engineers' FORUM

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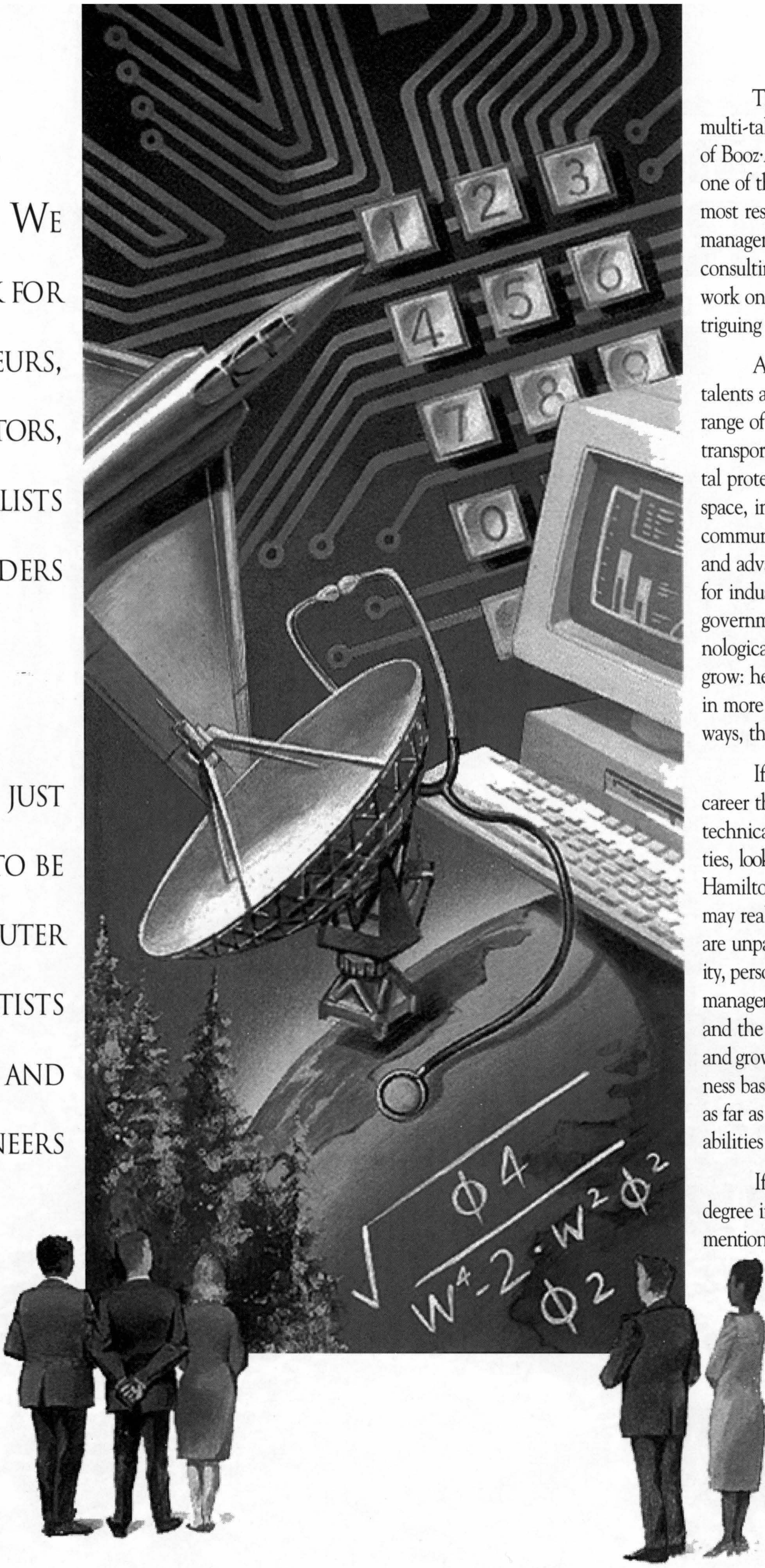

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EDITORIAL

Engineering a new image

Engineering students are traditionally apathetic. Is that true this year at Virginia Tech?

Everyone knows the engineering stereotype: Nerdy people who keep there noses stuck in a book and their pens stuck in a pocket protector. This has been a problem; major university policies were being passed but engineers were not involved.

Last year the Honor Court worked with the Student Engineers' Council (SEC) through the fall semester to get engineering students on the Court. At the end of the semester there were still no representatives from the College of Engineering.

The Student Government Association (SGA) is made up of the House of Representatives and the Senate. The Senate assigns seats proportional to the number of students in a particular college. There are 17 engineering seats in the Senate; only seven were filled last year.

This apathetic situation may look depressing, but a new trend is emerging. Engineering students are accepting more leadership roles and are getting involved in more organizations.

Kevin LeClaire, an industrial systems engineering student, is the student representative on the Board of Visitors. Scott Cappiello, a graduate of computer engineering, won the 1994 Man of the Year. This year the 17 engineering slots in the Senate are filled. Seventeen engineering students are involved in the Honor Court and two are associate justices. Inside the college, the SEC General Assembly attendance averages double last year's.

In the College of Engineering, this year will be remembered for the first annual Leadership Conference. The SEC invited several international companies to give presentations. Students also participated in workshops which involved them in group dynamics, exercised their innovative thinking skills, and taught them how to approach career decisions. The day gave engineers a chance to learn about leadership and teamwork. But there was another outcome; it got students motivated.

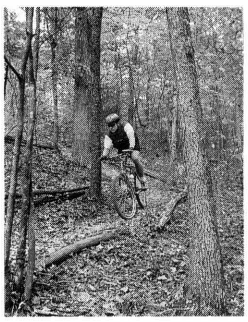
This motivation is exemplified in the Presidents' Roundtable, a council comprised of the presidents and leaders from every student engineering organization. In past years the Presidents' Roundtable was a simple informational meeting once a month.

This year, the meetings have evolved into a forum. The rows of chairs are turned into a circle, and members discuss issues concerning their societies. They work as a group to brainstorm and spark new ideas.

Engineering students are traditionally thought of as apathetic. At Virginia Tech the trend is changing. More engineering students are competing for leadership positions in the College and the University, and new, exciting things are happening. The students are engineering a new image.

Michael J. Reese

Mike Reese
Editor-in-Chief



ON THE COVER

Brush Mountain is a popular spot for biking enthusiasts. As the sport grows, mountain bikes are evolving, featuring new styles and new materials. Photo by Lisa Traub

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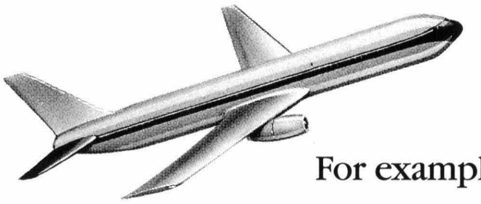

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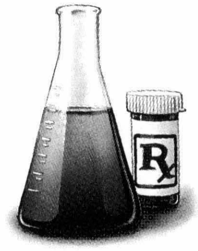

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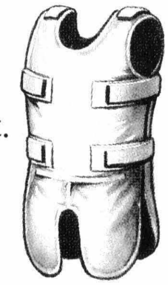

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COVER STORY

Mountain Biking:
Beyond Brush Mountain

by Scott Walters

> *There is a lot more to mountain biking than throwing together some parts from an old 10-speed or BMX bike. The art of constructing a mountain bike has become a highly-advanced process, utilizing the cutting edge of materials technology.*

It is a cool fall afternoon on the campus of Virginia Tech. Classes are over and many students are returning to their dorms and apartments. Some, however, grab their mountain bikes and head to the popular trails of nearby Brush Mountain. The rugged terrain of Southwest Virginia provides bikers with some of the best riding on the East Coast.

Students are drawn to mountain biking for different reasons. Some wish to enjoy the peace of the outdoors. Others just need a place to blow off some college stress, while others seem to be addicted to the natural rush of mountain biking. Whatever their reason to ride, all share in the fun and enjoyment of biking.

Mountain biking is a purely American invention. During the mid-'70s the first mountain bikes cruised down the trails of California. These early phat-tire machines were built by a new breed of bike enthusiasts. The bikes were built out of old used cruiser frames and motorcycle parts. They were heavy and awkward to ride, but their creators had started a new movement.

In the early '80s, mountain biking began to catch on with the masses. Overseas manufacturing allowed companies to produce affordable bikes. Many companies emerged just to cater to the mountain bike scene. Bike designs improved significantly. New materials made the bikes lighter and stronger. Better designs made the bikes perform better. This improvement process continues today and the interest in mountain biking is steadily growing.

The multitude of mountain bikes on the market can leave a buyer spellbound over which one to choose. Bikes come in various price ranges and are made of many different materials. Riders have to decide which model is the best for them. The most important aspect of the purchase is the bicycle frame. While componentry (brakes, cranks, wheels, derailleurs, etc.) can easily be upgraded or replaced, the frame should last for many years.

A variety of materials are used in mountain bike frame building. Each posess certain characteristics, such as strength, durability, and stiffness. Frame builders and bike riders all have their own opinions as to what is the best material. Dr. Ronald Landgraf of Virginia Tech's Engineering Science and Mechanics (ESM) Department believes that any material can be used as long as the frame has a good design.

STEEL

Steel is by far the most popular frame material. Its properties and traits have provided it with a long cycling heritage. Steel is relatively inexpensive, strong, durable, and easy to work with. According to Dr. Landgraf, steel is three times as strong as aluminum, three times as stiff, but three times as heavy. Bike frames are generally made of two types of steel: High tensile and chromolybium (cromoly for short). Both are alloys of pure steel. Cromoly has more alloys which result in a stronger steel. Less can be used in the frame, hence a lighter bike. High-tensile steel is found in less-expensive bikes. As the cost increases, so does the amount of cromoly.

A common practice in full cromoly frames is to use butted tubing. Butting is the process of tapering and adjusting the interior wall diameters of the tube, while the exterior wall diameter remains the same. The idea is to remove material from areas where it is not needed and keep it where it is needed. The wall diameter in the middle is thinner where less material is needed. Significant weight reductions can be achieved through this process.

The butting must be done immediately after the tubes are drawn. A mandrill is inserted into the tubes to adjust the internal diameter of the tubing. Single-, double-, triple-, and quad-butted tubing are all used in cromoly frames. Single-butted tubes have one taper at one end.

COVER STORY

Double-butted tubing has tapering at both ends. Triple-butting is similar to double-butting except the interior wall thickness of the two thicker end sections differs. Quad-butting is the same as triple-butting, but the thin middle section has a gradual taper throughout its span. Frame builders can customize the ride quality of steel frames by mixing the variety of butted tubing.

Steel frames can be built by two methods: Brazing and welding. Brazing is the more traditional form of steel frame building. In the last few years, however, it has fallen out of the mountain bike scene. The basic process entails using lugs or fixtures to join the tubes at their junctures. The tubes and lugs are then silver-brazed together at relatively low temperature. Brazing has proven to be a very strong joining method, plus the process is fairly easy. Because the joints are reinforced by the lugs, thinner tubing can be used. This results in a lighter frame. The one major drawback to lug construction is that it has to be done by hand, which increases the price. The tubes can also be directly brazed together without lugs. This process is know as fillet brazing. It is a very time consuming and expensive process, but the joints are among the most beautiful found on any frame. Tig-welding is the most popular form of steel construction. Because the process can be performed by robots, the price of these frames are very low. Improved designs and techniques have allowed these frames to be just as strong as brazed frames. The use of butted tubing has allowed them to be as light as well.

Professional race bikes are the proving or testing ground for new frame materials and designs. John Tomac's new full suspension race bike, pictured above, was recently displayed at the Philadelphia Interbike.

21st Century ride: Mountain bikers might be pedaling a concept bike like the one shown below in the future.

Photos: Scott Walters

ALUMINUM

Aluminum is generally regarded as the next step up from steel. Popularized by a few road bike deviants during the '70s and '80s, aluminum has found a happy home in mountain biking. Aluminum frames cost more, but significantly reduce weight. Aluminum also has the advantage of being corrosion resistant. Unlike steel, every spot of chipped paint will not rust. A common myth about aluminum frames is that the frames are very stiff and will beat a rider up. There is some truth in this myth, but it is mainly based on earlier frames.

Aluminum is not as strong as steel so more of it must be used in the frame to achieve similar strength. More material results in a stiffer frame. As companies have gotten better at designing aluminum frames they have been able to reduce this stiffness. Internal tapering (similar to butting) and overall design have contributed to the reduction. Aluminum tubing comes in aircraft grade and a variety of private manufacturing grades. The aircraft grade has a number of types, but 7075-T6 and 6061-T6 seem to be the most popular for frames. 7075-T6 is the stronger of the two.

Aluminum frames can be constructed in two ways: Welded or lugged construction. Tig-welding seems to be the norm for aluminum frames. Almost all companies use large diameter tubing. With oversized tubes, thinner interior wall diameters can be used. Lighter weights can be achieved without compensation in strength or stiffness. What differs between the companies is whether or not they grind off the welds. By grinding them off, weight can be reduced and frame can be given the appearance of a fillet-brazed steel frame. The downside is that strength is compensated. Companies that choose to leave the joints usually weld them in what is know as a fishscale pattern. In addition, some manufacturers choose to add gussets to the joints. This increases the strength but also adds weight.

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Biking

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The other method, lugged construction, is less popular than tig-welding aluminum. Here, aluminum tubes are bonded to aluminum lugs with special types of adhesives. The big advantage is that these frames are fairly inexpensive.

A new breakthrough in aluminum frame construction is the use of metal matrix. Here fibrous materials are added to the aluminum tubes when they are drawn. The result is a stronger and stiffer metal. Less material can be used in the frame and lighter weights can be achieved. Also, less material would yield less stiffness. Aluminum frames could be built that are not so hard on the rider.

TITANIUM

The past few years have seen an increase in the popularity of titanium in bike frames. Its light weight traits and strength is far superior to other metal frame materials. On the downside, it costs almost twice as much as other frame materials. The main reason for this is that titanium is very hard to work with and weld. It needs a very specific welding environment and a very skilled welder.

Titanium comes in two frame grades: 3Al 5V and 6Al 4V. These numbers represent the percentage of aluminum (Al) and vanadium (V) alloyed with titanium. According to Dr. Landgraf, both grades are good choices for frame building. In order to make the high cost worth it to the customer, the manufacturer makes titanium frames as light as possible. They can do this because of titanium's high strength. By using less material in the frame, extremely low weights can be achieved. Less material also equates to less stiffness. Titanium bikes generally have a springy feel to them. A few titanium bike companies have recently perfected the process of butting titanium tubes. Supposedly, this process improves the ride quality of titanium. Currently, the tubing is extremely expensive and only available in a few specific frames. In the years to come, this process will most likely become the norm for titanium frames.

CARBON FIBER

Carbon fiber has been used in bike frames for many years, but not until recently has the material made an impact on the industry. The older carbon fiber models were not designed well and often failed. Companies have spent many years redesigning, and current models have had much better success.The price has also dropped significantly.

The multitude of mountain bikes on the market can leave a buyer spellbound over which one to choose. Bikes come in various price ranges and are made of many different materials. Riders have to decide which model is the best for them.

Carbon fiber is a very unique material for frames. The fibers must be molded into the appropriate shapes. It is up to the company how the fibers are to be layered and arranged. This gives carbon fiber frames the ability to be extremely strong and lightweight. Plus, the custom arrangement of the material allows for a myriad of ride characteristics to be programmed into the frame.

Frames made of carbon fiber can be built three ways: Metal lugs and carbon tubes, carbon lugs and carbon tubes, and full one piece carbon. In the first method, aluminum or titanium lugs are bonded to carbon fiber tubes. This is the traditional method. These are also the same frames with the problems. Many of the bonded tubes were pulling apart from the lugs. Better adhesives and new designs have eliminated these problems.

The second and third methods are similar only in that the finished frames appear to look very similar. The second method bonds carbon fiber lugs to carbon tubes, while the third method generates a one-piece carbon fiber frame. The lugs are formed in molds and the tubes are wrapped. They are then bonded together. By painting and sanding the joints the manufacturer can give the frame the appearance of being seamless. The overall cost of this process is relatively low.

The third method of construction achieves the one-piece design that the lug design only mimics. Carbon fiber is layered into a full-frame mold. A lightweight foam is injected, inflating the carbon fiber and filling the mold. The frame then is allowed to cure. The lugs used in the second method are manufactured in a similar method. The molds and equipment necessary for full-frame molding are very expensive. For this reason the carbon tube/carbon lug frames are more popular.

Carbon fiber has the advantages of weight, strength, and ride characteristics. It does have disadvantages. According to Dr. Landgraf, carbon fiber is a very temperamental material. A nick or gouge in the fiber can greatly reduce the strength, possibly leading to frame failure. Paints and special protective coatings have reduced this possibility.

A few years ago, titanium and carbon fiber were the new experimental materials for frames. Now they are mainstream and just as common as steel and aluminum. New materials have entered the arena to take their place. Metal matrix and thermoplastics seem to be the new materials. Companies are currently experiment with these materials. Some are producing prototypes and production bikes. Eventually, these new materials will also become mainstream, as the constantly evolving sport of mountain biking moves forward. EF

Hybrid electric vehicle: **Project Neon**

by David Asbell

Last spring, Virginia Tech became one of 12 schools from the United States and Canada to receive the opportunity to modify a Dodge Neon to run on electricity. A group of ten senior mechanical engineering design students received a request from Dr. Walter O'Brien, head of the Mechanical Engineering Department, to submit a proposal for the conversion of a gasoline-powered vehicle to a hybrid electric vehicle (HEV).

An HEV is a vehicle that is powered by electricity and some alternate power source, such as compressed natural gas. The proposal was from the National Renewable Energy Laboratory and called for the conversion of a 1995 Dodge Neon. These students accepted the challenge and submitted their proposal, detailing their design for the conversion, during spring break in March, 1994.

More than 30 proposals were submitted by universities from the United States and Canada. These proposals were judged by the Society of Automotive Engineers, the Chrysler Corporation, and the Department of Energy. Twelve of the proposals were selected as the best and these schools received a 1995 Dodge Neon for conversion. The schools with the 12 winning proposals were: Univ. of Michigan, Univ. of Connecticut, Florida, Texas A & M, Texas Tech, Univ. of Texas, Concordia, Univ. of Tennessee, Univ. of

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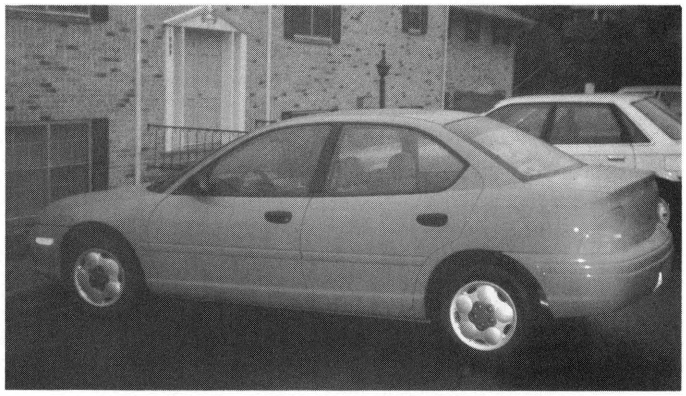
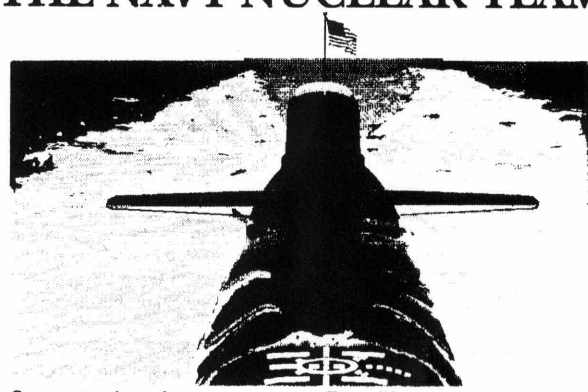


Photo: Dave Asbell

The Dodge Neon the VT design team is working on may be the solution to zero emission vehicles.



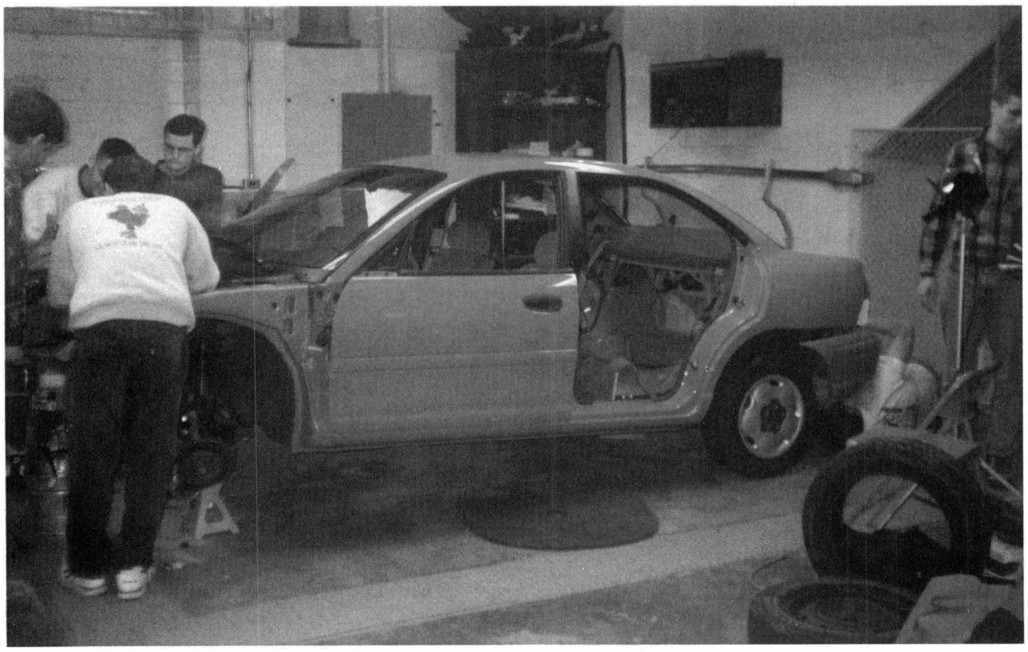


Photo: Dave Asbell

The Neon design project team gets hands-on experience.

Neon

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Illinois-Chicago, Western Washington, and Univ. of British Columbia and Virginia Tech.

Each of these schools are now building their design for the 1995 Hybrid Electric Vehicle Challenge. The 1995 competition will be the third year for the competition. The HEV Challenge is a competition sponsored by the Department of Energy to develop ideas for alternatively-powered vehicles for the future. The first year of competition was in 1993, and consisted of Ford Escorts and "ground-ups." "Ground-ups" are hybrid electric vehicles totally designed and built by individual schools. The Ford Escorts were new car conversions as are the current project for Dodge Neons. The second year of competition involved the conversion of new Saturns and Ford Escorts.

The cars are built or converted from their original state for the first year of competition. After the first competition, the cars are redesigned and improved for competition the next year. The different classes compete separately in the competition each year. The schools compete for two years in the competition, with the possibility of this becoming an ongoing yearly competition, to allow for improvements in the designs. If more than two years of competition are not allowed, then the cars will become useful tools in the research of alternatively-powered vehicles to be produced in the future.

Virginia Tech is now in the process of designing and converting of a 1995 Dodge Neon for the 1995 HEV Challenge. This is being done by a large group of mechanical engineering design students and electrical engineering students, as well as volunteers from other majors. This group has become known as the Hybrid Car Team of Virginia Tech and has become one of the ongoing senior design projects for mechanical engineering students at Tech and is a recognized student organization.

Because there are only two years of competition for the cars at this time, future proposals may be needed to make this a continuous project. The next available year for a proposal by Virginia Tech will be for the 1997 competition. Because of this new competition, universities from the entire country are coming up with and improving designs for what may be the vehicle of the not-so-distant future. EF

Society Information List

(current information as of October 12, 1994)

ACerS, American Ceramic Society
Elections: Late March
President: Jennifer Roeder 951-1721
Vice-President: Eric Wilkins
Advisor: Dr. Jesse Brown 231-6677
SEC Rep: Matt Schaft 232-1224

AIAA, American Institute of Aeronautics and Astronautics
Elections: Early April
President: Matt Sexstone 552-7102
Vice-President: Jessica Wilt 951-2435
Advisor: Dr. Fredrick Lutze 231-6409
SEC Reps: Rich Lange 951-4978; Keith Ferguson 552-8186

AIChE, American Institute of Chemical Engineers
Elections: Late March
President: Don Hearl 951-8230
Vice-President: Kim Anderson 951-1536
Advisor: Dr. David Cox 231-6829
SEC Reps: Mike Keesey 953-5547; Brian Lockhart 552-7852

APM, Alpha Pi Mu (Industrial)
Elections: Mid February
Office: 209 Femoyer 231-7832
President: Amy Levis 232-5096
Vice-President: Aaron Bangor 232-6417
Advisor: Dr. Robert Dryden 231-6656

ANS, American Nuclear Society
Elections: Early April
President: Brandon Fallon 951-7463
Vice-President: Craig Marcuson 552-3806
Advisor: Dr. Charles Reinholtz 231-7820
SEC Rep: Harry Brown 552-0409

ASAE, American Society of Agricultural Engineers
Elections: Mid April
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Vice-President: Craig Thomas 951-9197
Advisor: Mary Leigh Wolfe
SEC Reps: Angela Carter 232-5707; Tina Jeoh 961-5120

AE, Alpha Epsilon (Agricultural)
Elections: Late April
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Vice-President: Jim Kern 953-0568
Advisor: Dr. Lori Marsh 231-6815
SEC Rep: Angela Carter 232-5707

ASCE, American Society of Civil Engineers
Elections: Mid March
Office: 214 Patton 231-5833
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ASEE, American Society of Engineering Education
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Vice-President: Julie Prince 951-1348
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ASME, American Society of Mechanical Engineers
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Advisor: Dr. Charles Reinholtz 231-7820
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ASSE, American Society of Safety Engineers
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Advisor: Dr. Dennis Price 231-5635

BMS, Burkhart Mining Society
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BMES, Biomedical Engineering Society
Elections: Early March
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Vice-President: Sneha Patel 961-2663
Advisor: Dr. Wallace Grant 231-4573

XE, Chi Epsilon (Civil)
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Vice-President: Mike Buriok
Advisor: Dr. Mike Vorster 231-5009
SEC Reps: Brian Frey 552-1783

HKN, Eta Kappa Nu (Electrical)
Elections: Early April
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Vice-President: Paul Viani 961-5215
Advisor: Dr. Ted Rappaport 231-8229
SEC Rep: Dong Luong 232-3284

Forum, Engineers' Forum
Elections: Late March
Office: 108 Femoyer 231-7738
Editors: John Cole 951-8229; Mike Reese 951-8229
Treasurer: Justin Wirman 552-2263
Advisor: Lynn "Mama" Nystrom 231-6641
SEC Reps: Jon Phishman 951-8229; Suzi Greenburg 951-8229

HFES, Human Factors Ergonomics Society
Elections: Mid December
President: Vicki Lewis 951-7739
Vice-President: Greg Micheal

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Societies

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Advisor: Dr. Bob Williges 231-6270

IEEE, Institute of Electrical and Electronic Engineers
Elections: Mid February
President: David Moye 552-9038
Vice-Presidents: David Pinkert 951-8084; Jason Martin 951-4145
Advisor: Dr. C. Lindner 231-4580
SEC Reps: Roger Skidmore 951-7044; Melanie Tible 552-1168

IIE, Institute of Industrial Engineers
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Vice-President: Kevin Rooney 953-3433
Advisor: Dr. Jeffrey Woldstad 231-4972
SEC Reps: Mike Cole 951-3264; Ami Patel 961-6521

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Vice-President: Jennifer Adams 953-1422
Advisor: Dr. Aicha Elshabini-Riad 231-3362
SEC Reps: Paul Schindler 951-0246; Melanie Tible 552-1168

NSBE, National Society of Black Engineers
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SEC Rep: Lawanda Chisolm 232-2252

NSPE, National Society of Professional Engineers
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Advisor: Dr. Daniel Ludwig 231-6555
SEC Reps: Terry Bush 232-4392; Maggie Becker 961-5228

OXE, Omega Chi Epsilon (Chemical)
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Vice-President: Andy Woerner 552-8258
Advisor: Dr. William Conger 231-6631
SEC Reps: Lale Gokbudak 232-2353

OSA, Optical Society of America (Electrical)
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Vice-President: David Stonehouse 552-6924
Advisor: Dr. T.C. Poon 231-4876
SEC Rep: Ryan Bosley 953-0529

ORSA, Operations Research Society of America
Elections: Late September
President: Rich Cassady 552-4183
Advisor: Dr. Joel Nachlos 231-5357

PSAE, Professional Society of Asian Engineers
Currently disbanded with no advisor.

PTS, Pi Tau Sigma (Mechanical)
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SEC Rep: Keith Wilson 951-8992

SAE, Society of Automotive Engineers
Elections: Late March
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Vice-President: John Sadler
Advisor: Dr. Allen Cornhauser 231-7064
SEC Reps: Tim Richardson 552-8106; Jodi Farrell 552-9795

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Advisor: Capt. Kessinger 231-4804
SEC Reps: Matt Danza 232-2697; Marty Armentrout 232-2697

SAMPE, Society for the Advancement of Material Processing Engineering
Elections: Early March
President: Marty Swan 552-6290
Vice-President: Jeanne Hampton 951-1721
Advisor: Dr. Ron Kander 231-3178
SEC Reps: Rob Becker 552-5110; Michael Craven 232-3069

SEC, Student Engineers' Council
Elections: Mid March
Office: 110 Femoyer 231-6036
Fax Number: 333 Norris 231-3031
President: Lynn Henderson 232-6905
Vice-President: Luke Harris 953-3135
Advisor: Lynn Nystrom 231-6641

SES, Society of Engineering Science
Elections: Late April
President: Brian Gero 552-6459
Vice-President: Bill Wittmer 951-2275
Advisor: Dr. Mohamd Hajj 231-4190
SEC Reps: Linsay Cheng 951-3207; Melissa Zarn 232-3975

SGT, Sigma Gamma Tau (Aerospace)
Elections: Mid April
President: Anne Valdivia 953-1075
Advisor: Dr. Frederick Lutze 231-6409

SME, Society of Manufacturing Engineers
Elections: Late March
President: Gene Jackson 951-7280
Vice-President: Pete Emon 552-7191
Advisor: Dr. O.K. Eyada 231-6978
SEC Reps: Scott Wheeler 951-5051; Brian Lux 951-5203

SNAME, Society of Naval Architects and Marine Engineers
Elections: Late April
President: Tom Treakle 55204161
Vice-President: Dave Pogorzelski 961-5036
Advisor: Dr. Wayne Neu 231-7061
SEC Reps: Brent Cannaday 951-2926; Jim Benzing 951-0085; Brian Hill 552-1788

SOEE, Society of Environmental Engineers
President: Duane Osborne 953-2478
Vice-President: Bernadette Basham 552-5022
Advisor: Dr. John Little 231-8737
SEC Rep: Mike Nunley 381-1927

SWE, Society of Women Engineers
Elections: Late April
Office: PAB Building 231-6869
President: Andrea Campbell 552-4427
Vice-President: Teresa Odendhal 552-7463
Advisor: Dr. Andrea Dietrich 231-5773
SEC Reps: Janna Unterzuber 232-3589; Jennifer Maschner

Triangle, Triangle Fraternity
Elections: Late March
President: Eric Kuchinski 552-9253
Vice-President: Paul Guy 961-5407
Advisor: Dr. Hugh Munson 231-9548
SEC Reps: Lee Goodall 232-4896; Eric Yarrow

TBP, Tau Beta Pi
Elections: Mid March
Office: 126 PACK Building 231-6869
President: Scott Gregg 552-0324
Vice-President: Julie McCormick 552-9075
Advisor: Dr. Hayden Griffin 231-6643
SEC Rep: John Datovech 961-0513
Open House: Tom Leitch 951-9783; John Datovech 961-0513

The Nautilus Project: *An exercise in cooperation*

Engineers are working with the Nautilus Corporation to improve a popular product

by Jackie W. Arnett, Jr.

A group of students and faculty here at Virginia Tech are developing a beneficial relationship with the Nautilus Corporation. An ongoing project between the two institutions yielded immediate successes and the future looks bright as analysis and new ideas continue to blossom.

The group consists of 14 undergraduate and graduate students under the guidance of Dr. Reinholtz, professor of Mechanical Engineering. After attending a number of their weekly progress meetings, it is evident that divisions between undergraduate, graduate, and faculty are nonexistent. "Everyone is treated equal," boasts member Paul Tidwell. Dr. Reinholtz reinforces this attitude by stating that each member of the Nautilus project has their own unique strength and that when all of these contributions are tallied, the problem-solving ability of the group is very powerful.

The group successfully met the challenges presented to them by the Nautilus staff. They worked on the replacement of cam configurations with linkages. The cam and linkage synthesis techniques used along with powerful computer modeling software produced advancements in the fitness machines manufactured by Nautilus. Last year's crowning achievement was the modification of a Nautilus rowing machine used by the Washington Redskins at their training camp in Carlisle, Pennsylvania. It received rave reviews from players and coaches.

This year's group is busy once again gathering information to create a better, more efficient product. They are also testing fabric strength and analyzing strength curves. The students have full autonomy in this process and are receiving a great deal of practical, real-world experience. Each student agrees to take responsibility for different phases of the project. Not only are they gaining great experience, but most are also receiving technical elective or senior project credit.

Field work is also an important aspect of the design team. They plan in the future

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FEATURE

My Summer Vacation

This Tech student talks about applying her major in the beautiful state of Wyoming.

by Robyn McGuckin

Wyoming — The last frontier of vast open spaces, the Rocky Mountains, grizzlies, rattlesnakes, cowboys, horses, rodeos, and good frontier fun! As an engineer in soil and water resources in the Biological Systems Engineering Department (formerly Agricultural Engineering), I spent most of the spring semester setting up an independent study in the Big Horn Basin of Wyoming. I planned to design and install an irrigation system and implement some land and water conservation practices on the ranch my mom had just bought for breeding and training horses. Before committing, I carefully considered my options — stay and work in Virginia or go out to Wyoming and play in the Rocky Mountains. So, being the dutiful daughter and avid pursuer of knowledge, the choice was clear.

First, to prepare for the independent study, I searched for someone in my field in Wyoming with whom I could do volunteer work in exchange for supervision on my project. The Soil Conservation Service (SCS) has a volunteer program called "Project Earth Team" for which volunteers work on local conservation projects. What could be more appropriate? I also started doing research on the climate, soil type, irrigation systems, and land management problems in the Big Horn Basin.

Summer finally rolled around and it was time to play! Mom and I loaded up the trailer, shipped the horses, and set off on the three-and-a-half day drive to Wyoming.

A large part of Wyoming is in the Great Plains area; driving across it is like driving through nothing. Literally you see nothing, even though your line of sight is about 20 or 30 miles in any direction. It is all flat and desert-like — sage brush, sage brush, cactus, sage brush... Then we reached the Rocky Mountains — beautiful, breathtaking scenery. Finally, we scaled the last pass and entered the Big Horn Basin, the last place in the continental U.S. to be settled. It's approximately 200 miles long, 90 miles wide, and surrounded by mountains with only a few navigable passes. This region is the home of Buffalo Bill and his Wild West Circus; the mountains of this area are where Chief Joseph and his Nez Pierce warriors held off the U.S. Cavalry on their famous Appaloosa horses as the rest of the tribe fled for the Canadian border; the western-most reaches of the basin border Yellowstone Park and have many pools of sulfuric hot springs.

This is an excerpt from a letter I wrote to one of my friends shortly after our arrival:

I'm looking forward to some free time (once we get settled) to go trail riding in the mountains. The country is so beautiful and OPEN, you can see forever here. We're in an immense valley called the Big Horn Basin, surrounded by near and distant mountains. The sky is usually a deep turquoise blue, with almost every cloud formation imaginable (and then

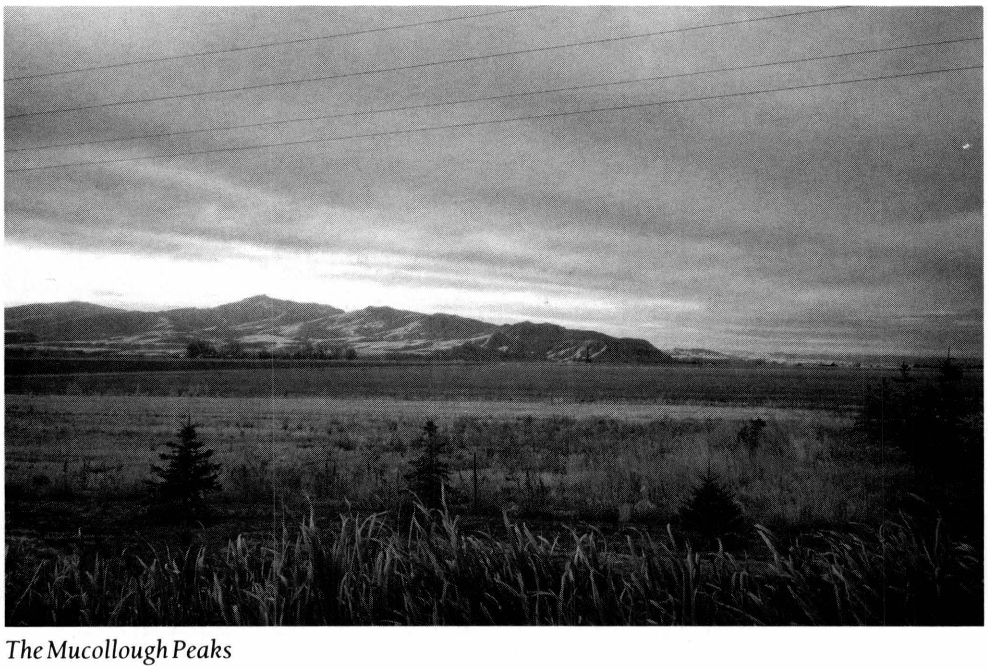


Photo: Robyn McGuckin

The Mucollough Peaks

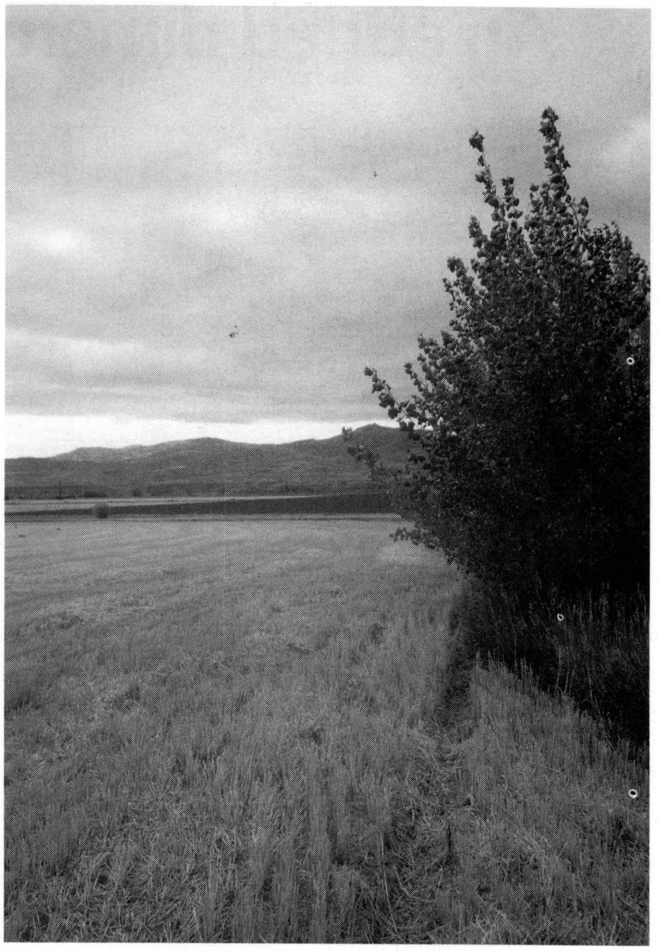
some) displayed at intervals throughout the day. The result is a sometimes breathtaking display of light and dark on the nearby Mucollough Peaks, which are a many folded range with alternating red and white sandstone stripes and an occasional patch of light brown/green vegetation. My Mom's farm is set in an immense valley of flat fields and benches. The parts that have been cultivated are a rich green, the parts that have not are a dun yellow/brown spotted with sage brush and the occasional clump of prairie grass. The only trees are those that farmers have planted around their houses, some have begun to spread along creek beads, but overall they are few and far between. The distant mountains are still snow covered, one of the ranges is called the "Bear Tooths," true American grammar at work! It sets the atmosphere for the area though: nobody really worries too much about anything, if you're an hour or two or three late it's no big deal. Hart Mountain is nearest to us, we're actually supposed to be on it, but looking out the window it seems at least 10 miles off.

It is all flat and desert-like—sage brush, sage brush, cactus, sage brush...

The Big Horn Basin was originally a desert; the annual precipitation is six to ten inches. The only substantial water supply comes from an incredible system of canals and channels run and maintained by a conglomerate of irrigation districts. All of the water comes from snow accumulation in the surrounding mountains; the runoff is routed into the Buffalo Bill Reservoir which supplies the entire basin. Any failure in this system, or low accumulation during the winter and spring months, spells a threat of disaster for farmers and ranchers throughout the area.

The Cody SCS covers a large part of the basin, with land types varying from urban areas to farm and grazing land to rangeland. The farm and range lands are the main concern. This summer, most of our time was taken up with the design and funding of irrigation systems, spring developments, and livestock watering systems. Everyone's main concern this summer was how bad the drought was, and whether or not it was getting worse. I also got a non-educational perspective on several issues: the environment from the aspects of farming/sediment runoff, rangeland overgrazing and runoff problems, wildlife management/endangered species, and the reintroduction of the grizzly and wolf. Meanwhile, I tried to design our own irrigation system.

I must admit, despite all the classes, reading, calculations, and diagrams, it was mostly trial and error. Actually, it was mostly error at first. I am the type of person who hates to look at the directions, "I can figure it out, no problem." But after you have busted a couple of pipes, you tend to think before you construct.



Looking across the fields of the Big Horn Basin.

Photo: Robyn McGuckin

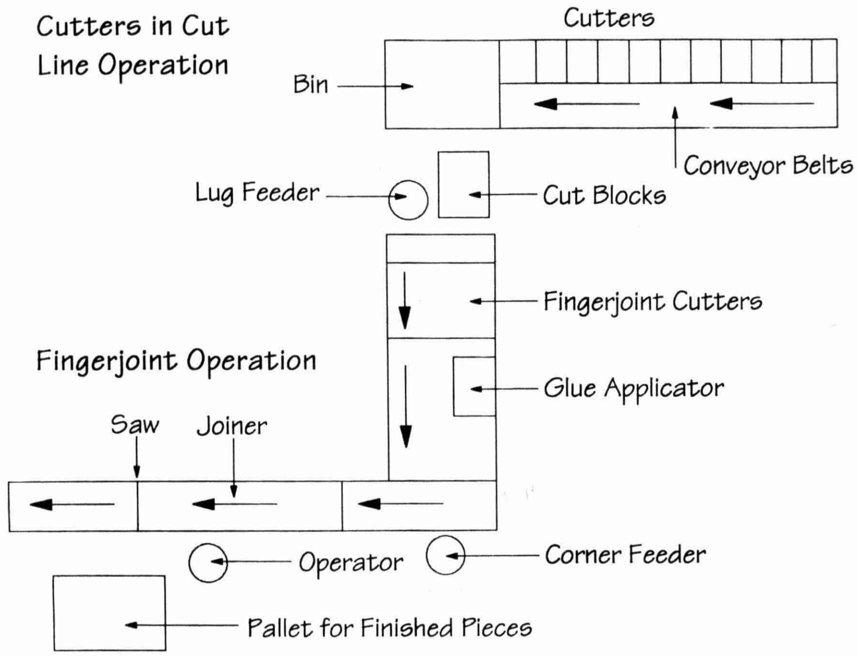
So I went back to the drawing board, literally, and started to do just that. Of course I had left all of my most useful texts at home, and brought all of the heaviest, useless, verbose ones "... to find the flow friction coefficient typical of this angle, take the triple integral of these 10 empirically determined variables." I learned when designing something, go back to the basics and work your way up from there. Also, even though it may work in theory, that does not mean that it will in practice. Be it unforeseen factors, obstructions, wildlife, old or faulty equipment, or even new, state of the art equipment, the field applications are never as problem-free as they are taught.

I did, however, get a working system going, and it is still working after two months without my constant monitoring and fixing. I wanted to get the horse fields seeded and irrigated so that next spring we would have good pasture grass coming in. I managed to design the system, but the actual implementation will require an additional head gate put onto the existing irrigation ditch; this lets water in at the most efficient location on the property. This is a process which is very costly and time consuming and must be closely monitored by the local irrigation district.

The summer was a great success. I put in over 102 hours of volunteer work at the SCS, and built an irrigation system that supports over three acres of orchard, lawn and garden. I also designed a system to irrigate our horse pastures which will, with a small miracle and a lot of money, go in next spring. With SCS I had the opportunity to experience first hand the land management practices of an arid region, the intense use of irrigation systems, and how crucial they are to any human habitation. EF

An added dimension in design projects

While senior projects in other departments may offer hands on design experience, the senior projects in the Industrial & Systems Engineering Department offer real life work experience.



A representation of the assembly line at Marley Wood Products.

Artwork courtesy of: Jennifer Frazier, Janet Bischof, Martha Christie, Diane Christie

by John Cole

The culmination of an engineering education at Virginia Tech is the senior design project. Each department places its own unique stamp on the senior design project, ranging from the nationwide Aerospace design contests to the construction of actual cars, which also compete nationally.

However, the Industrial and Systems Engineering (ISE) Department offers design projects that are unique and extremely rewarding. Students actually get out into industry, tackling industrial engineering problems posed by a company. "It is an excellent opportunity for the students because of the real world experience they get," commented Dr. J. William Schmidt. Schmidt is in charge of the senior design projects in ISE as a whole and secures projects from most of the participating companies. More often than not, the students' solutions to companies' problems are actually implemented. The projects also often lead to employment opportunities for students with their project company.

The senior design project is the capstone of the ISE coursework. It is a two semester course that spans all of the senior year. In the first semester, students form groups of three to four people and they pick projects on a lottery basis. The rest of the first semester consists of communication between companies and students, preparation of project proposals, and initiation of work on the projects. The ISE Department works with companies scattered all around the state, and also with companies located in neighboring states such as West Virginia and North Carolina.

In the fall of 1993, Jennifer Frazier, Janet Bischof, Martha Christie, and Diana Christie were assigned to work on a project with Marley Wood Products (a division of Marley Mouldings, Inc.) in Marion, Va. The plant makes wood moulding pieces for retail and industrial markets. Their fabrication process involves taking the wood from its raw form to the final product of the proper shape of moulding. Along the way, the strips run through an assembly line type process where imperfections and knots are cut out of the wood, leaving smaller sections. The smaller sections are then joined together to form the properly-sized pieces to be marketed.

The original goal of the project was to look at the assembly line process to determine where gains in productivity could be made. However, the group branched out and ended up incorporating a wide range of the different aspects of industrial engineering in their final solution. "It was a good project because it combined such areas as human factors, work methods, and even a little manufacturing," commented Frazier. The group was able to work within their own interests in focusing on the human factors problems associated with the process, in addition to getting experience in work methods and manufacturing. The end result of the project included the incorporation all of these aspects into a plan for more efficient operation of the company.

They started out the whole process by developing Gantt charts. Gantt charts are used to establish a timetable for achievement of goals. The human factors aspect of the project consisted of surveying a group of the workers concerning on-the-job injuries, along with an ergonomic analysis of stations along the assembly line. This work was aimed at eliminating such work-related injuries as Carpal Tunnel Syndrome and other repetitive motion injuries. The final report included recommended changes aimed at areas with unnecessary heavy lifting and repetitive movements by workers. They also focused on steps to make the work environment safer and easier to work in, such as facilitating the use of previously-used safety goggles and recommending anti-fatigue mats for the workers to stand on.

To focus on their productivity analysis, they performed time studies on one of the assembly line processes, finding wasted time in the existing process. There was also wood being wasted in the existing cutting process. They took their data from the amount of lost time and wasted wood and converted it into dollar equivalencies that the company was losing because of their inefficient operation.

One of their solutions included rearranging the assembly line process to premark wood before it is fed to a cutter. This saves time and wasted wood at the cutting end of the process. Another solution was to automate the cutting process. It was discovered that previously, some of the process was automated, but automation was discontinued due to an inability to perform machine maintenance. The calculated savings by reverting back to automation were substantial.

The end result of the project was that the human factors recommendations were implemented almost immediately. The company now employs an industrial engineer, whereas before there had been none, and they have also been actively looking at the recommended solution of automating the cutting process.

Three of the four students have gone on to industrial engineering jobs and the fourth is a graduate student in human factors here at Virginia Tech. Frazier summed up her experience with the project as "one that taught me a lot about time management and organization, especially on the large scale of managing a large project."

The experiences gained and the lessons learned by this project team have been experienced by many of the senior industrial engineering students of the last few years. There are numerous other projects that have been just as successful in implementing change in a major company.

In 1992/1993, the team of Chris Fawcett, Ron Honaker, Rahul Parikh, and James Williams used simulation to aid in successfully designing the third assembly line which was implemented at the Corning Plant in Christiansburg.

In, 1991/1992, a team of students designed a production line for Hubble Lighting in Christiansburg which was chosen for implementation over a production line Hubble had designed.

Projects for this year include work with such well-known companies as Yokohama Tire and AT&T Microelectronics. If past projects are any indication, both the students and the companies should have a lot to look for at the end of the spring semester.

Nautilus

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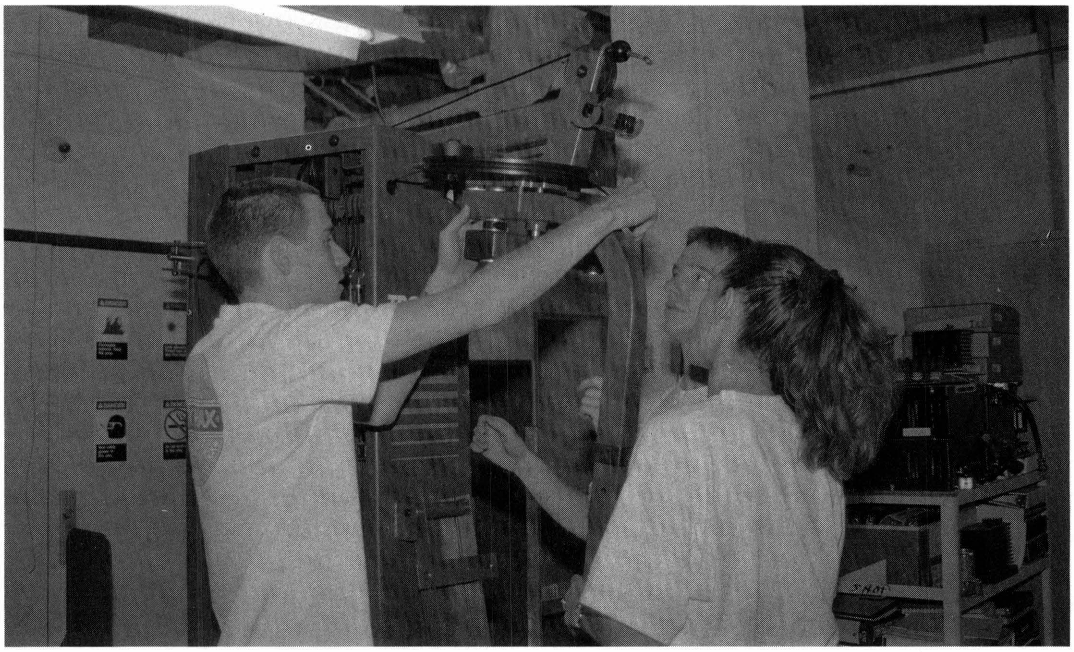


Photo: Lisa Traub

ME students work on the Nautilus Project.

to go to an area fitness club and actually take data on their equipment which they can then compare to the data taken in the robotics lab. Also, the group recently toured the Nautilus facility located in Independence, Virginia. This gave the team an opportunity to talk with the designers and see first-hand their ideas being brought to reality. The Nautilus staff was pleased with the work done and was impressed with the ideas and solutions given to them by the design team.

Students on the Nautilus design team also spent time making phone calls and talking to peers to get an overall opinion on the types of exercise equipment on the market. Tests conducted researched how well the equipment accommodates people of all sizes and strength levels.

Also, detailed analysis of Nautilus' competition is being conducted and this information will be of great use to the Nautilus staff, especially as they prepare to enter the home fitness market.

A symbiotic relationship indeed exists between Virginia Tech and the Nautilus company.

Opportunities such as this are unique in that all are encouraged to participate and contribute regardless of their ability. Many students at other institutions believe that you must be a graduate student before making any substantial contributions on a design team. That does not hold here at Virginia Tech where student involvement is a part of the everyday curriculum. Even those who do not join a design team get a taste of the real world in their senior design classes where small groups have the opportunity to brainstorm solutions and present those ideas in both writing and in oral presentations.

A symbiotic relationship indeed exists between Virginia Tech and the Nautilus company. Students and faculty on the design team receive valuable experience and the personal gratification that they made a difference. Nautilus benefits from a group of professionals working on their behalf to better their product. EF

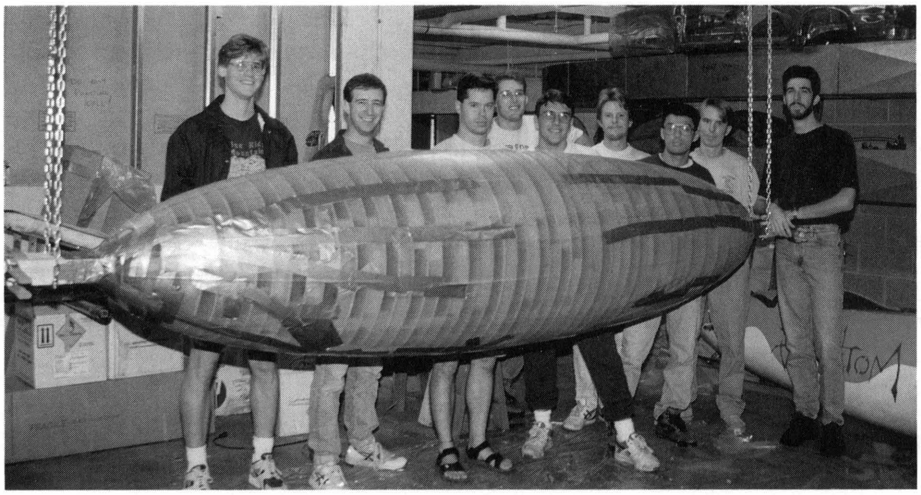
Mission: Submergible

The next generation VT Phantom crew takes the challenge

by Michelle Romanoski

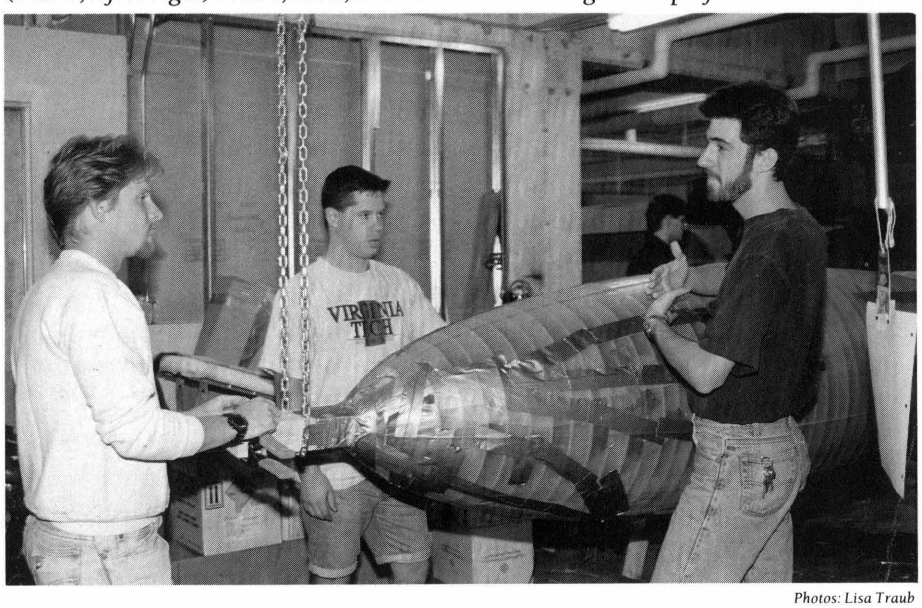
The rocky inner regions of the Appalachian Mountains is the last place one would expect to find a submarine. But those who are willing to search will find one in Virginia Tech's ESM Special Projects Lab. Sponsored jointly by the departments of Engineering Science and Mechanics and Ocean Engineering, the project is a submarine: The VT Phantom. It is currently being redesigned and rebuilt for the Fourth International Submarine Races in June 1995.

The original Phantom was developed for the Third International Submarine Races sponsored by the Perry Foundation. The requirements for the race were that the sub had to be a free-flooding, human-powered, two-person vehicle. The race was judged on cost-effectiveness, innovation and speed. An award for innovation award led the original VT Phantom crew to design their sub with a front-mounted propeller. Unfortunately, a crack in the buoyancy tank prevented the sub from placing in the last submarine races. Some of the original features were transferred over to the new design while many mistakes were phased out.



(Above, left to right) The VT Phantom crew: Bill Wittmer, Steve Dunn, David Breede, Richard Ward, Brian Cooke, Blaire Russell, Carl Penski, Eric Tensicthoff, Scott Wieczorek.

(Below, left to right) Blaire, Scott, and David discuss design concepts for the VT Phantom.



Photos: Lisa Traub

The sub is raced with a navigator and a propulsor. The navigator uses the control systems to guide the orientation of the submarine while the propulsor is the sole power source. Because muscle power is the only available propulsion, speed is gained primarily through increased efficiency in sub design. To further that goal, the current design is slimmer and sleeker than that of its predecessor. Furthermore, the front-mounted propeller has been replaced by a rear counter-rotating propeller. For the most part, all of the major subsystems have been redesigned.

The hull, originally a blunt-nosed torpedo shape, has been transformed into a perfect ellipsoid. Through CAD design, the locations for boundary layer trips must now be found. The trips cause the flow of water around the sub to alter from laminar to turbulent to delay separation from the fluid stream and reduce drag. The hull itself is to be constructed from a light foam core material and will be nearly seamless.

The transmission system that turns the propeller has also been redesigned. It was discovered that the original system, which used a bicycle pedal system, caused a great deal of drag on the legs of the propulsor. The bicycle system has been replaced with a linear drive that works similarly to a cross-country ski exercise machine. The drag on the legs is reduced thus allowing the propulsor to focus more energy into the

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Sub

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drive system.

The next major systems under construction are the control systems, buoyancy and life support. Control systems control the orientation of the submarine in the water. These are the main responsibility of the navigator during the race. Ballast systems are added after the submarine hull is complete and are tested in a water environment. Life support consists mainly of scuba gear; because of this, the team is going through scuba certification.

Testing the submarine can prove to be difficult for a land-bound university. As the nearest ocean is over 300 kilometers away, testing must be done in the swimming pool located on campus. This causes several separate problems. First, the lubricant that works throughout the drive system is harmful to the pool's filtering system. In order to maintain the privilege of using the pool, the construction team must clean away all oil within the systems. Because of this, the performance in the pool is not the same as it would be in an oceanic environment.

Subsequent wear and tear on the submarine parts is a prime result of testing without lubrication. This limits the number of times analysis can be made on the Phantom while underwater before actual ocean submersion. A second problem arises from the navigator's inexperience with ocean movement. The calm swimming pool on campus is hardly adequate training for the motion of the Atlantic Ocean. Another problem with being land-bound is the buoyancy difference between the ocean and the swimming pool. The goal for the Phantom crew is a neutral buoyancy vehicle so that little propulsion has to be focused toward placement in the water after initial correction.

When it comes time to run the race, there are final factors that can destroy even the best submarine. First, things break; the major problem for the previous VT Phantom was a buoyancy tank crack at the competition. Most designs are similar, so every design trick counts. The more efficient the sub is, the better it will work. Because it is a man-powered vehicle, everything counts. If the schedule is maintained, the Phantom may even be ocean-tested before the competition, thus giving the Phantom a better chance of rising to the top. EF

The Army Ant Project

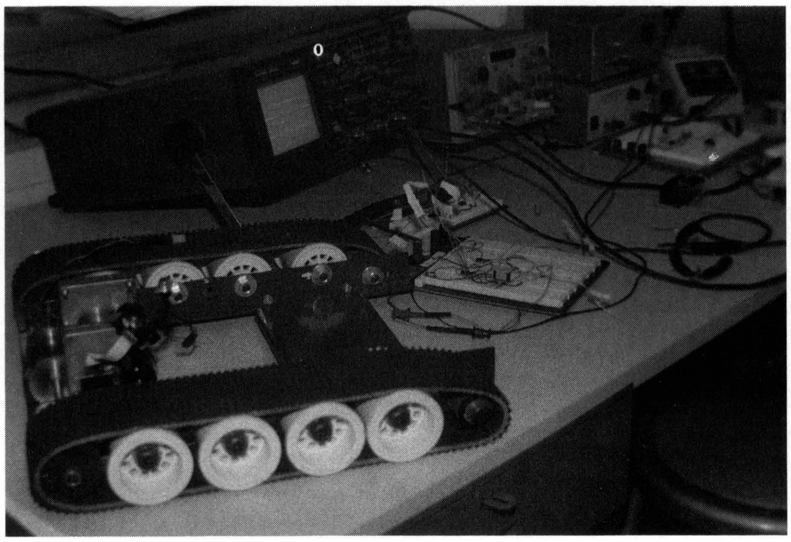
Students at Tech work on a project to revolutionize robotics.

by Nathan M. Phillips

The ability to achieve group coordination from many different robotic units has recently become an intense area of research. Here at Virginia Tech, the electrical, mechanical, and computer engineering disciplines have concentrated efforts in detailed robot design and development. One project, known throughout the college community as "Army Ants," has received national interest for working, low-cost, sensor-oriented robots that have the potential to perform a job with a team of similar machines.

The first-generation army ant was completed in 1992. This robot was used only to prove that low-cost robots could perform certain tasks, and that with more duplicate members the tasks would become progressively easier to accomplish. It was decided that the simple act of lifting and moving an object would be a sufficient test. A small, plastic, remote-control robot was built to show that a pneumatic lift/ball-and-screw mechanism could raise a significant amount of weight, and could be operated to move that weight to a new location if given the correct information. This attracted attention to the army ant project, resulting in articles in both the *Richmond Times-Dispatch* and *Popular Mechanics* magazine.

Dr. John Bay became the first electrical engineering robotics professor at Virginia Tech in 1989. After starting up interest among undergraduates, he began teaching senior level classes; this year, Dr. Bay has begun planning graduate level robotics classes for interested engineering students. With a new undergraduate lab, donated robots from Martin Marietta and Delco Electronics, and student interest in research projects, Dr. Bay helped the army ant project get started. Funding has come from the National Science Foundation, the Office of Naval Research, and the Naval Research Laboratory.



A look at the future: An army ant prototype.

Photo: Lisa Traub

Seven students make up the Army Ant Research Group (AARG) this year: Paul Johnson and Cem Unsal (Ph.D. students), Doug Gaff (Masters), and project design leader Bill Schnieder, Veronica Gauss, Navneet Gosal, and Troy Hille (undergraduates). Their teamwork and dedication has helped the second generation army ant move closer to completion, and has provided a different out-of-class learning environment.

The army ant robot is only about 18 inches long and one foot wide, yet it can lift over 100 pounds. Most lifting robots today must use an arm mechanism to pick up an object, but the army ant simply angles the platform on its back and pushes itself under a heavy object. This allows it to support the entire weight on its body, instead of trying to counterbalance the weight lifted by an arm.

The actual raising of the object is a little more complicated. The first generation army ant simply had an air compressor blow up a balloon, thus lifting a box enough to carry it across a room. The second generation, still being built, will use screw motors and a scissor drive system to lift its platform. This idea gives the army ant control over the angle it is carrying an object, and the ability to raise and lower the platform easily. This becomes important when the robots travel over uneven ground, or when one fails to work properly and the others must compensate. The platform and most of the body is steel, with five all-terrain wheels on each side. The scissor lift system will also be steel so it can be strong enough to support and raise excessive weight.

One of the most im-portant design constraints for the army ant project is cost: The design team has a self-imposed limit of $2000 for the entire unit. Since a lot of this had to go to the metal frame, motors, communications, and sensor systems, there was not much left for the control and computational hardware.

The army ant has two major control systems: one deals with programmed responses to specific data from the sensors and communications, while the other con-

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Ant

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trols the motor and lift in response to angle and pressure readings. The motor control system is used to coordinate and move with other units. An MC68HC11 Motorolla micro-controller takes in all of the information, and reacts accordingly. It must decide if the information received is relevant — for example, if one unit broadcasts that it needs help to move the next crate, and the closest robot is already moving something else, it must know not to answer the call until it has completed its original task. Filtering out pertinent information, deciding where to go next and how fast to go, and knowing when to find help are all determined by the micro-controller.

One of the unique things about the army ant robot is that there are no physically unique units — all of the robots are exactly the same. Most "group-coordinated" robot projects are actually one superior robot leading several inferior models; the major drawback to this is if the centralized intelligence fails, there is nothing to take over that role. It stops the entire operation, and often costs a company tens of thousands of dollars to repair or replace. With the army ant, if any one component fails, another robot could take over the role.

The idea of communication between individual robots is a little misleading — the army ants will report over broad-band radio that they need assistance, have found the next task objective, and possibly report speed or other coordinating information. It is the job of each unit receiving the information to decide if they need to know it. Broadcasting all of the information removes the identity of other units — it will not be necessary to know who the others are on your specific task, or where other robots are at any given time. The range of communication would also be small — probably within a 50-yard radius. This idea of "distributed intelligence" makes the army ant project unique in the field of robotics.

The sensors give all of the basic environment information for performing a task effectively. An infra-red detector is used to find a beacon allowing the army ants to determine which task to perform next, or where to place a carried object, etc. An ultrasonic pulse has been suggested as well, to find range and avoid obstacles. This would be necessary if an internal map is not included or if the environment could change. Since the army ant technology has been suggested for un-known or dangerous sur-roundings, ul-tra-sonic sen-sors will likely be included with the army ant prototype. Finally, capacitive proximity sensors may be included for research and collecting more detailed information.

Photo: Lisa Traub

Army Ant design team: Bill Schnieder, Navneet Gosal, Paul Johnson, Cem Unsal, Doug Gaff, Veronica Gauss, Troy Hille.

The Army Ant Research Group needed a working robot model to test their sensor ideas. "Curly" filled that role; this robot was purchased for $8000 as a test platform. Originally controlled remotely, a program was connected to give Curly free movement during tests, using information collected from experimental sensors. Using this method, the infra-red beacon and detector now works, and is ready for inclusion in the army ant prototype. The ultrasonic sensors were just completed on October 20th, and it is expected that all of the sensors will be interfaced and final debugging of the computing core will be completed by the end of this semester. Next semester's students will likely concentrate on the lifting mechanics, and continue to work with coordinating the efforts of many army ant robots.

Probably the most challenging aspect of the army ant project is the coordination of several duplicate robots, with no specific leader or superior robot. All of the robots are built to work with as many or as few others as necessary to get a job done. This level of adaptability, and the ability to add more units to better perform a given task is one of the strengths of this technology. Instead of having to buy a whole new robotic force to improve efficiency, or pay to repair or replace a damaged robot, a company could merely buy more of these inexpensive units. The ability to scale up or down the work force, and getting the individuals to act as a single unit to perform a task, is a major obstacle.

Dan Stilwell, a previous student working on this problem, wrote a C program to get the army ants to work together. Now, once all of the robots have reached a crate, they will to know how to move it most efficiently, where to take it, and how fast to move the crate. Paul Johnson, one of the PhD students working with the team, has expanded the program to include lifting and keeping the pallet from becoming uneven, terrain factors, and what to do if an army ant fails or loses touch with the crate. He also had to get the robots to lower the crate to actually finish the job, which went against the original programming that kept the crate level.

Paul Johnson's thesis for his master's degree, "Cooperative Control of Autonomous Mobile Robot Collectives In Payload Transportation," details his work with the army ant program. Once the robots have all gone under and lifted an object, whichever robot is in front serves as a guide. This army ant points itself in the direction of an infra-red beacon and begins lifting the pallet. All of the robots are equipped with inclinometers and force detectors, thus when the pallet moves the others react to it. As the angle increases, the other robots compensate until an appropriate height is reached. If at any time a robot loses touch with the pallet (if the two end robots act before the middle one, for instance), the army ant automatically raises its platform until it contacts the pallet. When the front unit begins moving towards the beacon, the other robots will sense the direction and speed, adjusting accordingly.

Since the army ant technology has been suggested for unknown or dangerous surroundings, ultrasonic sensors will likely be included with the army ant prototype.

Another feature of Johnson's program is that all of the army ants broadcast the amount of force they are supporting from the platform. Each will calculate an estimated average force to determine if they are within a certain "dead zone." This is necessary to keep them all working equally, within a reasonable margin of error for different locations and uneven distribution of mass from the pallet. If any problems arise, such as potholes or a rough surface, the next front-most army ant could guide towards the beacon. Also, other units could be called in if several are damaged or destroyed.

Coordinating movement while carrying the pallet was solved by giving the army ants 360 degree rotation — they would all turn left, rather than circling around and having the outer ones move faster, etc. To lower the pallet the front unit simply begins lowering, and to react to his movement the others would lower their platforms as well; thus the entire operation requires no direct communication, and only one broadcast to bring the task to completion.

It is obvious that such units could be used in several different applications. The example of warehousing or transporting crates could be expanded to loading a cargo plane or transport ship. Inexpensive robots with the ability to work together would be highly useful in such fields as mining, surveying, search and rescue, handling hazardous materials, mine sweeping, underwater or planetary exploration, or even multi-satellite coordination. Adaptability and simplicity are two of the guiding considerations with the army ant project, as well as keeping the size small and components inexpensive. Minimizing communication, preparation for changing environments, and recognizing the chances for inaccurate sensor data are all major goals of the army ant design team. The army ant prototype may be completed as early as next May; in the near future, Virginia Tech could determine how robots will be viewed and used in all aspects of life.

The Army Ant Research Group has a World Wide Web page, which can be accessed through Mosaic at http://armyant.ee.vt.edu/armyant-project.htm/. This includes additional information, pictures, related technical papers, and soon will have a movie of the first generation army ant. Cem Unsal, one the most helpful contacts in the Research Group, has his thesis on "Spacial Self-Organization" in the army ant directory, under /unsal WWW/ user-unsal.html1. EF

Invasion: Robot Dreams and

by Rich Parish

Having arrived on Earth, Celone is prepared to take the final steps to destroy the human race, while the few remaining people are forming emotional bonds and slowly becoming a force to be reckoned with.

Celone walked around the city, marveling at how well-preserved it looked. "You know, Mathan, this looks just like one of the exhibits at the Northgate Corporate Museum of Ancient History back home. You know what I'm talking about? I mean, just look at those cars..."

"They must have cleared out the city of all the dead bodies."

"Of course, if they hadn't this place would stink right now. And the last thing we need to do is tax our olfactory nerves."

"I'm surprised we're even able to breathe the air here. It must be similar to our manufactured air."

"Hey, have you been able to get in touch with Ria yet? I've tried but she's not been available."

"Yeah, Celone, I managed to get through to her a couple of hours ago. Turns out she's on that new shipment arriving in a couple of weeks. Wanted to come out and visit. I don't know, I think she wanted to try and make a holiday out of this with you."

Celone laughed, "Yeah, that sounds like Ria all right. She'll be here in two weeks?"

"That's right." Mathan pulled a folder out of his briefcase and opened it to the only page. "According to the Chief's report, the shipment will be arriving in two weeks and one day at 11:30 a.m. Earth time."

"Good. My new on-site quarters will be ready by then. But I don't think Hendou knows of her coming."

Celone and Mathan walked over to a park bench and sat down.

"Why don't you start eating your meal. I have a call to make." Celone pulled out his Vidiphone 380-P, the latest in portable video communications. He pressed the button marked 'DIAL' then said "H371034" and waited.

"Connection established!" enthused the portable vidiphone. "Enjoy your call!"

"Hendou? This is Celone. I have a favor to ask of you."

"Sure. What do you need, sir?" replied Hendou.

"Well, it turns out my companion is going to be here in a couple of weeks. Could you make sure my on-site quarters will accommodate her as well?"

"It will take a couple of days, sir, but it won't be a problem."

"Good. That's all I need. Oh, and there will be a bonus for you for the extra trouble."

"That's not necessary, sir —" Hendou started.

"Yes it is. It's not your job to cater to me, so if you're going to do just that, then I should at least repay you."

"But sir —"

"You know me, Hendou. When I have my mind set on something I won't take 'no' for an answer."

"Well, okay then. But please don't try to do that to me again. I like being able to help people out; I don't need or expect to get rewarded for it."

"I'll keep that in mind. I'll check in on the progress sometime tomorrow."

"Okay, goodbye, sir."

"Goodbye."

The vidiphone screen blanked out. "Thank you for placing your call with the Remote Communications Network. If you have any questions, comments or complaints —" Celone pushed the off button and put the phone away.

"I wish she wasn't coming here," was all Celone had to say to Mathan.

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Forrest backed out of the hole in the trunk of the tree. "We can probably climb up through the inside of the tree easier. It looks like the cavity goes over halfway up, and it lets out right above a large branch. Then we can climb to the top from there."

"But will it be high enough?" Alexandra asked.

"Once we get all the way to the top it will be. And it's a sunny day so we'll get even more visibility." Forrest entered into the dark hole and started scaling up the inner wall of the tree. He got halfway up the hole, then looked down to check on his companions progress. "Alexandra?"

"Yeah. I'm still here," came her voice from outside the tree.

"Aren't you going to come up?"

"Well, I thought since you were already going I could keep watch down here instead. You never know when a crazed logger is going to come by with a saw," Alexandra laughed.

"But then you'd get killed."

"Really...well..."

Soon Forrest heard her scuttling up after him, and he then continued himself. "Don't worry. It's not hard at all. There are handles the whole way up."

Alexandra quickly caught up and the two of them went out the hole onto the limb. "Wow. We're already pretty high up."

"Yeah, but look to the top. We can make it the whole way up no problem."

The two of them climbed up through the branches and leaves and reached the top. They looked around in awe for several minutes, but then Alexandra chose to speak.

"All the other animals are still alive; but the place still looks so dead. Nothing moving on the roads. No lights on in the buildings. It's amazing. And you can see for miles. What's that big silver thing over there?" Alexandra asked, pointing towards the river they had come from.

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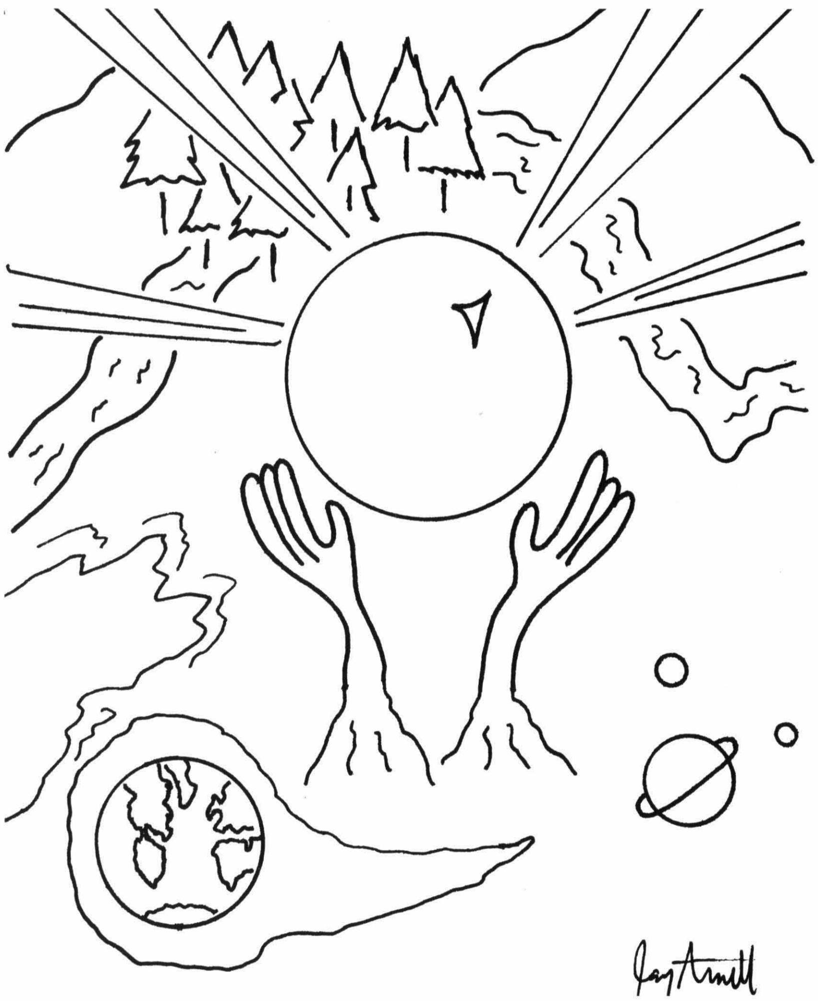
The Sonnix-A walked around the stream. Shiro had been the controller of the Sonnix-A, a large man-driven mechanical unit, for over a year now. He was waiting for the day when he would be promoted to Captain of the entire fleet. Until then he

Other Aspirations! (Part 3)

would just have to do the best job he could, and hope someone would notice. Right now his job was to find humans and exterminate them. His sensors had shown that humans had been by this creek recently, but there were not any to be seen. There were no tracks either, and his sensors were on the fritz as usual, so he couldn't try to locate them a second time. He knew he would not get in any trouble; all the humans would die anyway.



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"Whatever it is, it seems to be moving around. And slowly coming this way. I wish we could get closer."

"Naw, we don't wanna do that. I rekon that thing'll try ta kill us. Ya know, those government peoples were buildin' some sorta weapons stockade around here. We should go check it out. Might come in handy."

"Well do you know where it is?"

"I just might..."

Ray got up from the couch and walked over to a large bookshelf. "I recall readin' somethin' in the news about that place. And Doris, bless her heart, saved all the newspapers sayin' we'd love to look back at them one day. She was right." He flipped through paper after paper, tossing them on the floor one by one when he was done. "I know it's somewhere here."

Jim kept kneeling on the couch, looking out the window. "I dunno if it's actually moving. The sun glinting off it makes it hard to see."

"Here we go. 'Ammunition plant opens in Two Place amid protest' If only they'd known," Ray commented.

"Well, should we head out there?"

"Yep. Let's go," Ray said, heading for the door.

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"Do you realize what this all means, Forrest? We could be the last two people on Earth! And there might be people out to kill us!"

"Oh what? Like that robot thing?"

"I'm being serious Forrest! We survived the first round somehow, but there's no way we'll come out of this alive! We're just going to die!" Alexandra pulled out a pocketknife. "Well I won't let them get me."

"Alexandra! What are you going to do with that?"

"What do you think?"

"A pocketknife isn't going to hold off a 'horde of beasts' or whatever it is you say is coming."

"It's not for that. It's for me."

Forrest stopped walking down the road. They were heading towards the ammunition plant, hoping to find more people alive. It was the only government project for miles around, and someone was bound to be there. Someone good; someone who would help.

He turned around to see Alexandra lying on the ground. "Alexandra!!" Forrest ran back to where Alexandra was. He saw the knife lying on the ground next to her. There was a small puncture on her left wrist, so small that only a drop of blood came out. "Alexandra, wake up."

Suddenly the faint drone of an engine took over the sound of the rustling trees. Forrest's head shot up and looked around for the vehicle. At first he thought it was that silver thing coming to kill them, but his eyes soon spotted a car coming down the road towards him. He lay Alexandra's head on the ground and ran out to the middle of the road waving his arms and jumping up and down.

The car pulled over to the shoulder as it approached Forrest. Then two men stepped out of the car. One of them looked

Continued on next page

SCIENCE FICTION

Continued from previous page

to be in his mid 40s with dirty blond hair and a pair of thick-rimmed glasses. The other looked to be about 25 with black hair and piercing green eyes.

"What seems ta be the trouble, son?" the blond man asked.

"I don't know, I think she's fainted," Forrest replied.

"Well, let's put her it the backseat of the car and you can watch over her. My name's Jim. He's Ray," said the one with black hair.

"I'm Forrest. She's Alexandra. We were heading to the ammunition plant, but the scope of the situation kinda took her by surprise."

"There's some water in the glove compartment, and there should be a rag around the car somewhere. You can use that to help wake her up." Ray said.

After sliding Alexandra into the back seat, the three of them piled in, and they continued down the road.

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Everything was finally working again. It took a while, but after a bit of time to rest, even the sensors were ready for some more action. If you could call it that. Shiro could not believe how boring this mission had been. He was hoping someone would retaliate; put up a fight. The people were just running and letting themselves get caught and killed. All he wanted was a little excitement. Then suddenly Shiro realized he just might get that yet. His sensors picked up a group of four people together, and when cross-referenced with the map, it looked like they were at what humans called an ammunition plant.

"So, they're preparing to put up a fight, are they?" Shiro called up the On-Site Operations Coordinator on his portable vidiphone. "Hendou? I've found a group of four people that seem to be arming themselves. Permission to play around with them a bit and have some fun?"

The picture of Hendou thought for a moment. "Has it been that boring, Shiro?"

"Yes sir. This is probably the most boring assignment I've ever had."

"Well then, permission granted. Play around with them for a bit, but not too long. There's no need to torture them TOO bad in their final hour."

"Thank you, sir! Shiro out!" The vidiphone blanked out with those words.

"Thank you for using the —" Shiro pressed the off button before he had to listen to that speech again. A deliciously evil grin slowly came across his face.

"Well, well, well...four humans who think they can stop me. This will be fun. REAL fun."

To be continued...

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