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INITIATIVE

Key Technology Areas

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Modernizing the Grid Southeast Regional Summit

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Objectives

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- **Summarize the Key Technology Areas**
- **Review study results to date**
- **Receive your feedback**

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Key Technology Areas

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- **Integrated Communications (IC)**
- **Advanced Components (AC)**
- **Sensing & Measurement (SM)**
- **Advanced Control Methods (ACM)**
- **Improved Interfaces and Decision Support (DS)**

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Integrated Communications (IC)
The Key Technology Area Linchpin

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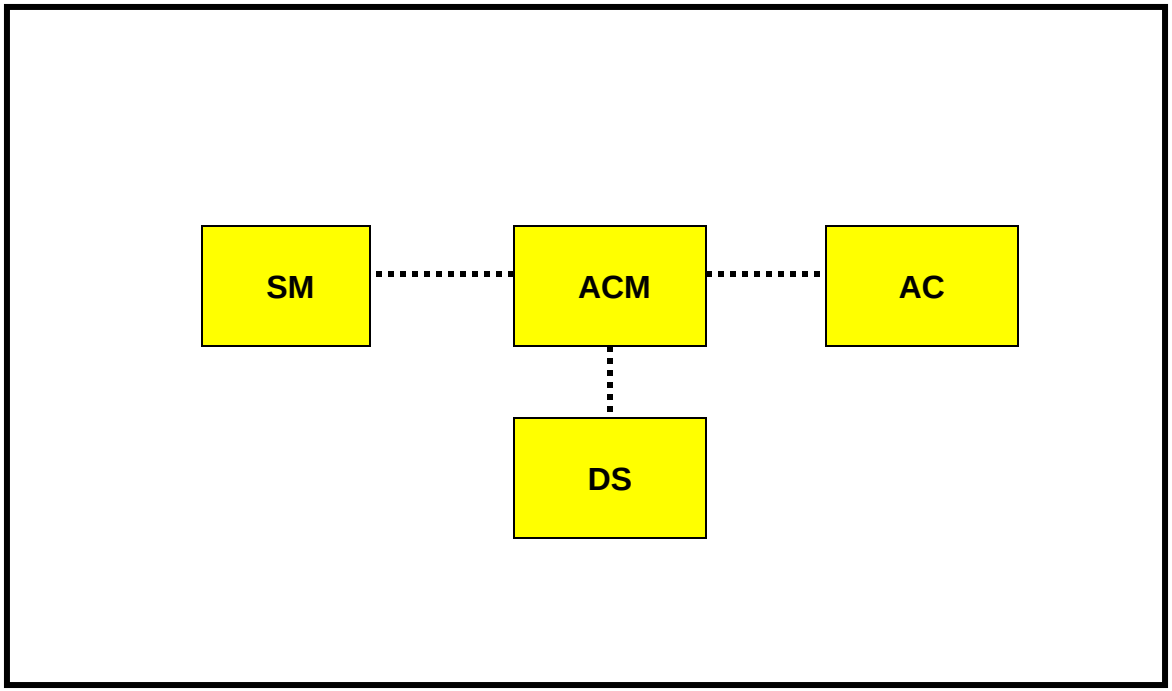

SM = Sensing and Measurement

ACM = Advanced Control Methods

AC = Advanced Components

DS = Improved Interfaces and Decision Support

Integrated Communications (IC): Overview

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An effective, fully-integrated communications infrastructure is an essential component of the modern grid:

- IC creates a dynamic, interactive “mega-infrastructure” for real-time information and power exchange
- IC allows the various intelligent electronic devices (smart meters, control centers, power electronic controllers, protection devices) and users to interact as an integrated system

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IC: Key Requirements and Examples

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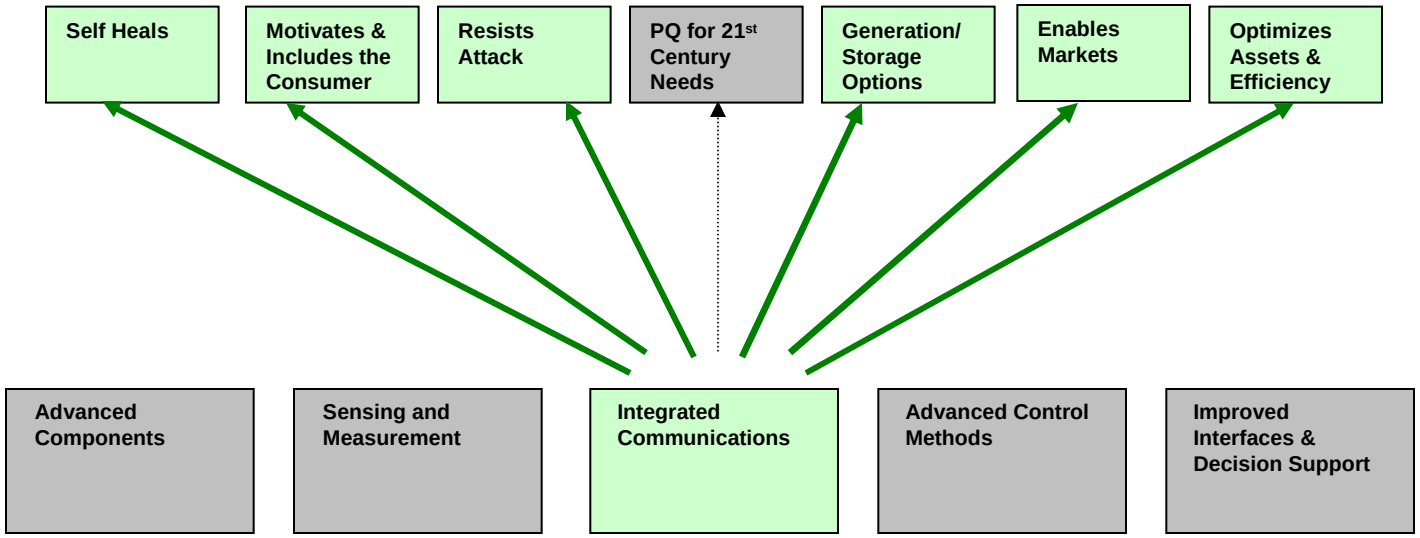
- **Open universal communication standards to enable information to be understood by a wide assortment of senders and receivers (e.g. CIM, IEEE P1901, IEC 61850…)**
- **Appropriate media to enable information to be transmitted accurately, securely and with the required throughput. Media examples include:**
  - Powerline communications (PLC and BPL)
  - Wireless (WiFi, WiMAX, 800 MHz, ,Satellite, Microwave…)
  - OPGW
  - Fiber
  - Land lines
- **Hybrid combinations of the above media, having differing capabilities, will be needed**

IC: Strongly Supports 6/7 Characteristics



IC: Observed Gap

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- **Slow standards development process**
- **Stranded investment concerns limit deployment**
- **Little visibility of competing technologies**
- **Lack of an industry vision for IC, with such criteria as:**
  - **Ubiquity** – All potential users can take advantage of the infrastructures
  - **Integrity** – Infrastructure noticeable only when it ceases to function effectively
  - **Ease of use** – Logical, consistent and intuitive ("plug and play") rules
  - **Cost effectiveness** – Value provided is consistent with cost
  - **Standards** – Basic elements are clearly defined and stable over time
  - **Openness** – Public infrastructure available to all on a nondiscriminatory basis
  - **Security** – Infrastructure can be used without fear of interference from others
  - **Applicability** – Bandwidth will support present and future functions

IC: Gap Closure Benefits

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- **Achievement of the modern grid vision is fully dependent on integrated communication technologies**
- **Huge opportunity in reliability, quality, security, economy, safety, efficiency and environmental performance**
- **Standards will allow continuing development and effective deployment of communication infrastructure and other technologies**
- **Visibility of communication options and the benefits to users and investors will stimulate penetration and eliminate stranded investment concerns**
- **Deep penetration (demand) will drive prices down**

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Advanced Components (AC): Overview

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Advanced Component devices play an active role in determining the electrical behavior of the grid.

The grid of the future will employ a wide variety of new components. These Advanced Components apply fundamental gains in materials and chemistry, superconductivity, microelectronics, and power electronics.

AC: Examples

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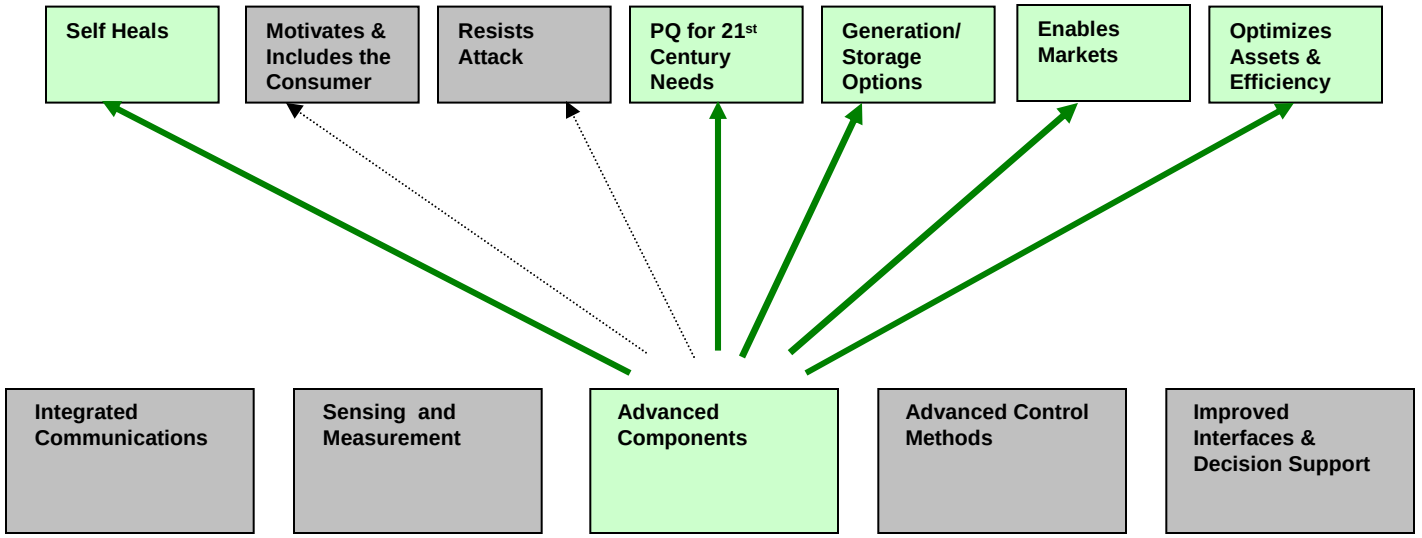
- **Superconducting transmission cable**
- **Superconducting rotating machines**
- **Fault current limiters**
- **Composite conductors**
- **Next generation FACTS/PQ devices**
- **Advanced distributed generation and energy storage**

AC: Strongly Supports 5/7 Characteristics



AC: Observed Gap

- **While progress has been made in virtually every area, massive investment is still needed to reach the desired state**
- **Today's components are mostly the same as those employed over the past half century or more**
  - Power electronics have not been developed or employed in sufficient scale to drive down cost
  - New energy storage technologies are still in the early stage of deployment
  - Superconductivity for generation, storage, stability and power transfer has not been developed for practical application on a large scale

AC: Gap Closure Benefits

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- **Huge opportunity for improved reliability, quality, security, economy, safety, efficiency and environmental performance**
- **US takes the lead in a number of critical development areas**
- **Government demonstrates support of US Energy Policy**

Sensing and Measurement (SM): Overview

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- **New digital metering technologies including two-way communications: supporting a variety of inputs (pricing signals, time of day tariff, etc) and outputs (real-time consumption data, PQ, etc) and including the ability to remotely disconnect loads**
- **Interfaces with generators, grid operators, and customer portals: enhancing grid measurements, providing outage detection, eliminating meter estimations, providing energy theft protection, and enabling consumer choice and Demand Response**
- **Advanced sensing and measurement devices and techniques: assessing the state and condition of grid elements, establishing their capacity and failure probability in real-time, and providing the basis for advanced system protection**

SM: Examples

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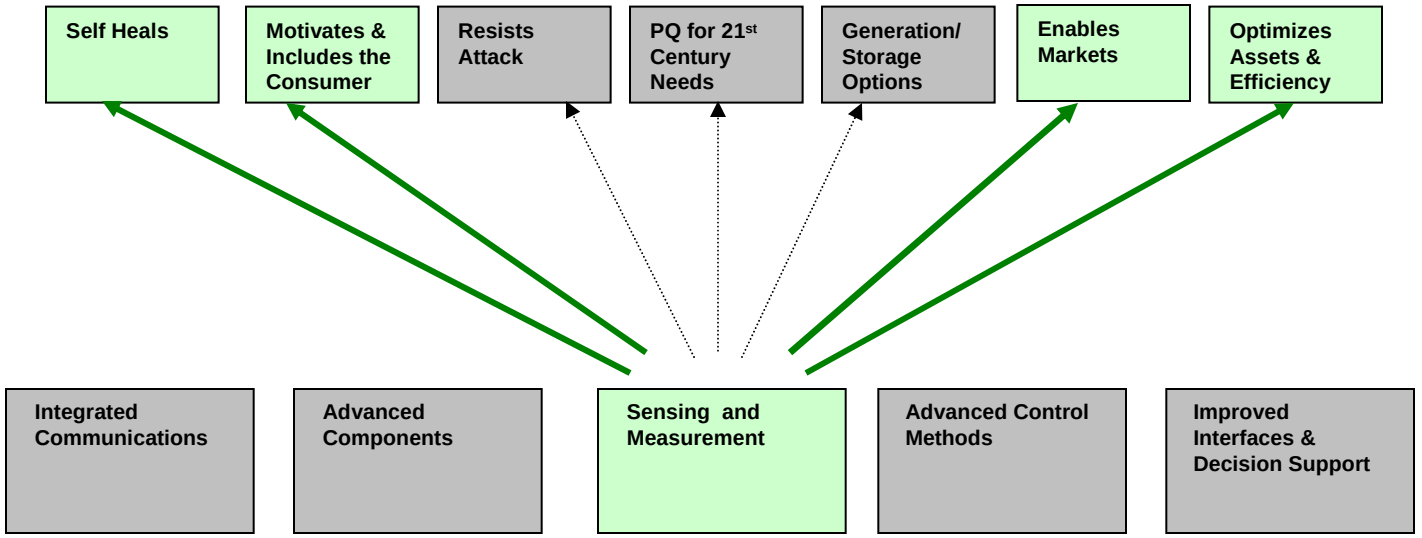
- **Dynamic rating of transmission lines**
- **Wide area monitoring systems (WAMS)**
- **Advanced system protection**
- **Consumer portal**
- **AMI**
- **Splice health sensor**
- **Insulator leakage sensor**
- **EMI detection of vegetation and equipment problems**
- **Electronic ITs**

SM: Strongly Support 4/7 Characteristics



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SM: Observed Gap

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- **Measurements**
  - Still a long way from each consumer having a communicating digital meter (portal)
    - Development activity underway (EPRI, CERTS, CEC…)
- **Sensing**
  - Still a long way from broad deployment of low cost advanced sensors to determine status, health and capacity of grid elements (components, circuits, systems) in real time
    - Development activity underway in such area as EMI analysis and dynamic circuit rating
    - PMUs now being integrated with standard relay packages

SM: Gap Closure Benefits

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- **New electricity markets flourish**
- **Huge increase in knowledge of grid conditions**
- **Better planning and asset management**
- **New tools for operations (Demand Response)**
- **Consumer empowerment and involvement**
- **Huge opportunity in reliability, quality, security, economy, safety, efficiency and environmental performance**

Bottom Line: a modern grid can't be built on a century-old measurement technology

Advanced Control Methods (ACM): Overview

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Broad application of computer-based algorithms that:

- Collect data from and monitor all essential grid components
- Analyze the data to diagnose and provide solutions from both deterministic and predictive perspectives
- Determine and take appropriate actions autonomously or through operators (depending on timing and complexity)
- Provide information and solutions to human operators
- Integrate with enterprise-wide processes and technologies

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ACM: Functions Example

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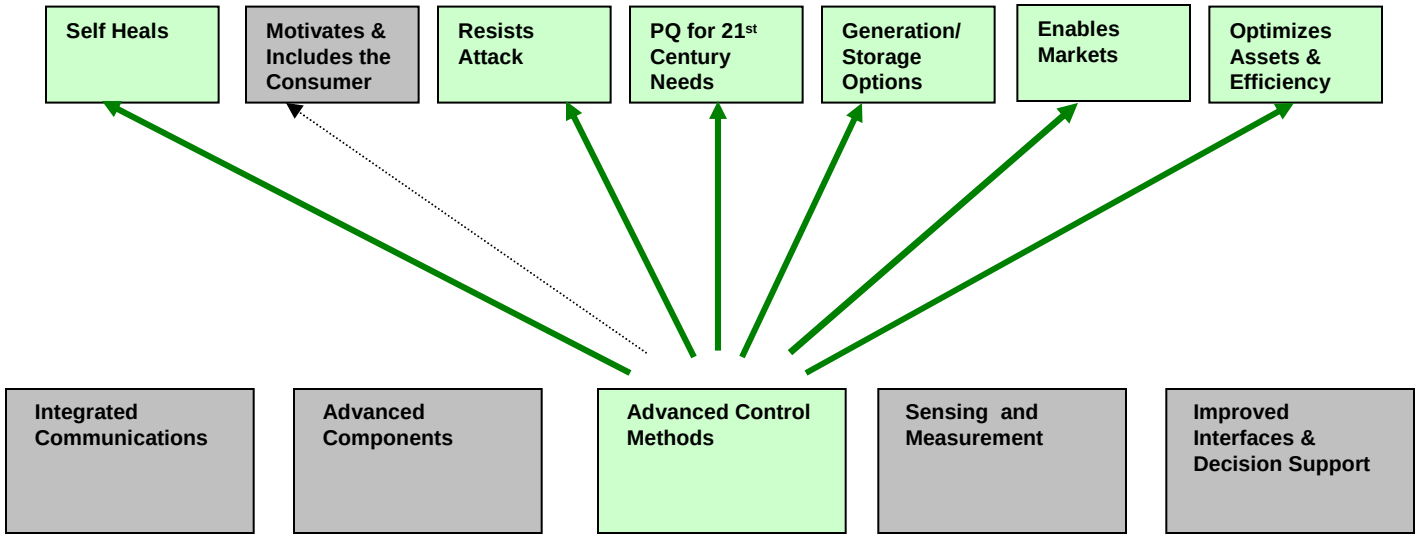
- **Smart sensors that measure power system parameters (including phasors) and monitor the actual condition of critical grid components, coupled to an integrated, high speed communications infrastructure**
- **Enabling advanced computer algorithms to interact with next generation control and protection devices**
- **Producing actions that deliver the self-healing characteristic of the modern grid**

ACM: Strongly Supports 6/7 Characteristics



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ACM: Observed Gap

- **Vision for desired end-state is not clear**
- **An integrated system-wide (region-wide or greater) control perspective has not been formulated**
- **Widespread deployment of intelligent electronic devices has not occurred, nor has a universal interface**
- **Integrated communications infrastructure is missing**
- **Availability of data is limited**
- **Cost of sensors (e.g. ITs) is too high**
- **Slow state estimation; supercomputers not employed**

ACM: Gap Closure Benefits

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- **Self-healing vision for the Modern Grid can be achieved**
- **Step change improvement in the effectiveness and efficiency of enterprise processes realized**
- **Huge opportunity in reliability, quality, security, economy, safety, efficiency and environmental performance**

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Improved Interfaces & Decision Support (DS): Overview

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- **DS technologies will transform complex power system data into information that can be understood "at a glance" by human operators**

- **Animation, color contouring, virtual reality and other data aggregation techniques will prevent "data overload" and help operators identify, analyze and act on emerging problems**

DS: Examples

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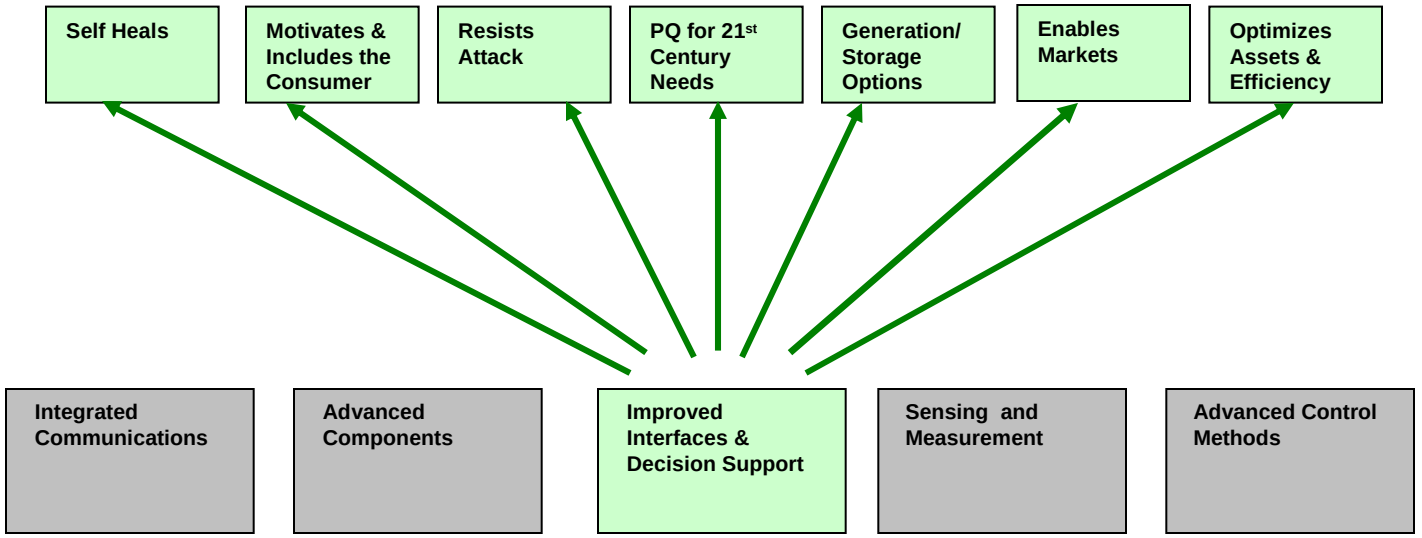
- **Data reduction**
  - Data reduced into the format, timeframe and technical categories most important to the operator
- **Visualization**
  - Presentation of information uses proven human factors techniques
- **Speed of comprehension**
  - Visualization methods provide information that can be rapidly converted to operator action
- **Decision support**
  - Artificial intelligence and agents identify existing, emerging, and predicted issues and provide for “what-if” analyses
- **System operator training**
  - Dynamic simulators and industry-wide certification programs significantly improve the skill sets and performance of today’s operators

DS: Strongly Supports 7/7 Characteristics



DS: Observed Gap

- **August 14, 2003 Blackout Task Force emphasized the need for improvements in DS**
- **It is more and more difficult for operators to understand the state and direction of an increasingly stressed grid**
- **There are no deployed supercomputers capable of instantly processing masses of data and recommending operator actions**
- **Operator training is not developing the advanced skills required for "real" operating environments**

DS: Gap Closure Benefits

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- **More reliable operation of the grid and lower incidence of outages from misoperation and natural events**
- **Added options for grid stability through knowledge-assisted control of consumer loads**
- **Huge opportunity in reliability, quality, security, economy, safety, efficiency and environmental performance**

Key Technology Areas Results to Date – Highest Impact

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- **Advanced Components**
  - Superconductors; power electronics
- **Sensing and Measurement**
  - Transformed metering; consumer portal
- **Integrated Communications**
  - Dynamic, interactive “mega-infrastructure” to manage a 100-fold increase in control nodes
- **Advanced Control Methods**
  - Advanced operations and protection algorithms
  - Integrated PRA in real-time operations
- **Improved Interfaces & Decision Support**
  - Semi-autonomous agent software (decision assistants)
  - Dynamic simulators for training