Microgrid Development For Tactical Operations

LOCKHEED MARTIN

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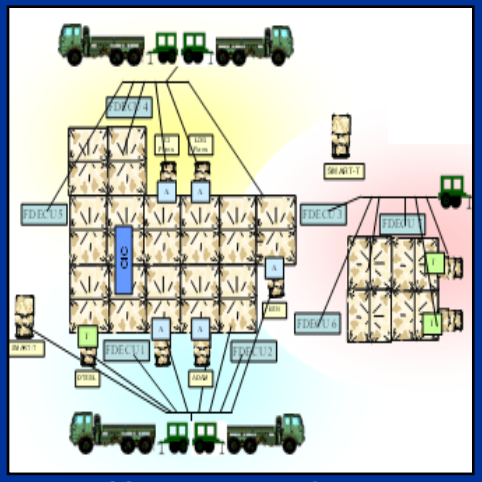
Current DoD Land Forces Power

Fuel Convoys

Vehicle Power



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Inefficient Architecture

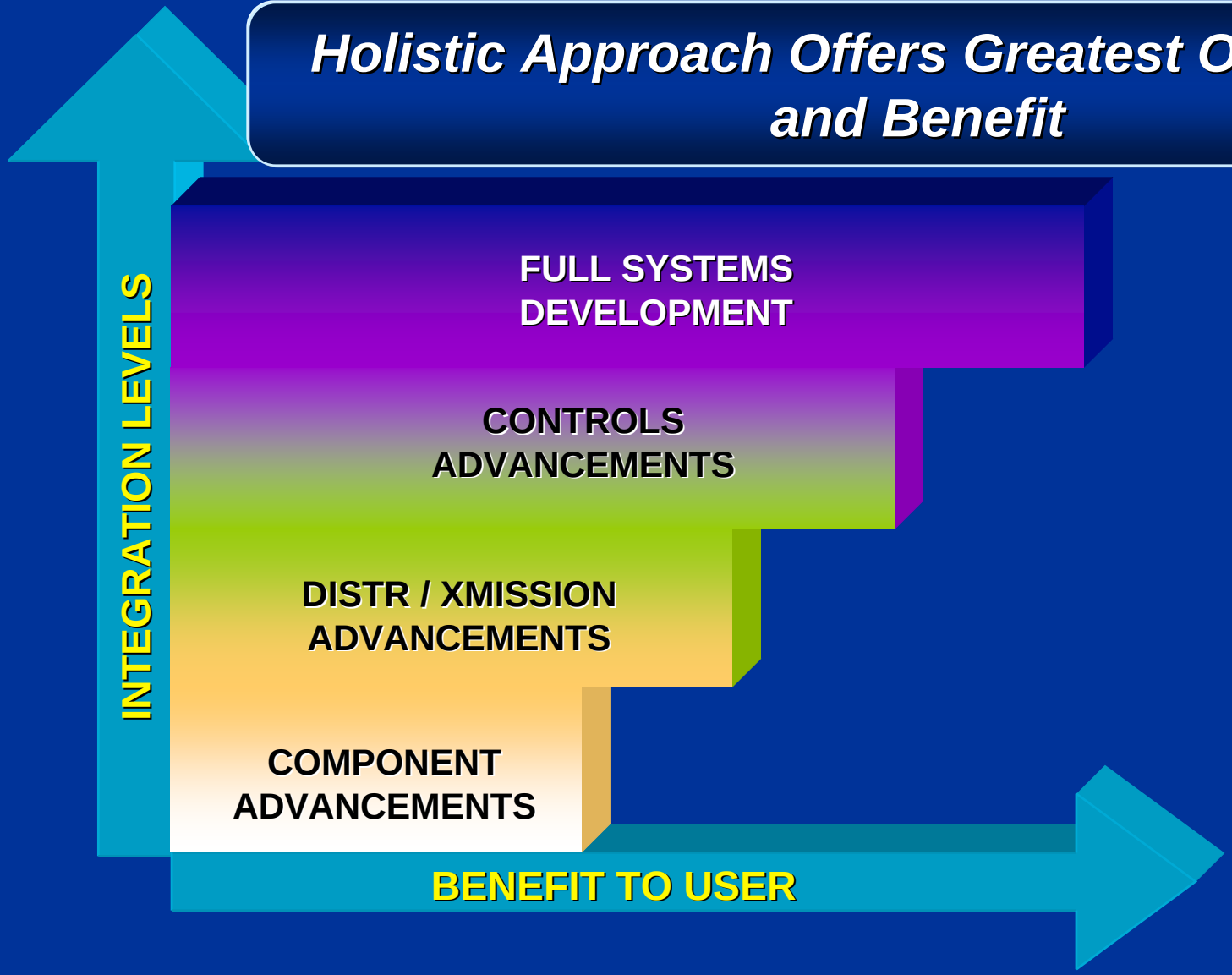
Capability Issues

- War Fighters at Risk
- Fuel Consumption
- Non-optimum SWaPc
- High O&M Costs

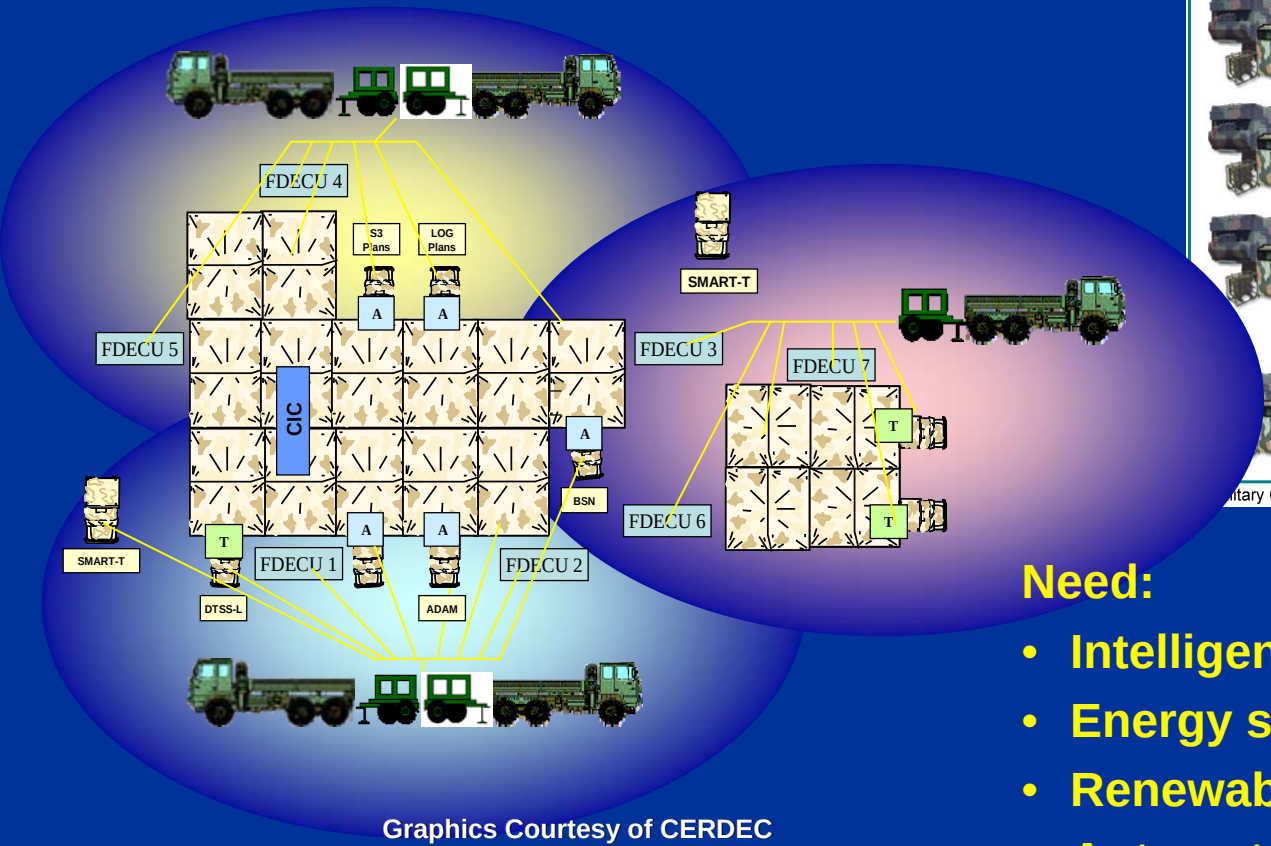
Hazardous Infrastructure

Power & Energy Integration Levels

Holistic Approach Offers Greatest Optimization and Benefit



Current Architecture



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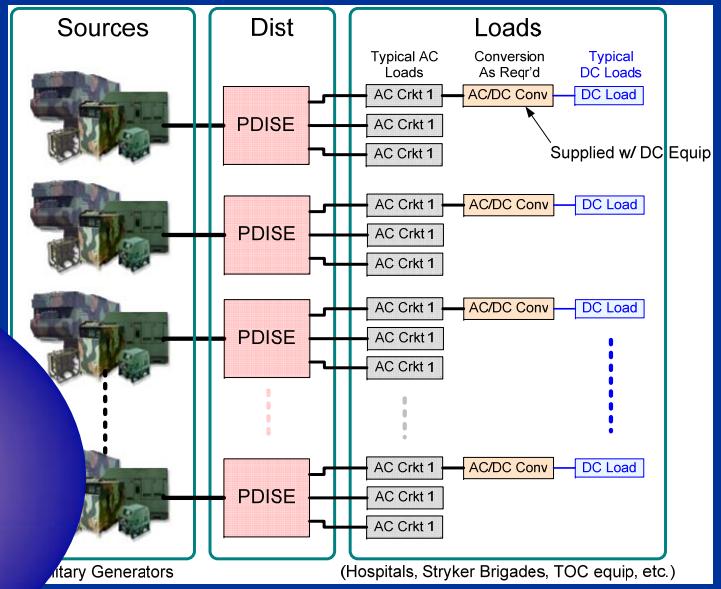
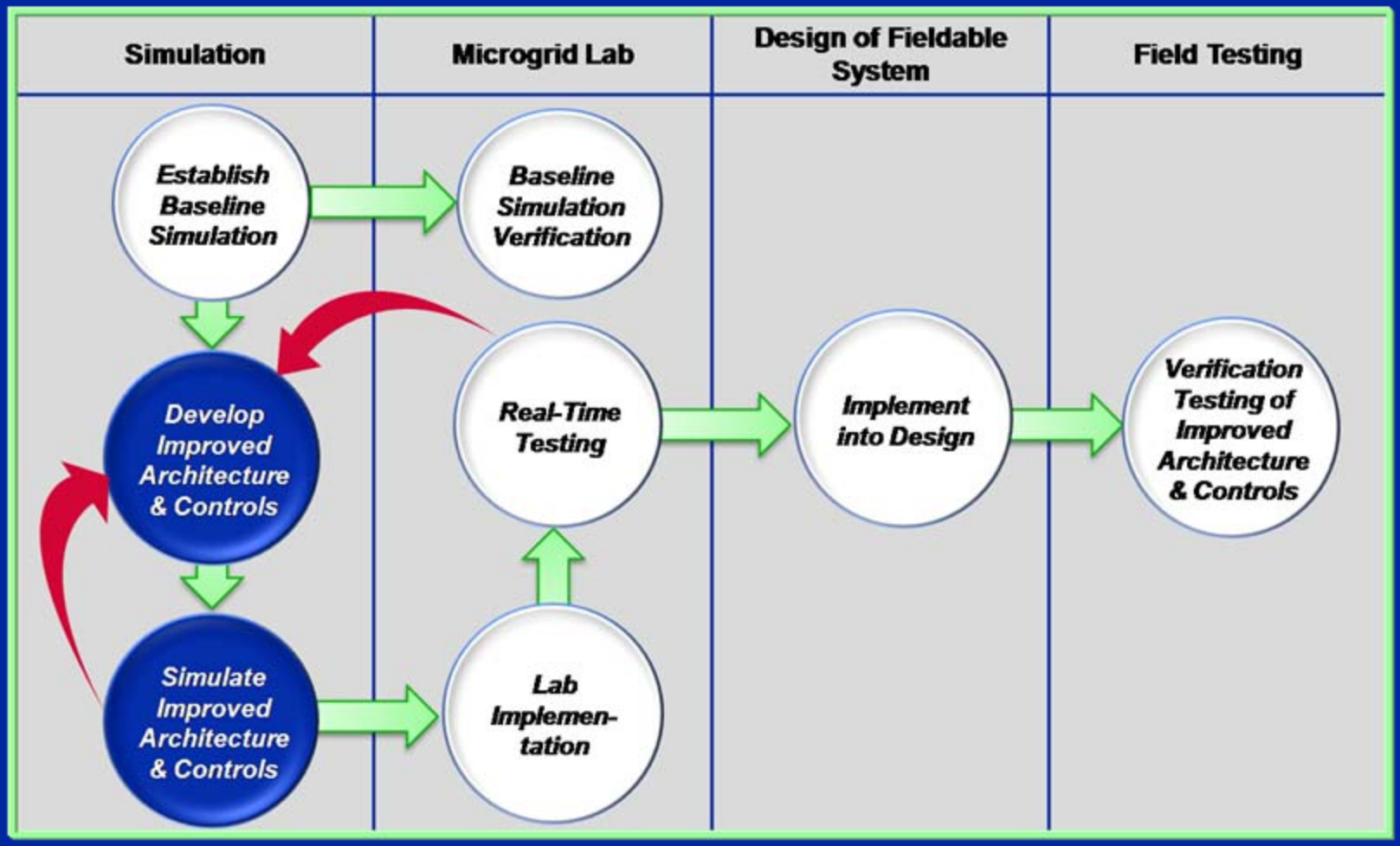


Need:

- **Intelligent distribution**
- **Energy storage**
- **Renewables**
- **Automated on/off genset and ECU control**

Remediation Requires Complex Integration and Multidiscipline Design Approach

Modeling and Simulation Approach



Simulation with Hardware Implementation Provides a Robust Design

Establish Baseline Simulation

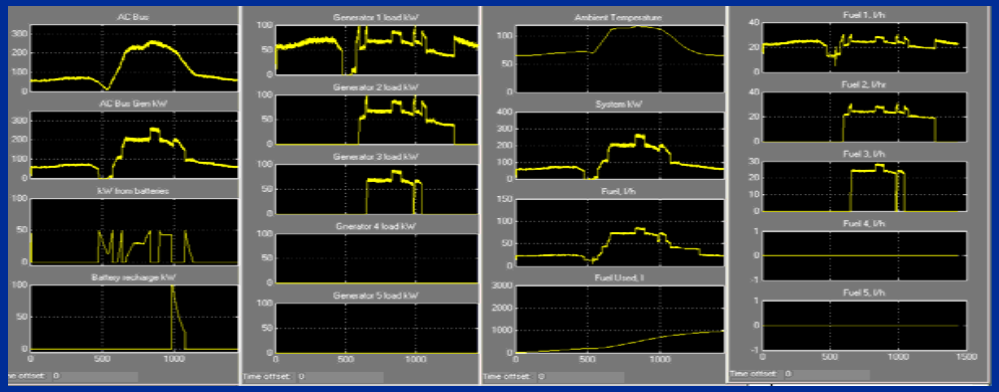
MATLAB Simulation for TOC/FOB/ power configurations

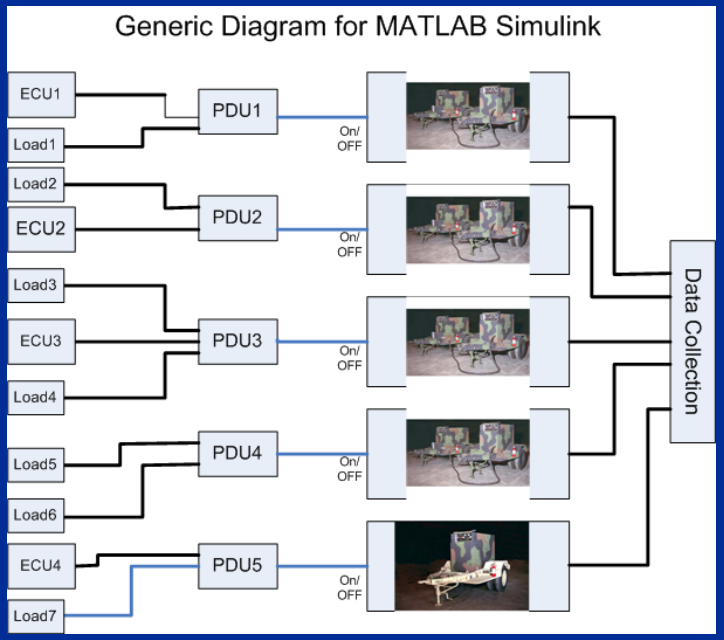
- User Load Profiles
- Establish performance char.
  - Fuel consumption
  - Generator run times
  - Load prioritization
  - Redundancy

Validation via hardware testing

Simulation Features

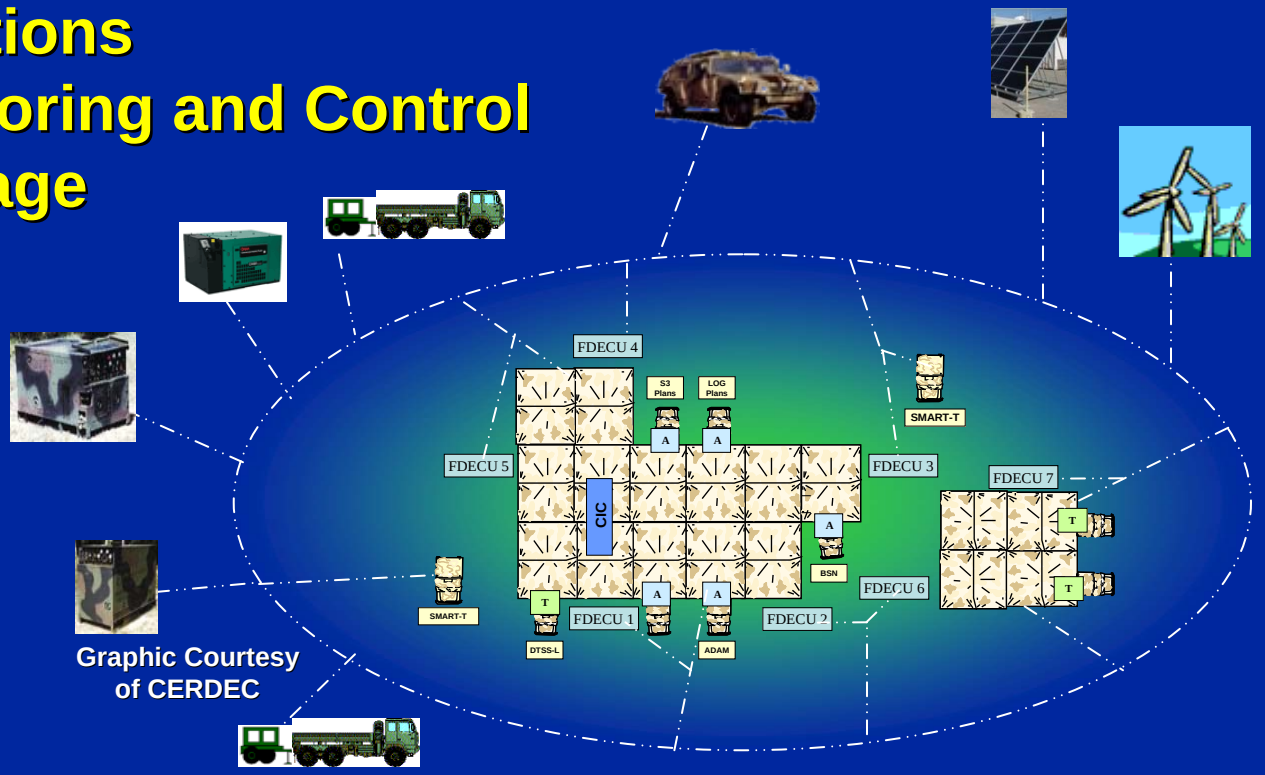
- **Low Fidelity Models**
- **High Fidelity Models**
- **Islanded Generators**





Microgrid Bus Concept

- *Common bus design with plug and play hardware*
  - New Power System Architecture
  - Advanced Power Conversion
  - Intelligent Bus Interconnects
  - Communications
  - Power Monitoring and Control
  - Energy Storage



Graphic Courtesy of CERDEC

Improved Architecture Simulation

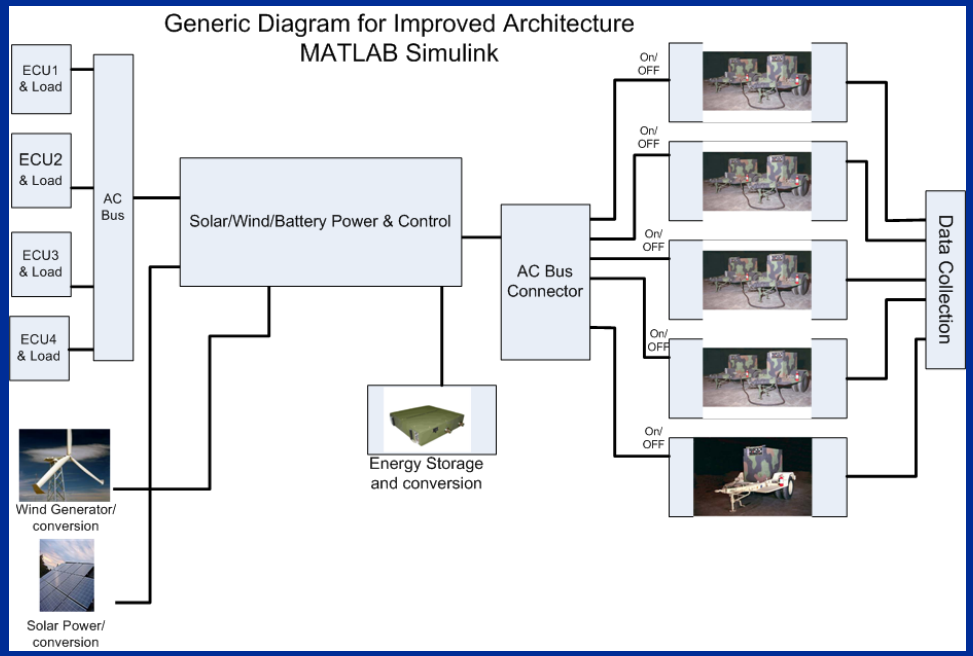
Simulations showing improved fuel consumption and increased efficiency.

- •Generators on a common bus
- •Energy Storage
- •Alternative Energy Sources

- Same user load profiles as Baseline
- Establish new performance char.
  - •Fuel consumption
  - •Generator run times
  - •Load prioritization
  - •Redundancy

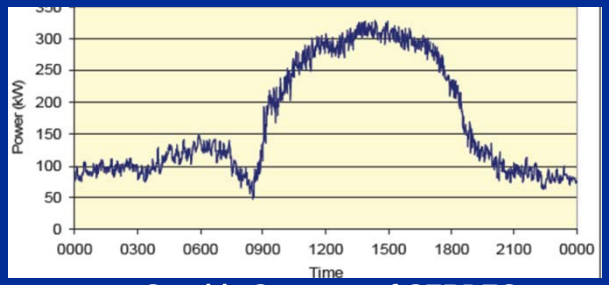
Simulation Features

- **•Low & High Fidelity Models**
- **•Common Bus**
- **•Alternative Power Sources**
  - **– Wind Models**
  - **– Solar Models**
  - **– Fuel Cell Models**

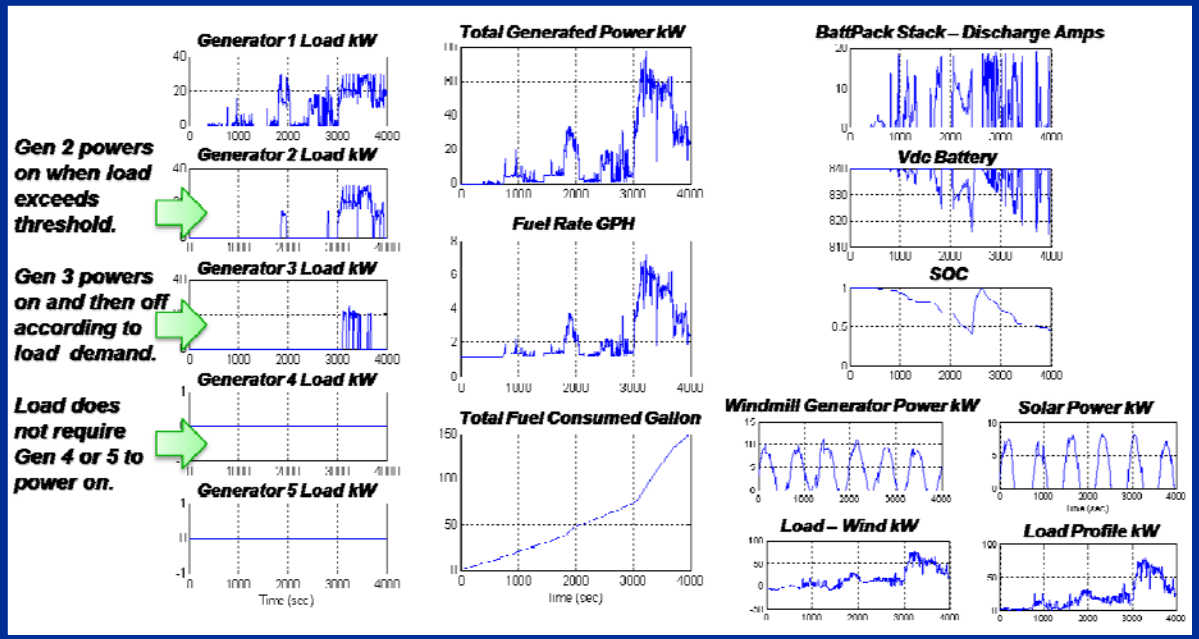


Simulation Shows Fuel Savings

- Simulation Runs with Same User Profiles
  - w/ Parallel Generators >30% fuel savings
    - Adding Energy Storage >35% savings
      - Adding Solar/Wind Power >50% additional savings.



Graphic Courtesy of CERDEC
Public Release data for Combat Support Hospital



- Fuel consumption reduced
- Reduced generator run times due to
  - Energy storage
  - Renewables

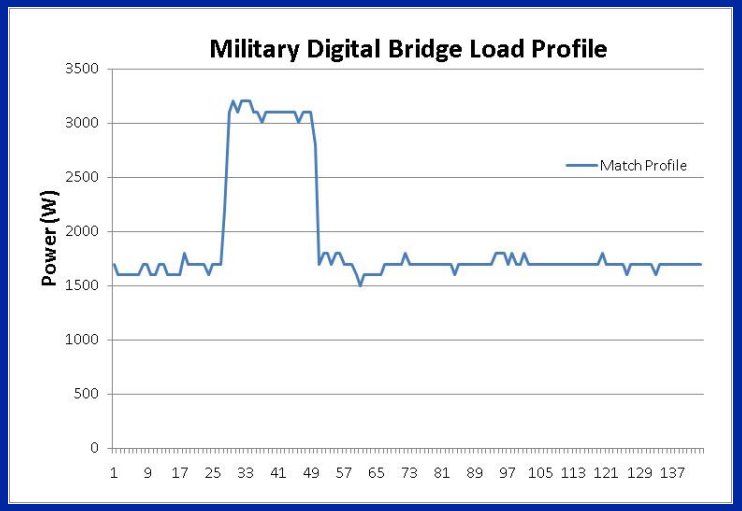
Energy/Power Management

- *Common Bus design facilitates peak load management by employing distributed energy sources.*
- *Simulations show increase in system fuel efficiency when energy storage is added to microgrids*
- *Design requires efficient power electronics*

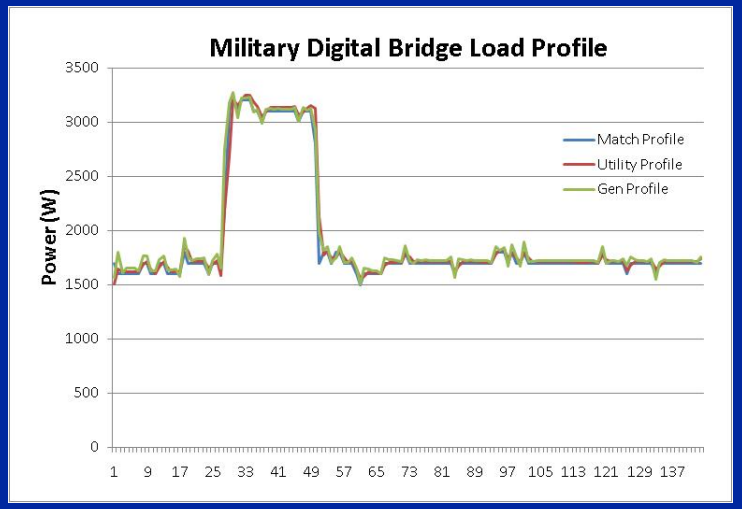
- *Implementing solutions for:*
  - *Efficient power electronics*
  - *Automatic on/off control of energy sources*
  - *Generator synchronization*

Simulation Results lead to Hardware Implementation

Hardware Implementation of Load Profiles



Public Release data for Digital Bridge Mission



- *Configure hardware to run military load profiles*
- *System controller (NI Chassis) manages operation of equipment.*
- *Run Digital Bridge profile*
  - *5KW generator*
  - *Two synchronized 2KW generators*
  - *One 2KW generator with Energy Storage*
- *Analyze and compare fuel consumption with each case.*

Upcoming Tasks:

Perform test with larger load profiles

Hardware Implementation-Laboratory

- **Power Distribution**
- **Power Monitoring**
  - Current and voltage measurements
- **Power Control**
  - High Current Relays controlled by NI Chassis
  - Fault protection

Instrumented Power Distribution

National Instruments Chassis
Voltage & Current Transducers
Power Measurement Equipment

With Power Distribution Control

Control Center

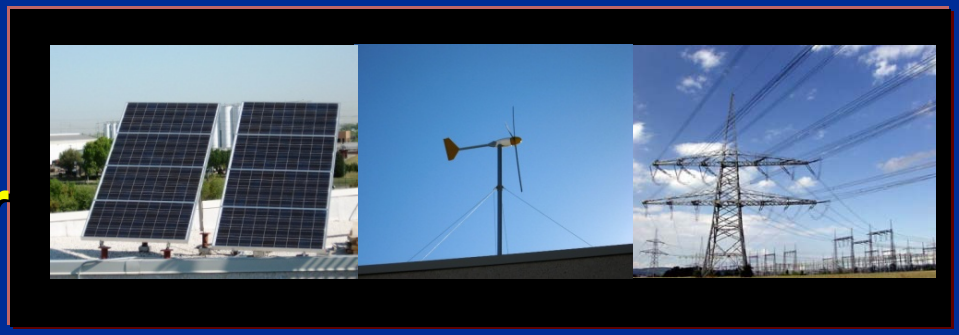
Generator House

Centralized Controller
(National Instruments Lab View)

Lab Power Components

Mil and Commercial Diesel Generators
Total power >70KW.

Wind/ Solar Power and Dedicated 3-Phase Power



Lab Loads Equipment

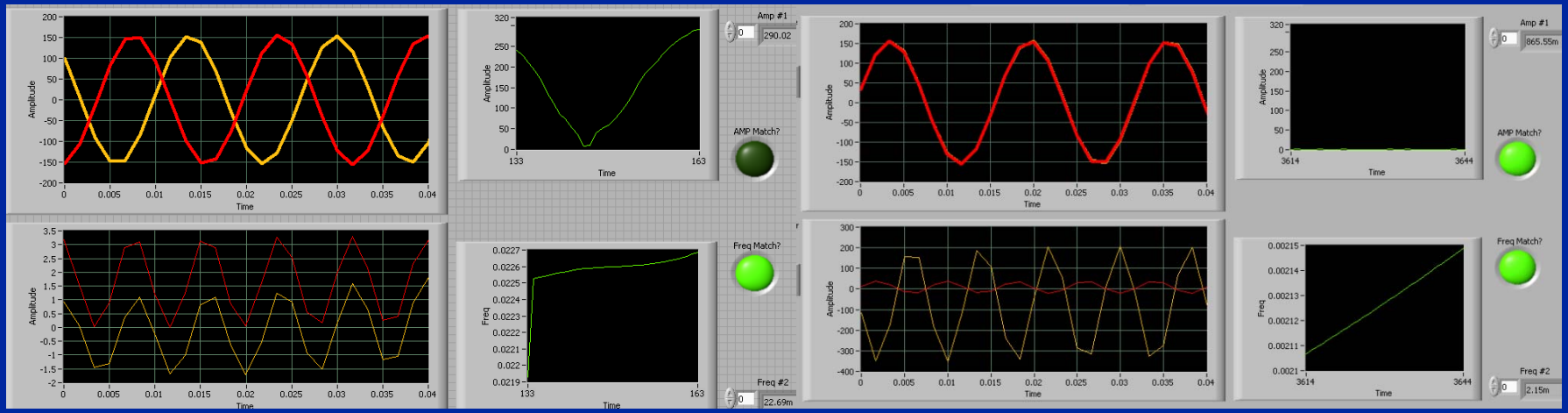
- Electronic DC
- AC Resistive
- Electric Motors
- Environmental Control

Energy Storage

- Li-Ion BattPacks
- Mil Batteries
- Commercial Lead Acid

AC Bus and Generator Synch

- *Using Microgrid Controller*
  - *Monitor voltage, frequency, phase of 2 or more generators*
  - *Outputs are synchronized and paralleled*



Paralleling Generators Offers Higher Efficiencies

Microgrid Lab –Alternative Energy Capabilities

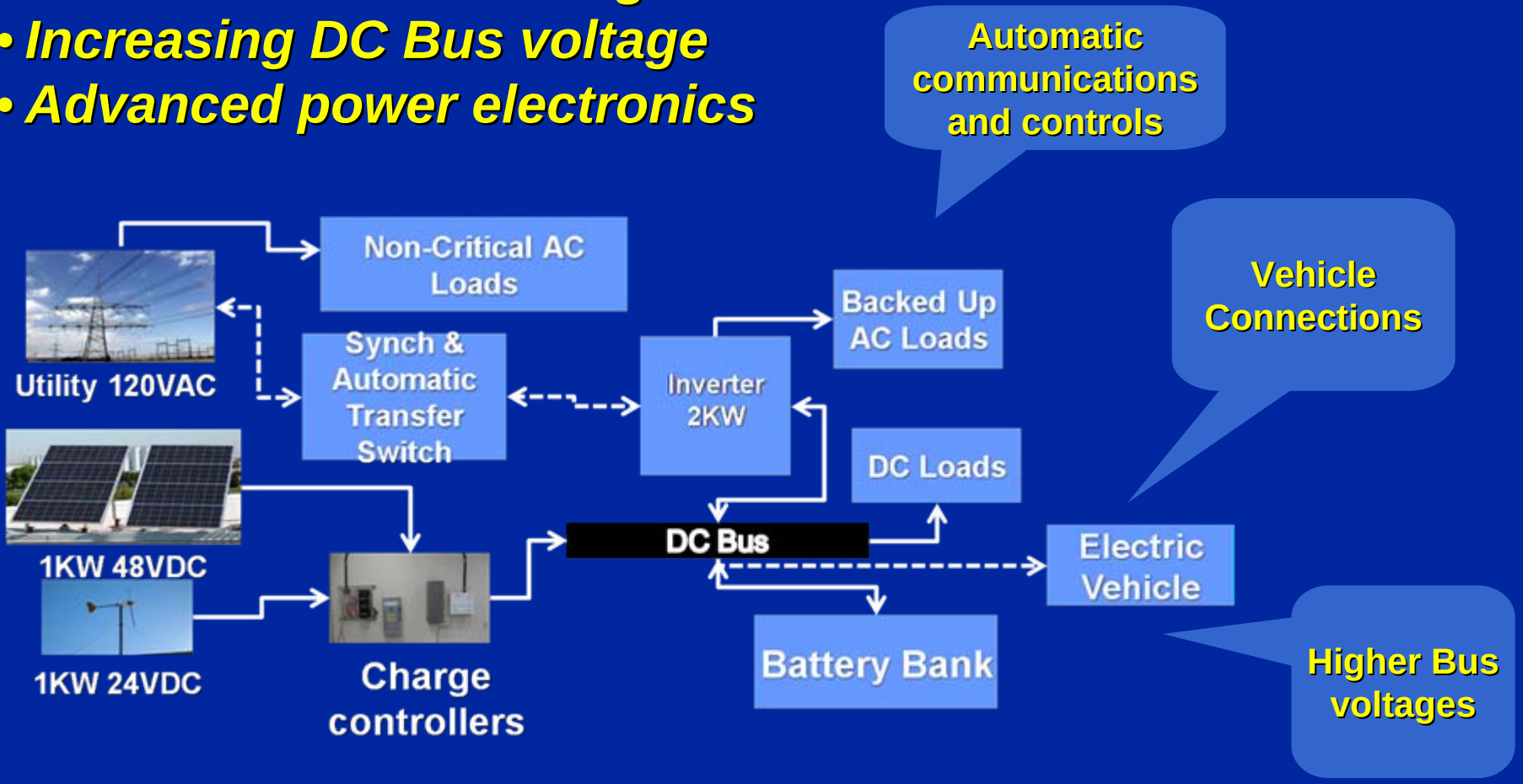
- *Wind Energy - 1KW*
- *Mounted on 30 ft pole*
- *24VDC output*

- *Solar energy - 1KW*
- *8 panels on building roof*
- *48VDC Output*

- *Charge controllers maintain battery bank at 28VDC.*
- *Integrating advanced energy storage*
- *Higher voltage buses to be evaluated*

Renewable Power within the Microgrid

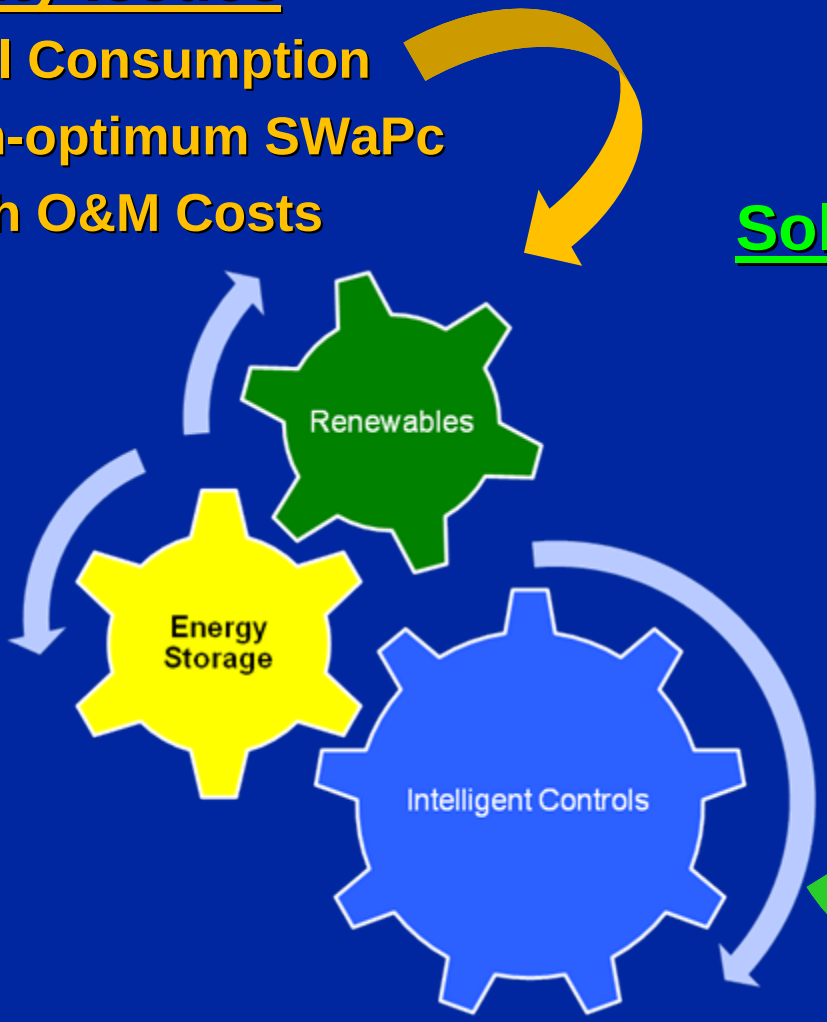
- *Initial Lab Setup for Solar/Wind Power*
- *Test plan includes connecting electric vehicles to DC grid.*
- *Increasing DC Bus voltage*
- *Advanced power electronics*



Development of Holistic Systems Approaches

Capability Issues

- Fuel Consumption
- Non-optimum SWaPc
- High O&M Costs



Solutions

- ✓ Reduce Generator Fuel Consumption
- ✓ Improve SWaPc with reduced number of generators
- ✓ Reduced O&M Costs by operating fewer generators.

QUESTIONS?