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Resiliency in Military Planning and Design:
New Technologies Enliven Old Ideas

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Overview

- Resilient design and planning – how to start?
- A few "old" idea with renewed purpose

From planning to resilient design

  - AFSOC in Japan
  - 920th Rescue Wing in Florida

1 Resiliency

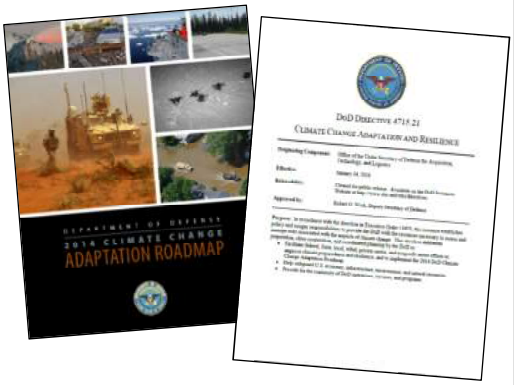
+ … "military installation resilience" means the capability of a military installation to **avoid, prepare for, minimize the effect of, adapt to, and recover from** extreme weather events, or from anticipated or unanticipated changes… in order to maintain, improve, or rapidly reestablish installation mission assurance and mission-essential functions.

USC Title 10. Armed Forces, section 101

+ *Resilience* - the capacity to adapt to changing conditions and to maintain or **regain functionality and vitality** in the face of stress or disturbance. It is the capacity to bounce back after a disturbance or interruption

per the Resilient Design Institute (RDI)

Drivers



- DODD 4715.12 - Climate Change Adaption and Resiliency
- Army Directive 2017-07, Installation Energy & Water Security Policy
- GOA Report, June 2019 - "CLIMATE RESILIENCE: DOD Needs to Assess Risk and Provide Guidance on Use of Climate Projections in Installation Master Plans and Facilities Design"

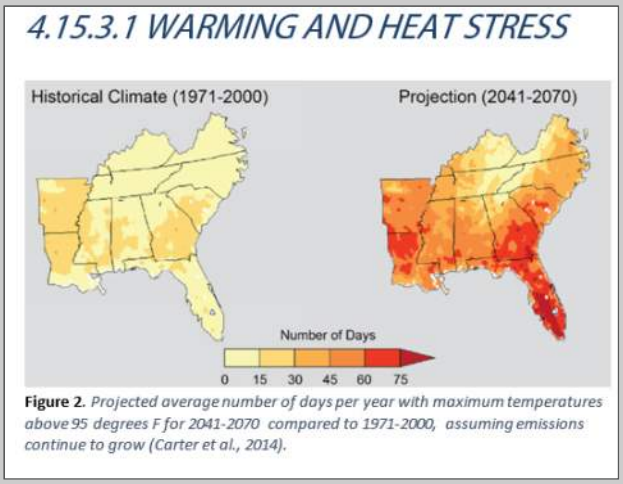
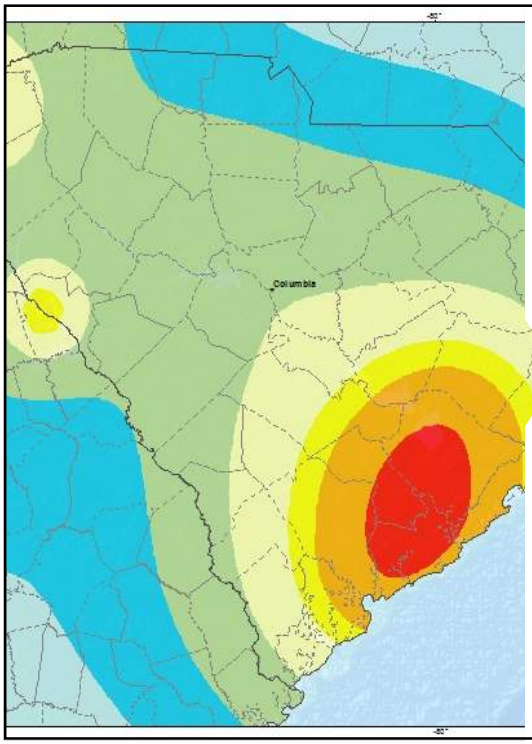


Figure from McEntire JNGB's Installation Complex Encroachment Management Action Plan

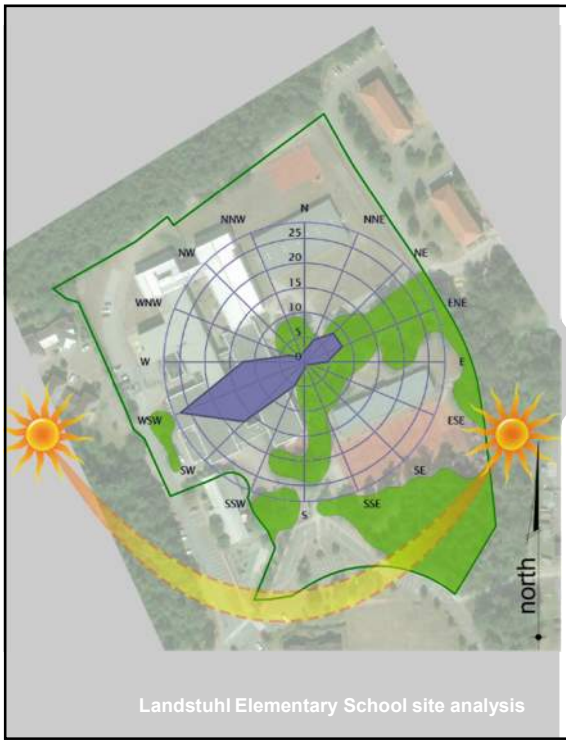
Resilient planning starts with site analysis

- UFC 2-100-01 updated last Nov 2018:
- "In order to anticipate changing environmental conditions… projections from reliable and authorized sources such as the… U.S. Global Change Research Office and National Climate Assessment (for climate projections) shall be considered and incorporated into military construction designs and modifications."



Resilient planning starts with site analysis

- What are your risks, present and *future*?
  - Conduct a hazard assessment
  - Rank hazards by risk
- Start with local hazard mitigation plan
  - In US, required for FEMA funding
- Characterize and get comfortable with *ranges*
- What are your assets?
  - Solar, wind, soil characterization
  - Water/hydrology and energy flows

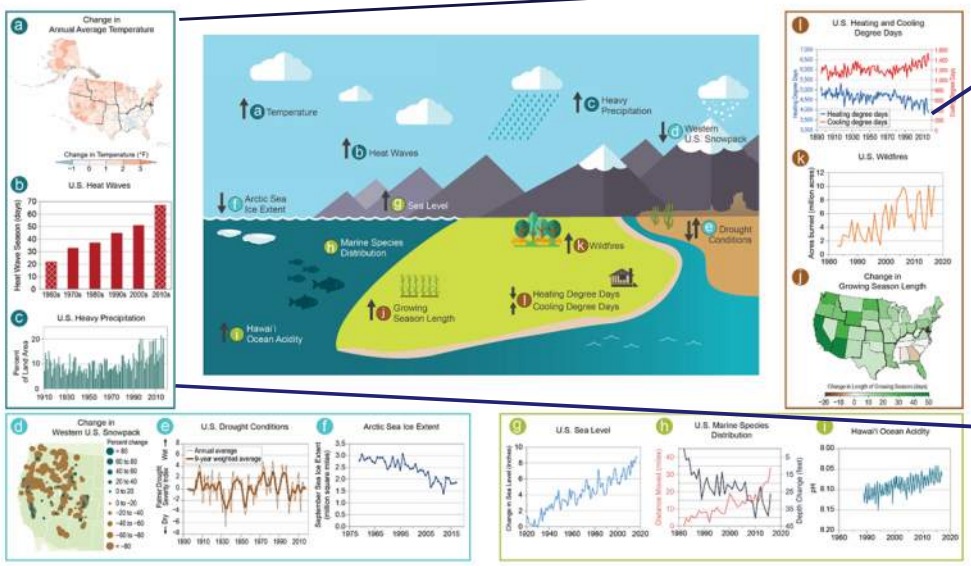


Landstuhl Elementary School site analysis

Resilient design starts with site analysis

- Identify risks likely *within the lifecycle* of planned facilities
- Then, model using *future* climatic conditions rather than past
- Locate critical systems to withstand extremes
- Wide variation in local/installation policy regarding design mitigation
  - Ex: Langley AFB vs. Patrick AFB
  - How to account for resiliency in LCCA?

Question your weather file…



Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II, Chapt 1
U.S. Global Change Research Program

UFC 3-400-02 *Design: Engineering Weather Data* requires design based on 30 year *past* record

UFC 3-210-10 *Low Impact Development* requires design based on at least 30 *past* years of rain event data

Risk Assessment Tool Kit

- U.S. Global Change Research Program
  - DoD sanctioned source for climate change projections
- Urban Adaption Assessment https://gain-uaa.nd.edu/
  - Free tool of 270 city's ability to adapt and readiness for adaptation to climate change
- NOAA sea level rise viewer
- EPA Climate Scenarios Projection Map
- NOAA's Regional Integrated Science Assessments teams' websites
- Renewables : NREL website for PVWatts & resource maps
- USGS Earthquake hazard https://earthquake.usgs.gov/hazards/hazmaps/
- "Regional Sea Level Scenarios For Coastal Risk Management" April 2016
  - Database with regionalized sea level scenarios for three future time horizons (2035, 2065, and 2100) for 1,774 DoD sites worldwide
- Climate Change World Weather File Generator http://www.energy.soton.ac.uk/ccworldweathergen/

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Resilient Design Strategies

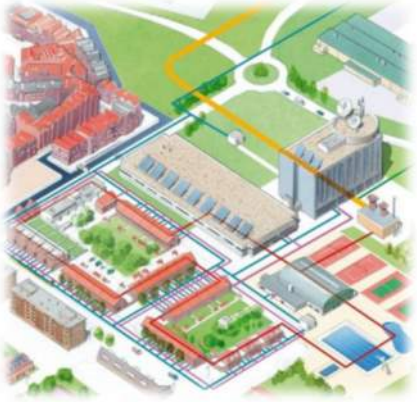
Resilient Design Strategies

Infrastructure

- Transportation – multi-modal
- Communication – multi-modal as well
- Energy – distributed power; smart/micro-grids; local
- Water – distributed storage and treatment
- Intelligent/smart controls

Buildings

- Extremely efficient
- Local power and water, with local control
- Include storage – thermal, water, power
- Passive heating/cooling & ventilation
  - Orientation
  - Operable windows



…are often most (or *only*) effective at a community, district or campus scale

Provide a Life Boat

"Create community facilities (resilience hubs) that can serve as gathering places during emergencies and interruptions in services, and outfit such facilities with access to key services, including water, electricity for charging cell phones, etc. Such capabilities could be integrated into schools and other existing community facilities." -- Resilient Design Strategies, RDI

Resiliency for AFSOC in Japan

2

ASIA

Okinawans Protest Deployment Of U.S. Osprey

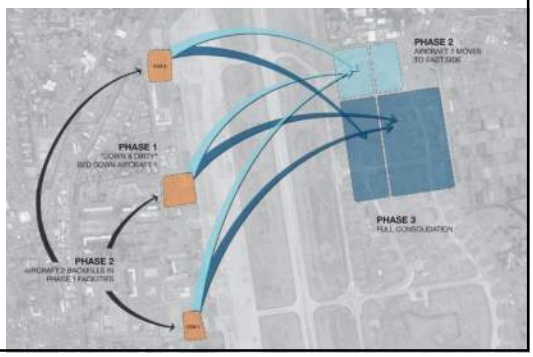
October 2, 2012 · 4:00 AM ET
Heard on Morning Edition

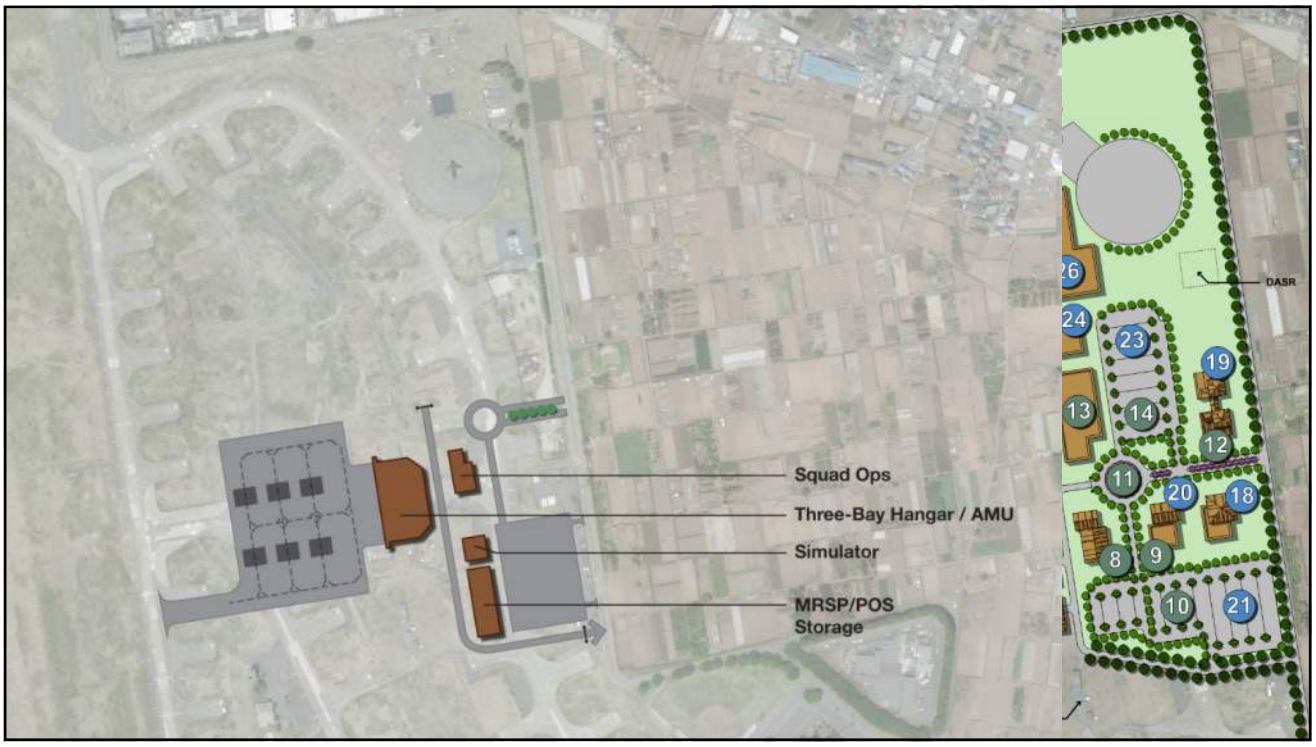
LUCY CRAFT

An Osprey arrives at U.S. Marine Corps Air Station Futenma in Ginowan city on Japan's southern island of Okinawa on Monday. Six Ospreys were deployed in Okinawa, drawing sharp reactions from residents amid persistent concerns about the aircraft's safety.

Plan for a new mission…

- Create an Area Development Plan (ADP) for Air Force Special Operations Command (AFSOC) "Plan B" airframes at Yokota AB
  - Sep 2013 – Sep 2014
  - AE Team = 5 people
  - Alternative Development Scenarios
  - Short- and Long-Range Plans
  - Phasing, Cost Estimates and 1391's





Long-Range Requirement	Program Amount	Scope
Simulator Facility	$15.5M	~11K SF
Airfield Apron	$25.3M	~457K SF
Hangar/AMU	$54.8M	~76K SF
Squadron Operations		~21K SF
Aircraft Parts & MRSP	$42.4M	~33K SF
Group Headquarters		~5K SF
Campus Development	$138M	~50 Acres

Next step: User Requirement Documents

- To justify future facility acquisition & verify PAs
- Effort included providing revised DD1391s
- Enter resilient design…

Resilient Design Ideas

Professional work environment

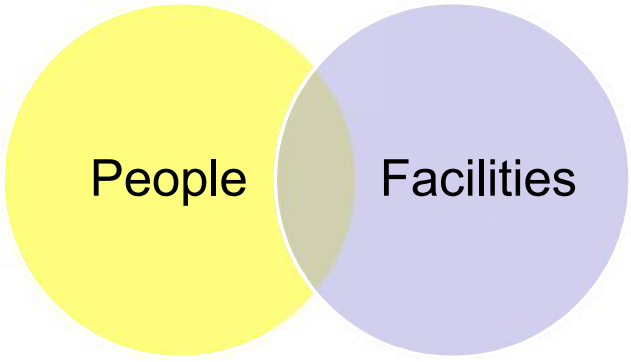
Unity & Purpose

Places of Respite

Sense of Place

Positive impression off-base

Safety & Comfort



Maintainable

Life-cycle cost effective

Energy efficient buildings

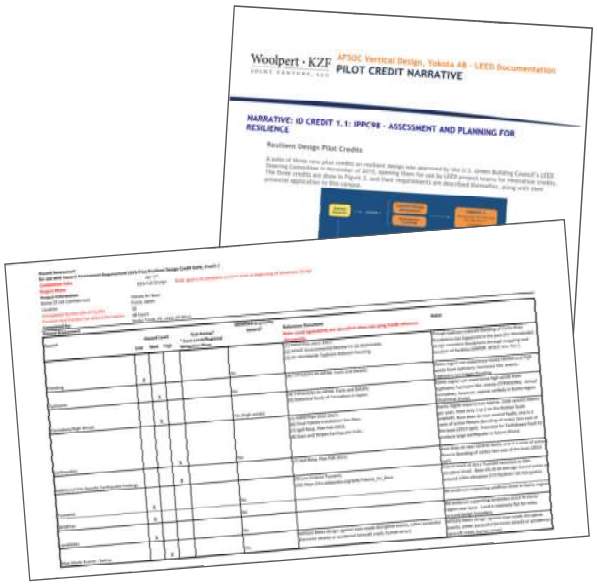
Redundant energy supply

Site adapted features

Low impact development

Resilient planning starts with site analysis
Example: AFSOC Campus, Yokota Air Base

- Site Assessment References
  - INRMP
  - Environmental Review (EIAP)
  - Inst. Development Plan
  - Spill Response Plan
  - Public sources/articles

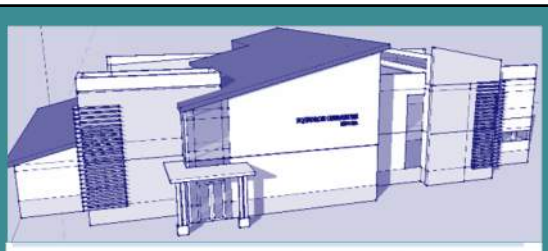


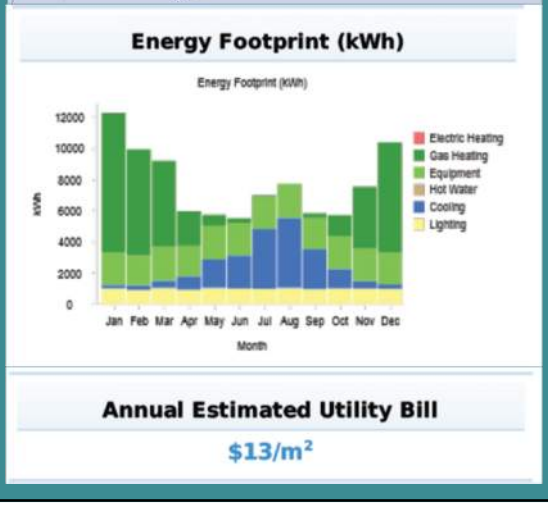
3

Resilient Design Strategies (with example)
Old idea find new relevance…

3.1 High-Performance Buildings

- Why you already used them?
  - Energy and water savings
  - Enhanced indoor environmental quality
- How are they also resilient?
  - Extreme efficiency necessary to make on-site storage and generation sufficient in times of need
  - *Passive survivability* design features allow continued operations during outages
    - Daylighting
    - Operable windows, stack ventilation
    - Vernacular design - practices prevalent before the advent of air conditioning and central heating

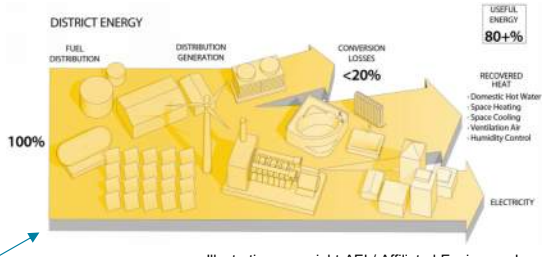




High Performance Building (Modeling)

- Designed to 30%+ efficiency over 90.1-2010
- 57% of interior spaces daylit
- Maximized PV potential of south-facing roof
  - Could provide 35% of energy; 50% of cost

3.2 On-site (Central) Plants & Generation



Illustration, copyright AEI / Affiliated Engineers, Inc.

- Why you already used them?
  - Peak load shedding to save money
  - More efficient & effective generation
  - Reduced staff and maintenance burden compared to distributed systems
  - Diversity of energy supply
- How are they also resilient?
  - If set up correctly, they can "island" during grid outages
  - Provide self-sufficiency during utility/infrastructure failures
- Through a resiliency lenses…
  - Caution: don't create a single point of failure either


Princeton on October 30, 2012. *(Tony Kurdzuk/The Star-Ledger)*

Princeton & Sandy

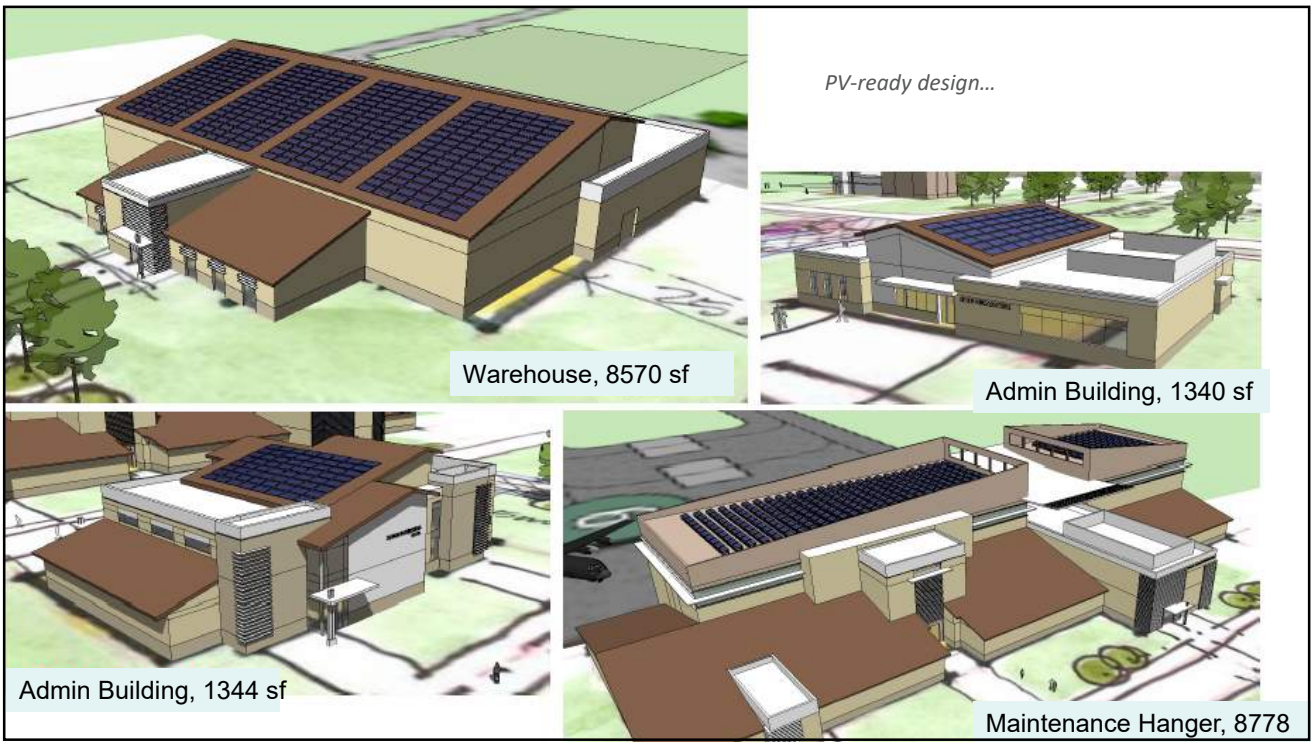
- Resilient design strategies
  - On site co-generation
  - Electrical microgrid
- University became a "place of refuge"
  - Community members could warm up, charge cell phones, use wireless, etc.

Solar Ready Design

- Estimated energy use intensity (EUI) of buildings
  - Est. 883 MWh/yr
  - Equiv. to one acre of PV
- PV in conjunction with microgrid & generators to provide resiliency

Solar-Ready Design

- Turned the warehouse, re-designed roofs
- Increased south-facing roof area to 67,823 SF
- Increased the solar potential ten fold



3.3 Micro-Grids

- Why you already used them?
  - Enables smart-grid implementation
    - Two-way communication and control integral to the grid
  - Enables "demand response" energy strategies
    - Allow utilities to power up or down equipment in times of need = $$ savings
- How are they also resilient?
  - Makes "islanding" during grid outages possible
  - Provide self-sufficiency during utility/infrastructure failures
- Through a resiliency lenses…
  - Caution: cybersecurity is key

Micro-Grids

- Improve reliability
- "Island" critical infrastructure
- Accommodates local, distributed generation
- Resiliency principle: allows *diversity and control* of energy supply
- Starts with planning

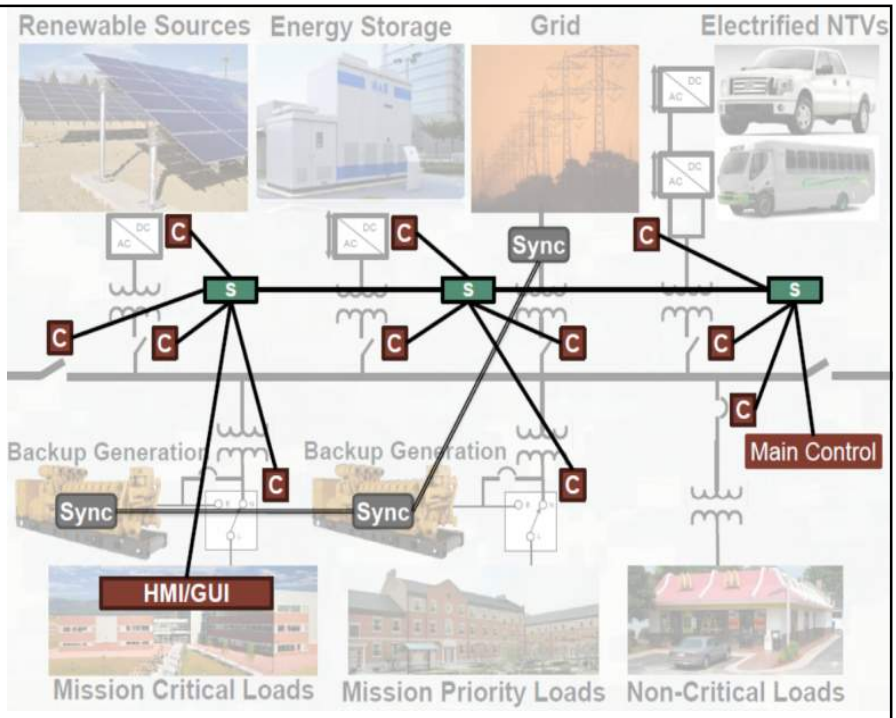
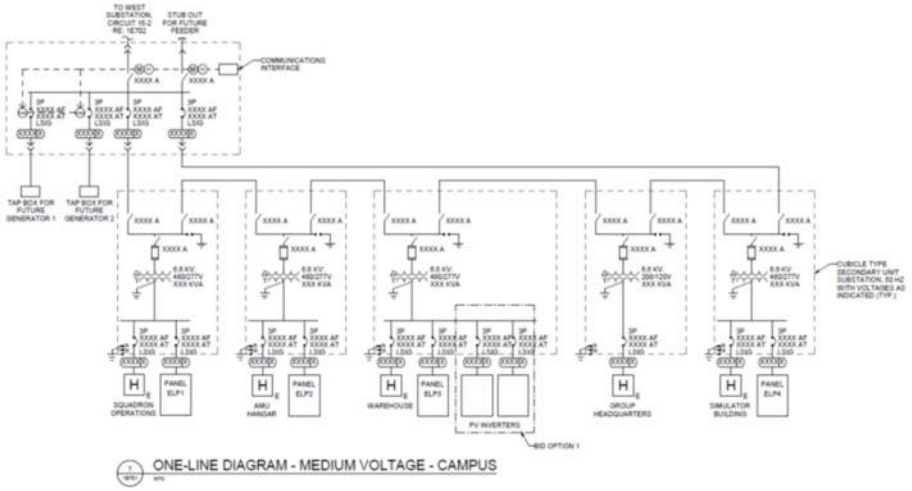


Photo credits: Melanie Johnson, USACE ERDC-CERL

Hybrid Micro-Grid

- Campus will be grid-connected
- Improve reliability
- Able to "island" if needed
- Accommodates future PV and generator power

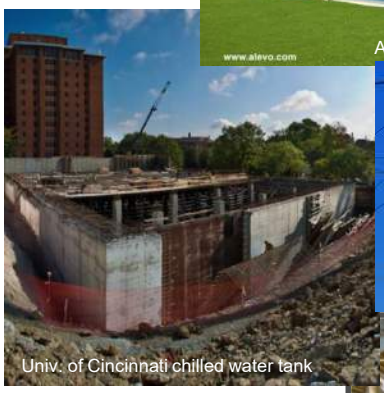


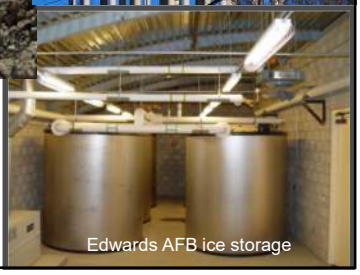
Credit: Jacobs Engineering

3.4 Storage

- Water
  - Tanks
  - Water features
- Energy
  - Batteries
  - Hydrogen
  - Ice/chilled water
  - Geothermal
- Reconsider your planning horizons
  - A 24~48 hour outage might not be long enough

Alevo's GridBank, an "energy reservoir"

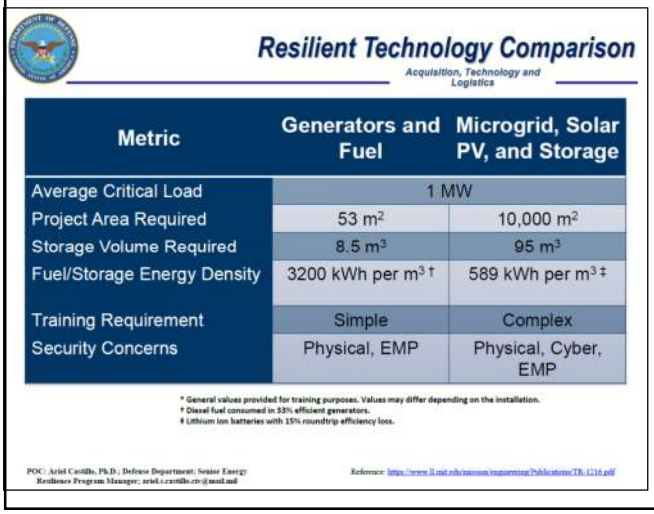

Univ. of Cincinnati chilled water tank


Edwards AFB ice storage

Storage

- Why you already used them?
  - Energy and water savings
  - Demand management
- How are they also resilient?
  - Self-sufficiency during outages
- Through a resiliency lenses…
  - Extreme efficiency necessary to make on-site storage and generation sufficient in times of need
  - Redundant & diverse systems might compete with efficiency
  - Favor passive or manual-override systems

Office of the Assistant Secretary of Defense, Energy, Installations, and Environment (OASD(EI&E)) Energy Resilience Initiative



Resilient Technology Comparison

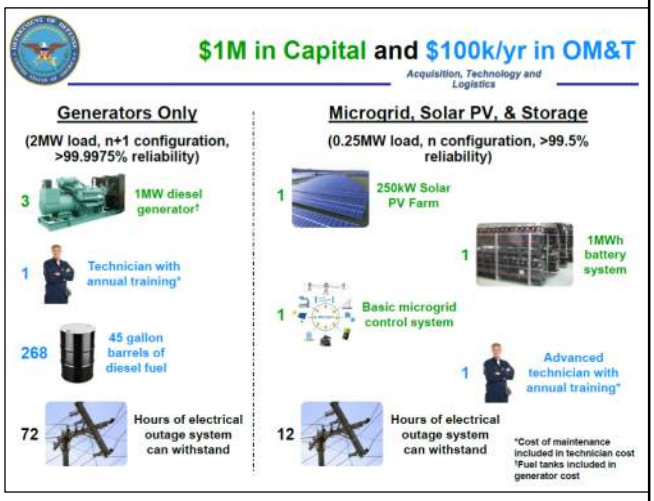
Acquisition, Technology and Logistics

Metric	Generators and Fuel	Microgrid, Solar PV, and Storage
Average Critical Load	1 MW	
Project Area Required	53 m^2	10,000 m^2
Storage Volume Required	8.5 m^3	95 m^3
Fuel/Storage Energy Density	3200 kWh per m^3 †	589 kWh per m^3 ‡
Training Requirement	Simple	Complex
Security Concerns	Physical, EMP	Physical, Cyber, EMP

* General values provided for training purposes. Values may differ depending on the installation.
† Diesel fuel consumed in 33% efficient generators.
‡ Lithium ion batteries with 15% roundtrip efficiency loss.

POC: Ariel Castillo, Ph.D.; Defense Department; Senior Energy Resilience Program Manager; ariel.s.castillo.civ@mail.mil

Reference: https://www.ll.mit.edu/mission/engineering/Publications/TR-1216.pdf



$1M in Capital and $100k/yr in OM&T

Acquisition, Technology and Logistics

Generators Only

(2MW load, n+1 configuration, >99.9975% reliability)

- 3 — 1MW diesel generator†
- 1 — Technician with annual training*
- 268 — 45 gallon barrels of diesel fuel
- 72 — Hours of electrical outage system can withstand

Microgrid, Solar PV, & Storage

(0.25MW load, n configuration, >99.5% reliability)

- 1 — 250kW Solar PV Farm
- 1 — 1MWh battery system
- 1 — Basic microgrid control system
- 1 — Advanced technician with annual training*
- 12 — Hours of electrical outage system can withstand

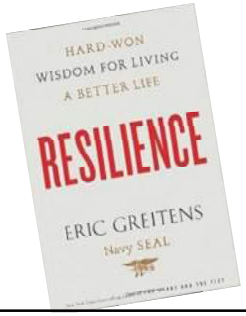
*Cost of maintenance included in technician cost
†Fuel tanks included in generator cost

3.5 Place-making

- Why you already used them?
  - A nod to “place”
  - Recreate, move and connect with nature
  - Build social cohesion and esprit de corps
- How are they also resilient?
  - Strong communities in which people know, respect, and care for each other fare better during times of stress or disturbance.
  - Natural systems have evolved to achieve resilience - maintain or restore them; use abundant local resources
  - Social equity and community contribute to resilience - can be as important as physical responses

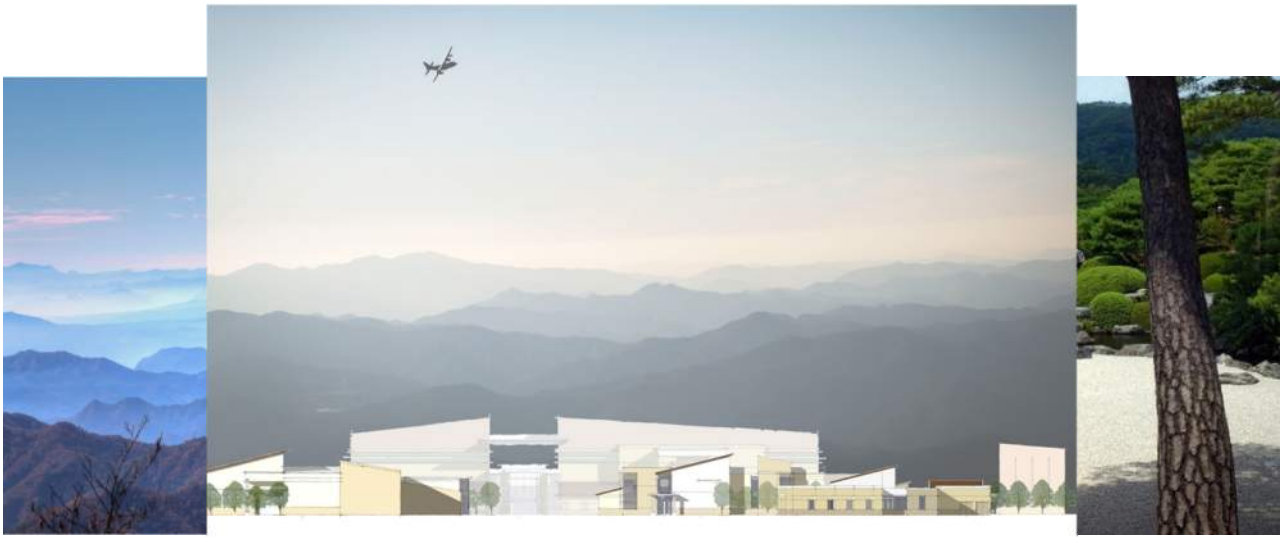
Place-making and Pedestrians

- Resiliency design supports the mission
  - Places of respite
  - Places of gathering
  - Places of ceremony



"Resilience is the virtue that enables people to move through hardship and become better."

Oku – Layered Planes

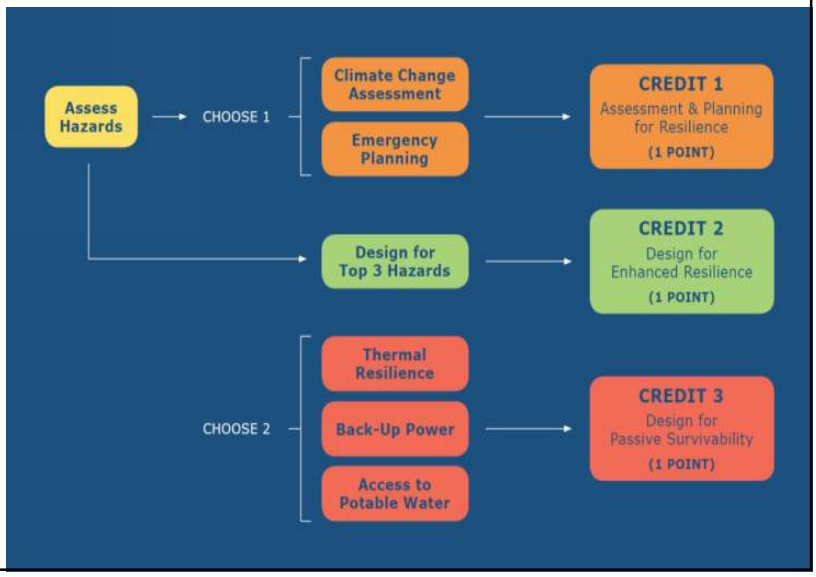



Walker Boulevard
ATC Transmitter/ Receiver
Credit: Jacobs Engineering


A resilient campus plan…

LEED Pilot Resiliency Credits

- Assessment and Planning for Resilience (IPpc98)
- Design for Enhanced Resilience (IPpc99)
- Passive Survivability and Functionality During Emergencies (IPpc100)



Summary

- Resilient design and resilient facilities
  - Start with a risk assessment
- A few “old” idea with renewed purpose
  - HPSB
  - On-site plants & generation
  - Storage
  - Microgrids
  - Place-making
- Resilient design case studies

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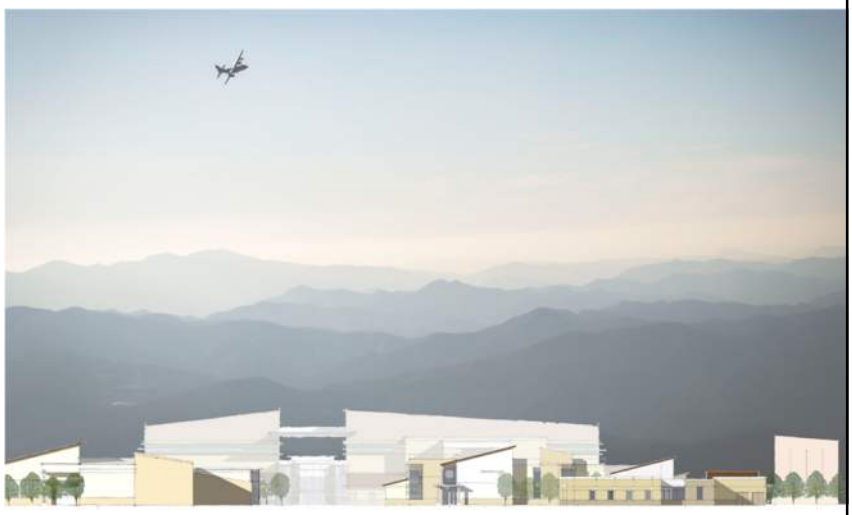

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