December 7, 2021

Jake Gentle
Program Manager,
Infrastructure Security
Jake.Gentle@inl.gov

Transmission Optimization with Grid Enhancing Technologies (TOGETs)

PJM Emerging Technology Forum

Idaho National Laboratory

INL/CON-21-65389

Grid Enhancing Technologies Report to Congress (June 2021) Overview

- **Congress requested** a report addressing:
  - Impacts of increased bulk transmission efficiency
  - Grid enhancing technologies (GETs) effect on energy cost
  - GETs cost benefit case study

- **Case Study:** compared techno-economic analysis of:
  - Base system without network upgrades
  - Base system with traditional transmission upgrade
  - Base system with grid enhancing technologies (GETs)

Grid Enhancing Technologies Overview

Grid Enhancing Technologies (GETs) include, but are not limited to:

1. ***Power Flow Control (PFC)* and transmission switching equipment**
2. **Storage technologies**
3. **Advanced *line rating (DLR)* management technologies**

   Also includes power flow control software (topology optimization) and dynamic transformer ratings.

Power Flow Control is a set of technologies that push or pull power away from overloaded lines and onto underutilized corridors within the existing transmission network. A number of power flow control solutions exist

Dynamic Line Ratings adjust thermal ratings based on actual and forecasted weather conditions including, ambient air temperature, wind speed and direction, and solar irradiance, in conjunction with active monitoring of resulting line behavior.

*https://cms.ferc.gov/media/7198

Recommendations

Selecting Locations – The impact of DLRs and PFCs is highly location-dependent and should be assessed on a per case basis

GETs Should be Considered - GETs should be evaluated as a candidate technology in resource and transmission planning and directly compared against traditional technologies.

Workforce Development – Stop the cycle of "pilots" by actively shifting organizational thinking. Consider the requirement of training for system planning, design engineers, and grid operators on new technologies and techniques so that when faced with the challenges of implementing innovation, they are trained and versed in new approaches more broadly.

Recommendations (Cont.)

Assemble a Task Force to Share GETs Data – Charged with providing industry with data needed for fair GETs consideration to ameliorate perceived risk of the modern technology. Such data would include:

Budgetary Cost Estimates- Costing estimates for traditional system upgrades are readily available and referenced by industry, academia, and other regulatory bodies. Detailed literature for GETs capabilities is not widely available, nor is a consistent cost range available in published studies. Providing industry with passive cost estimates will help planners consider the technology.

Hour by Hour Usage – The capabilities of GETs are becoming better understood, but the practicality and real-world usage of GETs is less documented. Understanding how the GETs that are deployed are being used will help others consider their usage as technologies mature.

Deployment challenges – Incorporating any new technology will include challenges. Understanding those challenges and the techniques used to overcome them will assist in alleviating utility concerns.

Recommendations (Cont.)

Further research is needed to accelerate adoption:

Expand scope of R2C study to include:
DTR, Storage, and Demand Response as additional GETs.
Interregional consideration of GETs as a bridge to the grid of the future.
Identification of the optimal GETs solution set.

Toolkit for incorporating GETs more collectively into generation dispatch decision-making, considering market rules, forecast availability, forecast accuracy, weather variability, and computational feasibility.

Improve transparency of congestion locations with a national level visualization platform for forecasted capacities.

Benefits / Cost Allocation / Incentives – The incentives to build GETs are often misaligned from those who benefit most. Many interested stakeholders whose primary focus is *not* on the efficient economic planning and operation of the power system.

Topology Optimization with Grid Enhancing Technologies

TOGETs Project for T&D Operations:

- This project aims to develop a task force to tackle business decision challenges that are inhibiting the operationalization of GETs including:

    - **Lack of Budgetary Estimates** – cost estimates of upgrades and passive cost estimates
    - **Need for clear use cases** – how are GETs used on an hour-by-hour basis, what is the operational functionality?
    - **Deployment Challenges** - integration challenges, cybersecurity requirements, data models, and communication shortfalls and mitigation techniques
    - **Lack of Validated Results** - rigorous, independent testing of the devices.

- Project has kicked of with the formation of a 20 member industry Task Force to inform the development of the project execution plan.

TOGETs Outcomes:

- Improve GETs Literacy – webinars, reports, stakeholder engagement
- Improve GETs Transparency – study disparity between capabilities and actual performance
- Validate GETs Capabilities – test and demonstrate complementary applications of GETs

TOGETs Project – Overview

Assemble Task Force

- Industry concerns need to be prioritized
- Task Force members include regulatory organizations, transmission operators, power industry consultants

Leverage existing work

- Many pilots and case studies have already demonstrated the value of GETs devices
- Most pilots exist as one-off studies that are difficult to apply directly to new projects
- TOGETs will catalog information from reports to generate comprehensive knowledge guides

Answer remaining concerns

- Reports do not document integration challenges
- Lack of information on operational integration of data into realistic uses

TOGETs Project – Two-pronged Approach

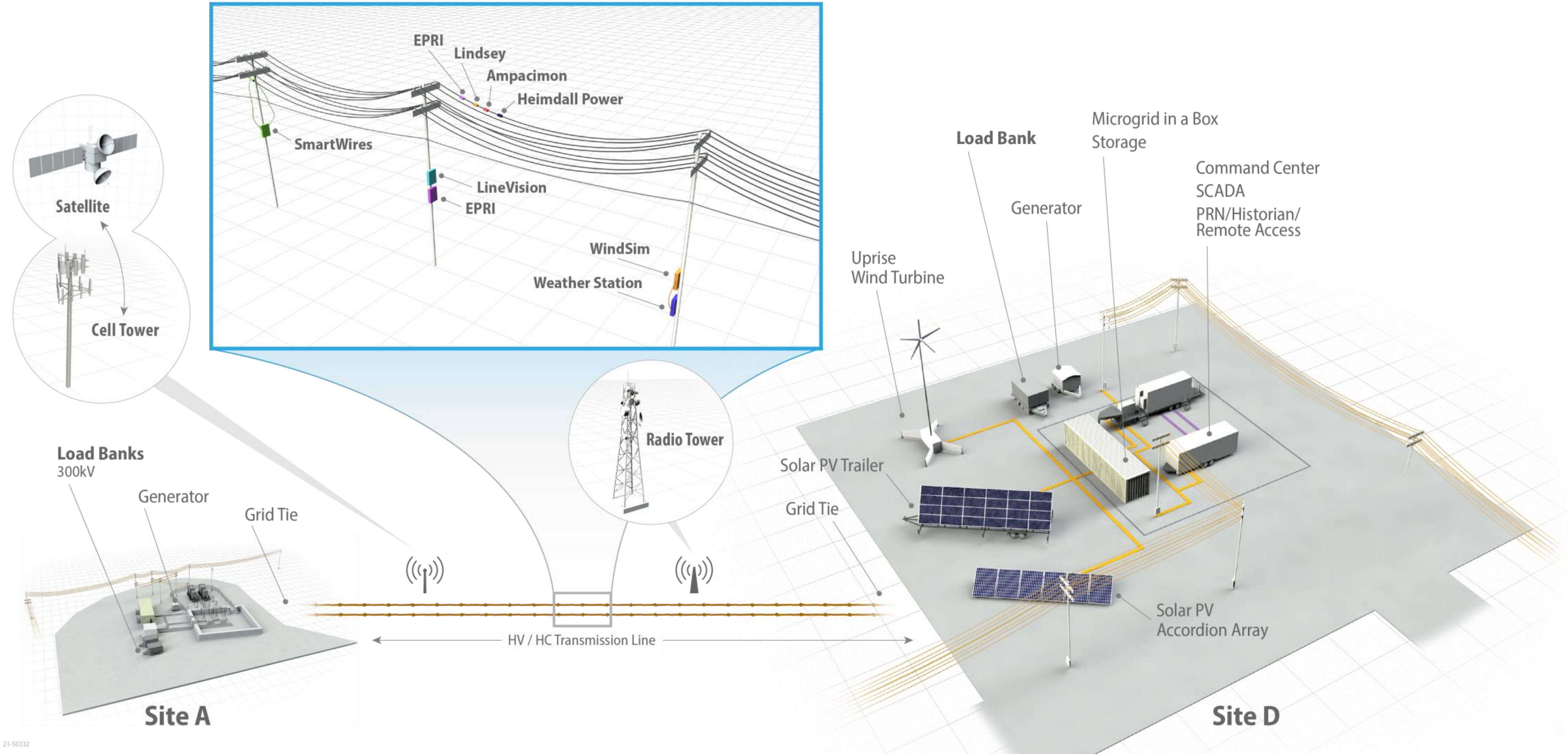
Compile previous studies into templated knowledge base

- Leverage publicly-available reports, Task Force member studies, available data
- Compile information on costs, goals, outcomes, challenges
- Input information from each study into a template
- Aggregation of templates serves as knowledge base for industry

Execute small-scale demonstration to address unanswered concerns

- Focus on DLR and PFC
- Document entire installation process
- Record cybersecurity questions and solutions for best practices guide
- Address communication, data, and integration concerns
- Develop common metric for evaluating performance/accuracy across different devices
- Create controlled scenarios to represent operating conditions of interest

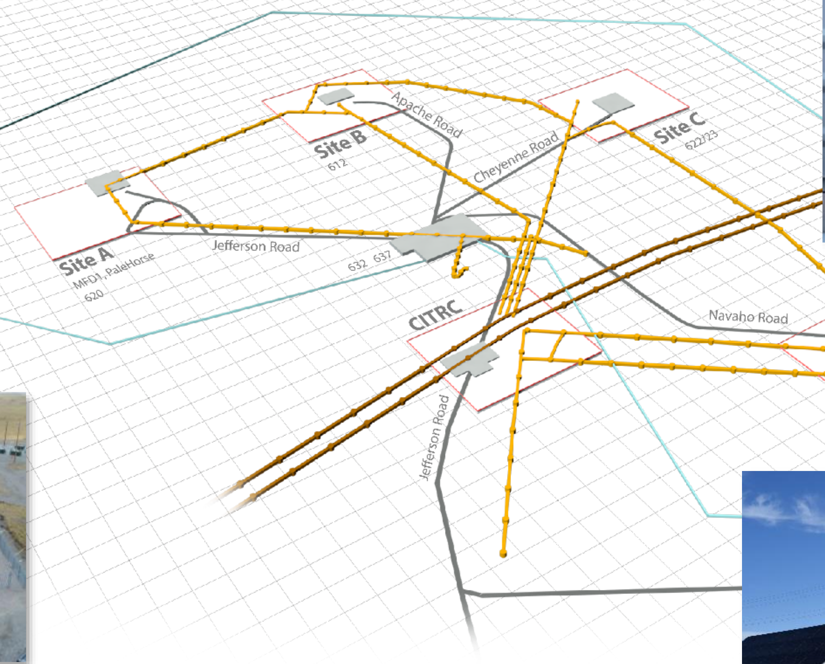
GETs Field Demo at INL's CITRC



Utility Transmission and Distribution Facilities

SITE RANGES

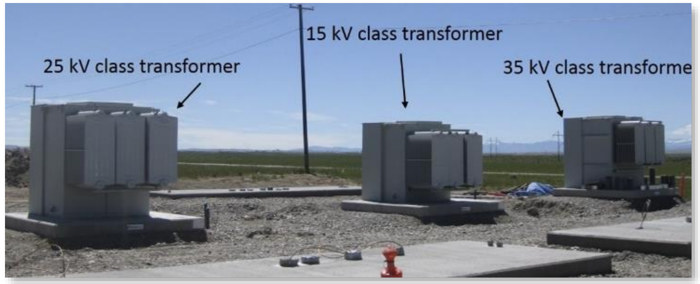
Configurable Mock Substation



NTIA Approved Test Site

Dedicated R&D Substation

Mobile Command Center, PV Super Array, and Wind Turbines



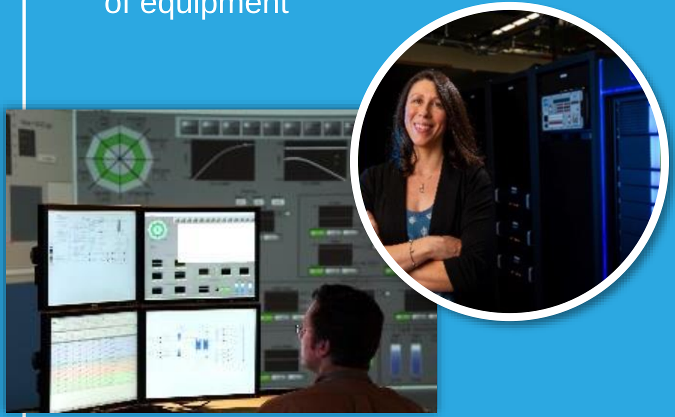
15/25/35kiloVolt Class Distribution Support

Official Use Only, Ex: 5

Official Use Only, Ex: 5

IDAHO FALLS

Cybersecurity and SCADA Labs
Research and development of equipment



Data Visualization and Advanced Modeling and Simulation

IDAHO NATIONAL LABORATORY

Key questions TOGETs demonstration will answer about integration

Modeling → Procurement → Installation → EMS Integration → Data Collection → Data Integration

Modeling
- What protection studies are needed?
- How do we integrate device models into system models?

Procurement
- What are common lead times?
- How much per span do devices cost?

Installation
- Can we safely do hot-installs?
- Where should devices be installed for maximum impact?
- How many devices are needed?

EMS Integration
- Does it require external connections?
- What data security measures are needed?

Data Collection
- How is data collected?
- How often should date be collected?
- How often should models and calculations be updated?

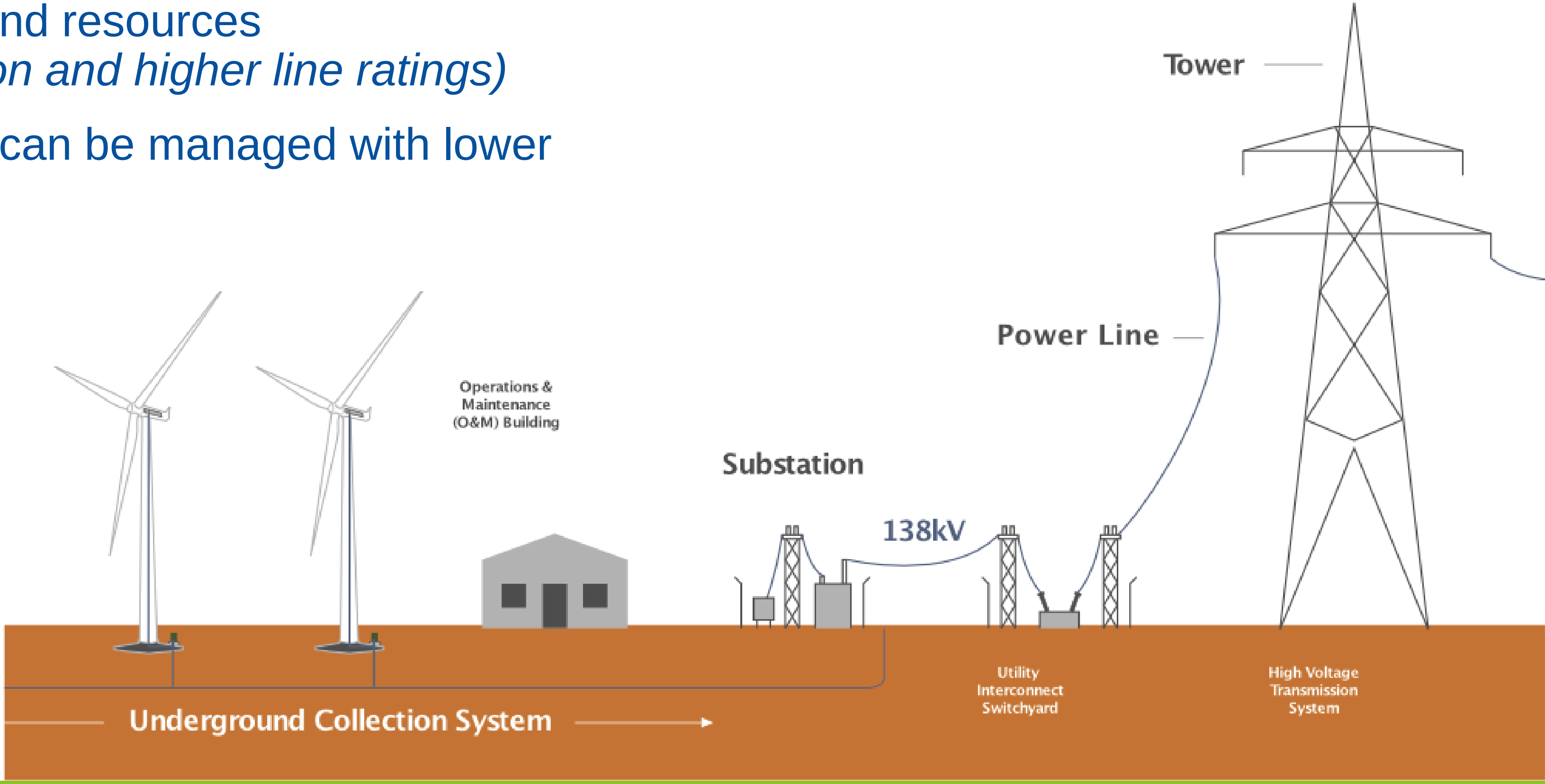
Data Integration
- How can data be leveraged from GETs to inform operation decisions?

Intended Outcomes

- Improved industry understanding of GETs technologies and integration challenges
  - Understanding of ease of implementation
- Best practice recommendations, particularly around security
- Knowledge base for previous studies to aid industry in selecting the right application for their system
- Transparent installation and integration process
- Generic metrics for performance across technology types

Long-term vision: What can be accomplished with GETs

- Renewable resources have variable generation sources, DLR can be used to increase line ratings for renewable generation
  - This is especially true for wind resources *(high wind = more generation and higher line ratings)*
- Resilience and reliability events can be managed with lower impact to end users (PFC)
- As there is a move towards electrification (vehicles, heating, etc.), DLR can identify higher transmission capacities to delay or eliminate the need for transmission upgrades



How can industry support TOGETs?

- What pilots should we examine to build our knowledge base to share?
- What is slowing your organization down in the adoption of GETs?
- What data needs to be collected to assure your organization of the value of GETs?
- What applications/challenges could GETs help your organization solve in the long term?

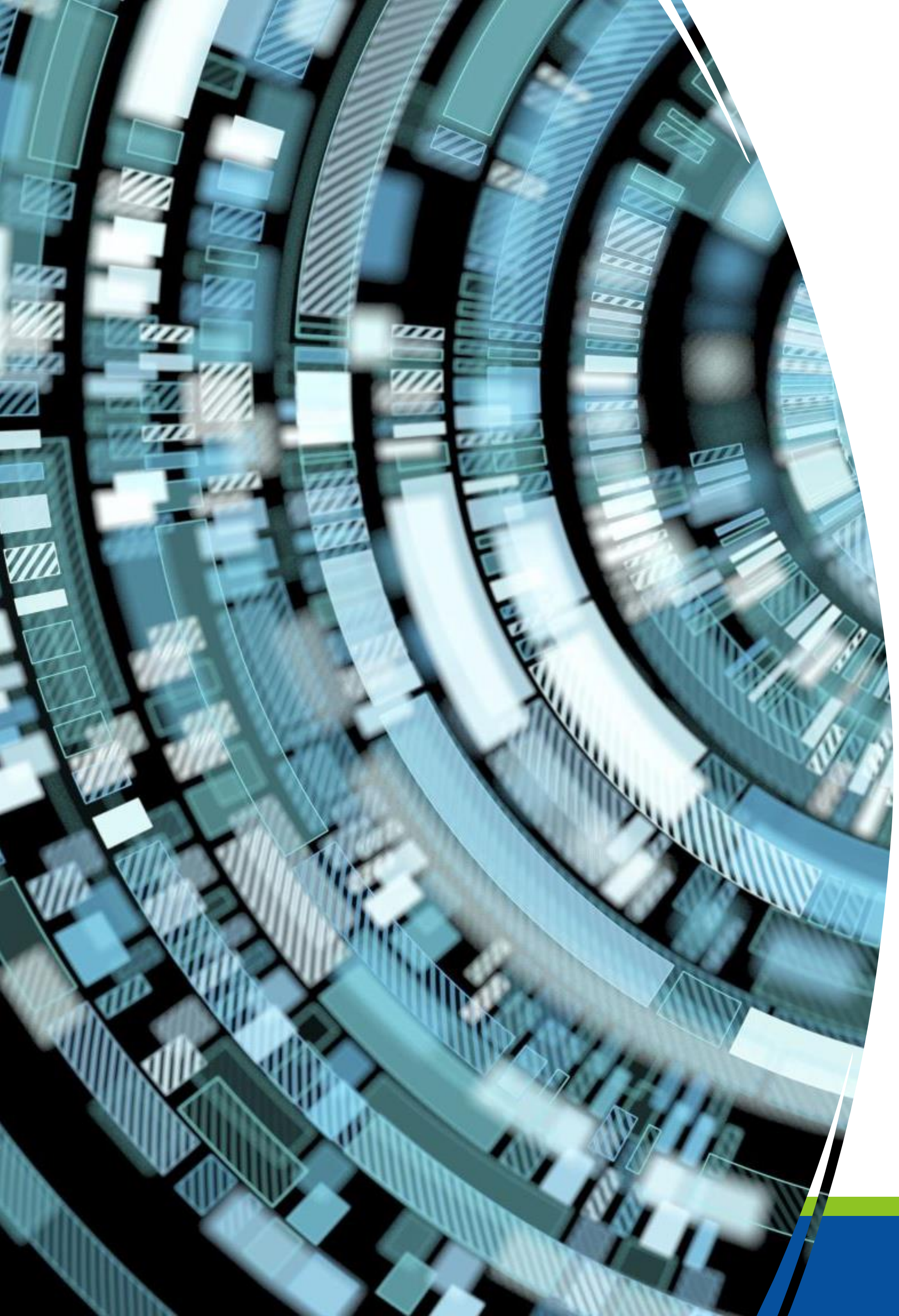
December 7, 2021

Jake Gentle
Program Manager,
Infrastructure Security
Jake.Gentle@inl.gov

Open Discussion

Idaho National Laboratory

Backup



INL Critical Infrastructure Test Range Complex (CITRC) Virtual Tour

INL Electric Grid Capabilities Overview

Operational Experts on Site

- 24/7 Grid Operations Staff
- 24/7 staffed dispatch and control center
- Power systems and communications planning linemen, electrician, maintenance and troubleshooting
- INL Security Force (ProForce)
- Dedicated medical department
- Dedicated fire department
- Cafeteria

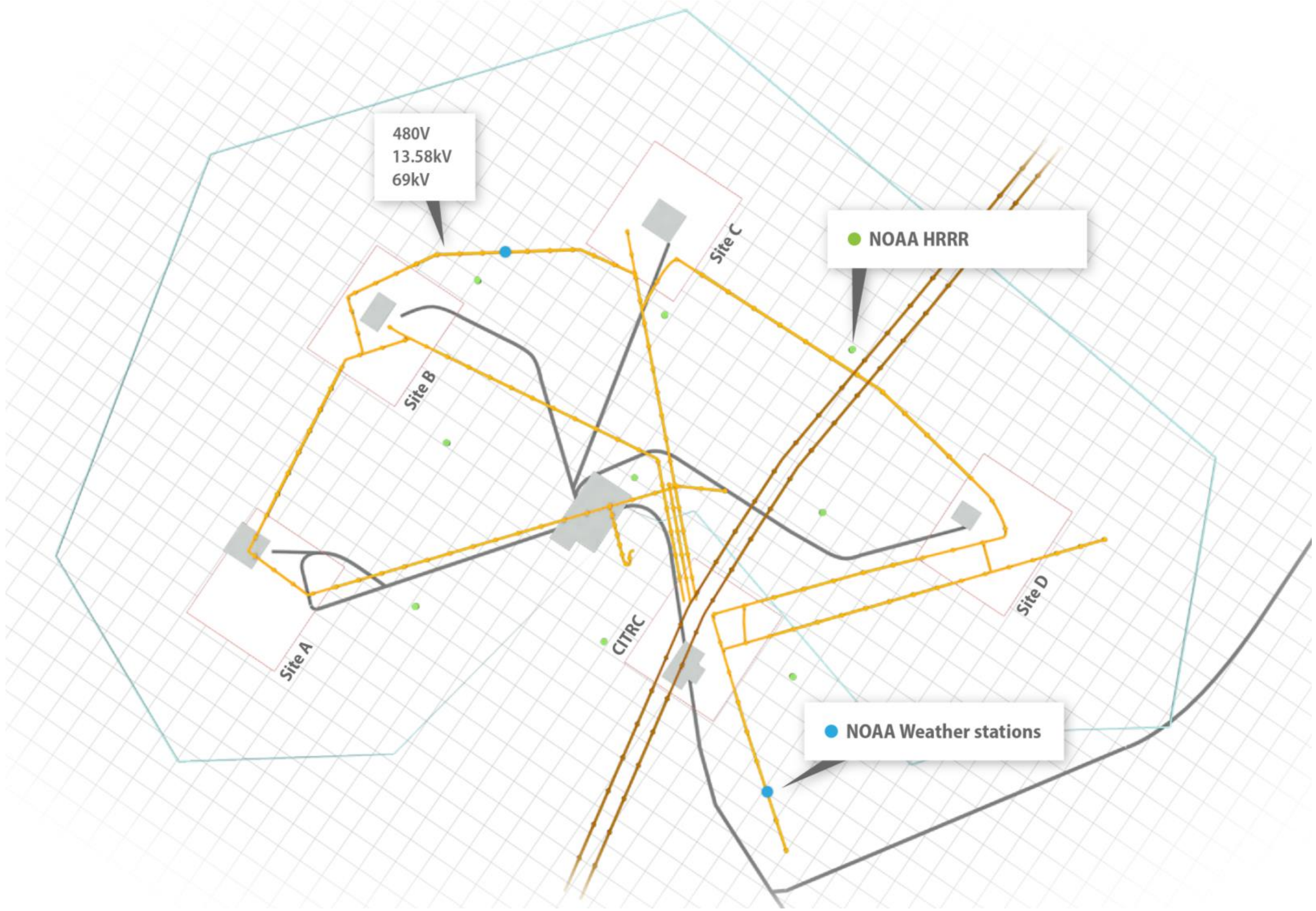
- Operational technology cybersecurity, power systems engineering and vulnerability analysis
- Established services and processes:
  - Resource management - personnel, networks, configuration control
  - Secure, IP protected multi-user facility
  - Broadband data access throughout the INL Site
  - Hardware prototyping and scientific labs
  - Visitor capability for U.S. citizens and foreign nationals

INL Named Grid Center of Excellence for GMD by DTRA

Other INL Critical Infrastructure Expertise

- Power control system
- UAV airstrip and pilot
- Microgrids
- Electric Vehicle
- Hydrogen
- Wind
- Solar
- Water
- Wireless Security Institute
- Control systems cybersecurity
- Communications engineers
- Spectrum Innovation
- Electric Vehicles
- Design, maintain and operate all INL utility systems

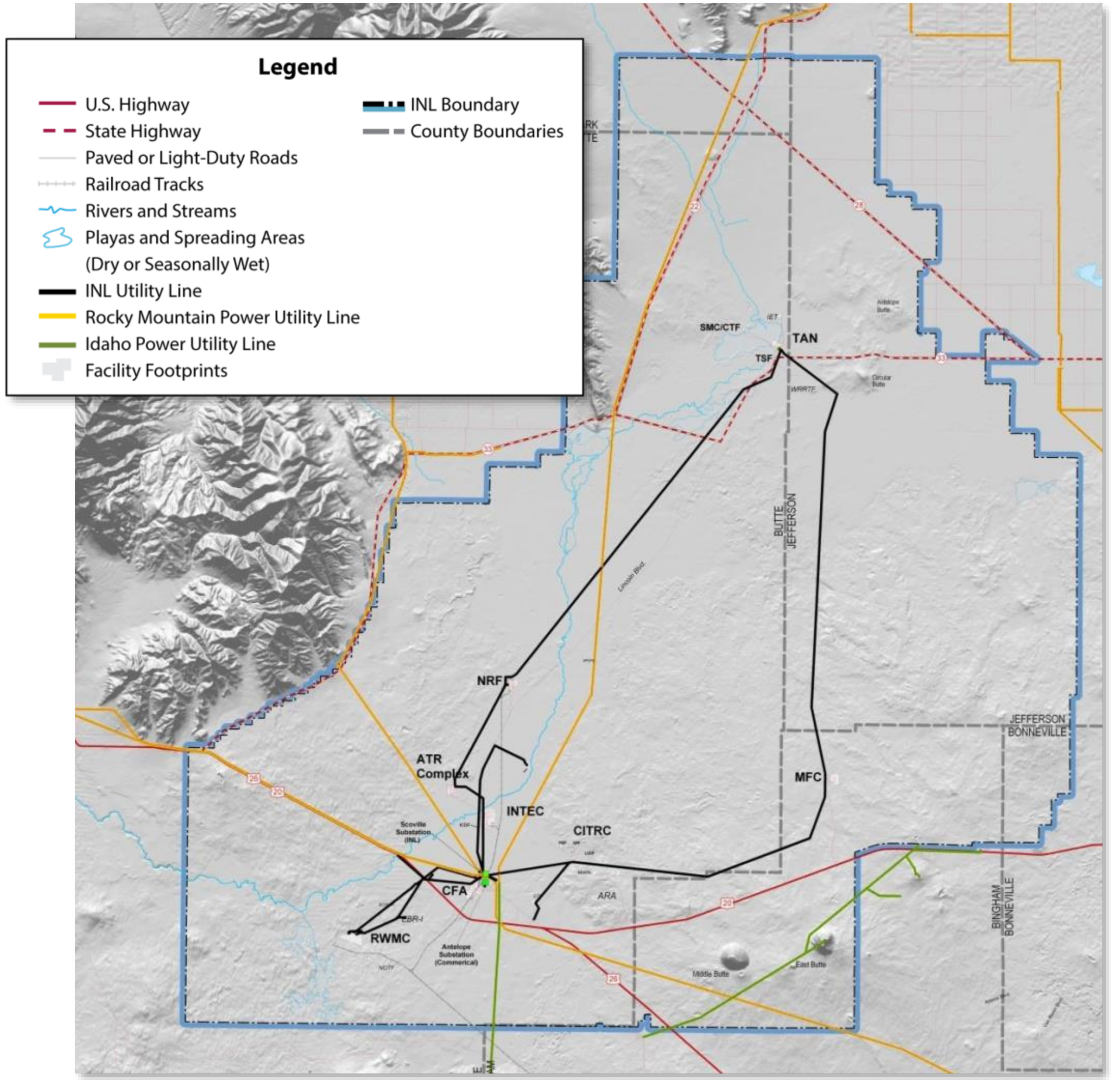
CITRC Existing Weather Data Capabilities for DLR



Full suite of NOAA weather information available at CITRC

- NOAA High-Resolution Rapid Refresh weather data
- NOAA weather stations

Full-Scale and Configurable Utility Capabilities



Utility-scale power grid with full-time INL monitoring and control at INL's 890 square mile federal reservation

- Secure power distribution system
- 61 miles of 138 kV transmission loop
- 7 substations
- 3 commercial feeds at 161kV and 230kV
- Central dispatch operations
- Real-time grid monitoring and control through centralized SCADA operations center
- Fiber optic communications
- Ability to isolate portions of grid for specialized testing
- Flexibility to conduct full-scale research on "stiff" grid
- Protection and restoration
- Research and analysis