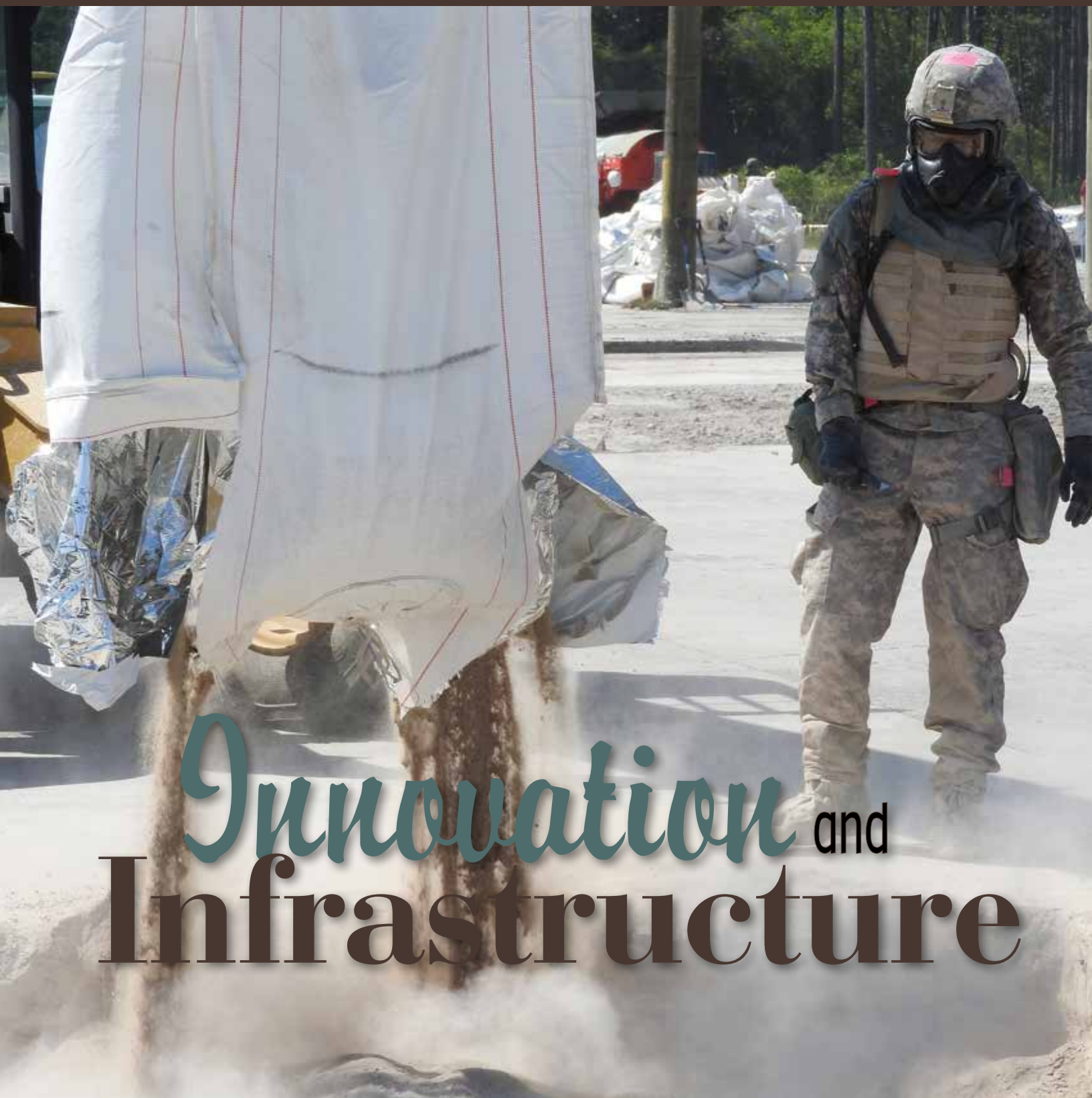
Air Force
Civil Engineer
By Engineers. For Engineers.
Vol. 25 No. 1 Spring 2017



Innovation and Infrastructure

Civil engineers keep installations safe, secure and resilient

Problem solving is at the heart of who we are and what we do as Airmen engineers. Innovation is a core element of our ability to solve problems and meet challenges, whether it is applying old techniques in new ways or creating something wholly new. As the world changes around us, we remain responsible to provide, operate, maintain and protect 183 Total Force Air Force installations around the globe. It is through our unyielding commitment to smart innovation and agility that the CE enterprise is able to best meet the needs of tomorrow using available resources. We must leverage foundational principles and develop cutting-edge solutions and strategies to ensure the resilience and effectiveness of Air Force installations.

In this issue, you will read about the role of engineering in the cyber domain. Control systems are integrated into every piece of our lives — from heating and cooling systems to water and wastewater plants. Over time, these elements of infrastructure became part of traditional information technology components to enable connectivity, automation and remote monitoring — thus creating vulnerabilities to cyberthreats. I cannot emphasize enough how critical it is that we take the precautions required to mitigate these cyberthreats to ensure safe, secure and resilient installations.

You will also learn about climate adaptation and resilience. Over the last few years, extreme weather events caused multiple millions of dollars in economic loss, destroyed homes and businesses, and adversely impacted military installations. As Airmen engineers, we are not focused on identifying and debating the possible causes of changing climate patterns. Our responsibility is to enable the Air Force to continue to execute our core missions in the decades ahead. See how Airmen are taking steps today and anticipating tomorrow and beyond.

After reading the Spring 2017 CE Magazine, I hope you will be inspired by the work that is being done to forge a better tomorrow. In every domain — from cybersecurity to climate change — you are part of a team that leads and shapes the future of sustainability and base resilience.

Engineers lead the way!

Timothy S. Green
Major General, USAF
Director of Civil Engineers

Innovation and Infrastructure

Features

Vol. 25 No. 1 Spring 2017

On the Cover

Civil engineers assigned to Detachment 1, 823rd RED HORSE Squadron, wear new chemical biological lightweight improved thermal ensembles, or CB-LITE, while performing simulated airfield damage repairs during a test at the Silver Flag exercise site on Tyndall Air Force Base, Florida. *(U.S. Air Force photo/Mekka Parish)*

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Air Force fosters climate-resilient installations

By Lynn Engelman
Directorate of Civil Engineers, Headquarters Air Force

Temporary aberrations in weather patterns or climate change: The debate continues. What matters most to the Air Force is understanding how climate-related impacts can affect an installation's ability to support mission preparedness and readiness, and what needs to be done to adapt to these conditions to foster climate-resilient installations.

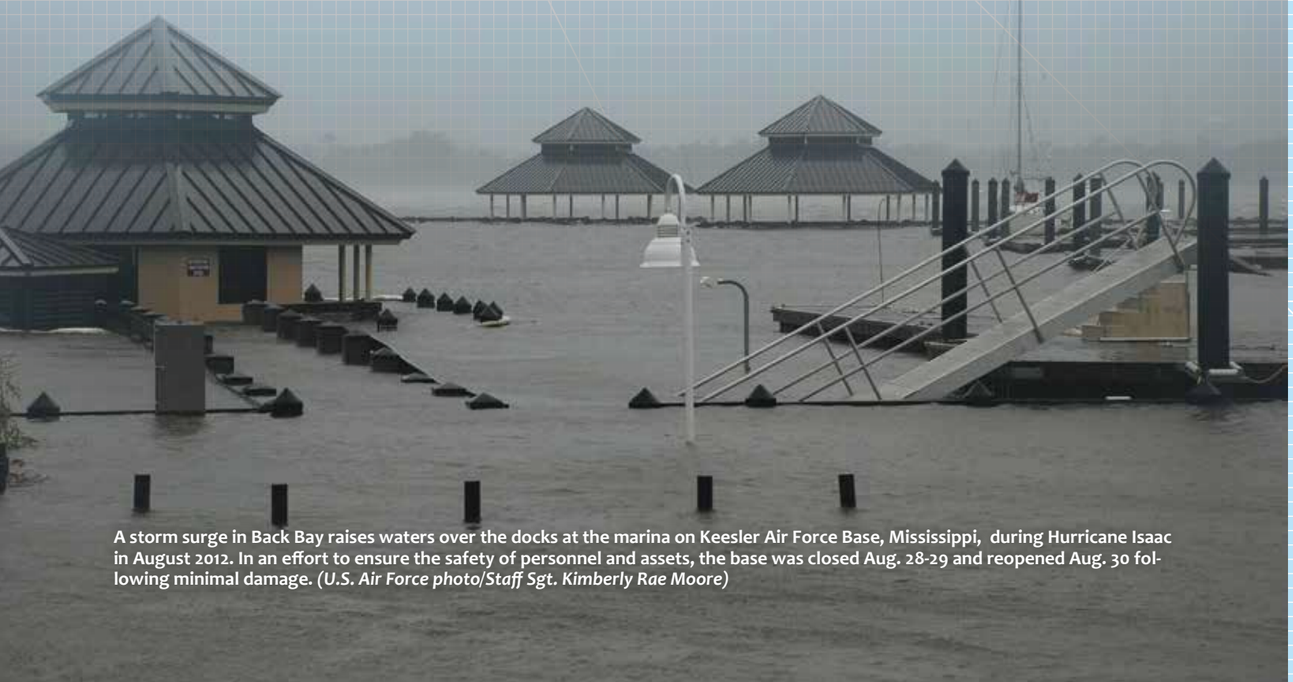
The Air Force is using several initiatives with natural infrastructure to mitigate climate-related impacts to its mission and built infrastructure.

Over the last few years, extreme precipitation events have caused millions of dollars in economic loss, destroyed homes and businesses and adversely impacted military installations, while at the same time, other regions have experienced extended periods of drought.

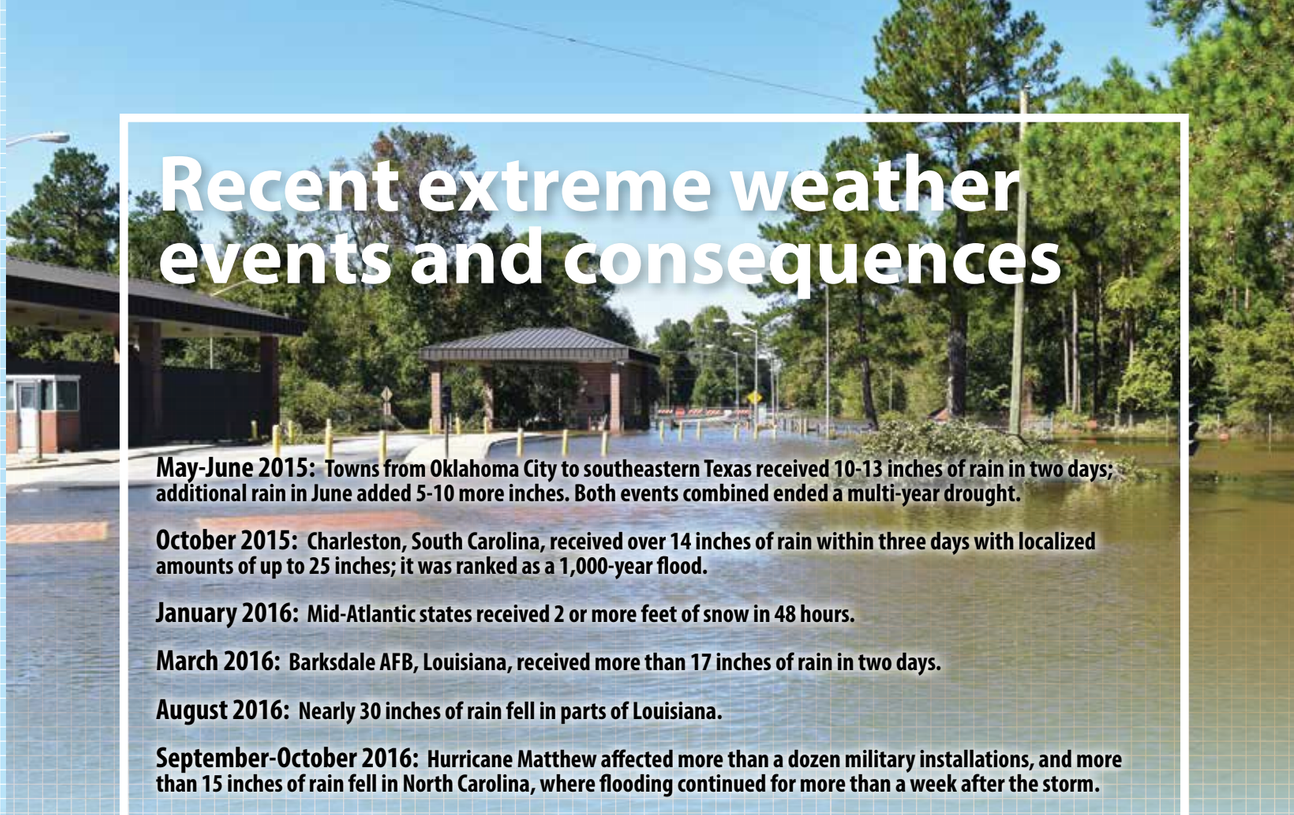
During his confirmation testimony, Secretary of Defense Jim Mattis, stated: "… where climate change contributes to regional instability, the Department of Defense must be aware of any potential adverse impacts this can have on our interests … the department should be prepared to mitigate any consequences of a changing climate, including ensuring that our shipyards and installations will continue to function …"

The Department of Defense 2014 Climate Change Adaptation Roadmap states, "A changing climate will have real impacts on our military and the way it executes its mission."

One of the four lines that supports the DOD's climate adaptation goals in the roadmap references "built and natural infrastructure, both of which are necessary for successful mission preparedness and readiness." In response to the threats posed by a changing climate, the Air Force has initiated a number of actions:



A storm surge in Back Bay raises waters over the docks at the marina on Keesler Air Force Base, Mississippi, during Hurricane Isaac in August 2012. In an effort to ensure the safety of personnel and assets, the base was closed Aug. 28-29 and reopened Aug. 30 following minimal damage. *(U.S. Air Force photo/Staff Sgt. Kimberly Rae Moore)*



Recent extreme weather events and consequences

May-June 2015: Towns from Oklahoma City to southeastern Texas received 10-13 inches of rain in two days; additional rain in June added 5-10 more inches. Both events combined ended a multi-year drought.

October 2015: Charleston, South Carolina, received over 14 inches of rain within three days with localized amounts of up to 25 inches; it was ranked as a 1,000-year flood.

January 2016: Mid-Atlantic states received 2 or more feet of snow in 48 hours.

March 2016: Barksdale AFB, Louisiana, received more than 17 inches of rain in two days.

August 2016: Nearly 30 inches of rain fell in parts of Louisiana.

September-October 2016: Hurricane Matthew affected more than a dozen military installations, and more than 15 inches of rain fell in North Carolina, where flooding continued for more than a week after the storm.

October-November 2016: A months long drought affected an area from central Mississippi to western North Carolina that created conditions resulting in several wildfires across several states .

February 2017: Lack of precipitation in Florida resulted in wildfires north of Avon Park Bombing Range.

January-February 2017: Record rainfall and snowfall along the U.S. West Coast stressed dams and levees, resulting in evacuations. Rain in June added 5-10 more inches, both events combined to end a multi-year drought.

Water floods Slocumb Gate during Hurricane Matthew, Oct. 9, 2016, at Seymour Johnson Air Force Base, North Carolina. Many cars and homes were flooded during the storm, but Team Seymour members helped each other endure the hurricane. *(U.S. Air Force photo/Airman 1st Class Ashley Williamson)*

On Jan. 18, the assistant secretary of the Air Force for installations, environment and energy and the deputy chief of staff for operations co-hosted a climate forum with some of the service's most senior leaders. Central to their discussion were concerns for the resiliency of installations in light of changing climate and impacts on mission assurance.

The U.S. Air Force Directorate of Civil Engineers stood up an informal climate adaptation and resilience working group made up of representatives from the Air Force Operational Training Division, the Air Force Civil Engineer Center, Air Force Installation and Mission Support Center and the deputy assistant secretary of the Air Force, Installations. The group will share information regarding climate change, projects and activities to ensure coordination and avoid duplication of efforts.

The air staff's Air Force Weather Directorate has established a climate plans office to help the headquarters staff navigate the state of effects-based climate information and its application to Air Force policy and strategy. The Air Force's operational climate services support the climate adaptation resilience efforts of all DOD components and the intelligence community.

AFCEC is studying the effect that climate projections could have on facility design. A project will be designed using current engineering weather data and existing climatic conditions, and then compared to the design for projected engineering weather data and climatic conditions.

Adapting to sea level rise, changing precipitation patterns, more frequent incidences of heat waves and other extreme

Potential effects of climate hazards on built and natural infrastructure

Increased inundation, erosion and flooding damage

Changes to building heating and cooling demand, impacting installation energy and intensity operating costs

Disruption to and competition for reliable energy and fresh water supplies

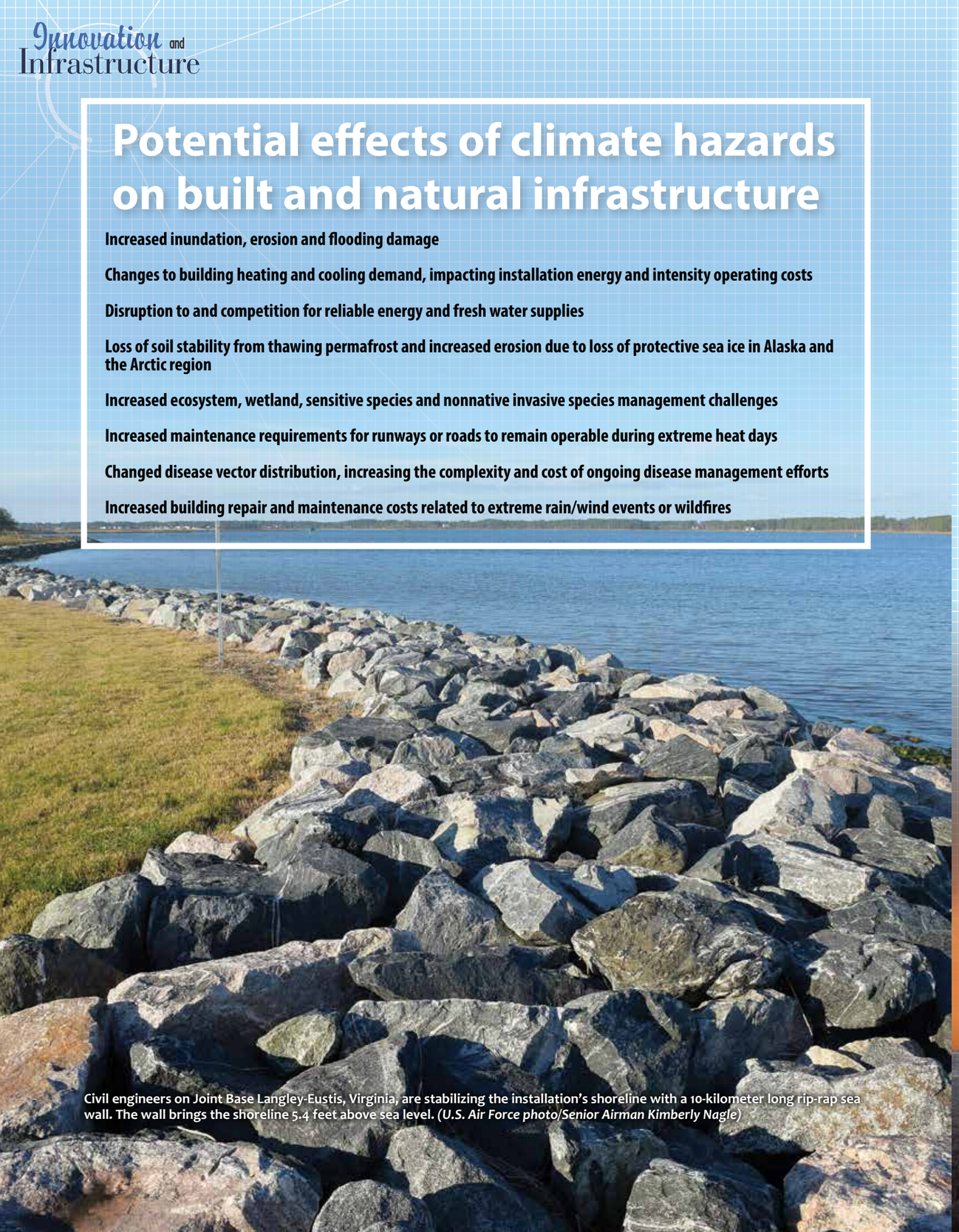
Loss of soil stability from thawing permafrost and increased erosion due to loss of protective sea ice in Alaska and the Arctic region

Increased ecosystem, wetland, sensitive species and nonnative invasive species management challenges

Increased maintenance requirements for runways or roads to remain operable during extreme heat days

Changed disease vector distribution, increasing the complexity and cost of ongoing disease management efforts

Increased building repair and maintenance costs related to extreme rain/wind events or wildfires



Civil engineers on Joint Base Langley-Eustis, Virginia, are stabilizing the installation's shoreline with a 10-kilometer long rip-rap sea wall. The wall brings the shoreline 5.4 feet above sea level. ***(U.S. Air Force photo/Senior Airman Kimberly Nagle)***

weather events is critical to supporting mission assurance. Climate adaptation and resiliency strategies can be as simple as taking advantage of elements of the natural environment and active management of natural infrastructure to minimize damage to the built environment.

Tinker Air Force Base, Oklahoma, recognized the value of this approach in 2007, when it published its Green Infrastructure Plan. The green infrastructure area at Tinker is centered around the flood plains, wetlands, creek systems and natural areas on the base. The plan is intended to guide development to support current and future military needs while not degrading these sensitive environments. The majority of the green infrastructure network on Tinker is not developable and lies within the 500-year flood plain. Green infrastructure preservation and enhancement affords numerous benefits including:

- Reducing and even eliminating future flood-related disruptions
- Preventing further exacerbation of flood conditions in local communities downstream from Tinker
- Ensuring natural areas are available for realistic training of military units, avoiding temporary duty assignments
- Improving water quality in streams, promoting wildlife movement, enhancing fisheries and stabilizing creek beds

The recent removal of development in the flood plain and the use of the 500-year flood plain for planning purposes have meant an increase in floodwater storage capacity and avoided having housing units damaged in the May 2015 flood.

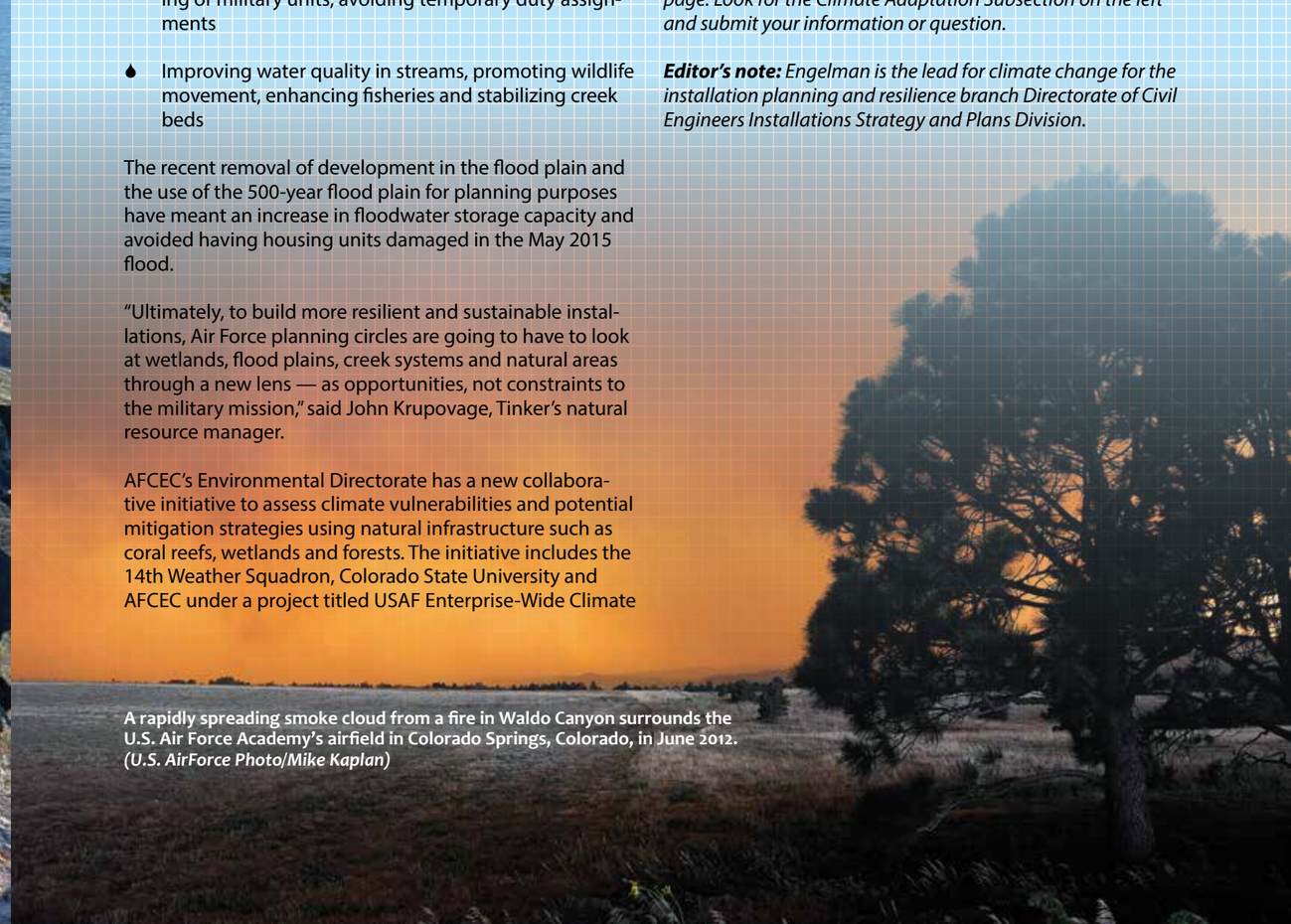
"Ultimately, to build more resilient and sustainable installations, Air Force planning circles are going to have to look at wetlands, flood plains, creek systems and natural areas through a new lens — as opportunities, not constraints to the military mission," said John Krupovage, Tinker's natural resource manager.

AFCEC's Environmental Directorate has a new collaborative initiative to assess climate vulnerabilities and potential mitigation strategies using natural infrastructure such as coral reefs, wetlands and forests. The initiative includes the 14th Weather Squadron, Colorado State University and AFCEC under a project titled USAF Enterprise-Wide Climate Change Assessment for Integrated Natural Resources Management Plans. The climatic data and expertise from 14th WS along with data and expertise of climate researchers at CSU will assist the Air Force in obtaining the most robust climate vulnerability analysis to ensure natural infrastructure is in place to address extreme weather and climatic events.

As regions of the country experience drought, the chance for wildfires increases, making preventative wildland fire measures at installations in drought areas more critical. Air Force Wildland Fire Center personnel were deployed in fall 2016 to support firefighting efforts in the southeastern states and again in February to Avon Park, Florida. Prescribed fire treatments conducted by fire center personnel at Avon Park protected Air Force property from significant burning and prevented the destruction of colonies of endangered red cockaded woodpeckers.

If you or your installation have taken actions to adapt to changing conditions or make your installation more resilient to extreme weather events, sea-level rise or extreme temperatures, or if you have a climate-adaptation or resilience question, go to our Climate Adaptation and Resilience Input/ Crossfeed feature on the CE Portal, CE Planning Policy Group page. Look for the Climate Adaptation Subsection on the left and submit your information or question.

Editor's note: *Engelman is the lead for climate change for the installation planning and resilience branch Directorate of Civil Engineers Installations Strategy and Plans Division.*



A rapidly spreading smoke cloud from a fire in Waldo Canyon surrounds the U.S. Air Force Academy's airfield in Colorado Springs, Colorado, in June 2012. ***(U.S. AirForce Photo/Mike Kaplan)***

Civil engineers are cyberwarriors, too

By Lt. Col. Patrick Obruba
Directorate of Civil Engineers, Headquarters Air Force

Cybersecurity. It certainly is a hot topic today. It seems everything from the Office of Personnel Management's security clearance database to a celebrity's photos to a bank's credit card repository have at some point been targeted, hacked and compromised. Closer to home, our thermostats are networked, our artificial intelligence assistants eavesdrop on our conversations, and our phones link to every personal aspect of our lives.

It is enough to make you want to delete all of your online digital presence, destroy your hard drive and unplug from society … however, completely unplugging is not enough in this day and age to mitigate your risk to cyberthreats. For instance, if you are sitting in your dorm room on base with nothing but a book, you are still potentially vulnerable to a hacker's malicious intentions. Today, the systems providing electricity to light your room, air conditioning to cool your building, even the pumps flowing water to the tower that supplies water to your bathroom are more than likely connected and operated over a network and, therefore, remotely accessible to anyone.

Most of the hacks reported in the news are targeting information through traditional cyberattacks to gather personal information, Social Security numbers, credit card data, etc. However, things have changed: Risk extends beyond compromising data to manipulating the physical environment.

Integrated into every piece of our modern lives, control systems are typically used to monitor or control the physical environment (e.g., electricity generation and distribution; heating, ventilation and air conditioning, or HVAC; water and wastewater plants; or natural gas distribution). Generally, control systems regulate the flow of electricity, fluids, gases, air, traffic and even people. In the Air Force, control systems are used extensively to automate and optimize resources supporting nearly all aspects of Air Force core mission areas. So, by extension, if a system can be compromised, so can the Air Force missions they support.

Until the 1980s or 1990s, control systems were neither automated nor networked. Today, these elements of infrastructure have been increasingly fused with traditional information technology to enable connectivity, automation and remote monitoring. This hybrid integration between the physical environment and traditional IT allows for greater operational capabilities, efficiencies and automation. However, new vulnerabilities are introduced that expose the control system, the physical world and the underlying IT network to cyberthreats. Many of these control systems reside within the civil engineering portfolio; therefore, it is our responsibility as civil engineers to respond accordingly.

Special precautions, operational requirements and cybersecurity considerations must be taken because of the unique nature of control systems. Control systems are extensively integrated into the physical infrastructure on Air Force installations and can have long lifespans (often 20-30 years), thus it is incredibly difficult to secure control systems after the fact. Additionally, in the traditional IT domain, cyberdefenders often focus on preventing disclosure of information, whereas, for control systems, it is paramount to actively keep the systems up and running. These are some of the differences in cybersecurity priorities that impact what procedures are appropriate to safeguard control systems compared with traditional IT. In all cases, security solutions must be tailored to the specific control system environment and verified to ensure their impact is not detrimental to a control system's operation.

We must conquer significant hurdles in order to effectively defend against cyberthreats to our infrastructure, not least of which include time, money and an acute lack of control-system cybersecurity expertise in the workforce. We all must accept that this is the new landscape the world is facing, and it is our responsibility as caring stewards to act and adequately defend the physical world that impacts so much of our lives.

Civil engineering leadership has been engaged over the last year or so to find answers to these most difficult questions and are moving forward on a plan to respond to the increasing threat against control systems, guided by the Air Force Control Systems Cybersecurity Framework (see Pages 10-11).

Facing page: Many modern-day control systems have been integrated with a Human Machine Interface to closely monitor production and respond to changing demands. As these complex systems become increasingly comingled with IT, securing this critical infrastructure becomes a primary concern. *(U.S. Air Force Photo/Senior Airman Joshua Turner)*

As electrical power substations become more complex, cybersecurity of substations must become a priority. *(Photo courtesy of U.S. Corps of Engineers, Clear Air Force Station, Alaska)*

We as members of the CE community must do more to contribute, increase awareness and be vigilant, as we are all protectors of our Air Force infrastructure.

This concerns you. All members of civil engineering are encouraged to engage in the June 2017 video feature that will provide our community with a foundation on control systems cybersecurity. You can register by going to the CE Portal.

If you would like to learn more about this growing area of importance, consider visiting the Air Force Control Systems Community milBook site and taking a look at the recently published AF guidance memorandum on CS cybersecurity (AFGM2017-32-01).

All Airmen are cyberwarriors. Think globally, act locally.

Editor's note: *Obruba is the branch chief of operations and maintenance for the Directorate of Civil Engineers Facilities Division.*

Airmen and contractors use an energy management control system to remotely monitor air-conditioning systems on Dyess Air Force Base, Texas. *(U.S. Air Force photo/Senior Airman Alexander Guerrero)*

AIR FORCE CONTROL SYSTEMS CYBERSECURITY FRAMEWORK

START HERE

The owners and operators of the Air Force's massive inventory of control systems have the mission to safeguard these control systems and other operational technology that support and enable the execution of the Air Force core missions. The scope of this effort encompasses thousands of control systems embedded throughout:

Air Force Installations – **183** (86 Major AF Bases, 10 AFRES, 87 ANG)
Buildings – **49,500+**
Structures – **47,960+**
Linear Structures – **30,800+**

This effort is further complicated by the fact that these "Systems of Systems" are geographically dispersed among bases and resources around the globe.

RISK TO CONTROL SYSTEMS

THREATS

FOREIGN NATION STATES
Typically the most skilled and dangerous type of Hackers—Foreign Nation States seek to gain intelligence on or cause serious harm to the people and interests of the United States.

CYBER MERCENARIES
Skilled and out for personal gain—Cyber Mercenaries may operate independently, as a group, or hired in part of a larger Foreign Nation State effort.

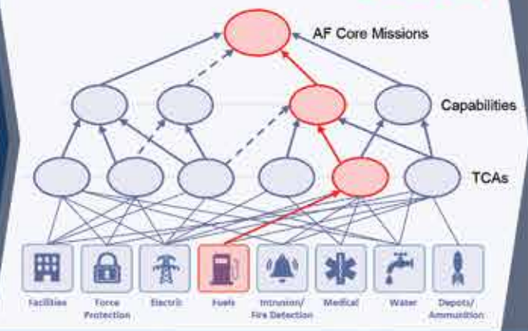
HACKTIVISTS
Often considered as "cyber-vigilantes seeking political ends." Hacktivists typically seek to coordinate attacks that create discourse by garnering major media focus.

SCRIPT KIDDIES
These cyber criminals typically use existing malware to attack systems for the purpose of vandalism or in order to gain personal notoriety

VULNERABILITIES

IMPACT TO MISSION

(Notional Mission Thread Critical Path)



CYBERSECURITY POLICIES, GUIDANCE & MANDATES

Executive Order 13636
Improving Critical Infrastructure Cyber Security

Presidential Policy Directive 21
Critical Infrastructure Security & Resilience

NIST Cybersecurity Framework
Framework for Improving Critical Infrastructure Cybersecurity

NIST Guide to Industrial Control Systems Security 800-82r2
Framework for reducing Cyber Risks to Critical Infrastructure

DoDI 8500.01
DoD Cyber Security Program

AFI 17-130
Air Force Cybersecurity Program Management

Unified Facilities Criteria 4-010-06
Cybersecurity of Facility-Related Control Systems

DoDI 8510.01
Risk Management Framework for DoD Information Technology

Draft DoDI 8530
Department of Defense Computer Network Defense

Draft DoDI 8150.01
Cyberspace Workforce Management

CNSSI 1253
Security Categorization and Control Selection for National Security Systems

AFI 17-101
Risk Management Framework for AF Information Technology

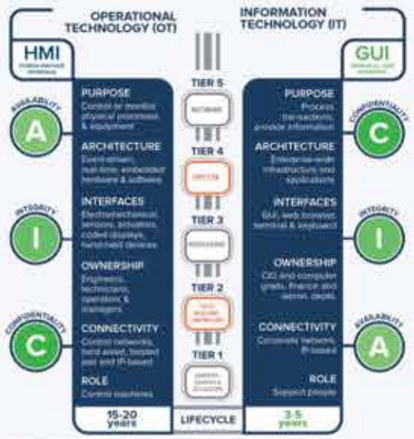
NSA ICS Cybersecurity Guides
4-Part series on assessing, improving and managing the security posture of ICS

AFGM2017-32-01
Civil Engineer Control Systems Cybersecurity Guidance Memorandum

STRATEGIC LINES OF ACTION

- LOA 1 — Mission Thread Analysis
- LOA 2 — Cyber Risk Management
- LOA 3 — Control System Defense & Operations
- LOA 4 — Cyber Workforce Development
- LOA 5 — Cyber Resilient Acquisitions
- LOA 6 — Control System Cyber Intelligence

CHALLENGES



CNSSI No. 1253 (Security Control Overlays For Industrial Control Systems)

AIR FORCE CONTROL SYSTEMS ARCHITECTURE

BASE-LEVEL

Perimeter Security Systems | Access Control Systems | Utility Control Systems | Building Control Systems | Intrusion Detection Systems | Fire Detection & Alarm | Fuel Management Systems | Aircraft Arresting Systems | Medical Systems | Airfield Lighting Systems | Power / Electrical Backup | Water, Wastewater

ENTERPRISE-LEVEL

BASE CONTROL SYSTEMS ENCLAVE

CS Network

AFIN

TRAIN CYBER READY WORKFORCE

Organize, train & equip

Attract & retain talent

Enculturate cybersecurity

Cultivate Information Assurance & Control System SMEs

Formalize cross-career-field awareness

Partner for knowledge-sharing

SECURITY ASSESSMENT PROCESSES

DEFENSE IN DEPTH & BREADTH

TASK FORCE CYBER SECURE

Holistic View:
Gaining the insight to conquer uneven and fragmented cybersecurity efforts across Air Force platforms and systems

Cyber Awareness:
Communicating cybersecurity methodologies across the Air Force to overcome disparate levels of cyber awareness

Subject Matter Expertise:
Cultivating a multi-disciplinary workforce and mindset, integrating cybersecurity and domain expertise, in order to enable mission assurance

PEOPLE, PLAN, PROTECTION

v 2.2

Right base, right place:
Strategic basing enables global airpower today and tomorrow

By Carol Ann Beda and Col. Terry Walter
Office of the Secretary of the Air Force
and Lt. Col. Kevin Parker
Directorate of Civil Engineers, Headquarters Air Force

Air Force installations serve many purposes — training centers, research-and-development hubs and organizational headquarters, but most are weapon-system platforms.

The Air Force operates globally from strategically located main operating bases and other locations throughout the United States and overseas. Bases are not just points of departure for expeditionary operations, but increasingly, they are the platforms from which multidomain combat power is directly employed.

Whether bases project power, launch satellites, train aircrews or conduct research, some locations are operationally better than others for enabling these activities. Strategic basing, the process by which the enterprise chooses locations for its missions and forces, is a key component of realizing its vision. The Air Force Strategic Master Plan established a strategic objective to "ensure the right installations (force structure and missions) are in the right place to support Air Force missions globally."

So how does the Air Force meet this objective? The strategic basing process, led by the deputy assistant secretary of the Air Force for installations, environment and energy, aligns installations with long-term mission requirements and considerations across the enterprise.

Air Force Instruction 10-503, Strategic Basing, states the purpose of the strategic basing process is "to provide an enterprisewide, repeatable process for decision-making to ensure all basing actions involving Air Force units and missions support Air Force mission requirements and comply with all applicable environmental guidance."

This process looks across the Air Force for potential basing solutions to any new or changing missions. Operational considerations are key to setting the right enterprise for any given action.

A first step is defining the "go, no-go" elements to determine which installations to consider during the basing process. Basing criteria such as mission requirements, capacity, environmental issues and costs are all factors evaluated to put the right missions at the right base. Mission requirements are proposed by the mission owner with the best understanding of the unique operational needs. Mission requirements for research and development activities might include proximity to civilian research centers. Flying training missions might include the number of good-weather days. Combat aircraft missions might include flight time to training airspace or a bombing range.

The strategic basing process has the high-level senior leadership involvement it needs to affect basing decisions. A cross-functional strategic basing panel reviews proposals and makes recommendations to a two-star executive steering group, which subsequently feeds into the Air Force corporate structure and ultimately to the secretary of the Air Force for a decision, when required. The process also includes engagement with members of Congress at appropriate points, usually after a basing decision. The process applies to large activities, such as the beddown of new weapon systems, such as the KC-46As and F-35As; and to smaller actions such as any unit relocation, manpower growth over 35 personnel and allowing another service or Department of Defense agency to move onto an Air Force base.

For the past five years, Air Force leaders have consistently testified to Congress about the need for another round of Base Realignment and Closure, because the enterprise expends precious manpower and funding to operate too many suboptimized installations. Under significant pressure to reduce costs and improve readiness, a whole-base closure can offer significant recurring savings. However, BRAC is frightening to many military communities, to the point Congress will prohibit the DOD from even planning for a BRAC, as it did in the 2016 National Defense Authorization Act.

Air Force leaders argue that a comprehensive look to optimize current and expected force structure, coordinated to support competing operational equities, would yield a better strategic laydown than conducting individual basing actions. BRAC undoubtedly would create savings and allow the enterprise to consolidate missions at locations more suitable for each unique operational requirement.

Absent base closure authority, new mission beddowns and realignments through the strategic basing process still allow the Air Force to better meet mission requirements while gaining efficiencies. BRAC would amplify these benefits by enabling the enterprise to consider other important factors, such as the optimum number of aircraft assigned to a squadron, the number of squadrons within a group or wing, and the number of bases of the same type needed to meet operational requirements.

Strategic basing is not a static analysis; the process is repeatable, transparent and defendable, but each action is unique in terms of mission, timing, capacity, component, geopolitical landscape or even budgetary constraints. Each time an action comes forward, the Air Force must assess emerging factors that could enhance or impede the mission. Looking further into the future, strategic basing may need to place increased attention on several additional factors.

Determining where F-35As ***(below)*** and KC-46As ***(left)*** will be based is handled through the U.S. Air Force strategic basing process. Multiple factors are considered, including mission requirements, capacity, environmental issues and costs. *left (Courtesy illustration) below (U.S. Air Force photo/Staff Sgt. Madelyn Brown)*

The global trend of growing urban population centers often creates a source of encroachment near installations with potential limiting consequences on operations. An increasing threat from longer range missiles makes some overseas bases more vulnerable. Rising sea levels could make flooding more frequent at coastal installations. And, natural disasters — more predictable in certain regions — not only impact operations but also add to the total life cycle cost of operating a base.

At its best, strategic basing helps the Air Force incorporate the most relevant factors into shaping smart basing decisions. If BRAC becomes a reality, this process will enable the enterprise to be better positioned to create fully informed recommendations that consider both structural and emerging requirements and constraints.

Editor's note: *Beda is the director of strategic basing and Walter is director of installation planning for the secretary of the Air Force's installation, environment and energy division. Parker is the branch chief of strategy and future concepts for the Directorate of Civil Engineers Planning Division.*

Air Force remains vigilant in tracking hazardous chemicals

By Kevin G. Gabos
Air Force Civil Engineer Center

Sarah Lane, electroplater, dips parts into a degreaser vat for cleaning at Robins Air Force Base, Georgia. The facility minimizes worker exposure and manages emissions and hazardous waste. *(U.S. Air Force photo/Sue Sapp)*

New federal regulations on production and use of chemicals may pose operational risks to military weapon system maintenance procedures.

On June 22, 2016, the Frank R. Lautenberg Chemical Safety for the 21st Century Act, which amends the Toxic Substances Control Act, was signed into law. This law mandates that the Environmental Protection Agency evaluate existing chemicals with clear and enforceable deadlines. As a result of this new law, the EPA identified the first 10 chemicals to evaluate under updated requirements. The goal is to ultimately determine if the identified chemical risk warrants voluntary or regulatory actions to reduce risk, creating the potential for voluntary withdrawal of certain chemicals from the marketplace or regulatory restrictions on their production and use. Maintaining military weapons systems requires unique corrosion control and performance considerations.

The Air Force uses a rigorous chemical authorization and tracking process to associate all consumable hazardous material inventory to the appropriate safety data sheet information when it arrives on installations. This tracking enables compliance with existing laws, regulations and reporting requirements and allows the service to assess potential risks of increased regulation or limited chemical availability.

Each chemical product is authorized to a specific organizational shop and industrial process using the Enterprise Environmental Safety and Occupational Health Management Information System, providing visibility to individual chemical product formations as they are consumed in various processes around the world. As part of any risk assessment, Air Force Civil Engineer Center personnel partners with representatives of the Headquarters Air Force Directorate of Logistics, Engineering and Force Protection and the office of the assistant secretary of the Air Force for acquisition. This partnership is critical to assess the mission-critical nature of any particular chemical.

The initial safety system data pull for the first 10 chemicals targeted by EPA indicated essentially no Air Force usage for half of the chemicals over the preceding 36-month period, but identified significant usage of several chemicals, including methylene chloride; n-methyl-2-pyrrolidone, or NMP; tetrachloroethylene; 1-bromopropane; and trichloroethylene. The Air Force's analysis of methylene chloride and NMP identified several military-specific uses that are critical for national security.

Subsequent interaction between the Air Force and EPA resulted in EPA granting a five-year deferment to restrict the use of methylene chloride and NMP for paint and coating removal. EPA included in this exemption corrosion-sensitive military aviation and vessel mission-critical components such as landing gear, gear boxes, turbine engine parts and other military aircraft and vessel components composed of metallic materials (specifically high-strength steel, aluminum, titanium and magnesium). Also included are composite materials that not only require their coatings be removed for inspection and maintenance but also would be so negatively affected by the use of technically incompatible, substitute paint-removal chemicals or methods that the safe performance of the vessel or aircraft could be compromised.

Tetrachloroethylene is used predominantly at the Warner Robins Air Logistics Complex, Georgia, and accounts for 94 percent of Air Force usage. The use is limited to an industrial-grade dip tank and vapor degreasing process that is transitioning to a new $65 million Advanced Metals Finishing Facility, which minimizes worker exposure and manages emissions and hazardous waste. Air Force depot maintenance operations involving vapor and other cleaning processes uses 1-bromopropane. The Air Force also uses trichloroethylene for weapon-system spray cleaning and degreasing in much smaller-scale industrial processes. Most usage is where trichloroethylene is a primary ingredient in one particular product.

Air Force vigilance in the authorization and tracking of hazardous chemicals enables compliance with environmental and health regulations and puts the agency in a proactive posture to understand mission dependencies and mitigate the risk of further regulation.

Editor's note: *Gabos is AFCEC's subject matter expert on hazardous material, hazardous waste and pollution prevention.*

Kyle Jackson uses an Aqua Miser to remove paint from an F-15 fuel tank at Robins AFB, Georgia. New improvements to the HVAC system will improve working conditions in the area. The Air Force uses a rigorous chemical authorization and tracking process that enables compliance with laws, regulations and reporting requirements for hazardous chemicals. *(U.S. Air Force photo/Sue Sapp)*

PUSHING THE energy envelope

By Robert Gill
Air Force Civil Engineer Center

The assistant secretary of the Air Force for installations, environment and energy recently released a new Air Force Energy Flight Plan, pushing the edge past the conservation frontier. The flight plan dated January 2017 sets the stage for a new approach toward energy that puts more emphasis on resiliency to assure a constant supply of energy to power Air Force missions.

The three strategic goals outlined in the plan are: improve resiliency, optimize demand and assure supply. Replacing and retrofitting energy equipment and infrastructure with innovative technologies is paramount to helping the Air Force stay relevant in the 21st century; however, the Air Force energy community also must include innovative business practices to ensure these core objectives are realized.

Recently, the Air Force Civil Engineer Center's Energy Directorate helped award two contracts to third-party, private companies to complete energy projects at Tinker Air Force Base, Oklahoma, and Vandenberg Air Force Base, California. Both projects, while executed with different contracting methods and business models, contribute to the installations' energy assurance in ways previous contracts did not.

The energy-saving performance contract, or ESPC, at the Oklahoma City Air Logistics Complex, or OC-ALC, at Tinker AFB was awarded Dec. 13, 2016, to Honeywell International Inc. It is valued at more than $262 million, making it the largest ESPC in the Air Force. By expanding the scope of the contract, the energy service company was able to take a holistic approach to the complex's opportunities for improvements in energy efficiency, water efficiency and industrial processes.

Additionally, the large scope of the project did not delay the contract's timeline; the Defense Logistics Agency Energy was able to execute the project within 21 months. This ESPC satisfies the flight plan's goal to optimize demand, which will in turn assure supply to other areas of the installation where energy is needed, not only in facilities, but in business operations as well.

The power purchase agreement, or PPA, at Vandenberg differs from previous agreements by being the first to have power delivered straight to the installation. A solar array to be erected by SunPower Corp. is expected to provide 54,500 megawatts of energy each year, or about 35 percent of the total installation energy usage. Furthermore, the array will feed energy directly to Vandenberg rather than being directed to the commercial grid first.

This project not only provides significant cost avoidance for the Air Force, but also a redundant, behind-the-meter source of energy for the installation and its critical space launch and tracking mission. Using a long-term contract with fixed costs ensures the installation will have the electrons it needs when it needs them and broadens the pool for power sources. In essence, this contract meets two of the three goals outlined in the Air Force Energy Flight Plan: improve resiliency and assure supply.

Aircraft Mechanic Steven Harris, 564th Aircraft Maintenance Squadron, preps window areas for installation on a KC-135 Stratotanker at the Oklahoma City Air Logistics Complex at Tinker Air Force Base, Oklahoma. The energy-saving performance contract awarded to Honeywell International Inc. at Tinker will include process energy conservation measures at the OC-ALC to reduce energy usage. *(U.S. Air Force photo/Kelly White)*

The Air Force will continue to utilize third-party finance models to achieve energy goals and objectives outlined in the flight plan and mandated by the Department of Defense. The Air Force Civil Engineer Center's goal is to always execute these contracts to meet one or more of the goals: improve resiliency, optimize demand and assure supply. These two innovative contracts will serve as models for future projects to include aspects of resiliency as well as energy conservation.

Editor's note: *Gill is AFCEC's director of energy.*

More than a dozen companies, the Oklahoma City Air Logistics Complex and the 72nd Civil Engineering Directorate energy teams showcase innovations to lower energy costs during an expo at Tinker Air Force Base, Oklahoma, last fall. *(U.S. Air Force photo/Kelly White)*

An energy company that recently was awarded a power purchase agreement is set to design and build a 28-megawatt solar photovoltaic array at Vandenberg Air Force Base, California. The array will span approximately 200 acres and will be tied directly into the base's power grid. *(Courtesy photo)*

Electronics mechanic J.D. Drake, with the 550th Commodities Maintenance Squadron, checks equipment at a compact range at the Oklahoma City Air Logistics Complex at Tinker Air Force Base, Oklahoma. Honeywell was awarded an energy-saving performance contract at the OC-ALC, which is expected to reduce energy usage by 35 percent. *(U.S. Air Force photo/Kelly White)*

Leadership working to relieve CE pain points

By Col. Monte Harner
Directorate of Civil Engineers, Headquarters Air Force

How many times have you felt frustrated about doing something that your squadron, flight or team didn't seem to be adequately resourced to accomplish? Did you find yourself wondering if civil engineer senior leaders have any understanding about the significant challenges you face each day and whether they are doing anything to try to mitigate them? We have all been told to "do more with less" and "work smarter, not harder," and have taken countless surveys that document just how thin our units have been stretched, but somehow the requirements never seem to change.

The CE Squadron Diagnostic Analysis was undertaken to provide the Air Force director of civil engineers with direct and unvarnished feedback from CE squadron commanders and directors and base civil engineers on their most visible and significant challenges. The effort was initiated after the March 2016 Base Civil Engineers Conference via an online survey that posed two questions:

1. How has the lack of resources affected you at an installation level? Give an example of a scenario where resources were limited but success was still accomplished.

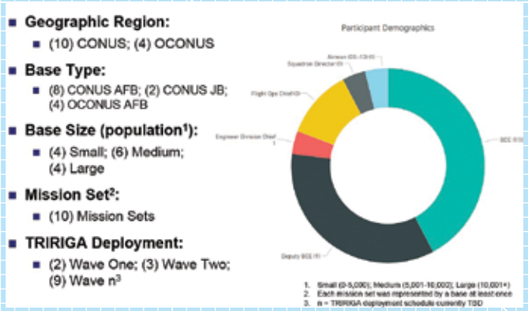
2. How have you or your colleagues developed innovative solutions to solve tough problems you face in your job?

To gather additional detail and perspective, these results prompted a subsequent analysis of CE squadron inputs, including one-to-one interviews with a subset of CE commanders or base civil engineers and staff, performing root cause analysis and developing proposed solutions.

Information was gathered and analyzed according to the methodology above. *(U.S. Air Force graphic)*

A series of interviews were conducted with select squadrons. Anonymity allowed participants the freedom to respond candidly without fear of retribution or retaliation and helped to reveal real challenges. Due to the frequency of responses surrounding additional duties, further analysis was conducted to identify those efforts outlined in the secretary of the Air Force/chief of staff, U.S. Air Force memos, "Reducing Additional Duties" (dated Aug. 18, 2016) and "Reducing Ancillary and Computer-Based Training" (dated Oct. 27, 2016). The implementation of these efforts is being worked through the deputy undersecretary of the Air Force, management, along with continuous process improvement support from the director of management improvement.

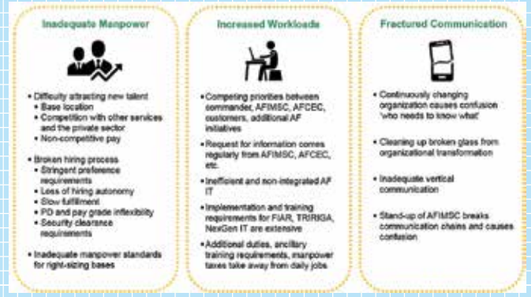
To provide an adequate sampling, several base attributes were considered in selecting units used in the follow-up interviews: base type, size, mission, location and status of TRIRIGA deployment. We collected 200 interview responses from 26 participants spanning 14 bases and bucketed them into six pain-point themes: inadequate facilities and deteriorating installations; lack of asset visibility; decreased resource allocation and availability; inadequate manpower; increased workload; and fractured communication.



Responses were gathered from 26 participants on 14 bases to ensure a broad-based demographic. *(U.S. Air Force graphic)*

It was recognized immediately that the first three major pain-point themes already were being worked through several existing CE enterprise improvement initiatives, such as: CE flight plan, CE capabilities, installations-of-the-future, NexGen IT deployment, financial improvement audit readiness, Air Force Common Output Level Standards realignment, the Air Force Civil Engineer Center's space management and optimization initiative, AFCEC 2.0 High Risk IPTs, etc.

Thus, additional deep-dive analysis was focused on the other pain points: inadequate manpower, increased workloads and fractured communications. Through this effort,



Further analysis revealed complaints fall into three categories: manpower, workload and communication failures. *(U.S. Air Force graphic)*

we identified more than 50 major root causes that were categorized further under people, processes, technology, organizational structure and communications infrastructure. We also developed an initial set of 36 potential solution sets, which were vetted and prioritized by the Air Force Logistics Engineering and Force Protection civil engineers division, or A4C, chiefs. This prioritization led to eight unique and robust solution recommendations, we're calling the Elite Eight.

The Elite Eight were validated and approved by Maj. Gen. Timothy Green, director of civil engineers, on the condition that, as decisions are made at the Air Force headquarters level, we remain mindful of how it could impact CE squadron commanders and their Airmen engineers. He further stated that all air staff members have a responsibility to think about what the headquarters is asking of the squadrons, and we should continually ask ourselves, "Does this truly provide value to the squadron?" and "Does this agitate or mitigate the challenges our squadrons face?" These solution sets were subsequently approved through CE's enterprise governance structure via the CE Board in November 2016.

The activities driven by the Elite Eight will contribute to our ability to: attract and recruit engineers (people); address squadron vacancies (people); minimize training requirements (people); advance civil engineer squadron capabilities within civilian hiring processes (processes); establish a base civil engineer best practice site (processes); expand leadership engagement forums (communications infrastructure); improve information technology systems training (technology); and march toward the CE squadron of the future (organization and processes).

The results of this analysis are beginning to gain momentum within our CE enterprise as the work is being communicated, including at AFCEC. The implementation of the recommended solutions will be developed and executed throughout the CE organization, but AF/A4C has focused the air staff on those opportunities that fall within its areas of responsibility and authority.

Elite 8 Solution Sets

PEOPLE	1.0 Attract and Recruit Engineers
	2.0 Reduce Squadron Vacancies
	3.0 Reduce Training Requirements
PROCESSES	4.0 Advance CES Capability Within Civilian Hiring Process
	5.0 Estabiish a BCE Best Practice Website
COMMUNICATION INFRASTRUCTURE	6.0 Expand Leadership Engagement Forums
TECHNOLOGY	7.0 Improve CE IT Systems Training
ORGANIZATION & PROCESSES	8.0 March Toward the Squadron of the Future

None of this work would have been possible without the participation of those who contributed their valuable time to support a variety of surveys, interviews, data calls and workshops. Because of your candid and honest feedback, over the coming months, we will begin implementing improved processes and tools shaped to ease the burden of our squadrons and Airmen engineers across the enterprise, enabling them to better focus on fulfilling mission objectives.

Know that your voices have been heard!

Editor's note: *Harner is the chief of the Installations Strategy and Plans Division within the Directorate of Civil Engineers.*

Innovations take flight with

U.S. AIR FORCE OEA

OFFICE of ENERGY ASSURANCE

By Robert B. Hughes
U.S. Air Force Office of Energy Assurance

The U.S. Air Force has a long-standing legacy of innovation when looking toward the future, identifying challenges and developing solutions. When it comes to planning for natural disasters, cyber- and physical attacks and other challenges, the Air Force is transforming the way it looks at energy to assure today's and tomorrow's mission.

In February 2016, the Office of Energy Assurance was established to serve as a storefront for installation energy across the Air Force enterprise. OEA focuses on developing large-scale, resilient, cost-effective, clean energy projects. As the dedicated storefront collecting energy project opportunities from Air Force and external stakeholders, OEA is finding creative ways to ensure success in achieving mission assurance through energy assurance.

Here are just a few snapshots of how OEA is exploiting lessons learned and developing new ideas to enhance and improve Air Force missions:

Resilient Energy Demonstration Initiative
REDI is aimed at developing a process for soliciting and partnering with industry to build microgrids that enhance mission assurance. Through a pilot program at Beale Air Force Base, California, OEA is developing a repeatable process to be used at other installations with minimal modification.

During Phase I, we learned the Air Force doesn't typically collect some information needed by industry partners to effectively design a complex microgrid. In Phase II, termed Priming Resilient Energy Procurement, the team is working to standardize data and infrastructure condition assessments to support microgrid development.

Meanwhile, OEA is taking lessons learned from REDI and incorporating them in workshops for installations and missions across the Air Force enterprise.

Energy assurance workshops
Achieving energy resiliency for critical missions is a complex endeavor that is difficult to do all at once with one funding source or contract mechanism. We also know that stand-alone energy projects that are not coordinated as part of a broader strategy fail to leverage economies of scale, capture complementary results and block off future assurance opportunities.

To solve this problem, OEA is helping installations develop comprehensive energy-assurance strategies driven by mission requirements. We also help installations determine optimal third-party funding and scope projects that require appropriated funding to meet overall strategy goals.

Microgrid operational and technology initiatives
Energy assurance isn't free, and part of our mission is focused on identifying new and innovative ways to pay for assured energy supplies. At Otis Air National Guard Base on Joint Base Cape Cod, Massachusetts, the Air National Guard is conducting an Environmental Security Technology Certification Program aimed at overcoming cybersecurity, technology and operational challenges to operate a microgrid that generates revenue from regional electric grid markets. OEA recognizes the ability to securely operate a microgrid as a dynamic asset generating revenue or producing savings through peak shaving and load management, will be a key factor enabling broad implementation. We're working hard to help crack that code.

While the focus at Otis ANGB is on solving an economic problem, at Joint Base Pearl Harbor-Hickam, Hawaii, we are watching the Air Force Research Laboratory pair existing traditional resiliency solutions with new technology and infrastructure to maximize resiliency through multiple tiers of backup.

The research laboratory is integrating existing traditional diesel generator configurations with alterative supply options and storage at the feeder and sub-circuit level to deliver tiered layers of security that demonstrate an optimal approach to respond to outages of any duration. At OEA, we view this tiered structure as the best way to blend existing assets, investment in newer technologies and operational protocols to deliver maximum assurance. Our intent is to help transfer principles and solutions from the Joint Base Pearl Harbor-Hickam microgrid across the Air Force.

Accelerator and incubator programs
Accelerator programs are a way of developing key energy technologies and speeding their penetration into the Department of Defense and Air Force markets. Since 2001, the research laboratory has been working with the Hawaii Center for Advanced Transportation Technologies, an accelerator program focused on developing fuel-efficient technologies for use in Air Force ground vehicles, support equipment and base infrastructure. The Navy also made an investment in a Hawaii accelerator program, the Energy Excelerator, to tap into groundbreaking energy technologies that help achieve energy goals through science and technology.

OEA is looking to collaborate under the accelerator model with Navy, U.S. State Department, commercial and other partners with similar goals. We're reviewing this model as a means to develop better solutions more quickly. To close the loop and bring these technologies fully into the DOD market through third-party funding mechanisms, we're partnering with the DOD environmental security program to develop problem statements that address Air Force and broader DOD requirements for energy assurance through advanced technology.

Energy as a service
OEA, with the assistant secretary of the Air Force for installations, environment and energy office, is exploring energy as a service, a business model in which the Air Force specifies a comprehensive suite of energy supply and resiliency requirements, and commercial providers develop the solution that best meets those requirements. This concept lets energy experts develop a solution that is not part of the Air Force core mission or capability set, transfer a portion of energy market risk to the commercial provider and provide the Air Force with a single solution that addresses: operation of and investment in on-base electric utility systems; procurement of supply; and implementation of energy conservation measures.

Using that model will ensure the Air Force has the power when, where and how it's needed, and provide the Air Force with a holistic view of energy assurance that eliminates silos and looks beyond planning for single points of failure.

Partnering with sister services
We're not doing this alone. The Air Force's OEA and the Army Office of Energy Initiatives are co-located and are working together to identify joint projects and leverage experience to enhance the development of energy assurance on Army and Air Force installations. Collaboration will facilitate multiple installation and joint energy projects that will benefit from an increased military profile in the marketplace and support Air Force, Army and Navy energy security goals and objectives. We are excited to be continually engaged in partnership with our sister service branches in pursuit of achieving common energy-related goals.

Editor's note: *Hughes is the director of the U.S. Air Force Office of Energy Assurance.*

Below: A newly installed 134 kW photovoltaic array at Joint Base Pearl Harbor Hickam, Hawaii, is part of the Pacific Energy Assurance and Resiliency Laboratory, a renewable-energy microgrid project demonstrating new ways for military facilities to address energy needs. *(Photo courtesy HNU Energy/Joseph Cannon)*

Petroleum storage solutions reduce environmental risk

By Robert R. Johnson
90th Civil Engineer Squadron

In June 2015, the Environmental Protection Agency updated rules that previously exempted monthly inspections for underground storage tanks and will require costly upgrades for emergency generators and airfield hydrant systems.

Collectively, the Air Force's three missile wings operate 485 underground storage tanks in remote and highly secure locations. Because of the locations of these missile sites, the wings will incur difficulty in complying with the increased monthly inspections and tank upgrade requirements. Of the 485 tanks supporting the nuclear deterrence mission, F.E. Warren Air Force Base, Wyoming, alone has 184 underground storage tanks in geographically separated locations covering three states and 10,000 square miles. The closest location is 33.5 miles and farthest is 151 miles from the base.

When the EPA regulations go into effect on Oct. 15, 2018, the missile wings will incur significant funding challenges due to additional manning and training in order to comply. As currently staffed, we will be unable to comply with the new regulations, which will result in fines imposed by the EPA as high as $37,500 per day for each of the tanks in the inventory. Tanks that do not meet the regulations could be prohibited from receiving fuel (be red-tagged) by regulators. This extreme action would prohibit emergency generation at the site for up to six months.

Using the current cost as a baseline, it was determined that monthly inspections at all of the locations will cost the base an additional $1.2 million per year. This requires the addition of eight military members and eight civilians to inspect the tanks assigned to F.E. Warren locations.

In January 2016, Greg Simonson of the Air Force Civil Engineer Center's installation support team at Peterson Air Force Base, Colorado, and I collaborated to develop a proposal to minimize costs and save on manning with minimal capital investments. To reduce the regulatory risk and enhance the mission, we gathered stakeholders assembled for an Air Force Smart Operation 21st Century event at the base in April 2016. Representatives included the Missile Engineer Office/Air Force Material Command, 90th Civil Engineer Squadron power production and environmental element, 90th Maintenance Group, as well as installation support teams from Offutt AFB, Nebraska; Peterson AFB, Colorado; and Hill AFB, Utah. Environmental element personnel from Malmstrom AFB, Montana, also participated.

The team evaluated four courses of action that addressed the imminent deficiencies with underground storage tanks:

- Upgrade existing tanks in-situ
- Use alternative fuels not subject to the new EPA regulations
- Replace the existing underground storage tanks with above-ground storage tanks
- Exchange existing underground storage tanks with vaulted above-ground storage tanks that reside underground

The first option explores continuing operations of the emergency generator system with underground storage tanks by upgrading to interstitially monitored double-wall spill buckets and double-wall sumps. This option could potentially cost $79,000 per site, or $38.32 million for all underground storage tanks across the three missile wings and take up to five years to complete.

Tanks found deficient would need to be replaced during the installation of the spill buckets, and sumps may cost an additional $150,000. Although the tanks would comply with EPA regulations, monthly inspections still would be required. This option adds manning and vehicles, and requires larger CE budgets. This option was unpalatable to the stakeholders due to long-term cost and stringent regulatory requirements.

The second course of action evaluated using alternative fuels to power the generators. This option evaluated utilizing propane and would require expensive system retrofits of the existing diesel generators. The team determined propane does not meet Air Force standards for emergency power generation.

The third course of action considered placing an above-ground storage tank on top of the existing underground storage tank. However, missile sites require additional evaluation to provide adequate security. The team was able to quickly dismiss this option because of security risks. The team chose the fourth course of action.

Underground vaulted above-ground storage tanks fulfill the requirements of the EPA rules while meeting security and hardness requirements of the nuclear mission. This option works by placing a precast or cast-in-place vault below grade in the same location as the current tank. The bottom of the vault will be at the current elevation of the low point of the underground shell and would have 12 to 15 inches of the vault top protruding above surface. The vaulted design would entail installing an above-ground storage tank with an Underwriters Laboratory designation inside the vault. The old tank would be removed and contact soils checked for leakage. This design removes stringent EPA inspection requirements, expensive in-situ system upgrades and reduces training requirements and certifications for inspections.

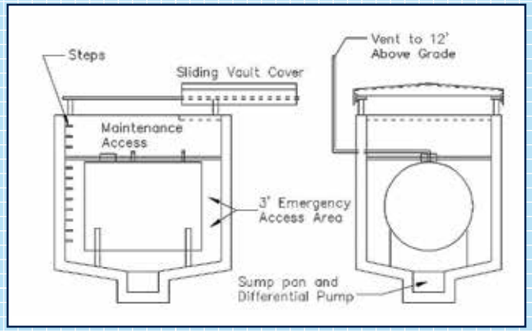
One benefit of a vaulted above-ground storage tank is the ability to quickly replace a faulty tank. The process would take a few days and cost about $50,000. Replacing an underground storage tank can take months, cost more than $150,000, and requires extensive regulatory coordination.

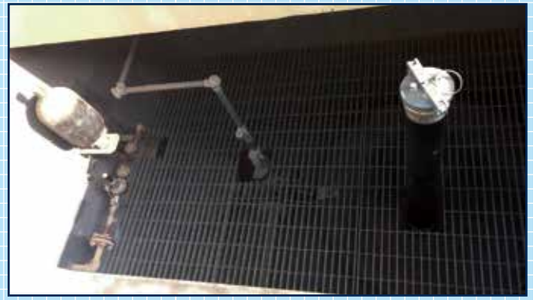
Another benefit of above-ground storage tank replacement is that manning requirements will be maintained at current levels due to the infrequency of inspection.

Training and certification costs are reduced as the vaulted tanks do not require EPA-directed, state-specific training and certification. All inspections would be performed by maintainers following the Storage Tank Accounting and Reporting database inspection checklist in combination with other inspections directed by major commands. An immense benefit to vaulted tanks is the formal inspection frequency, which requires an inspector to conduct only three formal inspections: upon installation and at 10 and 25 years afterward. In contrast, formal underground storage tank inspections require annual site visits and two trained and certified inspectors. Unlike with underground systems, cathodic protection in the vaulted above-ground storage tank system is not required.

A solution to mitigate the environmental risk posed by the age and configuration of underground storage tanks at the three missile wings is overdue. Many of the tanks have been in the ground for more than 50 years. The replacement project is needed to modernize and enhance the entire petroleum storage solution paradigm for the nuclear deterrence mission at Minot AFB, North Dakota; and Malmstrom and F.E. Warren AFBs.

This project is projected to save approximately $3 million annually in labor and training costs while complying with the new EPA rules. The immediate savings of safety and labor costs when combined with the projected long-term remediation savings of defective underground storage tanks is incalculable. This conversion will save money and provide a modern, environmentally friendly, mission-enhancing solution for petroleum storage to support the weapon systems well into the next 50 years of deterrence.





Top: Vaulted above-ground storage units allow for plug-and-play fuel operations for mission enhancements and reduced downtime.
Middle: The vault lid consists of sliding steel structures as shown or removable concrete slabs designed for easy inspection and replacement.
Bottom: Catwalk grating in the vault allows technicians to easily inspect the vault and tank without confined space entry. *(Courtesy photos)*

Editor's note: *Johnson is the storage tank manager with the 90th CES at F.E. Warren Air Force Base, Wyoming. He is a professional geologist.*

AFCEC lab supports warfighters in the field

By Craig Mellerski
Air Force Civil Engineer Center

The requirements, research and development, and acquisition division, part of Air Force Civil Engineer Center's Readiness Directorate, derives requirements, provides contingency support and develops materiel solutions to enable the Air Force civil engineer mission to support Air Force major commands and combatant commands.

The division was launched in October 2013 by realigning the Air Force Research Laboratory's Airbase Technologies Division, providing civil engineer R&D capabilities at Tyndall Air Force Base, Florida, to the newly established AFCEC. The acquisition branch provides contingency support with the Air Force Contract Augmentation Program branch through a $5 billion indefinite delivery, indefinite quantity contract for contingency services, construction and equipment. The second branch derives and validates CE new developmental capability requirements through the airbase requirements branch. The R&D and acquisition branch performs research and develops solutions for capability shortfalls.

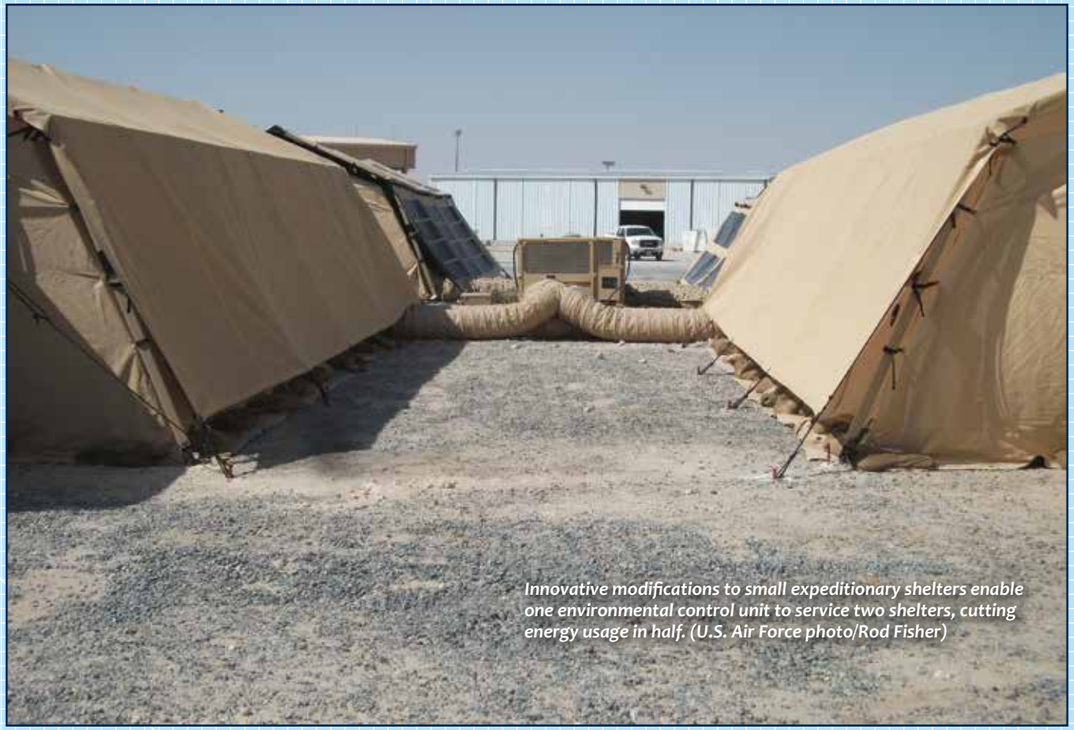
Airmen practice airfield damage repair techniques while testing lightweight protective suits. *(U.S. Air Force photo/Mekka Parish)*

The R&D branch relies on some remarkable and unique ranges, laboratories, equipment and intellectual resources in support of challenging research objectives of future scenarios. These facilities are the civil engineers' facilities. Solution development covers most, if not all, of the civil engineer capability areas such as airbase operating surfaces (i.e., pavements, structure, performance and materials); fire and emergency services (for fire extinguishing and extinguishing techniques and procedures); engineering mechanics and explosive effects (centered on ballistics and explosive threat protection technologies); robotics and unmanned systems (for technologies for first response, chemical biological, radiological and nuclear explosives and detection/neutralization, and air and ground airbase automation); base energy (for energy optimization, base self-sufficiency, power generation, waste and fuel reduction); and emergency management (chemical/biological, all-hazards, etc).

Research and prototyping facilities cover about 104,000 square feet of laboratories with multiple outdoor testing facilities. Wet laboratories comprise 11,100 square feet dedicated to materials and processes; chemistry, microbiology and pilot-scale testing; fire evaluation; pavement and structural material testing; and energy recovery, water and waste treatment evaluation. A full-scale fire testing facility with mock A-380 and C-130 aircraft is also part of the division's assets. That's right, the Silver Flag fire pit is operated by AFCEC's R&D branch. With regards to pavement research, a full-scale testing facility includes aircraft load simulators and an inclement weather test area. Robotic and automation ranges are operated to perform ground robotics, small unmanned aerial vehicle testing, operations and development. Lastly, a testing facility for explosive and blast studies includes a full-bay and exterior wall test structures and other structures for specific load tests.

A small, 'back packable' robot has been developed for use by explosive ordnance disposal teams. *(Courtesy photo)*

The newly created requirements, R&D and acquisition division is making a difference for the warfighter. One success



Innovative modifications to small expeditionary shelters enable one environmental control unit to service two shelters, cutting energy usage in half. (U.S. Air Force photo/Rod Fisher)

A waste-to-energy, large-scale gasification system prototype is energy efficient and eliminates hazardous emissions associated with open-pit burning. *(U.S. Air Force photo/Mekka Parish)*

story is the rapid improvement in airfield damage repair capabilities, which provides warfighters with a new definition of airfield repair with regards to new material, multi-use repair vehicles and repair processes.

Another success story benefited the explosive ordnance disposal team with the acquisition of a 'back packable' small robot in support of unexploded ordnance mitigation and hazard handling for those situations where vehicular transport was not possible or available. In this case, the short-time solution consisted of procuring a commercial off-the-shelf system rigorously selected among the existing and available technologies to best fit the EOD needs.

Furthermore, the division has been instrumental in developing materials that are candidates for replacing the currently fielded protective suits. The new material technology would provide chemical and biological protective suits that are lighter and with limited heat burden for the Airmen. The innovative technology solutions were scaled to low-rate production quantities, integrated into mission-oriented protective posture suits, and then evaluated at one of the AFCEC testing sites in relation to field operations requirements.

Another success story is in the area of energy at deployed sites. The division led efforts to minimize energy consumption for small expeditionary shelters. The energy research team identified, tested and demonstrated that with innovative modifications to the shelter (such as adding fly openings and insulated liners), the environmental control unit energy usage can be cut in half and still allow the cooling of two shelters with a single unit versus today's approach of one unit per shelter. Moreover, dedicated energy test sites hosted the evaluation of a prototype dedicated to waste-to-energy processes.

The prototype included large-scale gasification systems with the objective of disposing of solid waste in a manner that eliminates hazardous emissions associated with open pit burning. The process proved to be energy efficient, reducing the fuel required for combustion, and allowed generation of energy at the source. The system reduced or eliminated the requirements associated with open pit burning at the operational theater, limited exposure of deployed personnel to environmental hazards, reduced energy demand and reduced the demand of force protection by eliminating the need for a host nation to remove solid waste from the base or site.

Developments in additive manufacturing, small unmanned aircraft systems, airbase and energy resiliency, and new equipment and materials are being worked. You, the Air Force civil engineer, have access to it if you need it. We are looking for your problems and innovative ideas. Use major command civil engineers, execution panels (EOD, expeditionary engineering, RED HORSE, fire, etc.), program groups (operations, readiness, energy, etc.), subject matter experts or the AFCEC Reach-Back Center to reach out to us. Be innovative, take your ideas to reality. This is your lab, the Civil Engineer Laboratory.

Editor's note: *Mellerski is the chief of requirements for AFCEC's Readiness Directorate's requirements, research and development, and acquisition division.*

Left: A full-scale fire testing facility is among the requirements, research and development and acquisition division's assets. *(U.S. Air Force photo/Steven Wells)*

Below: Airmen practice rapid airfield crater repair techniques while testing new protective lightweight clothing for AFCEC's Civil Engineer Laboratory on Tyndall Air Force Base, Florida. *(U.S. Air Force photo/Mekka Parish)*

AFCAP: 20 years strong and leaning toward the next decade

By Wayland Patterson
Air Force Civil Engineer Center

The Air Force Contract Augmentation Program recently turned 20, successfully completing a second decade of contracted direct contingency support that began in 1997.

AFCAP was conceived as a means to leverage capabilities from the commercial sector and provide Air Force civil engineers and personnel with the Air Force Services Activity with a means to do "more with less." Twenty years later, and on the fourth contract, the program continues to be a significant force multiplier, not only for the Air Force, but also for other government agencies.

For the last two decades, the military has been shifting supply and support personnel into combat jobs and hiring contractors to do force sustainment, a move accelerated by force restructuring and changing resources. As the government support force ebbs, the mission can't survive without teamwork from industry. Increasingly, some of the team members that make this happen are private-sector contractors. Overall, support functions are being made leaner, lighter and more agile, and contractor support offers flexibility. AFCAP is a good tool created to capitalize on this contractor support capability and provide a bridge connecting the government and industry contractor teams.

AFCAP's first efforts involved storm recovery operations after Typhoon Paka, which hit Guam with wind speeds of 150-200 mph in December 1997. Through AFCAP, nearly $2 million in storm damage repairs at Andersen AFB were completed — a very successful start for the new program. But in the second year, there was no activity, and AFCAP almost ceased. On the first contract, the AFCAP contractor was Readiness Management Support, a wholly owned subsidiary of a joint venture between Lockheed-Martin and Johnson Controls. After the losses, due to no tasks in the second year, Lockheed-Martin pulled out.

In the third year, U.S. Air Forces in Europe requested AFCAP assistance, and Readiness Management Support responded. In 1999, RMS supported USAFE during Operation Shining Hope by building refugee camps in Albania for ethnic Albanians fleeing genocide in Kosovo. In the wake of the Kosovo Campaign, a new federal government customer needing fast response to catastrophic world events emerged. The Office of Foreign Disaster Assistance, a subdivision of the U.S. Agency for International Development, requested AFCAP assistance to provide materials to help ethnic Albanians returning to Kosovo with rebuilding their homes. Since then, AFCAP has helped OFDA provide just-in-time assistance to natural disaster and pandemic victims around the globe.

AFCAP's first project was storm recovery after Typhoon Paka hit Andersen AFB on Guam in December 1997. *(U.S. Air Force photo)*

AFCAP has provided support to all branches of military service, USAID and OFDA, as well as agencies such as the U.S. Immigration and Naturalization Service, the State Department, Department of Justice, the Federal Emergency Management Agency, the National Aeronautics and Space Administration, Homeland Security, Foreign Military Sales and the U.S. International Board of Broadcasters (the parent organization to "Voice of America").

The period since Sept. 11, 2001, has brought a multifold increase in effort for the program in support of Operations Noble Eagle, Enduring Freedom, Iraqi Freedom and more. The military mission, especially during the buildup to Operation Iraqi Freedom, was helped by the availability of a well-designed, fast-response contingency mechanism. For example, the ability to structure contracts into cost-plus arrangements was beneficial when AFCAP was tasked by USAFE to stockpile materials and buildings in Turkey in anticipation of a northern front for the operation. AFCAP was able to return $116 million of USAFE's funding when this effort was curtailed after the U.S. and Turkish governments failed to agree on terms.

Over time, the demographics of AFCAP have changed. During the first eight years, tasks were weighted more toward construction and commodities. Recently, over 95 percent of the efforts are "service" tasks such as production of electricity at Southwest Asia deployment locations, air traffic management, and operation and maintenance of forward-based infrastructure.

Air Force policy does impose a few restrictions on how AFCAP can be used. The initial response and force beddown for Air Force military operations or exercise scenarios are reserved for in-house military forces. AFCAP contractors are restricted from combat, but that doesn't mean they haven't operated, at times, under risky conditions. AFCAP contract employees have resided on almost all Air Force contingency deployment locations.

In 2007, the final fuel tank is removed from 'Stryker Village,' once used to support Saddam Hussein's 'Chemical Ali' troops to build chemical weapons before the Iraq war. *(Courtesy photo)*

In November 2005, the third iteration of the AFCAP main contract was the first Department of Defense multi-vendor contract mechanism. Speed-of-response remained for urgent tasks, but when time was available, the added competition among vendors served to keep overall costs down. The Navy followed the Air Force lead and awarded its new multi-vendor Global Contingency Construction Contract and Global Contingency Services Contract the following year. The Army benchmarked AFCAP and awarded its multi-vendor contract for the new LOGistics Civil Augmentation Program, or LOGCAP, in June 2008.

Since it began, the AFCAP team has awarded 942 tasks valued at $3.6 billion. The program currently has 27 open tasks in 11 countries with a total value of $149 million.

Over time, some of the biggest challenges supporting the warfighter came while the Army's LOGCAP main contract was under protest. The Army asked AFCAP to complete the building of Camp Taji in Iraq when its efforts stalled. The Army concept was to complete an eight-month planning phase before beginning construction. Since only six months remained until the camp had to be operational, the AFCAP vendor did a spiral design/build concept with construction underway as sub-segments of the design were completed. Under AFCAP, the construction was completed in six months, two months before the Army's planning phase would have ended.

Only a few individuals are aware of the impact AFCAP has on current missions. Today, if you were to ask anyone, "What do the fight against the Islamic State of Iraq and Syria; building of a new Air Force base in Africa; and providing early warning missile defense in Japan, all have in common," AFCAP would not be in the response.

The military's use of contractors is not a new concept. In fact, during the Revolutionary War, private firms fed cavalry horses. AFCAP is just a modern version of an established concept, now with 20 years of proven experience. As the Air Force Contract Augmentation Program moves into its third decade, we're ready to provide direct contingency support whenever needed.

For more information or to fill a contingent need through AFCAP, call DSN 523-2275 or commercial 850-283-2275.

Editor's note: *Patterson is the AFCAP branch chief and program manager in the Air Force Civil Engineer Center's Readiness Directorate on Tyndall Air Force Base, Florida. He is a retired Air Force officer and former base civil engineer, and air staff member with major command and number Air Force experience.*

Testing the power grid is key to mission success

By Maj. Josh R. Aldred
Air Force Civil Engineer Center

Electrical distribution systems are essential to launching and recovering aircraft; and supporting critical nuclear, space, intelligence, surveillance-and-reconnaissance and cyber missions.

As part of retired Air Force Col. John Warden's Five-Ring Model targeting strategy, military leadership should be targeted first, followed by the targeting of organic essentials and infrastructure. Organic essentials could include fuel — and by extension — backup power generation systems, which are normally fueled by diesel or jet fuel. Targeting of infrastructure includes critical nodes in the electrical distribution system such as substations, high-voltage transformers, overhead power lines, backup power generators, fuel storage tanks and power-switching components. Destruction or degradation of these components could result in sustained power outages, especially in remote locations with limited logistical capabilities.

The risk of failure increases as the grid becomes more complex and grid reliability becomes a function of the mean time to repair, or MTTR, for each component in the system. The MTTR is, in itself, a function of replacement part availability, repair crew expertise and switching capabilities required to complete a repair on an individual grid component. Therefore, part availability, human capital, training and grid complexity should all be considered when assessing existing critical infrastructure and resources for vulnerabilities.

Additional vulnerabilities in the Air Force's built infrastructure include a lack of investment and maintenance due to constrained fiscal environments, manning shortfalls, physical damage due to natural disasters, natural degradation due to corrosion and aging of critical components, and offensive cyberattacks on communications equipment.

Full-scale testing needs to be highlighted and supported by Air Force senior leaders because of the importance of these systems in accomplishing the mission. Most important, testing electrical systems needs to be accomplished in a manner consistent with the offensive capabilities of our enemies, including cyberattacks, the targeting of critical power system nodes off-base and the ability of our enemies to disrupt our utility systems inside the base perimeter.

Kunsan Air Base, Republic of Korea, is the home of the 8th Fighter Wing — also known as the Wolf Pack — and the wing's primary mission is to "Defend the Base, Accept Follow-On Forces, and to Take the Fight North."

Kunsan, about 150 miles south of the Korean demilitarized zone, is critical to rapidly projecting combat air power to deter North Korean aggression. To practice carrying out its mission, the 8th FW participates in bimonthy operation readiness exercises to test and stress F-16 sortie generation capabilities and the wing's ability to survive and operate in a chemically contaminated environment. Mission failure is not an option, and the wing is continuously innovating and testing new processes to become more resilient. A recent example is a basewide power outage during a flying day.

Facing page: Tech Sgt. Donald Ingram, 8th Civil Engineer Squadron, works to restore power to the main gate at Kunsan Air Base, Republic of Korea, Nov. 20, 2013. A mechanical failure caused the gate to shut down but the 8th CES worked to restore power the same day. *(U.S. Air Force Photo/Senior Airman Clayton Lenhardt)*

Below: Day or night, Kunsan Air Base, Republic of Korea, is postured to respond to any threat. A test of the power grid on a flying day offered several lessons. *(U.S. Air Force Photo/Senior Airman Colville McFee)*

Kunsan receives commercial power from Korea Electric Power Corp., and all power is passed through a single feeder and main transformer, where the power is stepped down to a lower voltage and routed to the installation's substation for secondary distribution. The main transformer is a single point of failure for commercial power supply to the base, and metal components and electrical insulation require annual maintenance because of the corrosive environment. Because of this, the base had been scheduling maintenance and basewide outages during weekends, eliminating major impacts to the flying mission.

In light of lessons learned from real-world transformer swap outs and facility outages during operational readiness exercises, the wing commander decided to schedule transformer maintenance during a flying day to determine mission impacts.

The outage was challenging; however, our team compiled 23 lessons learned and submitted 18 work orders to remedy the absence of backup generators to critical facilities such as communications transfer nodes, radio relay stations and lift stations.

We also determined that the standard one-hour monthly testing of generators did not adequately prepare the base for an outage. Kunsan's remote location, exposure to elements, oversized generators and challenges with receiving repair parts from the U.S. led to a perfect storm that required more testing than required by Air Force standards.

Despite a major focus on preventive maintenance, seven generators (about 10 percent) required major repairs (because of things like oil gasket failures, dead batteries and coolant leaks) during the 24-hour outage. Corrective actions to improve generator reliability include increasing the reorder points for commonly used parts and specify that newly installed generators be evaluated for component reliability and local access to spare parts. Additionally, nearly all of the generators were oversized and required a load bank for monthly load tests, implying that the generators should be resized or consolidated.

Other lessons learned include developing a generator inspection route to determine the locations of generator craftsmen if radio communications were lost or degraded. Communication was lost with generator craftsmen because of degraded radio capabilities caused by the power outage. A predetermined route with checkpoints would have allowed the command-and-control element to determine the approximate location of craftsmen. This practice should also be implemented for all logistics functions, including generator refueling.

A final lesson was that the installation's contingency response plan did not include an accurate listing of all real-property installed generators supporting critical facilities. The plan should be updated in accordance with the installation emergency management plan to prepare for natural disasters and emergency response capabilities. This requires buy-in and support from the installation commander and the base civil engineer.

Mission failure is not an option. The 8th Fighter Wing innovates and tests new processes to become more resilient. For example, in February 2016, 20 F-16s line up to test the ability to launch at a moment's notice. *(U.S. Air Force photo/Staff Sgt. Nick Wilson)*

Kunsan is a perfect example of an installation that requires consistent testing of the power grid — it is remote, there are numerous vulnerabilities to the power grid and there is a very high rate of personnel turnover. Continuous, rigorous and realistic testing of the electric grid and backup generators permit leadership to determine if previous vulnerabilities have been addressed and rectified — a process risk analyst N.N. Taleb has eloquently coined "post-traumatic growth."

We hope the lessons learned from Kunsan will inspire other installations to regularly test their critical electrical infrastructure and power generation systems to enable wing commanders to identify major vulnerabilities and shortfalls on their own schedule, rather than at a time when those mission-critical systems are needed most.

Editor's note: *Aldred holds a doctorate in civil engineering from the University of Texas at Austin and is a certified professional engineer. He is the chief of strategic energy initiatives for AFCEC's energy directorate.*

The author would like to acknowledge Lt. Col. Brian George, Lt. Col. Patrick Kolesiak, Capt. Brian Scism, Tarone Watley and Rex Belleville for providing feedback and comments. Additionally, Senior Master Sgt. Jean Fleury developed the courses of action for the power outage for the wing commander's consideration. Finally, Capt. Patrick Grandseart compiled the lessons learned during the power outage.

The Air Force continually tests operational readiness. Realistic testing of the power grid is just as essential to the mission. *(U.S. Air Force photo/Senior Airman Taylor Curry)*

Goodfellow team offers a case study in executing FIAR

By Maj Matthew G. Strickler
17th Civil Engineer Squadron

The stringent and time-consuming requirements of financial improvement and audit readiness compliance have impacted every Air Force civil engineer squadron, most notably within squadrons' asset accountability elements and execution support sections.

In early 2016, Headquarters Air Force Logistics, Engineering and Force Protection division, A4, held a real property summit to specifically address FIAR compliance. The summit identified 38 deficiencies and developed 38 corrective action plans, or CAPS. Installations supported 21 of those CAPS with a compliance deadline of March 31.

The plan of action by Goodfellow Air Force Base, Texas, hinged on understanding the CAPS; educating and obtaining support from the chain of command; and developing a plan with expeditious execution.

Kevin Bruce, Goodfellow's real property officer, immediately read the voluminous guidance provided by higher headquarters, the Air Force Civil Engineer Center and Air Education and Training Command. In order to successfully meet all milestones, Goodfellow had to fully understand each CAP's requirements and obtain clarifications on anything that was vague. Through a series of teleconferences with the Directorate of Civil Engineers, Headquarters Air Force, Goodfellow developed a clear picture of the audit documentation requirement and created an execution plan to collect and document the data to show compliance.

After developing a strategy to collect data, educating the chain of command and gaining support for the effort proved invaluable for successful program development. Leadership understood the time and effort required to comply with the FIAR tasking and fully supported the team, which included members from three flights. FIAR doesn't just affect real property interests. FIAR demands involvement from operations and engineering flights, AFCEC and the U.S. Army Corps of Engineers to provide timely and accurate transfer and acceptance of Military Real Property DD Form 1354s. Communication and teamwork provided the foundation for success, and leadership internalized the importance of FIAR compliance.

Bruce effectively educated squadron leaders on one of the most time-consuming and labor-intensive requirements, CAP Zero: existence and completeness and key supporting documentation. In CAP Zero, installations must prove they have everything in the field they say they have in the real property records, and verify that all existing real property in the field is contained in their records. The asset accountability element chief lobbied for and immediately obtained a two-person team dedicated solely to this book-to-floor and floor-to-book reconciliation. Bruce also relayed the important nature of the work needed for CAP A: linear structures. We expanded our team to include the geographic information systems office that documents linear structures. The GIS database now serves as the baseline for all linear structures on the installation.

After assembling the team, we needed to train members on a process to conduct the inventory and validation. Bruce developed a step-by-step checklist for the effort. In spring 2016, the two-person team, with detailed base knowledge and unfettered access to sensitive areas, spent two months completing existence and completeness by putting eyes on and photographing every facility and structure on Goodfellow, followed by a 100 percent inventory of all real property folders corresponding to the list they developed from the physical inventory and real property records. One key to this effort was identifying personnel who knew the base and had access to facilities others may have difficulty getting into.

While the independent team completed CAP Zero, Bruce focused on the time-consuming linear structures. He worked tirelessly with Vikki Draper, 17th Civil Engineer Squadron geobase manager, to perform a 100 percent accountability of what the real property records showed and what the GIS data indicated. GIS data/real property record reconciliation is a huge undertaking, requiring commitment and communication between the real property officer and the geobase manager. This well-oiled team successfully reconciled all differences and provided confidence the GIS data accurately reflects all linear structures on Goodfellow.

The team identified a few key lessons learned during this process. When updating communications assets in GIS, maps indicated a single line but in reality many of the ducts contained six to 10 lines, dramatically increasing linear footage for sustainment and accountability purposes. Also, the coordination efforts between the real property officer and the geobase manager must remain continuous in order to maintain accurate installation real property records. After inventory reconciliation, AFCEC sent a contract team from PricewaterhouseCoopers in August 2016 to train and provide CAP assistance. The team validated Goodfellow's efforts thus far and provided additional clarification on the CAPS still requiring completion.

If your installation is behind the curve right now, immediately dedicate a team to complete CAP Zero. Educate your leadership and your co-workers on why FIAR compliance is important to the installation. Accurate and auditable property and resources ensure your installation receives the funding required to sustain and maintain facilities and infrastructure to meet your installation's mission. Never underestimate the power of teamwork and communication.

Editor's note: *Strickler is the commander of the 17th CES, Goodfellow Air Force Base, Texas. Mike Noret, Kevin Bruce and Anne Coverston contributed to this article.*

Facing page: Real property office managers collaborated with geobase managers on Goodfellow Air Force Base, Texas, to comply with financial improvement and audit readiness standards. *(Courtesy photo)*

Below: Air Force Reservists from the 446th Civil Engineer Squadron and Washington Air National Guardsmen from the 248th Civil Engineer Flight get training on geographic information systems during an exercise at Camp Murray, Washington. *(Courtesy photo)*

Advances in IT transforming facility management

By Maj. Joshua Yerk
Directorate of Civil Engineers, Headquarters Air Force

Over the past 10 years, the Air Force has dealt with extremely tight fiscal boundaries and needed to determine a new way of doing business. Innovation has been an enduring theme as the means to change business processes to accomplish the mission in not only a cost-effective manner but also in a mission-effective manner.

One needs only to peruse Air Force strategic documents such as the Strategic Master Plan, Science and Technology Strategy and Strategic Environmental Assessment to see the emphasis senior leaders are placing on exploiting new opportunities in technology. Innovations in the world of information technology, or IT, are creating exciting new capabilities that open the aperture of how the civil engineering enterprise can provide resilient installations and why capitalizing on these innovations is a key component of the CE IT strategy.

Recently, the Air Force Civil Engineer Center made a concerted effort to break away from a reactive paradigm for facility maintenance by shifting focus toward preventive maintenance.

This pivot has certainly helped alleviate some issues, but base-level engineers still depend on hastily trained facility managers or in some cases, a passerby, to identify and report a problem. Until a pipe breaks, a circulation fan shuts off, or a tank overflows, it is difficult to foresee looming failures much less have time to plan and budget for the required fix. When a problem is reported, the information rarely contains specifics and typically identifies symptoms rather than root causes. As a result, our engineers spend significant time troubleshooting before returning to the shop to get the proper materials and tools to address the situation. These challenges are time consuming and expensive. However, recent innovations with smart and cognitive facilities along with superior data analytics soon may be able to put these challenges behind us.

Imagine a facility that warns of a pending heating, ventilating and air conditioning system component failure with enough time for engineers to plan effectively. Imagine a facility that can generate its own work order that provides real-time performance data for evaluation before a technician even leaves the shop. Imagine a facility that can tell you how effectively occupants are utilizing workspace and provide recommendations for space re-allocation.

All these capabilities are under development right now and are transforming facility management best practices as well as facilitating efficient allocation of funds to the highest priority with greatest return on investment. Private-sector companies are investing heavily into capability development for the internet of things in which everything is connected. These companies are ready and willing to partner with the Department of Defense in order to continue the development of the cognitive facility capability.

The Directorate of Civil Engineers and AFCEC are exploring potential partnerships with the private sector to conduct a pilot study at a few of our installations. The main goal from these studies is to expose relationships and dependencies among seemingly unconnected data sets and identify efficiencies in facility maintenance and space utilization. It is worth noting that all of these IT innovations require a modern information system in order to be effective, which is why the success of the new NexGen IT TRIRIGA system is so critical. Without a modernized platform, the CE enterprise will not be able to take advantage of IT innovations. These developments occur at an extremely rapid pace and with the deployment of TRIRIGA, the enterprise is posturing itself to take advantage of opportunities.

Editor's note: *Yerk is the information technology portfolio manager for the Directorate of Civil Engineers.*

Facing page: Senior Airman James Scott, 2nd Civil Engineer Squadron electrical systems craftsman, closes down an extension pole after making electrical repairs at Barksdale Air Force Base, Louisiana, in August 2016. A transformation in best practices for facility management is being developed. (U.S. Air Force photo/Senior Airman Luke Hill)

Below: Base-level civil engineers depend on others to identify and report a problem such as this broken water pipe on Barksdale Air Force Base, Louisiana, being repaired by Senior Airman Samuel Parker, left, and Airman 1st Class Ashmiru Sallu-Sam, water and fuel systems Airmen with the 2nd Civil Engineer Squadron. The water line was damaged in January while contractors were laying fiber optic cable. A new system may streamline reporting and addressing such problems. *(U.S. Air Force photo/ Senior Airman Luke Hill)*

HVAC controls: Untapped potential in the fight to save energy

By Capt. Miles Ryan
Air Force Institute of Technology
Civil Engineer School

Reducing energy consumption is about more than being environmentally friendly, saving money or meeting goals. In the context of the Air Force mission, reducing energy consumption improves our resiliency by providing the warfighter power when and where they need it to conduct operations. The Air Force is taking a multifaceted approach to reducing energy consumption, one of which is a renewed emphasis on optimizing HVAC controls.

Traditionally, tangible energy reductions have come as the result of project-level efforts. Today, a major program is underway to ensure 60 percent of facility energy consumption is metered by 2020; this will help identify opportunities for reductions. Once energy reduction projects are identified, multiple funding avenues are available. Previously, sustainment, restoration and modernization funds were set aside for energy-related projects. The influence of the energy focus fund exists in current business rules where life cycle cost-effective energy projects are funded on their own merit. Focus funds in the military construction, or MILCON program are available through the Energy Conservation Investment Program.

Today, the major push is for increased use of third-party financing. This was evident at last year's Energy Exchange conference, where 20 of the 126 technical sessions focused on such contracts. These avenues and others, including Energy Action Month, are necessary approaches to reducing our facility energy consumption. However, another piece of the puzzle has received minimal attention by the Air Force: the improvement of our existing heating, ventilation and air conditioning, or HVAC, control systems.

Optimizing use of our HVAC control systems offers substantial potential for saving energy. This fact is recognized within the energy industry as seen at the Energy Exchange, where 22 technical sessions specifically addressed improving the automation of HVAC systems. The Air Force, however, has yet to focus on these opportunities.

Historical elimination of available training

The Air Force Institute of Technology's Civil Engineer School once offered a four-week, in-resident course for mechanical engineers to learn HVAC control systems. The course was cut in the late 1990s because of budgetary constraints. For the next 20 years, the course never returned.

Similarly, technicians once had the opportunity to attend a five-week, in-residence course on HVAC controls the 366th Training Squadron at Sheppard Air Force Base, Texas. Over time, that course became outdated, as it primarily dealt with older pneumatic systems, and the training equipment degraded. It was cut in 2013 with no alternative training. Technicians were encouraged to seek unit funding for vendor-supplied training. However, this training now competes with other squadron funding priorities.

Loss of expertise

The shift to direct digital controls provides endless opportunities to optimize the performance of Air Force HVAC systems. Consequently, HVAC controls are getting more complicated each year. This consistent advancement of technology can be overwhelming and may be why we tend to shy away from the topic. We assume that someone else is taking care of it, but who exactly is that?

Above: U.S. Air Force Senior Airman Brandon Fleury, 7th Civil Engineer Squadron heating, ventilation and air-conditioning journeyman, adjusts the controls on a centrifugal water chiller at Dyess Air Force Base, Texas, in March 2017. The chiller is one of six that keep a large number of buildings on base at a comfortable temperature while still being energy efficient. *(U.S. Air Force photo/Senior Airman Alexander Guerrero)*

WENG 563 HVAC Control Systems Lessons

Module	1 Fundamentals	2 Control Strategies	3 Advanced Control Topics	4 Comprehensive System Topics
Lessons	Welcome and Course Intro Control Theory Controllers Control Valves and Dampers Sensors Control Technologies	Hydronic Systems Overview Ventilation Constant Speed Hydronic Systems Air Side Economizer Cycles Variable Speed Hydronic Systems Refrigeration Cycle Applications Air Systems Overview Primary Equipment Staging Constant Air Volume Systems Water Side Economizer Cycles Variable Air Volume Systems Life Safety Sequences	Elevated Air Speed Low Delta T Syndrome Variable Refrigerant Flow Thermal Energy Storage Predictive (Feed-forward) Control Model Predictive Control	Energy Management Control Systems Industrial Control Systems Security Control System Acquisition Process

There is a common belief that controls are the technicians' job to manage, yet the Air Force does not provide them with standardized training on the topic. Increased training could put expertise on the front line of this fight to save energy.

But do we really need to have our technicians bear that burden alone? If we give them quality systems to begin with, we would expect the engineers we employ and the design firms we work with to have expertise in HVAC controls, ensuring their new designs operate at high efficiency during all periods of the year. However, that is not always the case. At AFIT, student and instructor anecdotes commonly exemplify when designs fall short. For instance, one firm designed a ground-source heat-pump system that was incapable of being controlled in an energy-efficient manner for large portions of the year. It used more energy in its first winter of operation than the degraded system it replaced! Such design flaws may have been caught by the base mechanical engineer, if only he or she had adequate training.

Lastly, we may assume the expertise we desire is provided by a service contract our base may have with a local controls vender. That, too, is not always the case. Recently, after completion of a new MILCON project, a controls service contractor arbitrarily increased the differential pressure set point on a pump controller, because he "didn't think the engineer specified big enough pumps." Subsequently, the two parallel pumps operated at full speed for nearly a year before the base discovered the deficiency, consuming more energy than they should. After closer inspection, it was determined the pumps were sized correctly, the appropriate set point was put in place, and energy savings ensued.

To improve our facilities' operation and efficiency, we must confront these assumptions and not shy away from truly taking ownership of our facility HVAC control systems. It is apparent that some level of education and training is warranted.

A new educational opportunity

Developing expertise across the Air Force in HVAC controls presents challenges in manning, funding and training. AFIT has addressed one of these — educating the career field — in resurrecting the HVAC Control Systems course in a format that is resilient to future fiscal constraints. The course follows an online, self-paced format, is five weeks long, and covers a variety of topics. The lessons will cover basic control theory and teach students the most effective strategies to implement on the various HVAC systems they may encounter. It will explain where energy is wasted, how equipment is degraded and how comfort may suffer when such systems are incorrectly controlled.

Additionally, the course explains the intent and control methodology behind more advanced technologies being installed on our installations, such as thermal energy storage systems. The course finishes with presentations of several related topics. One such lesson includes discussion of the recently approved Air Force Guidance Memo, Civil Engineer Control Systems Cybersecurity *(see Civil Engineers Must Protect Cybersecurity, on Page 8 in this edition to learn the importance of this topic)*. However, more in-depth discussion on this hot topic is held for a separate AFIT course, Managing Security of Control Systems.

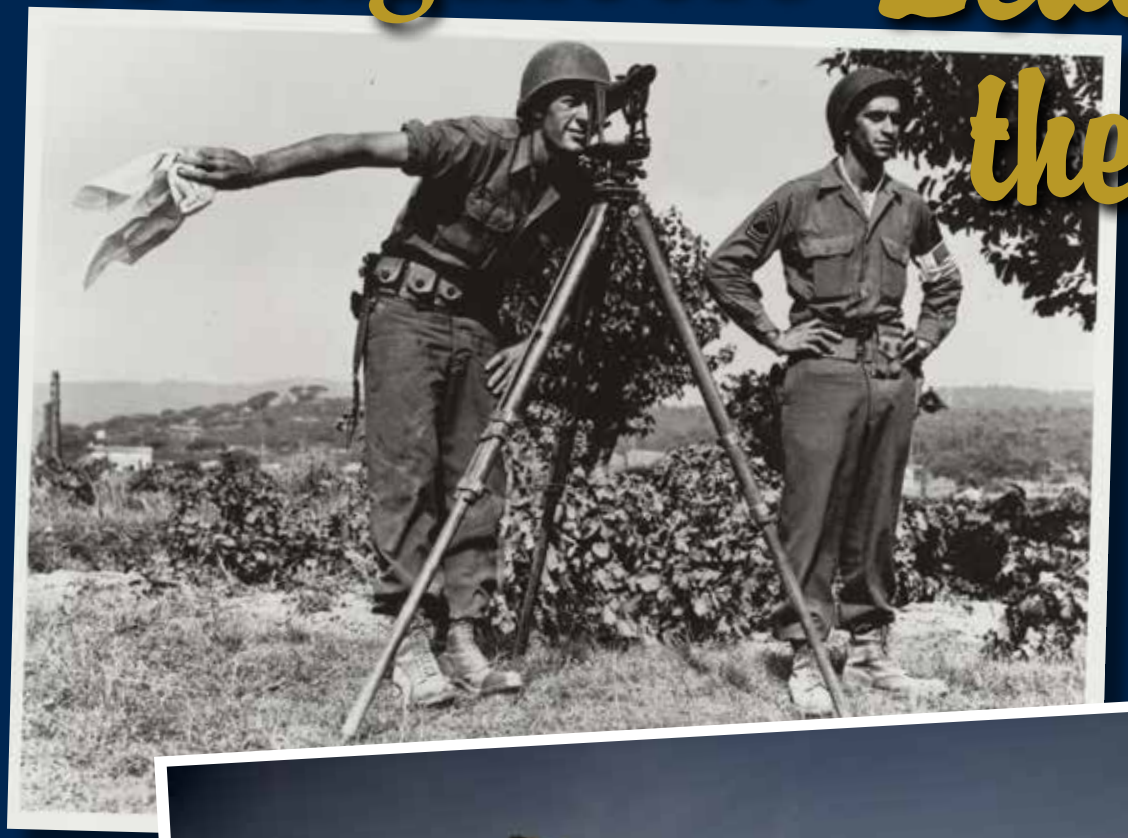
The best part: The HVAC Control Systems course is available to both engineers and technicians. If we are to make large strides toward controlling our existing systems more efficiently, we will need an army of personnel with intimate knowledge of how these systems may best be operated.

For more information on all Civil Engineer School courses, visit www.afit.edu/ce and click on the course catalog.

Editor's note: *Ryan is a mechanical systems and energy management instructor at the Civil Engineer School at the Air Force Institute of Technology on Wright-Patterson Air Force Base, Ohio. He is a certified professional engineer and certified energy manager.*

from the SCHOOLHOUSE

Celebrating 70 Years of Engineers *Leading the Way*



Engineering survey techniques have come a long way since World War II. Today's civil engineers employ geographic information systems, or GIS, to capture and analyze many kinds of data on one map.

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