2018 Annual INCOSE
Great Lakes Regional Conference
SYSTEMS AT THE CROSSROADS
17 - 20 October 2018 | Indianapolis, Indiana

C. Shull; Dr.R. Kenley; Dr. E. Dietz: Purdue University

COMMON RECOVERY SYSTEM TO DECREASE THE DURATION OF ELECTRICAL INTERRUPTION TO CRITICAL INFRASTRUCTURE

MBSE for Critical Infrastructure

www.incose.org/glrc2018

Bio

C. Shull, PhDc

Mr. Casey Shull is currently President of FOCS LLC and V.P. of Operations at OCM Engineering based in Indianapolis Indiana. Mr. Shull has 28 years' experience as an electric utility engineer in Indiana focusing in crisis and electrical outage restoration. Mr. Shull is currently a PhD candidate at Purdue University researching the development of the Common Recovery System using model-based systems engineering to produce a model for electric utilities to utilize for restoration of electrical service after electrical blackout. Mr. Shull has completed an MS, MBA, Senior member of IEEE, Member of InfraGard and holds a PMP certificate.

Dr. Bob Kenley

Robert Kenley has degrees from the Massachusetts Institute of Technology (B.S., Sloan School of Management), Purdue University (M.S., statistics), and Stanford University (M.S. and Ph.D., engineering-economic systems).

He has over 30 years' experience in industry, academia, and government as a practitioner, consultant, and researcher in systems engineering. His has worked at Lockheed Missiles and Space, the Idaho National Laboratory, and the MIT Lean Advancement Initiative. He also has been actively involved in the International Council on Systems Engineering (INCOSE), which is dedicated to advancing the state of the art and practice in systems engineering. He also has served in numerous leadership roles with INCOSE, including secretary of the council.

Dr. Eric Dietz

Dr. Dietz's research interests include optimization of emergency response, homeland security and defense, energy security, and engaging veterans in higher education. As a Director in Purdue's Discovery Park, Dr. Dietz is responsible for the catalysis of the Purdue's homeland security research, increasing the impact of Purdue research on society, and organizing interdisciplinary projects within the university. Prior to his current responsibilities, Eric was on loan from Purdue to Governor Mitch Daniels to serve as the founding Executive Director for The Indiana Department of Homeland Security, a new state agency of over 300 people responsible for emergency planning, training, fire and building safety, and disaster response for 6.2 million Indiana residents. During this period, Eric led Indiana's response to 7 Presidential Major Disasters and Emergency Declarations which included restoration and recovery of critical infrastructure. Eric also led the creation of the Indiana Intelligence Fusion Center and the Indiana Fire Training System both new government functions that were created with new laws and funding. Retiring as a Lieutenant Colonel from the U.S. Army in 2004, Dr. Dietz led a number of Army Acquisition and research programs throughout his career including power systems, chemical sensors and command and control systems. An Indiana native, Eric was graduated in 1984 from Rose-Hulman Institute of Technology after earning a bachelor of science in chemical engineering. He also earned a master's of science from Rose-Hulman Institute of Technology in 1986 and a PhD in chemical engineering in 1994 from Purdue University.

Critical Infrastructure – Imperative

CI at a Crossroads

- Critical Infrastructure Universe
- “The Grid”
- Regulations
- Regulatory Body’s
- State Rules
- MBSE to Develop Recovery Sys.

Inside out Modeling

- IDEF0
- 4-Pillars
- Unscramble the eggs
  - The P Model
- Identify requirements / needs
  - Lack of ‘measure’ for resiliency
- Develop Resiliency Index
- CRS Adaptability
- Questions

The Critical Infrastructure (CI) universe according to DHS / FEMA-FERC/NERC: A Quiz

Questions

1. What is the DHS / FEMA definition of CI based one?
2. What are the criterion for being a part of the CI using this basis?
3. How many parts does the CI have?
4. What is the common resource for all of the parts of the CI?
5. What is *not* the interface that provides this common resource to the CI?
6. What is the interface that provides this common resource to the CI?

Answers

1. It is based on effects
2. “Loss of CI has debilitating effect on security, national economic security, national public health or safety, or any combination thereof.”
3. 16 *Critical* sectors
4. Electrical power
5. The [High Voltage] Bulk Electric Transmission System (BETS)
6. The Lower Voltage Distribution Systems (LVDS)

“The Grid” - Two Electrical Systems

- North American Bulk Electric Transmission System (BETS)
  - Steel structures with high voltage (> 69kV) conductors transmitting electricity between US states, Canadian provinces, and portions of Baja California
- “Local” lower voltage electrical distribution systems (LVDS)
  - Wood poles and underground with lower voltage (<69kV) distributing electricity to users or consumers

What did we notice what did we do about?

- What did we notice?
  - Recovery of LVDS after a disaster does not focus on security or social systems to protect the public
- What did we do?
  - Used MBSE to ‘unscramble’ the eggs to identify system of systems responsible for coordination prior to disaster and during recovery
  - Used MBSE to define logical, functional architecture for a Common Recovery System to be implemented locally in physical world by the LVDS

Regulations: BETS and LVDS

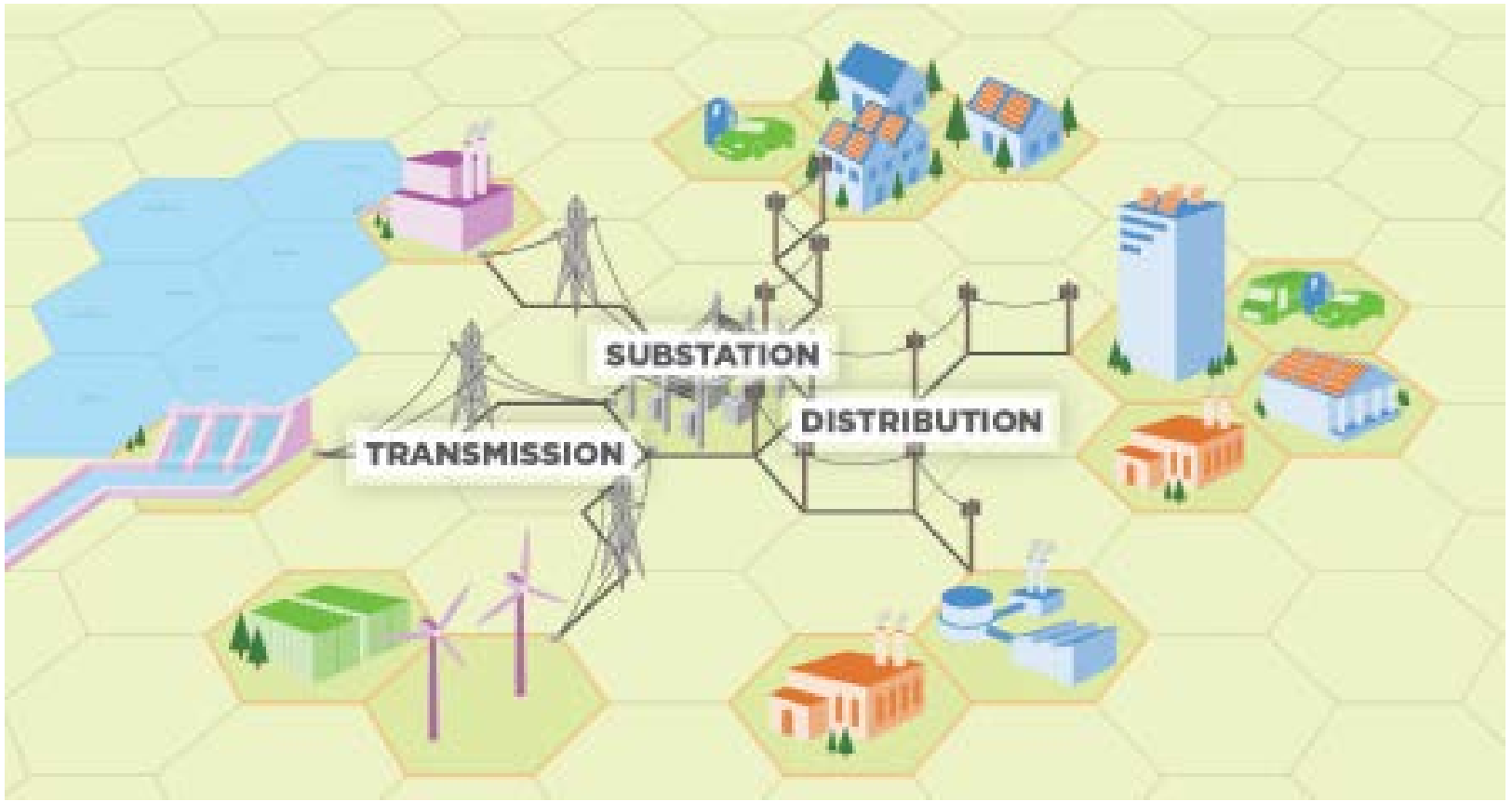
North America RULES for BETS (U.S. & Canada)

- FERC/NERC Regulations for National BETS
- FERC/NERC
- Regional Transmission Operator (RTO)
- Regulators manage, monitor and enforce rules required for recovery, reliability and resiliency

STATE RULES for LVDS

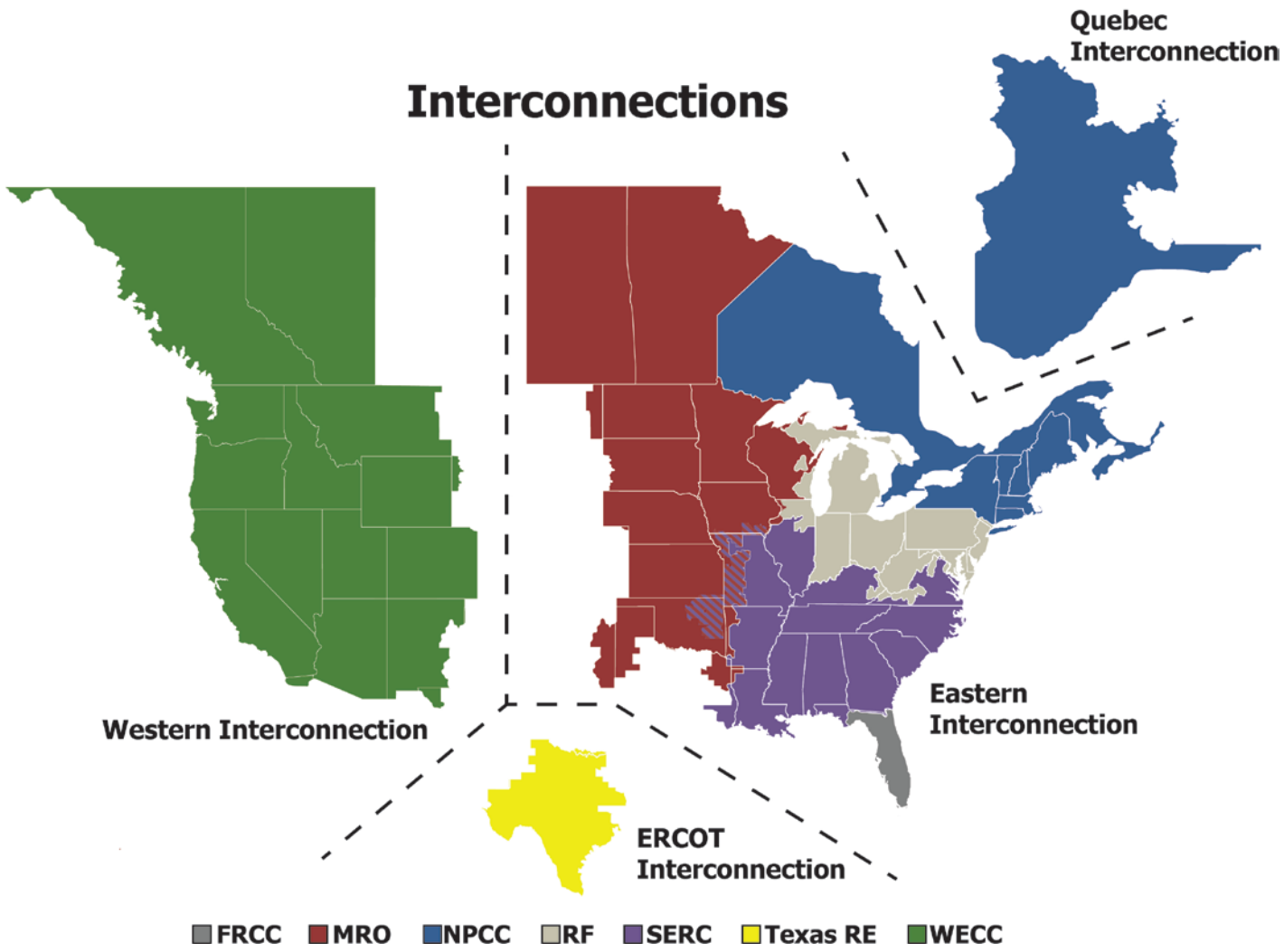
- State/Regional Utility Regulatory Commissions make rules for distribution
- (State or Region name) Utility Regulatory Commission
- Rules govern electricity rates and not recovery, reliability or resiliency

Regulations: BETS and LVDS



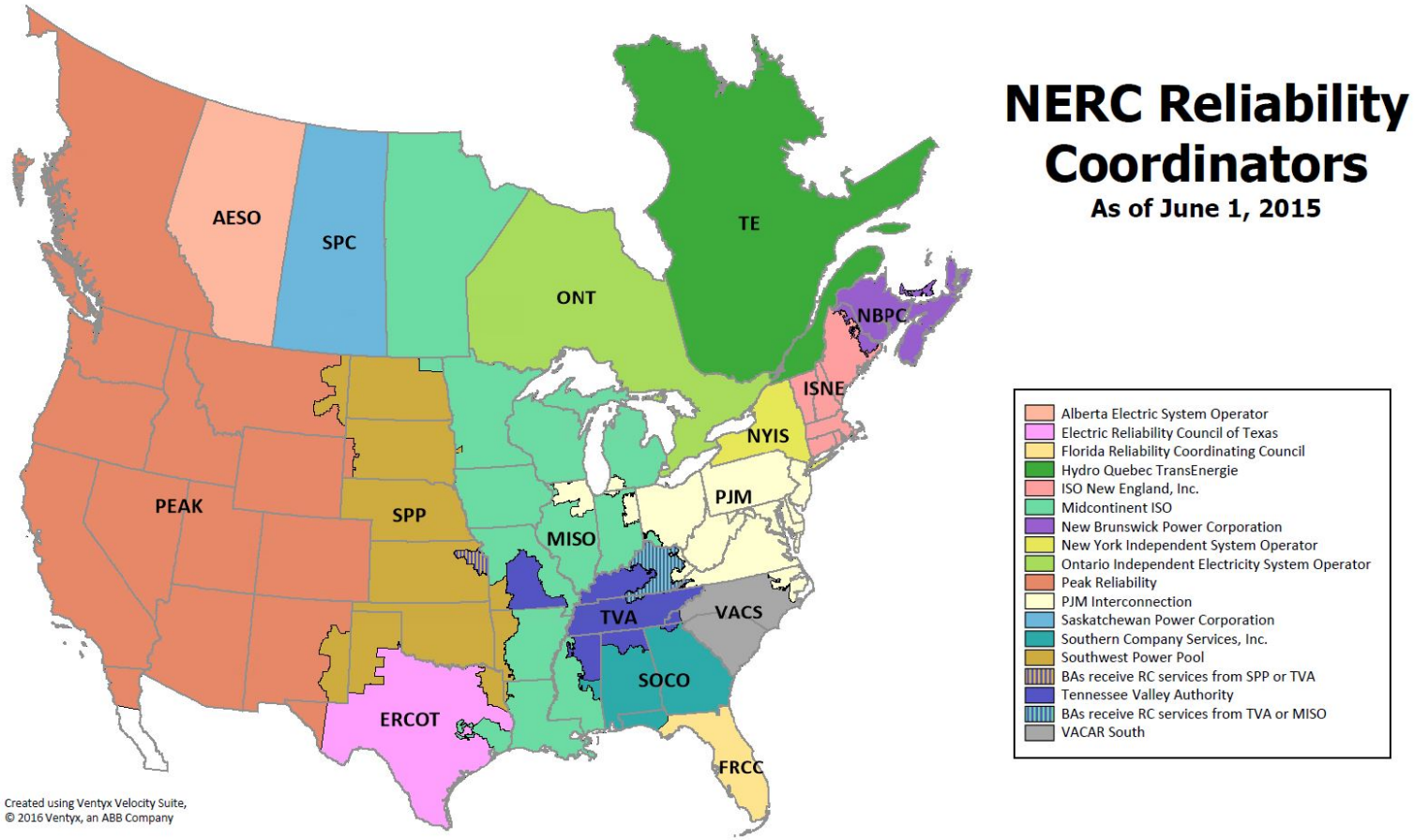
Source: https://www.epa.gov/energy/electricity-delivery 08/09/18

North American Electric Reliability Corporation



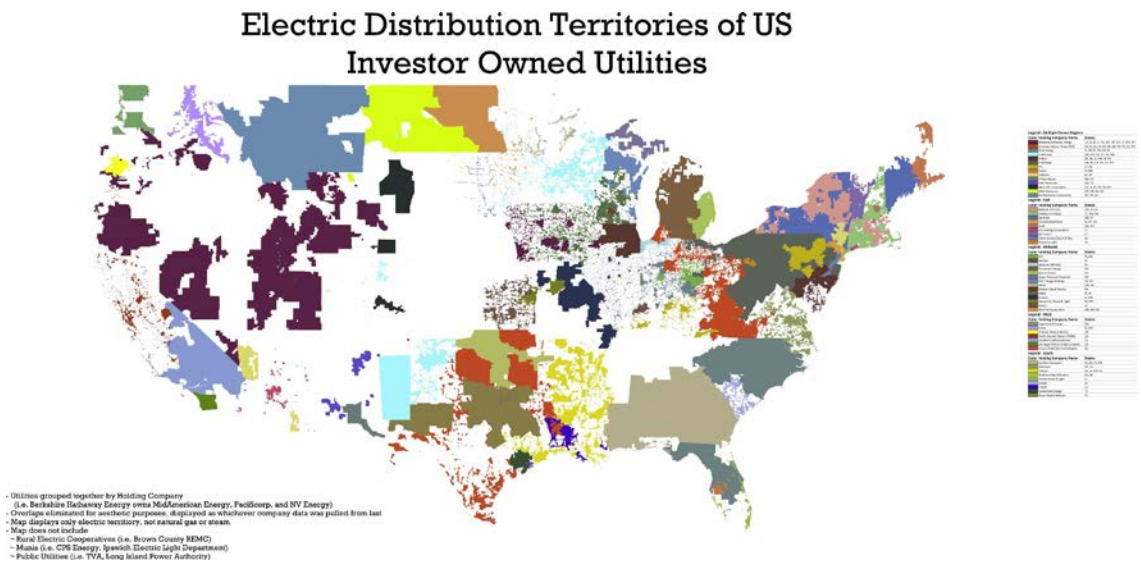
Source: https://www.nerc.com 08/09/18

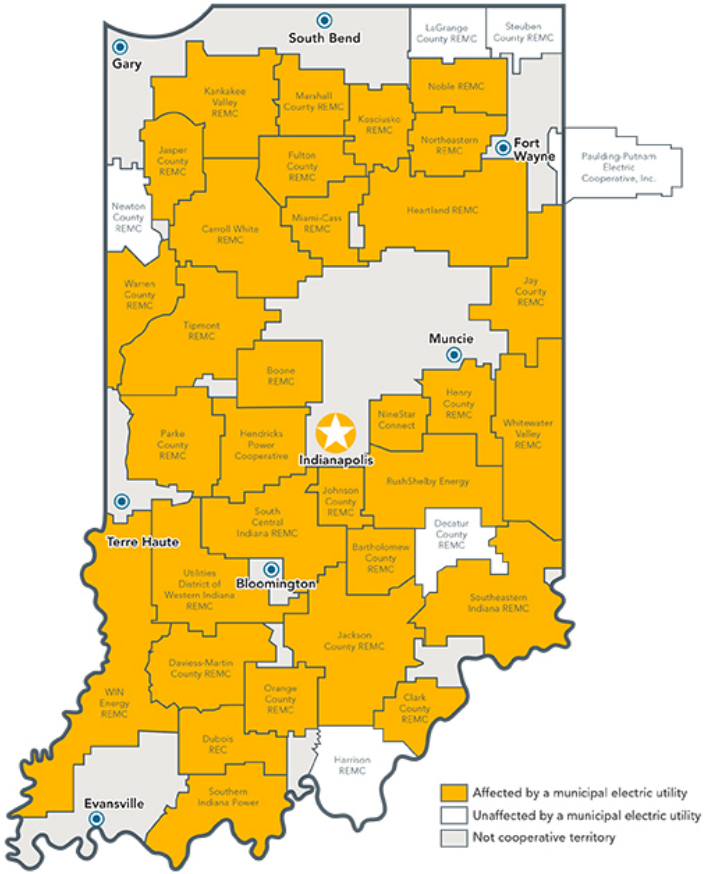
Regional Transmission Operators (RTO)



Source: https://www.nerc.com 08/09/18

State rules and regulations for LVDS





MBSE to develop a recovery system

STATE RULES for LVDS

- State/Regional Utility Regulatory Commissions develop plans recovery system training
- Identify operators of infrastructure necessary for social services to recover from disaster
- State and regional government authorities develop consortium of operators to begin recovery training
- Impose rules and standards for recovery of Critical Infrastructure (CI)

Modeling the recovery system

- Model existing regulatory rules for electrical reliability and resilience
- Identify state and local stake holders with regulatory authority
- Identify priority locations for CI
- Model recovery system to priority locations

IDEFO

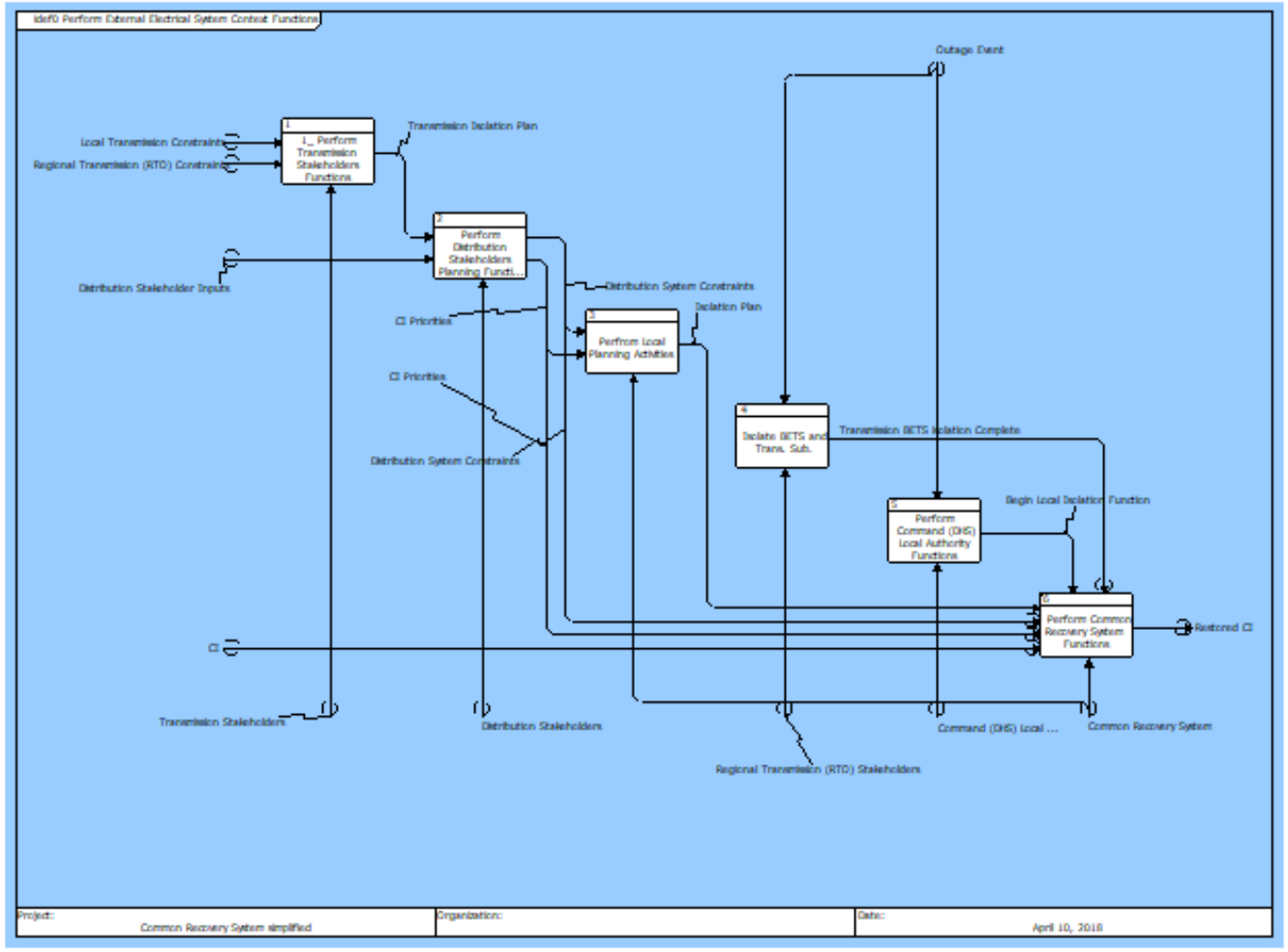


Figure 5 Perform External Electrical System Context Functions (IDEF0 Diagram)

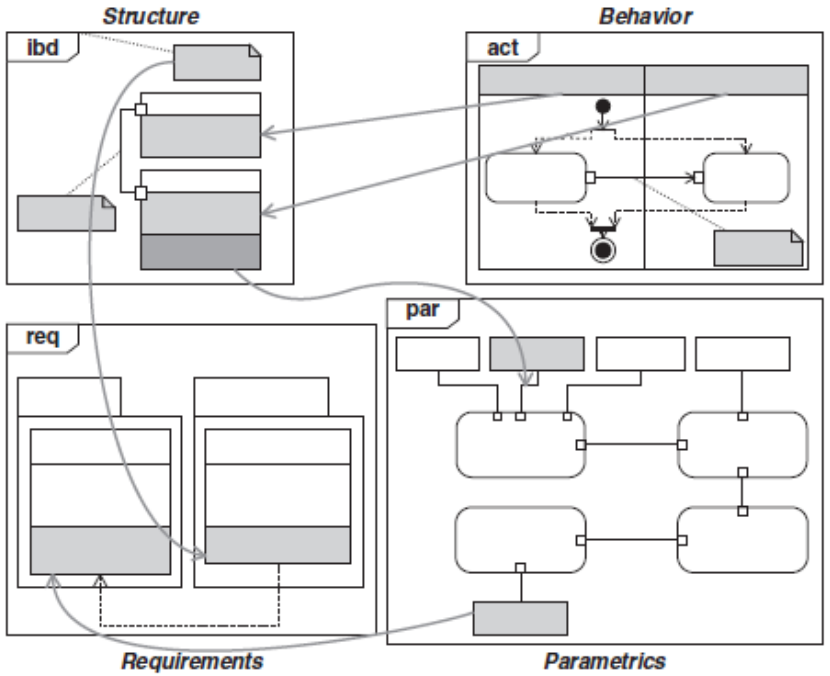
Existing Regulation Outline

- 1920 Federal Power Commission (FPC) created to monitor hydro-power.
- 1962-1962 ‘voluntary’ North American Power Systems Interconnection Committee (NAPSIC) created.
- 1968 FPC recommended formation of the North American Reliability Council (NERC) to manage electrical transmission.
- 1977 FPC reorganized as Federal Energy Regulatory Commission (FERC) to better monitor all sources of energy
- 1980 NAPSIC merged into a NERC to merge planning and reliability of electrical transmission
- 1981 NERC renamed to North American Reliability Council to be more inclusive of Canadian members which became ‘Corporation’ in 2007.
- 2006 to 2009 FERC and the Canadian federal and provincial governments certified and recognized NERC as the entity to manage reliability.
- ALL federal regulatory bodies manage and monitor power production and the transmission of power.

Proposed Resiliency Indices Outline

- Resiliency Indices to measure a regions ability to adapt
- Managed power – the ability to maintain power through low power and/or power outage
- Ability of a region to manage power to critical infrastructure (CI)
- Percentage of identified CI that have the ability for managed power
- Ratio of total # of CI to total # of CI that have managed power

4 pillars to MBSE



Retrieved from: Friedenthal, Sanford, Moore, Alan, Steiner, Rick. A Practical Guide to SysMl, Burlington, Mass., Morgan Kaufman, 2014

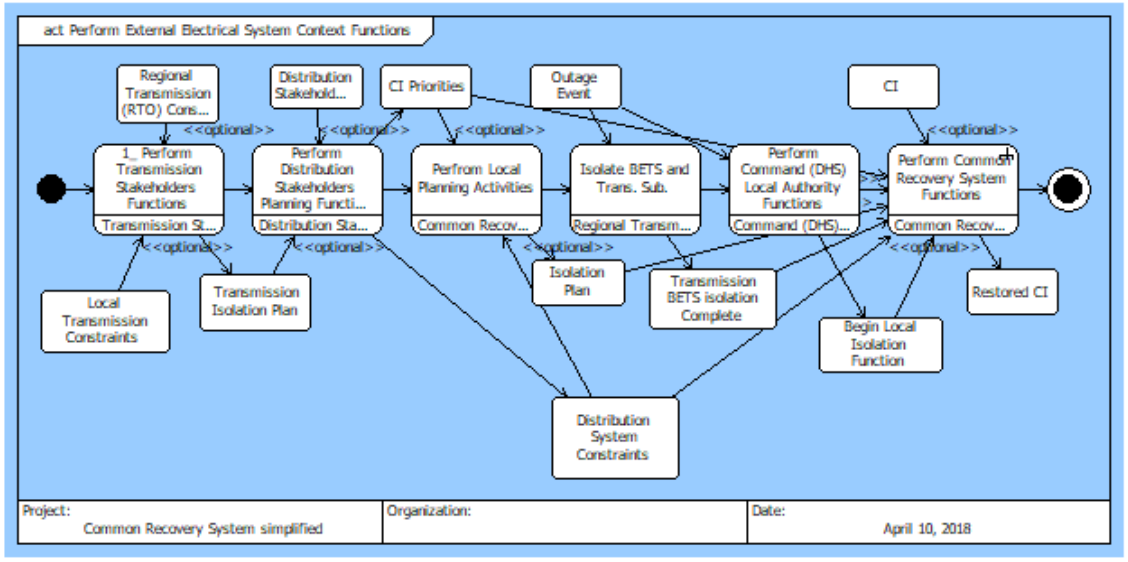


Figure 1 Perform External Electrical System Context Functions (Activity Diagram)

Behavior & Requirements

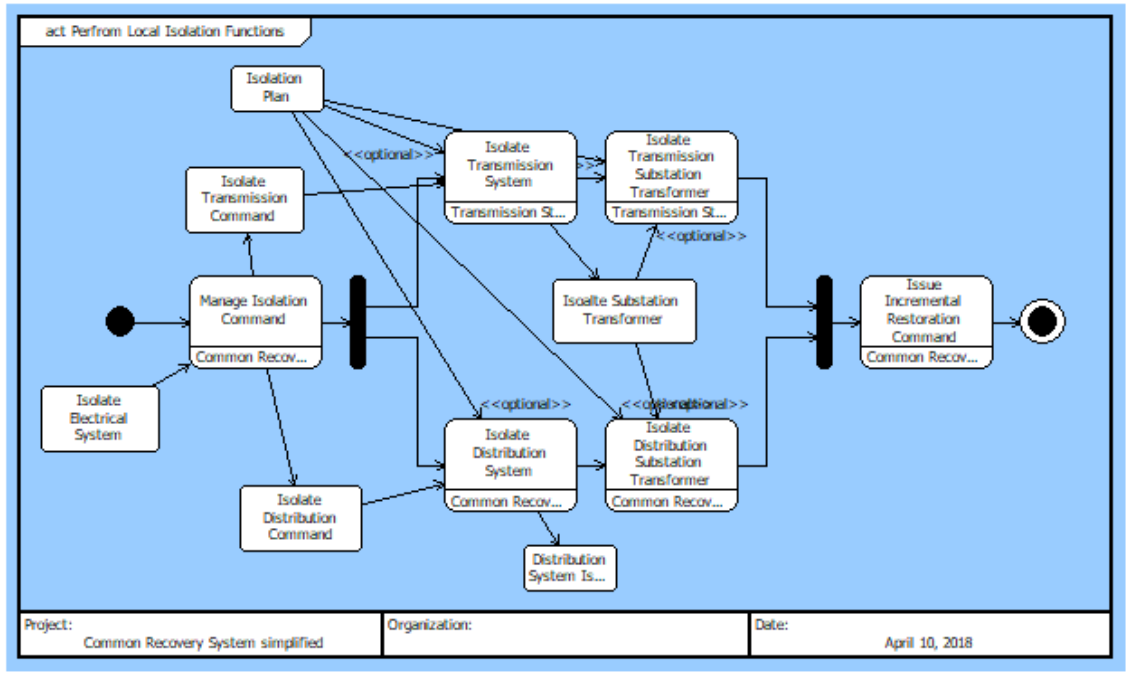


Figure 15 Perform Local Isolation Functions (Activity Diagram)

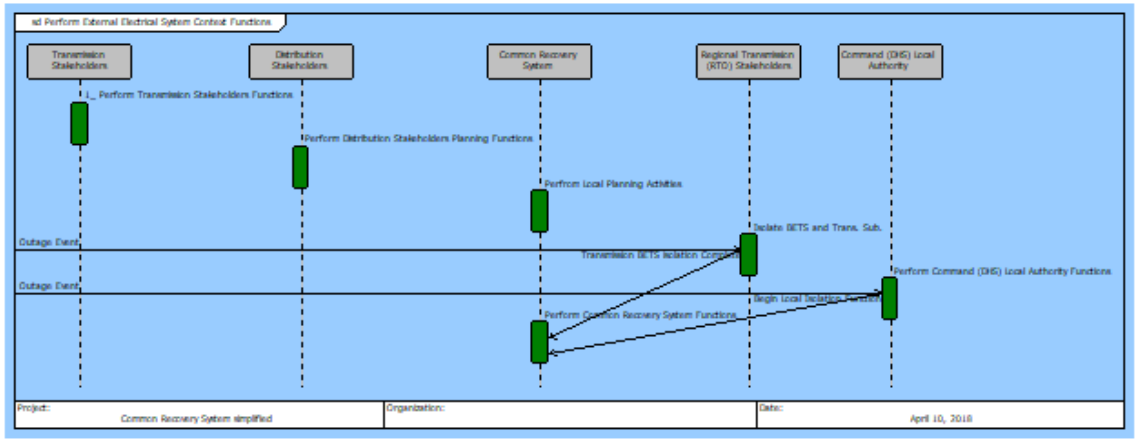
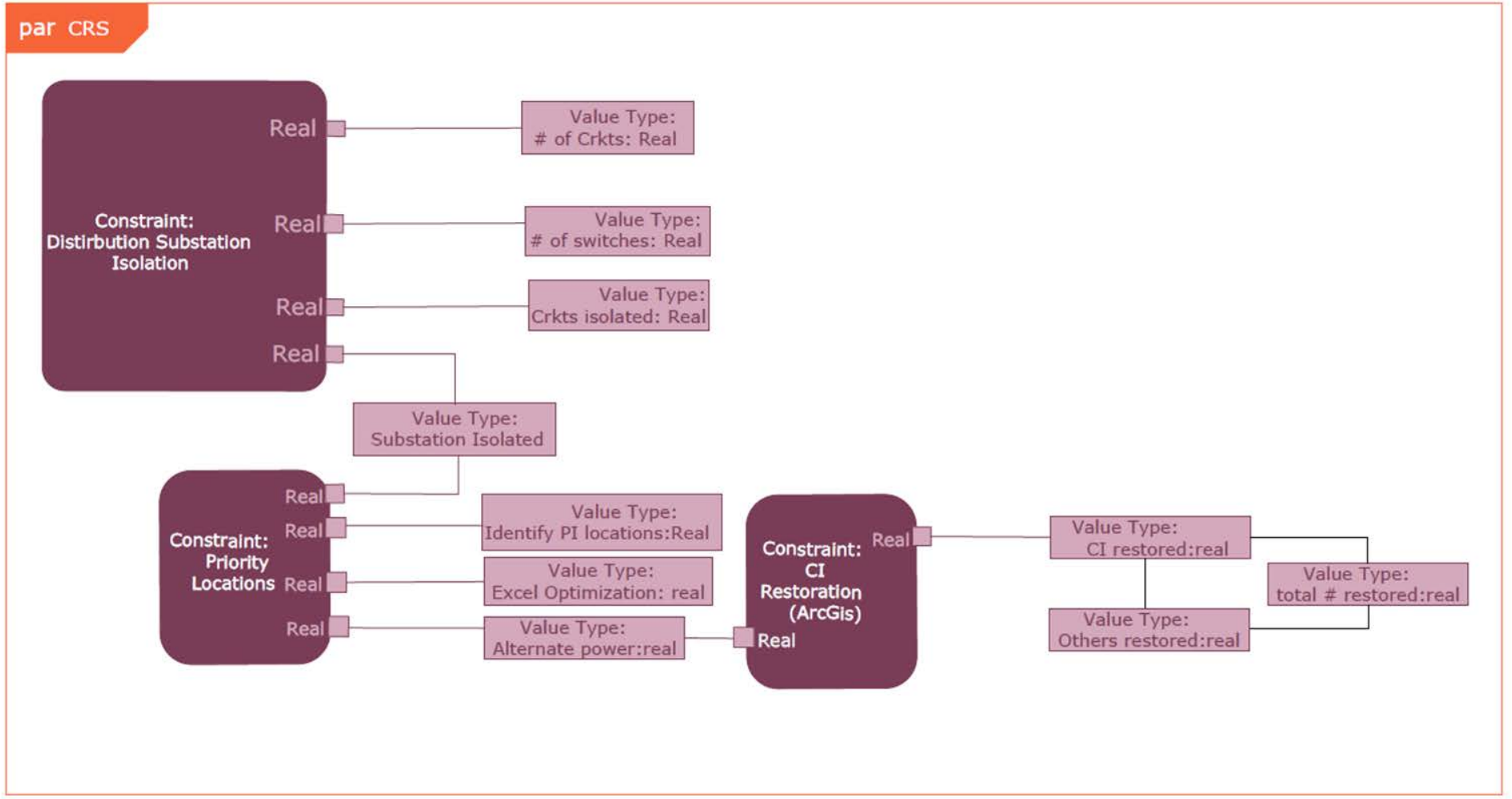


Figure 7 Perform External Electrical System Context Functions (Sequence Diagram)

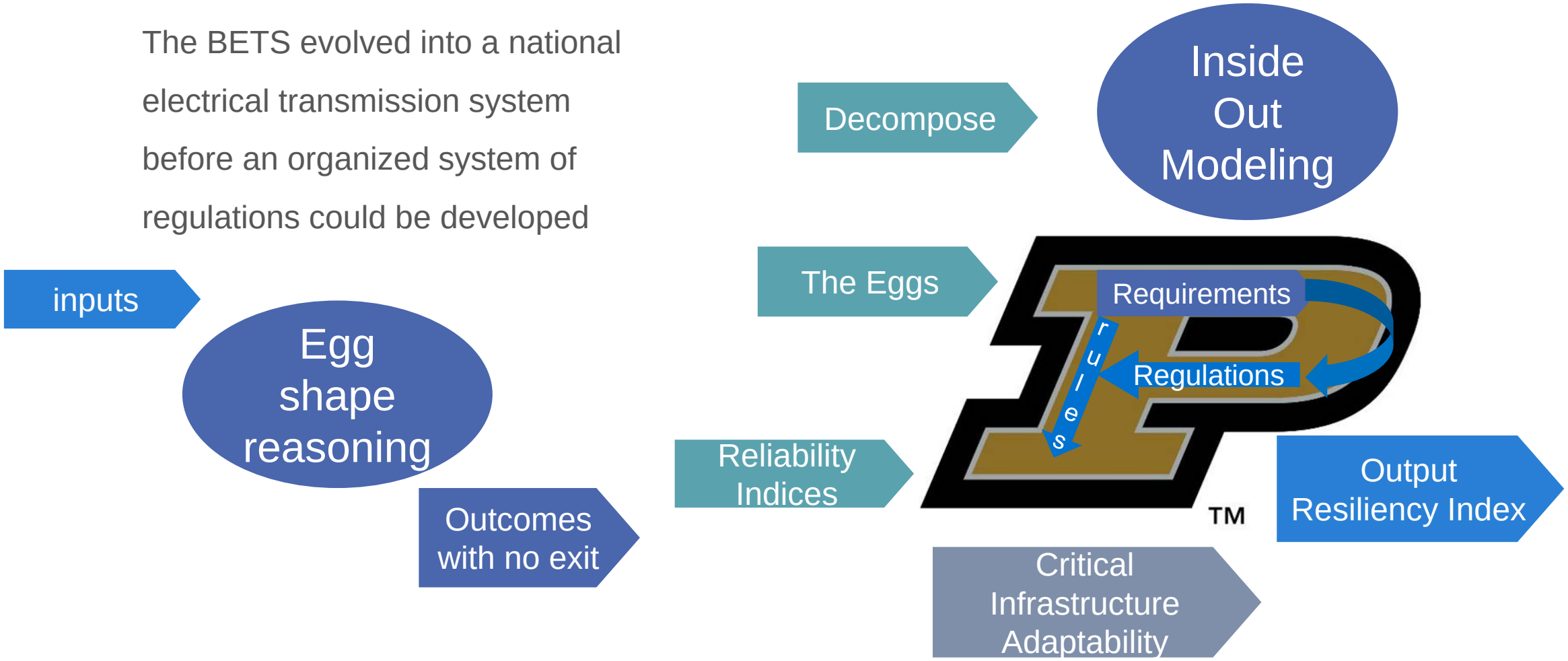
Parametric Diagram

Parametric diagram Constraint property



P - Modeling to ‘unscramble’ the eggs

The BETS evolved into a national electrical transmission system before an organized system of regulations could be developed



CI at a Crossroads – Modeling systems

MBSE to model the Regulations

- Develop use case
- DHS/FEMA push collaboration efforts to state and local decision makers
- State and local decision makers adopt CRS
- Rules and regulations pushed to electric utilities and operators of CI

Common Recovery System (CRS)

- Use Case for resiliency indices
- Model inputs and outputs
- Identify requirements
- Develop resiliency indices
- CRS introduced to state and local regulators

Critical Infrastructure – Imperative

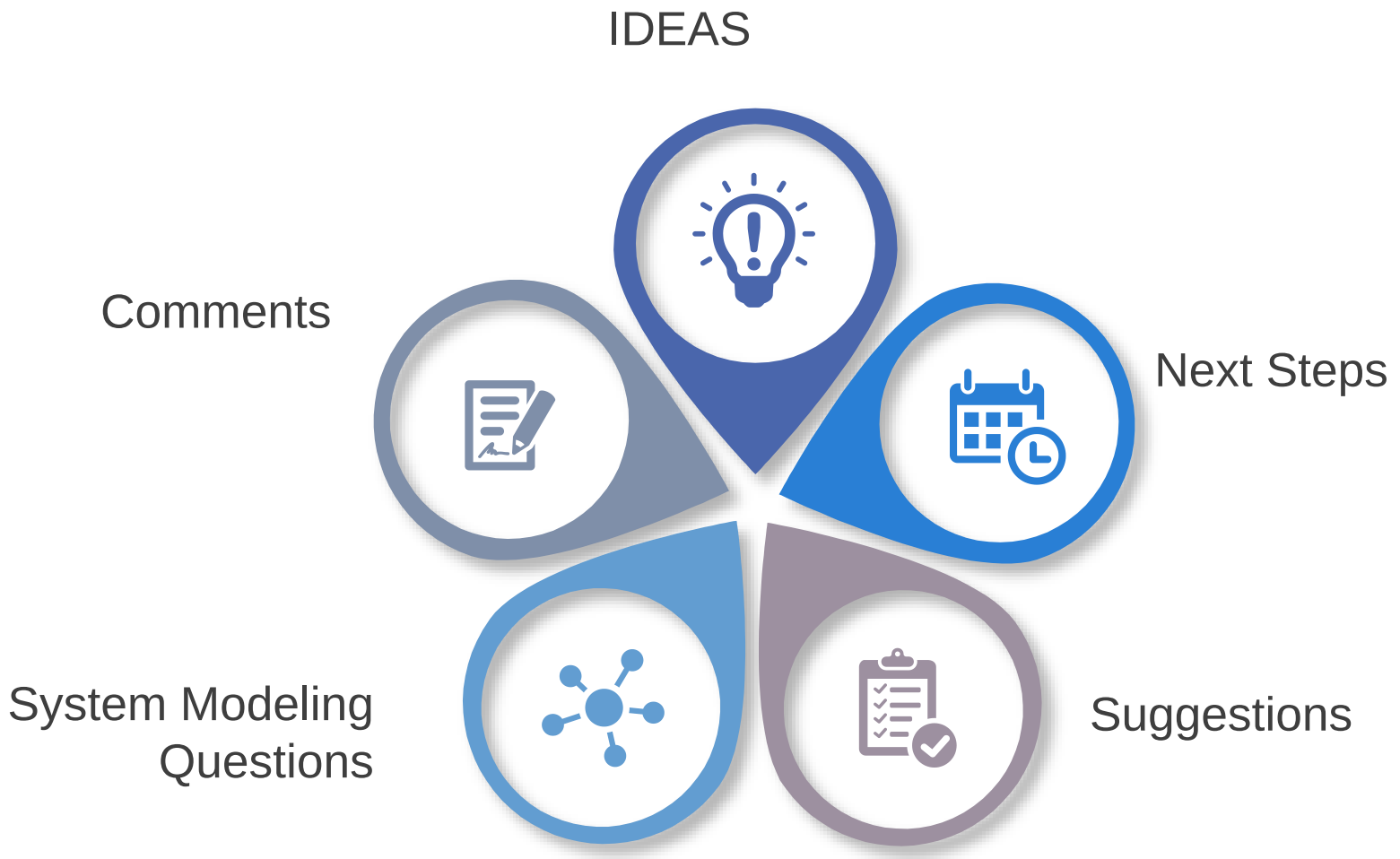
CI at a Crossroads

- Critical Infrastructure Universe
- Regulations
- Regulatory Body's
- State Rules
- MBSE to Develop Recovery Sys.

Inside out Modeling

- IDEF0
- 4-Pillars
- Unscramble the eggs
  - The P Model
- Identify requirements / needs
  - Lack of 'measure' for resiliency
- Develop Resiliency Index
- CRS Adaptability

Questions, Comments, Ideas, Modeling!!



2018 Annual INCOSE
Great Lakes Regional Conference
SYSTEMS AT THE CROSSROADS
17 - 20 October 2018 | Indianapolis, Indiana

www.incose.org/glrc2018