Smart Grid Thinking, Innervation, and Infrastructure Threats

Albert Boulanger

Center for Computational Learning Systems, Columbia University & World Team Now

aboulanger@ccls.columbia.edu

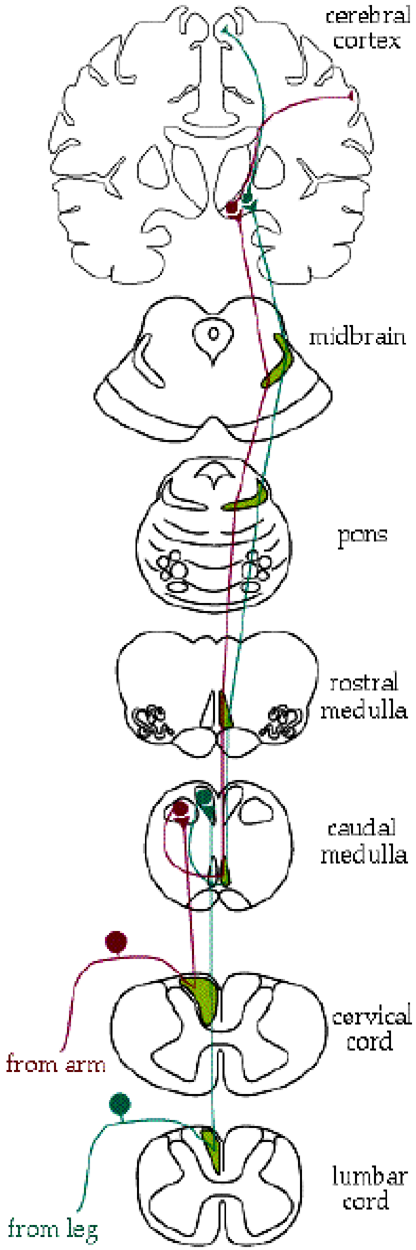
aboulanger@worldteamnow.org

Keys to a Resilient Smart Grid

- New way of doing SCADA -- Innervation, self-locating, self-organizing, self-identifying, and the data they produce self-storing.
- In order to control, one needs to model – Approximate Dynamic Programming (ADP). Five examples: ThreatSim (whole grid), Load/Source Optimization Controller (LSOC) and Dynamic Treatment (distribution grid), FedEx truck charging, intelligent building management (customer side of transformer)
- Grid and local storage is a key
- Policy changes and awareness are important

Innervation

- **Exploit economies of scale**
  - **Every company has thousands of "actuators"**
    - **Generally actuators are isolated physical systems, like wells in an oil company or generators on a power grid, but sometimes they couple. Innervation can optimize for these situations.**
    - **Clone learning loops and adapt to specifics**
- **Homeostasis, autonomous subsystems**
  - **Distributed, localized control for isolated sub-systems:**
    - **Sub-tasks, sub-regions, sub-structures, etc.**
- **Storage Area Networks: The network is the computer & the storage medium both!**
- **Build it like the Human Nervous System**



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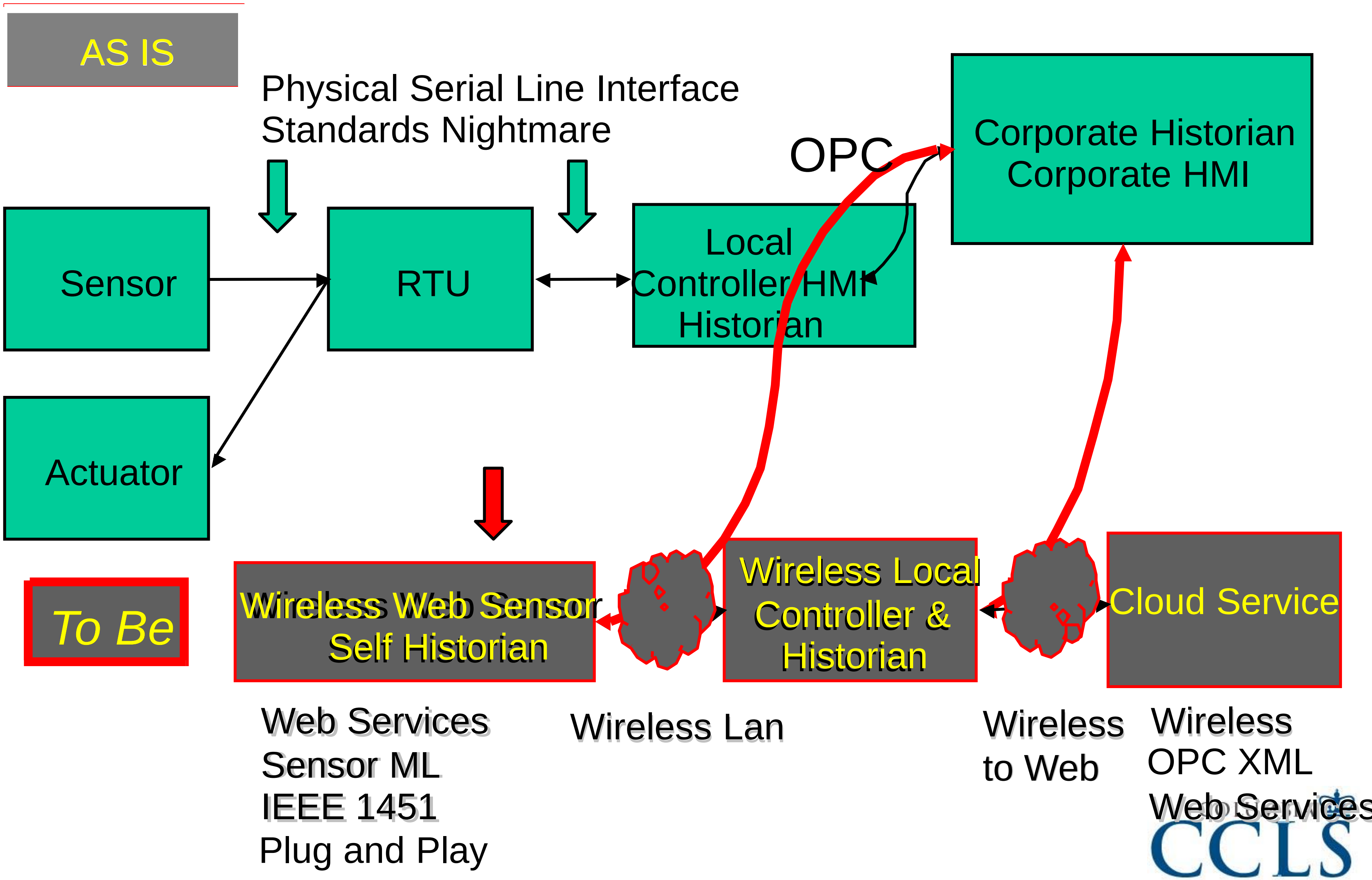
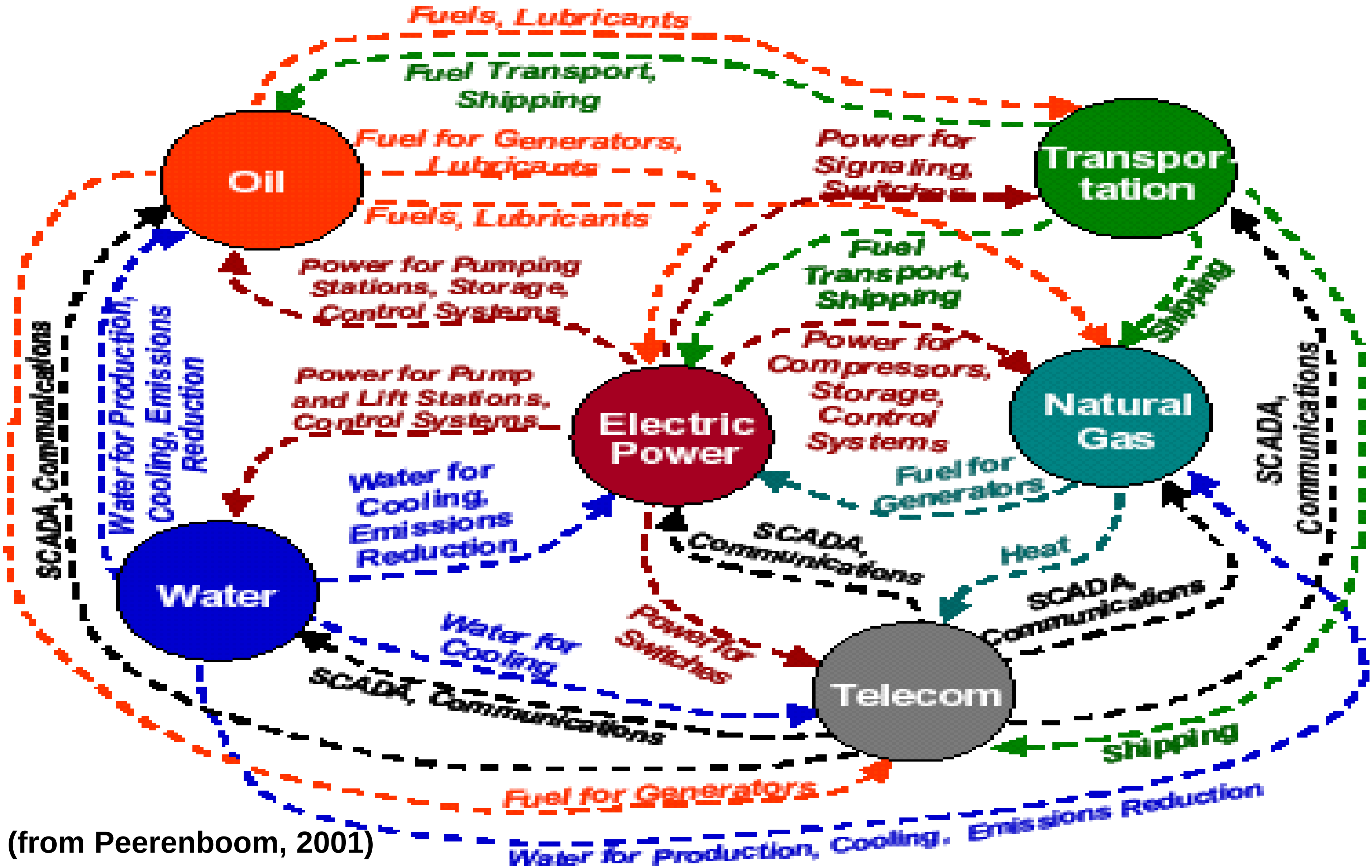
Digital Convergence
Rewriting the SCADA Equation



Infrastructure Dependencies



(from Peerenboom, 2001)

CCLS Smart Grid Work

- ThreatSim learning/simulation system
- LSOC - Make distributed resource control precise
- Dynamic Treatment - Make policies algorithmic and adaptive to real time data
- The other side of the transformer
  - GE/FedEx/CCLS Development of optimization of the control of Electric Deliver Truck charging. CCLS won an Ecomagination Award for its work
  - Intelligent operation of Skyscrapers.

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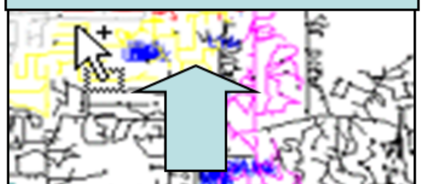
ThreatSim Concept

ThreatSim Learning System (includes Dimensionality Reduction)

Transmission Simulation

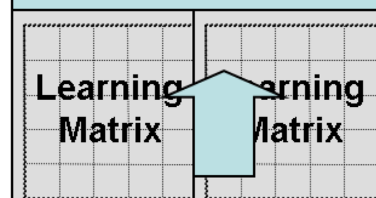
Transmission Data or SCADA

Distribution Simulation



Distribution SCADA

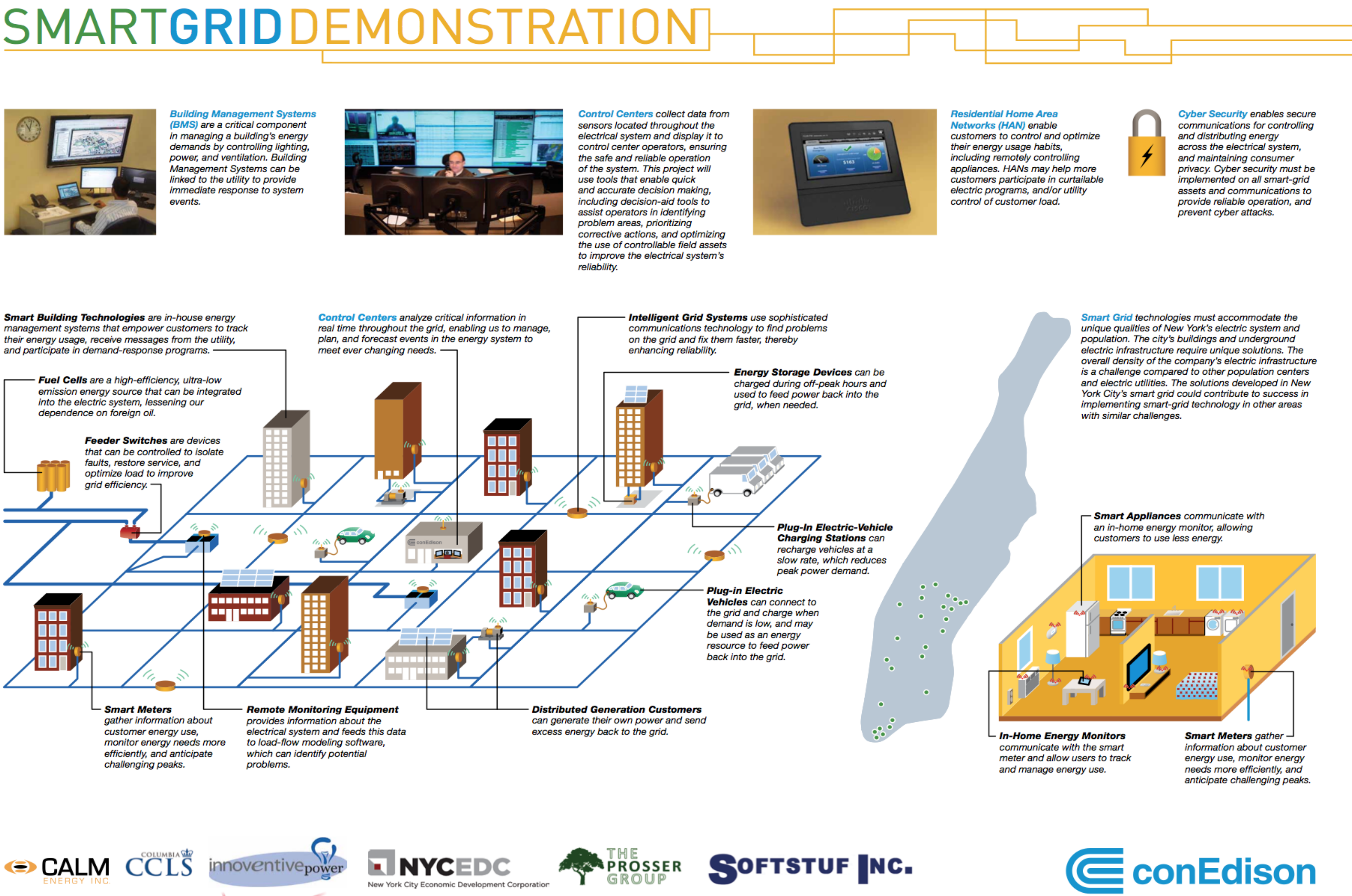
Learning Matrix "seeds" system



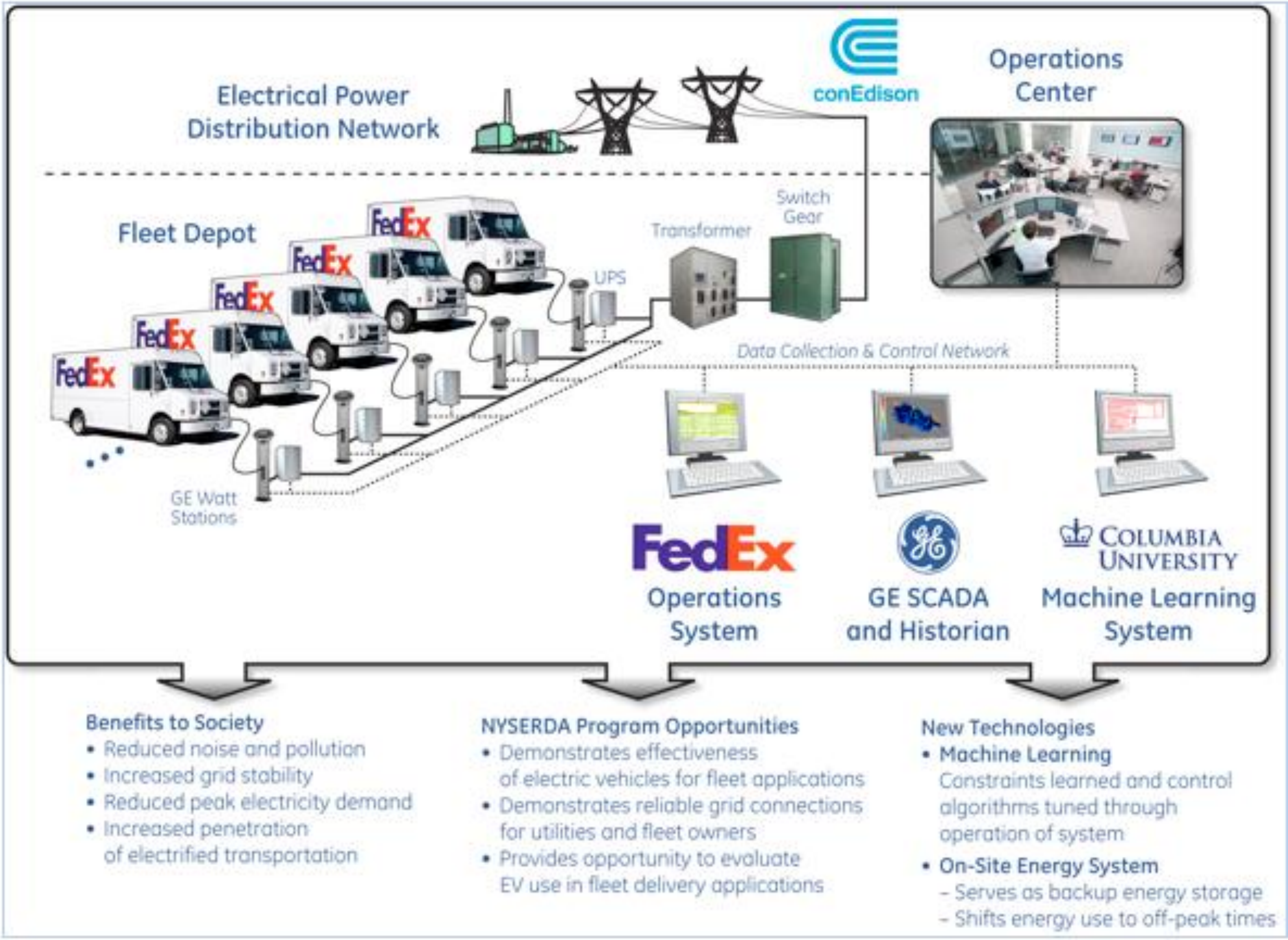
War Gaming Threat Scenarios captured as Learning Matrices

Single or multiple simulations of aspects of assets under threat

Machine Learning & ADP Providing Brain of NYC Smart Grid



Columbia Machine Learning System developed for FedEx EDV Fleet in Lower Manhattan



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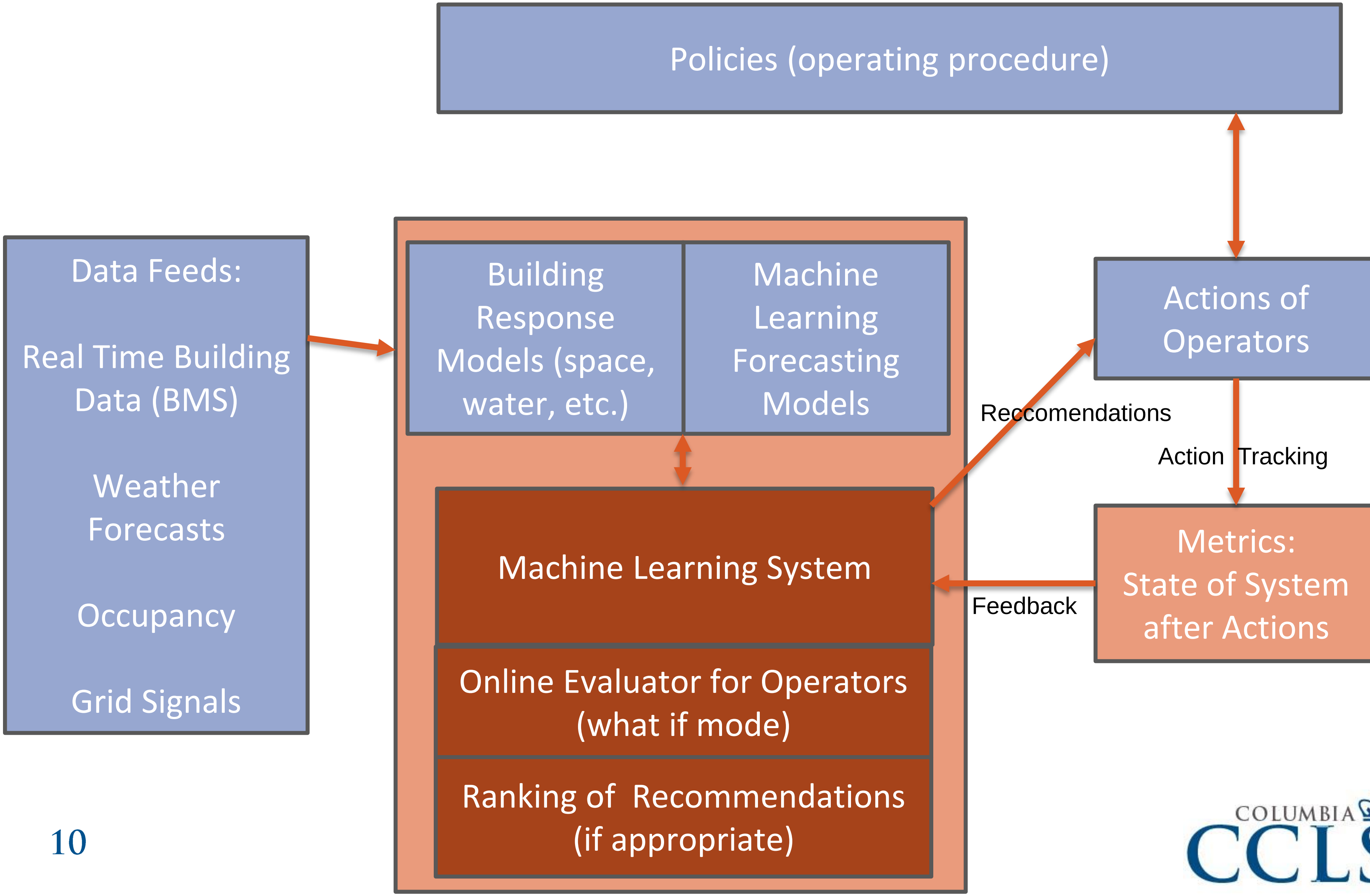
Smart Building Systems Architecture



Storage is a Key

- New Battery Technologies are needed and coming like EOS's Zinc-Air battery
  - No flammable or toxic materials.
  - Large number of cycles
- Thermal storage helps!

Policy and Awareness Important

- Lack of knowledge in the public on what is available, permitting issues, lack of policies and procedures at the city level, non-optimal, contrarian, or nonexistent incentivization hinder EV adoption, connecting renewables to the grid, finding the good in smart meters, etc.
  - Role of organizations to change policy and awareness. World Team Now is active in this area.

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Thank You

The future ain't what it used to be.
–Yogi Berra

No problem can be solved from the same level of consciousness that created it.

– Albert Einstein

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