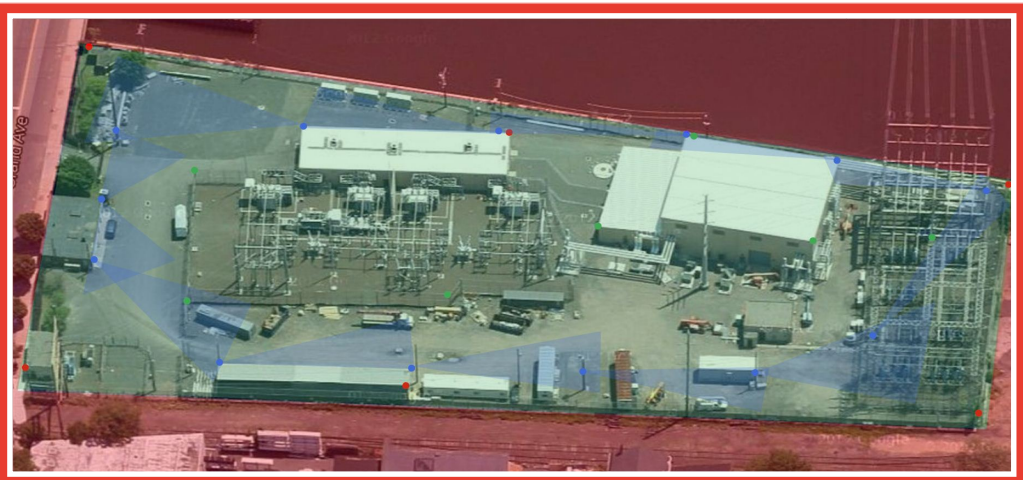
October 29, 2018

Gas Insulated Substations (GIS) for Enhanced Resiliency



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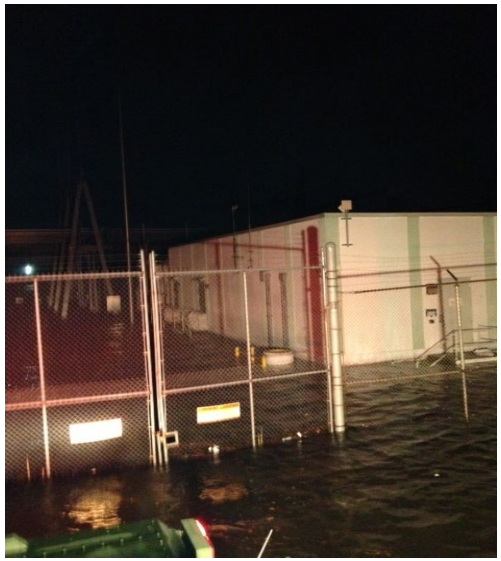
POWER ENGINEERS

What is a resilient substation?

It is impossible to design a substation that is 100% immune to naturally and human caused physical threats.

Resiliency is defined as “a means to withstand and to rapidly recover from disruption.”



With respect to critical infrastructure resiliency is:

“The ability of a facility or an asset to anticipate, resist, absorb, respond to, adapt to, and recover from a disturbance.”

Natural Catastrophic Threats and Human-Caused Physical Threats

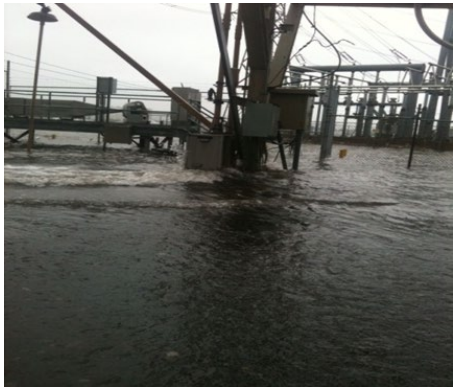
Conventional substation solutions may not be the best approach for critical substations

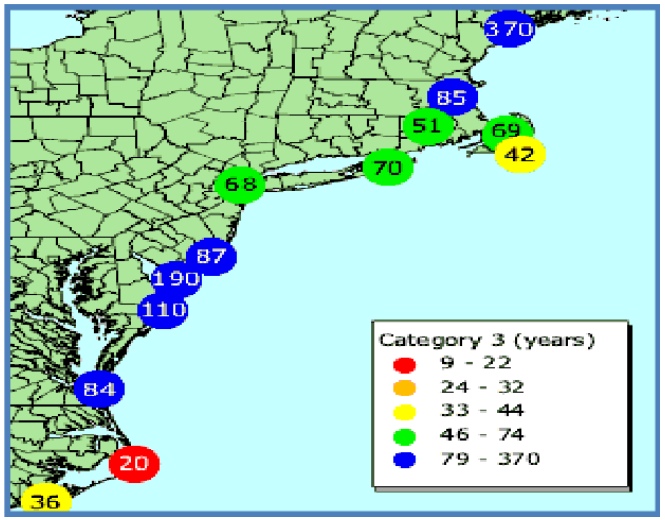
- Storms
- Severe environmental conditions
- Earthquakes
- Flooding
- Wildlife
- Physical attacks
- Criminal activities

History has taught us some important lessons…….

Superstorm Sandy

- From 1990-2008, population density increased by 32% in Gulf coastal counties, 17% in Atlantic coastal counties, and 16% in Hawaii (U.S. Census Bureau 2010)
- Much of the United States' densely populated Atlantic and Gulf coastlines lie less than 10 feet above mean sea level
- Over half of the nation's economic productivity is located within coastal zones
- 72% of ports, 27% of major roads, and 9% of rail lines within the Gulf Coast region are at or below 4 foot elevation
- A storm surge of 23 feet has the ability to inundate 67% of interstates, 57% of arterials, almost 50% of rail miles, 29% of airports, and almost all ports in the Gulf Coast





History has taught us some important lessons…….

Metcalf Sniper Attack

- A “sophisticated" assault on Pacific Gas and Electric Company's Metcalf Transmission Substation
- Gunmen fired on and damaged 17 electrical transformers
- $15 million worth of damage
- Reconfiguring the transmission system to continue to serve critical loads put the grid in a first contingency outage scenario for an extended period of time.

Actions – Prepare – Prevent Using GIS – Respond/Recover

Actions to effectively prepare for potential threats to a substation:

- ❑ Identification of the major physical threats to the substation (naturally and human-caused) and their characteristics
- ❑ Identification of the vulnerabilities with respect to the identified threats
- ❑ Assessment of the impact of the threats
- ❑ Maintaining an ongoing awareness of new risks and evolving threats

Prepare

Naturally Caused Physical Threats

- Tropical Cyclone Winds
- Tropical Cyclone Heavy Rains
- Storm Surge and Coastal Flooding
- Inland River and Flash Flooding
- Severe Cold, Heavy Snow and Ice
- Tornados
- Severe Thunderstorm Micro Bursts
- High Straight Line Winds
- Earthquakes
- Severe Humidity
- Desert and Severe Heat

Human-Caused Physical Threats

- Human-Caused Physical Attack
- Human-Caused Criminal Theft

Prepare

“Know the Threats, Vulnerabilities and Impacts”

Identified Threat and Characteristics	Vulnerability of Personnel and Equipment	Perceived Impact of Threat
Tropical Cyclone **Storm Surge and Coastal Flooding**	Flooding – submerged electrical equipment, access/egress problems and dangers for personnel, large floating objects Salt contamination – insulators, bushings, connectors, control/power /termination cabinets Long term corrosion – steel, cables, termination points	Requirement to de-energize the substation to minimize potential for major equipment damage due to faults. Long term restoration of equipment Critical power flows and critical load interrupted, national security risks and public safety risks

Prepare

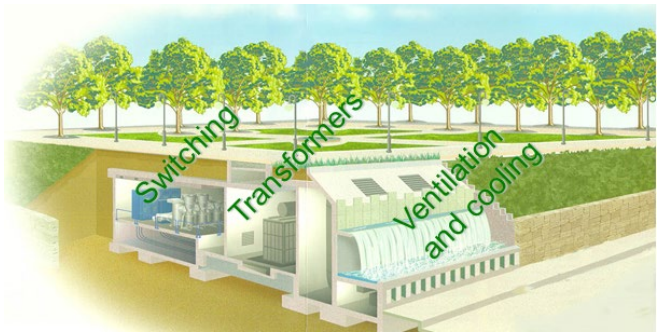
“Know the Threats, Vulnerabilities and Impacts”

Identified Threat and Characteristics	Vulnerability of Personnel and Equipment	Perceived Impact of Threat
Terrorist Physical Attack **Sniper Attack with Heavy Small Arms Ammunition**	Personnel at the substation can be targeted Puncture and rapid leakage of insulating fluids Destruction of support insulators for HV equipment Destruction of bushings on HV equipment	Threats to human life of workers Long term restoration of equipment Critical power flows and critical load interrupted, national security risks and public safety risks

Prevent Using GIS

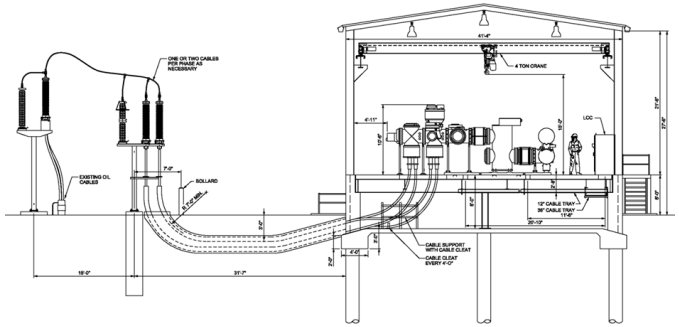
The advantages of GIS Enabled Construction Methods enhances substation resiliency:

- ✓ A smaller substation footprint (area and perimeter) that can be located inside a hardened building, underground structure or elevated structure
- ✓ Expansion of the security perimeter of the substation
- ✓ Reduced construction time and schedule risks during construction
- ✓ More easily located near load centers and critical infrastructure
- ✓ More easily disguised and aesthetically pleasing with the opportunity for no overhead line entry, “out of sight, out of mind.”
- ✓ Approximately 15 times the reliability of an air insulated substation performing the same duty



Prevent Using GIS

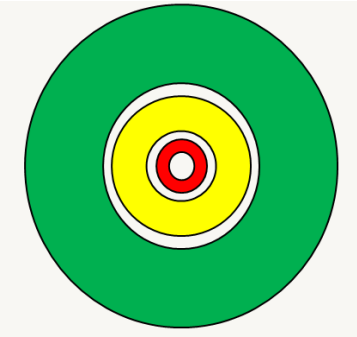
The Tropical Cyclone, Storm Surge and Coastal Flooding Example

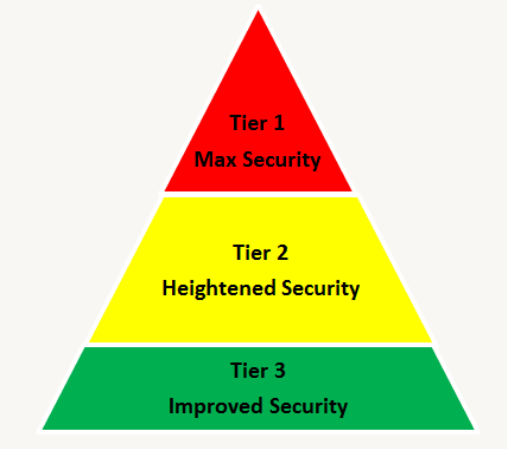


- Low-profile enclosure/structure that is rated for tropical cyclone force winds.
- Incoming and exiting transmission and/or distribution lines can be routed underground to protect line terminations.
- Mitigates the salt contamination issues associated with tropical system rains.
- Elevated above the maximum predicted storm surge level.

Prevent Using GIS

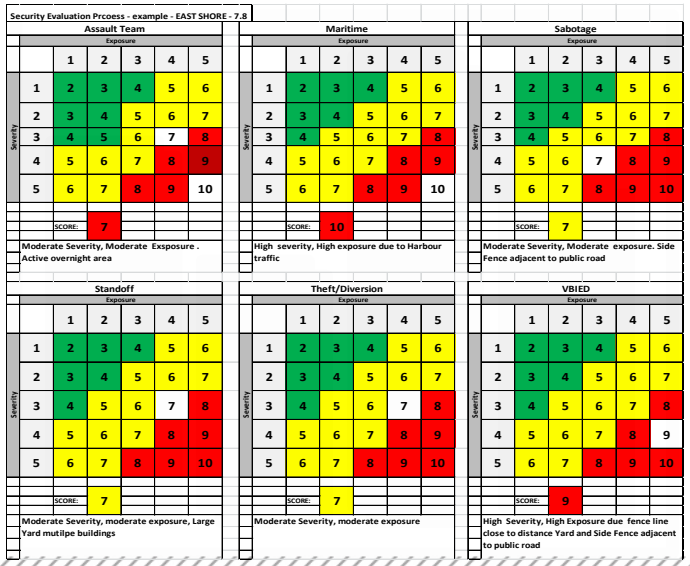
The Terrorist/Physical Attack Example





Physical Security Basics

- The application of concentric rings of security measures
- Inner most layers of security protect the most critical assets
- A structured process for evaluating protection based on impact and risk

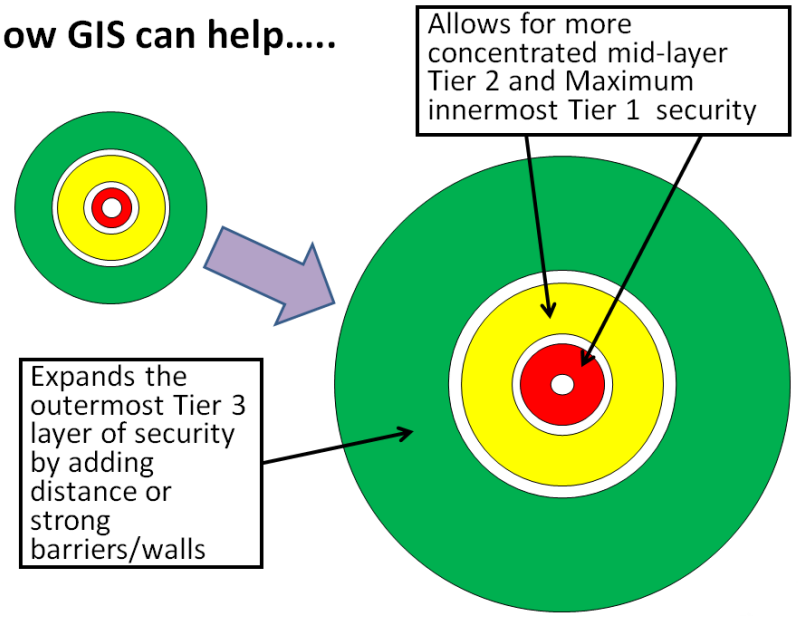


Prevent Using GIS

The Terrorist/Physical Attack Example

- Reduced area of the substation
- Reduced exposed perimeter of the substation
- Expanded Tier 3 security buffer, intruder neutralization devices can be more easily installed
- Concentrated Tier 2 and Tier 1 security layers with less potential for penetration
- "Out of sight, out of mind" to blend into surroundings and hidden from aerial imagery

How GIS can help…..



Prevent Using GIS

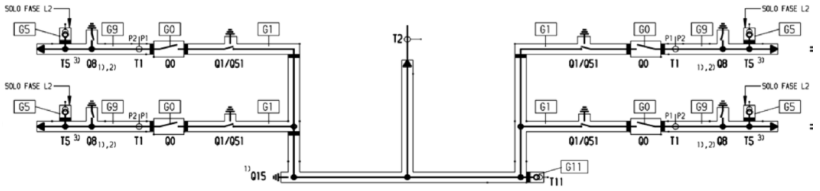
The Terrorist/Physical Attack Example

- No line-of-site to equipment for projectile weapons
- Switchgear is completely enclosed with fire protection
- Transformers and reactors can be enclosed and covered with grating overhead to minimize air assault
- Relay control rooms can be located at the interior of the complex to enhance protection
- Interfaces to transmission and distribution system can be more easily concealed underground

Respond/Recover

Mobile GIS equipment for complete temporary substation switching arrangements as a proactive solution for the following scenarios:

- ✓ Critical loads that develop in short time periods
- ✓ By-passes for transmission switching equipment during repairs or maintenance
- ✓ Major storm restoration options
- ✓ Temporary switching arrangements to aid in expediting construction of substations and lines
- ✓ A “ready backup” for critical infrastructure facilities (i.e. government and public services)



Conclusions

- ✓ The use of gas insulated substation designs is an effective method to protect a substation and its associated electrical equipment from severe damage from a naturally occurring catastrophic event or a human-caused physical intentional attack.

- ✓ The use of gas insulated substation designs is a cost-effective strategy that results in enhanced substation resiliency and higher reliability due to a reduction in substation area, perimeter, the ability to shield equipment and minimized exposure to external threats.

- ✓ The benefits of employing GIS designs in concert with GIS Enabled Construction Methods for use as a hardening tool and a response /recovery tool for substations, contributes to the overall resiliency of the transmission system.