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DESIGN & CONSTRUCTION • HUMANITARIAN EFFORTS • ENERGY MANAGEMENT • SPOTLIGHT ON WAKE ISLAND

The courtyard of a student housing complex shows the destruction that occurred at Tyndall AFB, Fla., after Hurricane Michael hit on Oct. 10, 2018. U.S. AIR FORCE PHOTO BY STAFF SGT. ALEXANDER HENNINGER

IMPROVING RESISTANCE TO, and Recovery from, Natural Disasters

Mapping tools, such as those provided through the U.S. Air Force's Installation Geospatial Information and Services Program, can help ensure a more resilient design before construction starts, and in the event that reconstruction is needed after a disaster hits.

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On Oct. 10, 2018, courtesy of Hurricane Michael, the strongest sustained-wind speed in 25 years hit Florida's Tyndall AFB, damaging every building on the installation and displacing 11,000 military and civilian workers. Just six months later, heavy rain and record snow melt in the Northwest pushed the Missouri River over its banks and onto runways. Water flowed up through storm drains into buildings at Offutt AFB, Neb., causing infrastructure outages and threatening U.S. Strategic Command Headquarters.

Extreme weather is impacting military installations, the resources they contain, and the services that they provide. Yet according to a June 2019 report from the Government Accountability Office, although a Department of Defense climate change adaption directive has been in place for years now, guidance on how to use climate projections in master planning and facility design still has many gaps to fill.

GEOSPATIAL TOOLS

Disaster-resilient planning and design are proactive steps in hardening key assets and getting mission-critical services back online again soon after a disaster. This process begins with a hazard assessment during early planning based on location, context, and mission. That is nothing new. However, using predictive models of future climate is. Yet without clear direction or ease of access to modeling, it is often not done.

Mapping tools, such as those provided through the U.S. Air Force's Installation Geospatial Information and Services Program (GeoBase) can help identify, visualize, and convey both constraints and opportunities. GeoBase provides precise location and portrayal of built and natural infrastructure assets to facilitate installation planning, development, operations, and protection.

GeoBase also can help identify the extreme weather and subsequent hazards to which each installation would be subject. That information is needed early, during the conceptual phase of planning or design, to reflect appropriate hazards and to brainstorm multiple scenarios and time periods. Design strategies, ranging from elevating critical equipment to developing a water-intrusion plan, are then integrated into the design.

GAUGING RISK

The Geospatial Integration Office at the Air Force Civil Engineer Center (AFCEC) in San Antonio has partnered with Columbia University's National Center for Disaster Preparedness to develop a disaster awareness map based on the school's Multiple Natural Hazard Index for U.S. Counties. The index aggregates disasters by type, providing an invaluable resource since events rarely occur independently.

While most maps combine all hazard types into one map, the Air Force Disaster Awareness Map has separate layers for each type of disaster, such as fire, flood, and hurricane. Designers of projects on military installations can benefit from this tool, as well as from referencing the local hazard mitigation plans, which municipalities must prepare to receive funding from the Federal Emergency Management Agency.

LEVERAGING TECHNOLOGY

Many agencies and institutes are producing models "down-scaled" from global climate change models to specific regions of the country. Air Force planners and designers use government-sanctioned sources for modeling, such as those developed by the National Oceanic & Atmospheric Administration and the Environmental Protection Agency, then overlay their geographic information system (GIS) data with GeoBase data specific to each site.

Because modeling varies by emissions scenario, planners and designers need to remember they will have to work with a range of possible temperature, sea level, flooding frequency, and storm surge conditions. They should engage installation personnel regarding acceptable versus unacceptable risks, including discussing dependence upon or service to the broader community during and after a disaster.

Once future risks are characterized, it is important to ask questions that will support any resilient design strategy.

- What assets (roads, treatment plants, parks.), services (water treatment and distribution, sewage collection and treatment, solid waste collection), and facility systems (electrical, water, thermal comfort) require continuity?
- Will they suspend function during or ahead of a disaster or will they continue to operate?
- Can or should this building act as a "life boat" after an event or be shuttered and its function moved elsewhere during or after an event?

DESIGN COSTS & BENEFITS

Implementing resilient design strategies often raises construction costs—and these must be justified. For example, when Woolpert designed a coastal facility for the Air Force Reserve, the project team chose to use insulated concrete forms rather than less-expensive, tilt-up or pre-cast concrete alternatives.

Hurricanes usually bring storm surges, caused by a rise in sea level by wind pushing water ashore. Insulated concrete forms are a stronger, more air- and water-tight solution. The increase in price at the outset will mitigate a storm's impact and greatly reduce the risk of losing specialized and expensive equipment in the wake of a disaster. The choice was made because of the criticality of the facility in a hurricane-prone region.

There are a number of additional considerations specific to designing hurricane-resistant buildings.

- Select the site with hazard minimization in mind.
- Raise finished floor elevation above the storm surge line, if doable.
- Develop a water-intrusion strategy: either dry-floodproof (create an air- and water-tight building envelope); wet-floodproof (define areas that can and will be inundated and design them with robust, mold-resistant, easy-to-clean-and-dry materials); or a hybrid (incorporate both dry- and wet-floodproof elements within the same building).

Disaster-resilient planning and design are proactive steps in hardening key assets and getting mission-critical services back online again soon after a disaster.

- Incorporate impact-resistant windows and doors.
- Reinforce the roof and minimize equipment on it.
- Elevate transformers, pumps, air handlers, communication hubs and other critical mechanical equipment within the building.
- Borrow regional vernacular design approaches to resiliency; for example, when power and air conditioning are out, day-lit buildings aligned to catch breezes through open doors and operable windows are inhabitable and functional.

Water damaged every building and covered one-third of Offutt AFB, Neb., home to U.S. Strategic Command, after the Missouri River flooded in March 2019. U.S. AIR FORCE PHOTO BY TECH. SGT. RACHELLE BLAKE

Another great resource for justifying the extra expense of resilient design strategies is the Massachusetts Institute of Technology's Break-Even Mitigation Percentage Dashboard, which can be used to quantify lifecycle cost savings for damage avoided.

Footage that had been uploaded to YouTube helped update the Air Force Geospatial Integration Management System to align geospatial information and services capabilities with strategic planning agendas from mission sectors across the Air Force.

GeoBase provides precise location and portrayal of built and natural infrastructure assets to facilitate installation planning, development, operations, and protection.

RECOVERY USING GEOBASE

While planning and design strategies are key to resiliency pre-disaster, a timely, relevant, and scalable GIS asset management protocol is crucial to recovery efforts post-disaster.

GIS aggregates damage reports; disseminates the state of affected assets and services, and displaced personnel; and quantifies how these elements will impact an installation's mission and its ability to support regional recovery.

When disasters temporarily cut off an installation's access to GeoBase, the Air Force Geospatial Integration Office at AFCEC provides immediate emergency GIS services. The task is enriched by information from many sources, including texts, photographs, video, and aerial and satellite imagery, that flows from local media outlets and social media platforms. This information must be vetted by GIS managers, who acknowledge that the verifiable quality of data often improves over time. AFCEC then interpolates social media data to verify attributes that can be constructively integrated into the GIS for use by asset managers on the ground.

This integration was used when Hurricane Michael hit Tyndall. When Offutt was flooded, AFCEC's Geospatial Integration Office reached out to the Nebraska Geospatial Integration Office and began using photographs posted on Facebook and Twitter to identify impacted assets and set up a similar web application.

The improvement of GIS, as well as advancements in planning and design tools, allow us to apply what we already understand and will continue to learn about the impacts of disasters. With this knowledge, we can better protect military installations—from their birth in design, to their rebirth in recovery.

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