing" which melts the two sides of the metal together. The metal is then hammered into the proper shape, put through pressure roller to get rid of the dents, and the two pieces are brazen together.

Once the pieces are joined the edges are sanded down to get rid of any the sharp edges. Finally the bell is shaped and molded, creating a perfected shape which goes through more sanding and the edges on the top of the bell are folded over, giving it a more 'finished' look while also reinforcing its structure.

The Body:

The body is made out of many small tubes, each of which are differently shaped, and have to be formed into one large piece. The tubes have to be properly made, and must not have any leaks or holes. Leaks and holes will dampen or damage the sound, not to mention the fact they'll make the tuba look bad. So the question is, how do they do it for so many sorts of shapes?

Tubes of metal are first filled with molten pitch, which then solidifies and protects the insides of the piping. The pipes are then bent into shape with the cooled pitch inside, preventing them from collapsing. The pitch is then melted out, and the pipes are then molded to their proper shapes which may be either conical or cylindrical. Conical pipes are molded into their proper shape with a device called a hydraulic blowout press, which puts the pipes in the mold and then shoots pressurized oil through the tube, forcing it to fill the mold. Cylindrical pipes have steel balls pushed through them, which beat out any deformations in the tube where it's too narrow.

All the tubes are then fit together, starting from the valve casings outward. Many U shaped parts are connected together, so workers use 'connecting rings' to cover the gaps. These connecting rings are soldered together, holding the majority of the casing together. Once that is all built the valve pistons and the movable tuning slides are inserted, creating the almost finished product.

The Finish:

Lacquer and plating make the tuba shiny, a feature that should not be underestimated in importance (they also protect the metal from tarnish and decay, which is probably important to). These features are applied to each individual pipe before they are assembled into the body of the tuba. It's all then polished, buffed, and engraved, completing the most important of all instruments: The tuba.

Daniel "Rapunzel" Bishop has been playing the tuba for six years and dances the Hokie Pokie at the end of the third quarter.

The Engineers' Forum Staff

Daniel "Rapunzel" Bishop, Pranav Angara- Webmaster, Fred Hussain - Writer
Christina Kazmer- Editor-in-chief, Travis Roth - Writer, Sarah Tanner - Layout
Not pictured: Sumedha Mohan - Managing Editor, Andrew Mussey - Chief Photographer, Wei Hann - Layout, Jeff Craley - Copy Editor, Katie Gloe - Writer, Allan Kirchhoff - Writer, Lynn Nystrom -Editorial Adviser

Interested in joining the Engineers' Forum? We're recruiting!

Three reasons to join the EF:

1) You get paid!
2) You gain useful skills and experience that employers value
3) Oh yeah... It's fun too!

No need to be an engineer - we welcome all majors! If any of our positions interest you, email **forum@vt.edu** or visit our website (**ef.org.vt.edu**) for more information! In particular, we are looking for:

Writers - The backbone of the magazine, writing is a great way to explore exciting topics while getting your work published

Graphic Artists - Magazines require more than verbage. This job could entail creating graphics for articles, photography post-production, contributing to layout, or decorating the website.