BRAIN WAVES

A compendium of ideas and views from UAH campus thought leaders

compiled and arranged by Ray Garner

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

The University of Alabama in Huntsville is an institution widely recognized as a place of excellence, of rigorous scholarship, as a leader in research, and a center for innovation.

The story of this institution is, in fact, the narrative of the remarkable people who fashioned the university across the generations, across so many fields of learning and who continue to remake it in new ways.

While the chapters of this book work together to speak to the quality of the institution and the outstanding production of knowledge at UAH, each chapter was written to stand alone.

This publication is not a history of UAH although it presents something of the university's history. Nor is it a celebration to all of the exceptional faculty who have been drawn to the university, although in these pages you will be introduced to a number of these faculty members.

The essays in this volume tell the stories of extraordinary individuals who came to play leading roles in their fields and make contributions of lasting importance. These faculty members exemplify, in different ways, the rare joining of determination, ability, commitment to excellence, and sometimes genius that marks this institution of higher learning at its best.

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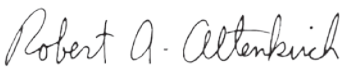
Foreword

Academic rigor and intellectual vigor is at the heart of The University of Alabama in Huntsville — the lifelong pursuit of the depths of knowledge and the communication of that knowledge to others. Both of these activities are crucial elements to the success of research universities. Our faculty not only teach students in critical thinking, but also in their ability to communicate and develop their capacity to be lifelong learners. The model at UAH is an educational environment where mentor and student are so thoroughly engaged in a search for knowledge that they become one in the learning process.

The University of Alabama in Huntsville is a unique research university that fuels a spirit of confronting monumental challenges. The vision and dream of UAH was powered by the drive and foresight of the women and men whose rockets carried mankind into space, to the moon and beyond. It is such a spirit that serves to inspire our faculty, staff and students to expand their horizons further.

This diverse collection of essays from UAH thought leaders demonstrates major contributions to scholarship and the expansion of our body of knowledge. I hope you find this collection informative.



Robert A. Altenkirch, President
The University of Alabama in Huntsville

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Opening a new window on the universe

By Tyson B. Littenberg
Research Scientist
Center for Space Plasma and Aeronomic Research

The fields of astronomy and astrophysics are undergoing a revolution and The University of Alabama in Huntsville (UAH) is helping blaze the trail. Albert Einstein's last great prediction, the existence of gravitational waves, has finally been confirmed.

Beyond just validating a 100-year-old idea, the direct measurement of gravitational waves will forever change our understanding of the universe, and open up new unfathomable opportunities to learn more of its secrets. Research done at UAH is paramount to the quest for making gravitational wave observations a routine tool in astronomy and astrophysics, and the university will be able to proudly claim an ownership stake in the pending discoveries.

Throughout human history we have looked to the stars. Either through boredom or curiosity, we began to recognize patterns in the night sky and attributed meaning to the constant, as well as changing, cosmos. The field of astronomy was born when Galileo trained his telescope to the heavens, confirming that the Earth was not at the center of the universe. This was a very unpopular idea in Galileo's time and he paid dearly for it. However, passing on knowledge is a close facsimile of immortality, and his ideas have persisted in glory.

For hundreds of years after Galileo lived out his days under house arrest, the arc of astronomy followed humankind's ability to construct bigger and better telescopes. By utilizing better astronomical tools, detailed observations of planetary motion ultimately contributed to Isaac Newton's groundbreaking description of mechanics — why and how bodies move around — arguably the dawn of "physics" as a discipline. Observations made by Edwin Hubble showed that our galaxy was but one island in a sea of others and, paradoxically, distant galaxies all appear to be receding into the distance. Playing the movie backwards we are led to the conclusion that the universe — once thought to be infinite and static — started out as an impossibly small, impossibly dense bundle of energy before bursting into existence at the Big Bang.

Little did we know these great strides were merely setting the stage for our true intellectual voyage through the cosmos. With the dawn of the Space Age — the heritage of which is still plainly visible in Huntsville — we were able to place telescopes beyond the confines of the Earth and receive signals otherwise blocked by our nurturing atmosphere.

A bizarre, expansive, violent universe was revealed to us, redefining our perceived place in the universe and spurring human insight and ingenuity to continually push the limits of our abilities to peer deep into the cosmos. As of today, it is fair to say that nearly everything we know about the universe — how big it is, how old it is, how it will end, how stars are born, how stars die, how planets form, which planets are habitable — comes to us from light.

We have learned a lot from light, and it has not finished revealing its secrets. However, the story we are able to piece together is incomplete. It is as if we have been watching news broadcasts for hundreds of years on mute. We can make educated guesses about what the story has to tell, and often the images are enough. However, to truly understand the details of the story, we need to hear the reporter. Before the end of this decade, we will — for the first time — finally turn on the "sound" of the universe and with it gain deeper understanding of how the cosmos works. To do so we must add a new sense to our toolbox for learning about the universe. Enter physicist Albert Einstein.

Einstein's greatest contribution to science was the General Theory of Relativity, or "GR" for short. Completed in 1915 (100 years prior to this writing), GR replaced hundreds of years of Newtonian physics with a revolutionary idea: Space and time are not absolute, but form a sort of fabric in the cosmos, space-time, that is, in a sense, malleable. The "force" of gravity is not a force at all, but a consequence of objects moving through warped space-time.

These ideas are so far from our conscious day-to-day experience that they can be off-putting; however, they have become integral to our daily lives. Without accounting for the fact that the rate at which time passes depends on one's location in the universe (time passes faster where there is less gravity), the Global Positioning System would fail to be of any use within a matter of minutes.

Like all theories of science that have stood the test of time, at the time of its genesis GR provided insight into unexplained truths (in GR's case, the orbital motion of the planet Mercury) as well as make predictions for phenomena not yet observed.

The observation by Sir Arthur Eddington that massive objects (like the sun) bend the trajectory light takes through space-time was the first confirmation of GR, and cemented Einstein's place among the pantheon of humanity's greatest minds. All other great predictions from General Relativity — time passing slower near massive objects, the existence of black holes, the twisting of space-time near massive spinning objects — have been experimentally or observational confirmed save one: gravitational waves.

In 1916, one year after completing the equations of GR, Einstein realized that the theory of gravity predicted waves, which would propagate through space when massive objects undergo accelerations. These waves were predicted to travel at the speed of light with phenomenally weak amplitudes. So weak, in fact, that Einstein immediately dismissed them as being a mere mathematical curiosity, with no practical importance to physics. Today we realize that even Albert Einstein's celebrated imagination was prematurely limited.

Strong, dynamic, gravitational fields emit gravitational waves. In other words, we need to get a lot of matter moving around at close to the speed of light. We cannot do this in the lab and in Einstein's day there was no evidence that any natural process could be violent enough. Advances in astronomy and astrophysics over the intervening century have revealed that the universe is a much more violent place than we had previously thought.

Stars end their lives as dense stellar remnants also referred to as compact objects. Stars like our sun will end up burning out as white dwarfs — a dense, glowing object near the mass of the sun made mostly of carbon and compressed to the size of the Earth. Stars more than about 10 times as massive as the sun collapse into neutron stars — in effect a giant atomic nucleus with the mass of the sun packed so densely that it would fit comfortably inside Huntsville city limits.

Should the mass of the stellar remnant exceed three times the mass of the sun, the force of gravity is too strong to support a neutron star and the object collapses into perhaps the most exotic denizen of our universe; a black hole. Black holes, neutron stars, and white dwarf stars are the universe's most accomplished way of packing a lot of material into a tiny volume, which gets us halfway to a good source of gravitational waves. The remaining step is to get these objects moving near the speed of light.

Fortunately for gravitational wave astronomers, the universe has one more trick up its sleeve. Most of the stars you see in the night sky are actually pairs of stars orbiting so closely that you cannot tell them apart. These binary stars are typically similar in age and mass, and will result at the end of their lives as binary white dwarfs, binary neutron stars, or binary black holes.

As the two objects orbit one another they emit gravitational waves that relentlessly, over the course of billions of years, drives the stars closer together as they orbit one another. As the separation between objects shrinks, they move around one another faster, emitting stronger gravitational waves. This runaway process leads to a cataclysmic merger of the two objects. The mergers of compact objects are the most energetic events in the universe. If we could see gravitational waves, the mergers of two black holes would outshine the moon from a billion light years away. Alas, this incredible output of energy is dumped into gravitational waves instead of light, and we have yet to directly observe this phenomenon. However, merging neutron stars are hypothesized to produce brilliant flashes of gamma ray light seen as gamma ray bursts. Huntsville has long been an epicenter of gamma ray burst observations, currently through NASA's Fermi Gamma-ray Space Telescope. Now, with the advent of gravitational wave astronomy, we aim to combine the gravitational and gamma ray observations to deeply understand the violent mergers of compact stellar remnants.

Detecting gravitational waves requires enormous and highly specialized observatories. Gravitational waves are a disturbance traveling through space-time. As gravitational waves pass through a region of space they will alter the distance between two points. By carefully monitoring distances we can determine when gravitational waves are passing by. Accurately measuring distances between objects sounds easy enough, but the change imparted by a passing gravitational wave is mind-bogglingly small.

If we wanted to use the distance to nearby stars as our ruler for gravitational wave detection, we would have to monitor changes in those distances to accuracies of less than an inch! Not only is the change we are looking for at the limits of our measurement capabilities, but there is a monumental technological challenge in protecting our measuring device from other disturbances that might cause similarly small changes.

Currently operating or under development are three complementary approaches to gravitational wave detection. Each is specialized to detect signals in a particular wavelength regime, much like we have specialized telescopes to observe different kinds of light. The Laser Interferometer Gravitational Wave Observatory (LIGO) consists of two identical facilities in the U.S., one located in Hanford, Washington, and the other in Livingston, Louisiana.

Viewed from above, each observatory is an "L"-shaped building four kilometers long on each side (or "arm"). At the corner of the "L" is a state-of-the-art laser that sends light down each arm toward meticulously polished mirrors hung from a suspension system designed to shield them from external disturbances. If no gravitational waves are passing by, laser light sent down each arm will return to the corner simultaneously. By looking for slight changes in the arrival time of light from each arm, we can measure changes in the length of one arm relative to the other. The precision of the measurement is the stuff of science fiction. A passing gravitational wave will alter the length of one arm of the detector by less than the width of a proton!

LIGO is searching for high-frequency (short wavelength) gravitational waves from the mergers of neutron stars and black holes with masses less than around 100 times that of the sun. LIGO began operating in the early 2000s but, at the time of this writing, has just completed its first observations after a major upgrade to improve the instrument sensitivity. The analysis of the first data collected is well underway and enthusiasm for this new field is at an all-time high. With LIGO's new capabilities the first gravitational wave detection could come any day.

The detection of ultra-low-frequency gravitational waves does not require specially made detectors on Earth. Instead we look to the stars once more. Pulsars are a special class of neutron stars, that emit a pulse of radio waves at precise intervals. The regular pulses are believed to be due to a small spot on the neutron star emitting a narrow beam of radio waves. As the neutron star spins the beam passes over the Earth, similar to how a lighthouse is visible in regular flashes.

The fastest spinning pulsars complete a thousand revolutions per second — a rate similar to the blades in a kitchen blender — do so with incredible stability. The radio signals from some pulsars are more reliable than atomic clocks. The North American Nanohertz Observatory for Gravitational waves (NANOGrav) monitors the arrival times of the radio signals using the world's most capable radio telescopes. Passing gravitational waves will stretch and shrink the distance between the pulsar and the planet Earth, causing the signals to arrive behind or ahead of schedule.

The most likely source of gravitational waves detectable by NANOGrav comes from supermassive black hole binaries at the centers of galaxies. Most, if not all, galaxies house gigantic black holes — millions of times the mass of the sun — at their center. Throughout a galaxy's life it will merge with several neighboring galaxies and the black holes will "sink" to the center of the merged galaxy and begin orbiting one another, emitting gravitational waves all the while.

Detecting gravitational waves by timing pulsars is a game for the patient. The sensitivity of our measurement increases the longer we monitor individual pulsars. While NANOGrav has not made any detection, the absence of any gravitational wave signals is helping astrophysicists rule out certain hypotheses about the conditions at the centers of galaxies and the rate at which they merge throughout cosmic history.

While the field of gravitational wave astronomy will be born on the ground through experiments like LIGO and NANOGrav, it will reach maturity when we are able to build detectors in space. Detectors in space can be built to hit the "sweet spot" in the gravitational wave spectrum — where the gravitational signals that go through one cycle every 1,000 seconds or so. This frequency regime is rich with sources from our own galaxy (white dwarf binaries) and throughout the visible universe, most importantly the final moments of the supermassive black hole binary mergers.

Placing a gravitational wave detector in space is an unprecedented challenge and will require a large international effort to pull off. One mission concept, the Laser Interferometer Space Antenna (LISA), has been thoroughly studied and a variant is scheduled to launch in the next 10 to 15 years. In December 2015, the European Space Agency and NASA launched the LISA Pathfinder mission to test many of the critical hardware components needed to fly a mission like LISA for gravitational wave observations.

UAH is on the front lines of gravitational wave detection. We are members of the LIGO Scientific Collaboration and NANOGrav, and are working closely with the LISA Pathfinder team to use the lessons learned during this experimental mission as a guiding force as we develop a space-based gravitational wave observatory. UAH gravitational astrophysics researchers have been pouring through the new LIGO data and helped find the first gravitational wave signal.

Meanwhile our colleagues on the Fermi Gamma-ray Space Telescope are sifting through their data looking for a gamma ray signature from any gravitational wave events we may have observed. Regardless of the outcome from the first observing runs for LIGO, gravitational waves will be detected this decade both from the detectors built on Earth and from the careful monitoring of pulsars in our galaxy. A new field of astronomy will be born and UAH will participate in the discovery one way or another.

One thing is for certain: This decade will go down in the record books as the dawn of a new field of astronomy. Once gravitational wave observations become a routine tool for astronomers and astrophysicists to learn about the universe, science will never turn back.

Dr. Tyson B. Littenberg is a research scientist at the Center for Space Plasma and Aeronomic Research and the Universities Space Research Association. He earned a Ph.D. in physics at Montana State University and joined UAH and USRA after research positions at NASA/Goddard Space Flight Center and Northwestern University. He is a senior member of the LIGO Scientific Collaboration and an associate member of the North American Nanohertz Observatory for Gravitational Wave. Dr. Littenberg's research interests include gravitational physics, high-energy astrophysics, and Bayesian inference.

The Middle East

No matter how bad the situation, it can always become worse

By Kathy Hawk

Associate Professor of Political Science

The Islamic State of Iraq and Syria (ISIS) seemed to appear out of nowhere in early 2014, grabbing headlines as it beheaded Western captives, burned a Jordanian pilot alive, and rapidly expanded its territorial control in Iraq and Syria. However, the group that controls territory roughly equaling the size of England in northwestern Iraq and western Syria has roots that extend back to the mid-2000s as Sunni extremist elements sought to both resist the U.S. occupation of Iraq and to stoke a conflict between the Sunnis and Shi'as in Iraq.

The group, also known as ISIL (Islamic State of Iraq and the Levant — the preferred term of the Obama administration) and Da'ish (the name derived from its Arabic acronym — al-Dawla al-Islamiya al-Iraq al-Sham — and widely used in the Middle East), now calls itself the Islamic

State (which the Obama administration refuses to do, saying it is neither). Whether one calls ISIS a terrorist organization, an insurgent group, a pseudo state, a radical religious movement, or a globalized network, it seems to defy logic that the strongest military powers in the world have been unable to squash it.

What ISIS wants

It is neither helpful — nor really possible — to separate the fighting force from its radical, religious-based rhetoric. The group has been quite open about its ideology and goals, and numerous audio addresses and statements from its senior leaders on wide-ranging subjects are posted on websites.

The movement is based on an extremist interpretation of Islamic scripture in which it has claimed to restore the Caliphate, a transnational political-religious state with dominion over all Muslims. The Caliphate was developed following the death of the Prophet Mohammed in 632 CE and existed with varying degrees of power and authority until formally abolished in 1924. In general, many of the ISIS leaders see the development of the Caliphate and the destruction of groups of non-Muslims and ancient non-Islamic historical artifacts as necessary to cleanse the area and to help bring about the apocalypse.

The movement is funded by selling energy resources (electricity, gas, oil) extracted from areas that it has captured on the black market, confiscating banking reserves, imposing assorted taxes on citizens and on the import and export of goods, extorting individuals and groups, and demanding ransoms to release victims of kidnapping. It also receives funds from assorted non-governmental supporters in the region, primarily from Jordan, Syria, Saudi Arabia, and Iran.

While ISIS did not cause the problems in Iraq and Syria, it took advantage of the chaos and lack of government control in order to rise and dominate those areas. Alienation of large swaths of the formerly dominant Sunni population in Iraq and the civil conflict in Syria left those areas vulnerable to the focused, brutal tactics of ISIS and weak neighbors hesitated to assist governments abusive of their own populations. Certainly the United States is concerned about losing the investments it made in Iraq during the past 12 years, but the consolidation of territorial control in Iraq and Syria by ISIS has far-reaching implications for the U.S. and for countries in the region and in the West in general.

ISIS's control over the large tract of territory has not only allowed its fighters to have a safe haven to regroup, train, and plan attacks in hopes of further expanding its territory and target other groups and countries, but also to gain access to the vast financial resources from those areas. While ISIS claims that its immediate efforts are directed against the "near enemy" — regimes in the Middle East that they see as having sold themselves out and do not exercise Shari'a rule, followers have taken on the mantel to attack the "far enemy" — the West.

The beginnings of ISIS

The group that we know today as ISIS morphed from earlier organizations that sprouted up in response to the 2003 U.S.-led invasion of Iraq. A variety of armed resistance groups organized shortly after the invasion both to thwart the U.S. occupation and as many Sunnis recognized that their preeminent role in Iraqi leadership and society was going to give way to domestic leadership by the majority Shi'a. While many different Sunni groups with different names and different leaders rose, most journalists — as well as much of the military — called almost everything AQI (Al Qaeda in Iraq). Although the leadership of some of the more prominent groups was foreign, the overwhelming majority of the members were frustrated Iraqis, not global jihadists.

It is important to note, however, that prior to the U.S. invasion, the Sunni-Shi'a sectarian divide was not a major factor in the average Iraqi's day-to-day life. Although Saddam Hussein, a Sunni, had privileged Sunnis in general — especially those from his tribe around Tikrit — he had also committed atrocities against Sunnis as well as against Shi'as, Kurds, and other groups, and had curried favor with certain leaders of the other sects as well. However, as chaos reigned in the aftermath of the 2003 invasion, groups began to lash out and retaliate in response to real or perceived attacks against their sectarian group. Once family or friends were killed simply because they were seen as Shi'a (or Sunni), responses occurred, triggering what became a sectarian conflict.

In 2006, one group began calling itself the Islamic State of Iraq (ISI). This was an attempt to give the Sunni resistance more domestic legitimacy in the eyes of Iraqis, and it was the beginning of an attempt to pursue the notion of founding of a state in Iraq that would form the basis for the Caliphate that would ultimately expand across the world.

Although the group spouted radical ideological rhetoric, it was not a major force on the ground in its early years. However, after the U.S. military withdrawal at the end of 2011 and the subsequent implementation of much more blatantly sectarian policies by then-Iraqi Prime Minister al-Maliki, a Shi'a, many Sunnis became increasingly alienated from the national government. This allowed ISI to rapidly gain support in the predominantly Sunni western and northwestern areas of Iraq. While most Iraqi Sunnis did not share the radical notions of restoring the Caliphate and the adherence to a very narrow interpretation of the Shari'a, some non-jihadi Sunni resistance groups formed tactical alliances with ISI to push the Shi'a-dominated Iraqi Security Forces, which were usually seen as corrupt, sectarian, and ineffective, out of areas in which Sunnis were predominant. ISI did provide some services to people in need and undertook some public works projects to provide employment, leading many Sunnis to give at least tacit acceptance to their rule.

After authoritarian leaders fell in Tunisia, Egypt, and Libya in what became known as the "Arab Spring," protests grew rapidly against Syrian leader Bashir al-Assad, a minority Alawite, leading a predominantly Sunni country. In 2013, the group changed its name to the Islamic State of Iraq and as-Sham (the local term for Syria, and hence the acronym, ISIS) as it expanded its area of operation to take advantage of the growing chaos and frustrations of the Sunnis in neighboring Syria. As a coalition of secular groups known as the Free Syrian Army (FSA) began capturing territory in northern and eastern areas of Syria, ISIS fighters found it relatively easy to take over those areas liberated by the FSA after the majority of those fighters had moved on to other areas. This not only divided the opposition to al-Assad, it undermined the support of many Western countries as they feared money and weapons given to the FSA were ending up in the hands of ISIS.

By 2014, ISIS had taken over most of the Sunni areas in Iraq and large swaths of territory in eastern Syria. The group then declared that its name was now simply the "Islamic State." It also declared that the Caliphate was now in existence and was led by Abu 'Bakr al-Baghdadi, a descendent of the Prophet Mohammed, and that all Muslims around the world had an obligation to come to its aid to advance its mission.

The U.S. response

The Obama administration has stated that it is committed to degrading and destroying ISIL (its preferred term for the group), claiming it poses a threat to the people of Iraq and Syria, to the broader Middle East, and to U.S. citizens, allies, and interests in the region. The administration argues that, if left unchecked, ISIL could pose a growing threat beyond that region, including to the United States.

The challenge to defeating the group, however, is that it is not limited to destroying a group of fighters. It is tantamount to destroying a utopian ideal in a vast area where the previous governments not only failed to serve the people, but were seen as illegitimate and corrupt.

While few think that ISIS can be destroyed or eliminated in the foreseeable future, current U.S. strategy has been to try to weaken it and undercut its ability to act. The Obama administration has outlined a broad array of efforts to counter the group. These have included supporting effective governance in Iraq, building partner capacity in regional governments, disrupting ISIL's finances, and using its leverage to stop Turkey from being a conduit for fighters, money, and supplies into Syria. The United States and other countries have also sought to counter ISIS's appeal and propaganda through publishing the atrocities and abuses ISIS has conducted as well as highlighting the misery it has caused to those living under its rule. Along with this, Muslim religious leaders and scholars are being encouraged to make the case that ISIS's behavior is illegitimate and contrary to the teachings of Islam.

While there has been reasonably broad support among U.S. political and military leaders for air strikes to support local fighters, opposition groups in Syria remain splintered and efforts to assist Iraqi security forces have not led to the development of effective local ground forces able to take on ISIS directly. During the past year, the United States has dropped more than 32,000 weapons on ISIS targets and provided advisors, intelligence, and some Special Forces in a support role. The United States now has about 3,550 military personnel in Iraq.

Although the U.S. airstrikes may be blunting the ability of ISIS to expand operations and even allowing friendly forces to recapture some limited territory, the ability to knock out major ISIS operating areas is limited due to U.S. concerns about inflicting civilian casualties. For example, in Raqqa, the capital of Islamic State's self-proclaimed Caliphate, as many as 10,000 ISIS leaders and fighters may be operating in the city. However, with no threat from ground forces, ISIS operatives often take over various floors of a building, leaving civilians living and working in the remaining portions to prevent it from being targeted by airstrikes.

Despite thousands of ISIS fighters being killed by U.S. airstrikes, new recruits continue to flow into Iraq and Syria to replenish their ranks. The movement attracts followers who are not only committed to religious ideals, but also those who are seeking glory, empowerment, a sense of purpose, and even just adventure or camaraderie due to the frustration and lack of opportunities in their homelands. A recently leaked State Department memorandum admitted that counterpropaganda efforts against ISIS were falling short, and that the thousands of messages promulgated daily by ISIS were overwhelming the efforts of the U.S. and its partners, who could not seem to get their message straight.

While it is easy to identify the shortcomings of current U.S. policy, there is no consensus on a better course of action. After more than a decade of sending troops to the Middle East, Congress and the U.S. public are wary of becoming re-engaged in a major way. There is very limited support for sending the large numbers of troops that would be required to conduct the type of operations necessary for the period of time needed — and the causalities that would result — from trying to destroy ISIS. The U.S. public is also fearful of allowing ISIS to act with impunity and allowing Iraq and Syria to crumble in the process.

The bottom line is that there is no simple policy to stop ISIS and roll back its gains. To do so will require a consistent and concerted effort over a period of years, not only by the United States, but also by many European and Middle Eastern countries that have yet to make the commitment to work together and take the actions needed to thwart the global network that ISIS has become. This is a fight that the United States cannot — and should not — attempt to undertake alone.

Although it satisfies no one, the strategy most likely to succeed over the longer term is to continue to pursue limited military actions while undertaking a significant diplomatic effort to bring together a broad-based coalition to contain and weaken ISIS. This will also require patient application of humanitarian assistance to support civilians fleeing areas under ISIS control, thus allowing them to remain in the area instead of seeking to emigrate to Europe and beyond. It will also mean continued pressure on the Iraqi and Syrian governments to help them develop more effective ways to integrate their alienated Sunni populations into governance structures.

Acknowledging this, the role of the United States is indispensable in encouraging, leveraging, and legitimizing action against ISIS. Without that role, other countries will almost certainly fail to step forward and undertake actions that will sufficiently degrade the group's ability to act. If ISIS is able to continue to control large swaths of territory and spout a radical ideology of intolerance that continues to attract new recruits, the passions and zeal of its adherents will mean that no area on this globe can truly feel safe.

While the citizens of Iraq and Syria will suffer most directly, more and more attacks may take place around the world undertaken by individuals who have little, if any, formal connection with the organization. They may simply take the mantle of the group's ideas on their shoulders and conduct attacks in its name. While these attacks may happen sporadically in the United States, they are much more likely to happen in other parts of the world where intelligence agencies are much less effective.

While the debate continues over whether the United States has done too much — or not enough — in this area, we are reminded of one of the old adages of dealing with the Middle East: No matter how bad the situation, it can always become worse.

Dr. Kathy Hawk is an associate professor in political science and teaches a variety of courses at the undergraduate and graduate level in international relations, U.S. foreign policy, and U.S. national security policy. She received her Ph.D. in political science from the University of Alabama. In addition to her academic experience, she was a U.S. Foreign Service Officer and worked at the U. S. Embassy in Cairo, Egypt, and served as a Press Secretary to a member of Congress. Professor Hawk is also a member of the U.S. Navy Reserve and has been mobilized to active duty twice in support of Operation Enduring Freedom during the past eight years. She holds the rank of Captain. She is also the author of the book Constructing the Stable State: Goals for Intervention and Peacebuilding.

Systems engineering amplifies the power of the human mind

By Paul *Collopy*
Professor of Systems Engineering

Every day in Huntsville, Alabama, we are reminded of some of the greatest achievements of the human race. The Saturn V rocket, a replica of the vehicle that NASA astronauts rode to the moon, overlooks the city. Nearby sits a prototype of the SR-71 Blackbird, the fastest airplane ever put into service. Every day, huge twin-rotor Chinook helicopters fly overhead. From Huntsville's airport, Boeing's largest aircraft fly freight across the world.

All these aerospace wonders were created in the 30 years following World War II. The middle of the 20th century gave us critical materials, manufacturing processes, and scientific advances that helped enable the engineering design and development of moon rockets, durable helicopters, and supersonic airplanes. How were these wonders brought about?

In each case, they were realized through the collaboration of thousands of engineers, a kind of collaboration that had never been achieved before. There is nothing new about teaming thousands of workers together for massive undertakings. In ancient Egypt thousands of workers hauled stones to build the pyramids. Moving a single stone toward the pyramid was a physical task so large that it required hundreds of people pulling together. In wartime, tens of thousands of soldiers fight together to achieve tactical objectives. In the invasion of Normandy in 1944, groups of dozens or hundreds of soldiers were executing the same task. Successfully conquering a particular bluff or pillbox was a military task so difficult that large formations of troops were necessary. So what is so special about thousands of engineers designing a large airplane or a transportation system to the moon?

To design a moon rocket or a jumbo jet, the challenge is intellectual rather than physical, which introduces a new type of difficulty. The engineering behind the Saturn V is too complex for one person, or even a team of a dozen people to understand. The Egyptians could combine with one rope the work of dozens of laborers. Systems engineering is the modern equivalent of a rope for effectively combining the separate thoughts of dozens, hundreds, and even thousands of intellectual workers. Systems engineering is the discipline that guides, coordinates and facilitates design engineers in large engineering projects. In a modern large engineering project, every engineer is engaged in a separate task. Because of this, every engineer sees the project in a different way. This is similar to the old story about a group of blind men who are tasked with describing an elephant by feeling it, and each perceives the elephant as a very different thing depending on whether he explored the trunk, or leg, or tail. When a modern aircraft or spacecraft is designed, a thousand engineers may team together and each will describe the aircraft differently from the point of view of their particular assignment.

The large engineering projects that followed World War II brought together large and diverse teams of engineers to take on vast cognitive tasks about which no one person, not even the project manager or the chief engineer, understood more than a few percent of the whole. Think about this. In the 20th century, humankind learned how to deliberately create artifacts that exceed human technical comprehension. Examples are software programs with millions of lines of source code, or integrated circuits with 4 billion transistors. Even more difficult to comprehend, however, are modern aircraft, rockets, and spacecraft that combine sophisticated mechanical systems with massive electronics driven by huge software programs. These very complex machines are designed by thousands of engineers, coordinated by hundreds of systems engineers. So, how does systems engineering work? How can people design things that are more complex than anyone can understand?

To get a grasp of this, consider the design of ships in 1900. The first complex engineered systems were large ships with a vast number of parts, such as battleships and ocean liners. Systems were needed for propulsion, steering, plumbing, lighting, and kitchens. Battleships also had armor and guns and sometimes torpedoes. Engineers dealt with complexity by dividing the ship into parts and designing the parts separately. One person would design the rudder, and another would design the propeller. The designers would discuss interfaces with each other to make sure, for example, that the boiler would fit inside the hull. During this period, design was successful without systems engineers because the design teams were not very large, and the interactions between different parts of the ship were fairly straightforward.

It was during the development of torpedoes around 1900 that our ability to design complex engineered systems hit a wall. Although ships had more parts than a torpedo, the torpedo was more difficult because almost all of the parts of a torpedo interacted with each other, usually in ways that caused the torpedo to miss its target. A torpedo is essentially an automated submarine with very complicated control systems managing speed, direction, and depth. The propeller interacts with the engine exhaust while the gyroscopes interact with the engine torque. For several decades, all the way up to World War II, the torpedo's systems problems were not effectively sorted out. A new way of managing complex engineered systems was needed.

This new way arrived with the development of intercontinental ballistic missiles in the 1950s. The Ramo-Wooldridge Corp., with help from The Boeing Company, led the design of a process for systems engineering. It worked like this: quantitative requirements for the system were defined, such as "the missile shall be able to strike a target 8,000 miles away and shall strike within 200 feet of the target on 50 percent of its flights." From these, similar quantitative requirements were derived for the engine, the nozzle, the structure, the guidance system, and all other parts of the missile. From the engine requirements, additional technical requirements were derived for each part of the engine, such as the combustion chamber and the fuel pump. Eventually, every part of the missile had technical requirements. Once the parts were designed, they were built and tested to be sure that every requirement was met. Then the parts were assembled into systems, like propulsion or navigation, and each system was tested to ensure that it met its particular requirements. And so on until the whole missile was tested.

In design, a missile is broken down into major systems, each system is broken down into subsystems, and each subsystem is broken down further. If the missile counts as level one, and the major systems are at level two, the early intercontinental missiles had about five levels. At the bottom level are parts, and the point of the whole process is to break down the whole system far enough that each part is simple enough for one engineer to design.

This process made sense. It should have been able to deliver the end product within specifications. However, in reality, there were often problems with interfaces where one subsystem had a very elaborate connection to another subsystem. For instance, the guidance system has a complicated connection to the steering system requiring a whole set of information to be passed back and forth very quickly and very accurately. Problems encountered during testing were often due to these interfaces. The engineers designing equipment on one side of the interface expected it to work in a slightly different way than the engineers on the other side. Nevertheless, once systems engineers realized that interfaces, especially complicated interfaces, needed a great deal of attention and care, the whole process generally worked.

However, during the last 40 years, the process has been working less effectively. Today's complex engineered systems, like the Boeing 787 airliner, have seven to 10 levels of decomposition, leading to around 100 times as many different parts. The connection between the overall airplane design and the individual part design is much more tenuous and much less clear. Under the stress of large complex applications, the systems engineering process that was so effective in the 1950s is exhibiting its shortcomings. Currently, 90 percent of our aerospace and defense systems cost more than we thought they would, averaging a 50 percent overrun of cost estimates. Systems require more years to develop than we expect. Between 30 and 50 percent of programs are cancelled, usually for cost and schedule overruns.

To put this in perspective, my own study showed that the Department of Defense alone loses $200 million per day to overruns, delays, and cancellations in the development of large complex engineered systems. (Defense is no better or worse than any similar organization. They keep more detailed public records, which makes their engineering performance easier to assess.)

Why does the simple, common-sense approach to systems engineering fail to successfully manage modern development programs? This question takes us back to where we started – these systems are so complex that no single person can understand more than one or two percent of the whole thing. When we set the overall system requirements, we are predicting what the system can do. However, because no one really understands the whole system, our predictions are in error. We cannot know what the system is capable of until we build it and test it. At that point, it is much too late to write requirements.

So where do we go from here? Imagine a future without requirements, where, instead of saying, "We want an airliner with a range of 8,200 miles," we say, "Let's make an airplane about this big, design it to be as good as it can be, and see how far we can get it to fly." Perhaps there is a way to engineer systems without predicting the design outcome. This would be very helpful since we prove on every project that we are not very good at predicting outcomes. Would we rather have an airliner that meets requirements, or have the best airliner that is possible? Because we cannot obtain a system that is better than the best possible system, why not make a systems engineering process that designs the very best possible system? Why settle for less?

The further we delve into such questions the more we realize that systems engineering is a discipline in its infancy and the best times for systems engineers are yet to come. Most of systems engineering is a collection of ad hoc processes, all of which seem to make sense. Unlike other fields of engineering, the processes are not grounded in scientific theory. They are not proven to be effective. They only seem reasonable.

A new wave of systems engineering is coming due that has this grounding in theory — a science of systems engineering. The new processes will be more effective and the impact on engineering design and development will be more powerful.

Systems engineering, at its best, amplifies the engineering power of the human mind. Large organizations become system-designing entities that comprehend systems thousands of times more complex than any one person could grasp. A greatly improved systems engineering approach could unleash the capacity of humanity for technological accomplishment. We could master our world and visit others. We could solve environmental crises while making cheap energy available to everyone. We could open the door to a new renaissance of human potential.

Dr. Paul Collopy is a professor of systems engineering and chair of the industrial systems engineering and engineering management department at UAH. He earned his Ph.D. in engineering-economic systems from Stanford University, and he was formerly a program director at the National Science Foundation. His research interests are engineering and systems design, complex engineered systems, systems science, and technology management.

Why we argue about climate change
'Settled science' isn't necessarily so

By John R. Christy
Distinguished Professor of Atmospheric Science

Why do we argue about climate change?

The reason there is so much contention regarding "global warming" is relatively simple to understand. In climate change science we basically cannot prove anything about how the climate will change as a result of adding extra greenhouse gases to the atmosphere. So, we are left to argue about unprovable claims. That's really what it boils down to.

Now, we can indeed measure and prove that the concentration of atmospheric greenhouse gases is increasing (primarily because we burn carbon — coal, oil and natural gas — for energy). In the laboratory, we can also measure and prove that adding greenhouse gases to a confined parcel of air, for example, will lead to further warming. We don't argue about these results.

But when it comes to how the actual climate system might respond to extra greenhouse gases, there is no "proof" to offer because the climate's complexities are innumerable and poorly understood.

Climate science is a murky science. When dealing with variations and trends that might be influenced by humans, we do not have an instrument that tells us how much of the change is due to humans and how much to Mother Nature. Measuring the temperature change over long periods of time is difficult enough, but we do not know why these changes occur. So, we argue about the "why" because there is no direct, reproducible evidence for the cause of the slower changes we see.

The real climate system is so massively complex that we do not have the ability to test global-size theories in a laboratory. Without this ability, we tend to come up with all sorts of explanations about what are essentially unprovable claims. These explanations might comfort our souls because we as humans crave certainty over ambiguity, but they generally won't stand in the light of a hard-nosed cross-examination.

Now, it is a fundamental characteristic of the scientific method that, when we understand a system, we are able to predict its behavior.

One way to check our predictive capability is to test computer simulations. If a system's important details can be represented properly in a computer model, predictions can be accurate and therefore valuable.

Unfortunately, even the most advanced set of climate model simulations does not deliver much confidence at all. I analyzed the tropical atmospheric temperature change in 102 of the latest climate model simulations covering the past 36 years. If greenhouse gases are warming the Earth, this is the first place to look because models indicate a rapid warming for this region.

I found that all 102 model runs overshot the actual temperature change on average by a factor of three. Not only does this tell us we don't have a good grasp on the way climate varies, but the fact that all simulations overcooked the atmosphere means there is probably a warm bias built into the basic theory — the same theory that we've been told is "settled science."

As important as models can be, we have a long way to go. It is troubling to realize that current policy is being based on these computer models, none of which has been validated by a formalized, independent analysis. Without direct evidence and with poor model predictability, we tend to look for explanations that confirm whatever biases we might have. It seems ironic to me that the less direct evidence there is for a position, more passion is applied and more certainty is claimed.

Some might look to certain short-term climate anomalies and convince themselves humans are the cause. I often hear claims that extreme weather is getting worse. Now, here we do have direct evidence to check. Whether it's tornadoes (no changes in 60 years), hurricanes (no changes in 120 years), or Western U.S. droughts and heat waves (not as bad as they were 1,000 years ago), the evidence doesn't support those claims. So, we argue.

One way to cope with the ambiguity of climate, and many folks tend to latch on to this, is to believe a self-selected "authority." This "authority" does the thinking for them, without them realizing that this "authority" doesn't have any more direct evidence than they do. Other avenues for explanations follow a different path: Without direct evidence, folks start with their core beliefs (be they political, social, or religious) and then extrapolate an answer to climate change from there. That's scary.

Then, there is that time-honored, media-approved, headline-grabbing source of truth — the opinion poll. The poll can be of scientists, non-scientists, groundhogs, or anyone with a smartphone. Think about this. If no one has direct evidence to substantiate any claim of the impact of greenhouse gases on climate, what will an opinion poll provide besides entertainment, or worse, justification for one's agenda?

If you give this polling tack some thought, it's relatively clever. Without evidence to prove or refute the claims of a climate poll, the poll becomes a way to support whatever claims are being made. With enough attention, a poll's climate claim morphs into "settled science." So, we argue even more; however, those on the minority side of the poll are considered heretics in the light of the authoritative poll.

Virtually the entire world has decided to continue to burn carbon to provide affordable energy for their people. Even two of the countries that have spent billions of dollars on alternative energy, Germany and Japan, are witnessing increasing emissions as they rely more on coal-fired power plants.

There is no argument that energy (represented in electricity, transportation, and industrialization) enhances the quality and length of human life (this is provable). As a result, climate change, as it impacts energy policy, morphs from a scientific issue to a moral issue — is it good to enhance the quality and length of human life? Right now and for the foreseeable future, the lives of billions of people will be made better because of carbon-based energy. That won't change because carbon is affordable.

Should we study new sources of energy? Absolutely. And, when they become safe and affordable, they could be ready for deployment. Until then, I'd rather see my five grandchildren have the opportunity to accumulate wealth, enabled by affordable energy, so they can face whatever vagaries the future world (and its climate) might throw at them rather than be made poorer and thus more vulnerable.

So, when you consider the human cost of raising energy prices by demonizing carbon (based on unprovable claims of climate change), this becomes much more than a murky scientific issue, and explains why the stakes, and thus passions, can be so high. That's why we argue.

Dr. John R. Christy is the distinguished professor of atmospheric science at The University of Alabama in Huntsville and the Alabama State Climatologist. Dr. Christy also served as a lead author on the United Nation's Intergovernmental Panel on Climate Change, which received the Nobel Peace Prize in 2007.

Serious concerns exist in control system security

By Rayford B. Vaughn, Jr.
Vice President of Research and Economic Development

This paper outlines serious security concerns associated with industrial control systems that are often found in critical infrastructure applications. The 10 concerns were developed based on more than six years of research using a unique industrial control systems security laboratory and sponsorship by the U.S. Department of Homeland Security, the National Science Foundation, as well as the Department of Defense. The concerns are not presented in any particular order as each concern is quite serious and introduces realistic attack vectors into a critical infrastructure.

All industrialized nations have recognized the need for protection of national infrastructures that society depends on to maintain quality of life and guarantee the safety and security of its citizenry. In the United States, a Presidential directive issued in May 1998 set up a national program of "Critical Infrastructure Protection." In Europe, the "European Programme for Critical Infrastructure Protection" (EPCIP) refers to the doctrine or specific programs created as a result of the European Commission's directive EU COM (2006)786, which designates European critical infrastructure that, in case of fault, incident, or attack, could impact both the country where it is hosted and at least one other European Member State.

However, while governments have recognized the importance of critical infrastructure, very little has been done to actually secure the underlying component elements of the controlling structures (e.g., human-machine interface software, radio links, development of prevention/detection tools, and secure protocols) beyond point-mitigation strategies. A comprehensive approach to control system security has not been established nor is third-party validation of the security functionality a common occurrence. Of special concern is the likely relationship between vulnerabilities and attack vectors in industrial control systems (ICS) versus automated weapon systems, which use similar control functions and control paths.

Since 2007, the author has been engaged in the research reported in this essay and has demonstrated both significant and exploitable vulnerabilities and strategies that are plausible, affordable, and reasonable to prevent or mitigate such attacks. Additionally, the author and a graduate student identified the first industrial control systems hacker who was convicted and jailed in the United States and is currently serving seven years in federal prison for implanting malicious code and manipulating a control system operating an HVAC system within a hospital which served as proof of attack viability and ease. This paper outlines 10 serious concerns (based on the author's experience and opinion) with industrial control system security that should be, at the very least, considered when investigating the cybersecurity aspects of ICS implementations and perhaps weapons systems reviews.

The top 10 cybersecurity-related control system concerns are described briefly in the paragraphs that follow:

Controlling software is often flawed

An ICS is normally monitored by an operator using a software package known as a Human-Machine Interface (HMI). Existing commercial products have been shown to have significant vulnerabilities that include fragile authentication, authentication bypass, and poor use of the underlying operating system security features. When software is built without adhering to established secure software engineering principles, the introduction of vulnerabilities is an assured result. Hundreds of such vulnerabilities have been reported and continue to be discovered. Without implementation of strong secure software design and implementation and competent third-party evaluation, this weakness is likely to continue.

No forensics trail

If or when a security relevant event occurs in ICS, there is generally no audit trail of what caused the event. There is no device similar to an airplane "black box" that can replay events that may have caused anomalous behavior in ICS systems or even significant events such as a power outage or gas pipeline explosion. While some audit files do exist, a comprehensive audit trail does not. Being able to recreate an event is fundamental to establishing cause and effect.

No third party validation

In government use of IT software with access to sensitive data, some third-party validation of the assurance level of the software being employed is required under ISO Standard 15408 (aka, the Common Criteria). Software in ICS environments is not subject to validation by any third party but probably should be. Such validation from an assurance standpoint could help in removing vulnerabilities and improving security architectures. This concern further implies that there is a need for architectural principles that evaluators would use as a baseline to evaluate against. Such architectural principles do exist for standard IT systems but have not been adapted for the control systems environment. Again, many of the information assurance principles embedded in the international Common Criteria and earlier U.S. Trusted Computer System Evaluation Criteria still apply.

Protocols are not standard or robust

The Internet protocol, TCP/IP version 4 or version 6, has some protection built in against certain kinds of network attacks or is at least standard enough in implementation that intrusion detection devices and firewall rules can anticipate and detect malformed packets that should be discarded. Protocols in ICS environments are often very vendor specific, are not robust, and are subject to basic attacks that are easy to implement. Examples of such protocols include MODBUS, DNP3, and many others prevalent in ICS.

Lack of tools for prevention, detection, and response

Because protocols are very vendor specific and not developed with resilience in mind, there has not been a large market for prevention, detection, and response tools that can be employed in the ICS space and the market has, so far, shown little desire to purchase and/or implement them. This would suggest that legislation might be needed to require cybersecurity defense strategies, implementation of prudent defense measures, and strong operational procedures within an organization.

Lack of awareness training in the ICS community

Very little awareness training or a requirement for such training exists in the ICS owner/operator community. Offering such awareness training is often problematic due to difficulties in obtaining access to the owner/operator community and the funding necessary for training expenses. While interest and awareness of the need seems to be growing, the ability to train the owner/operator workforce and to implement the result of the training is problematic today. Additionally, there are few such training programs available today, which the problem further exacerbated by introducing high registration fees and travel expenses.

Lack of vulnerability assessments in critical infrastructure ICS

Few red teams exist for this environment or are allowed to work within the ICS community. The Army has such a team at the Engineering Research Development Center in Vicksburg, Mississippi, as does Sandia National Laboratory in New Mexico. The author has heard that additional teams are being formed, but these are primarily for government applications. More such specialized teams are needed for the commercial sector.

Lack of information sharing

Critical infrastructure owner/operators are not generally willing to share vulnerability information or disclose details useful to others. Oftentimes security vulnerabilities or attacks go unreported. While the government has established a series of Information Sharing and Analysis Centers (ISACs) to facilitate such sharing, the results are somewhat limited. A more recent attempt by the government to address this can be found in the Department of Homeland Security's implementation of Information Sharing and Analysis Organizations (ISAOs). DHS indicates that organizations such as traditional critical infrastructure sectors need to be able to share and respond to cyber risk in as close to real time as possible. However, many companies have found it challenging to develop effective information sharing organizations. In response, President Obama has issued Executive Order 13691 directing the Department of Homeland Security (DHS) to encourage the development of ISAOs. This order intends to develop a means for granting government clearances to private sector individuals; promote coordination with ISAOs via the DHS National Cybersecurity and Communications Integration Center (NCCIC); and, select a non-governmental organization to serve as the ISAO Standards Organization, which will identify a set of voluntary standards or guidelines for the creation and functioning of ISAOs.

Supply chain concerns

The hardware and software components of ICS implementations often come from unknown or untrusted origins. This clearly introduces a concern with the vulnerability to introduction of malicious functionality. This concern is further exacerbated by the lack of any third-party evaluation of ICS products and the lack of protection/detection tools.

Educational opportunities in this area

Curriculum exists for IT professionals and for industrial engineers, but very little overlap between the two exists. Formal classes that involve both communities together are needed.

In conclusion, this paper has outlined 10 weaknesses that need to be addressed with respect to enhancing critical infrastructure security by improving the cybersecurity posture of industrial control systems. Some of the concerns are technical while others are procedural. Some will likely required congressional legislation in order to address them whereas others can be addressed now. The suggestion is made that industrial control systems are similar in design and architecture to weapons systems and additional investigation in that area is needed.

Dr. Rayford Vaughn is the Vice President for Research and Economic Development and a distinguished professor of computer science. He had a 26-year career with the U.S. Army where most of his service was as a software engineer and computer scientist. His teaching and research interests are software engineering and computer security. He earned a Ph.D. in computer science from Kansas State University.

Incivility in American political discourse

By Clarke Rountree
Professor and Chair of Communication Arts

In 2009, when President Barack Obama presented his health care plan to Congress, Representative Joe Wilson (R-SC) disturbed the House chamber and a nationally televised address by yelling out "You lie!" when Obama said that illegal immigrants would not be covered by his health care proposal. Attendees at "town hall" rallies carried signs showing Obama as Hitler.

Representative Alan Grayson (D-FL) claimed: "If you get sick, America, the Republican health care plan is this: Die quickly." Former GOP vice presidential candidate Sarah Palin claimed that the health care law included "death panels" that would decide who was worthy of living and who would be left to die. Senate Majority Leader Harry Reid (D-NV) compared Republican resistance to health care reform to those who resisted the abolition of slavery. For years, Obama detractors pushed the idea that the

44th president of the United States was born in Africa and ineligible to be our nation's leader, including billionaire developer, television star, and Republican presidential candidate Donald Trump, leading Obama to release his long-form birth certificate from Hawaii to prove his citizenship. Liberal MSNBC commentator Ed Schultz called conservative commentator Laura Ingraham a "right-wing slut" and California National Organization for Women president Patty Bellasalma called GOP gubernatorial candidate Meg Whitman "a political whore." More recently, Dr. Ben Carson, a GOP candidate for the 2016 presidential election, called President Obama a "psychopath."

Most Americans don't need to hear examples like these to recognize that we live in an age of political incivility. Such incivility leads to political polarization, legislative gridlock, and cynicism about government. Although we have suffered through rancorous times before — the Civil War era being the most notable — today's incivility is different. In a two-volume edited book I published in 2013, *Venomous Speech: Problems in American Political Discourse on the Right and Left* (Praeger), 23 scholars explored different facets of the problem of incivility today. I opened the book by explaining what I see as the key causes of our current political dysfunction. In this essay I will summarize those causes and explain why it may be difficult to change this situation in the short run. Three major causes of this incivility are the media revolution, the campaign finance revolution, and the reshuffling of political parties.

The media revolution started shortly after the Watergate scandal that toppled President Nixon and inspired journalists to be aggressive in rooting out corruption. That aggressiveness is reflected in a number of minor scandals that the media blew up into major news stories, often adding "-gate" to the end, such as Billygate (Carter), Irangate (Reagan), Troopergate (Clinton), Plamegate (Bush II), Bridgegate (NJ Governor Christie), and many others. The media became more interested in pursuing such stories with the advent of 24/7 television news after the launch of CNN in 1980 and several other news channels since then. The proliferation of cable channels led to "narrowcasting," whereby smaller and smaller audiences were reached by each channel, and networks could adapt their programming to political tastes, with Fox addressing conservatives and MSNBC addressing liberals. Instead of serving a broad audience as a public service, these news stations are required to turn a profit and rely on cheap, talking heads rather than expensive investigative reports to fill the endless news cycle. Those talking heads often draw bigger audiences by taking controversial positions, vilifying their political opponents, and engaging in dramatic disputes.

The Internet revolution took this media revolution to its ultimate end, allowing anyone with a computer to become a webcaster to the world. Those with a political axe to grind could float unsubstantiated, scurrilous rumors about politicians and their proposals. If they had enough followers that could lead major news organizations, whose stories are otherwise limited by journalistic standards and ethics, to respond to the "buzz" created by popular bloggers as news that has to be covered. This is how the ridiculous claims about Obama's "African" birthplace got legs and how a Dallas minister was able to undermine GOP presidential candidate Mitt Romney by publicly calling his Mormon religion "a cult." Today's news media are shaped by ideas between fringe figures on the web and major news media whose ability to filter our scandalous and unsubstantiated claims has been seriously eroded.

Of course, not all such incivility is propagated freely by the press; much of it is in paid advertisements. While George W. Bush was the first president to raise $100 million for his presidential bid in 2000, Obama's first race raised about $1 billion. And that was before the 2010 U.S. Supreme Court decision in Citizens United v. FEC released a tsunami of money into our political system. That decision gutted important parts of the 2007 McCain-Feingold Campaign Finance Reform Act. The result is that in 2012, several wealthy donors contributed $10 million to favored campaigns. The conservative Koch brothers have pledged almost $1 billion from their political organization to help elect a Republican president in 2016. Third-party organizations spend a great deal of money on negative advertising, attacking candidates so their preferred politicians can win. Because they are not supposed to coordinate with candidates — though some undoubtedly do so tacitly or surreptitiously — they can be more vitriolic, because the candidates can hold them at arms length and worry less about the negativity reflecting on themselves.

The negativity seen in campaigns also has been increased by the polarization of the leading political parties. Before the 1980s, Northeastern moderates and liberal Democrats would have to compromise with more conservative Southern Democrats to get things done. Republicans would have to pull together liberals and moderates from the Northeast, West Coast, and Midwest. And both parties would reach across the aisle to get legislation passed. That all began to change with President Lyndon Johnson's push for the Civil Rights Act of 1964 and the Voting Rights Act of 1965, which alienated Southern Democrats and opened the door for Richard Nixon's "Southern strategy" to peel off conservative Democrats by going soft on civil rights. President Reagan was the master of this strategy, combining an appeal to Christian evangelicals by allying with the Moral Majority, a newly active political group led by Reverend Jerry Falwell. Both Bushes followed suit, by allying with the Christian Coalition (Bush I) and Focus on the Family (Bush II). Issues like abortion and school prayer helped solidify the divide. Gerrymandering — both to ensure African-American equity at the voting booth and to ensure political advantage — has become the primary means for consolidating political power. It also has given greater power to the fringes of both parties who turn out to primaries (where only one-third of voters show up) and choose party candidates. These candidates speak to their base, leading to more corrosive discourse than would be required if they addressed a more centrist audience.

It is clear that the economics and culture of our news media, campaign financing, and reshuffling of political parties have made our discourse less civil. Is there anything we can do to change this situation? Unfortunately, there are few practicable solutions.

We could amend the Constitution to overturn the Citizens United decision and reduce the role of self-interested billionaires in our political process; but passing such an amendment is nearly impossible for those with a vested interested in maintaining the status quo. More likely is that a conservative vacancy on the Supreme Court might lead to a more progressive replacement that could reverse that 5-4 decision. We could reduce the election period, lessening the period of negative attacks — Great Britain's elections last only six weeks. However, political parties and states control this process now and states probably would not sacrifice the chance for politicians to woo them by visiting and learning about their concerns. Third parties might break up the tit-for-tat feud between the Democrats and Republicans, but our political system is decidedly unfriendly to third parties. And experience with the recently inaugurated

Tea Party — which has been among the most vitriolic sources of political discourse — does not suggest that new parties will yield more civility.

We could move elections to the weekend to encourage greater participation of the electorate and reduce the influence of voters on the far right and left, but Republicans actually are moving toward making voting less convenient through new voter ID laws to "crack down" on nonexistent voter fraud, resulting in the disenfranchisement of hundreds of thousands of voters. The only realistic effort we can undertake will have minor consequences: ensuring that public broadcasting continues to be supported (in the face of efforts to defund it), because it is one of the last bastions of political news that prefers substantive discussions over scandal, drama, and the "horse race" of elections. This is a depressing situation for our republic and one that likely will get much worse before voters actually rise up and demand change. For the immediate future, unfortunately, people will just accept that politics is a cynical game.

Dr. Clarke Rountree is chair of the Communication Arts Department. He received his Ph.D. in rhetorical studies at the University of Iowa. His research interests are judicial rhetoric, political rhetoric, Burkeian rhetorical theory, argument theory, rhetoric and race, and religious discourse.

Nursing education

Lifelong learning and academic progression

By Marsha Howell Adams
Professor and Dean of Nursing

The National League for Nursing (NLN) since its inception has represented all types of nursing education programs from the licensed practical/vocational nursing program to doctoral programs. This is one of the primary reasons that I decided to join this organization in the early 1980s. It is also why I became nationally and internationally involved and today serve as the organization's president.

As a practicing BSN nurse in rural health at that time, I worked side by side with the LPN/LVN, diploma, associate degree, and advanced practice nurse including the nurse practitioner, clinical nurse specialist, nurse midwife, and certified nurse anesthetist. I was able to see firsthand the impact that each of us had on providing quality and safe patient care based on our individual scopes of practice.

Since then, the healthcare system has become ever changing and more complex. The level of knowledge required to clinically reason leading to safe decision making has increased. With the Affordable Care Act in place, opportunities for all types of nurses, particularly advanced practice nurses, increases with a focus on preventative health and chronic care. Nurses will play a major role in interprofessional collaborative practice and coordination of care. Registered nurses will serve as care coordinators with the patient as the primary core of the patient-centered care team. The team will be composed of health care professionals such as physicians, and advanced practice nurses (nurse practitioners, clinical nurse specialists, and nurse anesthetists) as well as family members and community health workers.

More doctorally-prepared nurse educators will be needed to prepare the future nursing workforce. While the NLN has always been a champion for multiple entries into nursing practice, this organization also supports lifelong learning and its importance to meeting the mission of this organization: "to promote excellence in nursing education to build a strong and diverse workforce to advance the health of the nation and global community."

In the Institute of Medicine's 2010 report, "Future of Nursing: Leading Change, Advancing Health," the following four recommendations were made:

- Nurses should practice to the full extent of their education and training.
- Nurses should achieve higher levels of education and training through an improved education system that promotes seamless academic progression.
- Nurses should be full partners, with physicians and other health care professionals, in redesigning health care in the United States.
- Effective workforce planning and policy making require better data collection and information infrastructure.

This report called for a seamless pathway for nurses to progress along the educational continuum. Two goals were identified to promote academic progression: increase the proportion of registered nurses with a baccalaureate degree from 50 percent to 80 percent by the year 2020 and double the number of nurses with a doctoral degree by 2020. I think meeting the first goal will be an arduous task because of the barriers related to academic progression and the timeframe. With the creation of the Doctor of Nursing Practice (DNP) degree, meeting the second goal seems to be within reach.

Mechanisms have been put into play to begin to meet the first goal. In 2012, the Robert Wood Johnson Foundation created and funded the Academic Progression in Nursing program that awarded nine states known as action coalitions funding to develop models for creating a more highly educated and diverse nursing workforce. Barriers to academic progression such as loss of income, lack of incentives including tuition assistance, flexible working schedules and change in income post-graduation, and enrollment capacity in nursing programs will need to be addressed as these models evolve and are implemented. Organizations like the NLN are there to support nurse educators and their practice partners in the quest to provide quality nursing education at all levels and to promote lifelong learning and academic progression.

The University of Alabama in Huntsville (UAH) College of Nursing is working to do our part in meeting the Future of Nursing recommendations. The College offers an RN-to-BSN program that allows associate degree nurses (from two-year nursing programs) to complete their baccalaureate degree totally online (and they can work full time while going to the university) or individuals can choose to enroll in the RN/BSN/MSN and go from an associate degree to a master of science degree as an advanced practice nurse (nurse practitioner or clinical nurse specialist) or a leader in health care systems (administration).

If a nurse has already graduated with a baccalaureate degree, they can choose to attend the graduate nursing programs at UAH and work toward a family nurse practitioner or an adult gerontology (older adult populations) acute nurse practitioner degree. Both of these advanced practice nursing roles are needed to care for one of the fastest growing populations in the country and that is the older adult population. It has been estimated that, by 2030, the number of adults age 65 or older will more than double to 71 million, which has major implications for our health care system. The College of Nursing also offers a Doctor of Nursing Practice (DNP) degree awarded jointly with the other two campuses in the University of Alabama System. This totally online DNP is a post-master's degree program for advanced practice nurses and nurse administrators who want to develop critical clinical and systems skills with a focus on translating evidence-based care into practice and measuring patient, communities, and population outcomes. DNP graduates find themselves working as leaders in the health care setting or as nursing faculty in an academic setting preparing future nurses. At UAH, DNP students who are interested in pursuing a faculty role in the future can receive financial support while in school through the Nurse Faculty Loan Program.

According to a national Gallup poll, nurses are consistently ranked number one as the most trusted profession in the areas of honesty and ethical standards, and they have maintained this ranking for 12 years. Present evidence supports that patient outcomes improve, a higher level of quality and safer care is provided, and costs are lower when a more educated nurse provides care. It is imperative that lifelong learning becomes a way of life and an expectation for all nurses to produce the type of workforce needed to advance the health of our nation and global community.

Dr. Marsha Howell Adams, Ph.D., RN, CNE, ANEF, FAAN, is dean of the College of Nursing and a professor of nursing. Dr. Adams also serves as the president of the National League for Nursing.

Supply chain management

Leveraging unique capabilities within the university's strategic thrust

By Laird Burns

Assistant Professor of Management

Supply chain management is a relatively new academic field having arisen during the last 20 to 30 years to become a major field of research in business and engineering schools. The earlier view of supply chain management focused on logistics, distribution, and supplier relationships with significant research into developing competitive advantages, such as developing superior logistical and distribution systems, improving and integrating relationships with key suppliers and sub-suppliers into company operations, and understanding the true cost of ownership from components purchased from suppliers — beyond purchase price and transportation costs.

A more modern view also includes the recognition that excellence in supply chain management can be a strategic competitive weapon for firms that develop strategic capabilities across the span of supply chains — from end-customers to the origins of raw materials. These capabilities typically include balancing customer demand profiles with supplier performance, lowering inventories and improving throughput, and concurrent engineering to simultaneously leverage customer requirements and supplier capabilities to develop new products faster and at lower cost. UAH has several areas of excellence in supply chain management: excellence in teaching, excellence in supply chain mentoring, and excellence in supply chain research and outreach. Each of these is explored in the following sections.

Excellence in supply chain teaching

UAH undergraduate students in marketing, management, and information systems can earn a concentration in supply chain management, and MBA students can earn an emphasis in supply chain management. In addition, UAH recently added a master's of science degree in supply chain & logistics management, and offers graduate-level education through a certificate program in supply chain management. The university partnered with the U.S. Army — Army Materiel Command (AMC), Aviation Missile Command (AMCOM), and Logistics Support Activity (LOGSA) — and recently graduated a full cohort of Army civilians through the Supply Chain Management Graduate Certificate Program. Even though these programs and concentrations have been developed in the last few years, our students report considerable success in their supply chain careers after leaving UAH.

Excellence in supply chain mentoring

Our graduate and undergraduate students participate in many internships and academic co-op positions with commercial companies, not-for-profits, and governmental agencies in a variety of supply chain positions. In addition, students can participate and be mentored in undergraduate and graduate research assistantships that help them develop critical analytical and professional presentation skills while working in teams and on individual assignments to build skill sets that elevate their preparedness for their future careers. Our students are enthusiastic and grateful for the opportunities that they can leverage during their time at UAH. Our Supply Chain Management Association (SCMA) student club also provides opportunities for company and plant tours, guest speakers that help explain career opportunities, recruiting advice, and professional networking events with commercial companies, not-for-profit organizations, governmental agencies, and other colleges and universities.

Excellence in supply chain research and outreach

UAH has unique advantages in supply chain management due to our university history, geographic proximity to a wide range of organizations and technical experts in Cummings Research Park and Redstone Arsenal, and to our interdisciplinary approach to research. Perhaps some examples of prior and current research projects by faculty and research scientists will serve to illustrate UAH's unique opportunities and capabilities in supply chain management. In particular, our research is focused on developing an international reputation for expertise in complex supply chains, such as for weapon systems, space launch systems, transportation systems, and energy supply chains.

Supply chain performance metrics

Designing performance metrics systems to capture performance across many tiers in the supply chain can be challenging, but we have been fortunate to partner with Army commands to develop insights in these areas. An earlier multi-year research project focused on developing a performance measurement system for four tiers of the Army supply chain with major thrusts into on-time performance, cost, and quality performance.

This research involved: Tank-Automotive and Armaments Command (TACOM), Communication and Electronics Command (CECOM), Joint Munitions Command (JMC), Aviation & Missile Research Development and Engineering Center (AMRDEC), Tank Automotive Research, Development and Engineering Center (TARDEC), Communications-Electronics Research, Development and Engineering Center (CERDEC), as well as agencies listed above — AMC, AMCOM, and LOGSA.

More recent advances in this research thrust were sponsored by AMRDEC, and supported by AMCOM, to develop novel metrics for the Army's organic industrial base. This research produced a multi-level, near-real-time performance measurement system that measures quality, cost, and delivery by depot (or commercial company), as well as by levels in the organization, by program, by weapon system, and other views of depot performance. This system summarizes organizational performance using a unique performance index comprising of quality, cost, and delivery indices, which can be used to compare any depot to any other depot or commercial supplier. This research included a UAH collaboration among the College of Business Administration, the College of Engineering, the Center for Modeling, Simulation, and Analysis, and the Reliability and Failure Analysis Laboratory within the UAH Research Institute.

Complex supply chain transactional workflows

Analyzing transactional workflow across a large service organization, particularly when the organization is a governmental agency with international responsibilities, can be very challenging. The United States Army Security Assistance Command (USASAC) tasked the Center for Modeling, Simulation, and Analysis and the College of Business Administration with developing an advanced transactional workflow model that assessed resource and manpower requirements with inputs and outputs across multiple levels in the governmental supply chain for U.S. Army foreign military sales. This project required extensive supply chain mapping and an advanced computer model to properly verify and validate the model. This project also included a UAH collaboration with the Center for Management and Economic Research and the Office of Operational Excellence within the UAH Research Institute.

Assessing excess inventory for the Army Materiel Command

AMC manages what is perhaps the most complex supply chain processes on the planet. One of the many complex challenges that commercial companies and governmental organizations with physical supply chain processes must face is assessing inventory levels when facing demand patterns that are far from smooth.

In more simple supply chains where demand is "well behaved," we rely on decades-old analytical tools to calculate inventory levels and safety stocks to provide a targeted, high-percentage "fill rate" to support customers. But when demand is "lumpy," inconsistent, and highly variable over time, our tried and true methods do not work well. We were approached by the Army Materiel Command with a challenge: assess the requisite inventory stocking levels for highly complex and inconsistent demand levels.

In response to this challenge, we developed complex analytical models and computer models to produce a novel set of algorithms that expand the percentage of products that can be assessed for planning stocking levels relative to more traditional methods. This Army-funded research has gained the attention of several international commercial companies, who see the benefits of adopting the algorithms.

Excellence in systems engineering research

The College of Engineering, in collaboration with the College of Business Administration, the Center for Modeling, Simulation and Analysis, and external technical experts from commercial companies have collaborated with NASA to form the NASA/UAH Systems Engineering Consortium, which also includes several highly recognized faculty members from several other universities.

This multi-year research program has resulted in several research studies that have developed insights into lessons learned from decades of experience from top rocket scientists, a novel supply chain risk framework, and many technical advancements in our understanding of next-generation rocket science equations, sophisticated rocket science risk analysis tools, advancements in understanding decision-making in complex technical environments, and other achievements.

The supply chain risk research has also resulted in a research collaboration with the Center for International Manufacturing, a part of the Institute for Manufacturing at Cambridge University in England, one of the foremost universities in Europe with expertise in supply chain management.

Electrical energy supply chains

A research scientist working for the Center for Modeling, Simulation, and Analysis and a faculty member from the College of Business Administration have worked with Carina Technology, a local high-technology company, to pair their patented hardware and firmware with newly developed algorithms to classify and manage diverse electrical demand patterns by household into an integrated and real-time system for shifting peak electrical energy loads to non-peak time periods.

This approach and our algorithms have been field tested and proven to accurately manage this energy demand shift at a profit, reducing the necessity to build additional peak generators and reducing costs to all echelons in the supply chain. This research has led to requests for proposals to develop more advanced algorithms to take the research to an even larger scale.

The economics of solar energy in Huntsville

The Center for Modeling, Simulation, and Analysis and the College of Business Administration have collaborated with another local high-technology company to assess the economic feasibility of providing Redstone Arsenal with a larger-scale solar energy installation to help reduce the external energy generation requirements of the Arsenal. This study required converting ground-level solar radiation in the Huntsville area into solar energy conversion parameters for electricity production. This in turn required the assessment of complex solar energy cost structures against complex commercial energy cost structures to assess the long-term viability of solar energy in the Huntsville area.

Conclusion

Each of these areas and capabilities in supply chain management have been developed over the past few years at UAH. As we progress, we continue to improve our capabilities in supply chain management across teaching, mentoring, research, and community outreach to better serve our students, our university, and our community stakeholders. We look forward to our future in supply chain management, and look forward to partnering with you.

Dr. Laird Burns is an assistant professor of management and received his Ph.D. from Michigan State University. His research interests are operation and supply chain management, supply chain design, risk in supply networks, strategic risk assessment and management, and modeling of integrated supply networks. His teaching interests are operation and supply chain management, strategic integration, and competitive strategy.

Undue influence
Gatherers make it alluring to give away our information online

By Sandra Carpenter
Professor of Psychology
and
Feng Zhu
Associate Professor of Computer Science

Do you reveal too much information online? We know that some people disclose too much (TMI!) on social networking sites, such as Facebook, Pinterest, and LinkedIn. Whether or not that much disclosure is wise, people know that the information is available to others. But what about online sites where people don't intend to expose their identity, such as online auto insurance quotes or health support group sites?

Even if you fake your name and address on these sites, there is a two out of three chance (67 percent likelihood) that you, personally, can be identified by the combination of your gender, zip code, and date of birth.

Does this matter? Very possibly. The information is probably used to target you for marketing purposes. Although being deluged by marketing messages is annoying, it is not dangerous. The information you provide, however, may be sold to others with criminal intentions, such as identify theft. According to research by Latanya Sweeney of Carnegie Mellon University's Laboratory for International Data Privacy, some service providers collect as many as 100 identity elements from a user.

Unfortunately, most people don't consider their gender, zip code, and date of birth to be important to keep private. Our research at The University of Alabama in Huntsville (UAH) shows that most people agree that their social security, credit card, and driver's license numbers are critical to keep private in most circumstances. The research also shows that people do not think that date of birth, gender, and zip code are critical to keep private, so people are likely to reveal this information.

It is in the collaboration between psychology and computer science where the seed was planted for this research. A quote by privacy and security expert Bruce Schneier sparked the researchers' interest: "Only amateurs attack machines; professionals target people." This means that, although we can make hardware and software more secure, people often make bad decisions and disclose too much information.

In the early research, a big problem was that even when individuals knew the researchers were trying to collect their personal information, they were willing to give it out freely. Follow-up questioning showed that participants in the research trusted the university professors to keep their personal information secure. The researchers were then interested in whether people would be more cautious in disclosing their information if they thought the information was going to be given to a third party. This was, indeed, the case.

The current research program of the Privacy in Cyberspace Laboratory at UAH focuses on how data gatherers use psychological attacks to elicit information from online users. The researchers also design warnings to reduce exposure to this information. They are calling such inquiries "attacks" because while the requests for information seem friendly and innocuous on our screen — and are designed to appear so — we don't really know who is collecting the information or for what it is intended. Gatherers often use one or more social influence strategies that originate in marketing or cultural contexts, like providing us a reward, to increase their success rates.

One such social influence technique is reciprocity: “I’ll scratch your back if you scratch mine.” In experimental reciprocity conditions that we designed, people gave out more personal information than they did in the control group. In fact, people were three to five times more likely to disclose private information in the reciprocity attack condition.

It would be nice if something could effectively clue us in to all this by alerting us before our fingers go tappity-tap. Warning apps or plug-ins are possible outcomes of the research, but they’ll only work if they use effective methods that grab our attention.

The research has leveraged previous research on the aspects of warnings that are effective in industry for toxic chemicals, heavy equipment, and other dangers. The research is probing, with warning models, to discover which authoritative warning sources are more credible with users. The models indicate the stream of processes a person goes through to accept a warning. That includes assessing the strength of the authority issuing the warning, and the extent to which the person comprehends it, remembering it, changing attitudes because of it, and being motivated to modify behavior.

Experiments have been performed to examine disclosure behaviors when test subjects are not under attack, when they are under attack without a warning, and when they are under attack but have been effectively warned. When under attack with an effective warning, it is found that people disclose at about the rate of those not being attacked.

Current experimentation in the Privacy Cyberspace Lab includes an effort to identify the most effective strategies in reducing identity exposure. We are using eye trackers to acquire more precise information about human behavior. The eye trackers monitor where people are looking on a screen, be it on a PC, on a tablet, or on a phone. This will help determine which warnings are better at capturing and maintaining people’s attention.

The overall motivation behind this research is: How can we influence people to be more careful with the personal information they divulge online? The problem is: What will be effective warnings? Those are the solutions the researchers hope this research will produce.

Dr. Sandra Carpenter is a professor of psychology. She received her Ph.D. from the University of California-Santa Barbara. Her research interests are teamwork and social cognition, and the social psychology of cybersecurity.

Dr. Feng Zhu is an associate professor of computer science. He earned a Ph.D. in computer science and engineering from Michigan State University. His research interests are security and privacy for pervasive computing, as well as security and psychology.

Fusion propulsion will open interplanetary space for exploration

By Jason Cassibry

Associate Professor of Mechanical and Aerospace Engineering

We are going to Mars. It is not a matter of if, but when. The human desire to explore and ultimately thrive in new environments — no matter how inhospitable the destination or hostile the journey — is evident from our beginnings in Eastern Africa to the crossing of the land bridge connecting the Eastern and Western hemispheres of Earth, to the remote research station Amundsen–Scott South Pole Station in Antarctica.

Nearly half a century ago, yet another boundary was transcended as three humans, for the first time in history, left planet Earth and journeyed to another celestial body atop a 363-foot, three-stage rocket. Years later we are now developing the Space Launch System (SLS), an evolvable launch vehicle with a heavy variant capable of putting 130 tons into low Earth orbit. With the SLS and nearly two decades of experience in the construction and utilization of the International Space Station (ISS), we will soon have the ability to assemble large and powerful spacecraft in orbit for planetary exploration.

So where should we go with new spacecraft? To appreciate that question, one needs a convenient way to measure distance. When driving or flying, we use miles or kilometers (km), and the distance we travel varies from fractions of a mile to thousands of miles. In space, the distance to other celestial bodies is best measured in astronomical units (AUs), where one AU is 93 million miles or 150 million km, and likewise, these distances vary from fractions of an AU to thousands of AUs.

The moon is our nearest neighbor at 0.0026 AU from Earth. It sounds like a short hop, but it would take a commercial airliner more than three weeks of nonstop flying to travel that distance. Next to the moon, near Earth objects (NEOs) have elliptical orbits that bring many of them closer than 0.1 AU.

Mars, the nearest planet, lies in an orbit that is 0.5 AU from Earth. The distance to reach Mars is highly dependent on the trajectory taken by the spacecraft but would be close to 1 AU. Beyond Mars, if one were driving, the planetary road signs would read Asteroid Belt (2 to 4 AU), Jupiter (5 AU), Saturn (10 AU), Neptune (20 AU), Uranus (30 AU), and Pluto and the other Kuiper Belt objects (40-100 AU).

At 100 AU, a termination shock occurs where the sun's solar wind interacts with the interstellar background gas. Somewhere around 200 AU one would find long period comets, large icy bodies with orbits loosely connected to the sun. Those are the same type of comet that killed the dinosaurs millions of years ago and gives little warning prior to closing in on the inner solar system at 40 to 80 km. Beginning at 550 AU, the sun's gravity acts like an optical lense, which would enable detailed study of other solar systems. From 2,000 to 100,000 AU is the proposed Oort cloud, a very sparsely populated region of space containing mostly comets forming a halo around the solar system. Within the known physics we have available, the ultimate destination achievable within a human lifetime would be the closest stars, requiring 50 to 100 years to reach with advanced propulsion technologies. Proxima Centauri, the closest star to the sun, is 271,000 AU, or 4.22 light years, away.

To put that distance to the nearest star in perspective, 271,000 AU is 100 million times the distance from the Earth to the moon, so our journey into space is still in its infancy taking small steps. We will most likely return to the moon and asteroids as meaningful steps toward Mars. The moon and NEOs are readily accessible with the same technologies that launch humans to space, chemical propulsion, and require weeks to a few months to complete a mission. Because typical expeditions on the ISS last more than 200 days, these are missions with low risk while practicing excursions away from the planet. Visiting other planets however, introduces new risks and challenges, and it is in overcoming these challenges is that the benefits to human kind abound.

The journey to Mars with chemical propulsion is a much more difficult endeavor because of the great distance, which leads to a mission time of 1.8 to 2.5 years to complete. By comparison, the current record for human duration in space is 1.2 years. This longer duration brings harsh conditions to be endured by the crew. For example, the space environment subjects astronauts to the equivalent of eight chest X-rays of radiation per day, and the risk of getting cancer grows with each day in space. To shield against this radiation to the same level as Earth's atmosphere would require a hull of 15 feet of aluminum. Prolonged exposure to microgravity is another health risk, as muscle and bone mass will decrease in spite of routine excerise. Finally, there are psychological risks that are largely unknown, such as the strain of being so far removed from Earth, or the boredom that comes from being in a confined space for two years. To explore space beyond the Earth/moon system, we will have to overcome these new challenges.

The first missions will risk the lives of the crew and test the limits of human endurance. To reduce this risk, the trip time must be shortened by developing new propulsion systems not subject to the limitations chemical combustion. One promising pathway is through thermonuclear fusion, a class of nuclear reactions involving various light isotopes in the periodic table from hydrogen up to and including boron. The energy released in fusion reactions is more than 10 million times greater than that of the most energetic chemical reactions. Because of this tremendous energy release, a fusion-propulsion system has the potential to propel a spacecraft to Mars in under three months. For example, a recent conceptual design under NASA's Revolutionary Aerospace Systems Concepts (RASC) indicated a fusion-propulsion system capable of 5,000 newtons of thrust with exhaust velocities of 20,000-700,000 m/s could take humans from Earth to Mars and back in 7 months, during which the spacecraft will exceed 50,000 mph.

It is this potential of rapid transport to Mars that motivates the fusion-propulsion research under way at The University of Alabama in Huntsville (UAH). The objectives of the UAH Fusion Propulsion Research Facility (FPRF) are to 1) train the students to become researchers who can develop fusion-propulsion systems for human flight to the planets and 2) develop technologies, materials, and plasma sciences for reliable fusion propulsion for human-piloted space flight within a half century.

This effort initiated with the receipt of the 3-terawatt (TW) DECADE Module 2 from the Defense Threat Reduction Agency in May of 2012, which we have renamed Charger 1. The machine stores electrical energy and discharges it rapidly, similar to a camera flash. When Charger 1 operates, it will generate currents 30 times greater than a bolt of lightning with the fusion fuel reaching temperatures greater than the interior of the sun. The FPRF team is assembling and upgrading this machine as an experimental facility that will evaluate the fusion power and magnetic nozzle research necessary for understanding how to build a fusion rocket. UAH is working with NASA's Marshall Space Flight Center, Boeing, L-3 Communcations, Oak Ridge National Laboratory and Y-12 National Security Complex in this effort. The state of Alabama has also provided a significant innovation award to help with infrastructure.

Once Charger 1 becomes operational, it will be the largest pulsed-power machine in academia in the world.

With Charger 1, the FPRF team will explore the energy release from solid density "targets," including lithium deuteride and frozen deuterium. These materials will be formed into thin wires about the diameter of a human hair and an inch long. When Charger 1 fires its capacitor bank, 570,000 joules of electrical energy will start rushing one of these wires, generating magnetic fields in the hundreds of teslas. This generates the same type of force that causes a refrigerator magnet to stick, only in the case of our fusion experiments the force is so strong it will drive a shock wave through the inner core of the wire, compressing the material to several times the natural solid density of the fuel.

At peak compression, the maximum temperature will be reached in the center of the wire. Once the current reaches a maximum of 2 million amps, 50 years of experimental data from around the world suggest that the discharge, called a Z-pinch, will go unstable and take the magnetic field with it. What happens when hundreds of teslas of magnetic field suddenly drop to zero? A strong electric field takes it places, reigniting the current. In this process, some fraction of the high-density fuel will be accelerated to several thousand kilometers per second, all in a distance of millimeters. These high-velocity, high-density particles will smash into some of the stationary fuel generating most of the fusion in a bright flash that lasts 50 billionths of a second.

If we are successful, then these experiments will teach us about how to design both a new pulsed power system (Charger 2) and better, more optimized fusion targets which could produce more fusion energy output than the electrical energy input to the target by that pulsed-power system. Such a feat is called "break even," something only demonstrated in stars and thermonuclear weapons but never in a small-scale reactor.

Constructing Charger 2 and demonstrating break even will help us to take that next step. Interplanetary space will open up for exploration by humans. The journey to Mars will become as routine as sailing across the Atlantic Ocean three centuries earlier. New science missions will allow us to reach the outer planets in three years, compared to the decade it now requires. And back on planet Earth, a new form of clean energy will have been unlocked with an almost limitless supply of fuel in the oceans to sustain the power needs for humankind for millennia.

Dr. Jason Cassibry is an associate professor of mechanical and aerospace engineering. He was awarded his Ph.D. in mechanical engineering from The University of Alabama in Huntsville while performing research at NASA's Marshall Space Flight Center. His research interests are pulsed fusion for propulsion and power production, smooth-particle hydrodynamic modeling, and high-temperature equations of state.

Purposeful misattribution
The games academics play

By Alan Wilhite
Chair of Accounting, Finance, and Economics
and
Eric Fong
Associate Professor of Management

Although it may be difficult for people to understand, some scholars add authors and/or citations to their research projects even when those authors and citations have nothing to do with their work. Our research investigates this practice: how common is it, who does it, and why? We suggest that these actions are fueled by the intense competition for research funding and limited, high-quality journal space. Modeling this pressure as a zero-sum game we generate testable hypotheses about who manipulates and why and we test those hypotheses. The results suggest that manipulation is common and that many academics feel trapped in a system that compels them to participate in manipulative activities they find distasteful.

There are three common types of purposeful misattribution. The first is called honorary authorship, which consists of scholars who add authors to manuscripts or grant proposals even though they contribute little or nothing to the actual research effort. The second is coercive citation, which is when journal editors direct authors to add citations to their journals even though there is no apparent reason to do so. The third is padded citations, when authors add targeted or prestigious citations to their references even though those citations have little to do with the actual study but look good on the reference list. To gather data to investigate the frequency and reasons for such activity, we sent a series of surveys to more than 11,000 scholars from a wide array of academic fields (e.g., sciences, social sciences, medicine, and business). We found that manipulation is common: 35.5 percent of our respondents report that they have added an author to a manuscript and 20.8 percent have inflated the author list on grant proposals even though the contribution of those authors was minimal. Similarly, 40 percent of our respondents say they have added citations to manuscripts even though they did not use those studies and 15 percent have added unused citations to grant proposals. Concerning coercion, 14.1 percent of the respondents reported being coerced by scholarly journals.

Our studies provide a consistent message that the overwhelming majority of scholars disapprove of these practices: 79.7 percent say adding honorary authors is inappropriate or extremely inappropriate and 90.7 percent rate coercive citation similarly. Yet that so many still do it reveals an internal ethical struggle faced by scholars: many engage in activities of which they disapprove. As we shall see, a deeper investigation suggests that some authors and editors feel they have little choice — manipulation is the way the game is played. That finding may be the saddest result of all.

He found that scholars who lack political power (untenured assistant professors, associate professors) are more likely to add honorary authors and to be coerced by editors. Differences across discipline also exist with medicine and engineering more likely to add authors to grant proposals while the business disciplines add authors to manuscripts. The reasons for manipulation also vary. The most common reason individuals add an honorary author to a manuscript was that the honorary author was the director of the lab (24.6 percent of the responses).

The second most common reason (18.5 percent) was that the honorary author was in a position of authority and could affect the scholar's career. Third (11.4 percent) were mentors and the remaining reasons all fall below 10 percent. About 22 percent of the respondents selected "other." Regarding grant proposals, reputation was the dominant reason for adding an honorary author (56.9 percent).

We also looked at differences across funding agencies and found that the NSF, HHS, other federal funding, and corporate research grants are more likely to have proposals submitted to them with honorary authors than state research grants and grants from private, non-profit organizations. Otherwise, of more than 2,200 individuals who gave a specific reason as to why they added an honorary author to a grant proposal, there was little statistical variation in those reasons across disciplines, academic rank, or an individual's experience. Apparently, the reasons to add honorary authors permeate academia; it seems to be a part of the game and is practiced across disciplines and rank.

In conclusion, unfortunately, there is a significant level of gamesmanship in academic research even though our survey responses make it clear that most scholars consider such actions to be inappropriate or even unethical, but many feel compelled to participate because the competition for scarce resources is so fierce. And this competition is only getting tighter. If there is an advantage to be gained by coercing, adding authors, and adding citations then without safeguards these behaviors will continue to grow. Moreover, new types of manipulation will emerge; for example, citation collusion, in which multiple journals agree to pad each other's citation list has been uncovered, and "pay for publication" journals that falsely claim peer-review continue to proliferate.

While it would be difficult to eliminate such activities from academe, there are some policies that can help.

First, administrators need to promote clear rules concerning authorship. Far too many of our respondents said they added an honorary author because that individual could have an impact on their career. Whether these scholars are responding to an explicit or imagined threat, or trying to buy political support, matters little. It is not academically honest. Some institutions have historic norms in which mentors expect to have their names added to articles and/or lab directors are included on every activity that leaves that lab. New policies need to address such misattribution.

Second, we should increase the use of double-blind review in awarding grants. Blind-review focuses on the merit of a proposal and reduces honorary authorship incentives. The current system can inadvertently encourage misattribution. For example, some scholars are encouraged to visit granting agencies to meet with reviewers and directors of programs to talk about high-interest research areas. It is easy for them to interpret their visit as a name-collecting exercise, finding people to add and references to cite.

Third, the contributions made by each participant in a project should be made more transparent. Currently most journals do not require such transparency and that encourages inflated authorship lists.

Fourth, impact factors should no longer include self-citations. This simple act removes the editors' incentive to coerce authors.

Fifth, journals should explicitly ban their editors from coercing.

These steps have been taken by some journals, and while words do not ensure practice, signing a code of ethics reinforces ethical behavior because it encourages increased oversight by editorial boards. For example, in 2012, several journals, primarily in business, publicly denounced the practice of editorial coercion. It is our hope that these declarations will alter the culture in those fields. In the end, most scholars want to play it straight, and by enacting these types of policies we can make it less punitive for them to do so.

Dr. Alan Wilhite is chair of the economics department in the College of Business Administration. He earned his Ph.D. in economics at the University of Illinois-Urbana Champaign. His research interests are networks and computational economics.

Dr. Eric Fong is an associate professor of management. He was awarded a Ph.D. in strategy and organizational theory from the University of Florida. His research interests are executive compensation, labor markets, governance, and team effectiveness.

Bridging the gap

Promotion of full practice authority for advanced practice nurses in primary care

By Anna Benton

Clinical Instructor of Nursing

Advanced Practice Nurses (APNs) in primary care settings are well-educated, fully functioning, professional health care providers who should be able to enjoy full practice authority within their given roles across the United States.

Full practice authority refers to the nurse practitioner's ability to function in a provider role with the ability to diagnose, treat, prescribe, and refer without the supervision of a physician collaborator.

Because these scopes of practice are mandated by state nursing boards and adopted by legislation, opportunities for this type of major change in practice to occur must be present, according to the Institute of Medicine of the National Academies (IOM). Study in support of the scope of practice authority change is directed by the Institute of Medicine Report from 2010, "The Future of Nursing: Focus on Scope of Practice." This report indicates that APNs stand on the forefront of health care and because of their training and expertise should be practicing within their full scope of their abilities states the IOM. It has also been surmised that to fulfill the increase in volume of patients over the coming decades, this scope of practice change needs to also be adopted by governmental entities to ensure that legislation will be implemented nationwide says the IOM.

A way in which APNs can become advocates for change to practice authority within the body of nursing is through active membership and participation in professional nursing organizations.

These entities are able to provide nurses the opportunities for involvement from the local to national and international levels. The American Association of Nurse Practitioners (AANP) is a well-respected, highly recognized, professional nursing organization that supports the advancement and promotion of APNs in practice, according to the AANP. This organization has supported journal publications advocating this authority change.

One journal by the National Institute of Health Care Management offers support of APNs ability to function autonomously in primary care, and thereby advocates for all states to follow suit for these changes as well says the National Institute for Health Care Management.

There is currently a trend across the U.S. that governmental authorities are recognizing the contributions of APNs within primary care settings and thereby promoting legislation to support their full scopes of practice. Policies enacted through the Affordable Care Act of 2010 (ACA) offer funding and support of APNs in provider roles, especially in areas that are rural or underserved, according to the United States Department of Health and Human Services.

Because there is such a need for more provider care at this level of practice, APNs are eliminating the issue of the lack of physician providers. In addition, there is more incentive to treat patients more efficiently and more cost-effectively by providing a more inclusive approach. Wellness and prevention of illness then becomes the accord of care, rather than just narrowly focusing on the disease process. APNs are knowledgeable in these areas and are well trained for this method of care; thus, having full practice authority in these areas is crucial. APNs should be afforded the ability of functioning at this high-level capacity. APNs are highly influential and do have a voice for change. Challenges will arise as health care continues to transform.

However, with full practice authority granted to APNs, positive approaches will unfold. This will help ensure that patient needs are being met in primary care settings and that APNs are executing their skills at full capacity.

Dr. Anna Benton is a clinical instructor of nursing and received a Doctorate of Nursing Practice from The University of Alabama in Huntsville. Her academic specialties are adult and geriatric health, pediatric, obstetrical, and women's primary health.

Adapting digital to us

Education challenges and generation selfie

By Pavica Sheldon
Assistant Professor of Communication Arts

In his 1959 book, *The Presentation of Self in Everyday Life*, Erving Goffman described social life by using theatrical metaphors. All of us are performers who take on unique roles in different situations, according to Goffman.

We have a "front" stage behavior and a "back" stage behavior. When we follow formal societal rules, we are on the front stage playing a "role." Goffman argued that when an individual appears in the presence of others, he will want to convey an impression to them that is in his interests to convey. This also includes maintaining a positive self-image. In the world of social media, this can be easily done through a selective process of choosing which photographs to post on our Facebook and Instagram profiles. Not only do we have an option to choose a profile photo for ourselves, but we can also allow others to tag us in photos that we have not taken of ourselves. Through privacy settings, we can prevent an embarrassing photo from showing up on our timeline. In other words, social media allow us to manage our self-image more successfully than in face-to-face interactions. This, however, does not always lead to admirable consequences.

The generation of students entering colleges today grew up with digital and interactive media and, therefore, rely less on textual data. It is not surprising that many college students think that posting silly photographs on Facebook enhances their social acceptability. With different smartphone applications, many individuals spend so much time creating perfect, almost unreal images of themselves just to appear better looking or more skilled than their friends.

The quest for fame is real, and many social media sites, such as YouTube ("Broadcast Yourself"), encourage just that. Instagram, the image-based social network site, is another example of collecting followers who will "like" your perfect images. On Instagram, self-promotion triggers more self-promotion as users compare each other. This is not surprising considering that adolescents, in general, often experiment with different identities – which also includes an online identity. Through social media they are able to present themselves in an indefinite number of ways.

When talking with students at The University of Alabama in Huntsville (UAH), they almost unanimously agreed that they only post pictures that show them in a positive light. They worry that other people make judgments about what they post. Most female students expressed concern about their physical appearance, wanting to come across as attractive, good-looking, and perfect. This comparison behavior is a not a new thing.

According to social comparison theory, humans are naturally driven to compare themselves to others. When it comes to physical appearance, we engage in an upward and parallel comparison, meaning that we compare with someone who looks better than us. Considering that it is easier to attain an attractive body of a peer, rather than that of a model on television, most young people today compare with their peers. This comparison leads people to post images of their best moments only and omit those from their ordinary lives. We share statuses that are popular, instead of those reflecting our true reality.

So, what are the solutions to these negative uses of social media? Instead of blaming Millennials for their narcissistic images, we should look at possible solutions. Technology is here to stay, but we can adapt digital to us, rather than us to digital. When television was invented, people worried about the "mean world syndrome."

Today we worry about "Generation Selfie" being too narcissistic. We worry that students use social media only to entertain themselves. They sit in the classroom, but instead of taking notes, we catch them Facebooking and tweeting.

Social media literacy is one of the possible solutions. Being media literate means being competent to deal with social media in a critical way – either by selecting and using appropriate media or by being able to critically evaluate the content posted online. School is one place where young people could benefit from a media literacy program.

Students need to learn to critically evaluate information that they find on the Internet, as well as how to be safe online and how to appropriately use different sites. They should talk to their teachers – but also their parents – about the content that others post on social media, and what the purposes and benefits of those postings are.

YouTube is one example. Instead of using it to watch Rihanna or Justin Bieber, students could use it in a classroom to share a video project, or to analyze other students' projects. Blogs have already been used as digital portfolios for student assignments and as a discussion place for those who tend to be quiet during class time. Twitter can be a smart instructional tool if used correctly.

Unlike Facebook, most people do not use Twitter to post pictures of their kids or to describe what they had for dinner. Instead, they are following education-related posts. Another great feature of Twitter is that people can easily unfollow others as their interests evolve. Twitter can also help not-so-active participants in class to participate online.

Social networking sites, if used correctly, could promote learning inside and outside of the classroom. The U.S. Supreme Court has also supported the contention that teachers should be protected by academic freedom in their use of social networking sites to communicate with their students. Many students use social media to reach out for mentoring. Studies have found that both students and teachers benefit from friend-ships on social media sites. LinkedIn is the perfect example of it. Campus leaders also encourage students to use social media to broadcast their achievements in college. This keeps students both motivated and engaged.

Overall, research shows that when used for communicative purposes, social media often provide more benefits than when used for non-communicative purposes. Social media are here to stay, and we all have to adapt them to us, rather than adapting us to them.

Dr. Pavica Sheldon is an assistant professor of Communication Arts. Her research interests are media psychology, social media uses and gratifications, and interpersonal communication. She received her Ph.D. in communication studies from Louisiana State University.

An economist gets religion

By Wafa Hakim Orman
Associate Professor of Economics

During the course of the 20th century, the discipline of economics became increasingly mathematical. Most of our models of behavior assumed perfectly rational decision-makers, and ignored the role of religion, culture, emotion, altruism…many of the things that truly make us human.

Since the 1970s, though, increasing numbers of researchers calling themselves "behavioral" economists, began incorporating insights from psychology into standard economic models to understand what happens when people aren't perfectly rational — when we're being impatient, overconfident, unthinkingly following the herd, or even altruistic and caring for others. In other words, normal.

These behavioral economists ran experiments with human subjects, usually undergraduate students paid to play games in a laboratory. This appears odd, but it turns out that even that artificial, simplistic scenario can provide useful insights if the games are well designed.

Their findings answered questions that had puzzled economists for years — why do asset markets frequently form bubbles? Why do people simultaneously love risk enough to play roulette but hate it enough to buy expensive insurance? Or, in the case of open-source software, which I was studying at the time, why do people spend their time contributing to software that is then given away for free? Why, in fact, do people volunteer their time and effort for anything at all that benefits a whole lot of perfect strangers?

As a graduate student, I analyzed survey data and ran laboratory experiments to understand how communities of open-source developers are able to maintain high levels of contribution and produce quality products when many other community projects that rely on voluntary contributions either fail or are chronically underfunded. It turns out that as long as the people in the group who find it easier to contribute than others are in leadership positions, and they lead by example, the group can succeed at its task.

While working on incorporating more normal human behavior and emotions into my economic models, about 10 years ago, I attended a seminar presentation that gave me an entirely new perspective. (Anyone who regularly attends presentations involving PowerPoint will recognize that this is a rare event indeed.)

The presenter in question was professor Eli Berman of the University of California in San Diego, and the behavior he was trying to understand was that of suicide bombers. Berman's argument, bolstered by a mathematical model and data analysis, was that suicide bombers are rational — not that they are justified, but that their choices result from the goals they are trying to achieve. While their actions — attacking civilians and other soft targets — are evil, they are not crazy.

Understanding their motivations is therefore critical to developing a strategy to combat them. He took his argument further, arguing that their use of religious rhetoric was essential to their being able to develop loyal, cohesive groups. Religion can be a powerful force bonding people together, and the use of seemingly odd and highly visible rules, restrictions, and prohibitions — long beards, distinctive forms of dress, dietary rules—can help separate loyal insiders and true believers from the rest. Most of the time, this is benign or even beneficial as we see in close-knit communities such as the Amish, Hasidic Jews, Latter-Day Saints, and Islamic revivalist groups such as the Tablighi Jamat. But when the aims of the group turn to violence, that powerful sense of community combined with a selective reading of scripture can create highly effective, dangerous, and resilient terrorist groups.

At the time, Berman was at the leading edge of a small group of economists incorporating not just psychology but also religion and culture into their models, integrating economics with insights from sociology. To me, it was as if a lightbulb turned on in my head — religion is such an important part of life for so many people around the world, how could it not affect economic behavior? And if someone's actions seem puzzling or crazy, perhaps it is our understanding that is insufficient. Seemingly bizarre behavior can make sense if we truly appreciate a person's goals, constraints, and background.

I went to work as a postdoctoral researcher at the Institute for Studies of Religion at Baylor University. Instead of terrorism, we turned our attention to what is probably the most fundamental question in economics — why are some countries rich and others poor? Economists have known for a while that the rule of law and level of corruption are vitally important determinants of growth. Without secure property rights or basic safety, or if bribes and connections determine success more than skill and hard work, people are reluctant to invest in businesses and create jobs. We wondered to what extent the rule of law and control of corruption were determined by religion and culture, because they vary so widely around the world for reasons that are not immediately apparent.

Comparing countries with similar income and education, we found a stronger rule of law in countries with a religious heritage rooted in Protestantism, Asian ethnic religions, Catholicism, or Hinduism, relative to Orthodox Christianity or Islam, and that corruption levels are lower in countries that were historically Protestant. Our research adds to a body of work on the role of institutions and path-dependence in economic growth, which shows that historical events, governmental and religious structures, and culture can impact a country's trajectory for centuries.

Breaking out of the vicious cycle of poverty and corruption usually requires a fairly specific combination of changes to the government and justice system and a not-insignificant amount of luck. The so-called Protestant work ethic stems from the "bourgeois" virtues of thrift and hard work prevalent in trading, sea-faring nations like the Netherlands and England, where merchants had great social and political influence — and, chafing under the control of the Roman Catholic Church, paved the way for the Protestant Reformation. The invention of the printing press in what is now Germany allowed Martin Luther's ideas to be widely disseminated and enabled the spread of literacy. Conversely, the centuries-long Ottoman ban on the printing press retarded the growth of literacy and education in much of the Muslim world. Countries that were colonized by the British are, other things equal, better off today than those that were colonized by the Spanish, Portuguese, or Belgians — but countries did not exactly get to choose their colonial oppressor.

With my existing work on online communities of open-source software developers at the back of my mind, there was one more critical insight — the idea that religious groups provide not just spiritual fulfillment and guidance in the search for transcendence, but, in their role as communities taking care of their members, struggle with the same dilemmas as every other group trying to provide something for their members, or for the world around them, using voluntary contributions.

They need to minimize free-riding and ensure that everyone pulls their weight. This idea applies to extreme cases like terrorism, but also to the provision of day-to-day services like Sunday school and Bible study groups, or to charitable activities. So all denominations need a way to distinguish true believers from casual members, and once again, highly visible behaviors can serve this function.

My current research examines the effect of the 1980s farm crisis and the 2008 housing crisis on American religiosity, and it turns out that both those events raised religious attendance among those directly impacted (farmers in the case of the farm crisis, and those working in housing and construction-related industries after 2008).

Not only that, but membership in so-called "mainline" Protestant denominations like the Episcopalians, Presbyterians, and so on declined in response to the farm crisis, and rose in "Evangelical" denominations such as Baptists and the Church of Christ. Evangelical denominations notably frequently place a much greater emphasis on publicly witnessing one's faith than mainline denominations do, and perhaps this allowed them to better provide for members in trouble.

All science proceeds incrementally, in fits and starts, sometimes taking two steps forward and one step back. Economics began as a branch of political philosophy. The development of mathematical models with assumptions of a perfectly rational homo economicus at their core allowed us to understand and predict phenomena as wide-ranging as price fluctuations and unemployment rates. These models have enabled policymakers to determine tax, stimulus, and interest rate policies that have dramatically reduced the severity of recessions since the Great Depression and the decades before, when severe financial crises occurred about every 10 years or so.

As we have become more aware of the flaws in these models, social scientists have been working to refine and improve them, first by incorporating insights from psychology, and then from sociology and anthropology. As the science progresses, these integrated models will continue to improve our understanding of the world, sometimes in dramatic leaps, and sometimes in small incremental steps.

Dr. Wafa Hakim Orman is an associate professor of economics and received her Ph.D. in economics from the University of Arizona. Her teaching interests are principles of macroeconomics and microeconomics, economics of information technology and econometrics. She has refereed articles in the American Economic Review, Journal of Industrial Economics, Information Systems Journal, International Economic Review, the Journal for the Scientific Study of Religion, and the Journal of Institutional Economics.

Man-made environmental hazards are all around us

By Azita Amiri
Assistant Professor of Nursing

Many products built with good intentions to assist us in our daily life turn out to be environmental hazards that adversely impact our health. These hazards can be classified as biological and non-biological. Biological hazards are associated with viruses and bacteria. Non-biological hazards, which are the focus of this article, can be chemicals and electromagnetic fields (EMFs).

Chemicals can be found in the air that we breathe, personal-care products that we use, and the water and food that we consume. More than 80,000 chemicals currently listed or registered under the Toxic Substances Control Act were first synthesized within the past 50 years. Every year about 700 new chemicals are added to our environment. Among those environmental hazards are outdoor and indoor air pollutants. The majority of outdoor or ambient air pollutants are produced by burning fossil fuels, such as coal, oil, and gas. Outdoor pollutants of major health concern are particulate matter (PM), carbon monoxide (CO), ozone, nitrogen dioxide (NO_2), and sulfur dioxide. Indoor air pollutants include pollutants that are released from building materials and furniture or are produced as a result of household practices, such as heating, cooking, cleaning, smoking, etc. The common indoor air pollutants are formaldehyde, volatile organic compounds (including benzene, trichloroethylene, and Tetrachloroethylene), naphthalene, CO, NO_2, polycyclic aromatic hydrocarbons, and PM.

Other sources of environmental hazards are associated with water and food. Water can pick up lead from pipes or water tanks. Chlorination of water is also associated with health risks. The use of pesticides and fertilizers in agriculture add nitrate and pesticides to water. In addition, pesticides are introduced into aquatic organisms through surface water. In fact, pesticides can be distributed in the air, surface water, soil, and crops. Food can be contaminated through the use of pesticides, fertilizers, food packaging, and food containers, including plastics.

People are exposed to chemicals related to plastics, e.g., styrene, plasticizers, and phthalates, not only during manufacturing, but also by using plastic packages as some chemicals migrate from the plastic packaging to the foods that they contain. Personal care products such as shampoo and soap and products that are used for enhancing beauty such as cosmetics, hair dye, hair spray, and nail polish are other sources of chemical exposures. These chemicals not only adversely impact users' health, but also affect the environment and people and species when they are washed down the drain and end up in the water supply.

Environmental chemicals can enter into our body through inhalation, skin (or eye) absorption, ingestion, and injection. The International Agency for Research on Cancer (IARC) and are processed in the body through metabolism, storage, and excretion. Some chemicals, mostly those that are water soluble, e.g., formaldehyde, are metabolized or transformed in the body shortly after absorption. However, some others, especially fat-soluble chemicals, e.g., pesticides, are distributed and stored in specific organs and persist in the body for a lifetime.

Exposure to environmental chemicals can cause short-term or long-term health effects. Short-term effects occur after exposure to a high concentration of chemicals and usually result in allergic type reactions. However, long-term effects occur after repeated exposures to low concentrations of chemicals for years. The known long-term health effects of chemicals exposure are bronchitis, asthma, cancer, hypertension, diabetes, Alzheimer's, endocrine disruption, miscarriage, low birth weight, premature birth, infertility, etc. Some chemicals have teratogenic, mutagenic, or epigenetic effects and can be associated with congenital malformations and carcinogenic effects.

Evidence shows that EMFs that are produced by cellphones, iPads, and Wi-Fi devices can damage DNA, break down the brain's defenses, and reduce sperm count while increasing memory loss, risk of Alzheimer's disease, and even cancer. In 2011, WHO classified EMFs as a potential carcinogen.

Children are at greater risk of exposure to environmental chemicals because of their small body size, increased surface area to body mass index, and that the fact they eat and breathe more than adults. In addition, they are closer to the ground, where many contaminants are found, and their bodies and organs are growing rapidly. In fact, children may be exposed to environmental hazards even while in the womb. Almost all chemicals cross through the placenta and reach the fetus.

Although it is impossible to eliminate exposures, there are ways to reduce them. Antioxidants minimize damage to the cells from free radicals resulting from exposure to both chemicals and EMFs. Therefore, adopting a diet high in antioxidants, including fruits and vegetables, is the first line of exposure reduction. Other simple precautionary ways to reduce exposure include using organic foods when possible, using more natural personal-care products such as hair dyes, replacing plastics with glass water bottles or food containers, turning off the Wi-Fi when it is not in use, and not using iPads and cellphones close to the body.

Dr. Azita Amiri is an associate professor of nursing and received her Ph.D. in Leadership in Maternal and Child Health Nursing from the University of Alabama at Birmingham.

What factors determine success in defense acquisition programs?

By Richard G. Rhoades

Director of UAH Research Institute

Before joining UAH, I spent my first career in the Army missile community and was involved with programs that developed many of the missile systems used by the U.S. Army and Marines and our allies today. Some of these programs had a difficult time during development, and some never made it into production. During the final decade of my government service, I was heavily involved in deciding which contractor(s) would develop a particular system. These experiences resulted in my interest in better understanding what determines whether a program to acquire a new defense system will have a successful outcome. At UAH I was able to carry out research on that question, collaborating with Dr. William Lucas, an M.I.T. colleague.

Summary of research

In an Army-funded study, a structured case-study approach was used to examine the history and processes that had resulted in fielding 13 systems in time to make a positive contribution to the outcome of Desert Storm. These case studies included a wide range of Army systems, from high-performance tank ammunition and missiles to night vision goggles and attack helicopters.

The case studies were prepared largely based on interviews with key participants from the government/contractor team that developed each system and using a research questionnaire to structure the discussions. The document included questions on the development process, organizational relationship, critical technology maturity, and other factors that either the researchers' prior experience or the literature suggested might be relevant to determining the relative success of projects. This approach resulted in the collection of a common set of data for the systems studied that could then be analyzed to identify factors contributing to the relative degree of success in system development.

The heart of any systematic analysis is the definition of a common outcome measure that allows comparison. In this study the projects (cases) were compared based on their performance relative to their agreed upon goals and requirements. Each project had a budget, a system procurement cost goal, a set of technical requirements, and completion dates. In addition, questions of performance are immediately observable and easily remembered by project managers: Once production was started, were problems found that required that further engineering changes be made? And, did the system perform well in its use in Desert Storm?

Using structured questions, the researchers asked the key government and industry interviewees how well their projects performed in these areas, with a range of answers that characterized how much the projects had missed meeting their objectives if they had not been completely successful. The authors of each of these case studies had the independent views of at least two senior managers, as well as their own detailed study of their project, to enable them to make summary judgments on the project's success meeting these largely observable outcomes.

Six of these outcome measures were used to create a scale that scores the projects from zero to six according to the number of key outcomes a project achieved. If a project was 1) transitioned to production on time, 2) developed within budget, 3) had no late engineering changes, met both 4) the goals for system unit costs and 5) its technical requirements, and 6) encountered no difficulties when it was deployed in the field, it was awarded six points on this scale.

SUMMARY CASE INFORMATION

The duration of the APACHE attack helicopter was the longest at 108 months. The program was high in complexity and as a result only one of its outcomes were achieved. The Joint Stars Ground Station had a similar score after 105 months of development and rated as medium in complexity.

Conversely, three programs — the MLRS rocket system, the ATACMS missile system and the M829-A1 armor-piercing kinetic energy tank ammunication — all scored six on the key outcomes achieved.

MLRS's development was 33 months, the ATACMS was 37 months whle the M829-A1 took 36 months.

Previous reports on systems development have noted the importance of various factors that influence the stability of system acquisition programs. As part of this research, program funding uncertainty and cutbacks, changes to the system requirements (e.g., changes to the threat the system was being designed to defeat), and changes in key military personnel representing the user community were all examined to see to what extent any or all of these "instabilities" impacted program outcomes. The information that follows contains the aggregate results from questions used in the research categorized by type of instability.

PROGRAM STABILITY

Funding uncertainty: Seven of 13 projects experienced uncertainty about the future of project funding.

- Project slowdown: Eight of 13 projects were not stopped and restarted or slowed down.
- Funding cutbacks: Five of 13 escaped change forced by cutbacks in project resources.

- Turnover in Army user representatives: All projects experienced changes in key user personnel during development. This occurred only once or twice for 7 of 13.
- Change in systems requirements: Nine of 13 had changes in systems requirements during development.

A somewhat surprising result is that there was widespread occurrence of all these forms of instability in these pre-Desert Storm development programs. Looking back at the successful performance of new Army systems in Desert Storm, one might think that their development benefited from stable environments, but it is evident that the external environment then was not unlike what one might find today.

Taken together, these several relationships indicate that stability of program resources, staffing and objectives is a strong, statistically significant* influence on the relative success of projects. Certainly there is a wealth of anecdotal evidence that suggests that this should be the case. In reflecting on this array of instabilities that could impact system development, it became clear that the longer a system stayed in development, the greater chance it had to experience one or more of these program destabilizing events.

Support for this view is found when the occurrence of systems requirement changes are related to the duration of the 13 development projects studied here. The projects divided cleanly between seven that took 37 months or less, and six that took 48 months or more. Longer duration clearly allows more time for changing external conditions and priorities to lead to changes in system requirements. Four of seven of the shorter projects never experienced any changes in requirements and the remaining three only experienced minimal changes. None of the six projects that ran four years or longer avoided requirement changes, two saw changes once or twice, and four experienced either several or many changes. This correlation is statistically very strong despite the limited number of cases.

PROJECT DURATION AND REQUIREMENTS INSTABILITY

How often did systems requirements change?

37 months or less: Never (4) Once or twice (3) Many times (0)

Four years + : Never (0), Once or twice (2), Many times (4)

Given that longer schedules increase the risk of encountering instabilities, it is then not surprising that project duration is also negatively related to achieving desirable project outcomes. The effect on all six outcome questions is seen in the data below with the projects requiring longer development time having success on average on only two outcomes, where the shorter development projects had an average 4.7 successful outcomes.

LENGTH OF PROJECT DEVELOPMENT AND PERFORMANCE

Average number of successful outcomes

Three years of less: 4.71 Four years or more 2.0

The sensitivity of this key conclusion to project complexity was examined using a measure of relative complexity developed for this purpose because it was reasoned that more-complex projects often require longer development cycles and are more likely to experience funding difficulties. However, analysis showed that project duration is strongly correlated with outcomes independent of the influence of complexity.

There's more to the story

David McNicol of the Institute for Defense Analysis carried out a recent study to assess the impact of historic acquisition reform initiatives (the current round is entitled "Better Buying Power") on the cost of systems. His data covered the period since 1970 and he employed one key outcome variable, unit procurement cost. While he found no evident relationship between acquisition reform variables and the unit procurement cost of major defense systems, he did find a strong correlation between the defense budget environment at the time a system development started and the cost growth per copy of the system.

DEFENSE FUNDING CLIMATE / AVG. UNIT COST GROWTH

- 1970-1980 / Relatively constrainted - 35 percent

- 1981-1986 / Relatively accommodating - 12 percent
- 1987-2002 / Relatively constrained - 53 percent
- 2003-2007 / Relatively accommodating - 7 percent

To explain this finding, McNicol suggested that systems that begin development when defense funding is relatively more available are likely to have more realistic cost estimates, whereas when budgets are constrained, the estimates are likely to become optimistic (to "fit" within the limited resources).

In thinking about the relationship of McNicol's work to the research described earlier, it seems likely that starting the development of a system in a constrained resource environment will also result in an extended schedule being planned, because sufficient early year funding is typically not available. Given the strong correlation of project outcome to time spent in development demonstrated in this essay, one might expect such systems to exhibit poorer results in one or more of the outcome measures, such as unit production cost, as McNicol found.

** Despite the limitation that the analysis only includes 13 cases, the Tau B statistical test appropriate for these variables showed that the strength of the relationship between the variables analyzed is sufficiently strong that it could have happened by chance less than one to five times in a thousand, depending on the variables examined. One can thus have confidence that the reported relationships are statistically meaningful despite the small number of programs being studied.*

Dr. Dick Rhoades earned a Ph.D. from the Rensselaer Polytechnic Institute and has been the director of the UAH Research Institute since 1997. He has a joint appointment to the faculties of the Colleges of Engineering and Business Administration. [The Research Institute has a staff of more than 50 professionals and annual revenue of approximately $6 million, primarily from DOD customers.] Dr. Rhoades has published numerous articles on propulsion and management topics and holds two patents on propulsion inventions.

Getting the most out of Huntsville's innovation

By Kannan Grant
Director of Office of Technology Commercialization

The Huntsville area has a well-deserved reputation for innovation. The region's innovative spirit manifests in the Saturn V rocket towering over I-565 and in the pioneering work that continues at the federal laboratories for the U.S. Army and NASA.

Our innovation happens at Redstone Arsenal, which receives more than a billion dollars in R&D funds each year. The city's research park contains some of the world's most established technology organizations, and many smaller companies driven by state-of-the-art technologies. Impressive technology development also comes from The University of Alabama in Huntsville (UAH) and the HudsonAlpha Institute for Biotechnology. This innovation is driven by a population with the highest per capita concentration of engineers.

Huntsville is full of smart people and smart organizations doing smart work. But these efforts have not yet reached their full innovative potential. Too often, the cutting-edge technologies that the federal government, private companies, and universities spend millions to develop get applied in limited ways, never capitalizing on the multiple uses — and markets — that would truly maximize their potential. If we harness this potential, we can seize an opportunity to develop more jobs and more capital in more industries, increasing the economic pie to include a broader range of innovators and knowledge workers. We can also diversify an economy that is too dependent on a small range of industries, many of them reliant on federal funding. The dominance of these industries, vital as they are, leaves the entire economy vulnerable to budget cuts and sequestration.

The good news is that we can move toward economic diversity with the technology and innovative spirit we already have. Right now, Huntsville researchers and government contractors understandably focus their efforts on very specific, crucial goals, such as improving communication satellites or keeping our soldiers and our country safe.

But the same technology that protects soldiers' lives or puts satellites into orbit may have other marketable applications in everyday homes and offices. We have seen this kind of dual use before in the NASA-developed technologies that became memory foam, cordless vacuums, and airplane de-icing systems. We must once again consider the broader applications of our inventions and develop a culture that actively seeks dual uses and multiple markets for the technologies we currently create.

Making this change requires a cultural shift, one that encourages innovators and investors to take risks and find new uses for existing innovations. We need to support fledgling ventures and give ambitious, inventive entrepreneurs multiple chances to achieve success. We need to cultivate new sources of capital willing to fund technology commercialization and spinoff corporations. We need to foster "productive collisions" where talented and innovative people from multiple industries interact to share ideas and talk about how they might work together.

Other regions famous for innovation, such as Boston's research corridor and North Carolina's Research Triangle, have already fostered this culture, and they show us how it can be done. For instance, the high-tech complex Silicon Valley got its start in World War II when government funding, innovative people, and cutting-edge technology came together. Dr. Frederick Terman, the one-time Dean of Stanford University's Engineering School and the man widely considered to be the "father of Silicon Valley," built a university-government-industry partnership model that is as valid today as it was in the 1930s. Terman was a passionate supporter of entrepreneurs such as Bill Hewlett and Dave Packard, and he excelled at connecting federal funding with the brilliant young innovators who could bring pioneering technology to market. His efforts created a crescendo of innovation that attracted more and more top innovators who developed more and more groundbreaking technology. Huntsville has many of the same ingredients — DOD funding, innovative people, a "very high research activity" university, and advanced technology. Those factors launched Silicon Valley. It is time to bring these islands of innovation together so that we can foster the next generation of IBMs and Googles.

Our region already has resources taking us in this direction, such as Alabama's Comprehensive Economic Development Initiative and the Alabama Launchpad program that encourages and funds startups. Companies such as Adtran have become enormously successful with spinoff technologies. The growth of new high-tech industries such as gaming and biotechnology suggests a trend towards a more diverse knowledge economy. The Technology Transfer Office at Marshall Space Flight Center lists dozens of technologies ready for commercialization, and at UAH, the Office of Technology Commercialization has helped several startups find new applications for university developed technology.

Still, we can do more to encourage and drive technology commercialization. The innovative culture of Huntsville has even more room to grow. We can follow the model of other states, such as Tennessee and Texas, that allocate funds specifically to support innovative new companies. But the ultimate goal is getting innovators, investors, and entrepreneurs together to unite their efforts.

The region needs an innovation hub that acts as a catalyst for technology commercialization. By providing office and lab space, access to innovators and technology, connections to public and private funding, business coaching and mentoring, workshops, and support services, this hub could serve as a one-stop shop for entrepreneurs looking to spin off existing technologies into new startups.

The goal is to create a safe, productive space for startups to incubate while they are bringing technologies to new markets. The hub could draw on the expertise of successful entrepreneurs and innovators as well as the wealth of talent offered by UAH faculty and students in areas like engineering, biology, computer science, business, marketing, human factors and psychology, graphic and web design, and writing and communication. Once this hub starts launching exiting new companies, it will attract even more talent and investment, creating the kind of growth cycle that fuels high-tech innovation economies.

Huntsville can expand its reputation for innovation by moving our technology into new markets. The technology and talent needed for this opportunity is already here. We just have to determine how to get the most out of it.

Kannan Grant joined UAH's newly established Office of Technology Commercialization in 2007 as its director. He has more than twenty years of experience in technology transfer. Prior to joining UAH, he was associate vice chancellor for the Office of Technology Development at the University of Nebraska-Lincoln. Mr. Grant has also served as the CEO of FuturaGene Inc., and as an executive board member for FuturaGene Plc. He earned his undergraduate degree in electrical engineering at the University of North Dakota and his MBA from Texas A&M University.

The myth of the 97 percent global warming consensus

By Roy W. Spencer
Principal Research Scientist, Earth Science System Center

Nothing helps raise public awareness like a good meme, and at least on that score, the "97 percent of scientists agree" meme has been wildly successful in convincing people that the science of global warming is settled. But as we shall see, the statistic – even if it were true – tells us nothing particularly useful regarding the global warming debate.

The 97 percent number comes from a 2013 paper that was published by John Cook in *Environmental Research Letters* and that claimed to review about 12,000 published scientific papers on global warming and climate change. Now, for those of us who work in climate change research, it is well known that "climate change" is widely assumed to be mostly human-caused, despite the fact that very few published studies have actually attempted to demonstrate this to be the case.

Again, it is simply assumed.

And that is one of the (many) problems with Cook is literature review-study. It only established that there is widespread consensus that humans contribute to (not even dominate) global warming, a position that the vast majority of climate "skeptics" agree with – including myself. I do not know of any climate skeptic researchers who claim that humans have no influence on the climate system. The existence of trees has an influence on the climate system, and it is entirely reasonable to assume that humans do as well. The most pertinent questions really are: 1) just how much warming is occurring? (not as much as predicted); 2) how much of that warming is being caused by humans? (we don't really know); 3) is modest warming a bad thing? (maybe not); and 4) is there anything we can do about it anyway? (not without new technology).

Also, while the scientific consensus on climate change is a mile wide, it is only inches deep. Very few climate researchers can tell you what evidence points to (say) 50 percent of recent global warming being human-caused. There might be a few dozen scientists in the world who are familiar enough with the science to defend it. Instead, the vast majority of scientists simply repeat what they have heard, or are familiar within only a cursory manner. Climate change research involves so many specialties and sub-disciplines that few scientists have a knowledge base sufficiently holistic to make an informed judgment.

Consensus on the quantitative role of gravity in space flight is meaningful but consensus on the quantitative role of anthropogenic greenhouse gas emissions in climate change…? Not so much. Regarding just how wrong scientific consensus can be, I like to use the example of peptic ulcers. With millions of sufferers being treated over the last century by doctors, you would think we would know what causes them. Until relatively recently it was assumed that eating spicy food or stress caused them. But two Australian doctors, Robin Warren and Barry Marshall, had a theory that they were caused by bacteria, a fringe idea that led to them being shunned and ridiculed at conferences.

Yet they were correct, and were eventually awarded the 2005 Nobel Prize in medicine for their work. One can only imagine the thousands of published medical papers that simply assumed that ulcers were caused by stress or spicy food. Would it have been 97 percent? Or even more? I don't know. Yet they were all wrong. Now, if the physical cause of millions of peptic ulcers (which can even be studied in a laboratory setting) went undiscovered for so many years, isn't it possible that there are natural causes of climate change (for which we have only one patient to study, and it cannot be put in the laboratory)?

Climate change is a relatively young science. Computerized climate models do a reasonably good job of replicating the average behavior of the climate system, but have been almost worthless for forecasting climate change. They have not even been able to hindcast (let alone forecast) the warming rate of the past 30-50 years, generally overstating that warming by about a factor of two.

When I have discussed the evidences for natural causes of climate change with "consensus" researchers, they inevitably retreat to the position that "we need to get away from fossil fuels anyway." But there are no large-scale replacements yet available – even optimistic estimates place 80 percent of the energy generation burden on fossil fuels in the coming decades. You cannot simply legislate or regulate new forms of energy generation into existence.

And it should concern us that researchers, who should remain unbiased, are so easily swayed by their perceptions of energy policy that it would affect the way that their science is presented. How can the real policymakers rely upon scientists whose objectivity has been compromised by their particular political or economic views?

We really don't understand the natural sources of climate change on decadal or centennial time scales. I liken these sources as "chaos" in the climate system, most likely tied to small changes in ocean circulation that occur naturally, just because that's what nonlinear dynamical systems (like the ocean and atmosphere) do. We have published research that suggests as much as 50 percent of global average warming over the last 50 years was due to more frequent El Nino activity, which affects the ocean circulation, global cloudiness, and global temperatures.

Yes, human greenhouse gas emissions from burning fossil fuels almost certainly play a role. How much of a role is unknown.

Returning to Cook's 97 percent paper, it is now known that many (if not most) of the 12,000 papers reviewed didn't actually state a position on the cause of climate change. They weren't even reviewed by experts, but by environmental activists.

Nevertheless, the fact that consensus exists in the climate community cannot be denied. In my experience wmore thana 80 percent of all climate papers published do indeed assume that climate change is largely human caused. But this, by itself, is unremarkable in a field where so little is known regarding the natural source of climate change. We can't forecast chaotic climate variations any more than we can forecast chaotic weather variations, so researchers cling to what they do know: that carbon dioxide is a greenhouse gas that it is slowly increasing, and that it is the leading suspect in the search for causes of global warming.

The extreme popularity and success of the 97 percent meme tells us something about the global warming debate and how it is received. People gravitate toward simple ways to support and defend their preconceived beliefs. Global warming is one of those issues that the believer holds onto with an almost religious fervor. As a scientist I learned long ago that there is no point wanting this or that theory to be correct. Mother Nature really doesn't care what you believe. Instead, I just follow the evidence and generally assume that whatever is developed as an explanation is most likely going to be proved wrong eventually…as is the case with most published science.

Climate science isn't rocket science. It's actually much more difficult.

Dr. Roy Spencer is a principal research scientist in the Earth System Science Center. He earned a Ph.D. in meteorology at the University of Wisconsin-Madison. Prior to joining The University of Alabama in Huntsville, Dr. Spencer was a senior scientist for climate studies at NASA's Marshall Space Flight Center. His research interests are satellite information retrieval techniques, passive microwave remote sensing, satellite precipitation retrieval, global temperature monitoring, space sensor definition, satellite meteorology, and climate feedbacks.

Lifelong Learning Lab
Examining learning and memory processes across the lifespan

By Jodi Price
Associate Professor of Psychology

Children frequently wish to be older and count the days until milestone birthdays (e.g., 13, 16, 21). Then, at some point, we become cognizant of time flying by whether we want it to or not. The good news is that with greater life expectancy, people typically do have more time to enjoy all that life has to offer, even if that time seems to pass more rapidly in older age than it did as a child.

Typically, older adults are less concerned about quantity than they are with the quality of their golden years. How people define quality varies, but it often involves having the cognitive and physical capacity to engage in activities they enjoy, whether traveling, learning new things, or socializing with friends and family. Based on the aging literature, we know that normal aging is accompanied by both cognitive and physical changes.

Physically we see changes in muscle tone, reaction time, as well as in sensory abilities. In the cognitive domain, it is common for people to take longer to process and learn new information, while abilities developed through education and experience (e.g., vocabulary, or one's area of expertise) tend to remain more stable as we age.

These well-documented changes in cognition have implications for beliefs that individuals in different age groups may have about their memory, which can in turn affect how people of different ages approach learning new material.

In the Lifelong Learning Laboratory, undergraduate and graduate students working under my direction examine how learning and memory processes change across the lifespan in normal aging. Although many studies only test younger adults, we have now conducted a number of studies comparing younger (ages 18 to 25) and older (ages 60 to 85) adults' approach to learning new things, such as foreign languages.

The goal of the foreign language studies has been to examine whether learners' self-regulated learning decisions — what to study and how long to study material before selecting other items for study — differ as a function of age, allotted study time, item difficulty level, the point values assigned to different items, or presentation format (e.g., whether items are presented in an easy-to-difficult order or a difficult-to-easy order).

We have implemented these different manipulations to test three leading theories of self-regulated learning that yield divergent predictions regarding which items learners should select first for study.

One theory predicts learners will initially select the easiest items for study, while another suggests they will instead select the most difficult items, given that these items will have the greatest discrepancy between what the learner desires to know and currently knows. A third theory suggests that whether learners first select easy or difficult items will depend on the learning goals each learner sets.

This theory acknowledges that the formation of a learning goal takes time, and proposes that when study time is limited, learners may instead fall back on habitual selection patterns. Unlike goal-based selections, which would be manifested by learners focusing on the highest valued items, habitual selections may be manifested by learners selecting items in a left-to-right reading order.

The studies conducted in the Lifelong Learning Laboratory have shown that younger and older adults' selections are influenced by presentation order, such that both age groups are more likely to select items that appear first, thereby revealing habitual selection processes. However, point values also influence younger and older adults' selection decisions. Yet, older adults are less inclined than younger adults to select difficult items, even if those items are worth more points if correctly recalled. In most cases, older adults who report less confidence in their memory or have reduced memory capacity are most likely to avoid studying these difficult vocabulary terms.

In terms of study time allocation, younger adults tend to distribute their time across items of all difficulty levels, while focusing more time on items worth the most points. In contrast, older adults tend to focus their time on easier items and only later study moderately difficult items if time permits. These selection and study time allocation decisions affect recall performance, with younger adults obtaining higher recall rates than do older adults given that they have studied more items. We have obtained similar patterns of results using Spanish-English and Chinese-English vocabulary pairs. This is noteworthy given that many Spanish words are cognates of their English equivalents (aeropuerto – airport), whereas Chinese characters share no features with their English counterparts. These studies have thus provided insight regarding which factors are most likely to influence younger and older adults' selection and study time allocation behaviors while adding to the literature on self-regulated learning.

In another study, we examined how feedback frequency and dot patterns would combine to influence younger and older adults' ability to accurately estimate how many dots had been presented on a screen as well as their confidence ratings in those estimates. Numerosity estimation is historically inaccurate. Thus, we wanted to examine whether feedback might improve the accuracy of participants' estimates. We manipulated whether we provided feedback regarding the correct numerosity on zero percent, 50 percent, or 100 percent of the trials to determine whether the feedback would affect younger and older adults' estimation accuracy for randomized, clustered (i.e., groups of 3 or 7 dots), and stacked (i.e., column) dot formats. We expected that giving participants feedback after they provided every estimate (the 100 percent feedback condition) might increase the accuracy of their estimates and how confident they were in the accuracy of their estimates, relative to participants who only received feedback after every other estimate (the 50 percent condition), or never received feedback (the zero percent condition). We also expected feedback to be more beneficial for randomized dots than for the more structured (clustered and stacked) dot patterns.

We found that estimation accuracy was the same for younger and older adults, despite younger adults initially being more accurate. Feedback improved both age groups' accuracy. Stacked presentations were most accurately estimated, but were more likely to be overestimated than clustered and randomized presentations. Older adults gave lower confidence ratings than younger adults, despite both age groups showing increased confidence across blocks, for more structured presentation formats, and as feedback frequency increased. These results provided insight regarding the role of presentation format and feedback in producing age equivalence or age-related differences in numerosity estimation. The fact that older adults' estimation accuracy equaled younger adults is impressive given that the dots were only displayed for 250 milliseconds. This suggests that despite age-related changes in vision and reduced processing speed that older adults were able to benefit from feedback to the same extent as younger adults. Yet, even in this paradigm we found that older adults expressed less confidence than did younger adults, providing additional support for age-related differences in memory self-efficacy.

Finally, in another set of studies we examined how younger and older adults perceive words presented in different font sizes and styles. Studies from other labs have found that people perceive words presented in larger (48 point) font to be more memorable than those presented in small (18 point) font, but that recall does not differ as a function of font size. We examined whether this dissociation between predicted and actual recall, coined the font-size effect, would hold if small and large fonts were crossed with different font styles (regular, italic, and bold). We found that both younger and older adults predicted words shown in larger fonts would be more likely to be recalled than items in smaller fonts, but the font sizes and styles interacted such that the predictions for words in the two font sizes varied more for items presented in regular and italic fonts than for bold items. Both age groups predicted higher recall for items in regular and italic fonts than for items in bold fonts. Critically, both younger and older adults' predictions aligned with actual recall levels for the three font styles, but not for font size, thereby replicating the font-size effect.

Together, the results of these studies and others we have conducted in the Lifelong Learning Laboratory provide information about how younger and older adults approach learning novel material. The foreign language studies indicate that older adults' reduced memory self-efficacy may affect their willingness to study more difficult material, even if that material is worth more points. Similarly, the age-related differences in memory self-efficacy yielded lower confidence ratings for older than for younger adults in the numerosity estimation task, despite the age equivalence observed in estimation accuracy. The font studies further revealed that both age groups were able to track the impact of the font style, but not the font size, and manipulations on their ability to recall items. Given that learning is a lifelong endeavor, these results have implications for how to structure instructional materials for different age groups, an avenue that the Lifelong Learning Laboratory will continue to pursue in future studies.

Dr. Jodi Price is an associate professor of psychology. Her research interests are age-related differences in metacognition, metacognitive control, knowledge acquisition and problem solving, instructional design and educational technology, and memory accuracy and source monitoring errors. She received her Ph.D. in experimental psychology at the Georgia Institute of Technology.

A pathway eliminating the uncertainty in diagnoses that can cause anguish, alarm

By Krishnan Chittur

Professor of Chemical and Materials Engineering

It was a Sunday. I was in the neonatal ward at the hospital on June 23, 2002. Through the glass, I watched a nurse identify a very preemie baby, my new daughter, with dozens of tubes surrounding her little body and electronics monitoring her every breath. It was frightening.

A few hours after she was born, a physician looked at an X-ray of her tiny body and he concluded that she may have pneumonia. He ordered that she be given antibiotics right away to treat this possibly impending life-threatening infection.

Upon making that pronouncement, the physician also ordered a blood sample be taken and sent to a laboratory for analysis to confirm the diagnosis of pneumonia from his reading of the X-ray. The next three days were spent in agony not knowing if this preemie baby had pneumonia and what it may be doing to her very fragile body, and wondering if the antibiotics were in fact working. Late on Wednesday, the lab results were available and we were told that the blood sample did not have the pneumonia bacteria. A huge sigh of relief. The physician immediately ordered that the antibiotics be stopped.

Relief – yes, but also an incredible sense of frustration and the shocking realization of how little we know. Why, in the 21st century, can we not determine if someone has an infection right away? Why do we have to guess as to what the "possible" infection may be and then treat it almost blindly? And what are the impacts of sending antibiotics through a one-day-old baby? If the source of the infection is present in the body at time zero, do we not have methods/techniques to confirm that?

These were the questions whirling around my mind as I watched this preemie baby struggle during the first few days of her life. Skip ahead 13 years. My daughter has flourished, and she is now a teenager. But I still wonder: How did those three days of strong antibiotics affect her immune system, her microbiome, her health?

My own training has been as a chemical engineer. Whether it's new materials or enzymes in a lab, I'm trained to identify and solve problems in some logical manner. After working in private industry for some years, I found that my career enjoyment comes from teaching and research and that's what brought me to UAH. So, always in the back of mind was that haunting question: Is it possible to detect the source of an infection so quickly that the right drug is used, and only if it is needed?

The answers were to some extent already out there. Advances in genetics taught us that each living organism had specific and unique nucleic acids, in a sense, a DNA signature. But these molecules are so small that methods were needed to let them grow, and culture, so they could be identified as a bigger mass.

So, the question I asked was: Can we find a method to detect small amounts of DNA from patient samples to quickly provide the physician with the information needed to treat the patient? This question lingered in my mind over the years.

One of the things I enjoy about being a professor at a research university is the ability to work on problems of particular interest, and I was certainly very interested in figuring out how to look for DNA that caused infections in humans. I knew right away that I needed help from people who really knew their biology and DNA. I found such people. One of them was a graduate student who was working on some related problems with colleagues of mine on the UAH campus. After several weeks of discussion, we came up with an idea.

We then pitched this idea to the UAH Office of Technology Commercialization and received funding to test the idea. After a few months, we had data that convinced us that yes, it is indeed possible to detect DNA in patient samples quickly. We were encouraged to file for a U.S. patent, which was ultimately awarded to the university in 2007.

There we were with an intriguing idea and a patent. Now what? What use is this idea if I cannot turn it into a device or a technology that can help patients? So I began my journey into the world of turning ideas into products. I quickly discovered what a challenge that is. But what kept me going was that image of that tiny baby smothered with tubes and electronic devices. I must figure out a way to make it easier for the babies in the future, so I told myself keep going.

I realized that along with the good idea, I would need both financial and intellectual resources to create a product that could be commercialized to help babies and other patients. My journey took me in front of people who were both curious about our technology and ideas, and also interested in investing their money to help us achieve the goals we had set. There is a whole ecosystem of private capital risk takers, people who are willing to risk their money in the hopes of a winning product. And without that, so many ideas would sit on the shelf.

I also learned that just like scientists in the lab, there are experts in business who help translate ideas into concepts into products and eventually into markets. How fortunate for me that UAH is located in Huntsville, AL which boasts a collection of people who are entrepreneurs at heart and willing to take risks on both people and technology to make life better for all.

Along with a few others, I founded a company to develop a product for the rapid diagnostics market. I remain excited, and very grateful at the number of people who continue to have confidence in my team to take our idea to market. During the past few years, we have experimented with techniques and protocols to result in simple, fast identification of DNA from blood, saliva, phlegm, etc. We have built prototypes and we've tried various experimental paths, all on a journey to develop an accurate and affordable product. The company, GeneCapture Inc., now maintains a lab at the HudsonAlpha Institute for Biotechnology and is actively testing a prototype that has automated the process and is getting results in less than one hour.

Our business has allowed us to meet many interesting people in the field of infection detection. We've listened to the needs of physicians, lab directors, biosafety and biodefense agencies, the defense department, defense contractors, non-governmental agencies in developing nations, and business leaders from across the spectrum of venture capital to product distribution. Commercializing a product is a very complex and dynamic proposition. From engineering to clinical studies to marketing and investment capital, I have a deep respect for the effort and energy that goes into any product, and most certainly a health care product.

At GeneCapture, we are in the "validation stage," proving that our prototype can, in fact, identify a variety of germs from various samples. Our team includes molecular biologists, mechanical and optical engineers, entrepreneurs, and business support folks. We've found advisors to help us with partnering, strategic planning and intellectual property management. We are now working with various clinics and hospital

When that proof is complete, we will engineer the product for manufacturing and get the regulatory approvals and clearances needed to sell products. How rewarding it will be to go from the problem, to the genesis of an idea, to a discovery, to a working product. One of the product requirements we have established is to make the instrument portable and very affordable, so it can used outside the traditional medical setting thus allowing rapid diagnostics at clinics, at nursing homes, at airports, and in remote locations.

The health care industry is continually distributing the decision-making authority away from the hospital and to where decisions and therapies can be enacted quickly. This trend is shaping the way we live and we hope to be part of the wave that helps make that happen.

My own personal goal is to eliminate the uncertainty and turnaround time for many common medical diagnostic tests that can cause anguish, alarm, and harm to people. Hopefully, the efforts of our local research and business community will be successful in making this a reality.

Dr. Krishnan Chittur is a professor of chemical and materials engineering, and chief technology officer for GeneCapture Inc. Dr. Chittur has a deep expertise in biomaterials and genetic applications. His research interests are the investigation of adsorption phenomena, characterization of events at biomaterial-tissue interfaces, biological process monitoring and control, and non-invasive sensing. He received his Ph.D. in chemical engineering from Rice University.

What is sexual orientation?

Dr. William Wilkerson
Professor of Philosophy and Dean of the Honors College

Most people in the United States believe that sexuality comes naturally sorted into three main forms: hetero-, homo-, and bisexuality, and that strong and definite feelings determine which of these orientations an individual has. As the refrain of a popular pop song puts it, people are "born this way."

Yet, academics studying sexuality have long known that these three categories of sexual identity are not found in all times and places. Cross-cultural and historical studies of sexuality reveal that sexuality varies remarkably between cultures and across historical changes. Histories of sexuality show that even in the United States, this three-part sexual schema of hetero-, homo-, and bisexuality has not always prevailed. How can this three-part sexual scheme seem both obvious and determined by strong feelings, yet also be specific to our historical and cultural circumstances? Putting it more directly: how can sexuality seem at once determined by one's sexual feelings, and yet transformed by changes in the way society lives and organizes itself?

To answer this question, I have developed and defended a theory of sexual identity that I call interpretive social constructionism. In brief, my view claims that individuals must engage in some self-interpretation of sexual feelings in light of the way their society organizes sexuality. This self-interpretation changes the feelings themselves into feelings that match those of a particular individual's society.

In developing this theory, I rely on the view that a person's experiences do not come, as philosopher William James put it, "ticketed and labeled" — with their meanings and structures already given. Only through interacting with others and checking one's experiences against the linguistic and conceptual resources available in society can experiences take on comprehensible meanings that one can use to understand and act upon from. I call this process "interpretive" because people begin with inchoate experiences, ones that suggest a plenitude of possible meanings, which must then be narrowed and understood in light of social categories — a classic case of interpretation. In doing this, the experiences themselves come to change, as they come to be understood as an experience of "thus and such."

This view about sexual experience is plausible because many of our unconceptualized experiences are quite "thick" with possible meanings. To use an example relevant to sexual orientation, imagine a teenage boy who has strong feelings of attraction for another boy, but who is unsure what these feelings mean. He might also simultaneously have feelings for some girls. I use the word "feelings" here because the interpretive view will deny that always we begin with desires that are explicitly or obviously homosexual or heterosexual. Many coming-out stories include a long period of confusion such as this. What will this young man make of these feelings? First, he may not be certain what attracts him in each case. Does he like the other boy's masculinity, or his quick wit, or his intelligence? Are his feelings genuinely sexual, or are they just a "warm fuzziness" he feels when he's around this particular boy? Similar questions arise about his feelings for girls. He experiences each of these feelings in the context of the other, such that he might compare these feelings with each other.

Assuming that he lives in our society, he may well be aware that he could be gay, bisexual, or straight, but which possibility he chooses may not be obvious to him. Note that if he decides that his attraction to the boy is a sexual attraction to certain masculine features of the boy (his muscular body, his masculine comportment, his genitals), and further decides that this means that he is gay, he has interpreted his feelings and changed them in two respects. First, he has significantly thinned out his previously thick experiences by conceptualizing them and narrowing the range of their possible meanings. Second, by conceptualizing them and putting them into language, he has effectively changed them into the feelings that a gay person has; he has set aside his feelings for girls as secondary, perhaps just a result of social pressure to be heterosexual. Rather than the unconceptualized, thick, and ambiguous experiences, his interpretation has partially constructed them as feelings of a particular kind.

According to my interpretive view, we declare ourselves gay or lesbian, not because we have naturally given sexual orientations, but because sexuality in our time is culturally organized around sexual orientations, be they homosexual or heterosexual, and we interpret our sexual feelings and experiences in light of these concepts, bringing our sexual selves in line to match. People do have nonconceptualized feelings, some of which they can articulate, while others are inchoate and unclear. They spend time trying to understand them and rely on social ideals, roles, and identities to make sense of these feelings. In some cases, one might see that one obviously desires people of the same – or opposite – sex, but in many cases, one might be less certain. In the latter cases, sexual orientation is not just a given and persistent desire for other men, women, or both; people have lots of desires that can be confusing to interpret, and they take on the project of a particular sexual orientation because it is the closest match. This view brings desire and sexual identity much closer together. People develop their desires and their orientation based on their projected identity, much as they develop their identity based on feelings that they come to describe as a persistent desire and an orientation.

Interpretive social constructionism thus both preserves and changes the common concept of sexual orientation: sexual orientation is not a naturally occurring, persistent desire; it is rather a convergence of individual feelings, social constructs, and the interpretive choices individuals make about how to live their sexuality. Sexual orientation is more akin to an existential project than a psychological fact: it designates features of our existence that we take up and live in a particular social setting. People do have feelings, feelings that might have content that guides them toward some interpretations and away from others, but this content does not fully determine their sexual being.

But, you might ask, if people have feelings that fit with our current concept of sexual orientation, doesn't that mean that sexual orientations are naturally occurring? My view regards sexual orientation as forming at the juncture of an individual's feelings and the social roles and cultural possibilities of their historical and geographical location. It thus admits that people have feelings that they match to their social surroundings. But, surely, if some people have desires that lead them to adopt one, rather than another, sexual understanding and identity, then these desires have a meaning that could exist independently of social circumstances, and interpretation merely amounts to recognizing the truth of one's desires and experiences.

This objection claims that feelings are given and then subject to interpretation. But if feelings are subject to interpretation, then it must also be true that their meaning is not fully given, otherwise they would not be open to interpretation. Because there is something in the feeling that is subject to interpretation, there is something unclear or ambiguous in it, which the act of interpretation resolves through conceptualization. If its meaning is fully given, how could it change with context or even be construed in different ways? The objection asks us to accept the impossible: the interpretation of something that at the least requires no interpretation, and that at the most cannot be interpreted.

At issue here is the larger philosophical question of the degree to which our experiences constrain the interpretations we make of them and the knowledge we gain from them. Three views are possible: our experiences totally constrain (determine, even) the interpretations we make of them. I find this view implausible for two reasons. First, it makes little sense to speak of determined interpretations, since the interpretation of something implies the possibility that it could have been interpreted in another way, and second, because our interpretations of feelings can and do change. (Have you ever discovered your anxious feelings toward somebody were actually infatuation? That you mistook pity for love? That you thought you were happy but were really unhappy all along?) Equally implausible is the second view that we can interpret any experience in any way. In between, there is the view that experiences can suggest and constrain, without determining, our interpretations of them. This view is the most plausible. It fits well with familiar examples like interpreting literary works. A dense and thick work like Moby Dick supports many interpretations, but it does not support any interpretation at all. It is not, for example, a manual on how to assemble a tent. In the same way, the interpretive view of sexual orientation argues that a person's sexual feelings may guide their interpretation without determining it.

This account, then, allows that people's feelings may remain constant and that they may live out one particular sexual identity, which they regard as built from a particular sexual orientation. Yet it also allows for people whose sexuality focuses on other objects and sensations to find some other interpretive scheme that makes sense of their own particular sexual proclivities. People can learn to understand their own sexuality as, perhaps, a fetish, or a desire for masochistic sensation, and they can find roles and communities that support and help them understand their specific sexuality. People might change their interpretation of their feelings, or discover that their feelings may change, thus allowing that a person's sexuality can be fluid, even though such people could still tell a narrative about their changing sexual lives.

Sexual orientation, in my view, is perfectly "real" – it's just not real in the way that many like to believe. It's real in the way that other deep, powerful aspects of our personality are. It's something we shape and something that shapes us.

Dr. William Wilkerson received his Ph.D. in philosophy from Purdue University. He has published more than 20 articles in philosophy of mind, 20th century European philosophy, and gay and lesbian philosophy in journals including Philosophical Psychology, Continental Philosophy Review, Journal of Social Philosophy, Journal of the History of Philosophy, Metaphilosophy and Epoché. *He also has research and teaching interests in political philosophy, Marxism, feminist philosophy, and gender studies.*

A unit-level model of combat based on entity-level data

By Mikel D. Petty
Associate Professor of Computer Science

Introduction and motivation

Models of combat may represent the forces involved as units, such as battalions or brigades, or as entities, such as tanks or helicopters. Unit-level combat models can be computationally efficient, and thus are able to simulate large scenarios in terms of geographic scope and military forces involved and may execute faster than real time. However, existing unit-level combat models (such as Lanchester equations) don't exploit the detailed performance data and high-fidelity models that are available at the entity level.

In entity-level combat models, combat activities such as moving, sensing, and shooting are represented at the entity level using detailed models of each activity for each entity, which is both more intuitively acceptable to users and more directly supportable by available test and operational data on entity performance than the abstract equations of a unit-level model. However, current entity-level combat models are slower to execute than unit-level models, and they often produce unrealistically high attrition.

Model characteristics and features

Under sponsorship from the Defense Advanced Research Projects Agency, The University of Alabama in Huntsville (UAH), Gnosys Systems, and Science Applications International Corp. have developed a new mathematical model of combat in the form of an algorithm for determining the results of an engagement between units. The model is known as "Alternative Aggregate" or "Alt Agg."

Although Alt Agg is a unit-level model, within the model the representations of moving, sensing, and shooting are based on entity-level performance information, directly supportable by test and operational data. Entity-level performance is represented by a set of probability functions that eliminate as much entity level detail as possible while retaining the important effects of entity-level performance on combat outcome. These probability functions, all of which are based on entity-level data and models, include intervisibility, detection, and firing. The probability functions operate within an algorithmic framework that considers potential interactions between entity types and abstract locations of entities of different types.

The Alt Agg model includes submodels that are intended to replicate the effect of essential aspects of tactical combat without explicitly simulating all of its details. Those submodels represent indirect fire, with consideration of target priorities, target proximities, target visibility, and previous firings; doctrinal unit frontage, used to determine entity dispersal for incoming indirect fire; target selection rules for direct and indirect fire; movement, modeled using doctrinal entity movement rates in one-dimensional terrain; and operational activity, modeled using activity state transitions determined by unit status.

All of the submodels are highly abstract; the intent was to capture the effects of each aspect of tactical combat with a minimum of detail and computation. Care was taken when developing each submodel to add only minimal computational load during execution of the algorithm. In fact, from a modeling perspective, most aspects of the Alt Agg model are highly abstract; this was an intentional design philosophy. For example, "terrain" in the Alt Agg model is modeled as a one-dimensional line that represents only range and "intervisibility" as a probability function of range. As a result, despite its entity-level basis, the unit-level Alt Agg model is sufficiently abstract to allow fast execution. The Alt Agg model was implemented using object oriented methods and coded in C++. A scenario file syntax was developed in which each unit is labeled with its size, location, operational activity, and composition by a number of different entity types.

With the composition of units so defined, units need not be fixed; they can be ad hoc battle groups as easily as standard organizational units. Terrain location for each unit and entity type is given in one dimension and represents the range that separates it from the origin on the one-dimensional terrain. The implementation is able to handle snapshots of larger scenarios as a series of contiguous actions or vignettes in an efficient manner. An action can be executed for a user-defined time limit and the resulting order of battle from both sides written into a file. These files can be sequenced together or altered easily, making this approach favorable for a node-by-node exploration of "what-if" trees of tactical combat outcomes determined by operational decisions. Furthermore, mid-scenario environment changes such as weather, visibility, and trafficability are supported by the use of different data tables that can be loaded during a simulation.

Project objectives and results

Initially, the project's objective was to develop a model of conventional combat that operated at the unit level that was based on entity-level information, thereby enabling a possible increase in accuracy and credibility and avoiding the complexity and validity issues of multi-resolution combat models linking unit- and entity-level models. As the project proceeded, three additional objectives were subsequently defined: 1) the Alt Agg model should produce results that are usefully close to historical outcomes and the results produced by existing, more detailed models; 2) it should execute more quickly than existing models; 3) and it should be expanded to unconventional warfare, in particular counterinsurgency engagements. By the conclusion of the project, the project team had accomplished all of these objectives.

Despite its extreme abstractness, the Alt Agg model produces combat results that are usefully accurate. The model was validated by comparing its results to the actual outcomes for two historical battles: the Defense of Noville, which occurred Dec. 19-20, 1944, during the Battle of the Ardennes; and the Battle of Mogadishu, which occurred Oct. 3-4, 1993, during the U.S. intervention in Somalia.

These two scenarios were selected to test the model for conventional and counterinsurgency combat, respectively. Alt Agg's results were also compared with the results produced by a standard U.S. Army combat model, OneSAF, for the historical Battle of 73 Easting, which occurred Feb. 26, 1991, during the Gulf War. In every case, the Alt Agg model's results after calibration were statistically equivalent to the historical outcome of the OneSAF results.

Moreover, because of its extreme simplicity, Alt Agg executes very quickly indeed, approximately 100 times faster than comparable standard entity-level models. This makes it very useful for applications requiring many simulation trials, such as Monte Carlo simulation and "what-if" analysis. Finally, the counterinsurgency extensions to the Alt Agg model consider insurgents' advantages in regards to terrain familiarity and the exploitation of civilians as concealment.

The Alt Agg model does have constraints. For example, configuring Alt Agg for a new combat era requires the advance creation of a set of tables and probability functions for the weapons and sensors of that era, and off-line preprocessing is required for new terrain. Moreover, Alt Agg currently does not support air-to-ground or ground-to-air combat, or air-mobile operations.

Dr. Mikel Petty is director of UAH's Center for Modeling, Simulation, and Analysis. He received his Ph.D. in computer science from the University of Central Florida. He has more than 35 years of experience in modeling and simulation education and research, as well as software development and database administration. He has produced more than 110 funded research proposals and contributed to more than 190 research publications.

Environmental health disparities

Urban air quality from a coupled human environment systems perspective

By Susan Alexander
Clinical Associate Professor of Nursing

Increasing urbanization leads to changes in local climates and the composition of the atmosphere. When coupled with socioeconomic factors associated with urban spaces, such as human behavior, amenities, and resource availability, convolutions in spatial patterns in the natural and human system determines the feedback from the altered natural system to the human system, namely, environmental health impacts.

A multidisciplinary team composed of faculty, research scientists, and students from The University of Alabama in Huntsville (UAH) is conducting a series of experiments that will couple land-atmosphere and air-quality models, adding health care, urban population, and socioeconomic data to develop a human system dynamics model for an urban area in the Southwestern United States.

Objectives of the project include:1) examine the role of internal dynamics of human and natural systems in generating spatial patterns of relevance within each system; 2) determine if the convolution of spatial patterns of relevant variables within the coupled system result in human health inequalities; 3) and develop a conceptual understanding of the complex system considered and test different strategies for sustainable urban growth and the reduction of health inequalities.

The core hypothesis of the project is: Urban pollution and associated human health impacts are both modulated by the urban heat island effect, whereas the urban geography and socioeconomics lead to exposure and inhalation dose inequalities.

Our efforts will consider how the land-atmosphere (natural) and urban (human) systems interact to modulate the urban climate due to changes in air quality, and further how the changes in air quality impact population distribution with the urban settlement, human activity, and exposure to air pollution. While the relationship of air pollution and cardiorespiratory disease has been described in the literature, a gap exists that describes the human response to the modulation of air pollution exposure.

Analysis of health data in conjunction with best estimates of spatial distribution of urban pollution will be used to understand the role of socioeconomics in modulating air pollution exposure. A human system dynamics model will be created and used to integrate research findings and to develop feasible mitigation strategies for urban air pollution exposure. Development of this model is particularly important due both to the large numbers of people who reside in urban areas in the United States and the anticipated continued growth of urban areas by 2050.

The ongoing research seeks to answer questions including:

- What are the physical processes that define interrelations between urbanization, local climate, and urban air pollution?
- What is the impact of multiple sources of pollution, both natural and human, upon air quality in urban regions?
- What is the impact upon human health of air pollution from both natural and human sources, and are these effects modulated by geographic location?
- What relationships exist between the spatial distribution of air

pollution health risks, socioeconomic status, and urban environment?

Efforts to answer these questions will utilize atmospheric numerical modeling and air pollution modeling from an urban region of the Southwestern United States, assimilating a variety of observations to characterize the spatial distribution urban pollution for the period of 2002-2012. Coupling between the meteorology model (Weather Research Forecast [WRF]) and the air quality model (Community Multi-Scale Air Quality model [CMAQ]) will also be considered for a variety of land use and emission scenarios. Additional analysis of health care data will then be used to quantify the spatial distribution of health risk from air pollution.

Health Care Cost and Utilization Project (HCUP) Nationwide Inpatient Statistics (NIS) and National Emergency Department (NED) datasets will be used to supply needed health care data. An integrated assessment of the above-described analyses will be undertaken to explore approaches to mitigate the human health impacts of urban air pollution.

UAH's multidisciplinary team consists of Dr. Udaysankar Nair, Department of Atmospheric Science; Dr. Susan Alexander, College of Nursing; Dr. Sundar Christopher, Dean, College of Science; Dr. Louise O'Keefe, College of Nursing; Dr. Arastoo Biazar, Earth System Science Center; Dr. Rob Griffin, Department of Atmospheric Science; Dr. Kyle Knight, Department of Sociology; Manil Maskey, Information Technology and Systems Research Center; and Aaron Kaulfus, Student, Department of Atmospheric Science.

Dr. Susan Alexander is a clinical associate professor of nursing after having earned her Doctor of Nursing Practice degree from The University of Alabama in Huntsville. Her research interests are health disparities environmental research and mobile health applications in chronic disease management.

An organization's strategic approach to human resources can create a competitive advantage

By Ivey MacKenzie Jr.
Assistant Professor of Management

The human resources (HR) department is probably one of the most underappreciated departments in most organizations. Full disclosure, I teach human resources.

Knowing the audience for this essay would be individuals outside the field of human resources made choosing an essay topic an easy task. I would focus on the value of human resources. Even I must admit that last sentence alone could be enough to encourage some people to stop reading and move on to the next article or at best encourage a yawn and start the process of glazing the reader's eyes over but I ask that you continue reading with an open mind.

When I think of human resources, I think of something completely different than the punchline of a television sitcom joke or that faceless group of people that seem to make every manager's job more difficult. Instead, I think of an organization's employees and the people (managers included) that manage an organization's employees. I think of the policies and procedures that lead to creativity and innovation. To me human resources are a valuable tool that lift a company and its employees up and make everyone stronger, better, and more competitive. The purpose of this essay is to discuss the importance of adopting a strategic approach to human resources.

Many managers have a simplistic view of human resources; often this view comes from limited experiences with a strategic-focused human resources staff. Organizations that wish to adopt a more strategic approach to human resources must invest in training both managers and human resource professionals. Managers must fully understand the role and capabilities of a professional human resources staff. I have heard horror stories (at least horror in the mind of this HR professor) of departments composed solely of a former administrative assistant because it came to light that they once took an HR class in college.

It is critical that organizations recognize the value of HR and implement HR best practices. A strong business can be successful with poorly managed human resources, I have witnessed that firsthand. However, a strong business cannot rise to its potential unless human resources are valued and properly managed. To be fair, human resource managers share some of the blame here as well. HR professionals need to embrace a business mindset. They need to be as comfortable preparing an income statement as they are a performance evaluation.

Human resources performed well can substantiate its investments and make a business case for itself, even though its returns are often indirect and are not fully realized until long after they are implemented.

It is amazing how quickly the world and business changes. In business strategy we teach the importance of strategic thinking. Any business school graduate understands the importance of knowing his or her organization's strengths and weaknesses and the importance of paying attention to the external environment, always being on the lookout for opportunities and threats. Most of us have seen the impact of change during our careers, where the introduction of new technologies has completely changed entire industries. A typical person walking down the street has more processing power in their pockets than some people have on their desktop, cars are starting to drive themselves, and most of us take it for granted that we can easily connect and collaborate with people on the opposite side of the planet as though they were sitting across from us in a meeting.

Technology is truly amazing, and if there is one thing we can count on in business, it's that technology will continue to evolve and push organizations to change and adapt. Organizations such as Qualcomm, Alphabet (aka Google), and Facebook recognize the value of knowledge and those that create knowledge, a firm's employees.

Much of my research has focused on the value of human capital resources. Human capital resources are simply the talents of an organization's employees. In the academic literature we would refer to this as the aggregate knowledge, skills, and abilities (KSA) of an organization's employees. My research and others in my field seek to understand how organizations can better staff and leverage their human capital resources to gain a competitive advantage. The value of people is not a new concept; "the war for talent" has been a go-to catchphrase in HR since the 1990s.

Perhaps not surprisingly during this same time period we have also seen the role of HR evolve and develop. As organizations have strived to win the war for talent, by hiring, retaining, and leveraging their human capital resources to gain a sustained competitive advantage, the role of HR has evolved to reflect the value of people to an organization's competitive position.

Most successful firms that depend on human capital resources to be competitive have adapted their interactions with their own human resources departments. Human resources has moved beyond the administrative role of managing employee paperwork and basic employee relations to the role of strategic partner where human capital resources are a key determinant of an organization's competitive strategy.

Strategic human resources require an organization to consider all aspects of how it manages its human capital. It is not enough to simply select the most talented employees and expect that they will perform at desired levels. While much care should be given to selecting the most talented applicants, hiring talent is just the first step to developing an organization's human capital resources. Newly hired employees possess generic skills and have not received training specific to the organization.

Adopting a strategic human resources approach requires an organization to adequately train, motivate, develop, and retain top talent. Great care must be taken to onboard new hires so that they are able to hit the ground running and apply their specialized knowledge to organizational issues quickly and effectively.

Organizations must craft HR policies and practices that will adequately motivate employees to achieve organizational goals. It is critical for an organization to develop a strong culture that fosters innovation and creativity. Developing such a culture requires organizational leaders to truly embrace HR and develop a thorough understanding of how to lead and motivate a workforce.

No workforce will simply be motivated by catchy slogans and motivational posters much less one that is highly educated and skilled. Organizational leaders must leverage HR policies and practices to shape the culture of their firm so that workers are better able to respond and adapt to the changing competitive environment that they face.

A good organizational development initiative will adequately predict future KSA requirements and prepare existing employees to meet changing organizational needs. Employee development also requires an organization to prepare talent for future managerial and leadership roles. A strong approach to organizational development will make sure that these individuals are ready for future leadership roles and allow the firm to better leverage these organizational thought leaders in managerial positions.

One of the biggest issues facing competitive firms is retaining top talent; they are the key to an organization's competitive advantage. Organizations that achieve a competitive advantage place a target on themselves in regards to their own workforce. These organizations must work hard to retain the talent that was critical to their success. An organization that is able to fully leverage its human resources has the potential to achieve a sustained competitive advantage. Competitive organizations often strive to innovate and develop new products for the marketplace. Goals such as these are common among most technological companies. It is equally important for organizations to understand where these competencies are developed: its employees.

Organizations should strategically manage the individuals who directly lead to these achievements and recognize the value of a strategic approach to human resources. Organizations that wisely invest in their employees have the potential to gain a competitive advantage in the marketplace.

Dr. Ivey MacKenzie Jr. is an assistant professor of management and received his Ph.D. from the University of South Carolina. His research interests are strategic human resources, human capital resources, staffing, and situational judgment tests.

Closing the loop

Energy conversion and storage device remanufacturing

By George J. Nelson

Assistant Professor of Mechanical and Aerospace Engineering

The concept of designing products for reuse is well established. In *Cradle to Cradle: Remaking the Way We Make Things*, William McDonough and Michael Braungart outline some historical examples of this approach and propose a distinct model for the "eco-effective" design of materials and related industrial systems. Central to their proposal are the concepts of technical nutrients and products of service.

Technical nutrients are materials designed with the intent of being fed back into an industrial cycle that yields a product. They are the industrial analogs to biological nutrients, e.g., fallen leaves that compost and fertilize a tree. Technical nutrients are the underpinnings of products of service: things purchased for a given use period that are subsequently returned to the vendor for remanufacture at the end of the use period. The product of service stands in contrast to our ubiquitous products of consumption, which go "away" at the end of their useful life. This "eco-effective" paradigm is distinct from the current "eco-efficient" paradigm in its focus on creating cycles for products and seeking ways to eliminate current recycling approaches, which actually "downcycle" materials.

McDonough and Braungart give multiple examples of current recycling processes, such as those for plastics and automotive steel that generate recycled plastics and steels of inferior quality as compared to the input materials.

State of the art electrochemical energy conversion and storage technologies — batteries, fuel cells, electrolyzers, and supercapacitors — are approaching a point where the primary limiting factor is attainment of sufficient lifetime under increasingly rigorous operating conditions.

In the near term, the study of degradation processes will advance the robustness and reliability of batteries, fuel cells, and other devices. Understanding the fundamental processes behind undesirable materials degradation presents the opportunity to design materials and related processes that efficiently harvest key materials at what would typically be the end of a device's life cycle. These materials can be applied in the production of future electrochemical energy conversion and storage devices. Truly sustainable energy systems will be implemented using energy conversion and storage technologies that are products of services composed of technical nutrients. The critical questions that must be answered to achieve this objective are: 1) what technical nutrients are produced by the degradation processes in current energy conversion and storage devices? and 2) how do we engineer degradation in next-generation electrochemical energy conversion and storage devices to yield desired technical nutrients?

The robustness and sustainability of future electrochemical energy conversion and storage technologies can be advanced by coupling the study of materials degradation processes with materials design that applies multiscale modeling and materials characterization approaches to form an understanding of materials behavior that covers atomic-to systems-level scales, angstroms to meters.

Starting at the atomic scale, first principles calculations that predict electron configurations and resulting properties can be applied toward the selection of chemical combinations yielding materials with desired properties such as electrical or thermal conductivity.

Molecular dynamics simulations can be applied to further understand the interactions between basic particles, atoms, and molecules that govern fundamental material properties. These computational approaches can be complemented by 3-D materials imaging and characterization techniques, such as X-ray and neutron diffraction, transmission electron microscopy, and atom probe tomography, that enable us to view atomic structure and molecular configurations. Fundamental nanoscale information may be fed up the chain of scales to support investigation of interactions between material function and micron scale material structure. Material-geometry interactions at this scale are often critical drivers of performance and reliability.

Ultimately, this nano- and micro-scale information can be integrated into device-and systems-level modeling and characterization to yield a holistic approach to understanding and engineering the production, degradation, and regeneration of materials for electrochemical energy conversion and storage devices: batteries for electric cars or home energy storage and high-temperature electrochemical cells for renewable fuel production, etc.

This approach is bio-mimetic in its outcome, yielding a process that mirrors the growth, decomposition, and regeneration of the myriad multiscale functional systems that exist in nature. The solid-oxide fuel cell is an energy conversion technology that can readily lend itself to the development of a remanufacturing paradigm. Solid-oxide fuel cells are high-temperature devices that directly convert fuel-based chemical energy to electrical energy. Like most fuel cells, solid-oxide cells operate on hydrogen, but they have an additional capability of direct operation on hydrocarbons like natural gas or propane. While studied for many years, the solid-oxide fuel cell is approaching the cusp of broader commercial development. Prototypes have been developed for diverse distributed applications ranging from home power and water heating, to the combined production of heat, power, and hydrogen fuel, to distributed power supplies. One example of distributed power generation is the Energy Server developed by Bloom Energy, a fuel cell stack that can power a neighborhood or large office building in a footprint the size of a parking space. Their efficiency, scalability, and fuel flexibility makes solid-oxide fuel cells a strong candidate for distributed energy conversion and storage applications. The solid-oxide fuel cell employs rare Earth elements in key components and contains nickel and, potentially, more-toxic or -carcinogenic materials as products of degradation. These products can include nickel oxide, nickel sulfide, and chromium. These are not materials that should be released to the broader environment. Their elimination or containment within an industrial cycle would be desirable. Furthermore, nickel oxide is commonly applied as a precursor material in solid-oxide fuel cell fabrication.

Thus it is a candidate for a technical nutrient that can support the closed loop production, use, and remanufacture of solid-oxide fuel cells. Such nutrients must be identified in each component of the solid-oxide fuel cell and related system. Effective processes for recovery of these materials must also be identified. One can envision solid-oxide fuel cell systems that are effectively leased from a power or natural gas company for a given period after which the core fuel cell is returned for remanufacture.

The application of "technical nutrient" and "product of service" concepts to fuel cells provides a brief sketch of how multiscale design for materials reuse can be implemented for electrochemical energy conversion and storage technologies. This approach can be applied to other such devices. For example, the study of lithium plating that causes catastrophic failure of lithium batteries could be leveraged toward the efficient extraction of lithium from battery components. Beyond application to existing technologies, we can begin asking the more general question of what a technical nutrient looks like for these devices. The computational and experimental tools are available to answer this question. As engineers and scientists we must ask it and begin to eliminate the option of "away" to create a sustainable energy infrastructure.

Dr. George Nelson is an assistant professor of mechanical and aerospace engineering. His general research interests include transport phenomena, energy storage and conversion devices, sustainable energy systems, and multiscale modeling and analysis. He received his Ph.D. in mechanical engineering from the Georgia Institute of Technology.

Huntsville and the history of civilization

By Charles A. Lundquist
Director of Interactive Projects
UAH Research Institute

Few communities can convincingly claim that they were the focus of events that changed the course of civilization. Huntsville can! The first time that mankind left Earth and performed operations on another body in the solar system was such a course-changing milestone in the history of civilization.

Huntsville, indeed, was the center of a community with size defined by reasonable commuting distance that provided the essential transportation to go the moon. The first crewed lunar mission was executed in July 1969 as a key objective of the U.S. Apollo Program. The fundamental operational facts of the lunar missions are well understood and documented. NASA's Marshall Space Flight Center (MSFC) at Huntsville was responsible for the design, development, and management of the most essential aspect of Apollo, namely, the rocket vehicles to provide basic transportation. Other NASA centers and contractors had necessary Apollo roles, but providing transportation remained the most essential role. The part that the Huntsville community played in facilitating the successful lunar operations has not always received the recognition or appreciation it deserves.

This Huntsville saga began in 1950 when the U.S. Army permanently located its rocketry activities at Redstone Arsenal. Soon it was apparent that the community was faced with a daunting challenge. The community had to morph itself, in a few years, from an agricultural center into a world-leading, high-technology site. In the aftermath of World War II, rocket development became a high-priority objective for each of the advanced nations in the world. Army organizations, newly located in Huntsville, had been chosen to be responsible for the success of a significant fraction of the U.S. effort.

It is commonly recognized that a team capable of pursuing high-technology objectives, such as rocketry, is a broadly educated and cultured group of individuals. Such individuals want their home community to provide the cultural opportunities typical of a major population center. The initial rocketry group that arrived in Huntsville in 1950 consisted of more than 100 cultured engineers, scientists, and managers transported from Europe and a cadre of selected, high-performance Army personnel. The adults in the European families characteristically had degrees from prestigious universities, and the family heads had some years of practical rocketry experience. During the 1950s, this initial group recruited some hundreds of native-born Americans with similar cultural expectations, including many individuals with advanced academic degrees. It is a compliment to the members of the pre-existing Huntsville community that they welcomed this imposing influx of new residents who had very different backgrounds.

Music is an essential component of a cultured community and is also an instructive example of events in Huntsville. The pre-1950 population of Huntsville and nearby cities did have individuals with serious musical interests and talents. Some, particularly Alvin Dreger, had dreams of a community orchestra, but the community then was not large enough to have the required musicians and financial support. However, a significant number of the new arrivals from Europe and from around the U.S. were accomplished, avocational, classical musicians. The interested original residents and new arrivals quickly engaged in discussions and planning. Serious planning in 1954 led in early 1955 to the formation of what has become the Huntsville Symphony Orchestra.

The competent concertmaster for the first years of the orchestra, Werner Kuers, was a transplanted German. The orchestra evolved quickly, and by September 1959, engaged a part-time resident conductor, Russell Gerhart. The Huntsville community then had an orchestra performing regular seasons of classical music that was well attended and supported.

Another musical organization was the Huntsville Chamber Music Guild, which already existed in a rudimentary state before 1950. Its purpose was to provide an annual series of chamber music recitals for the community. After 1950, members of the population influx, a prime example being Gerhard Reisig, another transplanted German, quickly embraced the guild and enhanced its scope. Soon the guild offered full seasons, combining concerts by professional groups brought in from around the world and other concerts performed by chamber music artists from the community. The latter concerts were important because they gave the qualified local musicians an appreciated opportunity to perform for the public. An interesting example of a function sponsored by the guild was a series of haus-musik performances in the historic McCormick House. Following these intimate concerts, the German housewives served a delicious selection of German pastries.

Another aspect of the growth of culture was university education. The employment market in the 1950s was very competitive. Employers, such as the U.S. Army, had to offer attractive living environments to attract top-level new employees. A necessary component of an employment package for high school and baccalaureate-level recent graduates was the opportunity to advance themselves by taking off-work-hours university courses in appropriate disciplines.

Prior to 1950, some citizens of Huntsville, such as Pat Richardson, had attempted to convince the University of Alabama to establish an extension to offer traditional undergraduate courses in Huntsville.

Following Richardson's efforts and a media campaign by Huntsville Times editor Reece Amis, the university agreed to an extension center in

Huntsville. The first undergraduate courses with the new institution were offered in January 1950.

After their arrival in 1950, officers of the Army organizations immediately recognized and voiced the need for such courses, but even more urgently, the requirement for graduate courses in the disciplines important to Army programs. The existing colleges in Huntsville were not ready to meet these requirements. The Army needs were so significant that funds were allocated to support graduate courses. The first graduate courses under Army sponsorship were offered in September 1951.

The University of Alabama Extension, initially under the part-time leadership of Dr. John Morton, grew gradually during the 1950s and soon embraced the graduate courses. The Army appointed a Graduate Study Steering Committee, consisting of selected employees with advanced degrees, to interact with the university on details such as the courses to be offered. In 1952, the graduate faculty had 15 members, of which 10 were transplanted rocket pioneers from Europe.

On May 25, 1961, President John F. Kennedy committed the United States to sending men to the moon and returning them safely to Earth by the end of the decade. The Marshall Space Flight Center shouldered the responsibility for the basic rocket transportation for this very challenging commitment. The need for high-technology education for employees and contractors was magnified during the resulting buildup of Marshall manpower. The Army programs also evolved with more demanding objectives.

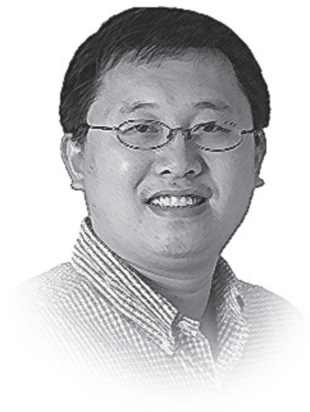
A historic coincidence transpired in 1969. NASA successfully sent the first men to the moon and The University of Alabama in Huntsville (UAH) was designated as one of three autonomous campuses of the University of Alabama System. Huntsville now had a full-scale, high-technology university with many auxiliary cultural advantages. In less than two decades, the community and state had met the educational challenges imposed on them in 1950.

A great variety of other quality-of-living cultural entities grew in Huntsville from 1950 to 1969. The newcomers, particularly Walter Wiesman, a transplanted German, were instrumental in forming a public radio station. A world-class museum complex, the U.S. Space & Rocket Center, was created under the initial directorship of Ed Buckbee, an MSFC alumnus.

In association with it, Space Camp sessions for interested students were initiated and became well attended. Theater groups matured. And the list of cultural advances goes on.

Hence, in 1969, Huntsville and its high-technology, cultured community earned prime-time recognition for its essential support for the first time mankind left Earth and traveled to another body in our solar system. The rocketry team members would not have prospered and succeeded without a favorable, cultured community for their residents. As 2019 approaches, the community must now plan for appropriate 50-year-anniversary commemorations and a second prime time in the international spotlight.

Dr. Charles A. Lundquist served as chief of the Physics and Astrophysics Branch of the U.S. Army Ballistic Missile Agency at Redstone Arsenal, participating in the planning and launch of America's first satellite into space, the Explorer 1; and was chief of the Physics and Aerophysics Branch and Research Projects Office at NASA's Marshall Space Flight Center. Dr. Lundquist also served as assistant director for science at the Astrophysical Observatory of the Smithsonian Institution in Cambridge, MA. He returned to Huntsville and retired as the director of the Space Sciences Laboratory at Marshall Space Flight Center. Dr. Lundquist joined UAH first as director of research and then as associate vice president of research.



Game On! Gaming systems lead to widespread learning, training, and entertainment

By Chao Peng
Assistant Professor of Computer Science

Video games became popular in 1970s. With the development of video arcade machines, game consoles, and computer games, video gaming gradually merged into mainstream entertainment and became an undeniable part of modern culture all over the world. Nowadays, video games have grown to a major industry, generating billions of dollars per year.

Today's video games are enjoyed by players of all ages. While people have fun playing games, they experience game technologies and enjoy the interaction with the device. Vision of game development has changed for the new growth path; not all modern games are designed for entertainment. In the United States, young people start playing video games at age four or five. Parents are often worried about their children spending time every day playing video games, but now they may think about encouraging them to play video games, because video games have been widely recognized as a great tool to help build foundational skills in math, science, social studies, and more.

Many researchers and educators agree on a common viewpoint that appropriate games can motivate people to learn things that they do not want to through gameplay in the virtual environment. For example, DragonBox Algebra, a tablet game that teaches children the foundations of algebra, engages students to learn math by using pictures, and mathematical logic and gives confidence through interactions rather than using numbers or variables.

Also, game technology is involved in many other industries like training, security and advertising, etc. For example, virtual reality (VR) gaming systems employ computer-simulated situations to make you believe and feel that you are actually in a situation. VR systems have been used in the areas of health care such as treatment and surgery to train the next generation of doctors, nurses, and other medical staff. They have also been used in military and industrial training scenarios. A VR gaming system shortens the reset time of training, so more repetitions are able to be done in a shorter amount of time.

The future of video games is bright. Portable devices, such as smartphones and tablets, have become low-end gaming platforms. While researchers and engineers continue advancing device technology, it is clear that more, and more diverse games will be available. Games will be everywhere.

This could include personal computers, next-generation game consoles, portable devices, and even VR headsets that are not yet viable products. The market for video games continues to grow, not only in sales but also in the diversity of content that games offer, which ranges from educational/serious games, to first-person-shooter games, as well as casual mobile games.

Developing a game is much harder than playing a game. Game development is a complex process involving many parts and steps. The University of Alabama in Huntsville (UAH) offers a curriculum for game development in the Department of Computer Science (CS). Non-CS students can earn a minor in game development, and CS majors can have a concentration in game development. The following paragraphs describe the breakdown of our game-development curriculum.

Design, assets, codes, and putting them together: Video games as a form of programed artistic content have led to collaborations between artists and programmers. To become a successful game developer, one should have knowledge of both. While emphasizing programming skills, good developers should know how to write game stories, design gameplay mechanics, create 2-D and 3-D art assets, and use sound and music.

We implement introductory courses to let students experience all aspects in a game production pipeline. These courses are a mixture of design, art, and programming.

The courses offered are Introduction to Technology for Multimedia and Gaming, and Introduction to Game Design and Programming Graphics programming: Computer graphics refers to drawing images on computers, but programming for computer graphics is a less artistic practice. It requires a good understanding of the architecture of graphics processing units and 3-D math like trigonometry, linear algebra, and even calculus.

Programming skills for computer graphics are essential for game development. Simulated events in the game must be visually represented to users. While a game runs, game content is updated frame by frame. Frames are converted to images and displayed on the screen. In our curriculum, we focus on preparation for the basic capabilities expected of a junior graphics programmer. We emphasize the geometries and mathematical foundations of computer graphics.

Some advanced topics may also be covered in our curriculum, which introduces students to state-of-art acceleration techniques used in many professional game titles, for example, real-time graphics programming. The key that motivates people to play video games is the interaction, which generates immediate feedback on their actions and promotes them to further plays in the game scene.

To reach this goal, developers must make game software that runs in real time. Each frame must be displayed to the user in a very short amount of time – usually less than one-third of a second. The time spent on processing a frame includes not only the cost of rendering the frame but also that of managing assets, updating the status of game objects (e.g., moving to new locations), and simulating visual effects (e.g., simulations of fire, water, etc). This requires programmers to not only write codes that generate correct images but also ensure the codes are executed efficiently.

Artificial intelligence (AI): This is a broad concept in computer science and robotics. The general goal of AI is to create smart systems to solve complex problems with the solutions generated on their own. The original intention of AI research concerns how to solve real-world problems with an emphasis on optimal solutions rather than hardware (e.g., game consoles vs. mobile devices) or time limitations.

In video games, AI programmers have to work with the limitations and compromise the results in order to achieve an acceptable level of performance. The prime task of game AI is to create intelligent behaviors for non-player characters (NPCs) that populate the game world. NPCs can be a variety of roles like enemies, allies, or other kinds of virtual creatures. There could be many types of game AI mixed in a game.

For example, pathfinding — finding a path from one location in the game world to another. It usually requires a data structure to guide the movement. The simplest data structure could store just a list of locations that the NPC has access to move to. One type of behavior that pathfinding usually simulates is making the NPC patrol an area. AI is a main factor affecting the user experience of the game. In our curriculum, we offer a comprehensive introduction to the use of AI for video games, with a focus on the fundamental principles of game AI.

Capstone: It's time to make your cool game! In the game capstone course, instructors guide students through a full game-production cycle that includes brainstorming, design, prototyping, asset creation, programming, and play testing.

Students learn the components that compose a game engine. They also learn the architecture of game engines as well as level design. Students form teams; each team is composed of students with programming skills and students with artistic skills. Students gain experience working intensively in a cross-disciplinary environment, which reflects the reality of game studios. In the capstone course, students integrate knowledge and skills acquired across the game-development curriculum to produce games that meet milestones.

Dr. Chao Peng is an assistant professor in the Department of Computer Science. Dr. Peng earned his Ph.D. in computer science from Virginia Polytechnic Institute and State University (Virginia Tech). His research interests include computer game development, big data visualization, character animation, GPU computing, and geometry processing. Besides doing research in computer science, he is an artist working on various kinds of digital art, including digital paintings, 3-D models, 2-D & 3-D animated shorts, games, and other interactive arts.

UAH is advancing the state of research into embedded computer systems

By Aleksandar Milenkovic
Professor of Electrical and Computer Engineering

Modern society relies on embedded computer systems to perform an increasing multitude of tasks; they are indispensable to modern communication devices, medical equipment, consumer electronics, home appliances, transportation systems, and military systems. Embedded computer systems are special-purpose computers partially or completely encapsulated by the device they control.

Unlike general-purpose computer systems, they are typically designed to perform pre-defined tasks using specific requirements. They operate in very diverse environments, from those implanted in the human body such as pacemakers to those that control various subsystems in modern cars such as engine controllers, antilock brakes, and navigation systems.

Embedded computer systems are shaped by technology, applications, and markets. In technology, advances in semiconductors have enabled an increased level of integration, miniaturization, and cost reduction. A trend of doubling the number of transistors on a single chip every 18 to 24 months, known as Moore's law, allows us to put more hardware components with more functionality and faster data processing in smaller form factors and lighter devices. Thus, microprocessors have evolved from simple designs with 2,300 transistors on a single chip capable of performing 100,000 operations in a second in 1971 to very sophisticated contemporary designs with billions of transistors capable of performing billions of operations in a second.

These advances have enabled revolutionary changes in software applications that have emerged in mobile computing and communications, health care, transportation and navigation, entertainment, and the military.

Thanks to embedded systems we can pursue new applications such as autonomous unmanned vehicles, smart infrastructures, the Internet of Things (IoT), ubiquitous health and wellness monitoring systems, and other applications that looked far-fetched just a decade ago. Market forces have contributed to the increased proliferation and diversification of embedded systems, while at the same time shortening the design and operational life cycles.

Opportunities and Challenges

Researchers and embedded computer system engineers strive to come up with new designs and applications that will offer more functionality and sophistication; provide faster response; guarantee reliable, secure, and autonomous operation for long periods of time; and achieve all these goals at minimal design and operating costs.

Meeting all these goals concurrently will represent a challenging proposition, especially with rapidly evolving technology, application, and market conditions.

To harness the full potential of advances in semiconductors and alleviate technical challenges such as limiting parallelism, the ever-increasing gap between processor and memory speeds, increased power dissipation, and thermal constraints, the computer industry has recently shifted its focus from single-core to multicore processor architectures. This shift poses a number of new challenges.

Computer engineers and software developers need new approaches in designing, programming, debugging, and operating multicore processors with thousands of processor cores on a single chip. For example, computer designers will need new insights into how to architect processing cores, memory hierarchy, and interconnection networks while minimizing power consumption, improving reliability, and reducing the cost.

System-software developers will need new approaches in building system tools such as operating systems, compilers, debuggers, software libraries, and system monitors. Software-application developers will need new programming paradigms and models to develop programs that will execute efficiently on scalable parallel machines. Finally, computer engineering educators are facing educational challenges caused by this shift in computing.

In spite of the numerous challenges discussed earlier, multicore processors offer a number of opportunities for researchers to develop and re-invent computing of the future that will result in truly scalable, secure, high-performance, and power-efficient computer systems. Our research efforts in the Laboratory for Advanced Computer Architectures and Systems are geared toward developing new architectures that will provide secure and dependable embedded systems and architectures that will enable faster and more reliable software development.

Toward Secure and Dependable Embedded Systems

The increased reliance of modern society on interconnected and embedded computer systems underscores the utmost importance of embedded system security and dependability. As the number of embedded applications increases, so do the incentives for attackers to compromise the security of these systems. They are often the target of software attacks typically launched across the network by exploiting known software vulnerabilities. Unauthorized copying of software is another major threat leading to billions of dollars in lost revenue.

Embedded systems operating in hostile environments are often subjected to physical attacks. Adversaries tamper with a system or use indirect analysis to extract critical secrets, reverse-engineer the design, or take control of the system. Security breaches in these systems may have wide-ranging impacts, from loss of revenue to loss of life. Maintaining security in embedded systems is therefore vital for the consumer, industry, and government.

This problem can be addressed at different levels, from more-secure software and operating systems to solutions based on hardware support. Most existing techniques tackle the problem of security flaws at the software level, lacking generality, often inducing prohibitive overhead in performance and cost, and generating a significant number of false alarms.

On the other hand, the ever-increasing number of transistors on a chip allows us to look beyond performance improvements and to utilize them for increasing system resilience to attacks. Given the potential for more-complex software to have potentially a larger number of defects, an increased number of attacks, and a proliferation of networked computing platforms, we believe that dedicated processor resources should be used to ensure trusted program execution.

To alleviate these problems, we have proposed several cost-effective hardware-based architectural extensions to embedded processors that ensure (a) code and data integrity, thus preventing the execution of unauthorized software or the use of unauthorized data; and (b) software and data confidentiality, thus preventing the unauthorized copying of instructions or data.

For ensuring software integrity, we have proposed a processor architecture that relies on hardware-supported, run-time verification of software using encrypted instruction block signatures. With this architecture, all programs are signed using cryptographically sound signatures during program installation, and secret keys are encrypted and embedded in the program binary. The keys are extracted during program loading and used during program execution to verify whether instruction blocks have been tampered with (in which case the program execution is terminated) or not (in which case the instructions are legitimate and can complete the execution).

Program data are also protected using dynamically generated signatures that include versioning to prevent replay attacks. Confidentiality is ensured by encrypting the code and data. We have developed several implementations and mechanisms aimed to counter performance, energy, and memory overheads induced by the security extensions and thus lower the cost of their implementation. The proposed secure architecture has been prototyped on a soft-core processor and demonstrated on an field-programmable gate array.

Toward Bug-Free Software in Embedded Systems

The growing complexity of software and hardware and tightening time-to-market deadlines make software development and debugging the most critical aspect of embedded system development. Software complexity in modern systems outpaces hardware complexity.

For example, just 15 years ago hardware accounted for 90 percent and software for 10 percent of the total engineering cost in a typical embedded system. Today, software accounts for more than 90 percent of the total engineering cost. A modern car may have more than 100 microprocessor-based control units networked throughout the car body running tens of millions of lines of code.

In these conditions, helping software developers produce bug-free code faster is of utmost importance.

A recent study found that software developers spend between 50 to 75 percent of their time debugging programs, yet the nation still loses approximately $20 to $60 billion a year due to software bugs and glitches. The recent shift toward multicore architectures makes software development and debugging even more challenging.

Traditional debugging is time consuming and may interfere with program execution, causing some bugs to become irreproducible and making it unusable in real-time environments. Moreover, tracing a processor's internal state during execution is only feasible for short program segments and requires large on-chip buffers or wide trace ports, either of which increases system cost and limits scalability.

Our research group has developed the next generation of trace compression methods and infrastructure to make continuous, real-time, unobtrusive, and cost-effective program, data, and bug tracing possible in embedded systems. The new tracing and debugging hardware resources can help programmers find difficult and intermittent software bugs faster, thus improving productivity.

For example, reducing debugging time by just one percent amounts to hundreds of millions of dollars annually in saved salaries, with a concomitant reduction in software cost and time-to-market. Moreover, higher-quality software may eliminate errors in medical, automotive, or mission-critical devices and thus save lives.

Dr. Aleksandar Milenkovic is a professor in the Department of Electrical and Computer Engineering. He received his Ph.D. from the University of Belgrade, Serbia. Professor Milenkovic's research interests span the areas of computer architecture, energy-efficient computing, embedded systems and wireless sensor networks, and very-large-scale integration design.

Being an informed consumer of health care

By Pam O'Neal
Associate Professor of Nursing

Healthcare cost in the U.S. is high and it is growing. Health spending in the U.S. was 17.2 percent of the gross domestic product in 2012, and it is projected to be 19.3 percent by 2023. Health spending is projected to grow through 2023 at an average rate of 5.7 percent. The National Health Expenditures are projected to be $3.207 trillion dollars this year, and the 2015 the U.S. population is around 320 million. This leads to an estimated spending of $10,000 per person. The U.S. spends roughly $2,500 more on healthcare than Norway, which is the second highest spender per capita with longer life expectancy (Norway 81.5; U.S. 78.7 years) and less obesity (Norway 10 percent; U.S. 28.6 percent).

What we know is that a lot of money is spent on healthcare in the U.S., and what is the benefit to you? Do you have access to healthcare services? Are the current healthcare services meeting your health needs? Do you feel comfortable asking your healthcare provider about important healthcare questions? The following will provide you additional information on how to be an informed consumer of your health and healthcare dollars.

How do I know what is covered by my insurance provider?

Your health policy provides many "benefits" to you. Your insurance provider usually provides a package of services that may include ambulatory patient services, emergency services, maternity and newborn care, tests, prescription drugs, and treatments. Many providers will have a "fact sheet" that may be easier for you to follow. You can review the "benefits" covered by your insurance provider online or you can call your provider and ask them to mail you an updated lists of benefits. You can also meet with your Human Resource Department's Benefits Coordinator to understand what is covered by the health insurance policy provided by your employer.

If I do not have insurance, how can I obtain insurance?

Affordable Care Act plans can be located online at www.ObamacareUSA.org. It might be helpful to have someone with you as you navigate through the website as the system is complex and many "clicks" are required to navigate through numerous screens.

Can I go see my healthcare provider about anything and it be covered?

Pre-approval or pre-authorization may be required to see certain specialty healthcare providers or for specialized tests and treatments. If you do not know what is covered by your insurance and you obtain services not pre-approved then your insurance provider generally will not cover the expenses. Be proactive in calling your insurance provider if you are unsure what may or may not be covered. General procedures that typically require pre-approval include but are not limited to the following:

- Durable medical equipment (walkers, oxygen tanks)
- Gastrointestinal tests (endoscopies, colonoscopies)
- Home-care services (home therapy, hospice, skilled nursing visits)
- Non-emergency ambulance services
- Pain-management services (nerve blocks and many others)

- Radiology services (X-rays, CT scans, MRIs, and ultrasounds)
- Sleep studies
- Specialty drugs
- Surgical procedures

What should I ask my healthcare provider?

You are encouraged to write down any question you have related to your health. Try to describe your health concern in as much detail as possible. For example, if you are having pain, then talk about the onset (when it occurred), provocation (what makes it better or worse), quality (sharp, dull, crushing, burning), region/radiation (where it is and where it goes), severity (scale 0 – 10 with 0 being no pain and 10 being the worst possible pain), and time (history – how long). This method is also known as the OPQRST method. It is helpful to be as descriptive as possible when sharing a problem or concern with your healthcare provider.

What will the cost be?

Most healthcare providers do not know the actual cost of a test. You can contact the billing department to have an idea of the cost of a test or X-ray.

In summary, healthcare is costly, and these costs are increasing. Most insurance plans do promote health prevention by paying for screenings, flu shots, and annual checkups. The healthier you can stay then the more likely your healthcare costs will be contained. Actively take advantage of the benefits your insurance provides, such as annual eye exams and teeth cleaning every six months. You can include fruits and vegetables in your diet to promote nutritional balance. The most important way to manage your healthcare dollars is to learn what benefits your health insurance provides to you and take advantage of the preventive benefits.

Dr. Pam O'Neal is a registered nurse and an associate professor of nursing. She was awarded her Ph.D. from Virginia Commonwealth University. Her clinical expertise is in pulmonary and cardiac critical care, nursing administration, and outpatient day surgery.

College of Education Making Things Happen by Supporting Linguistic Diversity in Region

By Jason L. O'Brien
Associate Professor of Education
and
Andrea Word
Clinical Associate Professor of Education

During the past two decades, the fastest growing subpopulation in the nation's schools comprises students who do not speak English as their first language. These students have the federal designation of English Learners (ELs). Many of these students are attending schools that, in the past, have had very little linguistic diversity. Teachers now face the challenge of teaching both subject-area content and English to these students with little to no training to do so. Alabama has been particularly affected as ELs have come to work in Alabama's agrarian industries.

Recognizing the need for resources to help teachers and students, two faculty members in the College of Education decided to tackle the issue. Drs. O'Brien and Word applied for a National Professional Development grant from the U.S. Department of Education. More than 200 applications were received for this grant, and only 24 were funded for this cycle. Drs. O'Brien and Word (through the College of Education) were awarded $1.2 million dollars for a five-year period. This grant, named Project HAPPENS (Helping Academic Professionals Prepare English learners for Newfound Success), has been instrumental in helping teachers in North Alabama more effectively teach students in their kindergarten through 12th-grade (K-12) classes. Funds have been used in several local districts, with particular attention to Decatur City schools and Madison County schools. Decatur City has had a recent influx of primarily Spanish-speaking students whose parents work in mostly agrarian environments. Several of these teachers participating in Project HAPPENS have classrooms in which more than 80 percent of the students speak a language other than English at home. Madison County's ELs are more linguistically diverse; currently, students speak 22 different languages in their K-12 classrooms.

Project HAPPENS has two components. The first is a series of professional-development workshops targeting area teachers. During a 10-month period, cohorts of elementary and secondary teachers travel to UAH for a series of four research-based training sessions that model strategies to help teachers more effectively teach ELs. Grant funds are used to pay stipends to teachers during the summer and to pay for substitute teachers during the academic year. These training sessions begin by introducing teachers to the language acquisition process and the need for teachers to create welcoming environments for ELs. Workshops two through four focus on the importance of modifying instructional language so ELs can access the content while simultaneously learning English. Drs. Word and O'Brien have created the acronym DIAL (differentiating instructional and academic language) to describe the training. As of the fall semester of 2016, 162 teachers have participated in this training.

The grant also provides monetary awards to teachers to pay for six of 11 courses necessary to earn a master's degree in teaching English as a Second Language (ESL). As a result of this monetary support from the federal government, the number of students in these classes has tripled in size over the course of the grant. Currently, 31 teachers have participated in this component. Teachers take courses in linguistics, grammar, differentiated instruction for ELs, and assessment for ELs. Project HAPPENS also pays fees for teachers to take their culminating state exam (called Praxis) so that they can be certified in ESL.

An added benefit of Project HAPPENS has been the strengthening of relationships with the partnership school districts. Through this collaboration, UAH's College of Education has gained increased visibility in North Alabama and feedback from participants of both professional development and coursework has been overwhelmingly positive. The next funding cycle for this grant program begins in 2017, and Drs. O'Brien and Word are already planning the next iteration of this project. With efforts like Project HAPPENS, they hope that the College of Education will be seen as a leader in professional development and collaboration in the Tennessee Valley.

Dr. Jason O'Brien is an associate professor of education and received his Ph.D. from the University of South Florida. His research interests are social studies teaching and learning, English Learners, and citizenship education.

Dr. Andrea Word is a clinical assistant professor in the Department of Curriculum in the College of Education and director of the Intensive Language and Culture Program at The University of Alabama in Huntsville. She received her Ph.D. from the University of Alabama.

Research universities are the key to success in knowledge economy

By Jeff Thompson
Research Scientist
Center for Management and Economic Research

The overarching mission of institutions of higher learning, such as The University of Alabama in Huntsville (UAH), is summed up with three words — education, research, and service.

The education mission of UAH is outstanding with robust academic programs and world-class faculty, and the research enterprise is nationally prominent and growing stronger. It's that third mission — service — that will validate UAH as an exceptional university.

The ability of the campus to leverage its education and research assets into a leading role for Huntsville's economic development future is what will perhaps allow the institution to provide its greatest value to

Huntsville and the state of Alabama. In an economy based on brainpower rather than natural resources, research universities and UAH hold the key to success.

Advanced economies have been moving toward knowledge-based technologies that rely heavily on a highly educated workforce and research. As such, it is intellectual development and knowledge that provides the edge in economic development. This role for universities is an open doorway for economic development opportunities, and Alabama Gov. Robert Bentley has asked the state's higher educational institutions to implement this concept.

UAH is no stranger to that role and has long been active in supporting the Huntsville-Madison County Chamber of Commerce in helping to attract new business and industry. But momentum is picking up to strengthen and expand the university's role for researching and commercializing that knowledge, as well as to encourage startups and boost job creation. What UAH is able to do is offer evidence of workforce development through specific types of laboratories, equipment, and technical expertise that is of value to the specific business or industry. The campus can partner with corporations and offer certain economic incentives to locate here.

UAH offers businesses human capital; scientific innovation; working partnership opportunities with scientists, engineers, and researchers; and lowered research and development expenses, because in a partnership the university picks up some of those costs.

The university has been an incentive to attract commerce to the region, working with state and local government, chambers of commerce, and private companies. There have been success stories in recent years. One example involving UAH was late 2013 when Boeing's Research and Technology Division announced plans to add 400 engineering jobs to an existing presence in Huntsville. The previous year, Raytheon unveiled a $75 million Redstone Arsenal missile plant, and company executives cited close proximity to UAH's strong engineering program as a factor in that decision. In 2012, Moody's issued an economic report on Huntsville's future prospects for job growth and reported that one of the key issues driving that growth was UAH becoming increasingly competitive.

Even more recently, Remington and Polaris both announced they are opening research and development centers in Huntsville because of the city's engineering talent.

While UAH is a draw for luring companies to the greater Huntsville area, the university's impact goes beyond simply attracting new business. Research collaboration with Redstone's federal agencies and corporations in Cummings Research Park are additional activities that create a positive environment for economic growth.

In terms of the local workforce, UAH is the center of Huntsville's intellectual development, graduating more than 1,500 students annually. Approximately two-thirds of UAH students earn a degree in business, engineering, or science.

As a workforce educator and a research technology generator, UAH is an economic magnet that is at the heart of made-in-Huntsville innovations and entrepreneurism. UAH is growing its effort at techno-entrepreneurism, which also boosts job creation and creates wealth.

Small-business startups

The College of Business Administration's Innovation Commercialization Entrepreneurship (ICE) Lab is one location for entrepreneurial assistance. Entrepreneurs network and exchange ideas, and working groups encourage multiple aspects of innovation in Huntsville.

UAH business students can also work directly with entrepreneurs in a class called New Venture Challenge. Graduate students from the college are paid to assist startups. Instead of working in a lab on a research project, the student is working with companies in the real world on an entrepreneurial and research project.

Entrepreneurs can also look to UAH's Small Business Development Center (SBDC) in the College of Business Administration. Using federal Defense Logistics Agency funding matched with UAH dollars, the SBDC works through its Procurement Technical Assistance Center with small companies that strive to be government contractors.

The U.S. Small Business Administration funds efforts by the SBDC to bolster companies with training programs, one-on-one counseling and mentoring, and loan application assistance.

Research collaboration

UAH is ranked among the nation's top research universities, according to the Carnegie Foundation for the Advancement of Teaching. That recognition is the result of producing a consistently high number of doctoral graduates as well as high levels of funded research. Research expenditures during fiscal 2014 exceeded $97 million, the highest in the university's history. As a matter of fact, for its size among public universities, UAH has the largest research expenditures in the nation.

The National Science Foundation (NSF) ranks UAH fifth nationally in federally financed aeronautical/astronautical engineering research, a key component of Huntsville's economy and an important source of job creation. UAH is also second in Alabama in federally funded research expenditures, according to the NSF's fiscal year 2013 data, the most recent available. It ranks first among Alabama universities in federal expenditures in the environmental sciences, including atmospheric science, math and computer sciences, and physical sciences.

This strong background in research allows the campus to be a generator of intellectual property (IP). During the past five years, UAH faculty and students performed in more than $421 million in contracts and grants, which supported 385 graduate students and created approximately $5 million in licenses and royalty fees.

Technology commercialization

The Office of Technology Commercialization harnesses and patents UAH's intellectual property. It markets this IP to commercial partners, monitors IP-creation activities on campus, and educates faculty on university policies. UAH plays a role in economic development and growing businesses by transferring technologies to the commercial marketplace. The university shares profits with its faculty, staff, and student researchers through a royalty arrangement. Cutting-edge research means that emerging technologies are often ahead of their field, and UAH has a process to determine which discoveries get patented for the future.

Also, UAH faculty members often get the entrepreneurial urge. Two faculty members to start new companies are biology professor Joseph Ng and chemical engineering professor Krishnan Chittur. Dr. Ng's company, iXpressGenes, is using the emerging science of synthetic biology to create "biological Legos" that will allow scientists to modify living organisms. Dr. Chittur's company, GeneCapture, is building a portable device that will identify an infection in about one hour instead of days. Both work in collaboration with the HudsonAlpha Institute for Biotechnology.

Educated in a world-class research environment, UAH students study such diverse subjects as nursing, education, business, arts, humanities, and the social sciences in addition to the sciences and engineering. These students develop inquisitive minds by designing and carrying on their discovery quest after they graduate.

Brainpower, and the knowledge that flows through the campus of UAH, is a key factor in the economic success of a community, region and state. And, as one of the leading research universities in the nation, UAH assumes that tremendous responsibility to ensure that outcome.

Jeff Thompson served as the director of the Center for the Management of Science and Technology and was formerly the chief operating officer for the Huntsville-Madison County Chamber of Commerce. Jeff also serves as executive director for the Alabama Aerospace Industry Association. His research interests are the analysis of systems for finance, accounting, strategic planning, management, and information processes. Jeff holds an MBA from the University of Alabama in Birmingham.

Nursing education: The challenge

By Monica Beck
Clinical Assistant Professor

The forces drawing students and nurse educators together in the collaborative undertaking, called nursing education, are strong and wide-ranging.

Students are drawn to the nursing profession for a variety of reasons: being altruistic, caring for an ill family member, experiencing care from an exemplary nurse, being inspired by a nurse family member or friend, and desiring job stability and attractive salaries. The reasons for entering the nursing profession are as diverse as the student body. According to the American Association of Critical-Care Nurses, student diversity is growing. The number of men, "non-traditional" students, and students from minority backgrounds has increased. The ranges of age, culture, learning styles, marital status, hours of employment, and comfort with technology are varied among and between each cohort. Class sizes have ballooned as enrollment has increased, amplifying diversity.

As the growing complexity of the health care environment continues to rise in tandem with nursing program enrollment and student body diversity, the challenges that are being faced by nurse educators are formidable. A more highly educated workforce is needed to meet the demands of an increasingly complex health care system, according to the Institute of Medicine.

Benner, Sutphen, Leonard, and Day argue that "new nurses need to be prepared to practice safely, accurately, and compassionately, in varied settings, where knowledge and innovation increase at an astonishing rate…There is an ever-increasing body of knowledge, new evidence for best practices, and shifts in the type of patients and settings in which nurses will provide care."

Nursing education is not for the feeble-hearted! Happily, this challenge can be surmounted with intentionality, caring, skill, and grit.

Becoming a nurse educator is one of the most rewarding and challenging experiences I have encountered in my 30-year nursing career. Students challenge my thinking and enrich my practice every day. I make a difference. The nurse educator role is challenging as I strive to connect, inspire, motivate, and cultivate a spirit of curiosity. My aim is to persuade nurse educators to create a vital connection between teacher and students, providing support by sharing strategies that I employ to make connections and engage students.

"Student engagement is the key to academic motivation, persistence, and degree completion." To that end, on the first day of class, I strive to make connections and actively engage my students. For example, in a class discussion format, I ask the students to identify characteristics of a stellar professor and a stellar student; factors contributing to and detracting from a learning environment; and personality characteristics (minus intelligence), such as persistence and determination, that contribute to academic success. Furthermore, the students and I voluntarily commit to exhibiting to the best of our ability stellar characteristics and contributing to a learning environment for the remainder of the semester. These characteristics and factors are recorded and posted for all students to access for the entire semester. In this way, students contribute to setting the tone and expectations for the semester.

Continuing on the first day of class, I set high expectations for student performance operationalizing two rationales. In *Educating nurses: A call for radical transformation*, it is argued that a stellar professor "invites students to develop a sense of salience, clinical reasoning, and clinical imagination necessary to become effective and ethical nurses." The second rationale argues that students actively engage in learning if they can perceive relevance. To that end, I show a video of a mother telling the true story of her 15-year-old son's preventable death. All of my second-semester students already possess the nursing knowledge to prevent this tragedy. The gravity of nursing's responsibility for the vulnerable patients we serve is palpable in the classroom.

I conduct a thorough pre-assessment of the students, soliciting information from students such as their reasons for entering the nursing profession, long and short-term goals, previous degrees, and current employment. I use this information to engage the expertise of each student, as they have rich life experiences that meaningfully contribute to their classmates and my learning. Coupled with high expectations, I strive to convey my commitment to student success. The assortment of rich resources, on campus and off campus, for success are reviewed and posted on our learning management system for the entire semester.

I use the analogy of a coach to share my philosophy of the educator role. I explain that I can teach students the necessary skills, facilitate reasoning, and share strategies for success, but I can't go out on the field and play for them. They must do so on their own. I emphasize that communication is essential. I tell them "I already have my license. This is not about me but about you." The first day of class is the most important one and we haven't even discussed course content.

With more than 25 years of clinical experience, I share my clinical experiences with students, illustrating clinical manifestations, describing workplace issues, preparing them for clinical practice. I disclose my clinical errors and share ethical dilemmas I encountered. I readily admit I don't know all the answers, nor is it possible. If I don't know the answer, we stop and look it up. In the clinical environment and classroom, I engage students and encourage clinical reasoning by asking a lot of questions. I rarely give students the answer, much to their consternation. However, I guide them to the correct answer using questioning. There are a multitude of additional strategies, such as case studies and simulation, lecture-capture, MP3, video, and response-system technologies that I utilize as well and that are quite effective with Millennials.

Although the challenges in nursing education are significant, these challenges can be overcome, yielding a deeply enriching experience for both educator and student. Making connections with students, actively engaging students in the learning process, and reminding students of our mission to safely care for the patient and communities are a few ways to overcome these challenges.

My experience as a nurse educator gives me great confidence: The future of our nursing health care needs is in good hands.

Monica Beck is a clinical assistant professor and is enrolled in the Ph.D. nursing science program at the University of Utah. Her academic specialty is oncology.

Classroom to the Board Room

Experiential learning helps students learn from real world circumstances

By John Burnett

Associate Professor of Finance

I don't really know where the expression came from – From the Classroom to the Board Room. I just know it fits perfectly and I've been using it for years to describe a very special program in the College of Business Administration called the Capital Management Group (CMG).

The CMG is a revolving group of top UAH finance and MBA students who manage two real investment portfolios. And when I say real, I mean the money is real, the decisions are real, and the consequences are real. They are a true investment management team in every sense. They just happen to be college students. You're probably beginning to get the classroom to board room idea. More on that in a minute.

Let me first describe how this all got started. The CMG is the result of a very special partnership. It all started back in 1998 when the chairman of the Tennessee Valley Authority (TVA) had a vision for providing a unique educational partnership with the universities in TVA's service region. The result was the TVA Investment Challenge Program, which generously funds student investment groups at 25 universities from Kentucky to Mississippi.

We jumped at the opportunity to take the knowledge our students were learning in the classroom and apply it in an actual investment setting. It is an innovative and unique partnership that fulfills an important part of TVA's economic development mission, but also gives us an incredible educational opportunity for our students. TVA has committed more than $10.1 million to the program with each of the universities now managing an equity portfolio worth more than $500,000. In 2007, the CMG was able to add a second portfolio, the Charger Fund, to its investment lineup. In order to broaden the scope of the CMG experience, the Charger Fund became an all-international investment fund, meaning the students could only buy securities representing international companies outside the United States. Now the students must think globally and consider events and issues from around the world.

The CMG experience is a prime example of experiential learning, a focus the College of Business Administration has now begun to adopt in many of our other academic programs. Experiential learning is an educational process where by students are given the opportunity to develop their knowledge and skills through experiences that take place outside of the traditional classroom setting. The University of Colorado's Experiential Learning Center gives the best description of the power of experiential learning: providing opportunities for students to take initiative, make decisions, and be accountable for the results, as well as the opportunity to learn from natural consequences, mistakes, and successes. There isn't a better description for what takes place in the CMG.

The CMG has undergone many changes during its 17-year span. Fast-forward to today and the CMG is now a 4-hour course where up to 11 students are selected to participate in the program based on their past academic performance, analytical abilities, motivation, and ability to work in a team. The group is required to complete a tremendous amount of work in a very short period of time. They must learn our investment strategy and methodology, analyze industry sectors and stocks, individually collect data on up to 84 companies, and then decide on the best investments for the portfolios.

But what makes this such a dynamic learning experience for our students is that this is an environment where the professor doesn't have all the answers.

In fact, there are no lectures, there is no textbook, and there really are no right or wrong answers. In other words, it's just like the real world.

Working in that kind of environment is something very new for most students. They're accustomed to the professor showing them exactly how to solve the problems, and then being able to look in the back of a textbook for the answers to all the odd-numbered homework problems. But that's not the real world. In the real world there is often no right or wrong answer, and you have to make some very tough decisions based on information that is shrouded in a lot of uncertainty. But that's the great thing about the CMG experience and experiential learning. The students get to practice making those decisions and experiencing the consequences while still in the protective confines of the classroom.

The other important aspect of the CMG experience is that the focus is not just on honing students' technical skills related to investment analysis. A good deal of emphasis is also placed on developing the "soft skills" that are so important to establishing a successful business career. For example, one of the highlights of the semester is being treated to a full-course dinner at a fine restaurant. But the purpose is not to have a fun get-together. The dinner is hosted by an etiquette expert who teaches the class about the importance of good business etiquette and the techniques of proper dinner etiquette. At the end of the semester the group writes a professionally published annual report that includes detailed summaries of the group's outlook for the U.S. economy, the global economy, and each of the domestic economic sectors.

The reports are sent to more than 100 business school deans and business professionals in the area, so it reflects on both the students' work as well as the College of Business Administration. In addition, at the end of the term the CMG convenes a professional meeting and presentation to report their results and analysis to TVA representatives and a host of other invited investment and business professionals. This is where the students have to account for their results and explain their challenges and successes. The presentation is followed by a luncheon where the students get to practice the etiquette skills they learned earlier in the semester.

When people used to ask me how the CMG was doing, I was all about our investment performance. I would puff out my chest when we did well, and wring my hands and make excuses when we didn't do so well. But now I always tell people the CMG had a great year. That's my response even if our investments have performed poorly. Because I've come to realize it's really not about the money. Don't get me wrong, we don't lose sight of our goal, which is to outperform our benchmarks and make money for our client. It's a tremendous feeling when we have a good year in terms of our investment returns, and believe me, no one wants to beat the other universities more than I do. But now I realize that every year is a great year, because our greatest return is not in the money we make, but in the difference we make by being able to help these students navigate the transition "from the classroom to the board room."

Dr. John Burnett is an associate professor of finance. His research interests are investments and finance education, and his teaching interests are investments, portfolio management, short-term financial management, and managerial finance. He was awarded a Ph.D. in finance from the University of Alabama.

Uh, um, you know

How discourse markers affect perceptions of speaker character

By Eletra Gilchrist-Petty
Associate Professor of Communication Arts

Public speaking consistently ranks among our greatest fears. Many people fear presentation-making because they are often judged by audience members and risk having their credibility questioned.

Speech instructors teach that establishing and maintaining credibility is essential to delivering a coherent speech, and the fluency of the speaker's delivery can have a grave impact on how the audience perceives the speaker's ethos — a term coined by Aristotle that is synonymous with speaker credibility.

Credibility has been further defined as "the image held of a communicator at a given time by a receiver" (Andersen & Clevenger, 1963, p. 59). A speaker's credibility is affected by a wealth of factors, but two of the most salient include competence (i.e., perceptions of intelligence, expertise, and subject knowledge) and character (i.e., perceptions of sincerity, trustworthiness, and goodwill). The more favorably listeners view a speaker's competence and character, the more likely they are to believe the speaker's message (McCroskey, 1966, 1981).

Because ethos is intimately connected with how audiences perceive messages, speakers are urged to establish their credibility early in a speech by stating their expertise on the subject and citing sources and other supporting material to substantiate ideas. However, listeners not only judge speakers based on what comprises message content, but also on the manner in which they communicate the content (Croucher, 2004). In other words, speakers' verbal establishments of credibility do not suffice in maintaining their overall ethos for the speech's duration. Hence, speakers can do an excellent job of stating their credentials, but if they proceed to use poor vocal mechanics, such as uh, um, you know, and other discourse markers, the audience may question their ethos.

The term discourse marker refers to filler words, cue phrases, disfluencies, and vocal hiccups (Croucher, 2004; Dér & Markó, 2010) that fill pauses in conversation and act as nervous glitches in speech (Davis, 1992). The occasional uh or um can be found in even the most competent communicator's speech and is generally perceived as part of our collective lexicon (Davis, 1992). However, people are not always aware of how frequently they use disfluencies or how vocal hiccups are perceived by others (Kjellmer, 2003). Repeated disfluencies can not only result in miscommunication between senders and receivers (Brennan & Schober, 2001), but also in negative perceptions of speaker credibility (Bristol-Smith, 2010).

Credibility is a multifaceted phenomenon (McCroskey, 1966, 1981), yet previous research has primarily focused on the extent that discourse markers can damage a speaker's competence. While we know that using repeated discourse markers can damage perceptions of a speaker's competence (Bristol-Smith, 2010; Howell, 2001), it is equally important to query the impact discourse markers have on a speaker's character, the other important half of Aristotle's concept of ethos. This essay offers a more complete examination of discourse marker use and the ensuing perceptions of speaker character. Two overall questions guided the present investigation: (a) Will students rate a speaker lower in character when the speaker's message contains discourse markers?, and (b) Will students rate a speaker higher in character when the speaker's message is void of discourse markers?

Study Results

To explore how discourse markers impact perceptions of speaker credibility, we surveyed a total of 207 UAH students (95 males and 112 females) enrolled in various classes across campus.

The sample included 82 freshmen, 63 sophomores, 41 juniors, and 21 seniors. After consenting to participate in the study, the students listened to two brief audiotaped speeches of identical content on the importance of higher education that were read by a female theater major who spoke without any foreign accent.

One of the audiotaped speeches was clear and contained no discourse markers, while the other recorded speech contained about 10 disfluencies per 100 words, which is equivalent to the average number of disfluencies spoken in spontaneous speech (Bortfeld, 2001). Initially, participants were told the speaker was a well-known higher-education advocate. The listening order was mixed each time the researchers visited a classroom, so that some listened to the speech free of discourse markers first, while others initially listened to the speech laced with discourse markers.

After listening to the first speech, participants completed McDroskey's (1966) 20-item character survey, which ranged from 1 (strongly disagree) to 5 (strongly agree). Sample questions included: "I trust this speaker to tell the truth about the topic", "This speaker is basically dishonest", and "The character of this speaker is good." Once participants listened to the first speech and completed the scale, the responses were collected and the process was repeated with the second speech.

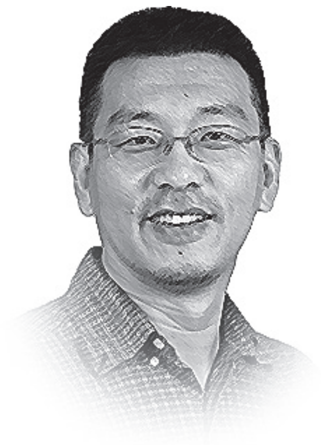
Data from this study were analyzed via paired sample t-tests, and the findings revealed that students rated the speaker's character lower when discourse markers were used ($M = 2.93$, $SD = 0.56$) and higher when the speech was void of discourse markers ($M = 3.57$, $SD = 0.55$). Findings from this study suggest that disfluencies or filler words impact how listeners perceive a speaker's credibility in terms of character. Specifically, the more a speaker says uh, um, you know, and other similar disfluencies, the less character he/she is perceived to have, even when the speaker advertises his/her credibility and is presumed to have subject-matter expertise (Croucher, 2004). This informs us that the speaker's prestige is not the deciding factor on whether or not the message is well received because delivery plays a crucial part in how the audience ultimately views the speaker.

Existing research has unequivocally found that discourse markers lower perceptions of speaker competence (i.e., intelligence, expertise, and subject knowledge [Croucher, 2004; Samovar & Mills, 1983]), but prior studies have not examined how discourse markers affect perceptions of speaker sincerity, trustworthiness, and goodwill for others (i.e., character). This void in the literature motivated this investigation.

From the findings we can now conclude that not only do discourse markers lower perceptions of speaker competence, as alleged by earlier research findings, but they also negatively affect perceptions of speaker character. As Aristotle noted at the onset of oratorical inquiry, a speaker's competence and character work hand in hand. Building upon this tradition, we now know that perceptions of competence and character diminish with increased discourse marker use, but these elements are enhanced when a message is void of discourse markers.

The findings have pertinent implications to anyone who delivers formal messages, including students, teachers, corporate employees, and business, government, and civic leaders. Speakers must be cognizant that audience members are constantly gauging one's competence and character, and using excessive discourse markers in a speech may not only make them appear ignorant on the subject matter, but also untrustworthy. If a speaker is perceived as incompetent and dishonest, the message, no matter how important, can be doubted and rejected by audience members.

Dr. Eletra S. Gilchrist-Petty is an associate professor of communication arts. Her programs of research focus is on instructional communication, interpersonal communication, and African American communication both from the quantitative and qualitative perspective. She received her Ph.D. in communication from the University of Memphis.



Chasing a better understanding of space weather in our universe

By Gang Li
Associate Professor of Space Science

Those living in the northern United States who stepped out of their houses before the dawn of March 18, 2015, were surely blessed. They were lucky enough to witness a once-in-a-decade stunning display of lights, the aurora borealis in the Northern Hemisphere.

The spectacular light show of aurora is a manifestation of a geomagnetic storm. A geomagnetic storm occurs when plasma (blobs of material and magnetic field) from the sun bombards the Earth's magnetosphere. One can think of the Earth's magnetosphere as a giant magnetic shield that deflects incoming charged particles from every corner of the universe. Most of these charged particles, however, are coming from the sun. The sun loses about one billion kilograms of material per second. This is a tremendous amount of material.

However, at a distance of about 94 million miles away at the Earth, the density of this material is quite small, about a few protons per cubic centimeter. Because material is constantly blowing out from the sun, we call it solar wind. In a mundane day, the solar wind is almost completely diverted by the Earth's magnetic field and very few solar wind particles can leak into the Earth's magnetosphere.

However, occasionally, some violent activities can occur at the sun, and massive and fast plasma blobs can propagate toward the Earth, hitting the Earth's magnetosphere very hard.

As a result of this bombardment, some energetic particles (mostly electrons and protons) can penetrate the Earth's magnetosphere and precipitate down. When they precipitate down, they do not free-fall. Instead, because they are charged particles, they spiral around the Earth's magnetic fields, like rotating beads on a string. These energetic particles then collide with oxygen (nitrogen) in the atmosphere generating green and yellowish (purple and blueish) lights. As spectacular as an aurora may be, the geomagnetic storm behind it, or more precisely, the solar activities that cause the geomagnetic storm, can severely affect our high-technology-powered society.

Two such kinds of activities exist: solar flares and coronal mass ejections (CMEs). Both are violent and they often occur hand-in-hand in solar active regions. A solar active region is where the sun's magnetic field is stronger than surrounding areas. Above an active region, the strong magnetic field is often highly sheared and twisted. As a result, it stores a lot of magnetic field energy. The shearing and twisting develops with time. When the stored magnetic energy reaches a critical point, a process called magnetic reconnection can occur.

During this process, magnetic fields with opposite directions can re-orientate themselves to a lower energy state, and by doing so, eject out a huge amount of material and magnetic field, the CME. At the same time, some particles can be accelerated to very high energies (for protons $>$ 100 MeV and for electrons $>$ 10 MeV). These high-energy particles, called solar energetic particles (SEPs), have been identified as the number one space hazard. They are accelerated either at solar flares and/or shocks driven by CMEs. After being accelerated, they propagate along the interplanetary magnetic field to the Earth. They can adversely affect not only beyond-low-Earth-orbit missions, but also aircraft avionics, communications, and airline crew/passenger health.

Studying the acceleration process of these SEPs near the sun and their subsequent transport from the sun to the Earth is a central problem of space plasma physics and space weather. At the Department of Space Science at The University of Alabama in Huntsville (UAH), some world-leading experts are working on these problems.

We are used to accelerations in our everyday life: we step on the pedals of our cars to speed them up. In this process heat from combustion is converted to kinetic energy used by the car. At solar flares and coronal mass ejections, the energy supply of SEPs is the magnetic field energy stored in the active region. SEPs are composed of protons, electrons, and some heavy ions, and they are all charged particles. We know that charged particles can be accelerated easily if there is an electric field. So, it is not a surprise to speculate that some form of electric fields may exist at solar flares.

Indeed, during magnetic reconnection, the magnetic field changes abruptly with time. Such a change of the magnetic field inevitably leads to an electric field, as ensured by Faraday's law. So it seems that charged particles can be easily accelerated at solar flares by these electric fields. The reality, however, is not as simple as that. This is because to obtain significant acceleration, one has to ensure that the electric field felt by the charged particles is coherent — if the electric field is rather random, then the particles will undergo alternating acceleration and deceleration.

While there are theories that suggest the existence of large-scale coherent electric fields in solar flares, more and more evidence tends to suggest that the reconnection process at flares are rather turbulent, implying that a large-scale coherent electric field is unlikely. If there are no coherent electric fields, what are other processes that can efficiently accelerate particles? It turns out that there is one mechanism that is very efficient in converting bulk plasma kinetic energy into an individual energetic particle's kinetic energy. This mechanism is called diffusive shock acceleration and is also known as the first-order Fermi acceleration because the great 20th century physicist Enrico Fermi first studied it. The concept of a shock stems from fluid dynamics. One may think of a shock as a water dam, with a much wider downstream than upstream and with the flow in the downstream much slower than that in the upstream.

Now picture yourself swimming between the upstream and downstream of the dam (shock), what happens? You get tired and stop swimming, of course. For a particle, however, things are somewhat different. Let us assume that the particle we are interested in collides elastically with fluid parcels. An elastic collision conserves a particle's energy in the plasma frame. So as long as the particle is in the upstream or the downstream, its energy does not change although its motion direction can vary due to collisions.

However, each time it crosses the shock, it is going to see a different plasma (recall that the upstream and downstream flow speeds are different). Believe it or not, this sudden change of the background plasma speed will accelerate the particle. Consider a simple analogy of a ping-pong game in which a ping-pong ball bounces back and forth between two paddles. Now keep one paddle stationary and bring the other paddle closer to it and you will find the ping-pong ball moves faster and faster. This is exactly how a particle gains energy by traversing the upstream and downstream of a shock multiple times.

Shocks may exist at solar flares or in front of CMEs. In both cases, particles can be accelerated at the shock front. Various factors can affect the acceleration process. For example, both the shock strength and the orientation of the shock can affect the maximum energy that a particle can reach. At UAH, we have developed a sophisticated numerical code, called PATH (Particle Acceleration and Transport in the inner Heliosphere), to study the particle acceleration process.

So far, this is the only code of its kind in the world. The code has been applied to large SEP events, and the numerical calculations (including both particle-spectrum and time-intensity profiles) agree nicely with observations in many of these events. Currently efforts are being converting the PATH code to an operational code so that one can use the PATH code in space weather predictions.

Another ingredient of the PATH code concerns the transport of SEPs from the sun to the Earth. As explained above, particles can be accelerated efficiently, e.g., at the CME-driven shock. As the speed becomes larger and larger, it becomes easier for them to escape from the shock.

When they escape the upstream of the shock, they will be in the interplanetary medium. As they move along the interplanetary magnetic field, they will experience some random fluctuations of the magnetic field.

The process of the particle moving from the shock to the Earth is best described mathematically by a focused transport equation. To understand this process, consider an inebriated man walking on the street. If he has no goal in mind, then his pattern of movement can be described as random.

If, however, the intoxicated man is not completely impaired and knows roughly where his goal is (be it home or the bar), his pattern is then not completely random, but somewhat focused, hence the so-called focused transport equation. What is interesting about the focused transport process is that the randomness of the magnetic field affects particles with different mass-to-charge ratios differently. As an example, a proton and Helium will behave differently under the same turbulent magnetic field. This is important, because NASA has flown many spacecraft that can separate different elements.

Therefore, by comparing the time-intensity profiles of protons and Helium or other heavy elements, one can deduce some characteristics of the randomness of the interplanetary magnetic field close to the acceleration site (the CME shock). This is remarkable considering that the CME-driven shock is some million miles away! Such studies have also been pioneered by faculty members in the Department of Space Science at UAH.

In summary, as a part of the newly established space science program at UAH, a vibrant group, including many world-leading experts in the field of space plasma physics, are working together trying to decipher how energetic particles are accelerated and propagated. We expect these works will provide a better understanding of space weather.

Dr. Gang Li is an associate professor of space science and earned his Ph.D. in physics from Indiana University. He was the recipient of the 2009 International Union of Pure and Applied Physics (IUPAP) Young Scientist award. His research interests are particle acceleration and transport in the heliosphere, solar energetic particle events, numerical astrophysics, and stochastic differential equation.s

Migration of agriculture may lead to a better path to sustainability

By Richard T. McNider
Distinguished Professor of Science

During the last century, a significant amount of the nation's food and fiber crop production systems has shifted from the East to the arid West due to the establishment of irrigation infrastructure and improved transportation. Similarly, with transportation improvements, corn and grain production became concentrated in the deep water-holding soils in a small area of the upper Midwest that avoided drought losses occurring in the shallow, poor-water-holding soils in much of the East.

This migration of agriculture, which largely occurred between1940 and 1970, was as remarkable in terms of its swiftness as its magnitude. The shifts that occurred in the last century were largely unplanned, driven by transportation improvements and the search for consistent water for optimal production. However, the immediate market economic efficiencies that drove the shift in agriculture in the last century did not fully account for the environmental externalities, the future competition for water supply, or the adverse societal impacts of abandoned agricultural land.

While many have voiced concerns about the vulnerabilities of agriculture to future climate change, less has been discussed about these changes in U.S. agriculture in the last century that have increased its vulnerability both to climate change and climate variability. The U.S. went from a distributed agricultural system in which a significant amount of corn was grown in almost every state to one in which nearly 90 percent of the corn production is now concentrated in the Upper Midwest. There has been decline in corn production in the Southeast.

A similar shift occurred with cotton, vegetables, and potatoes once irrigated production became concentrated in the river basins of the arid West. Western irrigated cotton rapidly reduced cotton production in the Southeast. Southern cotton farmers, whose output and quality were hurt by frequent drought losses, could not compete with irrigating cotton farmers in California, New Mexico, and Texas even after the boll weevil was controlled. In 1939, Maine, New York, and Pennsylvania led the nation in potato production. By 1950, Maine, New York, and Pennsylvania had lost their historical top rankings in potato production to Idaho and Washington as irrigation projects on the Snake River came on line. In 1950, 21 percent of the fruit and vegetables produced in the U.S. were grown in the Northeast; today they produce less than 5 percent. Instead, nearly 50 percent of fruit and vegetable production is now found in five arid western states.

In a positive sense, the migration of agriculture discussed produced an abundant variety of food at a low price. Remarkable results in grain production allowed prime cuts of poultry, pork, and beef to be a mainstay of America's diet.

Fresh fruits, vegetables, and nuts grown almost year-round in deserts displaced locally grown seasonal vegetables and canned goods. However, water for irrigation in the West is now under stress due both to supply and demand. Population growth and environmental restoration are competing with farmers for water supply.

The last 100 years in which Western irrigating agriculture evolved was likely the wettest in the last 500 years. Further, while regional projections of precipitation are uncertain, the consensus from climate models project significant drying in the Southwest but less change and in fact increases in parts of the East and Southeast. In the High Plains, irrigation in the southern parts of the Ogallala Aquifer has been reduced as ground water levels have dropped and climate projections show further drying. In Texas, municipalities' needs are competing with farmers and large short-falls in water are projected.

The migration of agriculture during the last century largely moved production to drier climates and required using large fractions of available water for irrigation.

Even in the best of times water is scarce. The present drought in the West and the 2012 Midwest drought give immediacy to the vulnerability of the new geography of U.S. agriculture. The shifts that occurred in the last century were largely unplanned, driven by transportation improvements and the search for consistent water for optimal production.

Also, environmental externalities such as the depletion of streams and aquifers in the West for irrigation were not considered. The concentration of production in the upper Midwest has overwhelmed the fertilizer assimilative capacity of the watersheds, leading to nutrient export into the Gulf of Mexico and resulting in a large area of hypoxic waters.

As mentioned above, the agricultural migrations that occurred in the last century not only made agricultural production more vulnerable to water resource availability, climate variability, and climate change, but the concentration of production has set the stage for other vulnerabilities to food security.

For example, concentrated and contiguous production makes the spread of disease and pests more likely. California produces more than 80 percent and sometimes more than 90 percent of most of the major vegetables such as broccoli, celery, leaf lettuce, etc. Local disease outbreaks in California among any one of these crops would be devastating to national fruit and vegetable availability.

The disruption of grain transportation out of the Midwest due to lock/dam failures or low water levels on the Mississippi, or the failure of one or more dams in California from earthquakes or terrorism would have a major impact on fresh food supply. Likewise, a dam failure on the Snake River would play havoc with potato production in Idaho and Washington.

Thus, the concentration of grain, vegetable, and potato production is a major threat to both short and long-term food security. To sustain the nation's agricultural production in the face of climate and environmental challenges, the East and especially the Southeast should perhaps shoulder a greater share of the agricultural production.

The nation should perhaps consider planned agricultural migration as a path to agricultural security. The redistribution of agriculture might not only sustain production but also reduce environmental pressures on rivers in the West and nutrient loading of the Mississippi.

The loss of agriculture in the East and Southeast was in large part due to drought losses that made rain-fed agriculture non-competitive with Western irrigated agriculture or with Midwestern farmers who were largely insulated from drought losses due to deep water holding soils. Thus, to be economically sustainable, increased production in the East must include additional irrigation.

Can irrigation be carried out in a sustainable manner to avoid the problems in the West? First, the East has much more water than the West. Rivers in the East are huge by Western standards. For example, the Tennessee River is twice the size of the natural flow of the Colorado River, and the Mississippi River has 10 times the flow of the Tennessee.

Consumption for municipal water supply, irrigation, and industry in most of the East is miniscule. Only about 1 percent of the Tennessee River is consumed whereas the Colorado River is largely a memory when it reaches Mexico.

Nevertheless, ecosystems in the East have evolved based on large amounts of water, so environmental flows must be protected. Even if irrigation in the East were significantly expanded, the region's rivers would not be as depleted as the West's. Because of natural rainfall, irrigation requirements in the East are less than a foot compared to three or more feet in the arid West.

Three percent of the Alabama River would support one million irrigated acres, compared with the nearly 30 percent of the Colorado River that is needed to irrigate a similar area leaving most of the flow for ecosystem services.

For the East to expand its agriculture, investments in irrigation infrastructure will be required. However, because of smaller irrigation demand in the East, storage and distribution systems are much less costly. California has proposed huge projects, such as a $25 billion plan to tunnel water under the Sacramento Delta to provide water to farmers in the Central Valley. The Temperance Flat Dam Project has been proposed as a solution to catch more water in the San Joaquin Basin. The cost of this project was estimated to be $2 billion in 2007 and projected to deliver an average of only 9,400 hectare-meters of water (~$256,000 per hectare-meters).

In the Southeast, on-farm reservoirs can be built at a cost of less than $20,000 per hectare-meters of water delivered or about one-tenth the cost of the Temperance Flat Dam Project. More importantly, because of natural rainfall, irrigation requirements in the East are only one-quarter of those in the West; therefore that 40 times more irrigated acreage can be supported in the East for the same cost.

In fact, the Temperance Flat Dam Project can be used as an example of fresh thinking in how water projects should be evaluated in the West if Eastern agriculture is considered as an option. As noted above, the Temperance Flat Dam Project will deliver approximately 9400 hectare-meters of water. California currently grows about 300,000 acres (121,200 hectares) of cotton of which about 150,000 (60,600 hectares) is upland cotton of the type grown in the Southeast. If we take the water needs of cotton at 0.75 meters per season, then the total water requirements for upland cotton is approximately 45,000 hectare-meters. Thus, reducing California's cotton acreage by 20 percent would replace all the water to be delivered by the Temperance Flat Dam Project.

Moving and distributing the geography of agriculture might not only help with food security for the nation, but also may solve social and economic problems. While the South was not the only area impacted by the migration of agriculture, it has had difficulty adjusting to the economic loss of agriculture.

When President Obama visited Selma, most of the press and visitors were appalled by the poverty they saw. The roots of Selma's poverty and decline are tied, ironically, to the actual roots of cotton and corn plants in the Black Belt soils.

Because of this combination of shallow depth and high clay content, they often failed to deliver the water needed to produce competitive yields, agriculture migrated out of the region and the economy collapsed.

Now government transfers are largely the basis of the economy. Investment in irrigated agriculture by the government to move water from the Alabama River (over which Obama walked) could resurrect the economy, reduce the government assistance transfers into the region, and help sustain the nation's agricultural production.

Dr. Richard McNider is a mathematician and atmospheric scientist. He completed his Ph.D in environmental science at the University of Virginia. He founded the Earth System Science Center at UAH, one of the university's largest research centers, and served as Alabama State Climatologist. Dr. McNider has served as dean of the College of Science and executive director of the National Space Science and Technology Center, and has also served on National Academy panels and is a Fellow of the American Meteorological Society. Dr. McNider is the author of more than 90 peer-reviewed publications.

Defending life on Earth from asteroids is an addressable challenge

By Richard Fork

Professor of Electrical and Computer Engineering

The asteroid that struck Earth on Feb. 15, 2013, in Chelyabinsk, Russia, reminded us of the continuing threat to life on Earth posed by asteroids. The meteor, technically a superbolide or "very bright fireball," had a mass comparable to that of the Eiffel Tower. This meteor was propagating at more than 40,000 miles per hour. The kinetic energy it released in our atmosphere was estimated to be 25 times the energy released by the atomic bomb detonated at Hiroshima.

We see "defending life on Earth" from such objects, should they be discovered on path to strike Earth, as a currently addressable challenge. We see university engineering faculty and students, such as in the Electrical and Computer Engineering Department at The University of Alabama in Huntsville (UAH), as having critically important roles. We expect no satisfactory solution until well into the future. There have been, however, major advances in both laser systems and optical engineering. We see these advances as potentially reducing current risks.

My students and I have written and published a number of papers related to this asteroid redirection task. In general, we see the current technical challenge as one of addressing problems that have both quantum and classical characteristics. These problems are technically challenging, but we also see clear opportunities for progress toward solutions of practical interest.

For example, a quantum phenomenon-based strategy, that won the 2005 Nobel Prize in physics stabilizes the repetition rate of pulses generated by mode-locked lasers. That rate can be referenced to atomic clocks. This helps to facilitate "cooperative" use of multiple precisely synchronized femtosecond laser systems. These precise temporal relationships of multiple mode-locked femtosecond lasers offer the major advantage that extremely powerful individual lasers are not required to redirect asteroids. Rather, a number of well-synchronized, mode-locked lasers working cooperatively can provide the total average power required for the redirection of a small asteroid. Also, responses to the asteroid threat that are more complex, such as relatively precise steering of the redirection event, appear possible.

A more recently demonstrated quantum phenomenon-based strategy is comb-calibrated 3-D mapping of an object at a distance. Two slightly different frequencies, but each with very stable pulse trains, are integrated so as to measure short distances in space with atomic clock-based precision.

Comb-calibrated maps have been generated using this method at several thousand resolution elements per second. We expect this capability will enable useful 3-D mapping of the asteroid from co-orbiting spacecraft.

We see yet a third quantum phenomenon-enabled capability as likely to be valuable for asteroid redirection. This is the synchronous transmission and focusing of groups of multimillijoule energy femtosecond pulses with durations of the order of 100 femtoseconds or less in the vacuum and microgravity of space. Such pulses have been available for more than 30 years; however, they have limited use on Earth. They rapidly lose energy if transmitted even a short distance in our atmosphere.

These energetic femtosecond pulses, however, when delivered optimally in the vacuum and microgravity of space, appear likely to be useful at multimeter distances with close to unit efficiency for asteroid redirection. A single such pulse can deliver multimillijoule energy. Such a pulse, if defocused, only slightly warms a cubic centimeter of water.

The same pulse, focused in the vacuum of space, will be able to ablate most solid materials in a manner that can be used to generate efficient propulsive thrust.

We find this ablative process, used optimally in the vacuum and microgravity of space, adequate for the successful redirection of, e.g., a Chelyabinsk-scale asteroid within a time of practical interest. A valuable, originally unexpected, advantage of femtosecond pulses is a measurable, consistently repeatable delay of one-trillionth of a second before the appearance of the ejecta, which causes the propulsive thrust. This brief pause is indicative of a novel physical regime. We see this phenomenon as also valuable in that losses due to the resulting optically absorbing ejecta can be avoided.

Multimillijoule energy optical pulses are not unusual in and of themselves. However, if compared with a nuclear phenomenon, such as the fission of a single Uranium 235 nucleus, the energy delivered by a single, currently available femtosecond pulse can exceed the energy delivered by thre fission of a billion Uranium 235 nuclei.

The point for this discussion is that a single such energetic femtosecond optical pulse, used in the vacuum of space, offers: 1) access to energy that substantially exceeds the energy generated in the fission of, e.g., 100 million Uranium 235 nuclei; 2) energy that can be delivered from stand-off distance practical interest in the vacuum of space with near-unit efficiency; 3) delivery that can be accomplished at rates and with a precision useful for efficient small asteroid redirection; and 4) no radioactive byproducts despite accessing power useful for redirection.

Multiple such events can be designed and implemented with the temporal precision of femtoseconds. The events can be located with sthe patial precision of a few optical wavelengths. Applied to a material object, such as a small asteroid, we expect energy adequate for useful redirection can be delivered within a time of interest to a Chelyabinsk scale asteroid from a physically separate location, such as a co-orbiting spacecraft. We expect the direction of net thrust can also be steered in a manner similar to the use of multiple thrusters on a spacecraft.

As regards accomplishing the redirection, the simplest and most efficient method of preventing the collision with Earth appears to be that of altering the velocity of the asteroid. One can cause a change in propagation velocity so that an asteroid fails to arrive "on time" for an otherwise accurately predicted collision with Earth.

This method of asteroid redirection requires accurate advance warning of an expected collision event. This is, however, the current plan of the extensive effort to identify and correctly predict the arrival of objects that appear to be threatening to Earth.

The average power required by this redirection strategy we describe can be quite small. For example, as little as 10 kilowatts of optimally delivered average power used over a time period of four months can, as predicted by our mathematical model, usefully prevent an otherwise expected collision of a Chelyabinsk-scale asteroid with Earth.

A practical constraint of this redirection method is that the optical source of the mode-locked laser pulse trains will need to be close to the asteroid, e.g., within the order of tens of meters of the asteroid surface. This constraint has the safety feature that the transmission of energetic laser beams over a substantial distance in space is not required.

A significant technical requirement of this method of asteroid redirection is generation and maintenance in real time of a high-resolution, detailed 3-D map of the asteroid surface. The surface of the asteroid will evolve at the ablation locations during the redirection event. This evolution of the surface can be minor, but will need to be measured and managed, and the surface again optimized throughout the redirection event if the predicted high efficiency is to be achieved.

Relevant high-resolution 3-D mapping was recently demonstrated at the National Institute of Standards and Technology at a 10-meter stand-off distance. In that work, the laser source and the object that was mapped in 3-D were rigidly fixed relative to each other. The task of creating, maintaining, and effectively using such high-resolution, extensively detailed 3-D mapping of a physically separate asteroid surface in real time in space appears demanding but we expect it will eventually be achievable.

I especially want to thank the UAH students in UAH's Electrical and Computer Engineering's laser systems engineering and cooperative quantum energy classes for valuable relevant discussions. Graduate students Luke Burgess and Grant Bergstue contributed strongly to this asteroid redirection research effort at UAH during more than five semesters.

Dr. Richard Fork is a professor in the Electrical and Computer Engineering Department at UAH. His Ph.D. is in physics from MIT. He worked in the Quantum Electronics Department at AT&T Bell Laboratories from 1964 to 1990. He was in the Physics Department at Rensselaer University from 1990 to 1994, and has taught in the UAH ECE Department from 1994 to the present.

Be the bridge and bridge the gap

By Delois H. Smith
Vice President for Diversity

In times of social, political, and religious polarization, I have often wondered why, in these turbulent times, we do not actively live up to the creeds we espouse on a regular basis about respect, dignity, and just plain human kindness. These seem to elude us at the times we need them most, but practice them the least.

In my younger years, I was at a crossroads in my life when I was terribly frustrated with what I saw as systemic indifference and duplicity in institutions all around me. Instead of becoming jaded and indifferent as well, I made a personal and spiritual decision to be a bridge rather than a chasm. I purposely decided to routinely take interest in and be a part of multicultural and diverse environments, cultures, races, and ethnicities.

As a result, those experiences, serendipitously, prepared me for a life's work on being a bridge in multicultural settings and environments. I learned early on the key lesson that greater strength and accomplishments are borne from and through diversity.

I adopted and often use a statement by songwriter Judith Henderson: "Our greatest strength as a human race is our ability to acknowledge our differences. Our greatest weakness is our failure to embrace them."

The university setting, with people who hail from a myriad of cultures and countries, affords many opportunities to explore, learn, and embrace a breadth of diverse cultures and viewpoints where dialogue, exchange, and collaborative interaction is open and free.

As an administrator in the division of Student Affairs, I found my haven among the students of the university who were open, eager to learn, believed change was indeed possible, and enthusiastically wanted to be a part of that change. Then in 2009, an even greater gift — being appointed to lead and develop the UAH Office of Diversity.

The associated challenges and opportunities have been varied, and at times, controversial, but all rewarding. The opportunity to teach, train, equip, and empower others in areas of diversity and inclusion has been validating and rewarding.

Being the BRIDGE that spans differences and opens channels of communication, dialogue and beneficial interaction has been a challenge and opportunity. Every day, I try to live by and pass on:

- Be aware of the underrepresented individual when you are a member of the majority culture, whether you are male, female, young, old, or a member of another race.
- Reach out to the minority individual, especially when they are alone.
- Initiate conversation if they do not, and introduce them to others.
- Determine or develop mutual points of interest for continuity of interchange.
- Garner, as well as give, information specific to the situation.
- Engage beyond the initial introduction when and if possible and maintain the connection.

We must always show civility in the community, respect for all people, patience with others and in all things, understanding of those who are different, and openness and willingness to learn. One of the university's core values in its 2020 Strategic Plan is, We honor the individual. We celebrate differences and use them to create unity.

Be the Bridge and Bridge the Gap.

Delois Smith is Vice President for Diversity where she provides leadership addressing diversity and equity as pillars of excellence for the university. She has been at UAH since 1980 in various counseling and administrative positions in the student affairs area. Ms. Smith received a bachelor's of science degree in psychology and a master's degree in educational psychology from the University of Florida. She is a nationally certified counselor, a licensed professional counselor with the state of Alabama, and a certified psychologist.

SWAP:
Program prepares students through work in a professional environment

By Gary Maddux
Director of Systems Management and Production Center

For almost three decades, I have had the privilege of working at The University of Alabama in Huntsville (UAH) where I serve as the director of the Systems Management and Production (SMAP) Center.

My first assignment in 1987 was to develop a paperless supply system for the Test and Evaluation Directorate at Redstone Arsenal. As a green but enthusiastic programmer, I managed to develop a fairly competent system that was widely used throughout the Research, Development, and Engineering Center at Redstone. The Automated Material Purchase System (AMPS) gave me a great sense of accomplishment and confidence at the time. With its success I hired my first student assistant, and then a second. All was well in my universe until one day when the Army changed its method of procuring material and my beloved AMPS was no more. Dang it – only two years into my career and my "product" was obsolete!

Luckily, there soon came another assignment, and then another, and then – well another and another. After almost 30 years they begin to run together. Looking back, you can lose track of all the systems, other than a few clever acronyms – AMPS, STARS, ACES, and my personal favorite, the Flying BASSETT. However, I have managed to remember the most critical element of that first assignment, and all the subsequent assignments. During the development of all those systems, we made extensive use of students. From those first two, Suzanne and Patricia, the SMAP Center has been able to not only benefit from excellent student support, but provide a stepping stone that helped launch scores of successful careers.

As with all good Army programs, it appears that it is required that everything become known by its acronym. So it was with our process of employing students. The Students Working at the Army in Parallel (SWAP) program was thus born. At the time of its naming, I just wanted to have a name I could remember, so we turned the "M" in SMAP upside down, to form SWAP. The rather lengthy title of the SWAP program did describe the essence of its being. We employ students to work for the Army who are also attending school. This was based on the simple realization that many — if not most — college students are working part-time jobs while attending school. We recognize that a student working part time in his or her field, i.e., as a mechanical engineer or finance SWAP employee, will absorb much more knowledge from those work experiences than the same student delivering pizza, selling shoes, and trying to get someone to "supersize those fries." Therefore, the guiding vision of the SWAP program is to have students working "within their field" in a professional environment.

Beyond that vision, there are actually few absolute rules to the SWAP program. Typically, I tell interested parties that there is only one rule: as long as it's legal and ethical, we will seek to make it work for the customer and the student. Our center is here to cost-effectively serve the Army, who is our funding source, and we are here to serve the students. To that end, we look to find a solution that is mutually beneficial. That may be, for example, hiring students from Texas A&M-Kingsville

to work on-site at Corpus Christi Army Depot, or hiring students from New Mexico State to work at White Sands. In those cases, we are providing support to the larger Army, helping students at other locations, and generating revenue for the university. Everybody wins!

From the previous example, it should be apparent that the SWAP program is not exclusively for UAH students. We hire from all surrounding schools within the area, with a substantial number coming from Alabama A&M, Calhoun Community College, and Drake State Community and Technical College, among others. This adds to our strength. We are quite proud of our center's diversity of backgrounds. While UAH students bring a wealth of knowledge in many fields, they do not bring "all" available knowledge. In addition, neither our center nor the Army (nor the defense community) wants exclusively UAH students. By sharing the pie, the pie actually gets bigger and everybody wins!

Another important aspect of SWAP is that we are not an academic program. We are also not the cooperative-education program. We do not consider ourselves competitors of the co-op program, but as another option for the student to consider. However, the absence of an academic tie-in has a huge built-in advantage for us. When our students graduate they do not have to leave. Because all participants in the SWAP program are employees of the university, they can and often do continue in an increased capacity upon graduation. In a typical scenario, an undergraduate student who has worked on-site at Redstone Arsenal for two years will earn his or her degree and quickly be promoted to a higher-level, full-time position.

Thus, the greatest feeder of the overall SMAP Center is our own SWAP program. This is extremely important, whether the graduating student wishes to work for UAH, the Army, or another defense contractor. Because most have expressed a desire to become federal employees and have invested their time in becoming valued members of the Army contracting workforce, they have a vested interest in staying. Conversely, the Army has provided funding to develop our SWAP students as their future workforce and has the same vested interest in these individuals remaining. Because opportunities for federal hiring are not always timely, the ability to remain and advance as an employee of UAH is an outstanding perk. In addition, as a full-time employee, many of these recent graduates immediately enroll within the UAH graduate program to pursue advanced degrees. Everybody wins!

The SWAP program is also not a financial-aid program. Our students work for their paychecks. However, when interviewing potential SWAP employees we are cognizant of financial situations. We look for "intangibles" during the interview process — the desire to work, the history of work and the need to work. Sometimes the best candidates do not have the best resumes.

I have recounted the story of one young lady I interviewed whose only work experience was in "her daddy's chicken house on Sand Mountain." Having grown up in that area and in that environment I knew one fact: if you're a young engineer and you get out of that chicken house on Sand Mountain, you'll work hard to never go back. We hired her on the spot, and she's currently an engineer with the Army. We actively recruit from the areas that others sometime overlook — the inner cities and the rural areas — where the young people just need a chance to prove themselves. They have the hunger; we provide the opportunity. Everybody wins!

Lastly, the SWAP program is not a recruiting organization for UAH, although we are extremely involved in recruiting. Our vision is to get the word out to the outlying areas regarding the many opportunities that exist within the Huntsville area. During recent months, a group of our SWAP students have been visiting other schools – at their invitation – to tell high school or community college students about the technologies with which we are involved. Visits to Cullman, Lamar, Pickens, and Jackson County have recently been completed, where SWAP students displayed and discussed UAVs, robotics, 3-D printing, and virtual-reality displays. By tapping into those "intangibles" that we look for, we have students volunteering to show up at 6 a.m. to ride to Fayette, AL, to help their younger peers. It is certainly not irrational to think many of the seeds planted by our current SWAPs will help motivate the next generation of students. Again, everybody wins!

So how are we doing? At some point in my youth I earned an accounting degree, and thus I have a tendency to "count" everything. Thus, since January 2004 I've been keeping track of where all of our employees go upon leaving UAH. During that 11-year period, 557 SWAP employees have left UAH. Of those, 232 were hired by the Army, and another 169 were hired by defense contractors. This translates to roughly three of every four students we have hired remaining within the defense sector.

While the Army is the largest recipient of the program, the many other contractors within Huntsville have received an enormous boost from SWAP. When a defense contractor hires one of our students, that new employee walks in with a degree, a security clearance, and the experience to contribute immediately. For the 25 percent of students who did not transition to the defense industry, there have been very few who have not benefitted from the experience. There have been transfers to other schools to pursue degrees in law or medicine, other government agency employment, and the pursuit of a myriad of splendid careers.

As I rapidly approach my fourth decade at UAH, I have come to appreciate the true impact of our labors. The SMAP Center has been extremely successful and has earned needed revenue for the university. I have personally worked on numerous systems and projects that were valued by the customer, but like the old AMPS system, they too will become obsolete as well.

When I have retired, few people — including me — will long recall that I balanced the books every month for 350 months, or that I posted the payroll every two weeks, or the other minutia that seems to occupy a typical workday. However, I do feel that the true legacy of our center will live long beyond our fleeting careers. The opportunities that we have provided, and the careers that we have helped foster, will be the source of my pride. And that product – the simple act of reaching back to offer a helping hand – will never become obsolete.

Dr. Gary Maddux is the director of the Systems Management and Production Center. He coordinates a staff of more than 300 engineers, programmers, logisticians, and network administrators that supports various Army customers, including AMCOM, RDECOM, SMDC, and the PEOs. A large segment of his center comprises students working at the Army on a part-time basis – known as the Students Working at the Army in Parallel, or SWAP. He received his Ph.D. in industrial and systems engineering and engineering management from UAH.

Philosophizing about reverse engineering biological complexity

By Nicholaos Jones
Associate Professor of Philosophy

Philosophers have a reputation for thinking too much. Pre-Socratic Greek philosopher Thales apparently fell into a well while lost in wonder at the stars. René Descartes became sick to death — literally — while traveling to discuss philosophy with royalty. John Stuart Mill reported having a nervous breakdown after trying, for some 30-odd years, to live by his mentor's ethical theory.

Philosophers' reputed obsession with self-examination derives, at least in part, from their efforts to understand who we are, what we're doing, and what everything means. But philosophizing does not require ignoring the world. This is especially apparent in the philosophy of science, one of the more recent specializations among professional philosophers. Philosophers of science aim to understand science as a reason-governed human activity. This involves, first, using standards of logic and good reasoning to extract from scientific practice information relevant to understanding the kinds of arguments scientists are making and, second, using this information to better understand how those practices and arguments help or hinder our attempts to better control and explain the world.

Contemporary philosophers of science only occasionally make grand claims about science as a whole. More often than not, we focus on particular sciences because disciplines that study different objects develop different kinds of practices and arguments. Whence there is philosophy of physics, philosophy of biology, of chemistry, of climate science, psychology, psychiatry, medicine — the list goes on. Moreover, within these sub-specialties, we focus on particular aspects of science, such as the use of idealizing assumptions in model building, strategies for constructing explanations, and standards for confirming or falsifying hypotheses. Finally, rather than use popular opinion to speculate about how science works or try to deduce from abstract standards how science should work, we base our understanding upon detailed case studies of actual science.

This is all better shown than said. Although space constraints preclude a detailed example, I'll attempt to give some flavor for the kind of research philosophers of science do by sketching some ideas from my recent research in the philosophy of molecular systems biology.

Here's the plan: after briefly sketching what molecular systems biology is, I'll present some details from a case study I'm developing and show how these details help us to understand some of the different affordances between research in molecular systems biology and more traditional molecular biology.

Traditional research in molecular biology focuses on discovering and understanding the molecular mechanisms in living organisms, including both their constituent molecules and the organizational relations among those molecules. This will involve both careful experimenting and minimal theorizing.

Many publications in molecular biology report incremental insights about interactions among small numbers of molecular components associated with specific biological behaviors. This kind of research remains the dominant form of research in many biological science departments.

But recent technological developments for generating massive amounts of data, coupled with limitations of traditional approaches for understanding biological complexity, are driving new research strategies. These strategies are popular among so-called systems biologists, scientists who aim to understand living organisms as integrated wholes rather than as collections of decomposable and localizable parts. From physics, systems biologists bring a penchant for mathematical modeling and simulation; from engineering, an inclination to ascribe responsibility for biological behaviors to design principles. This latter approach is often called reverse engineering, because it uses ideas about engineering design to hypothesize principles governing how living systems operate.

A good example for illustrating the notion of a design principle, and an example that should be familiar to engineers, is integral feedback control. This is a principle for control, because it directs systems toward a steady state – a state in which current behavior perpetuates itself into the future – despite changing environmental conditions. Systems that embody this principle satisfy two preconditions. First, their efforts directed toward achieving some steady state are imperfect, meaning that success takes time. Second, their controlling efforts are proportional to their error. Such systems embody a general organizational pattern: a proportional control mechanism ("Control") senses some environmental input to the system and exerts a control effort on the controlled system ("System"). The system produces an output in response to this effort, and a sensor calculates the system error by measuring the difference between this output and the desired system state.

This error is fed back into the system input, with the proportional control mechanism acting to reduce the error and thereby lessen its control effort. For systems that embody integral feedback control, the control effort is proportional to the time integral of the error, and the desired system state is a steady state. Think, for example, of thermostats, which take as input information about environmental temperature and exert, as output, control on heat production until the error between actual and desired temperature vanishes. In recent work, John Doyle's systems biology research group argues that the integral feedback control principle explains why different species of bacteria share a common behavioral pattern. The behavior of interest to his group is known as chemotaxis, which involves bacteria "running" in straight lines and periodically "tumbling" in different directions, all in order to move toward environmental regions with higher nutrient concentrations or lower toxin levels. The behavioral pattern of interest is known as robust perfect adaptation, which means that when environmental conditions suddenly change, bacteria show a rapid change in their chemotaxic tumbling frequency followed by a gradual return to their pre-change tumbling frequency.

The robust perfect adaptation of bacterial chemotaxis is an established experimental result for several bacterial species, including E. coli and B. subtilis. Doyle's research group explains why these species all exhibit robust perfect chemotaxic adaptation by giving a two-part argument: first, they show that the molecular mechanisms responsible for chemotaxic behavior in different bacterial species all embody an integral feedback control design; second, they prove that robust perfect adaptation occurs whenever a system embodies such a design.

There are quite a few interesting twists, turns, and nuances in the argument from Doyle's group. The philosophically interesting details, however, concern how their explanation differs from more traditional explanations – and in particular how it differs from explanations by those who are not systems biologists.

Traditional strategies for explaining the robust perfect adaptation of bacterial chemotaxis rely upon dynamical models of chemotaxis networks. These models are sets of differential equations that represent the molecular mechanisms responsible for chemotaxic behavior in particular bacterial species. These models differ for different species. For example, without a protein called CheB (chemotaxis protein B), E. coli cannot run but B. subtilis can.

Because the same protein has different effects for different bacteria, the molecular mechanism for chemotaxis in E. coli differs from the mechanism for chemotaxis in B. subtilis. Hence, when biologists explain robust perfect adaptation in E. coli by deducing it from their dynamical model for chemotaxis in E. coli, that same deduction does not also explain robust perfect adaptation in B. subtilis.

The argument traditional biologists use to explain a certain behavior of one bacterial species is limited to only that species, and explaining the same behavior for another bacterial species requires a different argument. The explanatory strategy from Doyle's group is not like this.

Because many different bacterial species all embody the same design principle, Doyle's group can use the same argument to explain why many different bacterial species behave in the same way.

This is a strength of the systems biological approach: it helps us to understand what unifies different species, when those species exhibit the same behavioral pattern, by ascribing that pattern to a common design principle. But there is a limitation too, namely, that the appeal to design principles provides no information about the molecular structures responsible for enacting those principles.

Systems biological explanations provide unification through design; traditional biological explanations and depth through detail. This is a difference scientists need not notice in order to do their work well. Nor are they conceptually trained to consider the significance of such differences. But philosophers are.

These differences are worth considering, not only for the sake of better understanding how scientists go about the business of giving explanations but also for the sake of helping the scientists themselves to understand whether different explanatory strategies are complementary or competing. Regarding this second task, the lesson I take from thinking about how biologists explain bacterial chemotaxis is that the price for unification is depth.

Dr. Nicholaos Jones is an associate professor of philosophy. He received his Ph.D. in philosophy at the Ohio State University. His areas of research concentration include the philosophy of technology, epistemology, logic, and ethics. Dr. Jones joined UAH in 2007.

Professional nurses make a difference in your health care

By Karen H. Frith
Professor of Nursing

As consumers of health care services, you know how important nurses are to your health. In fact, results from annual Gallup polls on Honesty and Ethics in Different Professions show that Americans rate nurses as the most trusted profession every year since 1999 with the exception of firefighters in 2001 after terrorist attacks (Gallup, 2014).

Nurses are essential to all aspects of health care from wellness, acute care, and chronic care to rehabilitation and end-of-life care. Nurses often translate medical terminology and treatment options into meaningful information for you to understand and make decisions about your care.

Nurses have a big responsibility to make sure that you get the right care, at the right time, in the right way. Nurses must be educated individuals who work as partners with the entire health care team to improve care. Let's examine the reasons why education is critical.

The Institute of Medicine studied nursing education and practice in its report on the Future of Nursing, according to the Institute of Medicine (IOM). That group called for nurses to "achieve higher levels of education and training through an improved education system that promotes seamless academic progression."

This call for change in nursing education set a goal of having 80 percent of practicing nurses holding a Bachelor of Science in Nursing degree (BSN) by 2020. Currently, only 50 percent of registered nurses in the United States have a BSN degree, according to the Center to Champion Nursing in America. Many students graduate from programs granting an Associate Degree in Nursing (ADN). In Alabama, 39 percent of graduates in 2013 received ADN degrees, states the Alabama Board of Nursing. It makes sense that a more-educated nurse can give better quality care, and research bears out this intuition. Studies show that an increase in the percentage of registered nurses holding a BSN degree decreases deaths in hospitals. Likewise, a higher percentage of registered nurses is associated with fewer medication errors.

Because the education of nurses matters when you are in the hospital, you might wonder what can be done to have a more-educated nursing workforce in Alabama. Preparation for a career in nursing begins with good choices in high school. Students can select science courses that prepare them for nursing including biology, chemistry, and human anatomy, and physiology.

Transition from high school to BSN programs is enhanced through electives. In the Huntsville City School System, high school students with an interest in nursing can select courses from the Biomedical Sciences (Clinical Applications) career academy. Other high schools in North Alabama offer health care occupations classes that can be taken as electives. Discussion with high school counselors and college advisors in nursing can help high school students understand the academic requirements for successful admission into BSN programs. Even after high school graduation, individuals who have delayed college or who are changing careers should examine all options for their nursing education. Whenever possible, it is better for future nurses to enroll in BSN programs. However, if circumstances make that option too difficult, then future nurses should enroll in an ADN program with a plan for immediate continuation to a

BSN program. The IOM called for schools of nursing to develop pathways between the associate and bachelor degrees to improve the transition to the higher degree. In North Alabama, The University of Alabama in Huntsville (UAH) has an active relationship with Calhoun Community College, Wallace State College, and other area community colleges to transition students directly from the ADN to the BSN program. Graduates from the ADN program can begin work while continuing their education.

Health care organizations have a role, too. The IOM suggested that health care organizations should require all nurses with an ADN degree to enroll in a BSN program within five years of graduation as a condition of employment or use incentives such as providing tuition reimbursement, setting promotion criteria that specify having a BSN degree, and giving a salary differential for higher degrees.

Hospitals are working hard to make sure that they give you access to quality health care, and attention to nursing education is one strategy to achieve their quality goals.

The need for BSN-educated nurses in Alabama will continue to increase as our population grows and as our citizens get older. Now is the time to make a commitment to having a highly educated nursing workforce in Alabama, and particularly in North Alabama. We can meet the goal of 80 percent of nurses in North Alabama having a BSN degree by 2020! It will take us all working together to achieve this goal.

Dr. Karen Frith is a professor of nursing and earned her Ph.D. from Georgia State University. Her research interests and academic specialty are nurse staffing and patient and organizational outcomes as well as stress in the nursing professor.

Novel approaches to treating infectious disease

By Robert McFeeters
Associate Professor of Chemistry

Microbes have been and continue to be a major challenge facing the human race. For the past century, pathogenic bacteria, viral epidemics, and fungal pestilence have been held at bay by breakthroughs in medicine, chemistry, microbiology, and pharmacology.

This temporary reprieve is now being threatened by the development of drug resistance. Human activity, including misuse or overuse of antimicrobial drugs, poor health care practices, and inadequate sanitation, accelerate the emergence of drug-resistant pathogens.

As new drug-resistant strains emerge and rapidly spread worldwide, effective treatments dwindle.

Research in the McFeeters group focuses on identifying new antimicrobial targets and finding novel approaches to treat infectious disease. Projects include antibiotic discovery against novel essential bacterial enzyme targets, developing carbohydrate-binding proteins into potent anti-viral entry inhibitors, and countering the effects of lethal fungal virulence factors. We take an interdisciplinary approach utilizing biochemistry, microbiology, and structural biology to address the global threat of emerging infectious disease. We also collaborate with natural-product chemists and take advantage of the remarkable chemistry within living organisms to discover new drug leads.

To address the need for new antibiotics due to the relentless development of drug resistance and re-emergence of pathogenic bacteria, the McFeeters group has characterized novel targets, including the promising new enzyme peptidyl-tRNA hydrolase (Pth1). Bacterial Pth1 is an essential enzyme in bacteria, recycling peptidyl-tRNA generated from premature termination of protein biosynthesis. There is no essential human homolog; thus, inhibition of Pth1 is likely to have no effect on humans.

The McFeeters group has discovered the first small-molecule Pth1 inhibitors, both from natural products and combinatorial synthetic libraries. We have characterized Pth1 enzymes from a diverse array of pathogenic bacteria and shown broad-spectrum as well as species-specific inhibition. In collaboration, we have isolated naturally occurring compounds that inhibit Pth1 activity in bacteria and characterized their interaction with the enzyme. Combining experimental data with computational modeling, we continue to improve pharmacological properties, providing stronger candidates for clinical evaluation. Thus, in addition to providing fundamental understanding into this promising new target, we are at the forefront of discovering new small-molecule inhibitors and developing them into the next generation of antibiotic.

Our expertise in protein biochemistry and infectious disease has provided new avenues for preventing viral infection as well. Though very different from bacteria, viruses are a particularly important class of microbes in terms of human pathogenicity. In addition to drug resistance and continued evolution, the threat of their use in bioterrorism looms. Many viruses are poorly understood and even more have little or no effective treatment options. The McFeeters group is developing a completely novel approach to blocking viral infections, targeting carbohydrates on virus envelope glycoproteins.

A major advantage of this approach is that it stops the virus before infecting the host cell. Consequently, cytotoxicity of this type of treatment is significantly diminished because the drug does not have to enter the cell. Anti-virals targeting envelope glycoproteins are effective against strains resistant to current drug regimens or engineered to have drug resistance. They can also be employed as topical microbicides, working to prevent viral transmission, not just having utility as a post-infective treatment.

Another advantage of targeting viral glycoproteins is that viruses do not have the capability to change the attached carbohydrate. Thus, the virus cannot develop resistance by evolving the carbohydrate component. Instead, the virus can only remove the attached carbohydrate, which is twofold detrimental to the survival of the virus. Viruses use host glycoproteins to evade the immune system; thus, removal makes them more likely to be detected and neutralized. Also, the carbohydrates on the glycoproteins are required for the virus to attach to host cells.

Thus the removal of carbohydrates from the viral glycoproteins reduces the ability of the virus to infect host cells. Herein lies the best asset of targeting viral glycoproteins: viral adaptation leads to reduced viral fitness and infectivity. To target carbohydrates on viral particles, the McFeeters group has engineered a suite of carbohydrate-binding biomolecules that specifically recognize high-mannose moieties on viral glycoproteins.

While every virus is different, high-mannose moieties are particularly vital for HIV-1, Ebola, influenza, Hepatitis C, and SARS. We have characterized the high-resolution structure of antiviral lectins, cloned a new species of lectin from saprophytic bacteria, and structurally engineered a class of lectins to have improved antiviral efficacy. In addition to improving therapeutic properties, we are working toward reduced production costs, including continual batch yeast expression and active expression in transgenic plants. Again our aim is to develop an effective, widely applicable new avenue for the therapeutic treatment of infectious viruses.

Rounding out the multifaceted, interdisciplinary nature of the

McFeeters group, we have embarked on studies of pathogenic fungi. Fungi represent a largely unexplored class of organisms, many seriously affecting human health and compromising the food supply. Drugs to counter pathogenic fungi are losing efficacy and generally have harsh side effects. For agricultural applications, few anti-fungals are safe for large-scale use and generally are rendered ineffective within a few years of sustained use. To address the deficiency in anti-fungal treatments, the McFeeters group is developing novel anti-fungals taking a target selective approach.

Our priority is the necrotrophic fungus Botrytis cinerea, the gray mold that is unwelcome but commonly growing on fruits and vegetables in your refrigerator. In addition to causing billions of dollars annually in agricultural losses, this organism also causes the human disease hypersensitive pneumonitis, commonly referred to as wine grower's lung. We have characterized the primary virulence factors of B. cinerea, the BcSnod proteins.

These proteins induce cell death once introduced into plant hosts. Thus, interrupting the process by which these factors initiate cell death would be a potent countermeasure. Our goal is generating transgenic plants with elevated resistance. The role of BcSnods in hypersensitive pneumonitis is slowly emerging and findings from this study will be applicable to numerous fungal respiratory infections.

In conclusion, the McFeeters group implements a combination of methods to provide fundamental research in novel approaches to treating infectious disease. We have bacterial, viral, and fungal components that share a common foundation of biochemistry, microbiology, and macromolecular characterization. We advance the fundamental understanding of infectious disease and continually develop new approaches for their treatment.

Dr. Robert McFeeters was awarded his Ph.D. in molecular medicine from Cornell University and was a postdoctoral fellow at the National Cancer Institute. His teaching interests are biophysical chemistry and his research interests are directed toward understanding the mechanisms of infectious agents and how to counter their activity. His research focuses on anti-viral entry inhibition and transcriptional regulation of the bacterial nucleoid. The specific projects are founded on biochemical, biophysical, and structural characterization. of the macromolecules governing these processes.

Cosmology and the evolution of our universe

By Max Bonamente
Research Associate
Center for Space Plasma and Aeronomic Research

"Our whole universe was in a hot dense state, then nearly fourteen billion years ago expansion started."

– Opening lyrics from The Big Bang Theory theme song

Less than a century ago, our knowledge of the universe was quite different from what we have now. We did not know if there were other galaxies besides our own Milky Way, let alone how and when the universe came into being.

Now the words "big bang" are as popular as the latest America idol, and everyone knows that the universe keeps expanding with every passing second. It's expanding ever outward but one day, it will cause the stars to go the other way. Collapsing ever inward, we won't be here, it won't hurt. Our best and brightest think it'll make an even bigger bang!

Our best and brightest have been very busy studying cosmology, figuring out how the universe started, and where it is going. For one, NASA has invested billions of dollars on the Hubble Space Telescope. It was named after Major Edwin Hubble, the early-20th-century astronomer who discovered that galaxies move away from one another and that the universe expands. The Hubble constant tells how fast the universe expands and its age. It took 20 years of planning and another 20 years of using the Hubble Space Telescope to determine precisely how fast the universe expands. Now we know that the universe is about 14 billion years old.

Cosmology is at an exciting time. From the long-wavelength radio frequencies to the fastest X-ray and gamma-ray waves, astronomers are scanning the skies to answer questions on the future of our universe. Will the expansion continue? Will it halt and the universe truly make and ever-bigger inward bang?

We are in the middle of this research at The University of Alabama in Huntsville (UAH). Edwin Hubble made his discovery with a 100-inch telescope at Mount Wilson, CA. Now a team of scientists at UAH and Marshall Space Flight Center is using an array of telescopes and instruments that is leading to new discoveries into the fate of the universe.

NASA's Chandra X-ray Telescope is the most powerful X-ray instrument we use, and it was developed and tested in Huntsville. It was placed in orbit around Earth by the space shuttle Columbia in 1999, and it is helping us observe the farthest galaxies in the universe, billions of light years away. What we have learned is that observing at more than one wavelength gives us a unique view of the expanding universe. So we teamed up with scientists at the University of Chicago, Caltech, and other universities to develop radio telescopes that combine with our X-rays to tell us how far those galaxies are. In 2006, we provided a new and unique method to measure the Hubble constant. It confirms and expands the findings from the Hubble Space Telescope.

Dark matter and dark energy are the cornerstone of our studies on the evolution of the universe. Visible objects like the Earth and the sun are only a small percent of what makes up the universe. More than 95 percent of the universe is dark! What we mean by dark is that we know it's there, but we can't quite see it. Planet Neptune was discovered that way: a wobble in Uranus' orbit gave it away; there had to be a planet pulling it. And surely enough, there it was. Discovering how much dark matter or dark energy there is requires different tools, but the same logic. We are not quite there yet. For example, we don't know what type of particles make up dark matter or dark energy, but it is definitely worth the effort. Wouldn't you want to know if one day our universe will be ripped apart by dark energy, or if it will crunch back on itself by gravity?

A UAH graduate, Dr. Esra Bulbul, was recently hired at Harvard, where she works to identify a possible candidate for dark matter. We don't know yet if she will be the next Nobel Prize winner in physics. She might be. After all, the Swedish committee already awarded the prize to the scientists who discovered that the universe's expansion is accelerating, so they are certainly paying attention to this field. And they should: If finding out the future of our universe is not exciting, I don't know what is.

What is fascinating about cosmology is its unique blend of philosophy and science. It is somewhat humbling to be part of a field of research that ends in "-ology." We have to speculate first and use our science tools later. And we have to be careful not to be blinded by our own prejudice. Albert Einstein made that mistake when he forced some of his equations to give the answer that he thought was the correct one. He believed that the universe was stationary. Was he wrong!

Nowadays, cosmologists are still debating some of Einstein's ideas on cosmology, especially on what is the behavior of the "dark energy" term that appears in Einstein's theory of general relativity. The Nobel Prize-winning discovery that the universe's expansion is accelerating was largely based on optical data, similar to what Edwin Hubble used. We use X-ray and radio observations to advance those discoveries, primarily because at our wavelengths we can look farther at more distant galaxies. And that also means that we look farther back in time. This study of the time evolution of the universe, in particular the formation of galaxies and clusters of galaxies, is what tells us that dark energy is about 75 percent of what the universe is made of, and that dark matter is 5 to 10 times more abundant than visible matter.

What makes cosmology even more exciting — some may say frustrating – is that even the ordinary visible matter that existed at the beginning of the universe now seems to be in hiding. How do we know, you ask? At the beginning of the universe, that "hot dense state" let some light out. That light tells us how much visible matter there was at the beginning of the universe before galaxies formed. Now that galaxies have formed, we measure their mass, and things simply don't add up. We come up short. Because matter can't disappear, we think it is hiding.

One idea we are working on is that this missing matter is hiding in very tenuous filaments connecting galaxies, like a spider web that is too thin to be seen directly.

To overcome that problem, we use bright distant objects in their background to hope that they cast a shadow that we can detect. A shadow is all we need to know that matter is there, just as well as seeing with the naked eye, and we are having good success with this method.

We are hopeful that soon we can at least solve this problem of the missing visible matter. It will not solve all of cosmology's problems, but it would be a major advance. UAH scientists are right there working on it, taking advantage of many NASA-and NSF-sponsored telescopes, from radio to ultra-violet and X-ray wavelengths.

You are probably getting the impression that there is more that we don't know, rather than what we do know, about the universe. You would be right. It is not easy to study the universe when you don't even have a yardstick long enough to tell how far away the Moon is. But this makes it even more fun and exciting, especially because the question we are trying to answer is "Where do we come from, and where are we going?" Exciting, uh? We think so.

Dr. Max Bonamente is a research associate in the Center for Space Plasma and Aeronomic Research. He earned his Ph.D. in physics from UAH. He also served as a postdoctoral associate at NASA's Marshall Space Flight Center.

Polymers
Long thread like molecules with biomedical superpowers

By Carmen Scholz
Professor of Chemistry

The reticuloendothelial system of the human body is the watchful "eye" that protects us from invasive objects ranging from bacteria to splinters. However, invading objects that provide beneficial functions or deliver therapeutic cargo, such as drugs, genes or theranostics and implants need to be smuggled by this watchful "eye."

Research into polymeric "invisibility cloaks" started in the Scholz group more than 10 years ago when the group joined the Boston Retinal Implant Project.

The Boston Retinal Implant Project developed an electric device that assumes the function of diseased photoreceptors in patients suffering from certain forms of blindness. The retinal implant is an intricate device developed by retinal surgeons, ophthalmologists, electrical engineers, micro-fabrication experts, biologists, computer scientists, and physiologists, to name just a few of the scientists involved in the project. To describe the entire device would go far beyond the expertise of this author and the scope of this article.

What mattered to us as polymer chemists was the part of the retinal device that is implanted into the sub-retinal space. This electrically active device, approximately 5 mm wide and 10 microns thick, needed to be protected from the watchful reticuloendothelial "eye" and its actions of protecting the body from intruders.

Because such a comparatively large piece of plastic and electrodes cannot be dissolved or enzymatically degraded, the body responds by forming scar tissue around the intruder, i.e., implant. Having a thick layer of scar tissue around a delicate electrically active implant renders it basically useless as the electric impulses provided by the electrodes will not be able to penetrate the tough scar tissue.

Among all the polymers that have been developed for and tested in biomedical applications, one stands out because of its unique ability to provide a biological stealth function to all objects it is attached to, thereby hiding them from the reticuloendothelial system: poly(ethylene glycol), or PEG) It was our task within the Boston Retinal Implant Project to make the implant invisible to its surroundings upon implantation into the eye. While PEG is exceptional in hiding things in the biomedical realm, getting the PEG to stick to things it is supposed to hide is a different story. PEG is chemically inert, which is a fancy way of saying: non-reactive or dead as a doornail. Unless PEG is furnished with an anchor it cannot be covalently, that is, lasting for a long time, attached to a surface. This anchor molecule needs to be judiciously chosen, as it needs to be non toxic, reactive towards a surface, biocompatible and its eventual degradation products must be non toxic as well, metabolizable, and excretable.

We turned to amino acids, also known as the building blocks of life, to construct a suitable anchor molecule. Proteins and peptides found in all living things on Earth consist of the 20 essential amino acids and few specialized ones, and the key to their function is that these 20 plus amino acids are lined up in a specific order or sequence, thus forming long, thread-like molecules, which then self assemble into a sequence-specific and highly repeatable three-dimensional structure. The order in which these amino acids are linked to one another and the resulting assembly in three-dimensional space will determine whether a protein will function as an enzyme that catalyzes chemical reactions in our bodies or whether it will become the hair on our heads.

Linking many different amino acids in a pre-described order or sequence is synthetically possible, but we needed the amino acid for one task only, that is acting as an anchor for the PEG molecule that provides an implant with a stealth character. So we settled for one essential amino acid: L-Cysteine, an amino acid with a thiol end-group. This sulfur-containing end-group was of particular interest to us because it reacts readily with gold. We linked a chain of L-Cysteine building blocks to the end of a PEG molecule, thus providing the PEG with the anchor it needed to hold on to the implant surface.

Because we can decorate the outside of the implant with gold nanoparticles we can attach the just synthesized PEG-poly (amino acid), PEG-PAA, coating or "invisibility cloak" to the implant surface. These polymers are referred to as block copolymers as they consist of two distinctly different blocks: the PEG block that provides biocompatibility and the PAA block that provides reactivity toward the substrate. On a more scientific note, amino acids can be readily activated to form cyclic N-carboxyanhydrides, which are suitable for ring-opening polymerizations. Using a heterobifunctional, methoxy-amino PEG as macroinitiator for the ring-opening polymerization of the amino acid N-carboxyanhydrides allows for the step-by-step formation of another polymer chain, here a poly (amino acid) chain at the amino end of the PEG molecule.

In our case, this poly (amino acid) chain contains poly (L-Cysteine) residues, which will act as the reactive anchor. Thus, an anchor moiety was attached to one end of the PEG chain with the other end of the PEG chain remaining unsubstituted, allowing it to expand away from the implant under physiological (aqueous) conditions to assume its function of shielding the implant underneath from approaching proteins that would trigger the cascade of cell adhesion leading ultimately to the formation of scar tissue.

Typically, two amino acids were used to form the anchor moiety, L-Cysteine N-carboxyanhydride was mixed with the N-carboxyanhydride of, e.g., L-Glutamate, thus producing poly(amino acid) copolymers. Using two different amino acid building blocks allowed for the control of the density of reactive functional groups along the PAA chain, thus giving us a tool to modulate the molecular architecture of the resulting surface coating material. Using poly(amino acid)s as anchor molecules provided yet another advantage: it is difficult to achieve dense PEG coatings due to the large extended volume of PEG in water, and while it is difficult to overcome that particular polymer-physical problem, having a poly (amino acid) chain covering the implant's surface helps to alleviate the issue of lose PEG packing.

Even if there are "holes" in the PEG coating the biocompatibility of the surface is preserved due to the poly(amino acid) chains coating the implant surface in a loop-like morphology. So basically, we laid down two polymers, PEG, the first line of defense that can be pictured moving like a feather duster and repelling approaching proteins, which would guide cells to the implant that would eventually form scar tissue. Should the PEG be overcome a second polymer is bound firmly to the implant surface occupying the spaces targeted by incoming proteins. We are currently involved in a project where we apply the same approach to the encapsulation of glucose sensors.

In the course of this work we gained tremendous insight into the syntheses of poly(amino acid)s and mastered the challenges that this type of polymerization presents. For example, all polymerizations need to be conducted under anhydrous conditions, a few water molecules will cause havoc among the growing poly(amino acid) chains. We determined conditions under which the polymerization is "living," a special case of polymerization that allows for absolute control of the length of the poly(amino acid) chains. When producing polymers for biomedical applications, it is quintessential that all chains are of approximately the same length; while this sounds easy, it is one of the Holy Grails of polymer synthesis.

We studied the growing poly(amino acid) chains when they were just a few repeat units long, found that they like to assume three-dimensional structures that are troublesome for the polymer formation process, and learned how to keep our polymers from behaving in this self-distracting way: as long as the growing poly(amino acid) chains are still rather short, they cannot yet form the helices needed for flawless chain growth and tend to form sheets that readily precipitate out of solution, thus terminating the polymerization. Breaking the hydrogen bonds between the chains that are responsible for the sheet formation is the key to overcoming this particular challenge.

We have since expanded our research to include the synthesis of PEGylated poly(amino acid)s for gene-and-drug delivery vehicles. A second look at the amino acids used for the syntheses described above reveals that they are structurally more complex than discussed so far. While two ends of an amino acid can be snapped into an N-carboxyanhydride ring, the activated form of an amino acid, they have yet a third end, called a functional group, that can be used for a variety of tasks; the surface modification via thiol functional group was already discussed. Using L-Lysine provides an additional amino functional group that is positively charged under physiological conditions hence making itself available for the condensation of DNA.

Therefore, poly(L-Lyisne) containing copolymers can be used as gene-delivery vehicles, for which we are currently investigating them. Using poly(L-Glutamate) introduces an anionic carboxyl group, which could be of use in drug delivery systems. There is also a variety of highly hydrophobic amino acids; introducing them into our copolymers makes the poly (amino acid) portion of the copolymer rather water-repellent and on a molecular scale this behavior drives the self assembly toward tightly packed aggregates.

Delivering any type of cargo, such as therapeutic drugs, theranostics, DNA, or RNA-variants to the human body is challenging as the delivery vehicle has to navigate through the harsh environment of the human body where, under the-ever watchful "eye" of the reticuloendothelial system, a battalion of enzymes with degrading powers are ready to destroy any intruding moiety. This inherent protective system evolved to protect the human body from disease-carrying bacteria, the action of dead cells and macroscopic intrusions. While "well-intended" by nature it makes the task of delivering therapeutics challenging. Hence, the stronger these delivery systems can be built the better they can protect their cargo.

Tasks such as protecting implants from scar tissue formation, constructing delivery vehicles that can deliver DNA or drugs target-specific where needed in the body, or RNA capable of silencing malfunctioning DNA can be performed because PEG, a well-known polymer that is sometimes referred to as the "grandfather" of all biocompatible polymers can be linked to another class of polymers, poly(amino acid)s, which are constructed from naturally occurring amino acids and contribute versatility, reactivity, and a broad range of chemical properties.

As the two polymers got together they improved each other, and their marriage yielded a product that polymer chemists call a "copolymer," a simple name for a synthetic construct that is involved in the changing ways that we treat some of the most devastating diseases.

Dr. Carmen Scholz is a professor of chemistry, and earned her Ph.D. at the University of Technology in Dresden, Germany. Prior to that, she was a research scientist at the University of Massachusetts and at the International Center for Biomaterials Sciences in Japan. Her research concentrates on the synthesis and characterization of biocompatible and biodegradable polymers.

Investing in research universities is smart strategy for the future

By Phil Williams
Alabama House of Representatives

Research universities are institutions that trace their genesis to 19th century America, and credible evidence exists that they are very effective wealth-creating machines for the U.S. economy.

On the campuses of research universities, you will witness students, faculty, and staff engaged in the pursuit of new knowledge, and the creative application of that knowledge, which can go a long way to meeting critical challenges in the national interest.

Progress in solving these challenges is essential to the future health, vitality, and security of the United States.

Alabama is fortunate to have several high-performing research universities within its borders. These institutions of higher learning meld the best and brightest students from around the world with top-quality faculty, aggressive research programs, and partnerships with government and private industry that lead to innovative products and services that have revolutionized modern society and led to the prosperity we enjoy today. Everywhere you look around the world you see nations making investments in the future, which recognize what the 21st century will look like – the century of innovation. Isn't it about time we did the same in Alabama?

The state of Alabama has been very successful in recruitment of industry and manufacturing. The economic activities that have been created by these companies in Alabama have provided tremendous benefits to Alabamians, and hopefully will contribute to our economy for many years into the future.

I want to challenge my co-policymakers in Montgomery to look at a similar investment for Alabama's research universities. While this strategy may not be as innovative of an approach as other states around the country, many of those states have moved ahead on supporting their research universities.

A strategic and comprehensive plan to support and enhance research universities has great merit. Even a fraction of the investment that we make in recruiting industry would provide adequate seed money to grow the research enterprise among Alabama's research universities.

It would be out-of-the-box thinking for our state, and a new concept for economic development. The economic models exist so there is evidence that this strategy would be successful. For instance, the University of Alabama at Birmingham is one of the leading medical research facilities in the nation and among the top employers in the state. It brings great benefit to not only Birmingham but to every corner of Alabama. The University of Alabama in Huntsville (UAH) is among the largest employers in Huntsville and ranks fourth in the nation in aerospace engineering research, bringing millions of dollars into our state while employing highly educated Alabamians and creating long-term jobs for our economy.

Alabama's aggressive approach of building a knowledge economy would also create a high-quality workforce that would be destined to remain in Alabama and make economic contributions for life. Investing in universities and research will allow us to retain Alabama's best minds, recruit the top intellectual talent in the world to our state, and put us down a path of developing technologies for commercial use, creating startup companies, and creating new jobs as well as new wealth. Can anyone find a downside?

U.S. Sen. Richard Shelby has given Alabama a means to take advantage of this opportunity. During the past decade, his influence has helped create massive infrastructure improvements at our research universities. The next step should be Alabama's — a strategic investment in intellectual talent.

Research universities are the first link in a chain of basic knowledge leading to applications that have revolutionized modern life. Investing in Alabama's research universities will allow this state to create a stronger first link in the state's economic fortunes.

Phil Willliams represents House District Six in the Alabama House of Representatives and is chair of the House Technology and Research Committee. He also serves as a member of the Education Policy Committee and the House Ways and Means Committee. Mr. Williams was the first graduate of the Foreign Language & International Trade program at UAH. After working as a contract specialist with the U.S. Army, he co-founded several companies: 3D Research Corp., Synapse Wireless, and Soldier 1 Corp.

Ripple Effect Make Students Aware of the Power of Positive Encouragement

By Jason L. O'Brien
Associate Professor of Education
and
Megan Shirley
Middle School English Teacher

Megan Shirley always loved to write, but she never wanted to be a teacher until she first set foot in a classroom and realized that a Secondary Education English degree would allow her to share that passion with her students.

What she didn't realize at the time was that a few simple kind words could have a profound impact on hundreds of students across Madison County. Megan, who earned a Master of Arts in English degree from The

University of Alabama in Huntsville, is now an 8th grade English teacher at Monrovia Middle School (MMS).

During the 2014-2015 school year, she and a colleague, Caroline Reed (the 8th grade computer technology teacher), began to notice that the students at MMS were respectful to adults while entirely disrespectful, cruel even, to their peers. This observation alongside the school's annual data survey showed that the students' two main issues in the school were: 1) The students did not treat each other with respect, and 2) Students did not respect one another's property.

Faced with this dilemma, Megan and Caroline decided to collaborate on a project in which students worked to create a more positive school culture through kind words. Megan and Caroline's two classes joined together in the drama room for a presentation in which word connotations (both positive and negative) and their long-lasting effects were illustrated through an activity. The students saw that words cannot be erased once they have been written, just like they cannot be taken back once they have been spoken. Students also began to see the negative effects of stereotypes and appearance-based judgments.

In the same way, they began to see the power in a simple kind word. They realized that one kind word had the power to change a person's day, causing that person to ripple a kind word to another, then another, and so on. The initial idea connecting all of this was "Positive Words, Positive World." Students, however, felt that the title was too long for social media purposes. Wanting a hashtag that had the potential to go viral and truly represent the "ripple" they hoped to create in the world, #ProjectRippleEffect was officially born.

The first part of #ProjectRippleEffect focused on making students aware of the power of positive encouragement. With the support of the administration, a video was filmed by the students in which negative stereotypes were destroyed and replaced by positive truths.

The students used balloons to represent the negative stereotypes for each group of people within the school (teachers, administrators, coaches, lunchroom ladies, students, school resources officers, etc.). Students took turns popping the balloons to symbolize the destruction of each stereotype, and the students went on to write specific and genuine compliments for a person representing each of the groups. Six students were chosen to write the compliments because researchers have found that it takes six positive comments to make up for one negative comment. The people receiving the compliments were then encouraged to make a positive ripple by sharing a positive word with another individual in the school (spreading the ripple to a student from each grade level, librarians, other administrators, office staff, etc.).

Upon reflecting on the #PRE video, Megan and Caroline decided to take the project one step further. It was not enough for students to spread kind words to one another if their actions did not match up with that positivity. Therefore, a second layer – the action component – was added to #ProjectRippleEffect. Students collaborated in groups to come up with ways to use both writing and technology as tools for advocacy within the school and the community.

Students decided to spread positivity throughout the community by actions, such as: writing poetry and making banners for children with cancer, making holiday cards for patients in nursing homes, writing and performing plays for the MMS special education department, helping the janitors keep the school clean by creating the event "Trashy Tuesday," and so much more.

With the two layers of #PRE, actions and words, coming together, students began to see a change in both themselves and the school as a whole. The hope for #ProjectRippleEffect is to continue making these positive ripples so that all the world can experience and spread the positivity that the project has to offer.

Dr. Jason O'Brien is an associate professor of education and received his Ph.D. from the University of South Florida. His research interests are social studies teaching and learning, English Learners, and citizenship education.

Megan Shirley received her Master of Arts in English from UAH in 2013. She is now an eighth grade English teacher at Monrovia Middle School.

Learning to experiment in early modern medicine

By Evan R. Ragland
Assistant Professor of History

Experimentation is a hallmark of much of modern science. And modern science, so the story goes, emerged in Europe in the 17th century. Philosophers and mathematicians such as Galileo, Descartes, Huygens, and especially Isaac Newton crafted increasingly sophisticated mathematical models for the natural world and tested those models in experimental trials. This is a good story, but it's not the whole story.

We still lack truly comprehensive surveys of how experimentation came to be a widespread way for generating natural knowledge. My current projects show that there are hidden treasuries of experimentation among the professors and students of academic medicine even before the rightly celebrated work of our philosophers and mathematicians from Galileo to Newton.

Stressing the popularity and foundational role of experimentation for Newton and his cohort should not encourage the myth that no one from the ancient or medieval periods bothered to make tests that look a lot like experimentation. Aristotle (384-322), for example, dissected eggs to see the process of development, and elsewhere he reported that he "made a trial" to support the claim that evaporated salt water forms fresh water. In the 100s CE, Ptolemy described measurements of the refraction of light by marking off a bronze disk partially submerged in water (though he may well have fudged some of the numbers to get the pattern he liked). At the same time, Galen used strong rhetoric and logic to reject the opinion of his predecessor, Erasistratus, that the arterial pulse is carried by the airy pneuma carried in the arteries.

More importantly, he also replaced part of an artery with a tube and fixed the ends of the tube to the sectioned arteries in the body. When he observed no pulse beyond the tube, he concluded (erroneously) that it was not the contents but the arterial tunic itself that brought about the pulse. Other physicians inspired by Galen and the much earlier Hippocratic literature also had to resort to tests of drugs, because most complicated drug actions did not obviously derive from the manifest qualities of the ingredients. Yet these are outstanding examples, and appear isolated even in the works of Ptolemy and Galen, and more so among texts from other ancient writers.

Just as in the ancient world, few medieval philosophers seem to have concerned themselves with actually performing experimental trials. Again, there are important exceptions. Ibn al-Haytham (d. 1038), for example, described tests for his theories about the rectilinear propagation of visual rays. In the later 1200s, two figures working in the optical traditions, Kamal al-Din al-Farisi and Dietrich of Freiberg, both developed experimental analyses of the rainbow. In Arabic and Latin, respectively, they attempted to "unweave" its colored strands by modeling the refraction and reflection of visual rays in raindrops with water-filled glass bowls and carefully measuring the angles.

In another instance, a Latin text claiming to be from the great alchemist "Geber" used laboratory trials to argue for treating matter as composed of particles of various sizes and bonds. His principles of sulfur and mercury, for example, resisted decomposition and could even reappear after distillation, indicating that their smallest particles enjoyed a "very strong composition."

These brilliant examples, and a few others like them, sum to a picture of comparatively rare practices of experimentation. Leading historians of medieval philosophy have repeatedly stressed the "bookish" character of most of medieval philosophers. Edward Grant and John Murdoch described some key medieval themes as "empiricism without observation" and "natural philosophy without nature," respectively.

So how do we explain later experimentation, such as Galileo's apparently abrupt departure from Aristotelian physics of falling bodies in his 1590 manuscript, "The More Ancient Writings on Motion?" Aristotle argued that heavy bodies fall with a speed proportional to their weight and inversely proportional to the resistance of the medium. In his 1590 writings, Galileo argued that "I have often made a trial" (saepe periculum feci) of how bodies fell by dropping wood and lead spheres from a high tower. Several prominent historians take this as the beginning of a clear-cut distinction in language and procedure between specific, historical experiments and a more general sense of common experience. But who else might have been talking about "making trials" and actually performing them?

Since at least the early 20th century, important historians of science such as Leo Olschki and Edgar Zilsel have argued that the Renaissance economies of profit and innovation helped to team craftsmen and scholars together, joining the laboratory or workshop and the learned search for causal knowledge.

This approach has a great deal of merit and is now enjoying a revival. We can see clear exemplars of this thesis in the work of Leonardo da Vinci on flight, the impact of projectiles, and even the flow of blood in a living body. And Galileo certainly lived within a milieu of artisan-engineers and practiced as one himself. The second of his "Two New Sciences," of course, was the science of materials. And William Gilbert's 1600 book "On the Magnet" used a variety of experiments with such things as needles, spherical lodestones, and freely moving compasses to argue for a new philosophy in which the Earth itself acted like a giant magnet. He had adopted practices from scholars interested in natural magic or the control of the hidden powers of bodies, and navigators who also had incentives to explore the interaction of magnets and the world. But there was another, much larger, group of scholars whose discipline joined theory and practice, the head and the hand, in a variety of uses and universities across Europe: physicians. In fact, Galileo had first trained in medicine at Pisa, and Gilbert was a physician to Elizabeth I.

My current project bridges the histories of science and medicine to reveal nearly ubiquitous practices and distinct ways of talking about "making trials" among physicians in the 16th century. As early as 1518, the Italian humanist Marsilio Ficino reports that he "made a trial" of a drug recipe against the plague. The assertive humanist-surgeon Berengario da Carpi presents another early case study, with his reports in his 1521 anatomical compendium that he "made an experience" testing anatomical vascular connections by forcing water through them with a syringe. He also attempted to resolve a debate over the action of the kidneys — did they work like sieves or actively select out the waste? — by again artificially pushing fluid through them.

It should come as no surprise that the best-known anatomist of the century, Andreas Vesalius, also described "making trials" in the 1543 and 1555 editions of his massive "On the Fabric of the Human Body." Aristotle had made the rather infamous claim that the male gonads of beasts generally only acted like counterweights on a loom. Vesalius reported, "in order to judge the opinion of Aristotle, which granted no power of generating seed to the testes, I made a trial" by neutering a dog. The dog convalesced well, but failed to sire any offspring.

Around the same time, the irascible physician Pietro Andrea Mattioli drafted a series of best-selling natural histories. His works catalogued the plants and animals that physicians might use as resources to prepare remedies by commenting on the preserved lore of the ancient authorities with observations of his own and his colleagues. But he tested his experimental trials against his contemporaries as well. Mattioli's rival physicians had claimed that viper fat prevented the regrowth of hair. So, as he did in dozens of other cases, he "made a trial" and spread a balm of viper fat over a place plucked free of hair. The balm did not prevent regrowth; it healed. Like other contemporaries, Mattioli also tested the efficacy of ancient remedies, such as the power of white beet-root to expel parasites. He used his own trials to reject ancient and contemporary claims and advertise his own skill and authority.

Working in Padua around the middle of the 1500s, the anatomist and physician Gabriele Falloppio also used his trials to end debates. Hot springs and other thermal waters had established reputations as places of healing, and they were particularly fashionable for Renaissance patients. As we might expect, various contradictory claims appeared about the nature and effects of the waters, so Falloppio waded in with a series of tests for waters from 17 different sources. He stressed two main themes: his trials proved that his learned opponents were not only wrong, but often liars; and making accurate tests to reveal the copper, iron, bitumen, or sulphur in a thermal water required rare skill. He used all the means he had at hand, from visual inspection and taste tests to repeated distillations and color tests.

Falloppio was also a famous anatomist, and his successor at Padua, Girolamo Fabrizi, crafted a more philosophical anatomy based on Aristotle's approach to the history, parts, and generation of animals. Like Aristotle, Fabrizi dissected eggs at intervals to observe the unfolding development of the embryo. In a 1600 work, he reports that he "made a trial" of the transparency of the eye by removing the ocular tunic and then peering through the eye at a candle flame. His famous 1603 discovery of "little doors" or valves in the veins also depended on experimental trials. Fabrizi reports that he was "led into the notice of such a thing" by observing that blood in the veins meets resistance when it is pushed away from the heart, toward the limbs. He had "made a trial" of the matter, and everyone could "make trials" as well.

Fabrizi concluded that the "little doors" served to slow the flow of blood into moving limbs. But his most famous student made his own trials, and argued that these doors remained totally locked to blood flowing away from the heart. Instead, this anatomist argued, the blood in the veins had to return to the heart. The trials of Fabrizi no doubt helped to point his student William Harvey toward the circulation of the blood.

Scholars have established that the experimental work of two physicians in the first half of the 1600s was a driving force and inspiration for experimental activity across Europe later in the century. William Harvey's experimental demonstrations and arguments for the circulation of the blood drove even his harshest critics to take up the experimenter's role. And his methods and doctrine inspired experimentalists from Robert Boyle and his friends in Oxford and London to the vibrant circle around Franciscus Sylvius in Leiden. Jan Baptista Van Helmont published his magnum opus two decades later than Harvey, but his work also provided crucial models for careful experimentation in chemistry.

His emphasis on the importance of mass balance and the isolation of causal relationships in an experiment certainly continued in Boyle's work, and may be detectable across the 1700s. With our new understanding of earlier physicians' language and practices of "making trials," we can begin to consider that the revolutionary, experimentalist medical systems of Harvey and Van Helmont are better seen as the harvest of the previous century.

With four to five hundred students a year matriculating in medicine at the University of Padua alone, we now have compelling reasons to think that early modern academic medicine became a leading tradition for the development and dissemination of experimentation across Europe. Renaissance medicine's lecture halls, anatomy theaters, laboratories, and private studies were key sites in the gradual emergence of experimental science.

Dr. Evan Ragland is an assistant professor of history. He received his Ph.D. from Indiana University. His areas of research specialties include the history of science, the history of medicine, early modern Europe, and the history and philosophy of experimentation. (Dr. Ragland left UAH to accept an academic appointment at the University of Notre Dame.)

The world as a visual puzzle

By Ramazan S. Aygün
Associate Professor of Computer Science

Solving a jigsaw puzzle, putting it in a nice frame, and then mounting it on a wall is priceless for a puzzle hobbyist.

The time may pass by quickly as textures, colors, or shapes of puzzle pieces are matched to build this art.

In a similar way, it may also be possible to visualize our world or even the universe as a big visual puzzle. Whenever a picture is captured by our favorite camera, camcorder, smartphone, or tablet, a piece of the visual puzzle is captured. Cameras can be considered a window of the digital world to visualize our world. At an instant, only one small view of the world can be captured. To capture more, a person usually moves the camera around, zooms in to get details, or zooms out to get the bigger picture. As the camera moves while recording, other pieces of the world are captured. This visual puzzle of the world can be solved by matching all these countless pieces captured by a camera.

Today some special cameras have a panoramic view option that allows people to capture a panoramic image of a beautiful scene by moving the camera in general around an axis. If the instructions are followed, an acceptable panoramic view can be captured. Generating the panoramic view from a video that is captured 30 frames (or images) per second by a typical camcorder is another level of this problem because the motion of the camera may not be restricted. Generating a big picture of our world by stitching together images of a video would be exciting.

Before solving this puzzle, it is important to have good information about the data to be used. Using our logical reasoning and the power of a digital environment, we should be able to solve this puzzle ourselves before developing algorithms. For example, each camera has a set of specifications including the resolution of the camera. A camcorder may capture 30 images per second depending on the video format.

For a full HD video recording, the resolution is 1920x1080 with a 16:9 aspect ratio. Each image (or frame) is considered a piece of the puzzle. Hence one issue for this visual puzzle is that all pieces (or images) are rectangular. While capturing 30 images per second is a good frame rate for video compression, it also provides significant overlap between images. So solving this puzzle requires aligning overlapping areas properly. We may assume that these images are semi-transparent to help proper alignment. When each image is aligned and put on a surface, the visual puzzle can be solved.

Alignment of pieces on top each other is the main step for solving this puzzle. Each image can be moved right, left, up, or down as a translational motion, or it can be rotated to align the overlapping areas between images. The digital world enables more operations on images such as pulling from the corners to enlarge the image or pushing corners to make it smaller, which corresponds to a scaling operation.

It is also possible to pull only a pair of corners in the horizontal or vertical direction, leading to more enhanced transformations such as affine or perspective transformations. We may assume that the frames are semi-transparent, so that when they are put on top of each other, colors from the bottom layers will also be visible. After all frames are aligned, the color value per pixel may be chosen as the color of an image pixel closer to the top or an average value per pixel location. However, the latter scenario may blur the puzzle, especially if we make small mistakes or pieces float even slightly.

Most puzzles are built on a planar surface. When the world is captured as the camera moves, it may be hard to map these images to the same plane. The cameras are equipped with vision sensors that have a planar surface. So, as the camera moves, the plane of the sensor also moves. If the planar puzzle may not be appropriate for some possible scenarios, they can also be built on other surfaces such as a cylinder or sphere. If the camera rotates around an interesting scene or an object, a spherical surface may be appropriate; if the camera rotates around its axis, a cylindrical surface may fit better.

In computer vision, mosaic generation, sprite generation, background extraction, image registration, image stitching, and video panorama generation are some of the terms used in the literature for this problem. There are a variety of applications in which these techniques can be utilized. For example, an unmanned aerial vehicle camera may scan a large area and the surface map may be built by solving these image puzzles. A spherical surface map of Earth or another planet can be built by processing images captured from an orbiting satellite. The video standard MPEG-4 Part 10 introduced the sprite concept where objects can be laid on top of a background for efficient video compression rather than frame-level compression. In surveillance videos, the motion or differences in the environment can be identified by taking the difference of a new scene from the existing scenes, if the background scene model can be built. Moreover, the first stage of human behavior detection is sometimes subtraction of the foreground moving objects from the background.

There are three stages of solving these puzzles or mosaic generation: global motion estimation, warping, and blending. Global motion estimation identifies the transformation the camera moves, warping indicates the alignment of an image using the global motion parameters, and blending is related to the choice of pixel for each position on the surface. Automatically solving these puzzles or mosaic generation is challenging. Our world is three-dimensional but a typical camera captures in a two dimensions, although new RGB-D cameras have started to appear in the market where D indicates the depth of a pixel from the camera. If the camera moves frequently, the biggest challenge is that whatever alignment has been made may not properly match the existing plane due to varying scene depth. Moreover, the presence of moving people, cars, and objects in the environment complicates the alignment process.

Because the moving entities are usually not part of the bigger scene, removing moving objects from the mosaic is required. Although there is a good amount of research work in this area, we have observed that researchers work on a small set of videos in general. In addition, an approach that worked for one video may not work for another video because the methods were specific to one video rather than others.

Therefore, we have considered categorization of videos and suggested the development of techniques for a set of videos sharing common properties. For example, one category is called tracking videos where the cameraperson tries to centralize a moving object (without the appearance of new objects at the boundaries). Our proposed sprite fusion technique can generate the background even though there is constant occlusion of the scene. We have considered a scenario in which around 80 percent of the center of the scene is covered but our system was able to produce the big image properly.

We have identified a new set of novel applications when such visual puzzles are solved: virtual camera control, aspect ratio conversion, and object mosaicking. Virtual camera control enables a user to pan, tilt, and zoom a pre-recorded video. This may provide a better selection of camera angles for the user. It is possible to centralize a moving object in a video without adding artificial boundaries or losing the resolution of the video.

When watching a movie on TV, due to aspect-ratio conversion, we may see a statement like "this video has been edited for television and formatted to fit this screen." Aspect-ratio conversion may add artificial black boundaries to left and right (pillarbox) or top and bottom (letterbox) or crop the original scene (pan-and-scan). In our method, the missing parts of a scene after aspect conversion were filled from the bigger picture of the environment without cropping or adding black boundaries. These applications require generation of the background scene and this may only be possible if the camera covers the surrounding sometime in the past or future. Object mosaicking enables the construction of a view of an object from its partial views. If the camera has a very restricted view of an environment, an object may not be captured as a whole. However, if the object moves, the view of the object can be completed from partial views of an object. This idea was used for face construction where the face of a person was partially visible at all times.

In the future, real-time and robust algorithms are needed for mosaic generation that can adapt to varying scene depths and different levels of object occlusion. This would enable the development of new applications and widespread use in commercial devices.

Dr. Ramazan S. Aygun is an associate professor in the Computer Science Department. Dr. Aygun received his Ph.D. in computer science and engineering from University at Buffalo, State University of New York. His research interests include multimedia databases, bioinformatics, P2P systems, semantic computing, multimedia networking, multimedia synchronization, and video processing.

Compressed guidelines for innovative thought

By James B. Blackmon

Research Professor of Mechanical and Aerospace Engineering

Innovation, creativity, and new ideas thrive on encouragement, not just "necessity." Some are fortunate to have an idea occur spontaneously. Seeing a problem, they come up with a creative solution that otherwise might never have popped up (hence the cliché, "necessity is the mother of…". But, such spontaneity can occur under conditions that are structured, planned, and conducted purposely to develop new ideas, when the necessity is barely realized.

Or so it seems. The following "rules" are offered as a starting point to test this hypothesis more widely than I've been able to do on my own. I encourage (Rule #5) anyone reading this to give these "rules" a chance; just don't dawdle (Rule #19). And let me know how it goes (Rule #9). Hopefully, the approach outlined below will be helpful plus, an interchange could result in an improvement (Rule #25), if only to these rules. Stories of success or failure are welcomed, and will be tracked (Rule #8). But first the rules:

Blackmon's Rules

1. Trust. Group creative thinking takes trust. Consider each idea as initially valid. A blind alley may cause a thought from someone else.
2. Be positive. Avoid rejecting ideas during the creative stage or ever.
3. Take risks. If it's worth doing, it's worth doing wrong a few times.
4. Cast a wide net. Seek ideas broadly. Avoid paranoia. You don't have to go it alone. Get more claims with co-inventors; if you don't, competitors could.
5. Encourage. Innovation lies outside their comfort zone for some. Even if they have good ideas, they may not act. But not playing guarantees you won't win. Encourage, ensure fairness, and give away credit with both hands.
6. Recognize. Recognize innovation, celebrate patents, write articles, mount plaques in high visibility areas, etc.
7. Reward. Provide innovators with bonuses, promotions, royalty shares, etc. Specifically, patents are property, with rights, so just having a patent is itself a reward.
8. Measure. Display useful metrics (disclosures, patents, licenses, royalties, products, patents per dollar invested, etc.) as trend plots. How do you stack up?
9. Share. Meet and talk in groups of three to five or so for about an hour. Avoid being judgmental. Have fun (Girl Scout Cookies and coffee). Laugh. Really.
10. Mind Map. Suspend criticism. Jump from one idea to another. Facilitator should jot down all comments; this encourages more. Avoid outlines, they come later. Second-graders learn mind mapping. So can grown-ups.
11. Try the opposite. You should literally try the exact opposite of the conventional approach.

12. Think evolution. Broaden the application. Add two ideas to get a third. Multiply ideas (e.g., single-barrel rifle to double barrel to over-and-under to Gatling, etc.).
13. Think revolution. Try disruptive ideas, even if only good for a laugh.
14. Question. Use open questions initially: What do you think? Use directive questions later: How will that reduce cost?
15. Critique. Once ideas are well-formed, begin to drill down. What are the costs, benefits, risks, improvements, processes, competition, etc? How do you define success and failure? Did you include all applications?
16. Protect. Use nondisclosure agreements. Describe/sketch and witness ideas in a bound notebook with no blank spaces. Then it's evidential. Don't just store on a computer. Consider a lower-cost provisional patent. If it's abandoned after a year, you still protect ideas so you could file a utility patent later.
17. Track. Document and circulate among others to improve claims, revisions, etc. Assign action items and track status. Stay in touch. Don't forget about it.
18. Support. Participate in the patent-filing process. Help with the patent search, you may learn a lot. Review the application. Respond to the examiner's findings thoroughly/comprehensively. You can often get claims that are initially denied.
19. Pedal to the metal. Execute quickly. It's "first to file," not first to invent. Shortened time to market really increases return on investment.
20. Form alliances. Band together to increase innovation and spread risk. Clear goals, mutual respect, trust, compatibility, communication, flexibility, consensus, scope, etc., are all important to the process. The main thing is results.
21. Buy it. Organizations acquire, merge, etc., for market share, cost reductions, economies of scale, etc., and for more innovation. Then encourage the newcomers, too.
22. Hang in there. It may pay to wait for better market entry or a better moneymaking period of a patent. But be wary, delay could hurt.
23. Learn from others' mistakes. Be aware of missteps, including

unprotected disclosures, legal bars, applications too narrow, drawings too limiting, etc.

24. Think like an achiever. Be optimistic, committed, confident. Don't self-limit. Lots of brilliant people never made it big with innovation, and vice versa. Brush off failures. Be patient. Ideas can occur in seconds after weeks of dry spells. Have a "can-do" mentality. If you've had an idea, you'll have many more.

25. Keep improving. Polish your technique as a way of life.

Now for the disclaimers. First, these are not "original." They are compiled from years (#22) of exposure to all sorts of sources (#4), plus mistakes I've made (#23). These could be simply judged as nothing more than a collection of clichés, but I hope readers will suspend critical judgment at least initially (#2), and give it a try (#3).

I've lost patents from dawdling (#19); seen others use some of my patents for ideas that I really, really should have come up with (#15) but failed to do so, mostly because I didn't "share" (#9), and thus had more restrictive patents than otherwise; etc. In other words, I can cite lots of examples of how things went wrong, or at least didn't go as well as they could have, but it helped me learn (#23…again). Also, these rules are presented in their current form … which could be made a lot better when polished (#25). But, even with these limitations, there have been some successes, and they resulted in at least offering to industry/academia, etc., alternatives to conventional approaches (#11, 12, and 13).

Second, although patents are stressed, it seems the same approach can be used more generally. It's just that I lean toward patents. Patents came about thanks in large part to Benjamin Franklin and are in the Constitution ("Congress shall have power … to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries.")

Once there was a chance to get something for their effort, innovation (Yankee ingenuity) skyrocketed. After World War II, research and development were further encouraged by federal contracts. But, exclusive licenses were not granted and the government was unsuccessful in attracting industry to license government-owned patents, because what belongs to everyone, belongs to no one. The Bayh-Dole Act of the

1980s changed that. Patents developed under federal contract funds could be held by the company, or university, or inventor. The results were an instantaneous quantum jump in the number of patents, royalties, products, companies formed, etc. Examples: Approximately 25 universities involved in technology transfer in 1980, jumped to more than 200 by 1990; from the mid-1970s to 1980s, less than 300 patents were granted annually to approximately 80 universities. But, in 1992 alone, about 140 universities received about 1,600 patents; annual licenses granted to universities jumped from about 100 per year (1974 to 1984) to about 1,500 in 1992 alone; in 1986, approximately 100 universities had $35 million in royalties/licenses. Nowadays, just the top 20 earn more than $600 million. In 2005, about 1.7 companies were spun off each day. The Economist dubbed the Bayh-Dole Act "the most inspired piece of legislation to be enacted in America over the last half century," and according to Ashely J. Stevens, the author of "In Defense of University Patent Policy," the act "contributed massively to the revitalization of the U.S. economy and the rise of the knowledge economy."

These incentives (owning a patent, copyright, acquiring royalties, etc.) are in keeping with Adam Smith's basic concepts in his "Inquiry into the Nature and Causes of the Wealth of Nations," which, in its time, was a substantial departure from conventional wisdom (#11). And it was heavily substantiated and well documented (#17), plus demonstrably true. And it shaped our free enterprise system. It was revolutionary (#13); our Founding Fathers loved it.

As a result, we continue to benefit (#25) from exceptional progress, liberty, and security, not to mention a whole bunch of material goodies, etc. Not bad for one guy, writing in turgid Ol' English. So, I urge you to think like an achiever (#24) and give it a try even it does seem a bit risky (#3). And feel free to share your experience (#9), because #1 might kick in and we might just come up with more good stuff.

Dr. James B. Blackmon is a research professor in the Department of Mechanical and Aerospace Engineering. He has more than 40 years of experience in space and terrestrial power, thermal management, and propulsion systems. He received Ph.D. in mechanical and aerospace engineering at UCLA.

UAH, R&D offers distinct advantage for region's economic development

By Ray Garner
Chief of Staff, Office of the President

For decades, most cities and states played the economic development game with straightforward rules: Set up an economic development agency, devise marketing strategies, begin looking for prospects, attend the right trade shows and send out brochures to prospects. Then when a hot prospect, say an automobile plant looks for a place to land, be prepared to hand out the juiciest package of incentives.

Some locales can do it differently. They can go beyond the basic economic development rules. Sometimes a community has something a little extra to offer. While Huntsville and Alabama have played the incentives card as skillfully as any other city and state, Huntsville's trump card for more than half a century has been the ability to carry on high-level research and development.

The end game of economic development is bringing and retaining companies and jobs, and during the past 65 years a series of government and private sector location decisions brought wave after wave of new jobs to the greater Huntsville-Madison County area. Those decisions transformed Huntsville from a small, quiet cotton mill town to a thriving town of technology. Most of it, directly or indirectly, is being fueled by a high-octane mix of educated manpower working on a wide array of technological challenges.

The genesis of Huntsville's intellectual brain trust

The Russian launch of Sputnik, the world's first satellite, prompted the first challenge. It was October 4, 1957, 10:29 p.m. Moscow time.

Suddenly, America saw itself behind in the Space Race. The nation moved quickly to catch up. Formation of the National Aeronautics and Space Administration in 1958 and its decision soon afterward to focus manned flight rocket development at the newly designated Marshall Space Flight Center put Huntsville's research and development efforts into high gear.

By 1961, a potent mixture of technological talent and the companies they worked for had assembled in Huntsville, and needed only the spark of a national goal to fire up the economic engine.

President John Kennedy provided that flash during a speech when he proposed to land a man on the moon and bring him safely back to Earth by the end of the decade.

Explosive population growth followed. By 1960, the year Marshall Space Flight Center was carved from the center of the U.S. Army's Redstone Arsenal, Huntsville's population had mushroomed to more than 72,300 from a mere 16,000 in 1950. Six years later, at the height of the Saturn rocket development program, that figure had grown to more than 143,000, more than eight times the population just 16 years earlier. And while the drawdown of the Saturn program in the '70s saw a small out-migration of technical talent, programs such as the Army's Strategic Defense Initiative, space shuttle research and development (R&D), the Hubble Space Telescope, and other programs boosted that figure to almost 160,000 by 1990.

That momentous shift from an agrarian and textile-based economy to a technology-based economy brought vast changes to the character of the city, and particularly an interest in higher education.

This influx of R&D people, most of them engineers, scientists created a climate of economic and technological development. It changed Huntsville from a small southern town to a progressive American city.

This movement of highly educated people to North Alabama not only valued education for themselves but for their children. New schools with motivated teaching staffs sprouted almost overnight, and before long local schools were seen as among the best in the state.

A local lawyer, Pat Richardson, took the lead in community efforts in the late 1940s to secure a satellite campus of the University of Alabama. Dr. Wernher von Braun, the father of America's space program and first director of NASA's Marshall Space Flight Center, seeing the need for his engineers and scientists to advance their own education as well as conduct leading-edge research, traveled to Montgomery to lobby the legislature for greater funding of graduate academic programs and research capabilities at UAH.

Huntsville's reputation grew as a center of "brainpower" with plenty of high rankings in enviable categories. Among these rankings: the highest concentration of engineers of any U.S. metropolitan area, and the highest number of non-medical Ph.D.s of any city in the Southeast. In 2009, Forbes called Huntsville as one of the Top 10 Smartest Cities in the World.

Now, 65 years later, Huntsville has achieved worldwide recognition for its research and development competence. Thousands of acres of land used for cotton and raising cattle now house offices and laboratories at Redstone Arsenal, Marshall Space Flight Center, Cummings Research Park, and The University of Alabama in Huntsville.

Research universities and workforce development

UAH does more than just turn out highly intelligent and motivated graduates. From its modest beginnings in the early 1950s, the institution grew to become a nationally renowned research university. Five research disciplines — aeronautical and astronautical engineering, computer science, business and management, atmospheric research and astronomy— rank among the Top 20 in the U.S. in federal research expenditures, according to data released by the National Science Foundation in 2014. Aeronautical and astronautical engineering research, perhaps the most crucial discipline in the greater Huntsville area economy, UAH ranks fifth nationally.

Thousands of UAH graduates have found employment with leading area government contractors and technology companies such as Boeing, Lockheed Northrop Grumman, and SAIC as well as with most of the federal agencies at Redstone. Many UAH graduates have gone on to create local, vibrant business organizations. That list includes founders, such as Jim Hudson of the HudsonAlpha Institute for Biotechnology, Dr. Marc Bendickson, chairman of the board and former CEO of Dynetics, Aegis Research, Bill Waites and Steven Hill, and Gurmej Sandhu at Sigmatech.

Almost since its founding, UAH has steadily evolved into a research partnership with the Army and NASA managing nearly almost $100 million annually in funded research contracts. Much of this happens at Redstone Arsenal where approximately 400 UAH employees support Redstone's mission activities. A large contingent of UAH students works at the U.S. Army's Aviation and Missile Research and Development Center, one of the Army's primary research labs, to solve a host of critical military and security challenges.

Those students get great hands-on lessons and the experience that prepares them to make immediate contributions to the local workforce, and many are hired as government employees upon graduation.

Research and job creation

UAH looks to take economic development to an even higher level. While graduates of the university earn accolades and generate patents, the aim of these efforts has been the solution of technical and research problems and not economic development.

This has led to UAH's plans to construct an "Innovation to Invention Center" on the campus to facilitate commercialization of such intellectual capital. A growing UAH entrepreneurial spirit is evolving as an engine of new job growth and wealth creation. The university's reputation and designation as a Carnegie Foundation High Research University attracts professors who not only want to solve technical problems, but profit from their inventions and innovations. To support those efforts, UAH established the Office of Technology Commercialization in 2007 to help research professors at the university's laboratories commercialize the intellectual property from their research.

The OTC is an important part of the effort to recruit and retain valuable faculty. The idea is that this environment will be able to stimulate the more entrepreneurial of our faculty.

Under the direction of Kannan Grant, the office can point to several startups. AdhereTech began after Dr. Emil Jovanov, UAH Professor of Electrical and Computer Engineering, decided his "smart" pill bottle is a better product that could help millions. The patented pill bottle reminds patients to take their medications and gives them a warning if they fail to do so. It also notifies doctors when patients begin slacking off from their prescription schedules. The idea was considered so novel – and so practical - that it won Jovanov the 2014 Inventor of the Year award from Alabama Launchpad, a program of the Economic Development Partnership of Alabama that helps recognizes statewide, research-based entrepreneurship.

Another company, iXpressGenes, sprang from the work of UAH biology professor Dr. Joseph Ng, whose research into enzymes extracted from deep sea, thermophilic organisms showed that these enzymes could be commercially viable.

One of the principal tenants at the HudsonAlpha Institute for Biotechnology, iXpressGenes has exclusive access to a suite of hyperthermophilic genomes from the deep sea vents of the Atlantic Ridge.

Yet another example is chemical engineering professor Krishnan Chittur. He has created GeneCapture. The company is developing a portable medical device to detect and identify any known pathogen in less than one hour, a vast improvement over the two or three days it may take today.

GeneCapture's technology is based on a patented DNA hybridization process. Each step of the GeneCapture process has been successfully demonstrated in the lab and an integrated prototype system is now in place.

Emerging trend: Companies co-locating R&D with manufacturing

Today, what may appear to become an emerging trend for corporations is tying their R&D capabilities to their manufacturing operations. This appears true with recent economic development announcements in Huntsville.

Polaris announced in early 2015 that it would build a vehicle manufacturing plant on a 505-acre site in Huntsville-annexed Limestone County. But the company's campus also has land dedicated to build a research and development center. In Polaris' announcement, Executive Vice President Ken Pucel remarked that Polaris is an engineering company. His remarks were echoed in the company's announcement, which said the area's highly educated workforce was a big draw for Polaris to locate in North Alabama.

Similarly, Remington Outdoor Company filed paperwork with the U.S. Securities and Exchange Commission that it acquired its facility in Huntsville to not only increase its manufacturing capacity but to expand its R&D capabilities.

Even more recently, GE Aviation has announced plans to invest more than $200 million to build two factories in the greater Huntsville area. The products manufactured in the plant will use some of the most advanced technologies in the world. One plant will produce silicon carbide (SiC) ceramic fiber, the first such operation in the United States. The only other plant in the world that produces SiC is in Japan. The adjacent GE factory in Huntsville will then use the SiC ceramic fiber to produce unidirectional ceramic matrix composites tape that is necessary to fabricate CMC components.

One important aspect of the recruitment of GE Aviation to Alabama included the capabilities and research of composite materials being conducted by UAH. Composites research has become an important area of interest at UAH, primarily because of the growing importance in aerospace, automotive, and civil structures for government and industrial customers.

R&D as an economic development strategy

No doubt, Huntsville's economic fortunes took off as the result of government R&D decisions. But could a strategy that uses R&D as an engine of growth succeed? UAH officials think it can.

One example is Boeing's decision to locate its Research and Technology Center on the north side of Redstone Arsenal. Eventually, that move is expected to bring more than 400 research and development jobs with it. Those people create wealth and the type of spinoff knowledge that creates more research and more economic growth.

UAH officials are firm believers in attracting and graduating people who will develop R&D-based companies that exist to solve problems and create jobs in the process.

The production and deployment of knowledge and innovation that supports economic growth is one of the reasons that universities figure prominently in any discussion of successful economic development and growth.

While research universities have long served as a source of technological advances for corporations, university–industry collaboration is intensifying as a result of four factors: 1) the development of new, high-opportunity technology platforms, particularly material science, computer science, and molecular biology; 2) the more general growing scientific and technical content of all types of industrial production; 3) the need for new sources of academic research funding created by budgetary stringency; 4) and the prominence of government policies aimed at raising the economic returns of publicly funded research by stimulating university technology transfer.

Of course, financial incentives still matter, but ongoing R&D ensures that companies continually innovate as they face increasingly competitive global markets. It's an edge that has and will continue to work in Huntsville and Madison County's economic development future.

Ray Garner is chief of staff in the Office of President at The University of Alabama in Huntsville. He also served in the Alabama House of Representatives with a seat on the Education Ways and Means Committee. Prior to joining the university, he was business editor at The Huntsville Times and was a contributing writer to Business Week, Forbes and the Wall Street Journal.

ACKNOWLEDGMENTS

This book project would be not possible nor complete without the cooperation from the participating faculty members at The University of Alabama in Huntsville. Their research and scholarship is very much a key part to the success of this university and their contributions to this publication are noteworthy and appreciated.

Members of the UAH staff who made significant contributions to this work include graphic designer Susan Altman, who was responsible for the layout of the book and the compelling cover design. Diana LaChance also provided her expertise by proofreading this material to ensure consistency of grammar and style among the various authors, and Stephanie Roach for bringing a consistency to the images of the authors.