

# Microgrid Design Toolkit (MDT)

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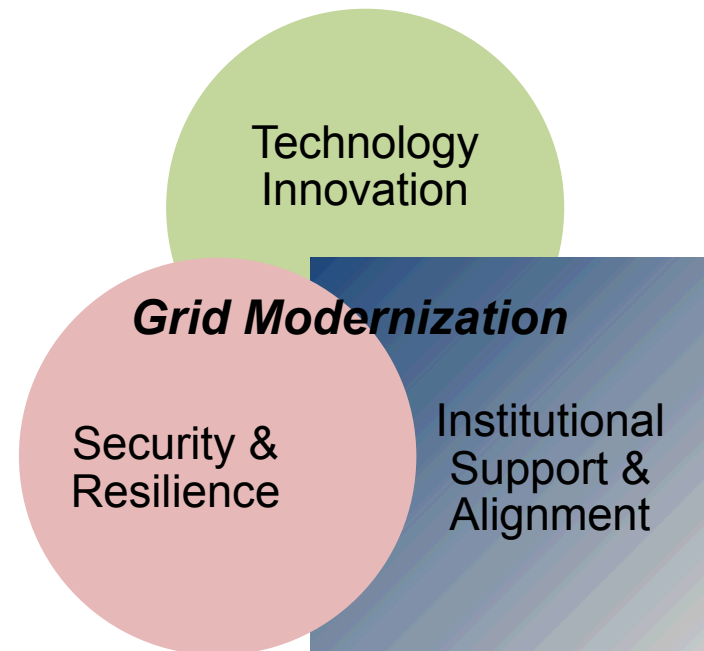


# Outline

- Smart Grid and Microgrid RD&D Program at the U.S. Department of Energy
- Microgrid Applications for Military and Civilian Critical Infrastructure Energy Resilience
- Sandia Microgrid Design Toolkit (MDT)
- Q&A

# DOE Office of Electricity (OE)

- **MISSION:** The Office of Electricity Delivery and Energy Reliability (OE) drives electric grid modernization and resiliency in the energy infrastructure.
- OE leads the Department of Energy's efforts to ensure a resilient, reliable, and flexible electricity system.
- OE serves as the Energy Sector Specific lead for Federal emergency response.



# DOE/OE Smart Grid R&D Program

## Areas

### **Microgrid Research, Development and Demonstr.**

*For commercial viability, reliability, and resiliency*

Continue R&D pathway to support achieving DOE program goals related reliability, efficiency, environmental impact, and cost effectiveness

Support the DOE strategy, leading to creating a smarter and more resilient grid and community.

### **Advanced Distribution Management System (ADMS)**

*Providing better control and visibility*

Develop architectures that integrate new & existing applications across the utility enterprise to accommodate rapid and complex communications/interactions between D&T; develop operational control strategies using advanced analytics.

### **Resilient Electric Grid Research and Development**

*For enhanced grid resilience*

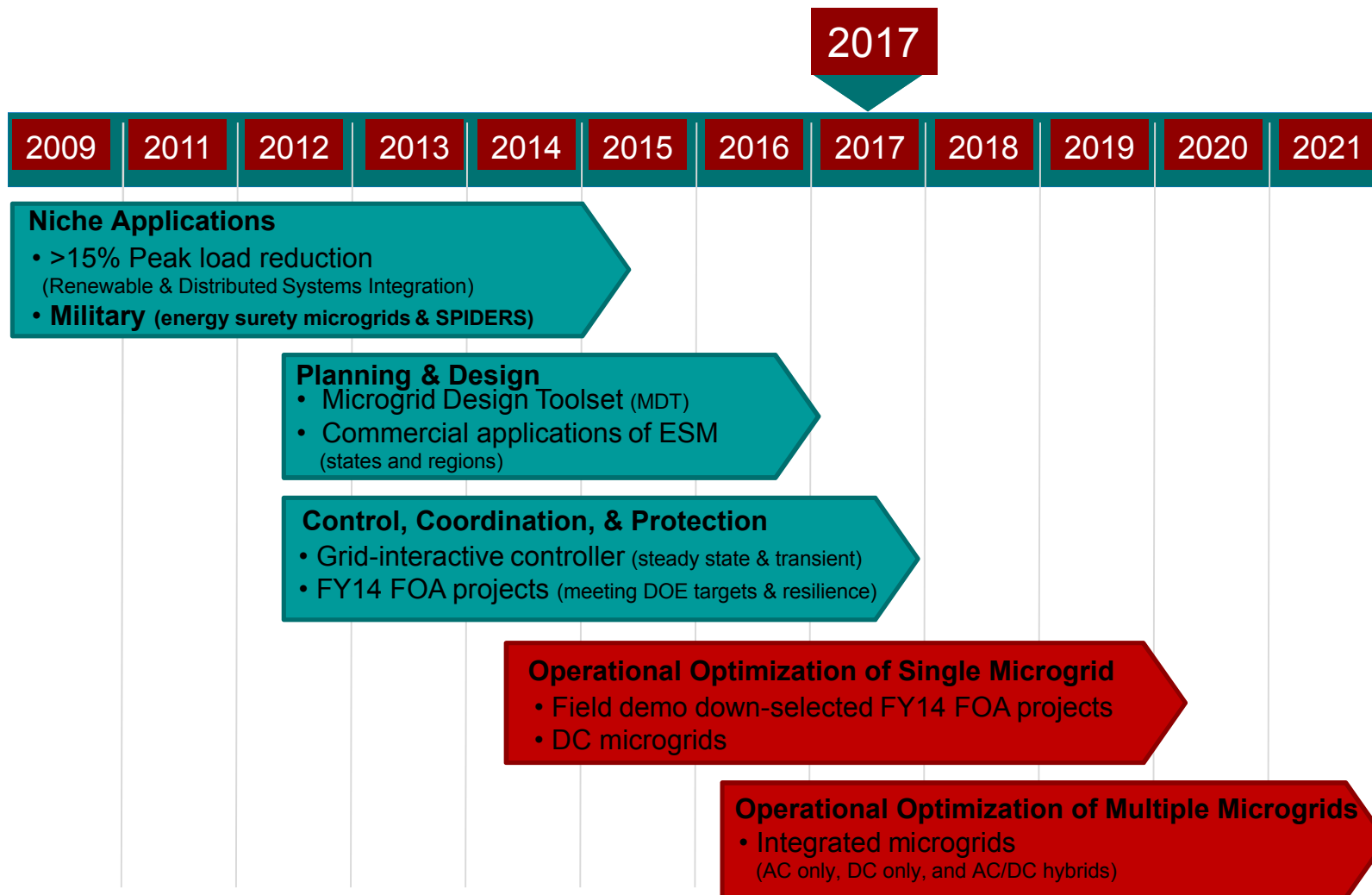
Implement high-priority R&D projects identified in the resilient grid roadmap, developed in a broad stakeholder workshop in 2014 and finalized during the QER in 2015.

### **Market-Based System Operations and Controls**

*Enabling economical and flexible stability*

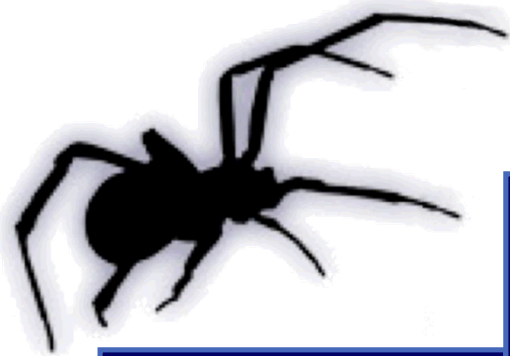
Develop simulation tools for the impact of transactive control, establish valuation basis for customer-delivered and grid-delivered energy services, and assess how to achieve a more distributed customer-driven grid.

# Multi-Year Plan R&D Timeline



# SPIDERS JCTD Program

- Smart Power Infrastructure Demonstration for Energy Reliability and Security



## PEARL HARBOR / HICKAM AFB CIRCUIT LEVEL DEMONSTRATION

- Renewables
- Storage
- Energy Management

## FT CARSON MICRO-GRID

- Large Scale Renewables
- Vehicle-to-Grid
- Large scale storage
- Critical Assets
- Demonstration to tie in with COOP Exercise

## CAMP SMITH ENERGY ISLAND

- Entire Installation Smart Micro-Grid
- Islanded Installation
- High Penetration of Renewables
- Demand-Side Management
- Redundant Backup Power
- Makana Pahili Hurricane Exercise

## TRANSITION

- Template for DoD-wide implementation
- CONOPS
- TTPs
- Training Plans
- DoD Adds Specs to GSA Schedule
- Transition to Commercial Sector via DOE
- Transition Cyber-Security to Federal Sector and Utilities

## CYBER-SECURITY

# SPIDERS Phase 2 – Fort Carson

## Microgrid

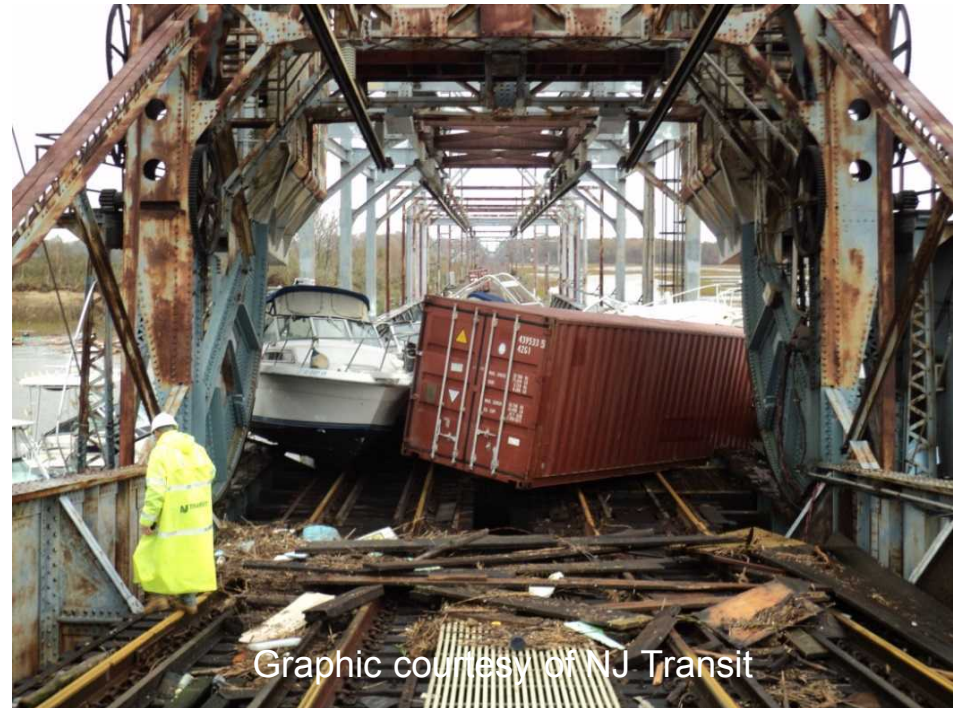
- SPIDERS microgrid elements
  - 1 MW PV, 3.25 MVA diesel genset
  - 5 electric vehicles with V2G capability
    - » Capable of providing demand response, peak shaving, and ancillary services, voltage support (EV chargers)
    - » Provide voltage/frequency stability in microgrid mode
- Successful operational readiness demonstration with all microgrid resources online
  - Identified operational process gaps/lessons
  - Control software refinements



*Courtesy of Melanie Johnson, USACE/CERL*

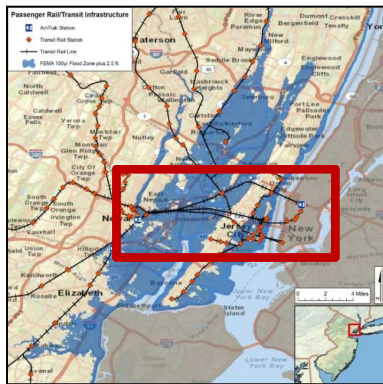
# Civilian Energy Infrastructure Resilience

- Superstorm Sandy (2009) caused major disruption to critical infrastructure in NY & NJ, including rail system
  - Impact to economy and cost of repairs are in the \$Billions
  - Re-build efforts emphasize resiliency with respect to future events

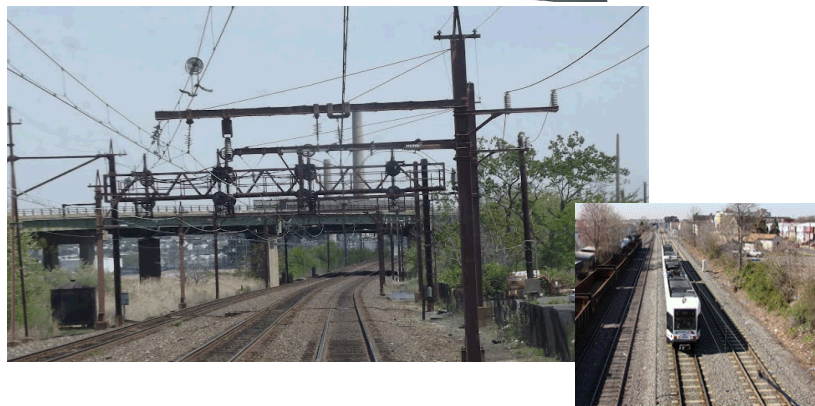
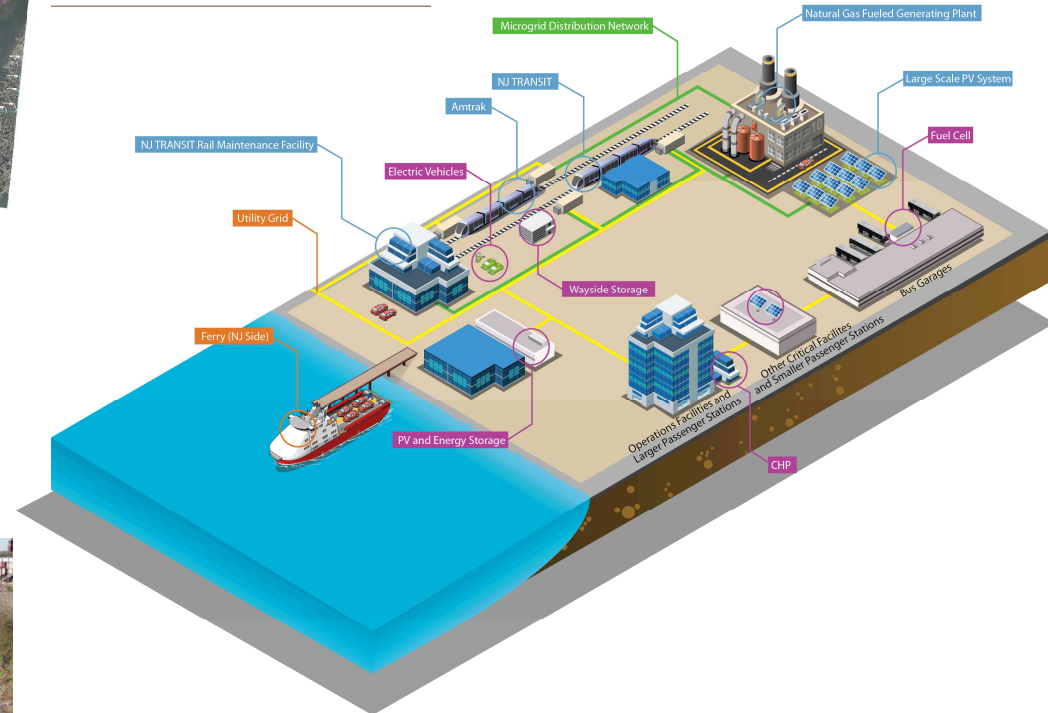


# Sandia and NJ TransitGrid Project

- Resilient rail transportation in the event of a storm and grid outage
- Conceptual Design: Large microgrid and distributed resources
  - Gas-fired generating station and other DER (PV, storage, CHP, EV)



N J T R A N S I T G R I D



# Energy Resilience Planning Process

- **Develop conceptual design**
  - Define system boundaries, design basis, performance objectives and metrics (typically risk-based)
  - Identify and characterize critical functions, related infrastructure and interdependencies
  - Identify conceptual designs and R.O.M. cost
    - » A microgrid is often one of the options to consider
- **Optimization across design alternatives**
- **Decision to proceed**
  - Procurement
  - Engineering design
  - Construction / Deployment
  - Operation

Sandia and other DOE labs have developed methodologies, metrics, and tools to address gaps in this application space.



# Microgrid Design Toolkit (MDT)

- MDT is a decision support software for microgrid designers in the early stages of the design process.
- Powerful search algorithms to identify and characterize the trade space of alternative design decisions in terms of user defined objectives.
  - Common examples of such objectives are cost, performance, and reliability.

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# Microgrid Design Toolkit (MDT)

Sandia-developed Microgrid Design Toolkit (MDT) characterizes the trade-space and provides what-if analysis of design choices to provide quantitative insights to decision makers for hybrid energy solutions

## Mission Requirements and Baseline Models

- Equipment deployed creates demand
- Or demand (load) models
- Or custom load models

## Equipment Data Base

- Energy demand/production
- Usage specification
- Reliability information

## Technology Options and User Inputs

- Identify energy producers and technology insertion options
- Select location and season (solar and/or wind profile)
- Reliability/maintenance data
- Select user mode
  - Performance analysis
  - Parametric study
  - Optimization



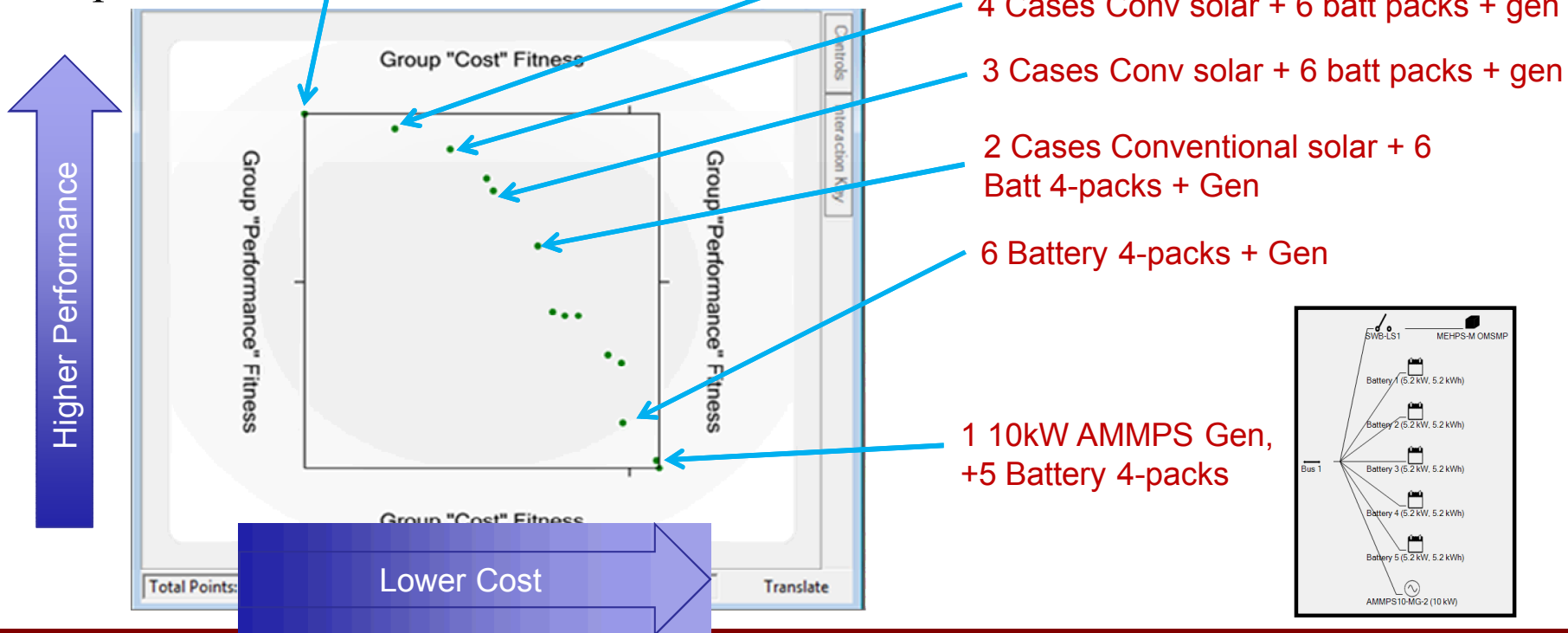
## MDT Results

- **Energy performance**
  - Energy availability, cost, fuel used, volume, silent watch, gen utilization
- **Parametric sweep results**
- **Optimal & feasible solution sets**
  - Generator types/counts
  - PV type/amount
  - Battery type/quantity

ITERATIONS to Refine Results

# Pareto Frontier of Feasible & Optimal Options

- All solutions shown in Pareto frontier; filter to show feasible solutions
- Examine progression of solutions with 10kW AMMPS generator
  - Starts w/ best performance, then adds technology to increase performance

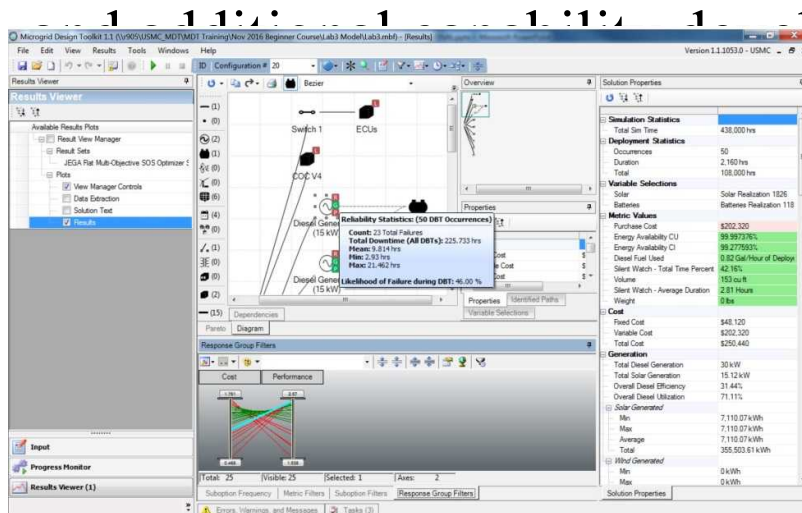


# MDT Origins and Technology Transfer

- Underlying analytic capabilities (TMO, PRM) developed as part of the DOE/DOD SPIDERS program.
- Subsequent DOE-funded effort combined TMO/PRM with various capabilities across national labs into a holistic microgrid design toolkit.
- Publically available
  - MDT Version 1.1 Beta (July 2016) is available for download from <http://www.energy.gov/oe/services/technology-development/smart-grid/role-microgrids-helping-advance-nation-s-energy-syst-0>
- Further MDT development recently completed with funding from US Marine Corps.
  - Improvements to both the analytics and the user interface.
  - 1.2 Beta has been delivered to USMC, will make available to public in near future.

# Recent MDT Enhancements for USMC

- Need: in-house analysis capability to help inform the USMC planning, requirements development and acquisition decision making processes about expeditionary energy technologies, including alternative energy technologies, microgrids, etc.
- In February 2017, Sandia delivered an in-house USMC version of MDT
- Follow-on support for model development, deployment/MDT-use



development

- **Usability:** Design drag-n-drop features, simpler information displays, etc.
- **Enhanced Modeling Options:** Silent Watch, battery usage profiles and operating modes, weight and volume performance metrics, etc.
- **Parametric Analysis :** Ability to sweep design parameter and discern performance trends (e.g., fuel utilization vs. battery size)

# Examples of MDC Applications



**The SPIDERS Program** used a predecessor to the MDT to develop the preliminary microgrid designs for 3 military bases.

- Joint Base Pearl Harbor–Hickam (HI)
- Fort Carson (CO)
- Camp Smith (HI)

These microgrids are currently in operation.



**The City of Hoboken, NJ** used a predecessor to the MDT to develop the preliminary microgrid design for backup power in response to Hurricane Sandy.

The primary goals of this design effort were to mitigate the impacts of extreme flooding on the distribution systems and electricity service throughout the city.



**The US Marine Corps Expeditionary Energy Office (E2O)** used the MDT to assess microgrid power systems and *Mobile Electric Hybrid Power Sources (MEHPS)* for expeditionary units and brigades.

Over **50 microgrid models** were developed in the MDT and used to provide design support for these islanded power systems. Assessed tradeoffs related to MEHPS diesel generator fleet.



**The US Marine Corps Systems Command (SYSCOM)** funded a specialized version of the MDT to aid in the USMC in making smart choices in planning investments in microgrids and renewable energy technologies.

This effort resulted in a delivered software product for in-house use by the USMC in making investment decisions related to the USMC portfolio of Energy Technologies and Systems.

# Spectrum of Potential Uses for MDT

Small Power

Big Power



Soldier as a microgrid



UAVs as microgrids



Gliders as microgrids  
24-hrs Aloft –  
Navy proposal



Military Bases



Urban Centers



Villages



*Towards 100% Clean  
Resilient US Energy*

# Questions? Comments?

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