Grid Modernization
– a System Operator's Perspective

Victor Wong
Sarawak Grid System Operator/
Senior Vice-President,
Sarawak Energy Berhad

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Grid Modernization – the challenges

- Utility assets are ageing and need refurbishment or replacement, assets are working harder and closer to thermal and dynamic ratings and stability limits
- Uncertainties introduced by distributed renewal energy resources
- New modern technologies and products are introduced
- More sensors installed, more data (BIG DATA)

How can we prepare our future technical workforce to handle the complexity of the Future Grid and operate it safely and reliably ?

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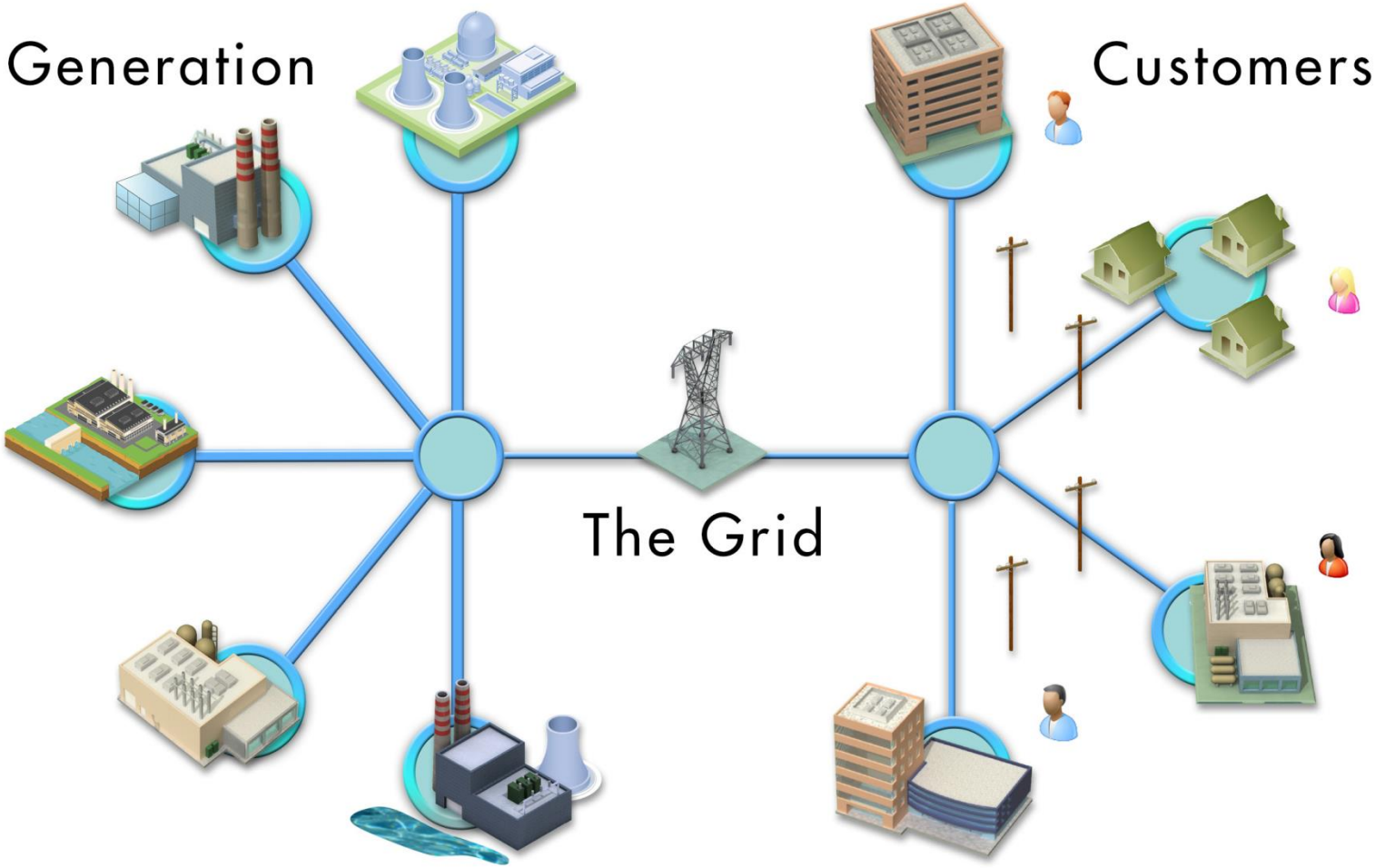

Today's Power System Characterized by Central Generation of Electricity, Transmission, and Distribution to End-Use Consumers

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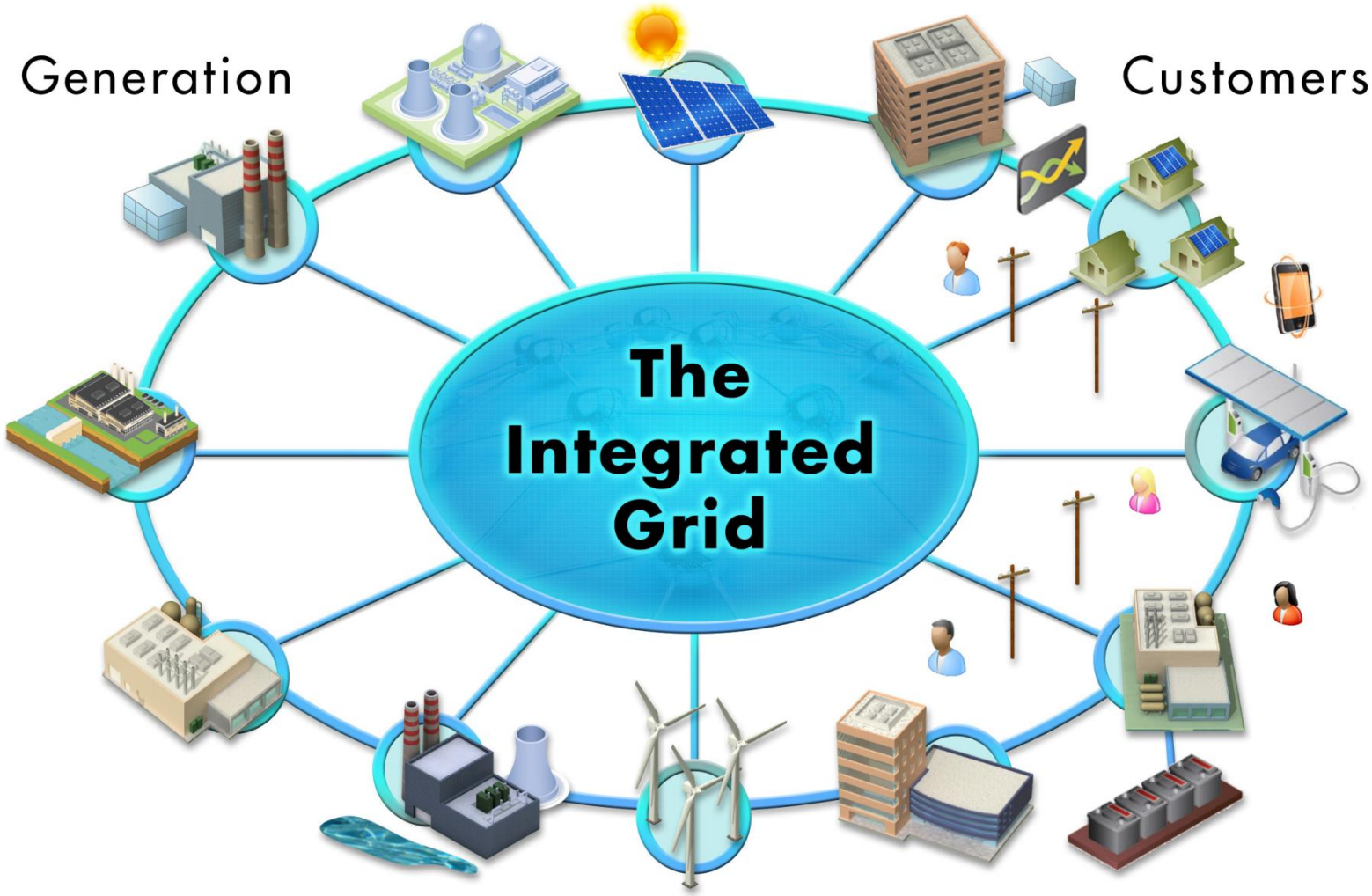

Creating an Architecture with Multi-Level Controller

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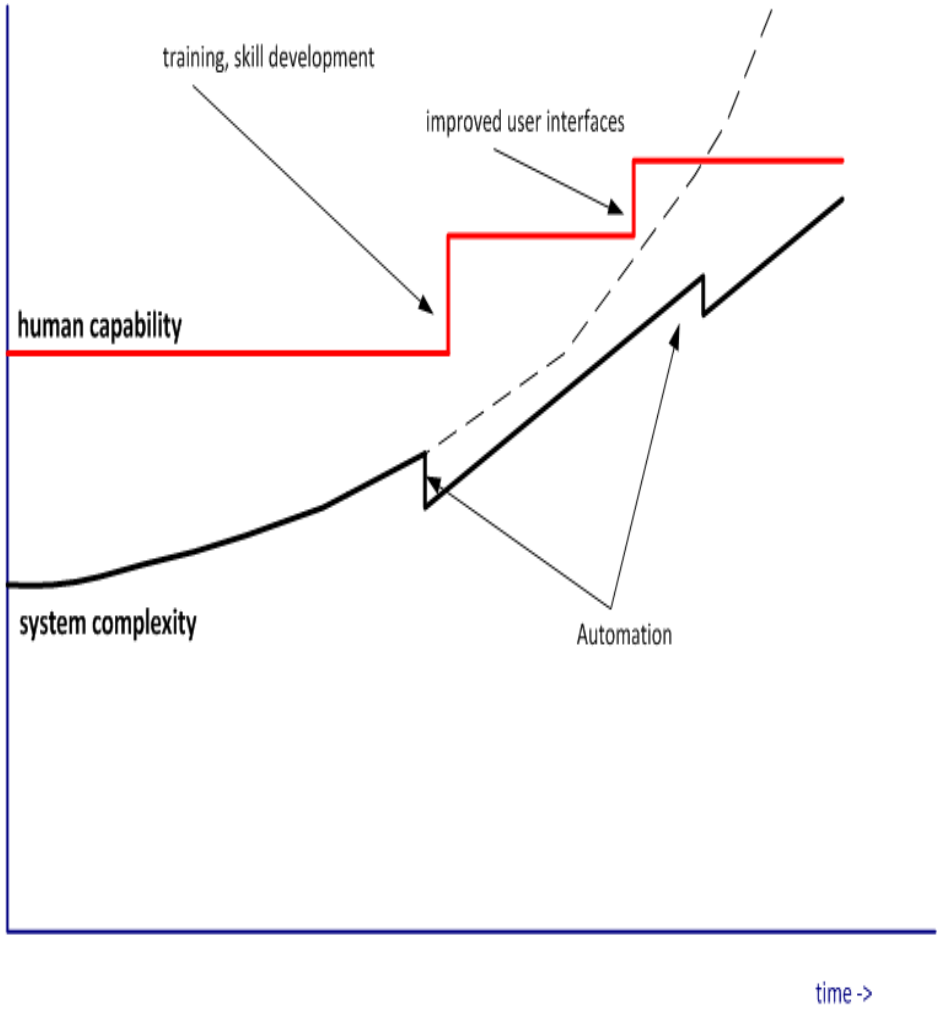
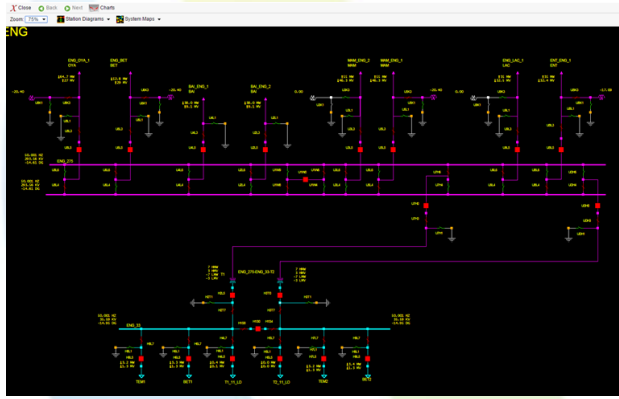
System Complexity vs Human Capability

- Complexibilty of TSO systems increased over time due to technical advancements
  - Such advancements also allowed complexity to be simplified eg, automation
  - However, complexity increases outweigh benefits from automation
- Human capability can be bolstered with training, or with improved user interfaces, but..
  - Risk that at certain point in time (say 5-10 years), system challenges in the electrical system will be much greater than the capacity of human operators in the control room



Knowledge Capture & Transfer

- Explicit knowledge is formal & systematic, can be easily communicated and shared, e.g.;
  - Operating procedures (SOPs)
  - Disturbance reports
  - Databases or computer programs



- Tacit knowledge is highly personal, hard to formalize, difficult to communicate to others;
  - Deeply rooted in one's own lived action, life experience and an operator's commitment to participate in his profession/craft
  - "We know more than we can tell"
- The distinction between tacit and explicit knowledge is the foundation for building a Knowledge Capture and Transfer Program

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Tacit to Tacit Knowledge Transfer

- Basis of On-the-Job training
- Trainee works side by side with experienced operator (Master/Apprentice)
- Learns his tacit skills through a long process of observation, imitation and practice
- Neither apprentice nor the master gain any systematic insight into their craft knowledge
- Because their knowledge never becomes explicit, it cannot easily be leveraged by the organization as a whole

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Explicit to Explicit Knowledge Transfer

- Occurs when an individual combines discrete pieces of explicit knowledge into a new whole
- Explicit knowledge includes books, technical publications, company's operating procedures etc
- Vast amount of explicit knowledge on the art and science of power system engineering been published mainly by the academic community
- In contrast only a small amount of explicit knowledge that has been published on the art and science of power system operations

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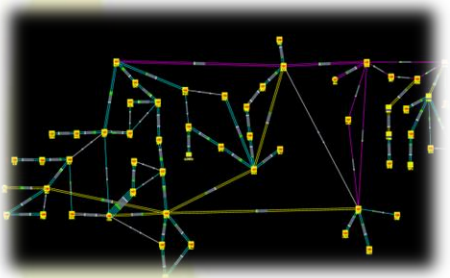
Power simulator as a Catalyst



- The development of explicit knowledge from tacit knowledge is often one of the more difficult transformations and it has a very high payoff
- With a Power Simulator the process becomes very systematic
- The simulator provides a catalyst and context for expert/master operators to express their tacit knowledge
- Actions of the master operator and how he responds to solve various problems can be recorded
- Operating principles that the master operator applied can be documented and explained
- Explicit to tacit knowledge transfer occurs as operators perform the simulator exercises and develop their skills in power system operation
- Explicit knowledge is assimilated by the operators and they begin to internalize it.

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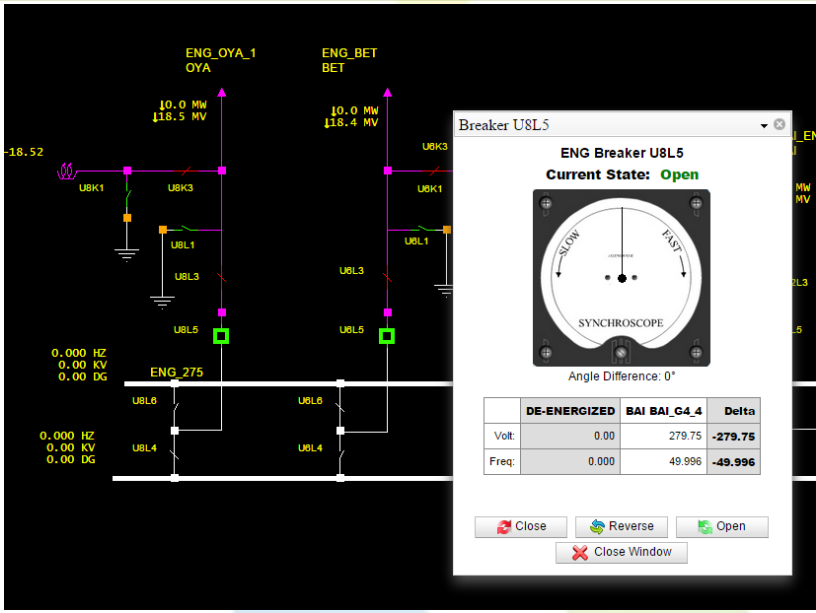
Spiral of knowledge



- Step 1
  - Articulation by the experts
  - Converting tacit knowledge to explicit knowledge
- Step 2
  - Internalization by the apprentice
  - Using that explicit knowledge to extend the apprentice's own tacit knowledge base
- The master has to stretch and grow to communicate more of what he knows
- The apprentice has to stretch and grow to apply the explicit knowledge and extends his own operating skills

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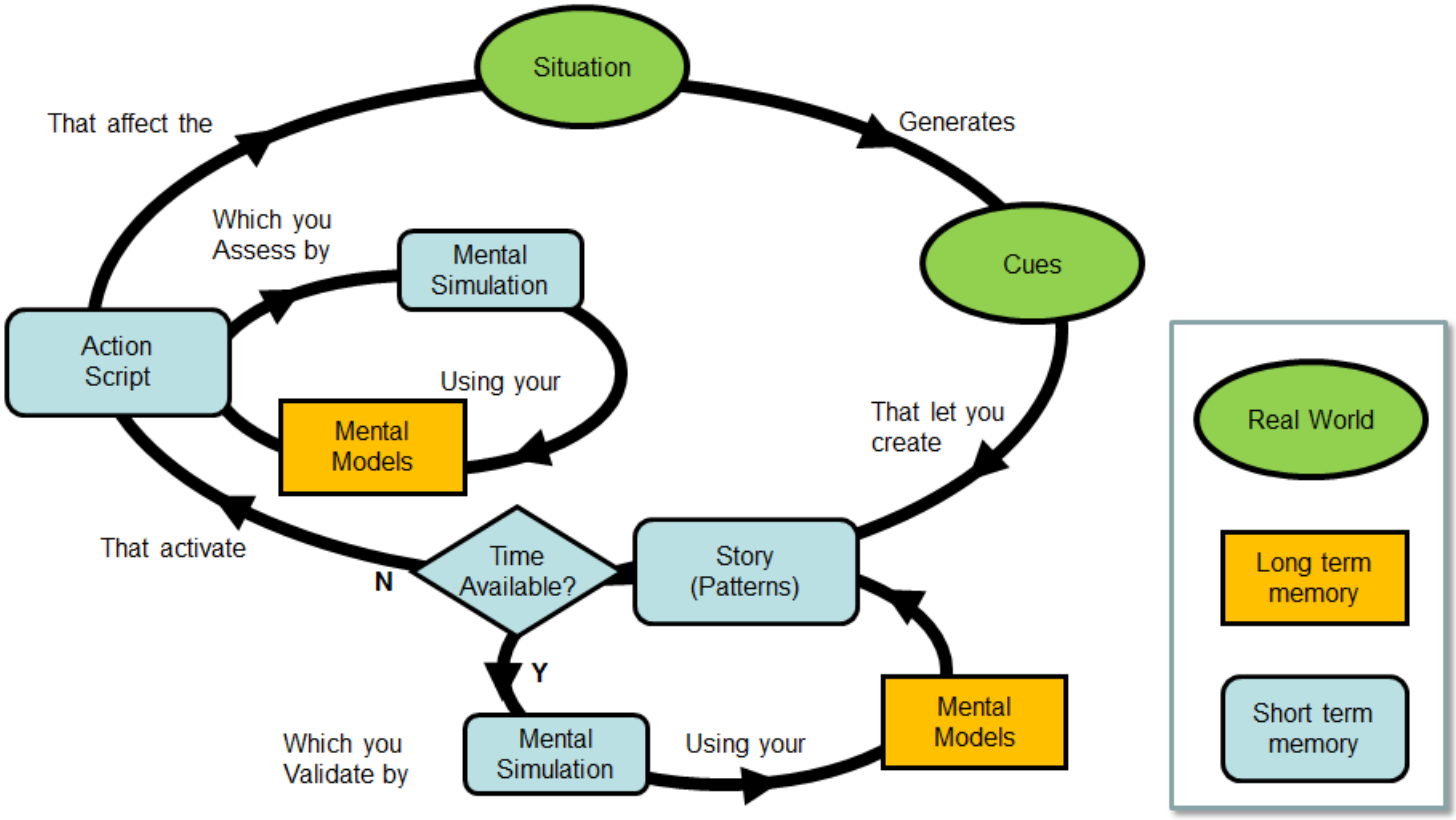
Extended Recognition Primed Decision Model



Further reading – Gary Klein, "Recognition-Primed Decisions Model", Sources of Power, The MIT Press 1987

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GSO Initiative #1: System Operator Training and Certification Program

- Power Simulator as the platform
- Knowledge capture and Transfer
- Enhance the company's On Job Competency (OJC)
- Review the NERC System Operator Certification program to adopt or develop own certification program
- Auditable process

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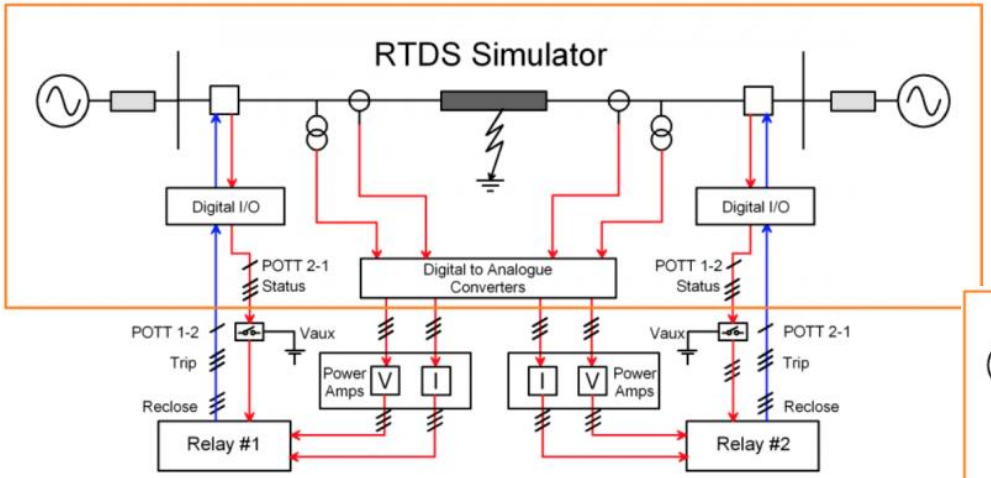
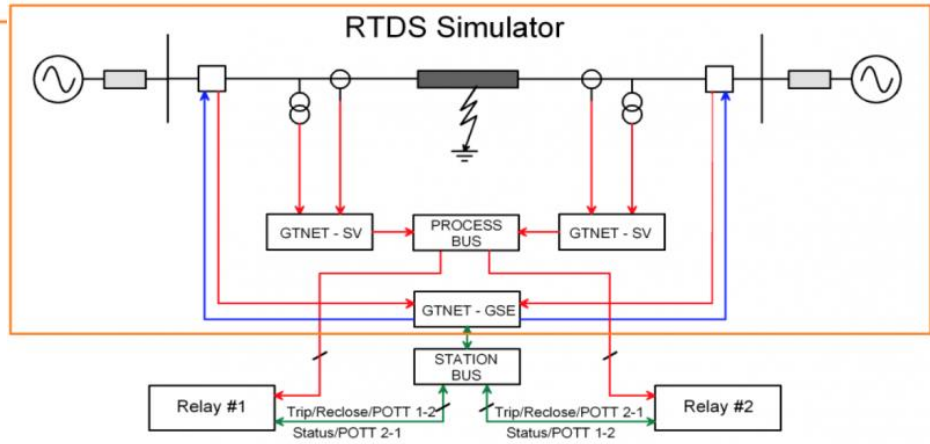
GSO Initiative #2: A Next Gen Digital Substation Demonstration Project

- Using a RTDS (Real Time Digital Simulator) to simulate the electric system and the primary equipment of a substation
- Provides the necessary voltage, current and other electrical signals and status signals to operate the secondary equipment





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Next Gen Digital Substation Demonstration Project

- Avoid major capital investment in primary equipment and land etc
- A versatile platform for learning and training engineers in protection system, monitoring systems, IEC 61850 etc under a controlled and safe environment
- Develop the company's technical specifications for future substation requirements
- Product testing & compliance certification

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Q&A?

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