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## The AFIT ENgineer, Volume 5, Issue 3

Graduate School of Engineering and Management, Air Force Institute of Technology

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# AFIT ENGINEER

## Shaping the Future of Cybersecurity

### Education and Research Empowering Tomorrow's Cyber Experts

**By Lt. Col. Wayne Henry, PhD, USAF**  
**Assistant Professor of Electrical Engineering**  
**Interim Director, Center for Cyberspace Research**  
**Air Force Institute of Technology**

The Air Force Institute of Technology has one of the leading cybersecurity programs in the nation supported by the Center for Cyberspace Research (CCR). The Center's award-winning faculty, world-class facilities, and rigorous curriculum prepare students for successful cybersecurity careers in the Air Force, Space Force, and the Department of Defense (DoD). AFIT is well-positioned to continue its leadership in the field of cybersecurity.

#### Award-winning Faculty

CCR is home to some of the most respected, award-winning faculty in the field of cybersecurity. In the past year, several faculty members were recognized for their outstanding work, including Dr. Mark Reith, Assistant Professor of Computer Science, who was named Department of the Air Force (DAF) STEM Outreach Champion and the Air Force Association Colonel Charles Stone Award winner. Maj. Richard Dill, Assistant Professor of Computer Engineering, was honored with the DAF Outstanding Scientist and Engineer Award for senior military. Dr. Scott Graham, Professor of Computer Engineering, was recognized with the DAF Outstanding Scientist and Engineer Award in the mid-career civilian category and Dr. Scott Nykl, Associate Professor of Computer Science, was recognized with the DAF Outstanding Scientist and Engineer Award in the junior civilian category. Lt. Col. Wayne "Chris" Henry,

Assistant Professor of Electrical Engineering, was named Air University Field Grade Officer of the Year. This is a significant amount of high-level recognition for the faculty, and it is a testament to their dedication to excellence in cybersecurity education and research.

#### Top Tier Students

Over the last three years, the CCR has educated over 100 master's degree students in Cyber Systems, Cyber Operations, Computer Science, and Computer Engineering programs. These talented students and faculty were responsible for advancing science and technology through numerous patents, over 50 published journal articles, 64 peer-reviewed conference papers, and 15 books/book chapters. These students have also excelled by participating in a cyber capture the flag team, bringing home numerous first-place honors and keeping AFIT on the map for cyber education.

#### Cyber Equipment and Facilities

The CCR owns and maintains the Cyber Defense Network (CDN), a unique environment designed to support cyber-related research applicable to the interests of the DoD and other federal agencies. The CDN is specifically designed to allow research in advanced cyber topics, such as hardware/software vulnerability assessment, exploit development, malware analysis, machine learning, and cyber-physical systems. The CDN includes over 100 servers, 690 virtual machines, as well as 300 desktops/laptops. The CDN gives students access to 280TB of network storage, 5TB of memory,



U.S. Air Force photo by Jaima Fogg

**Graduate students attend the Introduction to Cyber Warfare and Security course at AFIT.**

and various lab equipment and testbeds. The CDN provides an isolated sandbox for over 1000 faculty, staff, and students that gives them freedom to conduct cutting-edge cyber research and education, even if it involves the use of dangerous code that would be forbidden on other networks. The CDN is a valuable resource for the CCR and its partners, providing a safe and secure environment for cybersecurity research, collaboration, and education.

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[www.AFIT.edu/EN/afitengineer](http://www.AFIT.edu/EN/afitengineer)



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# Moving AFIT's Education Mission Forward

This issue of the *AFIT Engineer* marks the completion of the first three quarters of the 2023 calendar year. As we enter the fourth and last quarter of 2023, I am delighted to welcome you, once again, to this highly-acclaimed newsletter, which is now in its fifth year of linking our academic enterprise to our internal and external stakeholders. As I write this piece, I am attending a special event at the University of Maryland, College Park, where I am an invited speaker on two related academic topics:

- Artificial Intelligence, Digitalization, and other emerging technologies in the future of infrastructure
- What changes in the curriculum do we need to address?

Both talks are convened under the umbrella of a UMD roundtable event entitled, "The Bipartisan Infrastructure Law and Its Implications: A Roundtable of Heads of Civil and Environmental Engineering and Federal, State, and the Private Sector."

The theme and topics confirm that civilian institutions face the same challenges that we face in our curriculum design, development, and delivery options. As I prepared for my talks in the days leading to the October 3rd event, I could not help thinking about the hullabaloo playing out in the US Congress regarding the possibility of a government shutdown. Thankfully, a shutdown was averted and I could proceed on my official travel to present my two talks. First, the bipartisan theme of the event is a far cry from what played out in Congress. Second, the event's collaborative platform of Federal, State, and the Private Sector demonstrates how we must all work together within the spectrum of national and local governance. Although a government shutdown did not happen (this time), the furious administrative preparation for a shutdown seriously disrupted and impeded our academic business. Although we got back into our normal education



mission, the threat of future incursions exists. The moral of choosing to write about this topic in this newsletter is to sensitize the AFIT community and stakeholders to the fact that we are not immune to what happens in government debates and we must pay attention through advocacy and participatory avenues. From our usual team perspective, we must strive to continue to move AFIT's mission of education forward. We welcome readers' teamwork participation in this effort. I invite you to enjoy this newsletter issue and look forward to future issues of the *AFIT Engineer*.

With technology, process, and people, we move the mission forward.

**Adedeji B. Badiru, Ph.D., PE**  
Dean, Graduate School of Engineering and Management



# AFIT Welcomes New Graduate School Associate Dean

Col. Shawn Willis returned to the Air Force Institute of Technology's Graduate School of Engineering Management as the Associate Dean in July 2023. His return is 20 years in the making having earned his master's degree from AFIT in 2003.

As the Associate Dean, Willis is responsible for the day-to-day operations of the Graduate School encompassing six academic departments and seven research centers. He leads a team of more than 280 military and civilian faculty teaching 57 graduate degree and certificate programs.

Willis brings experience as an instructor and researcher to the leadership position. He served as a research physicist in the Air Force Research Laboratory, an assistant professor of physics and deputy department head at the U.S. Air Force Academy, a space vehicles division chief and legislative liaison at the National Reconnaissance Office and deputy chief of the Enabling Capabilities Science Division at the Defense Threat Reduction Agency. He plans to integrate his experience as a

student and faculty leader to remove roadblocks to accomplishing the mission and enhancing AFIT's reputation.

"I want people to look at AFIT and see a high caliber degree granting university that is also a great place to come and work," said Willis. "Additionally, I would like to promote a culture of a Graduate School that is united and works together and with the other Schools at AFIT." Willis looks forward to making a positive impact on teamwork at the Graduate School during his time here.

"I like to have a team with a good sense of belonging," said Willis. "We are all on the same team and want to make AFIT better. That is the environment that I want to foster."



**Col. Shawn Willis, Graduate School of Engineering and Management Associate Dean.**

**LEARN MORE ONLINE**  
Read the complete story online at: <https://e.AFIT.edu/tyrq7>

# AFIT Faculty Research Featured on Journal Publication Covers

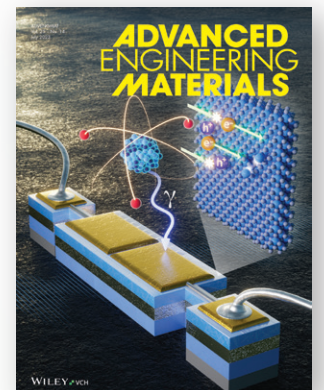
*Advanced Materials Interfaces* journal recently featured AFIT faculty research on the cover of its publication (Vol. 10, Issue 9). The publication cover art shown below illustrates aluminum nitride transduced microelectromechanical resonators, as described by **Lt. Col. David D. Lynes** and **Dr. Hengky Chandralim**, Associate Professor of Electrical Engineering, in the article *Influence of a Tailored Oxide Interface on the Quality Factor of Microelectromechanical Resonators*.

By including a tailored oxide thin film in the resonator's body, the quality factor is increased by up to 400% for devices operating at very high frequency and super high frequency bands. The quality factor enhancement persists at operating temperatures as low as -200 °C up to +200 °C. Read the full article at the link below:



AFIT faculty members recently published their research in the *Advanced Engineering Materials* journal (Vol. 25, Issue 14). The article *Effects of Gamma Ray Radiation on the Performance of Microelectromechanical Resonators* is featured on the cover of the July issue (shown to the right).

This illustration portrays the effect of Co-60 gamma ray radiation on piezoelectric microelectromechanical resonators. Compton scattering initially occurs, resulting in electron ionization and the scattering of a lower-energy X-ray photon. The resultant electrons and photons interact within the material, instigating a cascade that produces hundreds to thousands of electron-hole pairs. Read the full article by **Lt. Col. David D. Lynes**, **Dr. Hengky Chandralim**, Associate Professor of Electrical Engineering, **Maj. James E. Bevins**, and **Dr. James C. Petrosky** at the link below:



<https://onlinelibrary.wiley.com/doi/10.1002/admi.202202446>

<https://onlinelibrary.wiley.com/doi/abs/10.1002/adem.202201837>

TEACHING WHAT WE RESEARCH. RESEARCHING WHAT WE TEACH.



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# AFIT ENGINEER

The Source for Air Force Institute of Technology Graduate School News

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# 2023-2024 ACADEMIC YEAR

Welcome to the Air Force Institute of Technology

## New Student Orientation

The Graduate School of Engineering and Management proudly welcomed 206 graduate students to AFIT during the annual New Student Orientation held on August 30. The AFIT Foundation greeted new students with gift bags, and then students attended in-processing briefings to get acquainted with AFIT and their respective academic departments.

**206**  
GRADUATE STUDENTS\*

\*Number of registered new students as of 9/12/2023



Contributed photos

## AFIT Annual Burger Burn

On August 31, the AFIT Student Association hosted its annual Burger Burn Celebration welcoming new students to AFIT. New students and their families were joined by Graduate School faculty, staff, and current AFIT students at the Fairborn Community Park. Attendees enjoyed food, drinks, live music, and games. The annual event gives new students the chance to meet faculty and student peers before the academic year begins.



**22,000+** DEGREES AWARDED  
SINCE 1956

## New Faculty Orientation September Kick Off



Contributed photo

New military faculty members attended the course design workshop on the AFIT campus, while new civilian faculty attended online prior to the start of the academic year on Oct 2. The workshop was led by Dr. Brett Borghetti, Professor of Computer Science.

The second full week of September kicked off the Air Force Institute of Technology's New Faculty Orientation for the Graduate School of Engineering and Management. Prior to the start of each new academic year, the Graduate School conducts the orientation and course design workshop to assist new faculty in acclimating to their roles of teaching, advising, and mentoring AFIT's students.

Dr. Alice Grimes, Director of the Center for Innovation in Education, along with Graduate School leadership and faculty, welcomed 21 new faculty members to AFIT during a five-day hybrid (in-person and online) orientation. The new faculty group consisted of a mix of both military and civilian faculty members who will join current Graduate School faculty members working across six academic departments.

The orientation consisted of a comprehensive review of critical information such as education technology support and services, the computer help desk, library services, student records, AFIT research programs, faculty council, lab safety, and more. New faculty also participated in a course design workshop led by Dr. Brett Borghetti, Professor of Computer Science, designed to assist faculty with creating and managing the courses they will instruct.

The AFIT Graduate School 2023-2024 academic year begins on Oct. 2.

## PROGRAMS OF STUDY

**184** Master's Degree



**12** Doctoral Degree

**10** Certificate

## 7 STUDENT CATEGORIES

- US Air Force
- US Space Force
- Army
- Army National Guard
- Navy
- DoD Civilians
- DoD Contractors



U.S. Air Force photos by Katie Scott



## AFIT Nuclear Engineering Students Organize Events for AFIT Alpha Chapter

The American Nuclear Society (ANS) has enjoyed a long history at The Air Force Institute of Technology. Did you know AFIT's Alpha Chapter was first registered as a local student section in 1956? In the nearly 70 years since its founding, Alpha Chapter has organized numerous nuclear-focused social and educational activities for the AFIT community, offering both students and faculty networking and learning opportunities.



In 2023 the Alpha Chapter continues to be active as it embarks on a new, post-COVID revival. Under the leadership of nuclear engineering students 2d Lt. Lucas Heaton, 2d Lt. Brayden Buckley, and Mr. Christopher Smith, the chapter strives to host one event per month. Most recently, Alpha Chapter has hosted three nuclear science and technology-related events, garnering participation from approximately 70 students and faculty members. A summary of each event is included below.

In one of the first Alpha Chapter events since COVID-19 suspended activities on campus, student chapter president, 2d Lt. Heaton, and his team organized a summer BBQ and cornhole tournament. Approximately 30 students and faculty members attended the June event and competed for gift cards and the chance to be crowned AFIT's best cornholers. In the end, it was recent Texas A&M graduates, Second Lieutenants Colin Foley and Dawson Friesenhahn, who would emerge victorious and claim the title. The event served as an opportunity for new chapter members to get acquainted and marked a successful start to Alpha Chapter activities.

In July, Alpha Chapter organized a group outing to see Christopher Nolan's Oppenheimer movie, which saw participation from students in three separate AFIT academic departments, as well as additional family members. Overall the film was well received; however, some

chapter members were disappointed it didn't focus sufficiently on the relevant physics involved.

In August, the chapter attended a one-hour tour of the Ohio State University Research Reactor (OSURR) in Columbus. The tour was presented by the Nuclear Reactor Lab and chapter participants enjoyed the educational opportunity. Tour topics included reactor history, general reactor operation and safety measures, and the fundamental physics behind nuclear power.

Alpha Chapter events are planned with three goals in mind: to promote nuclear science education, to discover and discuss the latest developments in nuclear science and engineering, and to encourage peer networking at AFIT. Participation is encouraged across the Graduate School, regardless of nuclear background or expertise.

Future events in the works include nuclear facility tours, another BBQ before winter weather arrives, trivia nights, and a fall viewing of Chernobyl. AFIT students and faculty who are interested in our upcoming events are encouraged to watch AFIT email and campus monitors for upcoming event announcements and details.

The American Nuclear Society is a national professional organization which aims to advocate for and advance the application of nuclear science and technology for society's benefit. Its membership includes all levels of nuclear participants, from dozens of the United States' leading nuclear scientists, engineers, and educators to "amateur" nuclear aficionados and followers. Alpha Chapter is one of over 50 student sections across the country.

➤ **Contact 2d Lt. Lucas Heaton at [lucas.heaton@afit.edu](mailto:lucas.heaton@afit.edu) with any inquiries.**



Contributed photo

**Dr. Adedeji Badiru, Graduate School of Engineering and Management Dean, recognized Dr. Richard Martin for providing outstanding support to ongoing AFRL research.**

## Dr. Richard Martin Recognized for Support to AFRL Research

Dr. Richard Martin, an AFIT professor within the Department of Electrical and Computer Engineering, was recently recognized for his outstanding support to the Air Force Research Laboratory Munitions Directorate's Seekers Branch, EO/IR Seeker Section.

For the past seven years, Martin has been a tremendous contributor and valued collaborator to AFRL's research into temporally multiplexed spectropolarimetric LiDAR. His central technical contribution was the application of machine learning to the spectropolarimetric database for quantifying probability of correct classification and optimal feature sets.

Martin also led in the development of system performance models and applied those models, along with statistical signal processing, to quantify system level classification performance and requirements. Additionally, he provided general consultation on signal processing and helped mentor Northwest Florida students in machine learning.

Martin's influence and collaboration with AFRL's research team has resulted in three journal articles (and two forthcoming), nine conference presentations, and one patent.

## AFIT Hosts Introduction to Hypersonic Short Course

The Air Force Institute of Technology, in partnership with the High Speed Systems Division of the Air Force Research Laboratory's Aerospace Systems Directorate, hosted a short course on selected hypersonic disciplines and fundamentals on 20-22 June 2023. The course focused on aerodynamics, propulsion, materials and structures, and stability and control, with the overarching theme of experimentation and testing and multidisciplinary analysis and design.

"We developed a series of tutorials to give a basic overview as a way to bring incoming researchers and engineers into the hypersonics world as quickly as possible," said Dr. José Camberos, AFIT associate professor of aerospace engineering.

Air Force employees, interns and contractors who were not familiar with hypersonic principles were the primary audience. Over 200 participants attended the course from AFRL, Air Force Life Cycle Management Center, National Air and Space Intelligence Center, and other organizations across the DoD, academia and industry.

"As an aircraft performance technical expert, I was QUITE impressed with the material that was covered," said Barry James, an attendee from the Air Force Life Cycle Management Center's Flight Technology Branch. "My knowledge of this subject was exactly ZERO and now I have a pretty robust understanding of it and the limitations thanks to your choices of material. It was all very informative and gave a solid foundation for the hypersonics flight regime challenges."

During the three days, 25 subject matter experts from AFIT and AFRL covered topics on basic hypersonic aerodynamics, propulsion, stability and control, power and thermal management, vehicle design and analysis, and flight research and experimentation applications. Attendees also had the opportunity for a guided tour of AFRL's hypersonic test facilities by Dr. Mike Brown, principle scientist for AFRL's High Speed Systems Division, Aerospace Systems Directorate.

**"We're hoping to make connections, build partnerships, encourage collaboration and communication across the spectrum – it's true workforce development and research collaboration."**

**DR. JOSÉ CAMBEROS**  
PROFESSOR OF AEROSPACE ENGINEERING

"The unique part of this short course is the subject matter experts have been working in hypersonics or the sub-specialty their entire career; it isn't one teacher giving lectures all day," said Dr. Ramana Grandhi, AFIT professor of aerospace engineering.

Lunch-and-Learn presentations highlighting hypersonic related programs were included in the agenda. Dr. Russ Cummings introduced the Hypersonic Vehicle Simulation Institute at the Air Force Academy and Dr. Bernd Chudoba from the University of Texas at Arlington discussed the need and vision for a future programs office for hypersonics.

"The practical insights shared by presenters were as important as the technical content," said Dr. Jack Lesko, director of engineering research at Northeastern University's Roux Institute.

Attending the course also enabled the students to network with subject matter experts to build partnerships, highlight AFRL expertise and learn about educational opportunities available at AFIT.

The course concluded with a visit to the National Museum of the U.S. Air Force where students learned about legacy vehicles and technology like the X-plane collection developed to advance the study of aerodynamics and propulsion.

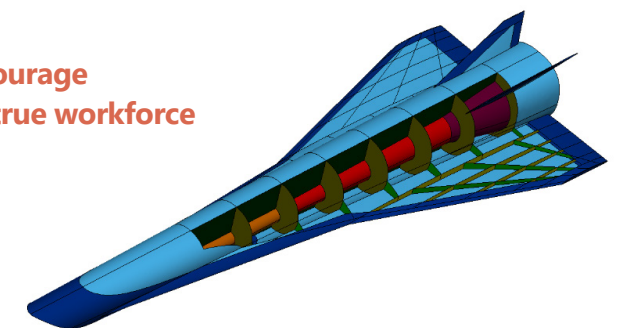
"Some of the subject matter experts are retired, but they are willing to help transfer their knowledge," said Grandhi. "Two of them in particular, Bob Mercier and John Schell, gave tours of the X-plane and Blackbird SR-71 to share their success stories and challenges as they worked on those programs."

"Because we invite and prioritize participation from summer visitors, interns and students, the course also serves as inspiration for the next generation of incoming researchers," said Camberos.

## QUICK TAKEAWAYS

- ▶ This is the second year AFIT has partnered with the High Speed Systems Division of the Air Force Research Laboratory's Aerospace Systems Directorate to host the hypersonics short course.
- ▶ Over 200 participants attended the course from AFRL, Air Force Life Cycle Management Center, National Air and Space Intelligence Center, and other organizations across the DoD, academia and industry.
- ▶ During the three days, 25 subject matter experts from AFIT and AFRL covered topics on basic hypersonic aerodynamics, propulsion, stability and control, power and thermal management, vehicle design and analysis, and flight research and experimentation applications.
- ▶ For more information on AFIT's research and education opportunities in the hypersonic field, visit the website at [www.AFIT.edu/hypersonics](http://www.AFIT.edu/hypersonics).

The course originated with the High Speed Systems Division in 2016, led by Camberos in his former role at AFRL. This is the second year AFIT has hosted the short course and plans for next year's offering are underway.





## Joint Research Effort Results in Patent Award

A successful collaborative research effort in the Department of Systems Engineering and Management at the Air Force Institute of Technology has resulted in an innovative patent that will not only reduce costs for the Department of Air Force, but will also help protect the health of Air and Space Force personnel.

Dr. Jeremy Slagley, AFIT Associate Professor, Col. Robert Eninger, Assistant Professor (2015-2019), and Capt. Stephanie Ohms, AFIT MS Industrial Hygiene (2020), were awarded a patent for their invention of a “Filter-based Air Sampler Capable of Integration into Small Unmanned Aerial Vehicles.”

The patented device is a small 3-D printed aerosol sampler which has been fitted onto an inexpensive low-power computer fan. The lightweight device was designed to be mounted onto a small unmanned aerial system (UAS). It can be integrated into the UAS power supply, or run independently via a small battery. This device will provide the ability to collect an air sample of potentially harmful aerosols safely from a distance.

“During potential chemical, biological, radiological, or nuclear (CBRN) event responses, the Department of the Air Force sends service members, suited in protective clothing, into a suspected contaminated zone to collect samples and characterize potential health risks. This presents a health risk to the men and women who are asked to do the job. A small, low cost, disposable sampler that could be flown into the contaminated area would prevent that risk,” said Slagley.

The idea for this patented device developed during a search for possible standoff aerosol sampling capabilities. Col. Eninger began researching drone-based air sampling when he was at a Fellowship with Argonne National Labs. At the end of his Fellowship in 2015, Eninger arrived at AFIT as an Assistant Professor to direct the Graduate Industrial Hygiene program. In 2018, when Capt. Ohms arrived at AFIT to begin her MS in Industrial Hygiene, the pair teamed up to pursue more research. Ohms took the unmanned aerial systems (UAS) sequence of courses at AFIT, and began to set requirements for a system in size, weight, power, and performance. Then she designed the sampler, had it 3-D printed at AFIT, and tested it inside a large aerosol test chamber that AFIT has hosted at UES, Inc. The success of the test led the team to apply for a patent. Slagley and fellow faculty member Lt. Col. Casey Cooper followed up Ohms’ test by guiding three additional AFIT students who tested the device on biological aerosols. The patent was eventually awarded on April 4, 2023.

Slagley explains that various organizations have begun using drones for sampling the environment. The Defense Threat Reduction Agency (DTRA) has also investigated drones for CBRN sampling. However, AFIT’s patented sampler is small, lightweight, low-cost (only about \$10 each), 3-D printable in the field, and can be disposed of after sampling.

“It worked on biological aerosols comparatively well to the gold standard biological aerosol samplers. I think it could easily be integrated onto any drone platform, including UAS or the ground-based robots, for sampling in contaminated areas,” Slagley said.



Contributed photo

From left: Dr. Jeremy Slagley, Col. Robert Eninger, Capt. Stephanie Ohms, and Dr. Adedeji Badiru from the AFIT Department of Systems Engineering and Management celebrate the recent patent award for student and faculty research.



### Filter-based Air Sampler Capable of Integration into Small Unmanned Aerial Vehicles

**PATENT #** 11,619,570

**DATE:** April 4, 2023

**INVENTORS:** Col. Robert Eninger, Capt. Stephanie Ohms, Dr. Jeremy Slagley

**ABSTRACT:** A filter-based air sampler, more specifically a filter-based air sampler capable of integration into small unmanned aerial systems is disclosed. The filter-based air sampler may include a filter assembly which has as its component parts: an open faced air intake component, a filter, and a filter support that has a central supporting grid. The filter assembly may be joined to the housing of a fan, such as a centrifugal fan, with the supporting grid of the filter support being disposed over the air inlet of the fan.

**LINK:** <https://image-ppubs.uspto.gov/dirsearch-public/print/downloadPdf/11619570>

## AFIT Makes Impact on DAF Digital Transformation

AFIT faculty and alumni are making an impact on the digital transformation efforts across the Air and Space Forces. The Department of the Air Force (DAF) Digital Transformation Office named seven faculty and alumni members as “DAF Digital Agents of Change” on their LinkedIn web page.

Current AFIT faculty members to be named are **Dr. John Colombi** (PhD Electrical Engineering, 1996 and M.S. Electrical Engineering, 1992, DG), **Lt. Col. Amy Cox**, PhD (M.S. Space Operations, 1999), and **Mr. Richard Sugarman**.

As an expert in electrical and computer engineering, Dr. Colombi is advancing AFIT’s mission to deliver leading-edge education in digital transformation, equipping students

with the skills to enhance mission readiness and success. He works closely with faculty and staff to develop a curriculum that equips students with the knowledge and skills to incorporate digital thinking, tools, and techniques into daily weapon system materiel management activities.

Lt. Col. Cox’s expertise in developing and delivering graduate and continuing education is making a meaningful impact on the DAF’s digital transformation. Thanks to her extensive knowledge and bias for action, she’s helping to ensure the workforce is equipped with the necessary tools and techniques to incorporate digital strategies into daily management activities. The result? A new wave of advanced thinkers who are poised to achieve their goals and maintain the DAF’s dominance.

AFIT alumni **Capt. Connor Crandall** (M.S. Systems Engineering, 2020), **Kevin Hadsall** (M.S. Aeronautical Engineering, 2012, DG), **Capt. Tyler Goodman** (M.S. Systems Engineering, 2016), and **Ms. Felicia Reinhart** (M.S. Computer Engineering, 2005) were also named.



Learn more about the DAF Digital Transformation Office online: <https://dafdto.com/>

View the DAF Digital Agents of Change on AFIT’s LinkedIn page: <https://e.AFIT.edu/8qrFFFWhh>

## International Student Receives Silver Commendation Medal

Royal Australian Air Force Flight Lieutenant Nat Thomason was awarded the Silver Commendation Medal by Wing Commander Chris Meddins on behalf of Air Vice-Marshal Stephen Meredith during an All Call at the Air Force Institute of Technology on 18 May.

Thomason is an electrical engineering master’s student at AFIT’s Graduate School of Engineering and Management studying RADAR sequence.

The medal was awarded in honor of Thomason’s achievements as a system engineer for Project AIR6500 Phase 1 Tranche 2 Competitive Evaluation Process Stage 2. AIR6500 is a Joint Air Battle Management System designed to synchronize air and missile defense operations, improve situational awareness and enhance the speed of decision making within the Royal Australian Air Force.

Thomason was extremely happy to be recognized for the award.

“My team and I did our very best to produce a document which will enable the acquisition of a fit for purpose integrated air and defense system for the Australian Air Force,” said Thomason.

The medal commendation states that Thomason’s efforts in the delivery of a high quality, logical and well-structured function and performance specification cannot be understated. Noting the challenges presented due to the unique first of type and agile delivery methodology which defense has not previously encountered in an acquisition categorization 1 project activity before. His achievements are of the highest order and in keeping with the finest traditions of the Capability Acquisition and Sustainment Group, the Royal Australian Air Force and the Department of Defense.



U.S. Air Force photo by R.J. Oriez

Royal Australian Air Force Flight Lieutenant Nat Thomason was awarded the Silver Commendation Medal by Wing Commander Chris Meddins on behalf of Air Vice-Marshal Stephen Meredith during an All Call at the Air Force Institute of Technology on 18 May.



# Faculty Academic Promotions

The Air Force Institute of Technology's Graduate School of Engineering and Management has completed the academic year 2022-2023 promotion and tenure cycle. Eight faculty members underwent a rigorous evaluation of their teaching, scholarship and service resulting in a promotion in academic rank and/or award of tenure.

By Katie Scott | Air Force Institute of Technology

**Dr. Ramana Grandhi**  
Professor



Dr. Ramana Grandhi, Professor of Aerospace Engineering, earned tenure within the Aeronautics and Astronautics Department. Prior to joining AFIT in 2018, he was a Distinguished Professor at Wright State University, where he served as Director of the Engineering Ph.D. program for 15 years.

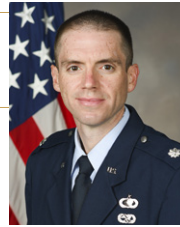
His research interests include hypersonics, multidisciplinary analysis and optimization, aircraft structures, risk-based design, and advanced manufacturing processes. He has obtained approximately \$3M in research funds while at AFIT with a career total of about \$15M. He has published 200 peer-reviewed journal articles, 250 conference proceedings, 40 technical reports, and a textbook with more than 11,000 citations per Google Scholar.

During his tenure at AFIT, he has advised one doctoral and two master's students to graduation and is currently advising two doctoral and three master's students as well as several visiting scholars.

Grandhi has increased AFIT's profile in the hypersonic community serving as a principal investigator for AFIT's participation in the University Consortium for Applied Hypersonics, a visiting lecturer at the Missile Defense Agency, Sandia National Laboratories, Air Force Research Laboratory, and Navy events, coordinator of an annual hypersonic short course, and editorial board member for six journals.

He is a Fellow of the American Institute of Aeronautics and Astronautics and the American Society of Mechanical Engineers.

**Lt. Col. Milo Hyde**  
Professor  
with Military Tenure



Lt. Col. Milo Hyde earned promotion to Professor of Optical Physics with military tenure within the Engineering Physics Department. He is the fourth active duty military member at AFIT to receive promotion to full Professor. He was promoted early to the rank of Associate Professor during his first tour on the AFIT faculty from 2010-2014, and was among the first selected for an extended AFIT military faculty tour from 2014-2017. He returned to AFIT in 2020 after serving as the Air Force Deputy for Operations, Defense Science Board, Washington, D.C.

Hyde's research interests include electromagnetic material characterization, guided-wave theory, and statistical optics. He has been a Principal Investigator or Co-PI on 22 grants with a personal share of research funding of \$2.1M. He has collaborated with the Air Force Office of Scientific Research, Air Force Research Laboratory's Directed Energy Directorate, and multiple Phase II Small Business Technology Transfer projects. He has one textbook (in press), one patent, 84 journal articles, and 89 conference papers with more than 1,430 citations per Google Scholar.

Hyde has previously advised 10 master's and three Ph.D. students to completion, and served on an additional 33 committees. He serves as the AFIT Optical Sciences and Engineering Curriculum Chair and is a Faculty Research Council representative.

**Dr. Matthew Robbins**  
Professor



Dr. Matthew Robbins earned promotion to Professor of Operations Research with tenure within the Operational Sciences Department. He joined the AFIT faculty in 2010 after retiring from Air Force active duty at the rank of Lieutenant Colonel. His research focuses on the advancement of operations research and artificial intelligence techniques for solving computational stochastic optimization problems. He has received over \$1.1M in research support from the Air Combat Command, Air Force Life Cycle Management Center, Air Force Office of Scientific Research, and the Air Force Office of Strategic Development Planning and Experimentation. He has written 34 archival journal articles and seven peer-reviewed conference proceedings with more than 960 citations per Google Scholar.

Robbins' has advised 25 master's and three doctoral students to completion and is currently advising two master's and two doctoral students. He has developed two new courses and received above average student feedback while teaching four offerings annually with an average of nearly 18 students per class. He is the Chair of the Operations Research Doctoral Program Committee and initiated the Master of Operations Analysis program.

"Achieving promotion and tenure is the ultimate testimony of the superior performance of academicians," said Dr. Adedeji Badiru, Dean, Graduate School of Engineering and Management. "I am very proud of the performance of our faculty here at AFIT in comparison to our peer civilian institutions. Our faculty perform admirably in all the typical metrics of academia with respect to teaching, research, consultations, and professional service."

**Col. Jason Anderson**  
Associate Professor  
with Military Tenure



Col. Jason Anderson was promoted to Associate Professor of Logistics and Supply Chain Management with military tenure within the Operational Sciences Department. He is a senior military faculty member currently leading the digital transformation effort at AFIT.

Anderson's research interests include transportation, logistics management, inventory, sourcing, operations management, and simulation. He was a partial Principal Investigator for a \$440K grant with the Air Force Materiel Command and the PI for a \$1M AFWERX grant to develop the next generation of Air Force pilots.

He is the author of 10 peer-reviewed journal articles, one currently under revision, one paper submitted for review, and more than 100 citations per Google Scholar. He was a co-editor for the *Joint Defense Analytics and Logistics* journal. He established a special edition of the *Air and Space Power Journal* to provide an avenue for peer-reviewed military research.

Anderson has served as a master's thesis chair for 25 students and a Ph.D. chair for one student. He has taught 16 classes across five different programs averaging close to 16 students per class, and co-taught multiple classes providing simulation-packaged games and lesson materials. He has developed new capstone courses for department programs emphasizing supply chain leadership, simulations, and analytics. He has served as the chair of the Operations Management program that included the Advanced Study of Air Mobility program and the School of Advanced Nuclear Deterrence Studies. His AFIT leadership roles include Deputy Department Head for the Operational Sciences Department, the Air University Det. 1 Section Commander, and the Associate Dean of Students.

**Lt. Col. Robert Bettinger**  
Associate Professor  
with Military Tenure



Lt. Col. Robert Bettinger earned promotion to Associate Professor of Aerospace Engineering with military tenure within the Aeronautics and Astronautics Department. Prior to joining the AFIT faculty in 2017, he served as the Senior Military Analyst and Kinetic Effects Analyst for the Counterspace Analysis Squadron at the National Air and Space Intelligence Center.

His research interests include cislunar trajectory design and operations, spacecraft survivability, reentry dynamics and prediction, space law and doctrine, and optimization and control for aerospace applications. He has received 38 research grants totaling approximately \$2.95M, including support from the Air Force Research Laboratory and the Space Test Program.

Bettinger has published 31 refereed journal articles, two book chapters, and 41 conference papers, including the award-winning article entitled "Cislunar Debris Propagation Following a Catastrophic Spacecraft Mishap" at the 2021 American Institute of Aeronautics and Astronautics Science and Technology Forum and Exposition. He holds two patent with one provisional patent application, and has nearly 150 citations per Google Scholar.

He has successfully advised 21 master's students, one doctoral student, one master's capstone project, and serves as the research advisor for 13 master's and three doctoral students. Bettinger teaches graduate courses in astrodynamics reentry, spacecraft safety and survivability, multi-body dynamics, and spacecraft reverse engineering. He has created three new courses and taught 29 special study courses during his time at AFIT.

**Dr. Hengky Chandralhim**  
Associate Professor  
with Tenure



Dr. Hengky Chandralhim earned promotion to Associate Professor of Electrical Engineering with tenure within the Electrical and Computer Engineering Department. He joined the AFIT faculty in 2017 where he also serves

as the Director of AFIT's Microfabrication and Characterization Facility overseeing the daily operation of the cleanroom and characterization labs.

Chandralhim has led the development of nanofabrication techniques to create 3D multifunctional microsystems on virtually any substrate. These techniques have enabled the realization of 3D freeform geometries that have nanometer-level precision — a feat which cannot be accomplished using conventional lithographic patterning methods on the same scale.

His team is actively investigating novel thin-film electromechanical transducers such as solid dielectrics, liquid dielectrics, ferroelectric, and piezoelectric thin-films to efficiently generate high quality mechanical waves in solids. The results of this research have enabled the realization of highly miniaturized frequency agile radio wave processors on chip-scale platforms. At higher technology readiness levels, these devices can be used to facilitate the implementation of Multifunction Advanced Data Link in F-22 and F-35 jet fighters with about a 100 times reduction in cost compared to the existing technology.

Chandralhim has trained students from different departments at AFIT in the study of novel nanoelectronic-based paints to economically and accurately identify strain on aircraft parts. The team was selected as the finalist in the Air Force Materiel Command's 2020 Spark Tank Competition.

His research has resulted in ten patents, five pending patents, and one invention disclosure. Chandralhim has been the principal investigator with 100% control on 13 sponsored research grants, worth \$1.2M. His success is largely due to his focus on establishing research partnerships with the Air Force Research Laboratory and the Air Force Office of Scientific Research.

He has authored two book chapters, 27 journal articles, 28 peer-reviewed full conference papers, including a best student paper award winner and a finalist for the best student paper award, and 16 peer-reviewed conference abstracts, including five invited papers and one of the top 20 best papers, and has more than 890 citations per Google Scholar.

He has advised seven master's students and one doctoral student to graduation and is currently advising two master's students and one doctoral student. In addition, he has also trained one postdoctoral associate and six undergraduate research assistants.



**Maj. Daniel Emmons**  
Associate Professor  
with Military Tenure



Maj. Daniel Emmons earned promotion to Associate Professor of Physics with military tenure within the Engineering Physics Department. He joined the AFIT faculty in 2017. Emmons' research interests include laser kinetics, plasma chemistry, and the effects of ionospheric disturbances on radio wave propagation.

He participated in 14 research grants totaling over \$2.3M, with ownership of six awards and intellectual control of \$860K. He received funding for space environment research from the National Reconnaissance Office, Air Force Research Laboratory, Air Force Office of Scientific Research, Air Force Technical Application Center, Defense Advanced Research Projects Agency, and the National Aeronautics and Space Administration.

Emmons has published 24 peer reviewed journal articles in 14 different journals, and has more than 170 citations per Google Scholar. He has advised eight master's and two Ph.D. students, served on 17 additional thesis committees, taught multiple offerings of seven different space environment and other courses, and received multiple Graduate School-level teaching awards.

Emmons is a member of the Federal Space Weather Operation, Research, and Mitigation Subcommittee, representing the DOD in support of the National Space Weather Strategy and Action Plan. At AFIT, he has served as a Teaching Evaluation Tools Committee member, Engineering Physics Department Division Chief, and a 2d Lt. Mentoring Program facilitator for more than 150 brand-new officers.

**LEARN MORE ONLINE**

Read the full faculty promotion article in AFIT news:

[www.afit.edu](http://www.afit.edu)

Graduate School faculty bios:

Find out more about graduate school faculty and their research areas of interest.

[www.AFIT.edu/BIOS](http://www.AFIT.edu/BIOS)

**Dr. Clark Taylor**  
Associate Professor  
with Tenure



Dr. Clark Taylor earned promotion to Associate Professor of Computer Engineering with tenure within the Electrical and Computer Engineering Department. He joined the AFIT faculty in 2018 following eight years at the Air Force Research Laboratory's Sensors Directorate and six years as an Assistant Professor at Brigham Young University, Provo, Utah.

Taylor's research interests include Bayesian Estimation, distributed data fusion, vision-aided navigation, and EO-based geo-location. He is also the Director of AFIT's Autonomy and Navigation Technology Center.

He has supported funded research projects totaling over \$3.6M, including approximately \$1.9M in personal funding with sponsorship from the Air Force Research Laboratory, Army, and Navy organizations.

During his time at AFIT, Taylor has published 14 journal papers, 19 peer reviewed conference papers, one book chapter, one magazine feature article for the Fall 2022 edition of Inside GNSS, and has more than 1,900 citations per Google Scholar. Externally, he has reviewed approximately 65 journal and conference paper submissions and has been a Track Chair for the Institute of Electrical and Electronics Engineers/ Institute of Navigation Position Location and Navigation Symposium, a Session Chair for ION Global Navigation Satellite System+, and a Tutorial Instructor for ION GNSS+ and ION PLANS.

Since joining the AFIT faculty, Taylor has advised nine master's students to graduation, with six master's and two Ph.D. students in progress. He has taught 12 courses and two short courses to more than 100 students. Additionally, he created or completely redesigned three courses foundational to the guidance, navigation, and control track in the department. His efforts included adaptations to enable participation by distance learning students and increased statistical content.

He served as the GNC Track Chair, department Awards Committee Chair, and is currently the Faculty Advisor for the AFIT chapter of the International Honor Society of the Institute of Electrical and Electronics Engineers Eta Kappa Nu.

**BY THE NUMBERS**

Accumulative achievements by these eight AFIT Graduate School faculty members:

**900+** publications + 2 textbooks

**140+** students advised

more than **\$17.6M** in sponsored research funds

**13** patent awards

**16,680+** citations per Google Scholar

INNOVATION THROUGH EDUCATION

# CYBER SECURITY

HOW AFIT IS ADVANCING THE WARFIGHTER

LEARNING THROUGH SERIOUS GAMES

SPACE SYSTEM CYBERSECURITY

HANGAR 18 SOFTWARE FACTORY

STUDENT CYBER RESEARCH



# LEVELING UP

## CYBER EDUCATION WITH SERIOUS GAMES

"ONE OF THE ADVANTAGES OF GAME-BASED LEARNING INVOLVES A GENERAL INCREASE IN MOTIVATION AND ENGAGEMENT. THIS IS PARTICULARLY IMPORTANT TO THE STEM COMMUNITY IN HIGHER EDUCATION BECAUSE TOPICS ARE OFTEN COMPLEX AND LACK SOCIAL INTERACTION."



BY DR. MARK REITH

ASSISTANT PROFESSOR OF COMPUTER SCIENCE  
DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

For at least the past decade, AFIT has annually hosted ROTC cadets from across the nation as part of its summer Immersive Cyber Education (ICE, formerly known as Advanced Cyber Education) program. In most years, we receive cadets from across the various military services, although the demographics tend to trend Air Force and Army. While the program provides an impressive technical education, our perennial challenge involves how to initiate learning with an event that appeals to the students, harnesses their enthusiasm, serves as an icebreaker, and provides context for the rest of the curriculum. Naturally, we decided to play a game.

Battlespace Next™ (BSN) is a low-cost, serious education game designed by Maj. Nathan Flack, class of 2020, and built upon the earlier work of Lt. Col. Alan Lin and other department faculty. BSN was developed to teach Joint All Domain Operations (JADO) concepts across air, space, cyber, land and naval warfighting domains to the DoD workforce. It emphasizes the interrelationship between the cyber domain (information operations, intelligence, exploits) and the other domains. ICE cadets often appreciate that their service is represented as they learn how cyber offense and defense capabilities affect their warfighting capability.

Captain Michael Hastriter, pursuing a MS in Computer Science, recently led cadets through the initial game setup and rules, then assisted them through initial game play this past summer. Capt. Hastriter is investigating the relationship between serious games and learning as he develops tools and techniques that demonstrate how game elements, decision points and outcomes may satisfy learning objectives. The survey results collected from the cadets help inform this relationship as well as validate game-based learning (GBL). Of the 42 ICE cadets, 24 responded, and the majority responded favorably in terms of effectiveness (83% of respondents) and memorability (87% of respondents).

LEVELING UP CONTINUED ON NEXT PAGE ►►



ROTC CADETS LEARN CYBER OFFENSE AND DEFENSE THEORIES THROUGH PLAYING BATTLESPACE NEXT™ DURING THE SUMMER IMMERSIVE CYBER EDUCATION PROGRAM.

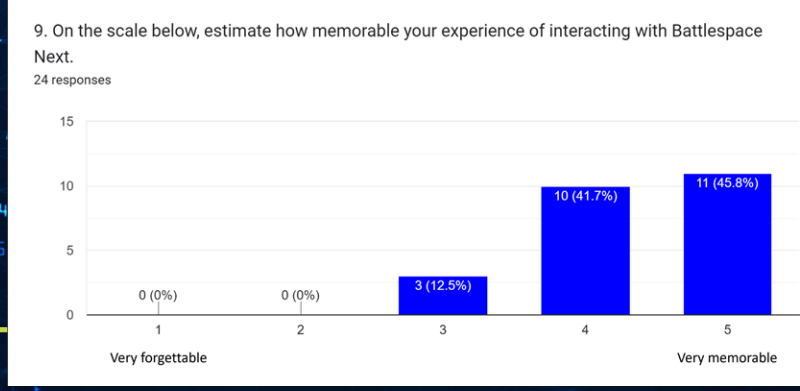
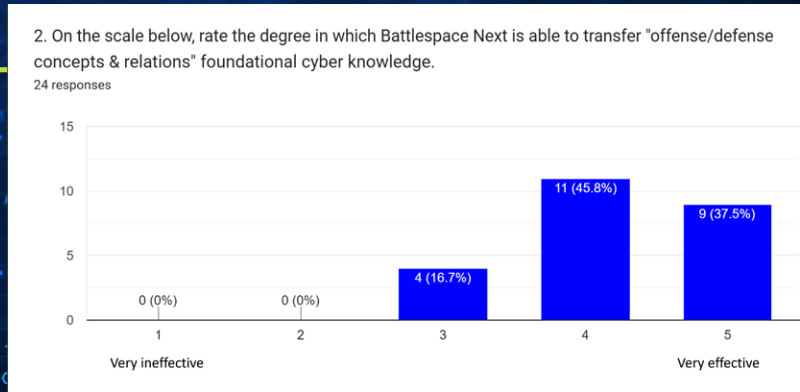
CONTRIBUTED PHOTOS BY MARK MCDONALD



# SURVEY STATS



When ICE cadets were surveyed about the Battlespace Next™ Game, the majority responded favorably in terms of effectiveness (83% of respondents) and memorability (87% of respondents).



# CYBER EDUCATION

## Many Forms of Cyber Education at AFIT

BY MAJ. JOSÉ A. GUTIERREZ DEL ARROYO, PHD, USAF  
ASSISTANT PROFESSOR OF COMPUTER SCIENCE  
DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Citing near-peer competition in the global stage and a need to maintain a technological edge, Secretary of the Air Force Frank Kendall III has placed a renewed emphasis on graduate education across the Air Force and Space Force, and the AFIT Graduate School of Engineering and Management is leading the charge. AFIT graduate programs provide students the time, space, and flexibility to tackle difficult technical problems. Through rigorous coursework and an extensive research exercise, graduates learn to become deeper thinkers and better problem solvers.

graduates awaiting pilot training. Those students pursuing graduate degrees must also complete advanced graduate-level mathematics courses and breadth courses, and they must complete and defend a research exercise, often making contributions to active research in cybersecurity in the form of tools, novel techniques, and peer-reviewed best practices. That said, many non-degree seeking students are still able to interact with AFIT cyber courses through certificate programs. Certificate programs are available to students who are not actively pursuing graduate degrees or to students who wish to augment their programs with additional cyber-specific coursework. Those include the Certificate in Cyber-Physical Sensing: Artificial Intelligence, and Cyber-Physical Sensing: Cyber Attack, both of which expose students to subsets of the courses available to GCO students.

With respect to cyber-specific education, the school offers a bevy of degree opportunities related to cyber operations, cyber security, and cyber-physical systems and technologies. Its cyber crown jewel is the 18-month Master of Science in Cyber Operations (GCO), in which students are exposed to a wide variety of topics, including cyber warfare in military operations, cyber attack and defense, secure software design and reverse engineering, data security through cryptography, and cyber-physical system security. Students in the Master of Science in Computer Engineering (GCE) and the Master of Science in Computer Science (GCS) programs may also choose to pursue the Cyber Security or Computer Networks sequences within their respective programs, which expose them to a subset of the topics offered to the GCO students.

Many of the students in the cyber programs are Cyberspace Operations (17X) officers and consequently move on to contribute directly to military cyber operations. Past graduates of the AFIT cyber programs have gone on to fight in offensive and defense cyber operations as operators, developers, planners, and leaders – with abilities to solve problems far ahead of their peers.

The Air and Space Forces continue to value the world-class education that AFIT provides, sending nearly 30 students each year to complete cyber degrees. Given the ever-changing nature of the cyber warfighting domain, where new tools and techniques age quicker than they are produced, and where new difficult technical problems arise every day, warfighters with graduate education are in exceptionally high demand. ■

The most recent addition to the graduate catalog is the 12-month Master of Cyber Systems (GCY) program, which comprises the same course requirements as the GCO program but carries a shortened research exercise in the form of a capstone – this program is only available to recent US Air Force Academy

One of the advantages of game-based learning involves a general increase in motivation and engagement. This is particularly important to the STEM community in higher education because topics are often complex and lack social interaction. From a systems engineering perspective, the game may be viewed as a model or simulation where the degree of detail is tailorable. However, from a social perspective, the game may bring students together in some form of collaboration or competition. This is important for at least two reasons. First, GBL may provide students with additional motivation to learn complex topics. Rather than wonder why they need to comprehend concepts that have no immediate value to their lives, the game provides that immediate need in support of social achievement. Second, the game provides experience to those with little or none. Post-game discussions tend to be highly interactive because every participant has a personalized story to share. These stories are sufficiently similar to be relatable, but sufficiently divergent to remain interesting. Sharing stories allows others to learn from both successes and failures. It also allows the instructor to emphasize the learning objectives and mitigate negative learning. While GBL has certain limitations and costs, it is often sufficiently flexible to support non-cyber topics as well. Faculty can learn more about GBL in a new eBook assembled by the Faculty Learning Community due out this fall quarter.

As the ICE cadets continue their educational journey, they'll take their BSN game and experiences with them. A few cadets have introduced BSN to their peers back at their ROTC units. Some have organized cadet wing-wide events and sent pictures back to highlight their enjoyment. While the AFIT branding on the cards may hint at future educational opportunities, the real value is a memorable experience on how cyber impacts their profession in the years ahead. ■

RIGHT: IMMERSIVE CYBER EDUCATION (ICE) CADETS LEARN CYBER CONCEPTS FROM SERIOUS GAME PLAY.



BELOW: BATTLESPACE NEXT™ GAME CARDS DEVELOPED AT AFIT.



### ▶ FUTURE OF CYBERSECURITY CONTINUED FROM COVER

#### Distinguished Review Board

In 2023, the CCR underwent a Distinguished Review Board (DRB) for the first time since the COVID outbreak. Maj. Gen. David W. Snoddy, Deputy HAF A2/6, presided over the board which included members from AFRL, US Space Force CIO, USAFA, and 16th Air Force. The DRB evaluated the quality of the program's curriculum, faculty, and facilities. The CCR received numerous compliments from the board, which is a testament to the Center's high standards.

#### Re-certified as an NSA Center of Academic Excellence – Research Institution

AFIT is one of only a few academic institutions in the nation that has been designated as a National Security Agency (NSA) Center of Academic Excellence – Research Institution. This designation is a testament to the Center's commitment to excellence in cybersecurity research.

#### Developing New Certifications

In the past year, CCR faculty developed three new certification programs to support the continuous educational objectives of mission partners in the AFRL Sensors Directorate. These certifications are in the field of Cyber Physical Systems, which combine physical and cyber components to accomplish well-defined tasks. Interested students can find out more information here by visiting our website: <https://e.AFIT.edu/JVflrmn>.

#### New Interim Director

In 2023, Lt. Col. Wayne "Chris" Henry took over as the Interim Director of the Center for Cyberspace Research from Dr. Scott Graham. Lt. Col. Henry is a highly-experienced cybersecurity professional, and he brings a wealth of knowledge and experience to the Center. ■

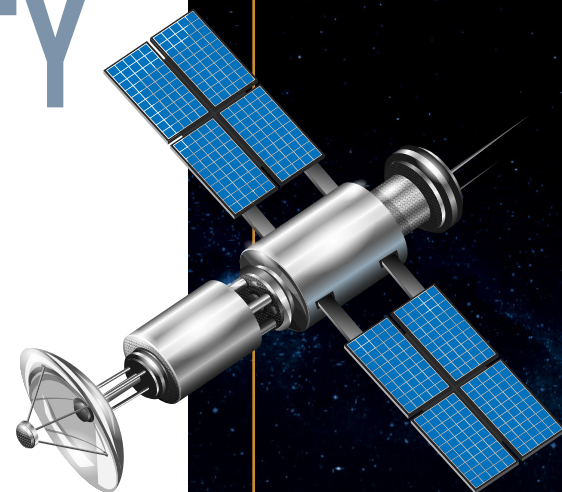


# DEFENSIVE SPACE SYSTEM CYBERSECURITY RESEARCH

BY LT. COL. WAYNE "CHRIS" HENRY, PHD, USAF  
INTERIM DIRECTOR, CENTER FOR CYBERSPACE RESEARCH  
ASSISTANT PROFESSOR OF ELECTRICAL ENGINEERING

In the complex and rapidly evolving arena of space warfare, the Air Force Institute of Technology (AFIT) has been at the forefront of ground-breaking research in space system cybersecurity. This year marks significant advancements in this critical field, with AFIT researchers pushing the boundaries of what is possible and setting new standards in space defense.

A key factor in AFIT's success in this field has been the strong partnerships it has fostered with other leading institutions and organizations. AFIT closely collaborates with NASA, the Air Force Research Laboratory (AFRL), Aerospace Corporation, MITRE Corporation, other national defense mission partners, and academia throughout the country. These collaborations have been instrumental in driving forward research in space system cybersecurity. ▶▶



The cyber attacks on ViaSat and Starlink by Russia during the Ukraine invasion highlight the importance of defensive cybersecurity in space. These attacks disrupted communications and navigation for both civilians and military personnel in Ukraine, and they demonstrated how an advanced adversary can use cyber to target assets in the space domain.

One of the key areas of research focus is in the development of space-based intrusion detection systems to protect our space assets from cyber threats. As space systems have become more complex and interconnected, they also become more vulnerable to sophisticated cyber attacks. These attacks can disrupt mission-critical operations, compromise sensitive data, and even cause physical damage to the spacecraft at speeds that cannot be prevented through operator interaction. Therefore, the implementation of on-board intrusion detection systems

is crucial. These systems serve as an early warning mechanism, identifying and mitigating cyber threats before they can inflict significant harm. By continuously monitoring and analyzing the spacecraft's network activity, these systems play a vital role in maintaining the integrity, confidentiality, and availability of our space assets.

Another exciting area of research is the development of secure communication protocols for space systems. Space-based communication presents unique challenges such as extremely long delays and high error rates. Existing protocols are not suitable for this extreme environment, so our researchers have been pioneering new protocols that can provide secure communications for space systems.

AFIT's research in space system defensive cybersecurity is not just about developing new technologies and methodologies. It

is also about understanding the unique challenges of the space domain, such as the vast distances involved, the harsh environment, and the limited bandwidth. By understanding these challenges, researchers at AFIT can develop more effective and efficient cybersecurity solutions for space systems. AFIT is also preparing our future leaders and innovators for the challenges they will face in the increasingly contested and congested space domain. By training students in the latest cybersecurity techniques and technologies, researchers at AFIT are ensuring that our future leaders will have the knowledge and skills they need to protect our space systems from attack.

As we continue to push the boundaries of what is possible in space system defensive cybersecurity, we are confident that the research being conducted at AFIT will play a crucial role in shaping the future of space warfare. ■

**"ONE OF THE KEY AREAS OF RESEARCH FOCUS IS IN THE DEVELOPMENT OF SPACE-BASED INTRUSION DETECTION SYSTEMS TO PROTECT OUR SPACE ASSETS FROM CYBER THREATS. AS SPACE SYSTEMS HAVE BECOME MORE COMPLEX, THEY ALSO BECOME MORE VULNERABLE TO SOPHISTICATED CYBER ATTACKS."**



# HANGAR 18

## AF CyTCoE Innovates and Executes Software Development

The Air Force Cyberspace Technical Center of Excellence (AF CyTCoE) at AFIT innovates in cyberspace education, training, and research leveraging AFIT's vast amounts of cyber expertise across its faculty, staff, and students. AF CyTCoE's mission is to enhance the USAF's ability to develop cyber warriors capable of delivering strategic, operational and tactical effects by leveraging the most cutting-edge technologies and tactics available. In October 2021, AF CyTCoE partnered with the Air Force Research Laboratory (AFRL) to create the Hangar 18 software factory, which was born from a need to create an Agile approach to help the Air and Space Force communities in efficiency and deliverables in a cost effective way.



Hangar 18 is a DAF-endorsed Software Factory whose mission is to bring Agile and DevSecOps to the Digital Transformation and Digital Engineering communities at Wright-Patterson AFB. Hangar 18 accomplishes this by developing tools and tool pipelines, assisting and guiding technical programs, and engaging in workforce development with formal and informal education and training. Hangar 18 delivers software and data solutions to the warfighter across a broad spectrum of domains, leveraging a diverse portfolio of technologies spanning prototypes to enterprise-grade systems.

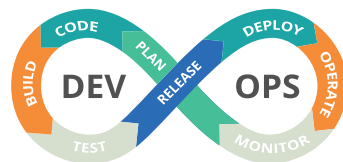
Hangar 18's niche is supporting data and data models for its AFRL and AFIT research-based customers while also providing consultation and project execution to its partners. Visit Hangar 18's website to schedule time to discuss Hangar 18's expertise in code approval and deployment, DevSecOps and Hangar Agile, and its lessons-learned working with researchers across AFIT and AFRL.

### APPROVAL AND DEPLOYMENT

Achieving an approval to deploy software, and knowing how and where to do it, are no small feats. For many efforts, this is the most difficult and uncertain part of the lifecycle. Hangar 18 offers broad experience in meeting the military's stringent cybersecurity requirements, and in configuring the most appropriate environment for numerous forms of software.

### DEVSECOPS

DevSecOps (development, security, and operations) automates the integration of security at every phase of the software development lifecycle, from initial design through integration, testing, deployment, and software delivery. The benefits of DevSecOps are simple: enhanced automation throughout the software delivery pipeline eliminates mistakes and reduces attacks and downtime. Hangar 18 provides DevSecOps processes and tools on its projects to control code changes, find security issues early, and deploy software to the customer quickly and often.



### USER CENTERED DESIGN

User Centered Design is the process of building insights about users' experience through usability testing and other forms of user research into product development through an iterative design process. This process allows the user to be included in every step of the development process, while prioritizing features that are the most beneficial. User experience (UX), which deals with the specific experience users have with a product, is a component of the UCD process.



### AGILE MINDSET

Agile is a framework that breaks the developmental process into iterative steps, allowing for flexibility, testing, and change throughout the lifecycle of the project. Hangar 18 teams complete work in sprints, which are typically broken out into two-week chunks of time. Various checkpoints throughout the project allow the team to change direction as needed. Compared to the waterfall model, implementing Agile development practices puts the user in control with the development team delivering value within a few sprints of work, not months or years where development teams build software in a vacuum with minimal communications with the customer. Agile development supports an approach to rapidly deliver working code or fail-fast and move on.

### EDUCATION, TRAINING & CONSULTATION

Hangar 18's partnership with the Air Force Institute of Technology provides immediate access to education, training and experience on project management, systems engineering, DevSecOps, and much more. Whether delivering a seminar, short course, or working alongside customer team members, Hangar 18 brings teams up to warp speed.

### DIGITAL ENGINEERING

Hangar 18 aims to address digital engineering problems at the infrastructure and data level, without locking the DAF into specific tools or techniques. Team projects have demonstrated significant cost savings for data management and capability deployment, while also providing greatly shortened feedback time for data analysis and improved overall data quality. ■

## HOW TO MAKE CONTACT



**WEBSITE:**  
HANGAR18.IO

**EMAIL:**  
HANGAR18@AFRESEARCHLAB.COM

**PROJECT CASE STUDIES:**  
<https://www.HANGAR18.io/projects/>

# IronNetInjector:

## Weaponizing .NET Dynamic Language Runtime Engines

BY MAJ. ANTHONY ROSE

AFIT GRADUATE STUDENT  
DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Due to its widespread use and ease of integration on Windows systems, the .NET Framework has become an essential tool for adversaries, especially Advanced Persistent Threats (APTs). The versatility and accessibility make it a prime target for exploitation, with many APTs leveraging it through tools like PowerShell and C#.

A significant aspect of the .NET Framework is the Dynamic Language Runtime (DLR), which serves as a potential attack vector. The DLR allows for language-agnostic compilation, enabling tools built within the .NET framework to interact with various functions, irrespective of the language, as long as it's supported by .NET. While beneficial for developers, this flexibility also offers adversaries a potential avenue for exploitation.

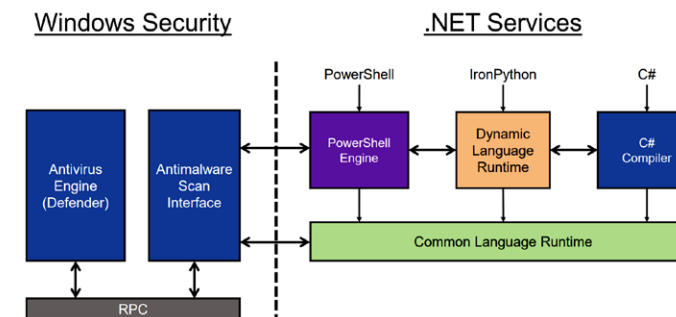


Figure 1: Architecture diagram of the DLR and CLR interactions with compilers and the operating system services [1].

One such exploitation technique is the Bring Your Own Interpreter (BYOI). This method allows developers to embed dynamic languages into .NET, seamlessly integrating various languages. Turla, a suspected Russian APT, has used this technique for evasion purposes and deployed a tool called IronNetInjector. This tool, which uses IronPython (a .NET variant of Python), is designed to reflectively load .NET assemblies, making it a potent tool in the hands of adversaries.

The Antimalware Scan Interface (AMSI) plays a crucial role in defending Windows systems. It serves as a primary line of defense, scanning scripts for potential threats before execution. However, the dynamic nature of languages like IronPython poses challenges for AMSI, allowing for potential evasion techniques. One such method involves bypassing AMSI using IronPython, which has been demonstrated to be effective in evading traditional security measures.

The .NET framework's design supports many programming languages, allowing them to share libraries seamlessly. While beneficial for developers, this design choice also provides adversaries with potential

attack paths. The DLR interacts directly with dynamic languages and has been a focal point for many adversaries. Tools leveraging languages like PowerShell and C# can access functionalities within the DLR, potentially without the user's knowledge.

AMSI's role in this ecosystem is paramount. It serves as a versatile interface that integrates with any antimalware product, enhancing overall malware protection. However, its effectiveness is under scrutiny, especially with tools like IronNetInjector in play. This tool, associated with the Russian APT Turla, is designed to bypass modern Windows detections and deploy custom implants.

Embedding dynamic languages within the DLR is a legitimate feature of .NET. This method allows for embedding third-party dynamic languages into .NET and provides adversaries with a powerful evasion technique. One such tool that leverages this technique is IronNetInjector from Turla. IronNetInjector is named due to its IronPython implementation and serves as a wrapper for hosting their NetInjector loader. Its primary objective is to load unmanaged code implant, ComRAT. While not entirely clear, its deployment method is believed to involve a .NET assembly, providing Turla with a versatile deployment option.

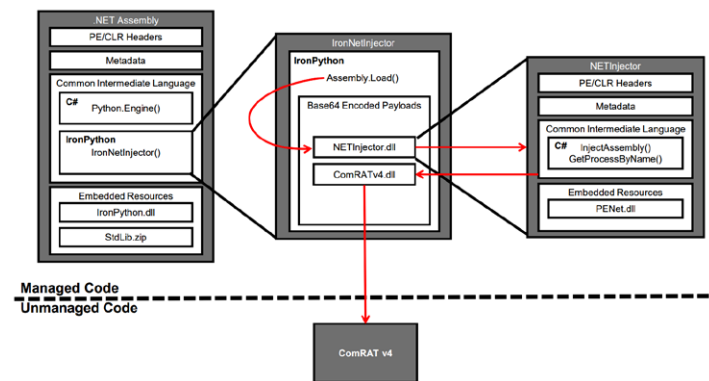


Figure 2: Turla's IronNetInjector attack path using C#, IronPython, .NETInjector, and ComRAT [1].

In conclusion, the .NET Framework, while designed to offer developers a versatile and integrated platform, also presents potential vulnerabilities that adversaries can exploit. The continuous evolution of Tactics, Techniques, and Procedures (TTPs) by APTs underscores the need for robust and adaptive defense mechanisms. The weaponization of tools like IronNetInjector and the potential bypass of security measures like AMSI highlight the challenges in cyberspace. ■

[1] A. Rose, S. Graham, and J. Krasnov, "IronNetInjector: Weaponizing .NET Dynamic Language Runtime Engines" Digital Threats: Research and Practice. May 2023.



# Malware Detection Analysis with ThreatScrapper



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The digital landscape of today is in a state of constant flux, with the rapid evolution of malware and computer viruses continually challenging the proficiency of anti-virus programs. One method of combating these threats lies in the proactive detection of malicious files, which pivots on the timely updating of virus signatures by these programs. Given the myriad of anti-virus tools on the market, ranging from Microsoft Defender and Symantec to McAfee, it becomes pertinent to examine their detection speed and the potential collaboration in signature sharing.

While typical organizations rely on Anti-Virus (AV) programs such as Microsoft Defender for their endpoints, some stand-alone networks and systems utilize other AV programs such as Clam AV, McAfee HBSS, and Symantec. Each of these programs come with their own virus definitions, but do not typically share the same definitions as other programs. Therefore, it is important to understand how quickly these programs identify potential malicious files and which groups suggest that signature sharing occurs between AV providers. To assist our ongoing research, we developed and utilized a program called ThreatScrapper to track individual anti-virus program detections over a specified period determined by the user. This program serves as a front-end interface to submit suspicious files to [www.virustotal.com](http://www.virustotal.com) and pull reports that are saved locally for further investigation.

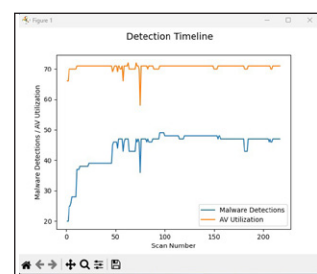
## ThreatScrapper

ThreatScrapper was developed in Python and utilizes VirusTotal's version 3 of its API interface to submit files, pull reports, and rescan submitted files. The data pulled from VirusTotal's website is saved into an Excel document specified by the user, and each new report is saved on a new line in the document. To help visualize the data, the number of detections over time are displayed on a line graph that will display after pulling a report. Along with this is a pie chart showing the total number of positive detections, contrasted by the percentage of negative detections amongst anti-virus programs hosted on VirusTotal. Finally, a table is displayed with the results of the most recent scan, containing names, versions, and dates of each anti-virus program hosted on the website. This program has been accepted at both Black Hat and DEFCON 2023 conferences in Las Vegas for their tool presentation segments.

## Preliminary Results

A sample set of 10 obfuscated viruses were submitted to VirusTotal to test the ThreatScrapper program. Each of these viruses are the same trojan component of the Empire penetration testing platform, named "Sharpire," and obfuscated utilizing the ConfuserEX C# obfuscation tool to generate individual hash values for each virus. Each of the 10 samples submitted to the site averaged 21 positive detections beginning on May 11 at 2013 hours and quickly rose to a maximum of 49 average positive detections at its height on May 16 at 0046 hours. All samples were consistently within 1 to 2 positive detections of each other, with variations emerging due to assumed heuristically positive results from a few AV providers. The largest increase in positive detections occurred on May 12 at 1250 hours, rising from 27 detections to 39 detections, with minor jumps in detections moving forward. Each new detection by an AV provider correlate to a fresh definition version update, which suggests that the signature for the files had been added to their own capabilities.

AV Vendor	Signature Version	Version Date
Cynet	4.0.0.27	20230512
Baidu	7.2.3.7796.0	20230512
APEX	6.41	20230512
BitDefender	7.2	20230512
Avast	22.11.7701.0	20230512
Emsisoft	2022.6.0.3	20230512
CMC	4.0.14.446	20230512
Sophos	35.24.1.0	20230512
Microsoft	1.1.20300.3	20230512
Gridinsoft	1.1.20300.3	20230512
ViRobot	2022.0.0.1	20230512
AhnLab	1683900192	20230512
MAX	6.0.6.653	20230512
Panda	4.5.5.54	20230512



The images above show evidence of the largest increase in positive detections which occurred on May 12.

## Benefits of Our Research

The results of our research will aid the Air Force in determining which AV programs consistently display the ability to detect malware reliably and as early as possible. ThreatScrapper can enable organizations to submit malicious files for analysis and track the progression of those files over all available AV platforms. This will allow an organization to become informed on the effectiveness of their AV platform being utilized on their networks and help them explore their options in possibly moving to a more capable and responsive AV program that will fulfill their cyber defense requirements. ■

AV Vendor	Detection	Version	Signature	Date	AV Vendor	Detection	Version	Signature	Date
ALYac	True	1.1.3.1	Trojan.GenericKD.67000204	20230706	Acronis	False	1.2.0.114	None	20230219
APEX	True	6.429	Malicious	20230704	Baidu	False	1.0.0.2	None	20190318
AVG	True	22.11.7701.0	Win32:RATX-gen [Trj]	20230706	CAT-QuickHeal	False	22.00	None	20230705
AhnLab-V3	True	3.23.3.10396	Trojan/Win.Generic.C5225766	20230706	CMC	False	2.4.2022.1	None	20230619
Alibaba	True	0.3.0.5	Trojan:MSIL/Generic.64ea9145	20190527	ClamAV	False	1.1.0.0	None	20230705
Antiy-AVL	True	3.0	HackTool[VirTool]/Win64.Empire	20230706	DrWeb	False	7.0.59.12300	None	20230705
Arcabit	True	2022.0.0.18	Trojan.Generic.D3FE578C	20230705	Gridinsoft	False	1.0.126.174	None	20230705
Avast	True	22.11.7701.0	Win32:RATX-gen [Trj]	20230706	Jiangmin	False	16.0.100	None	20230705
Avira	True	8.3.3.16	TR/Agent.luutdg	20230706	Kaspersky	False	22.0.1.28	None	20230705
BitDefender	True	7.2	Trojan.GenericKD.67000204	20230706	NANO-Antivirus	False	1.0.146.25785	None	20230706

A screenshot of ThreatScrapper is shown above. To help visualize the data, the number of detections over time are displayed on a line graph that will display after pulling a report. Along with this is a pie chart showing the total number of positive detections, contrasted by the percentage of negative detections amongst anti-virus programs hosted on VirusTotal. Finally, a table is displayed with the results of the most recent scan, containing names, versions, and dates of each anti-virus program hosted on the website.

**"WE DEVELOPED AND UTILIZED A PROGRAM CALLED THREATSCRAPER TO TRACK INDIVIDUAL ANTI-VIRUS PROGRAM DETECTIONS OVER A SPECIFIED PERIOD DETERMINED BY THE USER."**





# CALENDAR EVENTS

## SEPTEMBER 2023

### **AFIT Graduate School New Faculty Orientation**

11-15 Sep 2023 | AFIT Campus, WPAFB, OH

### **AFIT Graduate School Commencement Ceremony**

14 Sep 2023 | Dayton, OH

### **AFIT Annual Fall Celebration**

25-29 Sep 2023 | AFIT Campus, WPAFB, OH

## OCTOBER 2023

### **AFIT Graduate School Fall Quarter Classes Begin**

2 Oct 2023 | AFIT Campus, WPAFB, OH

### **AFIT Board of Visitors**

24-25 Oct 2023 | AFIT Campus, WPAFB, OH

## NOVEMBER 2023

### **AFIT Graduate School Winter Quarter Registration Opens**

6 Nov 2023 | AFIT Campus, WPAFB, OH

## DECEMBER 2023

### **AFIT Graduate School Fall Quarter Classes End**

8 Dec 2023 | AFIT Campus, WPAFB, OH

### **AFIT Graduate School Fall Degree Conferral (No Ceremony)**

21 Dec 2023 | AFIT Campus, WPAFB, OH

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