

Electric Grid Resiliency Real world Perspective

D.O.E - GMI Peer Review

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Agenda

- Resiliency
- Examples
- Future needs
- Summary

Resiliency

- Acceptance - Vulnerability
- Protect – Reasonable measures
- Respond – Innovative designs & practices
- Share – Knowledge, Equipment and Resources

Example – (1)

Challenge: Large Power Transformers (LPT) replacement

- Spares on hand
- Transport – size and weight
- Time to assemble & energize
- Impedance

Solution: Siemens single phase resiliency auto transformers



Example (1) Siemens single phase auto transformers

Salient features: 3 day restoration Vs 3 weeks

- Multi voltage:
 - 300 MVA – 345 to 138 kV
 - 150 MVA 138 to 69 kV
- Lightweight – each phase tank - 98 tons oil filled
- Load tap changer - +/- 12%
- 170% Overload capability 5 minutes
- Air transportable – C5A Galaxy
- Plug in solid resin core bushings – bullet resistant
- Flexible high voltage 230 kV cable with cable extender
- Modular relay & control cabinet with plug in wire & fiber connections



Example (2)

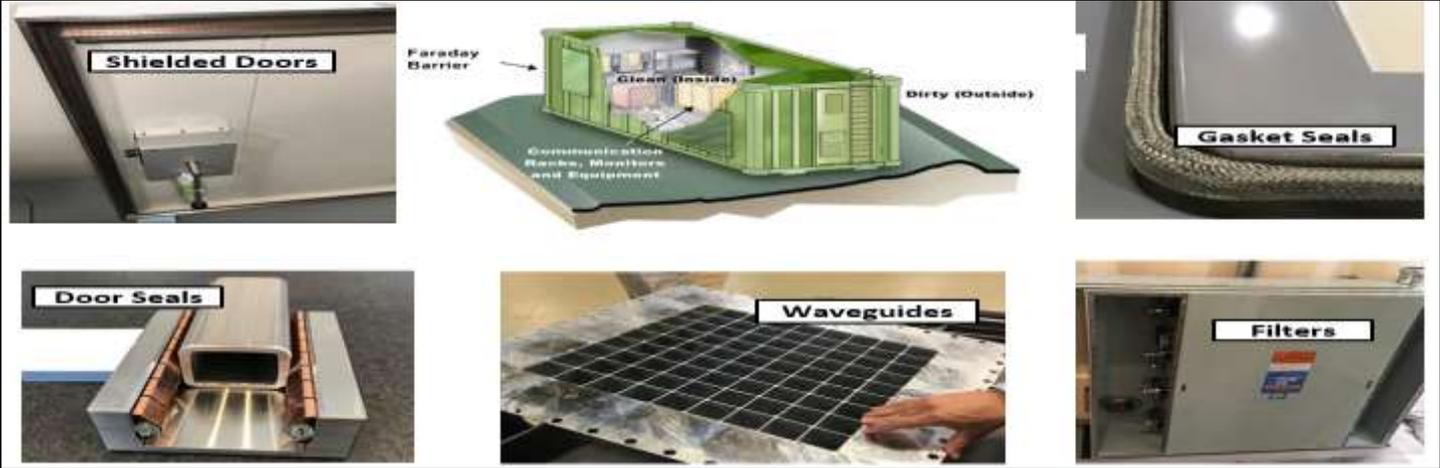
EMP proof - mobile Energy Control Center

Goals

- Storage
 - Sealed and protected
 - Receive periodic updates from production systems
- Transport
 - Pre-Planned routes
 - DOT Approved
 - Pre-determined deployment locations
- Deployment
 - Rapid mobilization
 - Quick connect into Verizon infrastructure
 - Utility Power or Generator

Example (2)

EMP proof - mobile Energy Control Center

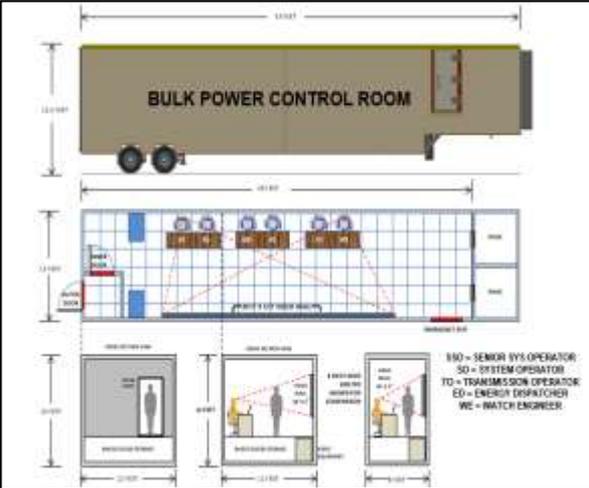
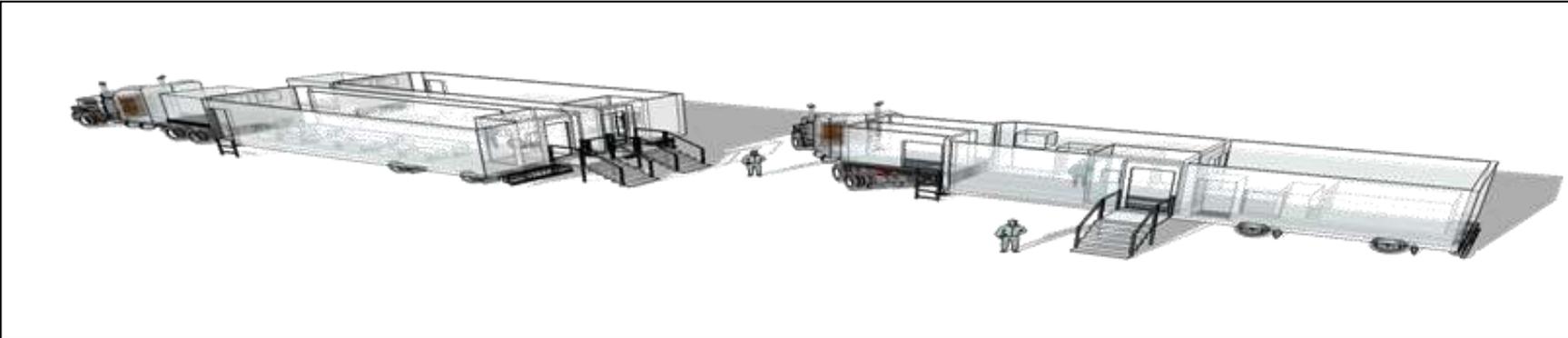


Hardware Systems

Connectivity	Communications Systems	Energy Management System		FMS and OPNET	Networking and Others
1	2	3	4	5	6
verizon	GarrettCom SEL	GE XA/21™ System		splunk	IP360 CISCO FORTINET

Example (2)

EMP proof - mobile Energy Control Center – ESP Inc.



Example (3)

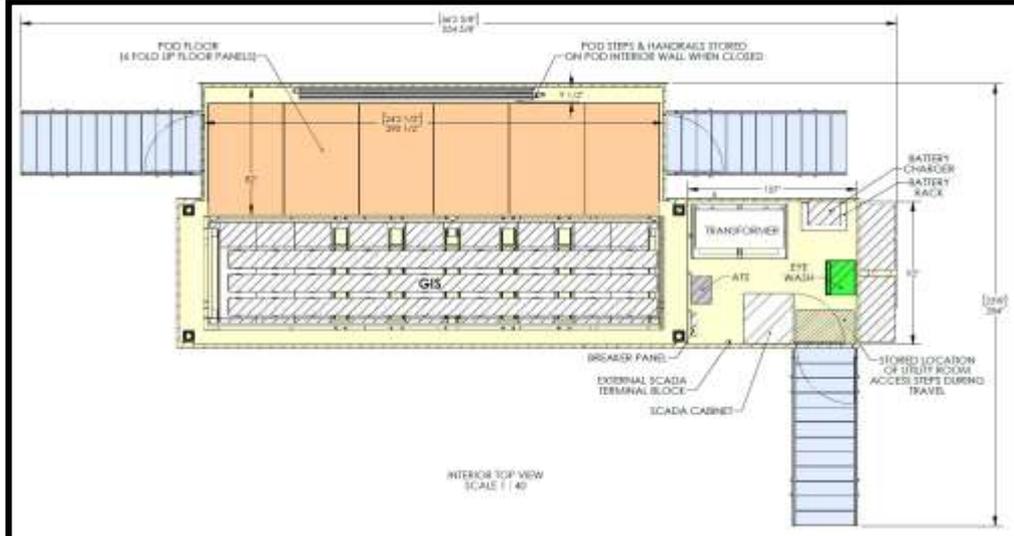
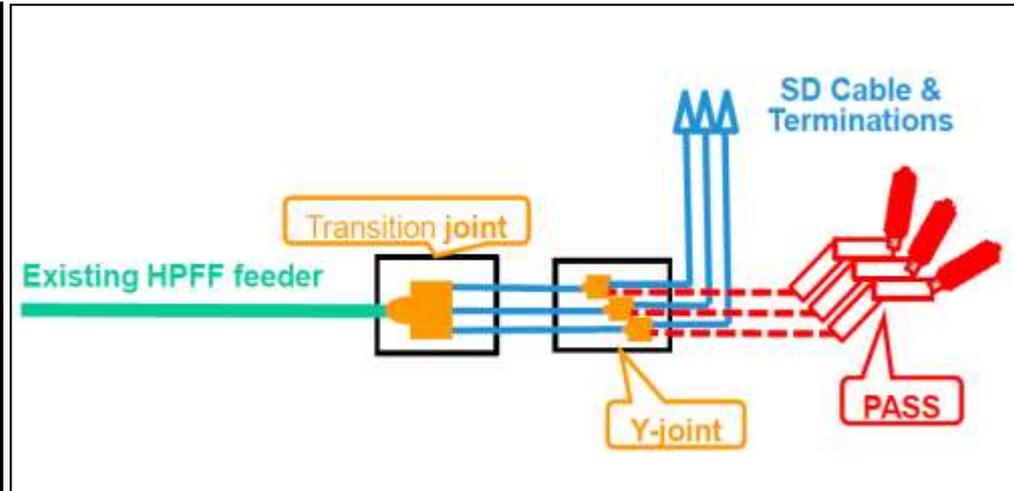
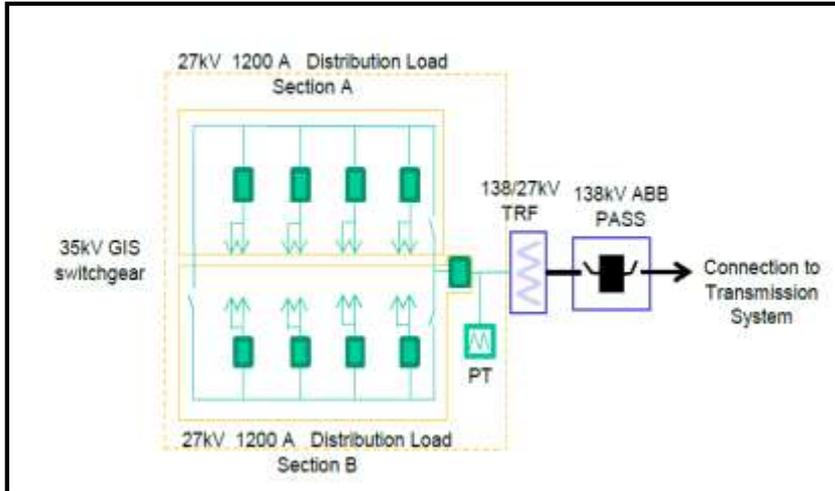
Loss of a distribution substation – Mobile 450 MW substation

Goals

- Mobile 100 MVA transformer
 - 138 kV to 13.8/27/33 kV with load tap changer.
- Mobile MV Switchgear
 - 4000 AMP – 24 circuit breaker total with cable bus connection – Double SYN bus configuration
- Transport
 - Pre-Planned routes
 - DOT Approved
- Deployment
 - Rapid mobilization
 - Energization at N-1 within a week

Examples

Loss of a substation – Siemens - mobile 450 MW substation



Near Future Needs

DOE & National Labs

- Cyber threat mitigation & recovery
- Adaptive relay protection and control systems
- Data conversion into actionable information
- Advanced material science
- Advanced HPI tools
- Efficient electrification

Summary

Leadership

- Culture shift – sharing & collaborating
- Engage - DOE & National Labs
 - We provide use cases & talent
 - Labs provide additional talent & workable solutions
- Engage - PUC for acceptance and approval