Requirements, Architecture and Tools for Implementing Reliable Command and Control for a Demand Responsive Energy Grid

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Need of Reliable Command and Control for DR

- California will increase its reliance on demand responsive resources to meet peak energy demand requirements.
- Utilities and the CA ISO must have a means to accurately predict the amount of demand responsive load available at any given moment and dispatch it just like any generation resource if it is to replace traditional peaking resources
- Communication latencies and other uncertainties in large distributed system such as a demand responsive systems have been shown to cause inherent system control instability in similar systems in military applications

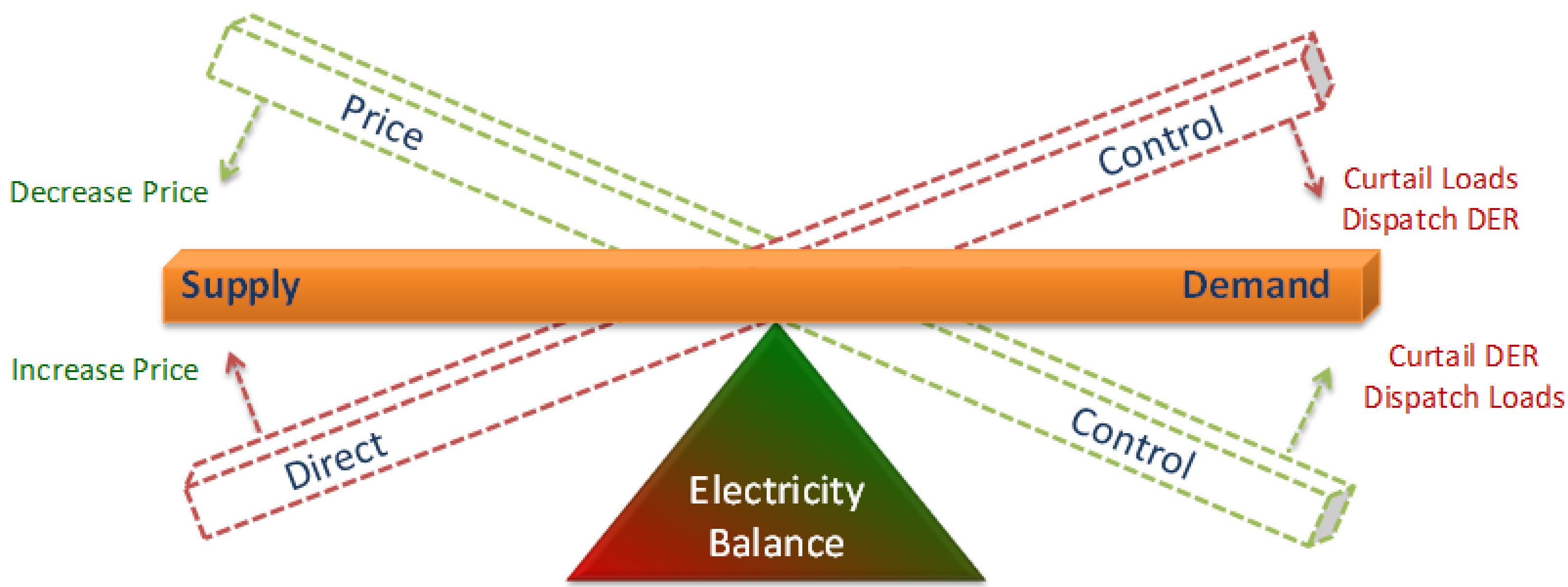
DRACS Project Objectives

- Develop a system modeling capability to explore the emergent chaotic behavior problem of a large distributed demand response control system

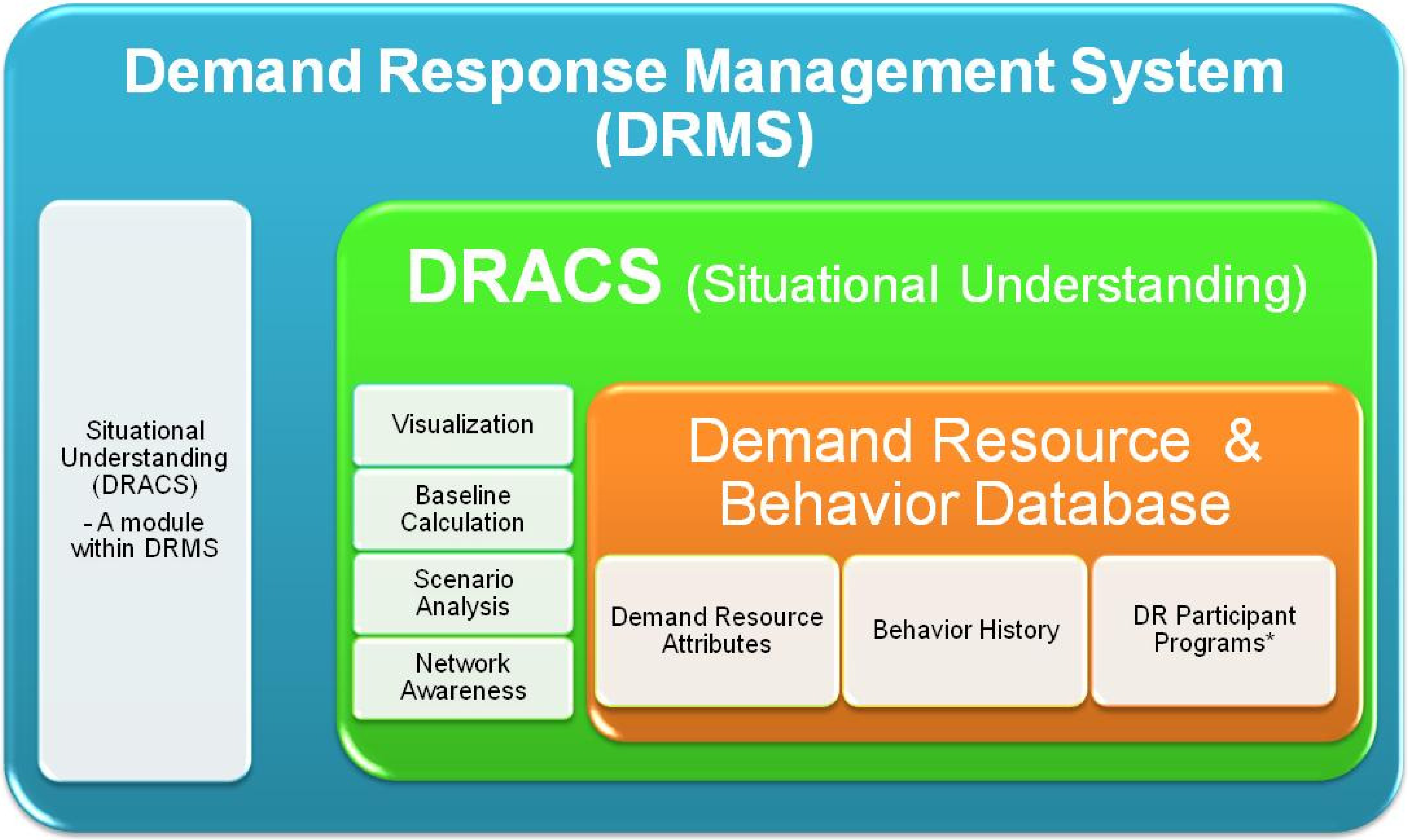
- Develop methods to detect, avoid, and/or mitigate such control instabilities

- Develop a set of tools and application building blocks usable by the CA ISO and utilities to be aware of available demand response resources at any moment and dispatch those resources (Distributed Resource Availability and Control System – DRACS)

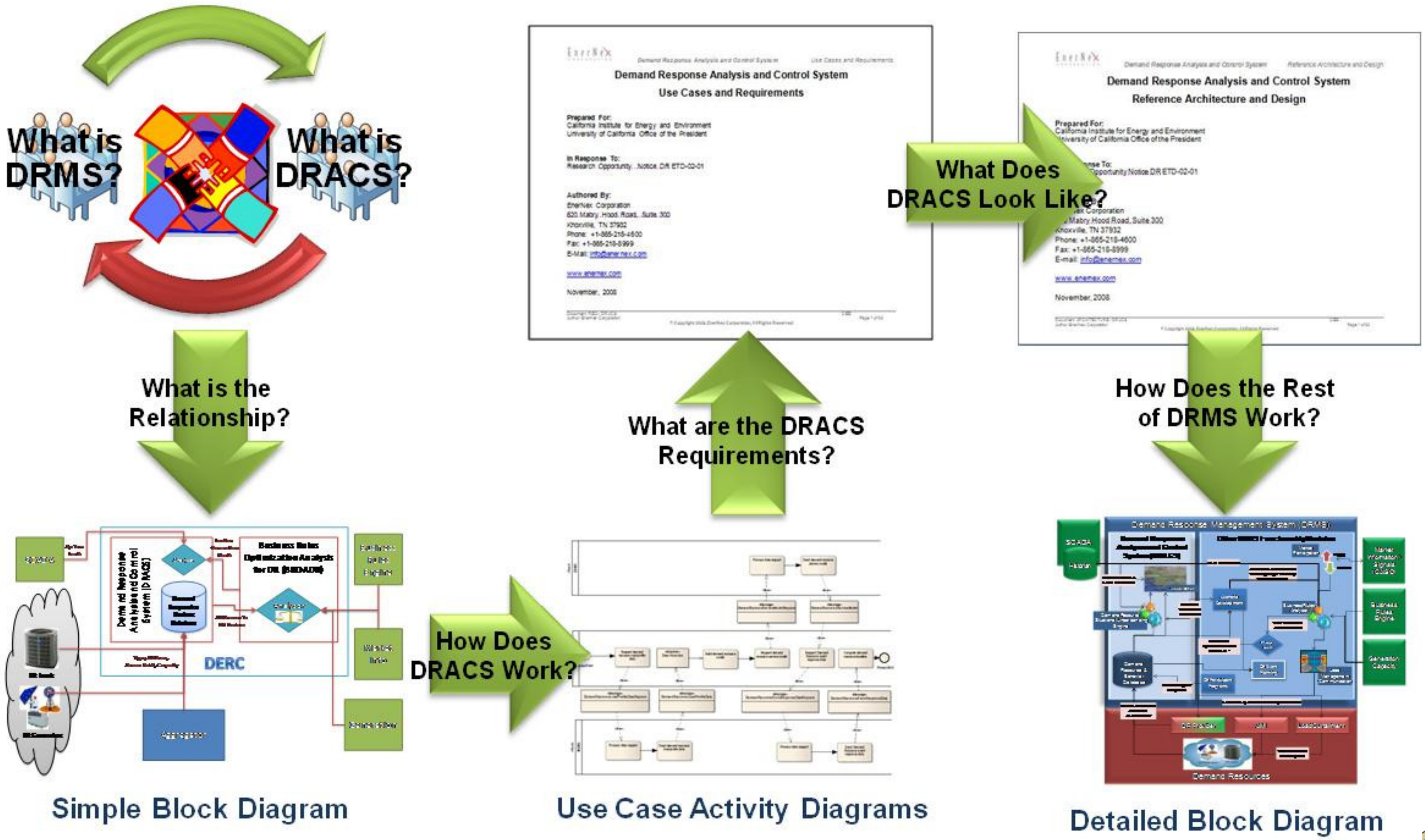
Electricity Balance



DRMS-DRACS Functional Components



DRACS Project Thought Progression



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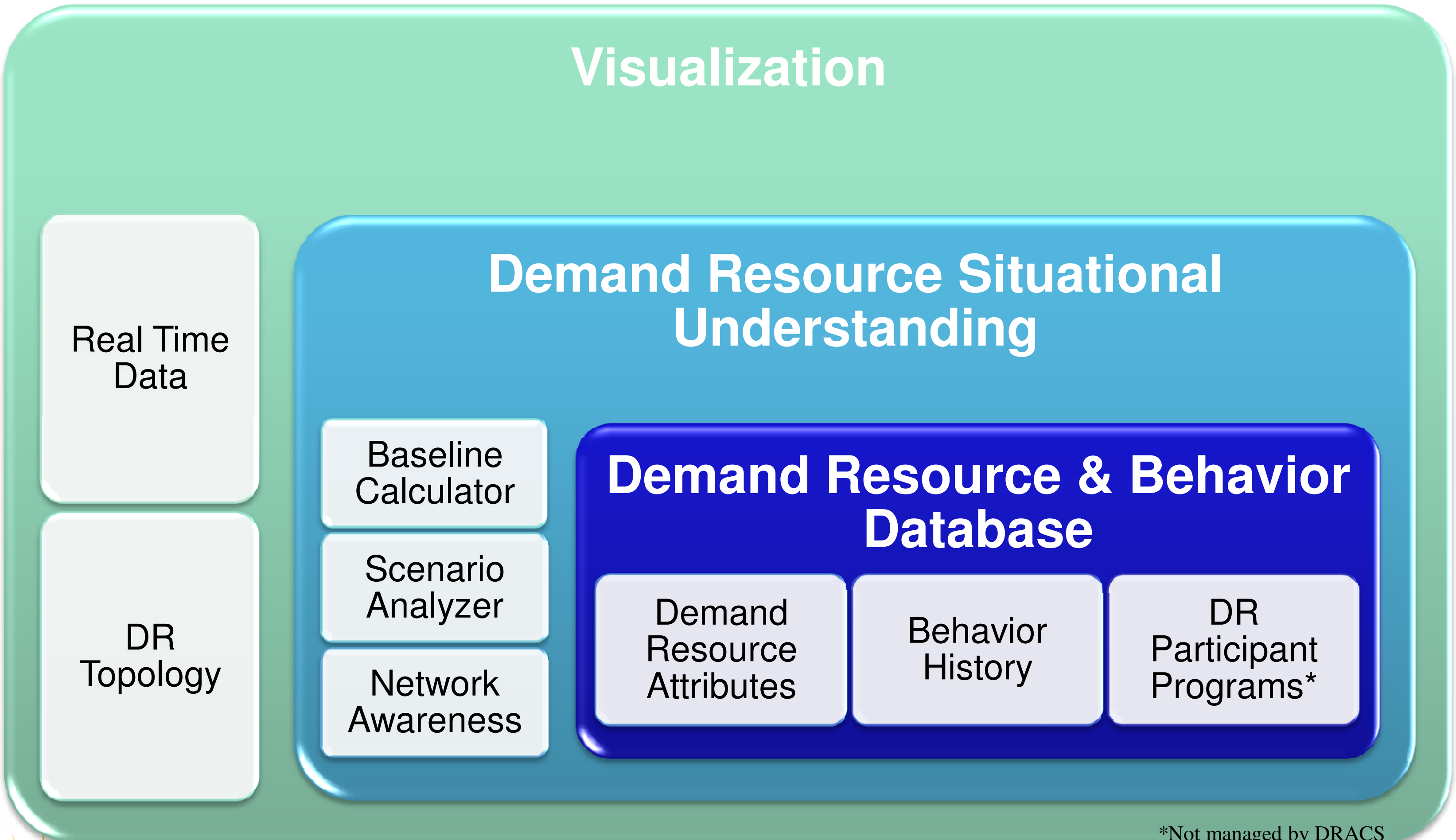
DRACS MISSION– Situational Understanding

- The application of analysis and judgment to form logical conclusions: Identify and assess risks and provide evidence and information for successful implementation of Demand Response events
- Real Time data/events: Real time network awareness to include weather, outages, voltage loss, congestion, or other pertinent information which can affect the ability to support a DR request.
- DR topology: Each active Demand Resource, its potential DR capacity, and historical behavior patterns must be understood in order to develop effective DR request scenarios and implementation strategies.

How DRACS Works – 5 Use Cases

1. DRACS monitors and stores real time network information
2. DRACS manages information on demand responsive resources
3. DRACS captures and stores behavior information on Demand Resources
4. DRACS analyzes demand response scenarios
    - Database lookups of resources
    - Database lookups of behavioral patterns
    - Calculation of confidence interval
5. User navigates Demand Resources topology

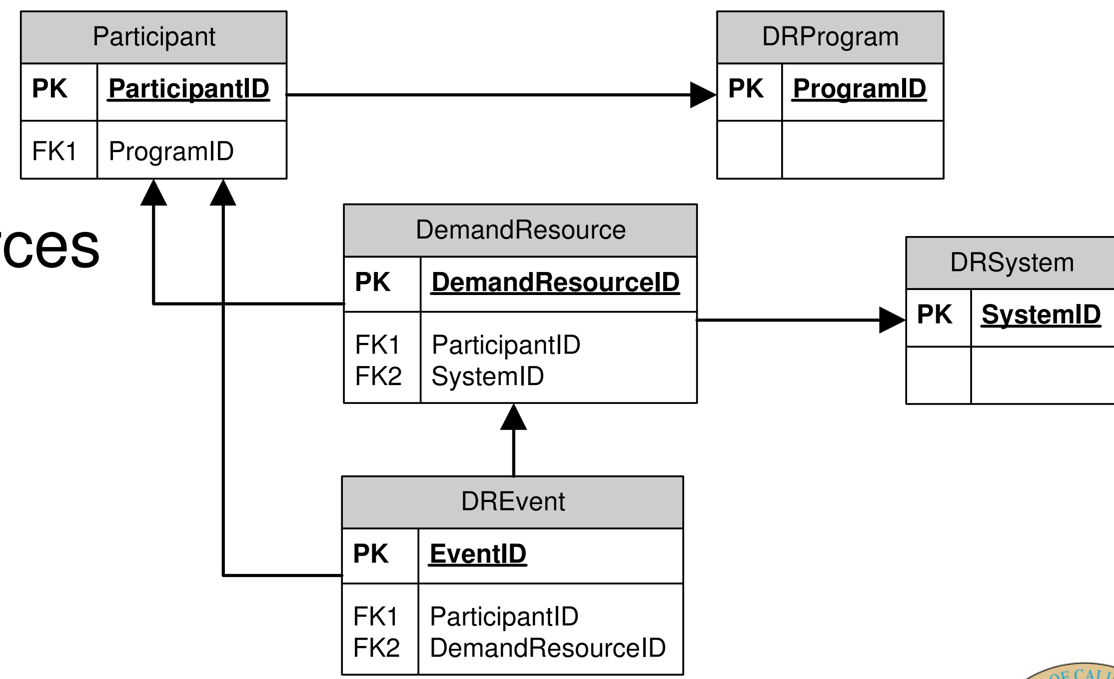
What DRACS Looks Like – Architectural Components



*Not managed by DRACS

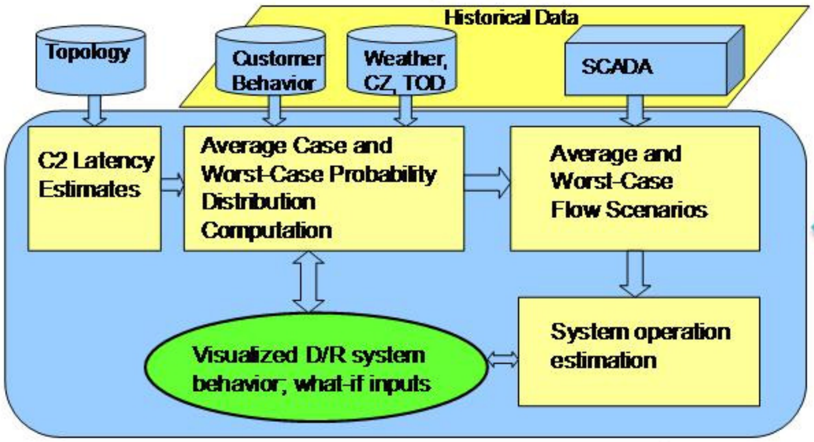
Demand Resource & Behavior Database

- DR high level reference architecture
  - Participants
  - DR programs
  - Demand Resources
    - Attributes
    - Behavior
  - DR Events



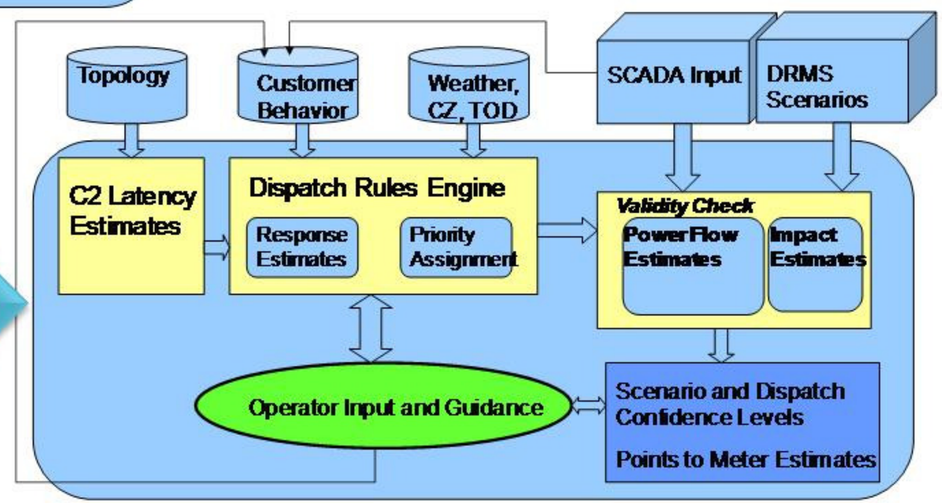
Complimentary DRACS Situational Understanding Tools

Offline Operation



Worst Case Planning Tool/Scenario Generator

Operational Scenario Confidence Analyzer



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Online Operation

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DRACS Architecture – Scenario Analysis

STEP 1: Receive Scenario from DRMS with desired confidence level

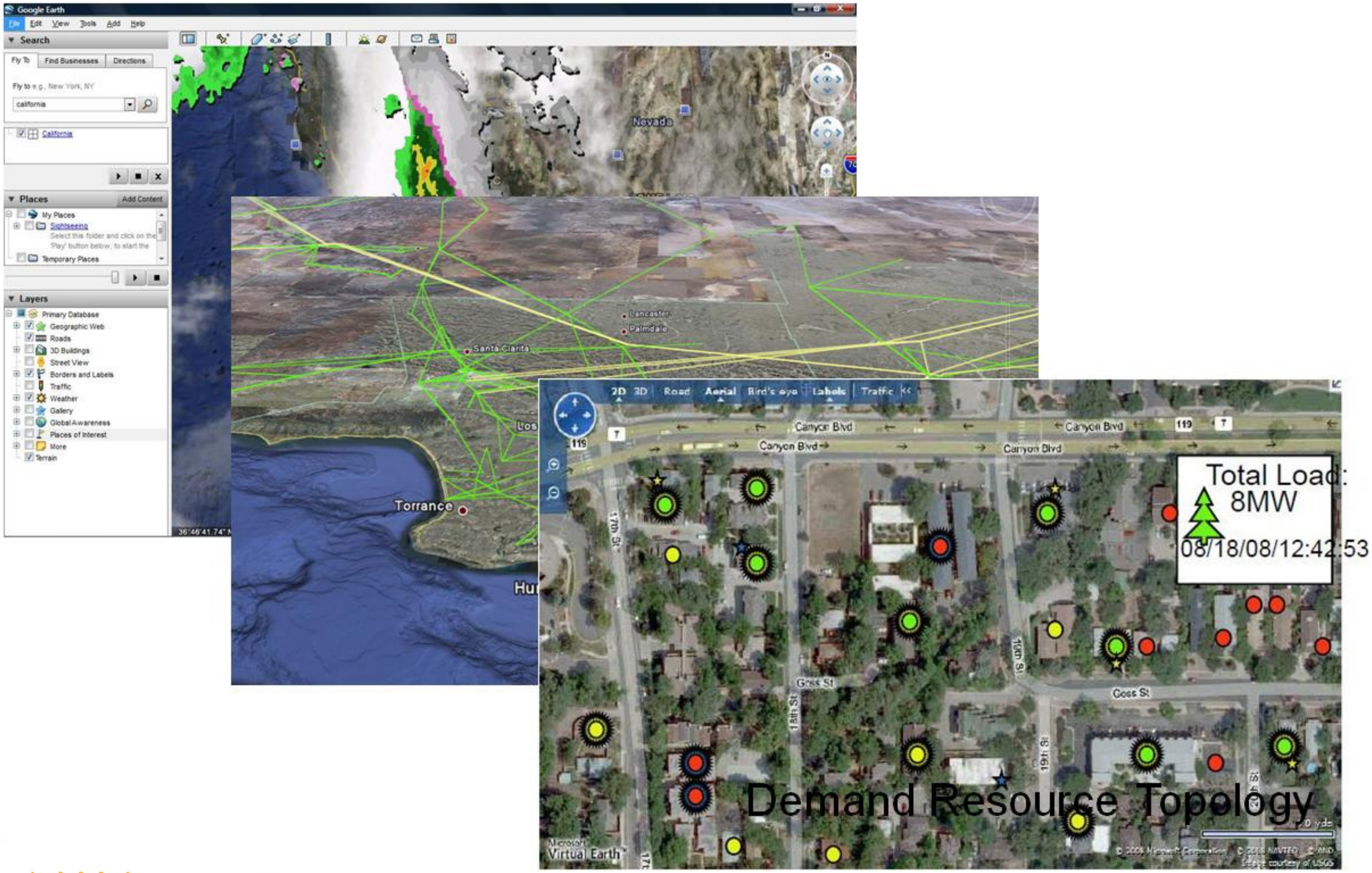
STEP 2: Calculate necessary statistical sample size of Scenario Demand Resources

STEP 3: Calculate Expected Load Response mean and standard deviation for the Demand Resource sample (Baseline – historical response)

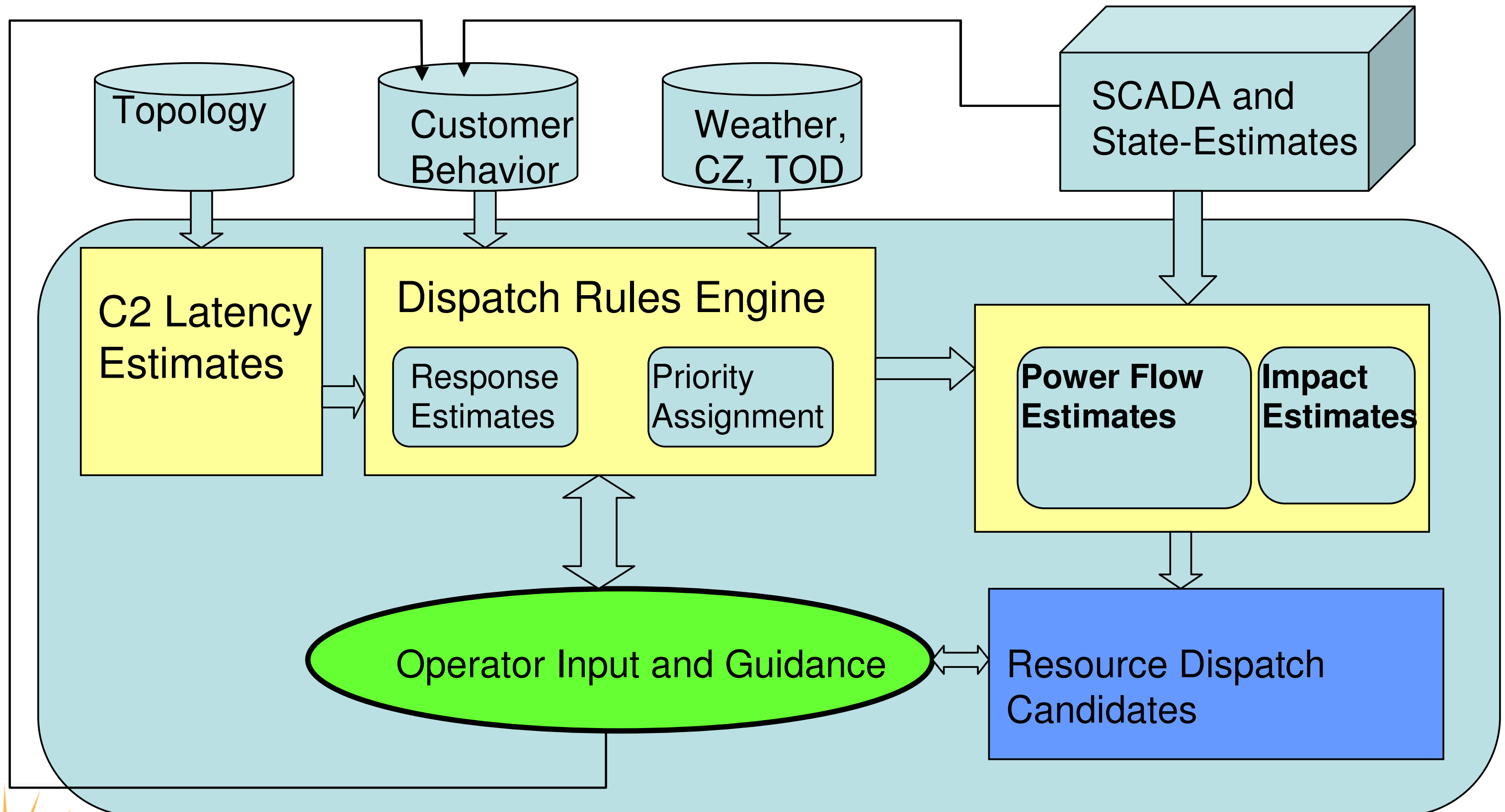
STEP 4: Multiply mean by total number of Scenario Demand Resources for expected Load Response

STEP 5: Calculate confidence interval for total Load Response

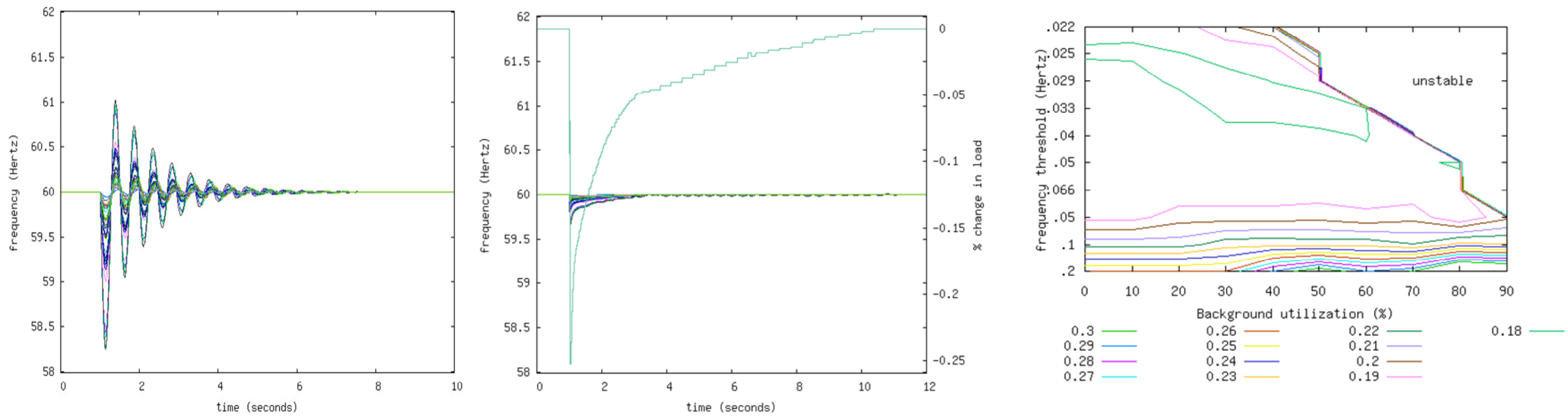
DRACS Architecture - Visualization



Operational Flow in Simulator Components



Simulator Framework
Case Study Example



IEEE 118 Bus Test Case:

(a) No Active Control (left)
(b) (b) Active Control (middle)
(c) (c) Stability Region (right)

Military Mission, Org Requirements

Tight coordination of multiple command structures controlling individual resources and assets integrated into a coordinated action to achieve an objective in support of a mission.

Utility Mission

Mission is singular (lowest cost electricity at highest reliability) and non-changing although objectives are evolving and changing with the advent of new Smart Grid technologies such as integration of distributed generation especially renewables

- implementation of smart metering
- providing customer access to energy usage
- integration of advanced grid control devices
- integration of demand response resources
- serving plug-in electric vehicles (PEVs)

Demand Response Recommendations

- Development of a full prototype simulator for creating and evaluating DR scenarios
- Automatic device registry mechanism for demand response resources
- Demand Response Resource behavior models for each customer class and device class
- Input into industry groups such at Open Smart Grid AMI Enterprise Working Group.   See Open SmartGrid AMI-Enterprise Use Cases 1.0 *http://osgug.ucaiug.org/utilityami/AMIENT/Shared%20Documents/Forms/AllItems.aspx?RootFolder=%2futilityami%2fAMIENT%2fShared%20Documents%2fUse%20Cases&FolderCTID=&View=%7bAE210767%2d1957%2d42A0%2dA6B4%2d46E383ED6114%7d*
- Standardization of Demand Response business processes at NAESB. (See NAESB Demand Side Management and Energy Efficiency Working Group *http://www.naesb.org/dsm-ee.asp*
- NIST Smart Grid Interoperability Standards