Engineers' Forum

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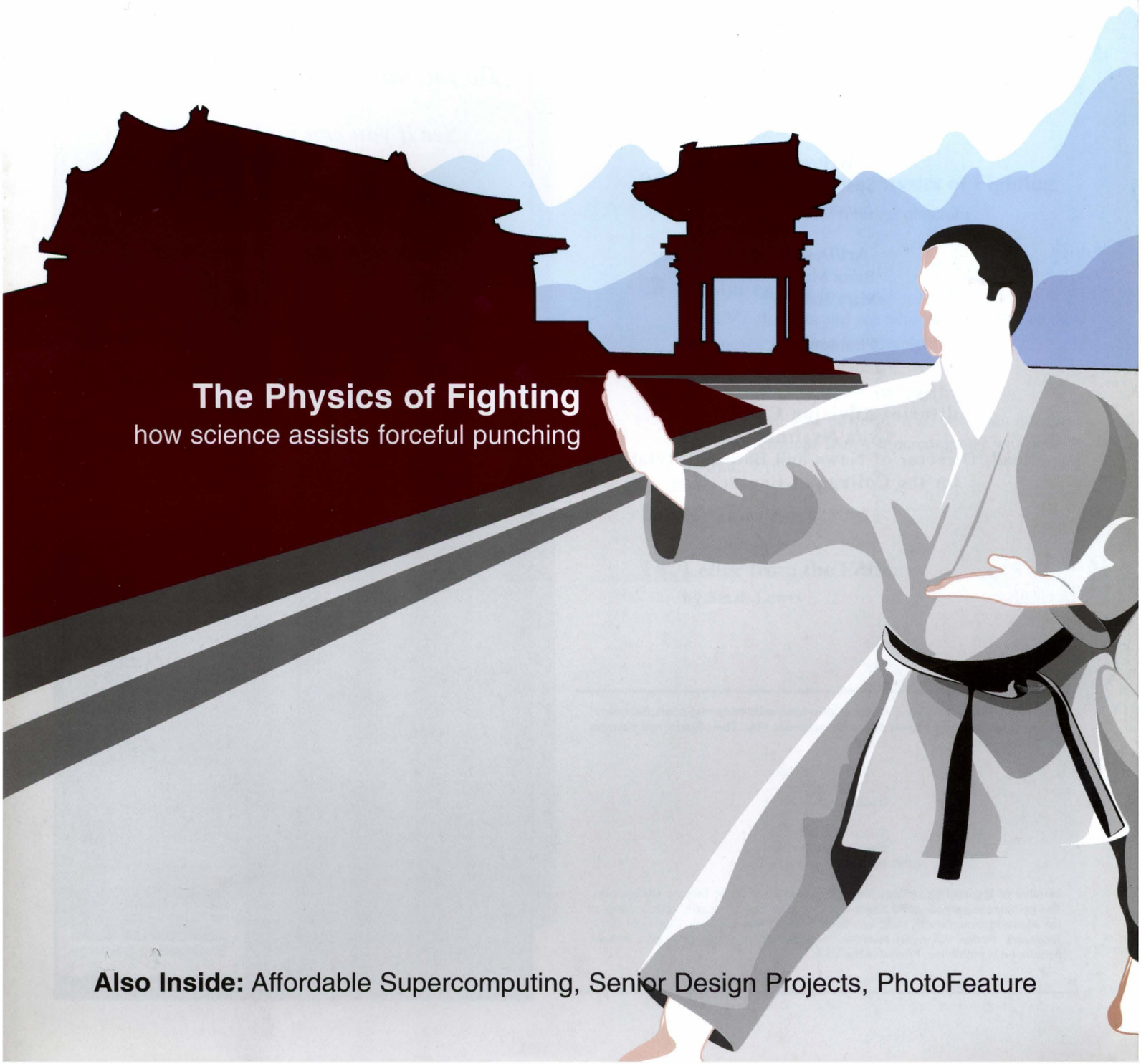

The Physics of Fighting

how science assists forceful punching

Also Inside: Affordable Supercomputing, Senior Design Projects, PhotoFeature

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Cover Art: illustration of a martial artist by Brian McGill

Skip the EKIP

look at what Tech's Engineering senior design project students are doing

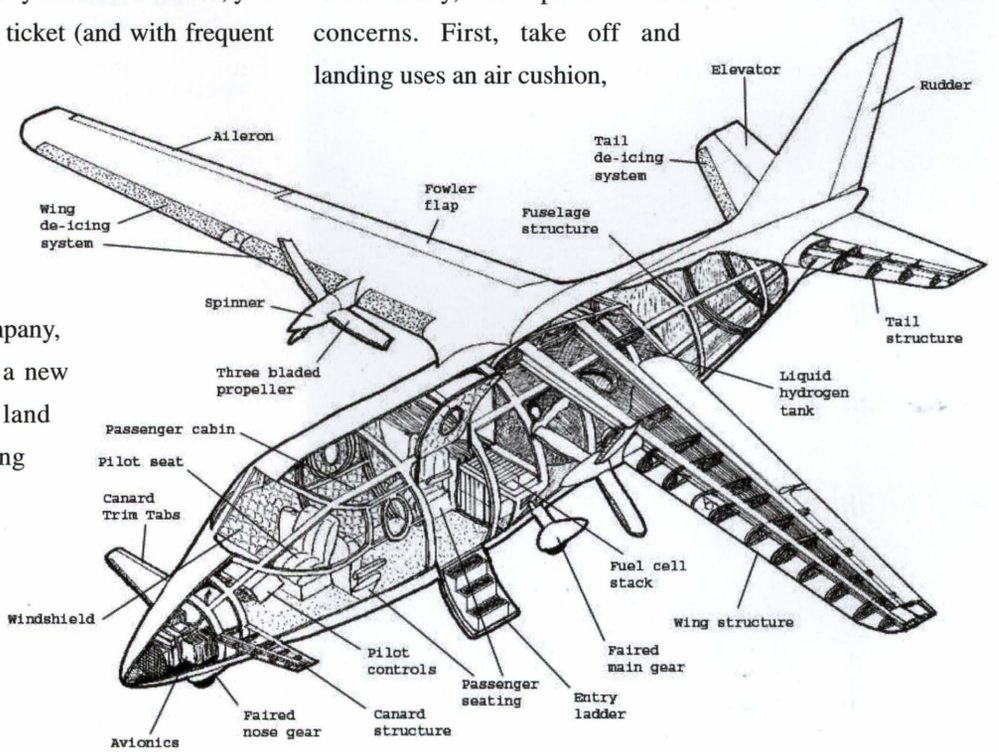
written by Sarah Lewis

Since man first looked at a bird in wonder, instead of only equating it with tonight's dinner, the human species has dreamt of flight. Even today, we continually look for new and better ways of reaching higher, faster, and for longer. We have landed on Mars and sent back pictures of her barren, red landscape; we have reached for the stars and touched the moon, broken the sound barrier, and made the world accessible to anyone with enough money. If you want to go half way around the world, you only have to purchase a plane ticket (and with frequent flyer miles even that is not much of a deterrent), and only a few hours later you can reach your destination, almost no matter how remote.

Even now, the Russian company, "Aviation Concern" designed a new kind of airplane that can land virtually anywhere, including water and unimproved terrain. The company's information brochure can be found at http://www.ekip-aviation-concern.com. Though this is not the first plane capable of landing on water, it also possesses several other features that make it so unique.

The EKIP plane designs have the capability of carrying over one hundred-ton loads, at five hundred to seven hundred kilometers per hour, for thousands of miles when cruising eight to thirteen thousand kilometers above the surface. Not only can they move as a standard plane does, but they only need a maximum of six hundred meters to take-off fully loaded.

Additionally, this plane addresses several environmental concerns. First, take off and landing uses an air cushion,



3D cutaway of students' design concepts for the Liberty project in 2003.

allowing for much steeper angles of decent and elevation. The steeper angles decrease area noise pollution, as compared to other equivalent sized airplanes. Second, the EKIP can hold over one thousand passengers, using natural gas or hydrogen fuel. Unlike common petroleum based fuels, this reduces several common air pollutants such as carbon dioxide and carbon monoxide.

Tech engineering students have created a name for themselves around the country and around the world, in design competitions.

Russia does not hold the market on talented designers, however. It does not even require a PhD to design a new kind of airplane or other vehicle. Just look around the Virginia Tech campus. Tech engineering students have created a name for themselves around the country and around the world, in design competitions.

Virginia Tech AOE and ISE students worked with a group of students from Loughborough U (from the UK) to create the winning design for NASA's Revolutionary Vehicles Concepts and Systems Competition, in 2003. Also, Virginia Tech design teams for the American Institute of Aeronautics and Astronautics (AIAA) Undergraduate Team Student Design Competition have received awards for the past thirteen years. Virginia Tech students have also taken first place eight times since 1990. For more information on this competition and 2003 winners, visit NASA website at http://avst.larc.nasa.gov/comp_2003_results.html.

Not all of Tech's winning teams, however, work on aerospace projects. The Autonomous Challenge, where the school has won at least one award since prior to 2000. Last year, during the 2003 competition, Virginia Tech's two teams won first and second place in the national competition. For more information on this competition and past winners, visit the IGVC (Intelligent Ground Vehicle Competition) website at http://www.igvc.org/deploy.

Also, a Tech team has been selected as one of twenty teams invited to participate in the DARPA Grand Challenge Event (autonomous ground racing). This competition will be held in March 2004. Teams will race their autonomous vehicles from Barstow, CA to Las Vegas, NV for a chance to win one million dollars. For more information on the DARPA challenge, visit their website at http://www.darpa.mil/grandchallenge/index.htm. Good luck from the staff at the Engineer's forum, and congratulations to all our other competition winners.

The Physics of Fighting

how science assists forceful punching

written by Sunny Chang

From the "art of killing" originates the touch of death, the one punch kill – 'ikken hisatsu' – and invincibility of the soul. All of these amazing feats of athleticism have been depicted through stories, movies and legends of Martial Arts. The techniques taught through this art vary from punching to grappling to gravity defying actions; all appearing to be magic.

However, martial arts such as karate, tae kwan do and ju jitsu require immense training and proficient manipulation of one's body. It is, after all, a sport. And like all sports, martial arts are not magic. Every movement, every seemingly supernatural technique can be explained logically using physics for a better conception of using strength efficiently.

For centuries, martial arts has defended honor, honed spiritualism, and disciplined the psyche. The art form centralizes around and emphasizes developing both the mind and the body to work harmoniously. Behind all the mystery, intrigue and bewilderment, there is a science to breaking blocks or heaving an opponent across the room.

On the most basic level, methodical fighting is a system which advantageously varies the proponent's forces used during a fight. When punching, the most important objective is to strike a target as quickly as possible in the smallest amount of surface area available. This action creates a powerful hit.

However, no matter how much strength is applied, if weak form is demonstrated, then the strike has no effect. There are a few pointers to remember. The fist must be held tightly closed; at the same time the first two knuckles, fist and wrist must all be aligned in order for the maximum amount of momentum to transfer through the arm to the target. If the strike is executed through an open hand or loose fist, then the force of the attack spreads across the palm and fingers causing the force to dissipate through a wider surface of the hand. The goal is to concentrate strength into a relatively small area.

Behind all the mystery, intrigue and bewilderment, there is a science to breaking blocks or heaving an opponent across the room.

Consider that a martial artist is capable of striking an opponent at 190 Joules of energy. The average hand has a measurement of 6 inches long and 4 inches across. So an open handed hit, exerted with 190 Joules applied to an area of 24 square inches, results in applying 7.92 J/in2 to the target. However, if the area is reduced to the surface area of a palm measuring 2 x 1.5 inches the resulting force becomes 63.3 J/ in2. Imagine the amount of force that could be applied once the hand

FEATURE

is clenched in a tight fist.

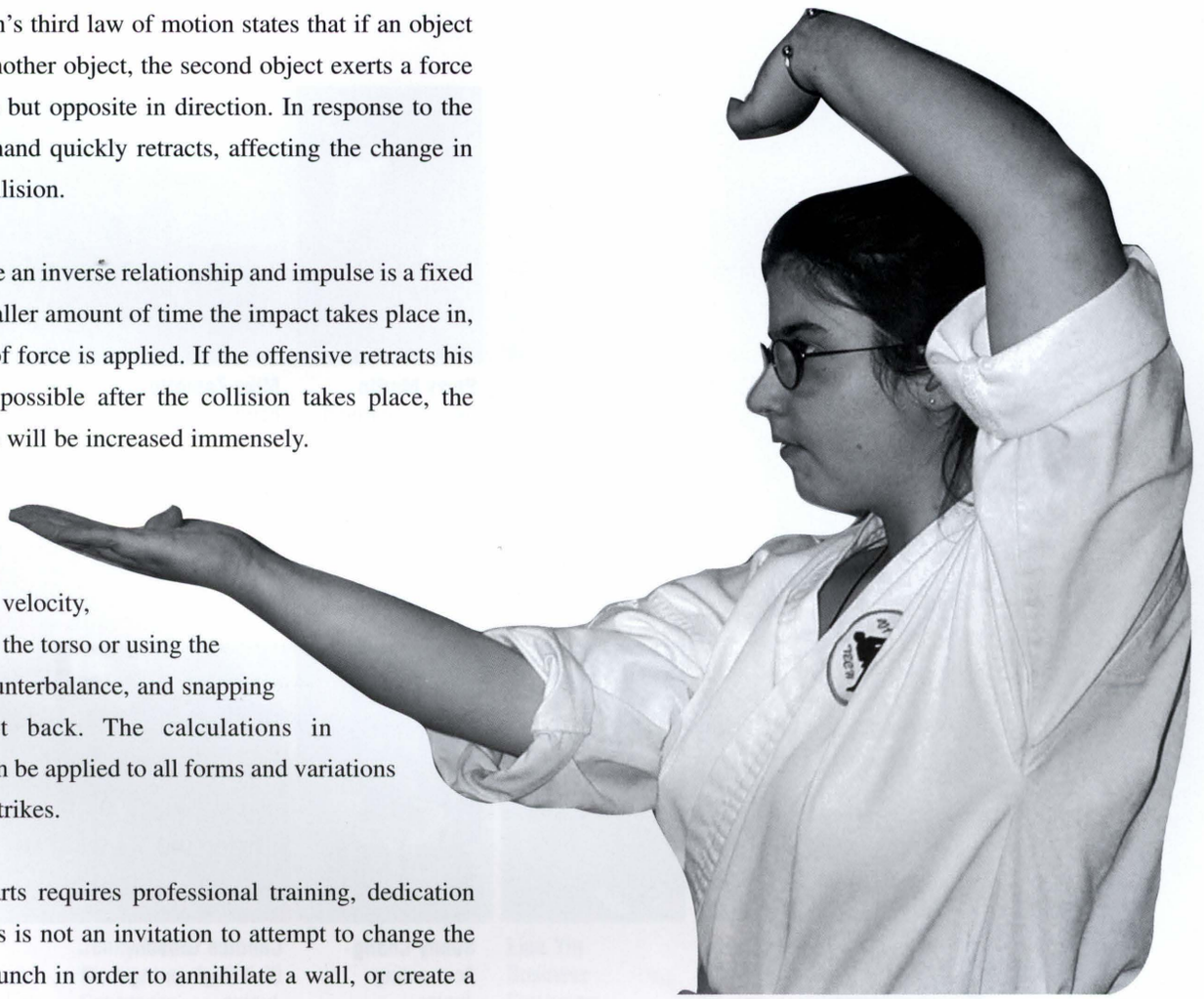
Once form is perfected, minor adjustments can be made to increase the power of the hit. Looking at the act of punching analytically, the collision of the target and the hand should be examined in terms of force and momentum. Force (F) is calculated by finding mass (m) times acceleration (a). F =ma. Momentum (p) is determined by multiplying mass times velocity (v) or p =mv. Acceleration is defined as the change in velocity over time (t). $a=\frac{\Delta v}{\Delta t}$. Given the equation, F =ma, substituting a with the determined equation for acceleration and then distributing m results in the following formula for Force: $F=\frac{mv_1-mv_0}{\Delta t}=\frac{\Delta p}{\Delta t}$. Δp equals the change in momentum, otherwise known as impulse. Impulse finally derives into $\Delta p=Fx\Delta t$. Momentum is a conserved quantity, meaning it cannot be created nor can it be destroyed, consequent to the theory of conservation of momentum. Instead, it passes from one object (the hand) to another (the opponent).

In addition, Newton's third law of motion states that if an object exerts a force on another object, the second object exerts a force equal in magnitude but opposite in direction. In response to the force exerted, the hand quickly retracts, affecting the change in time, during the collision.

Force and time have an inverse relationship and impulse is a fixed quantity, so the smaller amount of time the impact takes place in, the larger amount of force is applied. If the offensive retracts his fist as quickly as possible after the collision takes place, the power of the punch will be increased immensely.

The retraction can be assisted through rotational velocity, created by twisting the torso or using the other hand as a counterbalance, and snapping the dominant fist back. The calculations in increasing force can be applied to all forms and variations of hits, kicks and strikes.

Learning martial arts requires professional training, dedication and discipline. This is not an invitation to attempt to change the acceleration of a punch in order to annihilate a wall, or create a novelty parlor trick. However, it is important to understand that once the art of fighting is mastered, it only requires a few adjustments in weight and body placement and muscle memory (promoting repetition) to improve offensive strikes. As the old saying goes, the best defense is the prefect offense. There is no better offense then to apply the "one punch kill" to an enemy.



Jess, member of the Tae Kwon Do Club here at VT.

Who will win the democratic bid for **presidency**?

Absent for a couple issues, the PhotoFeature is back in full swing! Meet students from around campus who are asked questions pertaining to a different theme each issue.

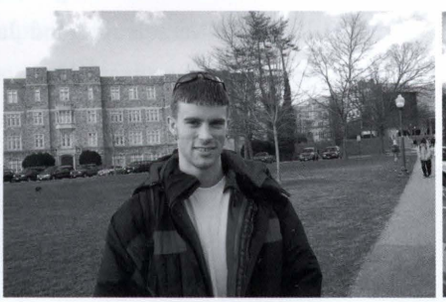
Perry Martin
Service Learning
Staff
Answer: Edwards

Mike Zambito
Economics
Sophmore
Answer: No Idea

Sunny Chang
Accounting
Junior
Answer: Dean

Candice Gibson
Civil Engineering
Junior
Answer: Kerry

Nik Costanzo
Mech. Engineering
Junior
Answer: Clark



Philip Patterson
Classics
Junior
Answer: Kerry

Parke Hultman
Comp. Engineering
Junior
Answer: Clark

Scott Werner
Civil Engineering
Sophmore
Answer: Clark

Josh Blount
Wildlife Sciences
Sophmore
Answer: Kerry

Jenny Wolk
Biology
Sophmore
Answer: kerry

Lisa Yin
Business
Freshman
Answer: Kerry

Joe Sanderson
AOE
Senior
Answer: Dean

Affordable Super Computing

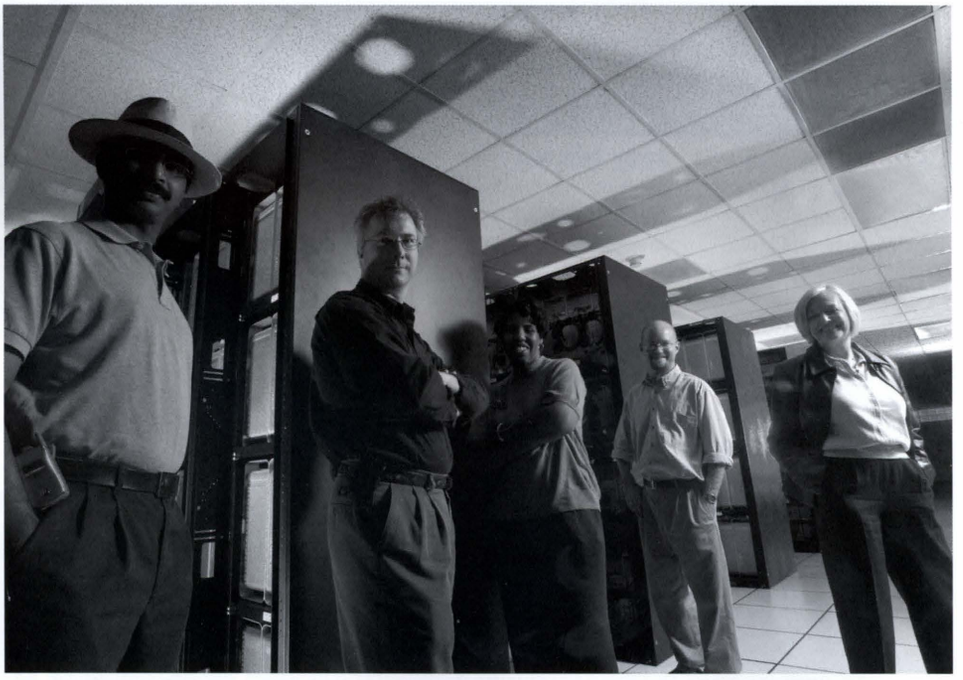
written by Staff Writer

The story is as close to a feel-good fairy tale as one might vividly imagine.

The protagonists were a novice, unlikely team. They included a brilliant young computer scientist, a creative architect turned multimedia expert, a diligent aerospace engineer, a former technocrat in Gov. Doug Wilder's administration, and a woman with a doctorate in curriculum and instruction. Their coaches were a former chief scientist for the San Diego Supercomputer and one of the developers of the Blacksburg Electronic Village (BEV).

They entered a race where there was already a "TOP500 List" of contestants. They emerged as international heroes. The Virginia Tech team had outplayed every other university in the world. The underdogs built the world's fastest supercomputer in higher education circles, and the third fastest among all competitors. Equally amazing was the price tag, about one-tenth the cost of the average supercomputer.

The game plan started with a burgeoning friendship in the spring of 2003. Srinidhi Varadarajan and Jason Lockhart worked in separate areas of Torgersen Hall, a building dedicated to multidisciplinary research. Varadarajan directed a small



From left to right are Srinidhi Varadarajan, director of Virginia Tech's Terascale Computing Facility, Kevin Shinpaugh, associate director of the TCF, Glenda Scales, assistant dean for research computing and distance learning, College of Engineering, Jason Lockhart, associate director of the TCF, and Pat Arvin, associate vice president for information technology.

supercomputing facility and Lockhart administered the College of Engineering's Multimedia Laboratory.

Varadarajan was a boy wonder in his homeland of India. At 15, he had designed one of the first marketed anti-virus computer software programs. Pace Computers sold his product, and the software, PC-Clinic, gained prominence when the Indian Institute of Management adopted its use.

Reared in an intellectual household, Varadarajan's father directs one component of India's space program and his mother is a Sanskit lecturer at the LD Arts College. Vararadajan moved to America in 1995 to pursue his doctorate in computer science at the State University of New York at Stoneybrook. Afterwards, he joined Virginia Tech and quickly became a National Science Foundation CAREER Award winner. When he secured an additional NSF grant to upgrade the Virginia Tech facility he directed, he started brainstorming with Lockhart.

Lockhart's immediate supervisor was Glenda Scales, in charge of distance learning and computing for the College of Engineering. One of her goals was to foster a closer relationship with the University's Information Technology organization, managed by Erv Blythe of the BEV fame. NBC commentator Tom Brokaw once recognized BEV as representing the "most wired town in America." Working for Blythe were Patricia Arvin, an associate vice president who had enjoyed strong ties to state government, and Kevin Shinpaugh, who holds a Ph.D. in AOE from Virginia Tech. Scales' boss was Hassan Aref, the new dean of Virginia Tech's College of Engineering, a physicist by training. His credentials included a stint as chief scientist at San Diego's supercomputing facility. The team began to plan their strategy.

Vararadajan's idea was to use off-the-shelf products and design a supercomputer that recorded a minimum of ten trillion operations per second, or ten teraflops. He targeted price/performance since he did not have the hundreds of millions of dollars available to him that it took to build the current top two supercomputers in the world. Japan's Earth Simulator, estimated to cost between $250 and $350 million, remains number one at 35.86 teraflops. The Department of Energy's ASCI-Q, a dedicated weapons facility continues in the number two slot, operating at about 14 teraflops with an estimated construction cost of $215 million.

Engineering student volunteers who worked on the unpacking of the G5s as they arrive and got them ready for the cluster.

Vararadajan and Lockhart brainstormed. How would they achieve this incredible goal of building a ten teraflop machine that would rank among the top five in the world, and do it in a race against time. They had about six months left to make the Oct. 1 deadline when Jack Dongarra of the University of Tennessee puts together the annual TOP500 List of supercomputers. This listing would then constitute who was eligible to compete for funding with NSF's Cyber Infrastructure program, a new agency thrust area.

Lockhart was an Apple Mac devotee. Varadarajan had yet to use one. The entire team decided to try partnering with Dell Computers. For two months they worked together on the details of the plan. At the final hour when papers were ready for signatures, Dell withdrew. Now mid-May, the team was devastated for about 24 hours. Then, they quickly returned to work, had some talks with a few vendors that did not materialize, and settled in on Apple and its newly announced Power Mac G5 With the support of Aref and Blythe, a contingent flew to Cupertino, Cal., and met with Barry Wright, vice president of

education sales.

Although Apple had never played in the supercomputing business, Wright promised the Virginia Tech team delivery of 1100 G5s as they rolled off the manufacturing line in August. The race became much tighter. So, Arvin and Scales assumed stronger roles, establishing time lines, weekly internal meetings and conference calls between Apple, and the three other companies that contributed to the project: Mellanox Technologies, Emerson Network Power and Cisco. The industry representatives assumed the excitement of the project, moving glass ceilings in their companies to meet seemingly impossible deadlines.

For example, Mellanox provided the primary communications fabric between the 1100 G5s. But its product, InfiniBand, had never been used with Apple's Mac OS X on a Power Mac G5. And Mellanox was based in Israel where its engineers, several thousand miles away, worked day and night to execute their part of the project. Emerson provided a new rack mounted cooling system designed specifically for the Virginia Tech cluster. If the 36 tons of equipment in the 3000 square foot machine room had been cooled by traditional floor mounted systems, generated winds would have exceeded 60 miles per hour.

On the opposite side of the world from Mellanox was Japan's Kazushige Goto who optimized the IBM processor, a PowerPC 970, used in the Apple G5 for the Virginia Tech team. Back in the states, Dhabaleswar K. Panda of Ohio State assisted with the communications language between the 1100-node cluster.

Lylah Sartin, computing center's facilities manager, coordinated the construction crews, as if she was building the arena for a U.S. Olympics event. She prioritized orders, cleared hurdles with town government, and even helped host a congratulatory party for the contractors who had worked double shifts for weeks to keep on target.

The management team relied on student power. Volunteers worked assembly lines to unpack and process the G5s as they arrived, getting paid in pizza and free T-shirts. Running at full speed, the students processed 238 machines in under two hours. "We were all dead tired. We worked on the physical aspect of the project with everyone, but we were also mentally working out everything," Lockhart recalls.

If the 36 tons of equipment in the 3000 square foot machine room had been cooled by traditional floor mounted systems, generated winds would have exceeded 60 miles per hour.

The main architect of the new supercomputer, Vararadajan, familiarized himself with the Mac. Within three days of having a PowerBook, he was a convert. He then compiled his own compatible software, and he had to make his one other ace in the hole responsive to Macs. Vararadajan had created Déjà vu, a software program currently being licensed by Virginia Tech Intellectual Properties (VTIP). Déjà vu provides a fault tolerant software environment so that if any one component in the new supercomputer failed, the queuing system was alerted. Within milliseconds a free node takes over, averting the need to restart a calculation from scratch, a time frame that can potentially represent months.

As the project progressed, leaks to the media occurred. With more than 100 student volunteers, the Geek underworld started talking. The web sites, ThinkSecret.com and Slashdot.org created some of the first buzz, forcing the University to distribute its first cautiously worded release in September. By mid-September the University took a stronger stand while co-hosting a major information technology conference. A release, based on University President Charles Steger's announcement that Virginia Tech was building a supercomputer that would land in the top ten in the world, was distributed to about 100 outlets. The British Broadcasting Corporation decided the venture was worth a trip to Blacksburg. Ian Hardy, the BBC correspondent, produced a five-minute feature that BBC aired for seven straight days, estimating some 250 million viewers.

Now the world was taking notice. The N.Y. Times, Business Week On-Line, the Chronicle of Higher Education, the Voice of America, Fortune magazine, the Wall Street Journal, and others were calling to talk with the team members. An Associated Press story written by Chris Kahn of Roanoke went international. The Indian, German and the French press called. In late September, Vararadajan received a standing ovation at a computing conference. And the announcement was not yet official.

On Nov. 16 at the Supercomputing 2003 conference, Virginia Tech's newly named System X, representative of the more than 10 teraflops of speed it recorded, officially became the third fastest supercomputer in the world and the fastest at any academic setting.

Jack Dongarra of the University of Tennessee, who also holds an appointment at Oak Ridge National Laboratory, compiled the listing. Dongarra, interviewed earlier by the Richmond Times Dispatch, said the "notable aspect" of Virginia Tech's supercomputer "is the $5.2 million price for all that computing power."

continued on page 15

E-mail Bag

After digging through old issues, we flash back to the 1950s for some old humor...

Student: "Have you any four volt, two watt bulbs?"
Clerk: "Four what?"
Student: "No, two."
Clerk: "Two what?"
Student: "That's right."

And as they say in Mechanics-"Every Couple has its moment."

C.E. Prof.: "Explain the operation of a steam shovel."
B.F.: "Don't kid me, you can't shovel steam."

A person who claims that absolute zero is impossible to obtain hasn't taken a Machine Design test yet.

She: "My dad is an engineer. He takes things apart to see why they won't go."
He: "So what?"
She: "So you better go."

Textbook style: "The puissance of hydrochloric acid is incontestable; however, the corrosive residue is inharmonious with metallic persistence."
C.E. style: "Hydrochloric acid eats hell out of steel"

"Professor," said the engineer in search of knowledge, "will you try to explain to me the theory of limits?"

"Well, John, assume that you have called on a pretty woman. You are seated at one end of the divan and she is seated at the other. You move halfway toward her. Then you move half of the remaining distance toward her. Again you reduce the distance seperating you from her by 50 percent. Continue this for some time. Theoretically, you will never reach the girl. On the other hand, you will soon get close enough to her for practical purposes."

LETTER FROM THE EDITOR

Looking Ahead

I want to take this opportunity to introduce myself and say welcome back for the 2004 spring semester. After a long and hopefully good winter break for everyone it is once again time to stand in unbelievably long lines at the bookstore, say hi to old friends and hopefully make new ones, and try to keep all those New Years resolutions about getting better grades and studying more. Good luck to you all. One of my goals for this new semester is, with the unequaled help of an amazing staff, create the most enjoyable magazine possible.

My name is Sarah Lewis. I am currently in the second semester of my junior year, majoring in Professional Writing and Biochemistry (though this may be up for some modification). I began my stay here at Virginia Tech as an engineer. During my sophomore year in Aerospace engineering, however, I decided it was not the right path for me and I switched majors. I still love the subject, however, so the Forum is the perfect place for me.

Some fun facts about me include: I love to write, design web pages, as well as dance, sing, listen to good music, and hang out with my friends. I grew up in Forest, Virginia, just outside of Lynchburg, in Bedford Co. Coming to Virginia Tech was one of the best decisions of my life. I have met such great people, grown to know myself better, and finally discovered what I want to do with the rest of my life. I hope for all of you freshmen, your experiences here are as good as mine have been. To everyone else, we are part of what makes Virginia Tech what it is, and that is something to make you proud. To the graduating seniors, good luck during this, the beginning of the second half of your lives! Spread the Hokie spirit to wherever you go.

My advice to everyone, who has not already done so, is get involved in campus activities. We have so much to choose, from greek life to inner tube water polo. You can meet new and exciting people who share some of your own interests. Now time for some shameless self-promoting. If you are still wondering which group is right for you, come check out the Forum staff. I promise we do not bite. We are open to anyone, any major who wants to have some fun (plus it looks great on your resume). This semester, we hold weekly Wednesday meetings at 3:00 PM in Norris 229. If you would like some more information, offer a suggestion, or just talk to one of our awesome staff members, check out our website at http://filebox.vt.edu/eng/forum/, or email me at forum@vt.edu or salewis@vt.edu. Even if you do not like writing, there are several other positions available, or we can even create one.

Sarah Lewis
editor-in-chief

Supercomputing continued from page 13

"We believed that we could build a very high performance machine for a fifth to a tenth of the cost of what supercomputers now cost, and we did," Aref says. "And we wanted to have our own supercomputer to use for our new Institute for Critical Technology and Applied Science where we will be conducting multidisciplinary work on such topics as nanoelectronics, aerodynamics, and the molecular modeling of proteins. With this machine, our researchers will be able to build computer modeling in days, not years."

Exhausted, but thrilled, the team has already announced its next plateau. With the first machine named "X" for ten teraflops, they thought it might be fun to name their second one a higher Roman numeral. Time will tell that number.