Digital Transformation of Nuclear Plants:

Non-Invasive Retrofit Technologies

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Delivering the Nuclear Promise - USA

US Nuclear Fleet

- 99 Reactors, 100 GW
- Average Age:
  37 Years (as of 2019)
- Many plants re-licensed
  to 2035 and beyond - 60 year
  life-span
- Modernization and
  digitalization programs are
  critical to reduce cost,
  enhance operations

In December 2015, the Nuclear Energy Institute (NEI) launched the Delivering the Nuclear Promise (DNP) Strategic Plan, calling on operators to reduce generating costs by 30% by 2018.

Source: https://analysis.nuclearenergyinsider.com/us-utilities-must-commit-digitization-cut-operating-costs-30

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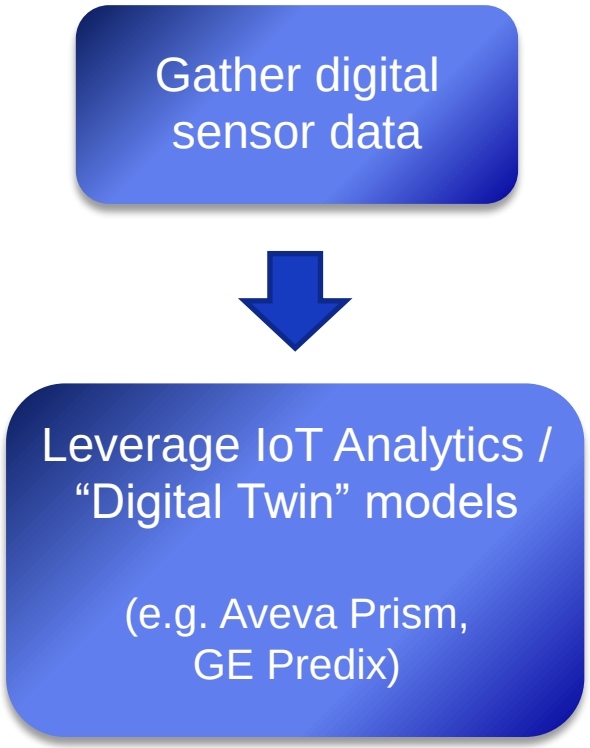
IoT, Big Data and Digital Transformation

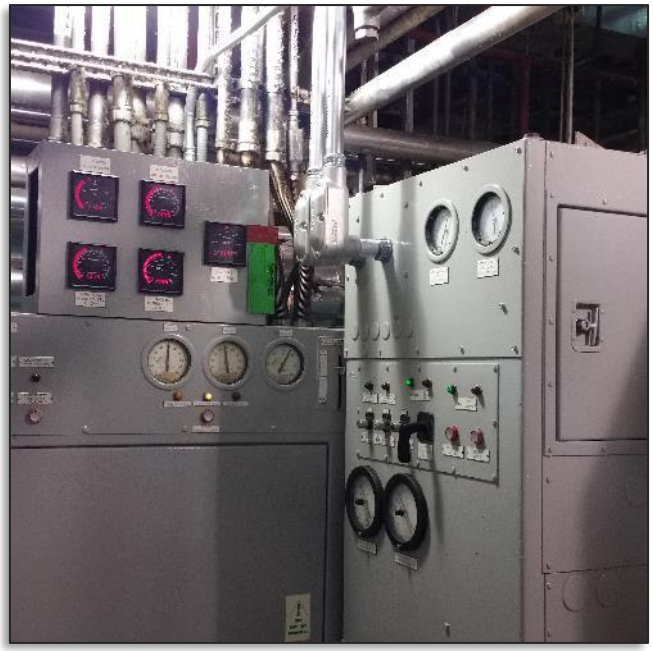
Objectives:

- Enhance safety, ensure compliance
- Reduce unplanned downtime
- Minimize radiation exposure to workers
- Optimize plant performance
- Lower labor costs



Major challenge: Traditional methods to "digitalize" existing plants too expensive and too disruptive to operations

Most Plant Data is NOT Digitalized



Legacy mechanical, manual instrumentation for flow, temperature, pressure, pneumatic actuators – cannot communicate with cloud

Difficulty of Digitalizing Existing Plants

- Just to read a simple pressure process value:
  - Run wires (power and/or signal)
  - I/O panels, termination
  - Break seals, leak checks, material compatibility, safety checks
  - Engineering assessment, documentation
  - Process downtime
  - Cybersecurity concerns

There are thousands of these devices with critical process data, but it costs over $20,000 to instrument each one using conventional technology, plus cost of process downtime.

Typical traditional solution:
INVASIVE AND COSTLY

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Need for Non-Invasive Digitalization Technology

Non-Invasive Sensors:

- No breaking seals, no leak checks, no wetted parts
- Lightweight, no structural impact
- No power wires, no signal wires
- Little/no engineering review/analysis
- Takes minutes to install, no plant downtime required
- No new software to install, works with existing plant infrastructure

Cypress Envirosystems: Problems We Solve…

Dial Gauges, Hour Meters

Steam Traps

Legacy Instrumentation:
Labor Intensive
No Visibility/Fault Detection
Waste Energy

Humidity & Temperature Indicators

Analog Transducers, Indicator Lights

Non-Invasive Retrofit Solutions

Wireless Gauge Reader

Clamp-on
Installs in Minutes
SCADA Integration
No Wires, No Batteries
No Leak Checks

Wireless Steam Trap Monitor

Wireless Humidity & Temperature Monitor

Wireless Transducer Reader

Wireless Gauge Reader (WGR)

Compatible with most dial gauges, hour meters, panel meters:

- “Electronic Eyeball” reads gauges and transmits readings wirelessly
- Non-invasive, clamp-on to existing gauges in minutes
- No downtime, no leak check, no wiring, no drawings
- Battery life of 3+ years at 15 minute sample rate
- IP56/NEMA 4 rated for outdoor use
- Various size and types of mounting adapters to fit most existing gauges
- Reads dial gauges, hour meters, LED/LCD displays

Wireless Humidity and Temperature Reader (WHTM)

- -20 ^{O}C to +70 ^{O}C (-4 ^{O}F to 158 ^{O}F) Temperature Range
- 0 – 100% Relative Humidity Range
- Magnetic Mounting for steel walls or columns
- Adhesive Mounting for other surfaces
- Battery life of 3+ years at 15 minute sample rate
- IP56/NEMA 4 rated for outdoor use

Wireless Transducer Reader (WTR)

- Enables wireless remote monitoring of virtually any analog transducer or instrument with the following outputs: 4-20mA, 0-5V, or 0-10V, RS-232, RS-485, thermocouple, thermistor
- Compatible with most existing flow meters, current meters, particle counters, thermocouples, weigh scales, etc.
- Battery life of 3+ years at 15 minute sample rate
- Optional enclosures for NEMA 6, IP 67 protection
- Enables data logging to enable trend analysis, notification, or statistical process control

Wireless Steam Trap Monitor (WSTM)

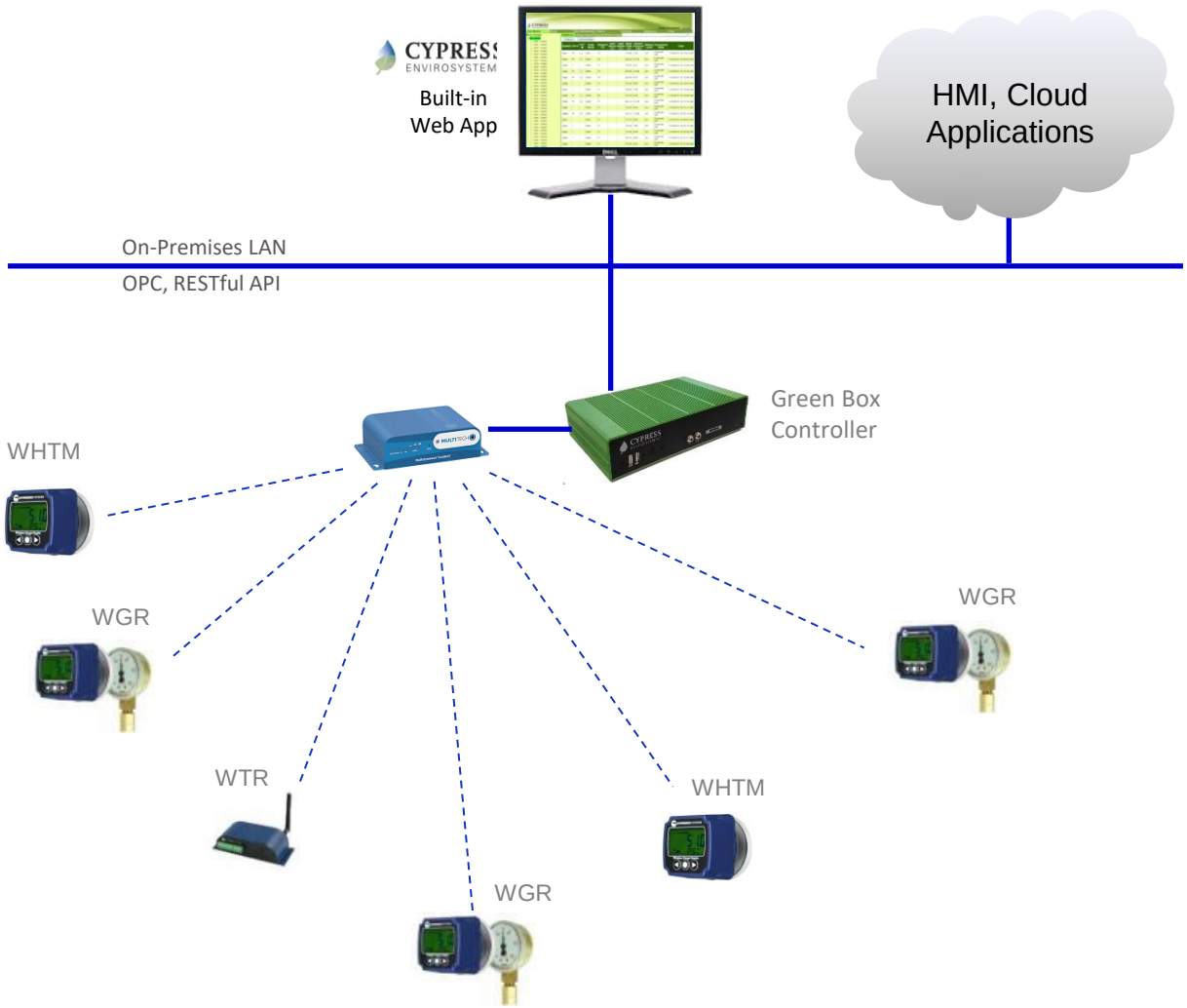
Leaking Traps Waste Energy

Typical Steam Trap

- Typical Steam Trap failure rates of 10-20% per year. Failed traps leak steam and waste energy, or become block and cause overpressure
- Manual inspection typically done annually – labor intensive, do not catch problems in timely manner
- Solution: Wireless steam trap monitor detects faults and sends notifications, avoiding expensive failures
- Non-invasive installation: no breaking seals, wireless, integrates with automation system
- Battery life of 3+ years at 15 minute sample rate
- Optional IP67/NEMA 6 enclosures rated for outdoor use

Wireless Communication Architecture

- LoRaWAN open protocol - US and EU frequencies available
- Secure, encrypted communications
- Star network configuration, 300-500 ft range
- Industry standard OPC-DA, OPC-UA and RESTful API interfaces



Legend

	Wired Ethernet
	LoRA Wireless
WGR	Wireless Gauge Reader
WTR	Wireless Transducer Reader
WHTM	Wireless Humidity / Temp Monitor

Current Deployments – Nuclear Generation

- Exelon (4 reactor units installed and in progress)
- Ontario Power Generation (2 reactor units in progress)
- Duke Energy (11 reactor units fleetwide)
- Xcel Energy (3 reactor units fleetwide)
- NextEra (8 reactor units in progress)
- Arizona Public Service (pilot project in-progress)
- Entergy (1 unit – decommissioned)
- EPRI Charlotte - Nuclear Applications Center (installed)

- Typical Time Schedule for Deployment
  - 200 units – one week, no operational downtime
  - Scalable to 10,000 units or more per site
  - **10% of the cost of conventional approaches**
  - **1/20th of the time to implement vs. conventional approaches.**

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Case Study: Feedwater Level Controller Monitoring

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

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Case Study: Pneumatic Valve Condition Based Monitoring

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.

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Summary

- IoT, big-data and analytics technologies promise to unlock huge savings and value in existing plants, but ***digitalization*** is key.

- Digitialization of legacy plants is a very expensive, disruptive process using conventional technologies.

- Non-invasive technologies offer a fast, low-cost, proven solution to achieve digitization without disruption to operations – ***for nuclear power, at 10% of the cost, 1/20 of the time needed for alternative solutions.***

- Further discussion:

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