ARC Advisory Group

vision experience answers FOR INDUSTRY

OT and IT Convergence in the Nuclear Fleet

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Digital Plant Innovation

Exelon Generation

Power Generation

- Largest merchant fleet in the nation ~33 GW of capacity, with unparalleled upside
- **One of the largest and best managed nuclear fleets in the world (~19 GW)**
- Significant gas generation capacity (~10 GW)
- **Renewable portfolio (~1 GW), mostly contracted**

Constellation

- Leading competitive energy provider in the U.S.
- **Customer-facing business, with ~2.5 M customers and large wholesale business**
- **Top-notch portfolio and risk management capabilities**
- Extensive suite of products including Load Response, RECs Distributed Solar

Exelon Utilities

BGE, ComEd, PECO, & PEPCO

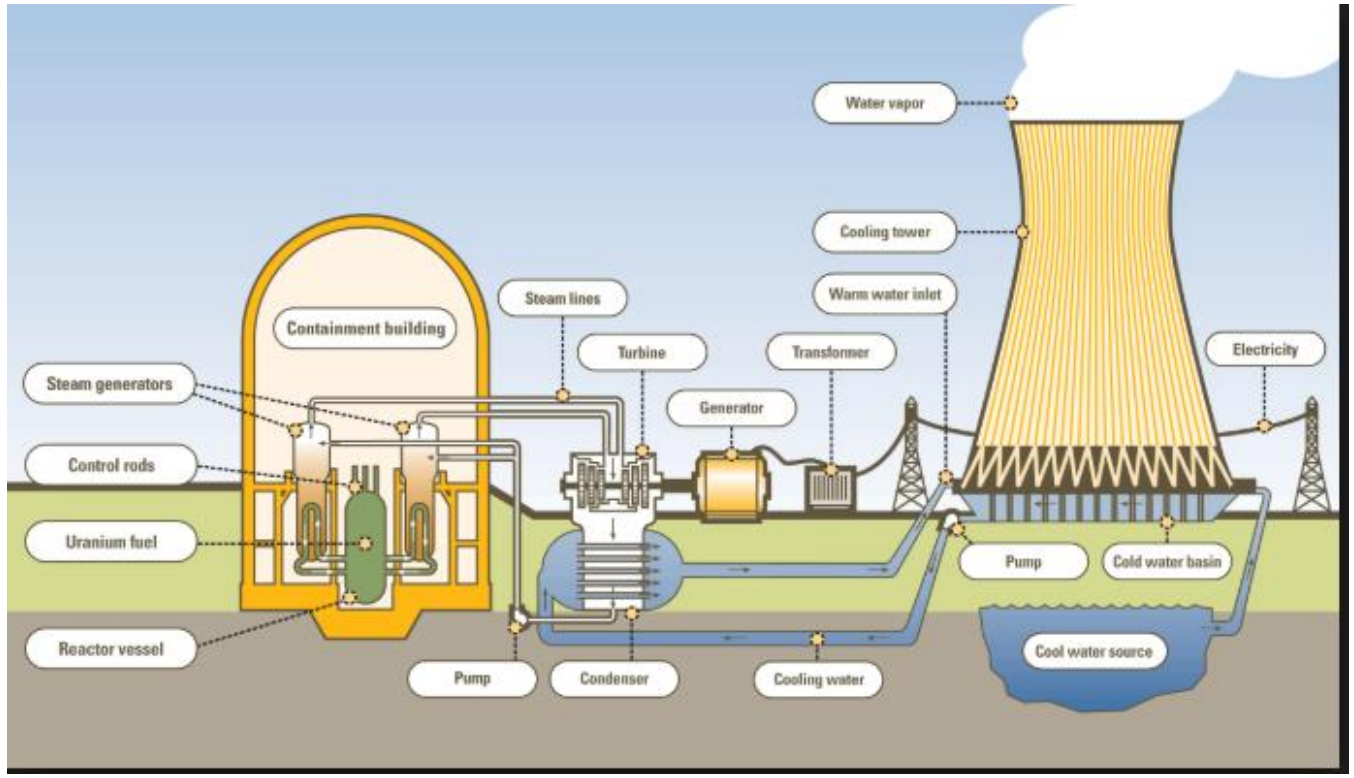
- Largest electric and **gas distribution company in the nation with ~10 M customers**
- **Diversified across multiple jurisdictions - Illinois, Maryland, Pennsylvania, Delaware, New Jersey, Wash DC**
- **Significant investments in Smart Grid technologies**
- Transmission infrastructure improvement at utilities

Competitive Business — Regulated Business

Exelon is the largest competitive integrated energy company in the U.S.

Overview of a Typical Nuclear Power Plant

- Two types: Pressurized Water Reactor (Westinghouse) & Boiling Water Reactor (GE)
- Most plants were built in 70s & 80s
- Everything is analog, pneumatic & local display – 80s technology
- ~1,000 staff on site
- Lots of concrete & steel - very costly to run wires
- Every site had a custom design - no standard



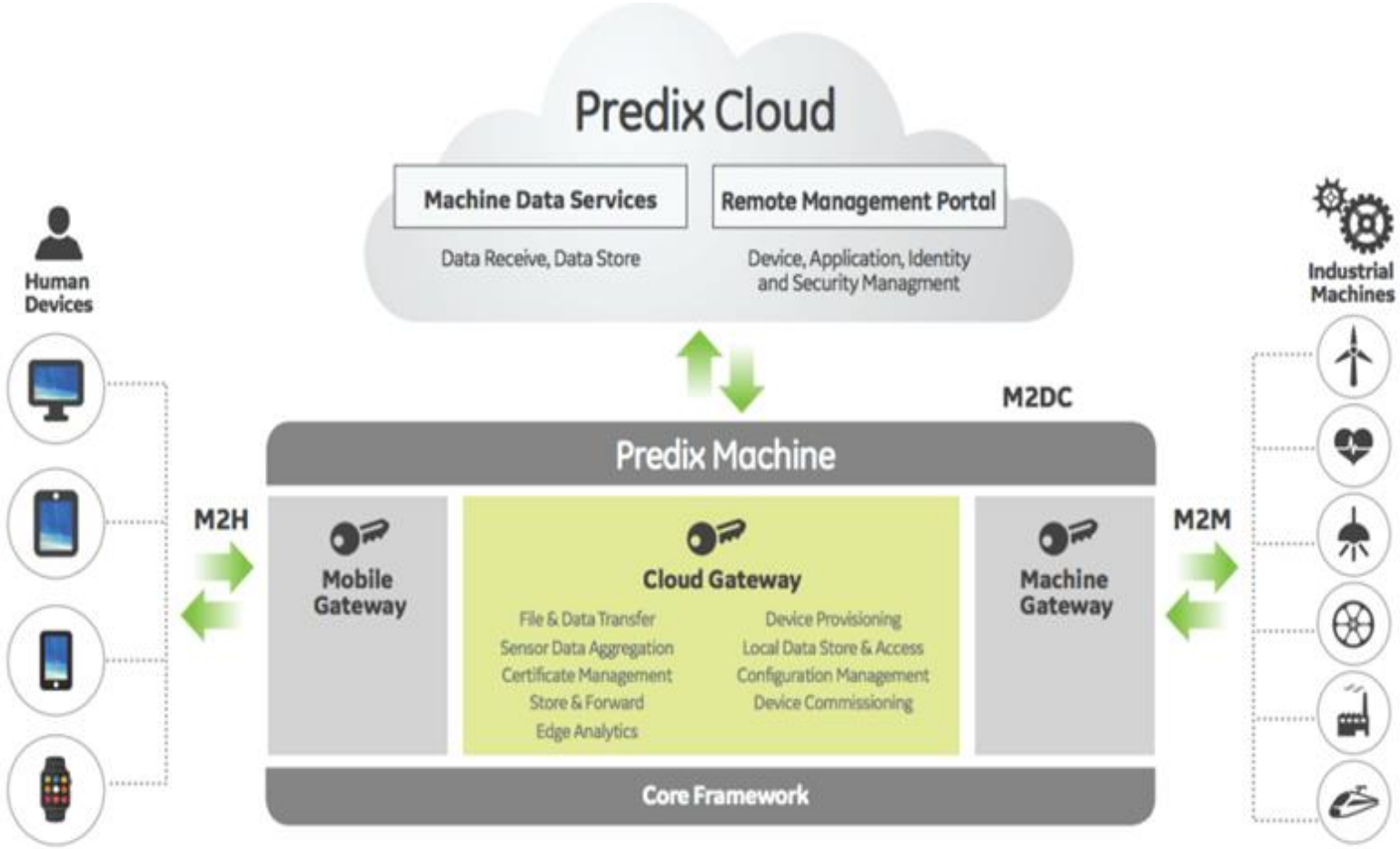
“Delivering the Nuclear Promise” Industry Wide Initiative

Nuclear power industry costs increasing while facing unprecedented competition from low-cost shale gas based power generation

Nuclear Energy Institute (2015):

- Over the last 10 years, generating **costs** for U.S. reactors has increased roughly 28%. In response NEI and the **nuclear** industry developed the **Nuclear Promise**, which is designed to **reduce** generating **costs** by **30**% by 2018

The IT Vision – IoT for Delivering the Nuclear Promise



Source: GE Predix

- Gather data from sensors.
- Leverage Predix "Digital Twin" analytics:
  - Reduce unplanned downtime – condition based maintenance
  - Reduce labor costs
  - Improve safety and reduce worker radiation exposure
  - Optimize process efficiency
  - Streamline compliance

The OT Reality – Typical Existing Plant

- Plants built 30-40 years ago, unable to digitize due to stringent and costly regulations and cannot disrupt operations.
- Manual and analog instruments, pneumatic air operated valves and controllers.
- No plant data network, limited power outlets in plant locations
- Technicians conduct manual rounds, but must limit radiation exposure.

The Gap Between the IT Vision and OT Reality

The "Gap" Challenge:

- Huge investment in IoT analytical software (Predix) promises significant operational benefits
- But lack of access to data to feed Predix is limiting full IoT potential
  - No existing wireless or data networks
  - Traditional methods to "digitize" existing plants too expensive and too disruptive to operations

Two Key Strategies to Address "Gap"

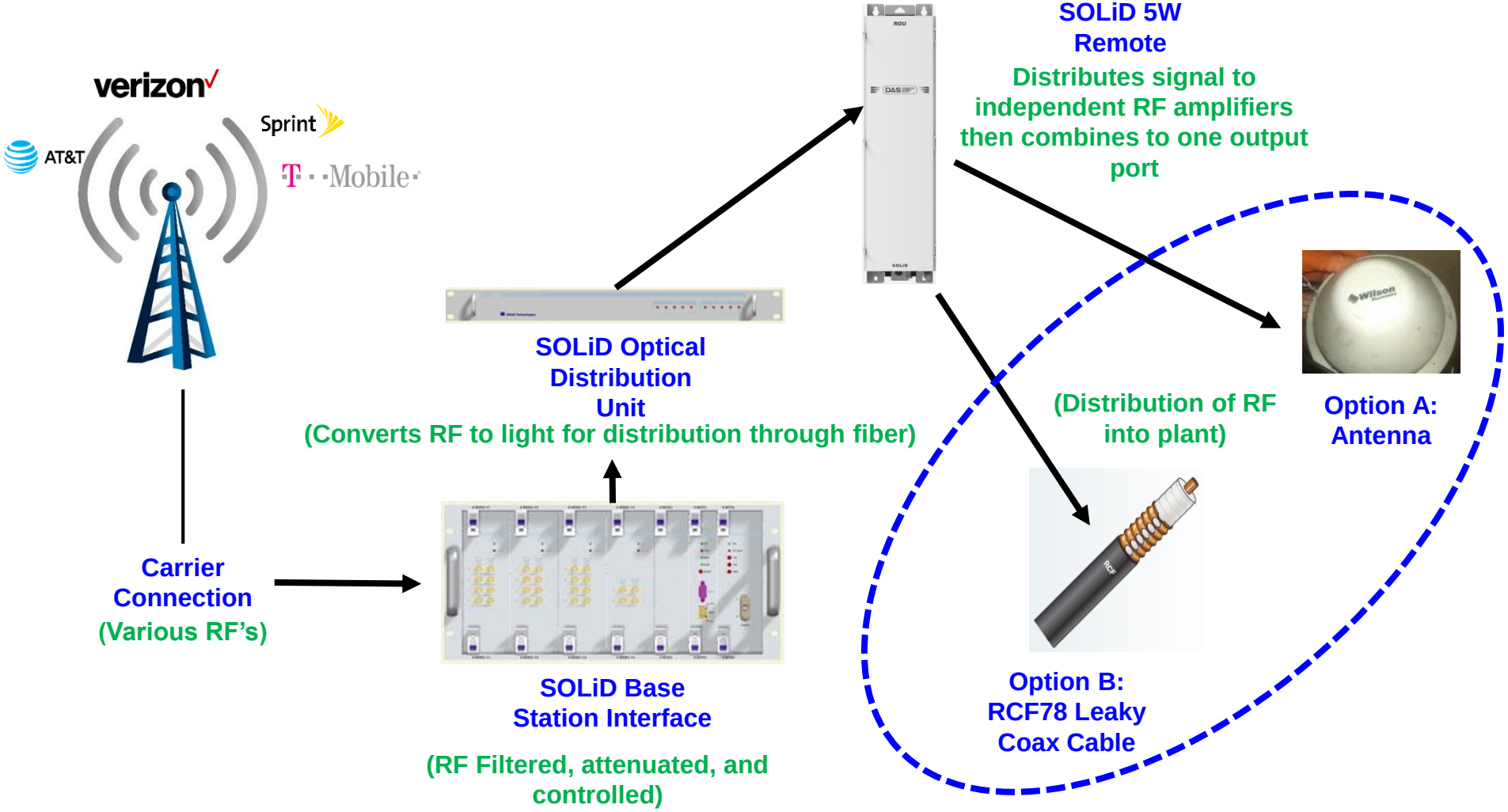
Deploy Distributed Antenna System (DAS):

- Single wireless backbone to satisfy broad range of application needs – in-plant cellular coverage, high-rate process data, low-rate equipment health data, mobile workers and devices, telex radio

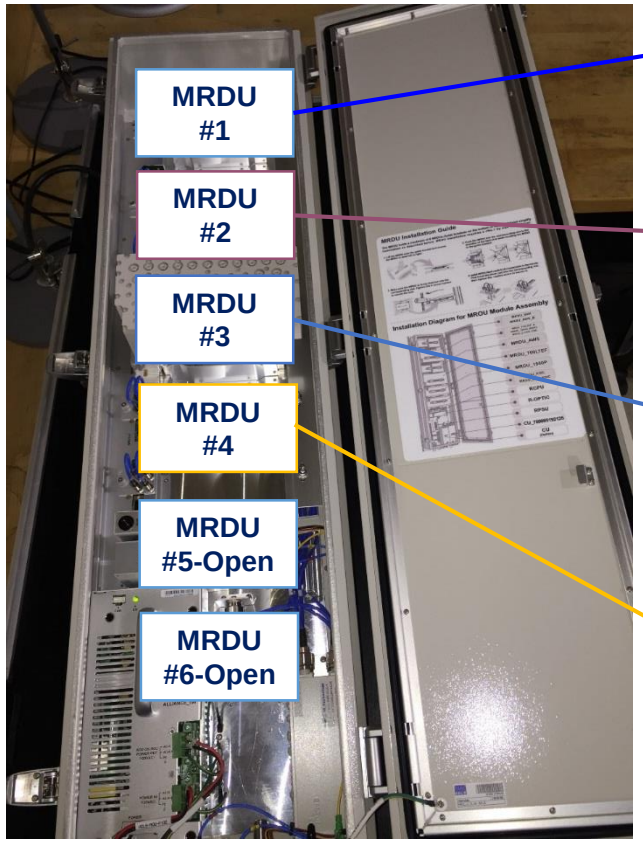
Deploy Non-Invasive Wireless Instrumentation:

- Use new non-invasive wireless clamp-on technologies - no downtime/process disruption
- Limits expensive safety and engineering review/analysis, costly cable runs
- Interface with Predix and existing plant IT systems (e.g. historian)

How DAS Works…



Solid-DAS Allows Multiple Platform on Same DAS



900 MHz – Wireless Sensors Network

700 LTE – tablets/ cellular LTE wireless sensors

450-850 MHz – radio communications

Telex radio

Example Non-Invasive Digitization: Wireless Gauge Reader (WGR)

Pneumatic Level Controllers

Wireless Gauge Reader

- "Electronic Eyeball" transmits readings wirelessly
- Non-invasive, clamp-on to existing gauges – less than 15 minutes per gauge to install
- Installed Cost per Gauge $1,500
- No process downtime, no leak check, no wiring
- Estimated 10,000 potential data points per site which can use this technology to capture data

"Digitized" Pneumatic Controller

Case Study: Pneumatic Valve CBM

Pneumatic Actuated Valve – Water Level Control for Feedwater Heaters (36 units "digitized" in Plant)

NON INVASIVE
DIGITIZATION

- Valve faults can cause feedwater disruptions which reduce plant power output, or even result in plant shutdown in a more serious case.
- Single unplanned plant shutdown costs $3M (actual case).
- Cost to retrofit with digital positioners > $100,000 each, not including plant downtime impact.

- Non-invasive Wireless Gauge Readers enable Condition Based Monitoring to predict and avoid excursions/shutdowns.
- Data collected allows "Digital Twin" feedwater optimization. >1% efficiency improvement, $12M/year benefit.
- Installed cost per unit approx. $8,000. Time to install under 1 hour – no disruption to operations.

Benefits

- **Reduce unplanned downtime**
  Increase revenue and MWhrs online
- **Minimize PM costs**
  Transition from time-based maintenance to condition based maintenance
- **Work process improvement**
  Data driven to analyze, document, & resolve issues
- **Improve process efficiency**
  Enable “digital twin” model to optimize process parameters
- **Increase plant safety**
  Enable “digital twin” to predictively identify faults
- **Enhance worker safety**
  Minimize radiation dose exposure for routine work
- **Standardization and Compliance**
  Fleet wide consistent monitoring of performance, governance, oversight

Lessons learned & Future Plans

- **AWS.GOV Cloud**
  Switching from AWS to GOV cloud delayed project about a year

- **Predix APM Development Has Been Slow**
  Unified APM (combine smart signal and Meridium) – do *sooner*

- **Limited Sensor Selection in 915 MHz range**
  Develop and deploy low-cost and ***non-invasive*** wireless instrumentation

- **IT/Cybersecurity**
  Get teams on-board early

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Thank you

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