Wireless in Nuclear at Exelon

Bill Ansley
Digital Plant Innovation

Exelon Generation®

Exelon Overview

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.

What are the Possibilities?

Advanced computer applications

- Implementation of pattern recognition software and physics/operating experience based “Analytics” to provide advance warning subtle but real failure modes
- “Analytics” identify the type of failure and recommend outages including work order generation, parts and scheduling of the asset outage
- “Analytics” monitor key performance indicators (cost, inventory, maintenance strategy, etc) to identify potential vulnerabilities as well as savings opportunities

Organizational Performance

- Technology allows for the centralization of data and more effective monitoring
- Improved computer applications/interfaces allow for improved productivity and performance of plant staff

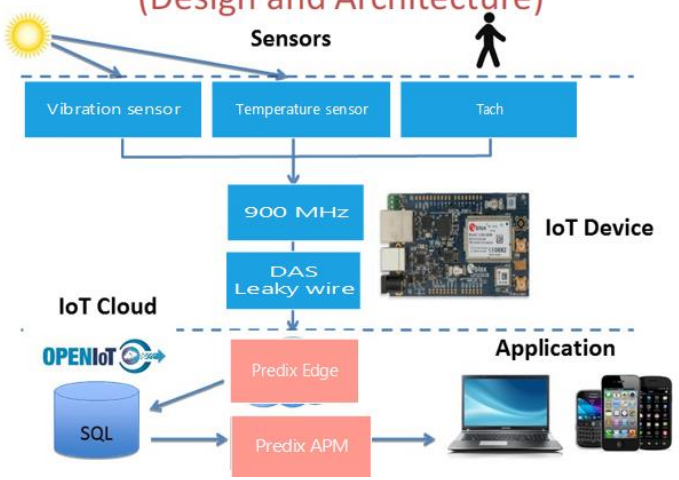
State of art communications infrastructure

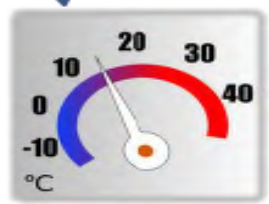
- Wireless infrastructure that provides cost effective method to utilize wireless sensors and innovative monitoring/predictive technologies
- Low cost wireless sensors (design once-install many) installed to improve predictive technology and facilitate elimination of high cost time based maintenance

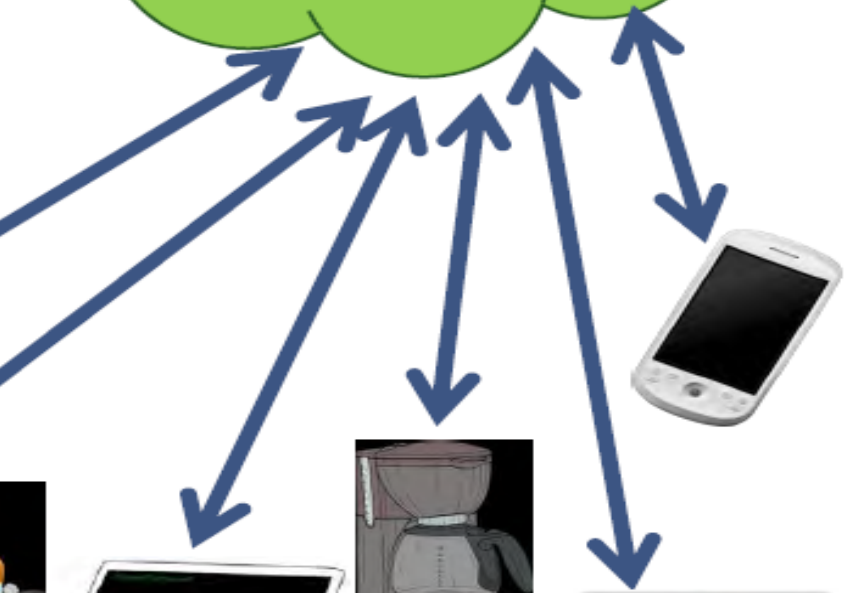
Internet of Things

- The Internet of Things enables multiple devices to communicate through a common interface, which is typically a wireless connection to the cloud
- Many different types of devices can be connected to IoT (Phones, thermostats, appliances, vehicles, etc)
- Ultimately, data is sent back and forth between the devices that comprise the IoT
- Sensors are used to collect data from devices

(Design and Architecture)







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Predix Asset Performance Management (APM)

- Transform PRiSM APR models to Predix APM
- Co-developing advanced analytics models including
  - Fault diagnostic
  - Thermal Performance
  - Load following
  - Startup & shutdown monitoring
- Form Building software for data collection (PI Process, user created apps, etc.)
- Direct Web Hosted Applications for Desktop, and mobile applications
- Meridium APM – Maintenance Optimization

Unified Platform across all of Ex Gen

Core Products & Platform

- Presently Available
- Under Development

Core Products

Asset Performance

RELIABILTY
Increase availability and longer asset life

Operational Optimization

RISK MITIGATION
Lower operations and financial risk

COST REDUCTION
Lower operating costs with great efficiencies

Business Optimization

PROFITABLE GROWTH
Increase production for market advancement

Cyber Security

SECURE PLATFORM
Monitoring of connected industrial equipment

Advanced Controls

AUTOMATED SYSTEMS
Control System will be automated based on Analytics

Custom Solution Platform

OPEN DEVELOPMENT

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APM Reliability Management

Centralized Performance Monitoring

Wireless Sensors

RadPro Sensors

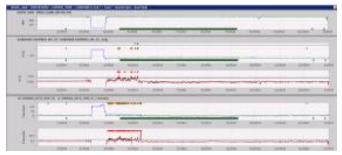
DAS/ WiFi

Digital Worker (EWP)

Thermography/ Acoustic Continuous Monitoring Sensors

AMS Bridge Predictive Data

Computers Data Historian (Edge Devices)



Pattern Recognition

Work Order Data

LEGEND

- IMPLEMENTED (Continue to develop)
- NOT IMPLEMENTED (Implementation in progress)
- IN DEVELOPMENT (Development in progress)

GE PREDIX (APM/Watchtower)
(Integration of Data sources, Advanced, Analytics, Machine Language, etc.)

Centralized Monitoring

Stakeholders (Engineering, Work Management, Maintenance, etc.)

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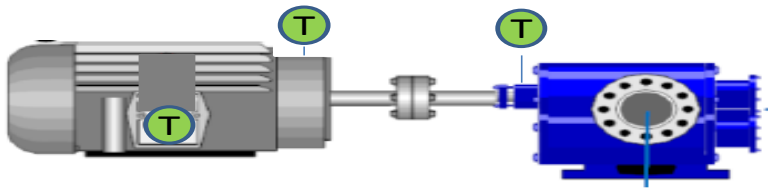
Value of Additional Sensors – Condensate Booster Pump Example

What we have in M&D APR Model Today:

Pump Status – turn model on/off
Thrust Bearing Temperature
Stator Temperature
Motor Lo Sleeve Bearing Temperature



What we don't have:

Individual Pump Suction Pressure (Local Gauge Instrument)
Individual Pump Discharge Pressure (Local Gauge Instrument)
Suction Flow (Not available – HDR FLOW ONLY)
Discharge Flow (Not available –HDR FLOW ONLY)
Header Discharge Pressure (in PI – cannot be correlated at the component level)
Header Flow (in PI - cannot be correlated at the component level)
No motor current or voltage
No vibration data (taken monthly manually)
No oil information in PI

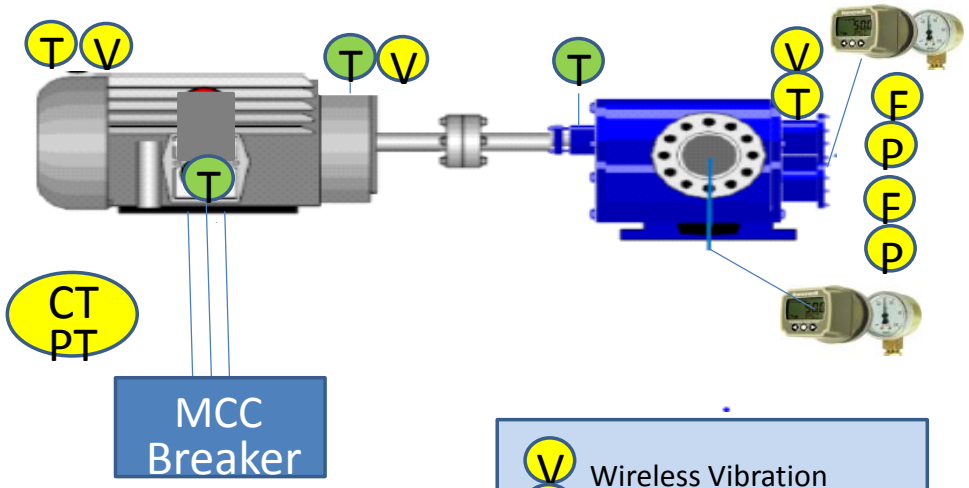
Motor/Pump Failure Modes

Limited Focus Today

- High Bearing Temperature
- High Motor Winding Temp
- Worn Thrust Bearing
- Motor Bearing Lubrication
- Worn Motor ODE Bearing
- Worn Pump DE Bearing

No Sensor Coverage

- Worn Pump Internals
- Shaft Misalignment
- Shaft Imbalance
- Power Supply Harmonics
- Power Cable Damage
- Rotor Bars Broken
- Stator Winding Fault
- Rotor Eccentricity
- Loose Foundation
- Pump Cavitation
- Supply Line Power Problem



Advanced Motor Current Analysis

V T Wireless Vibration & Temperature

F P Wireless Gauge Readers

Motor/Pump Failure Modes

High Bearing Temperature
High Motor Winding Temp
Worn Thrust Bearing
Motor Bearing Lubrication
Worn Motor ODE Bearing
Worn Pump DE Bearing
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Loose Foundation
Pump Cavitation
Supply Line Power Problem

Truth in Numbers – Think Applications

Current State

Wireless radios

Mobile Workers (electronic work packages)

Temperature sensors

Vibration sensors (limited)

Future State

Current State plus:

More vibration sensors

Dosimetry

Gauge readers

Valve position sensors

RFID tags

Structural Health Monitoring

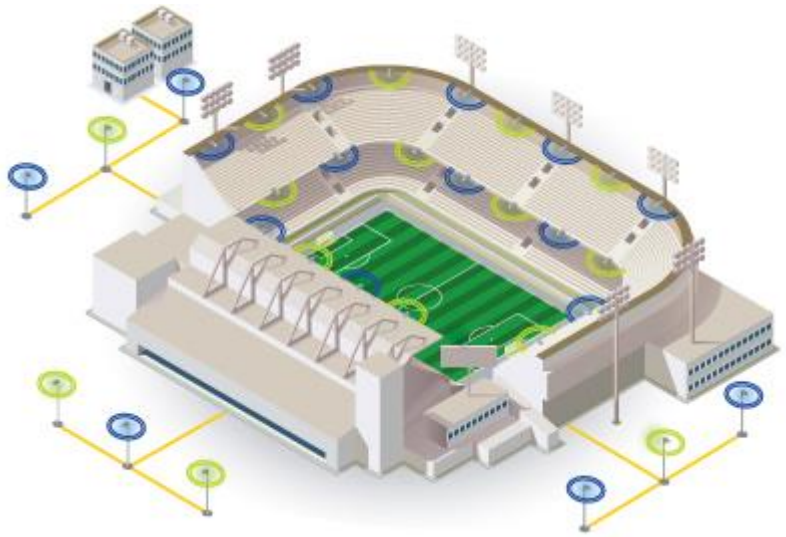
We could add over 1,000 sensors per unit

Why the Focus on Wireless?

Wired sensor cost adds up quick....

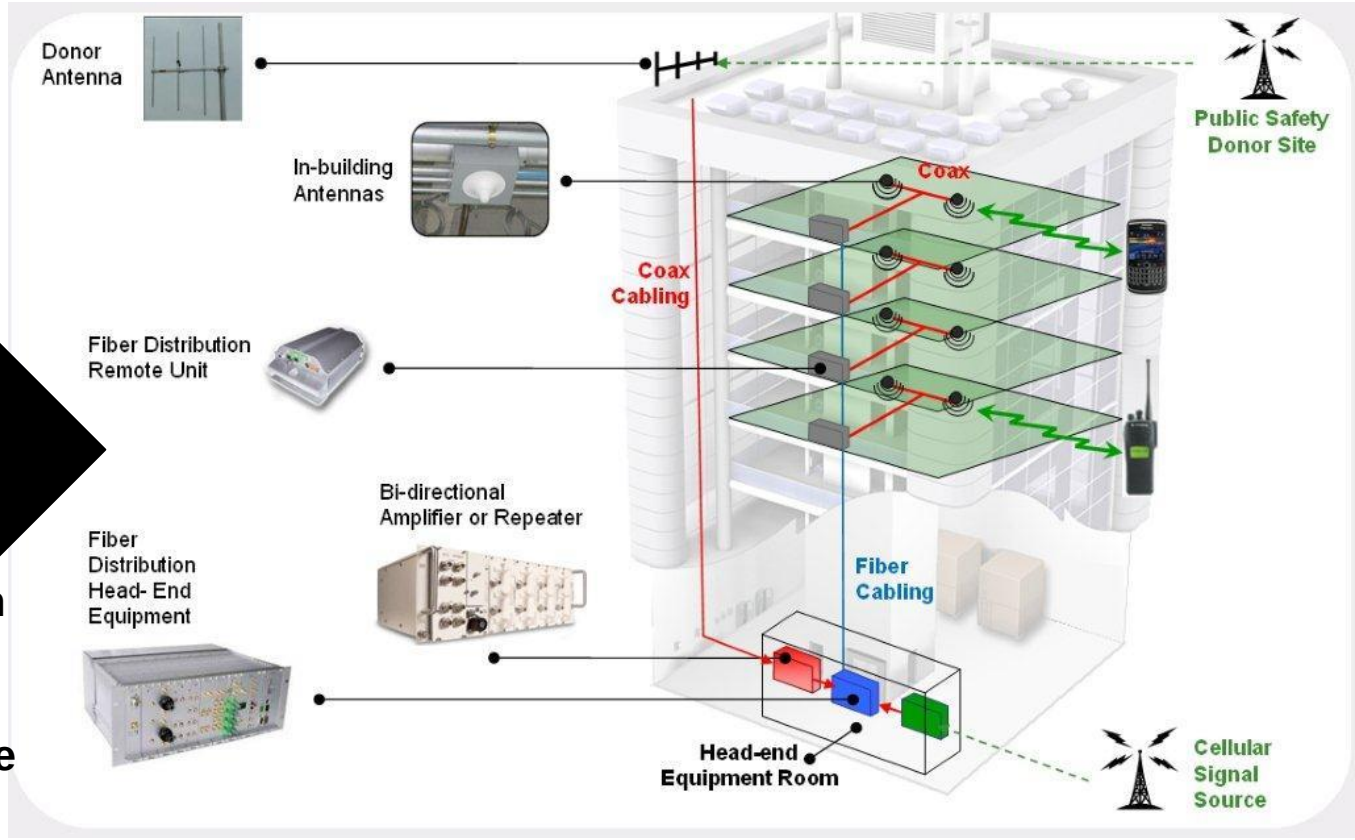
An Attractive Alternative

Distributed Antenna Systems (DAS)



Control network volume and performance

Verizon
AT&T
Spring
T-Mobile



Bring signal into areas that have poor coverage.

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How it Works

verizon
AT&T
Sprint
T-Mobile

Carrier Connection
(Various RF's)

SOLiD Base Station Interface
(RF Filtered, attenuated, and controlled)

SOLiD Optical Distribution Unit
(Converts RF to light for distribution through fiber)

SOLiD 5W Remote
Distributes signal to independent RF amplifiers then combines to one output port

(Distribution of RF into plant)

Option A: Antenna

Option B: RCF78 Leaky Coax Cable

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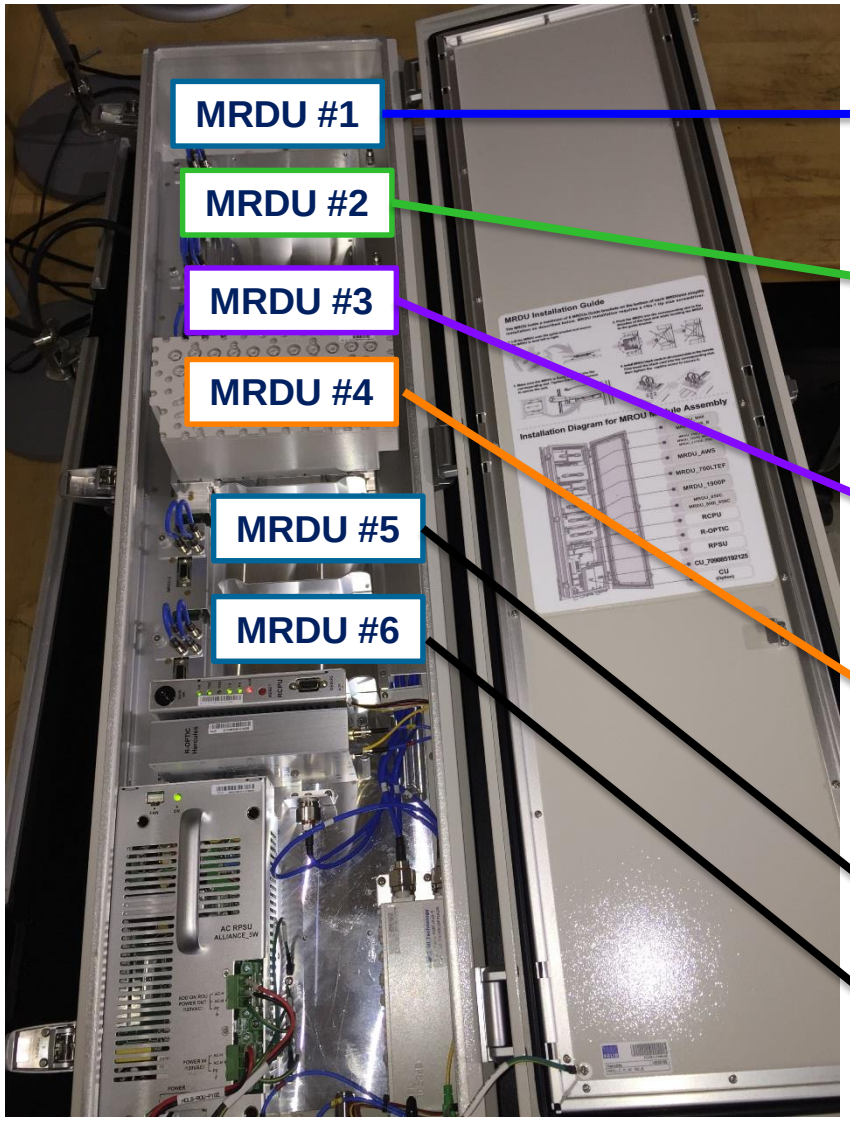
Ideal Configuration for Power Plants (example)



433mHz – Sensors and radio communications

700 LTE – tablets/cellular devices for mWM

450mHz – radio communications

900mHz – Sensors

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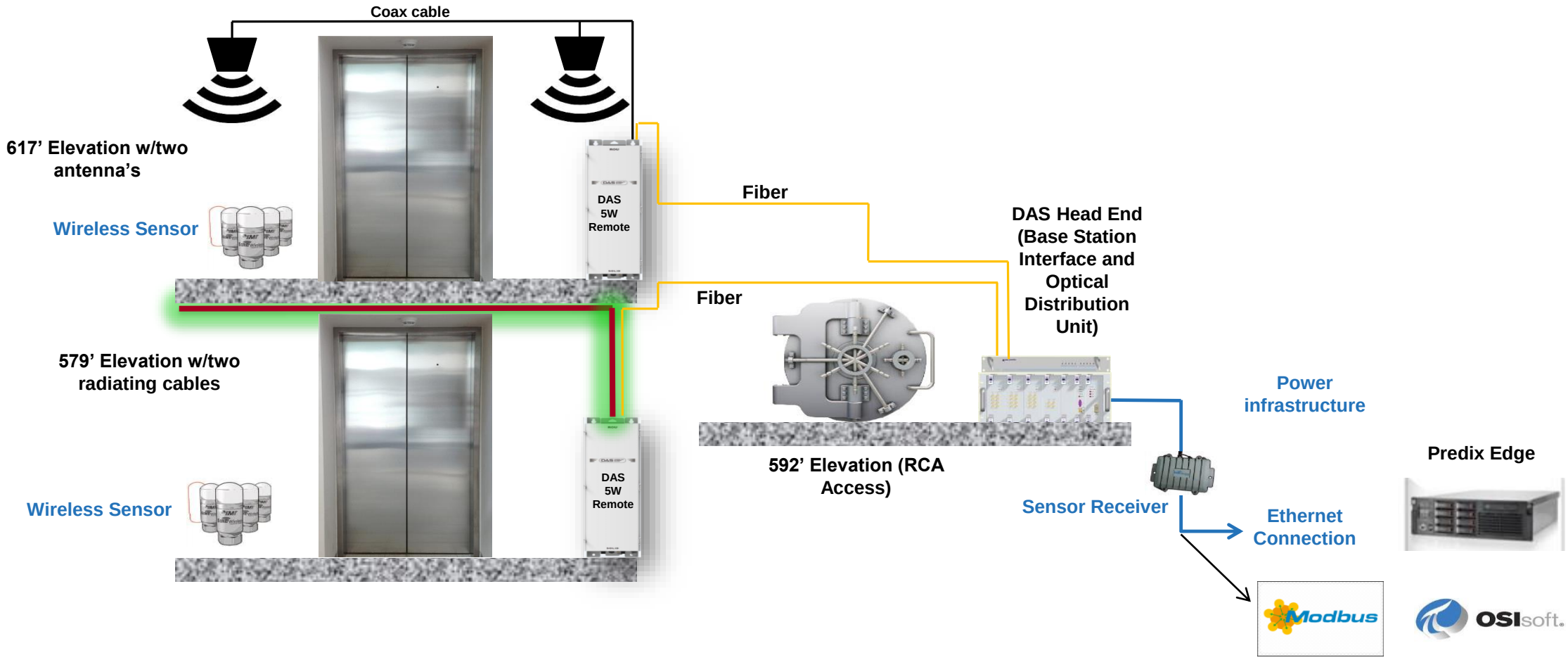
DAS Wireless Sensor Network Setup – Typical



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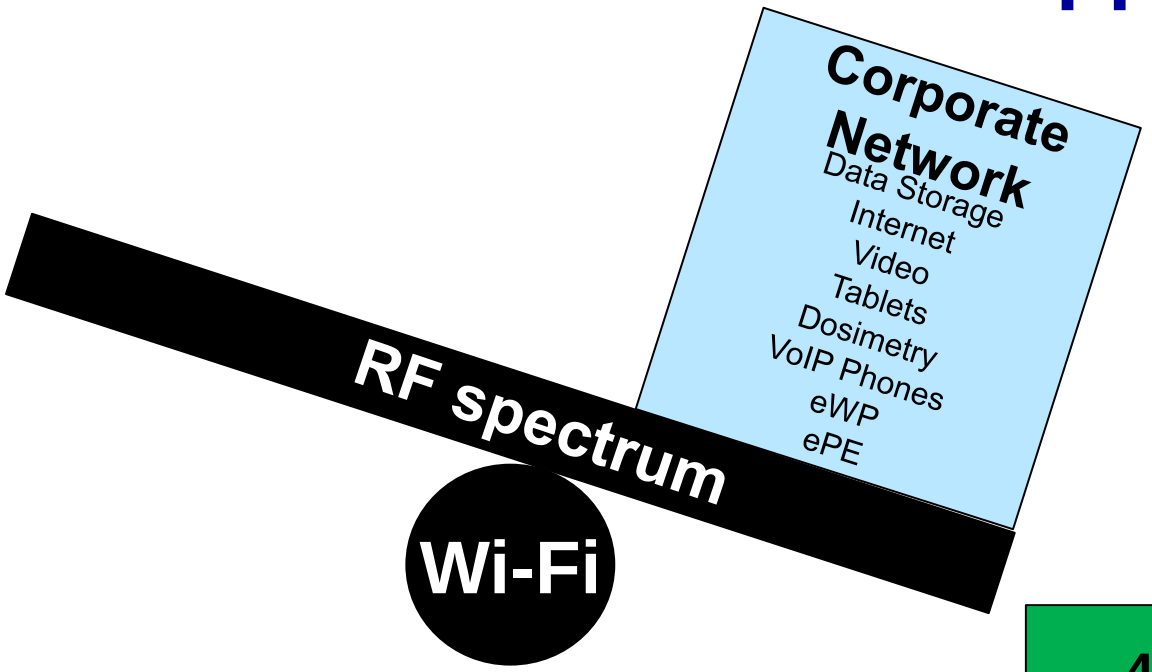
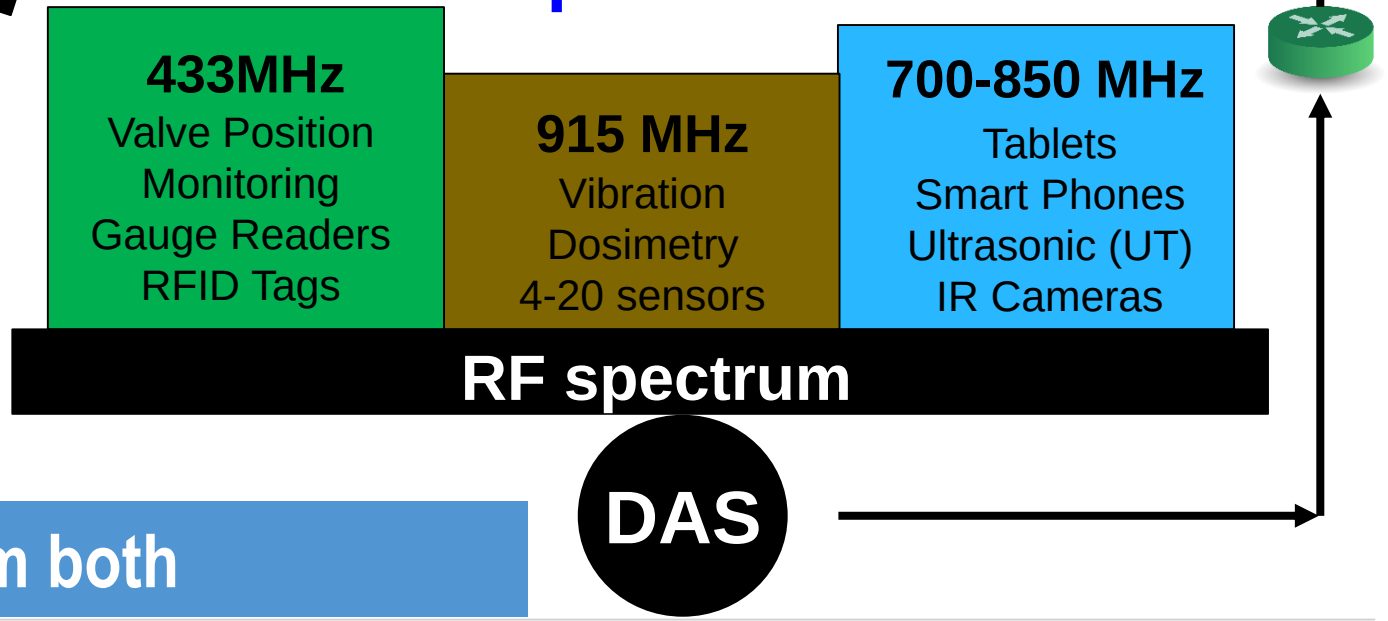
Wi-Fi verse DAS – Which Approach is Better?



Option A

Option B



Answer – we need them both

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IIoT Requirements...*Voice, Video, Data and Sensor (VVDS)*

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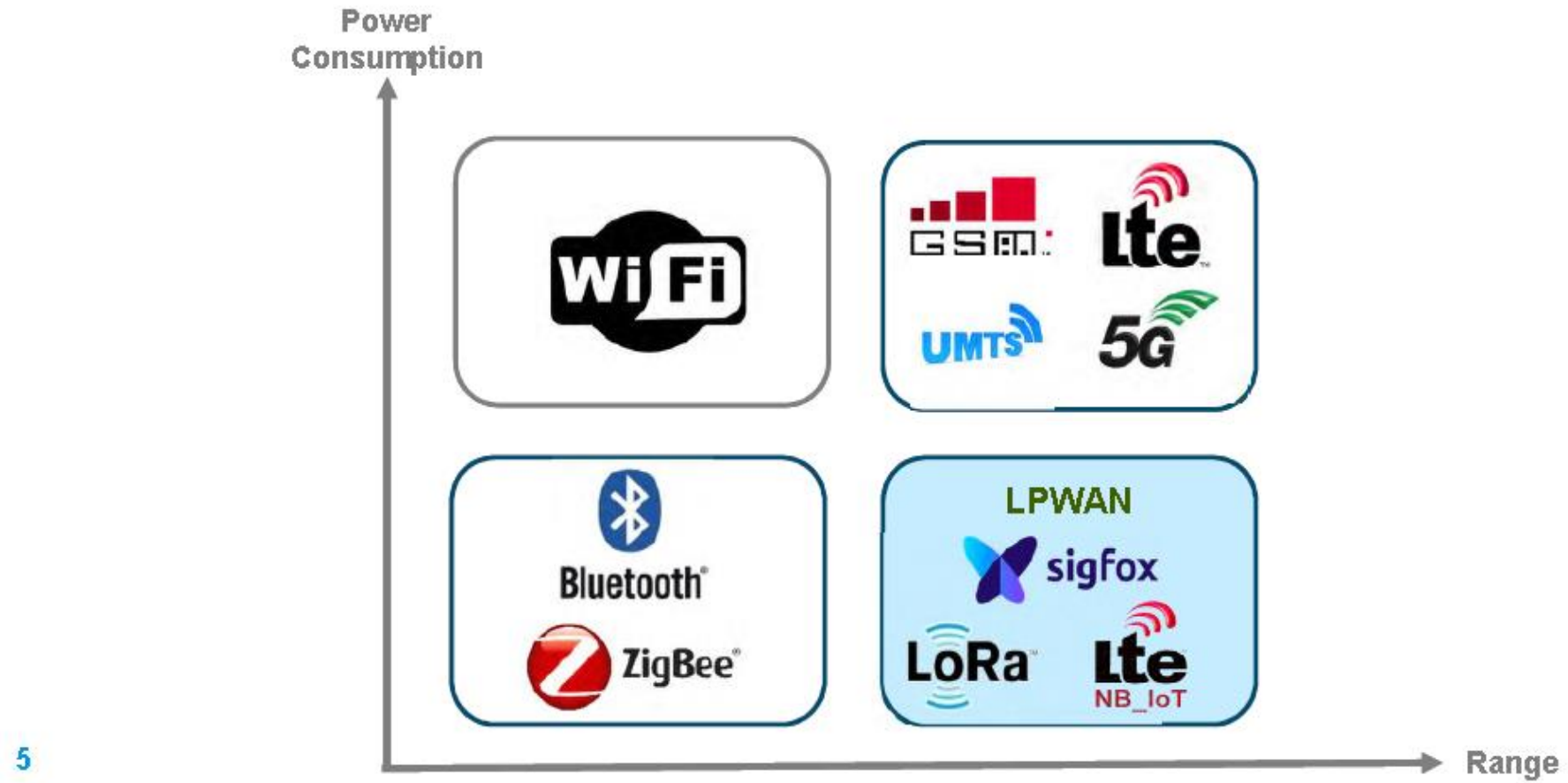
Why many different wireless technologies?

- Solution → Filling up the Technology gap



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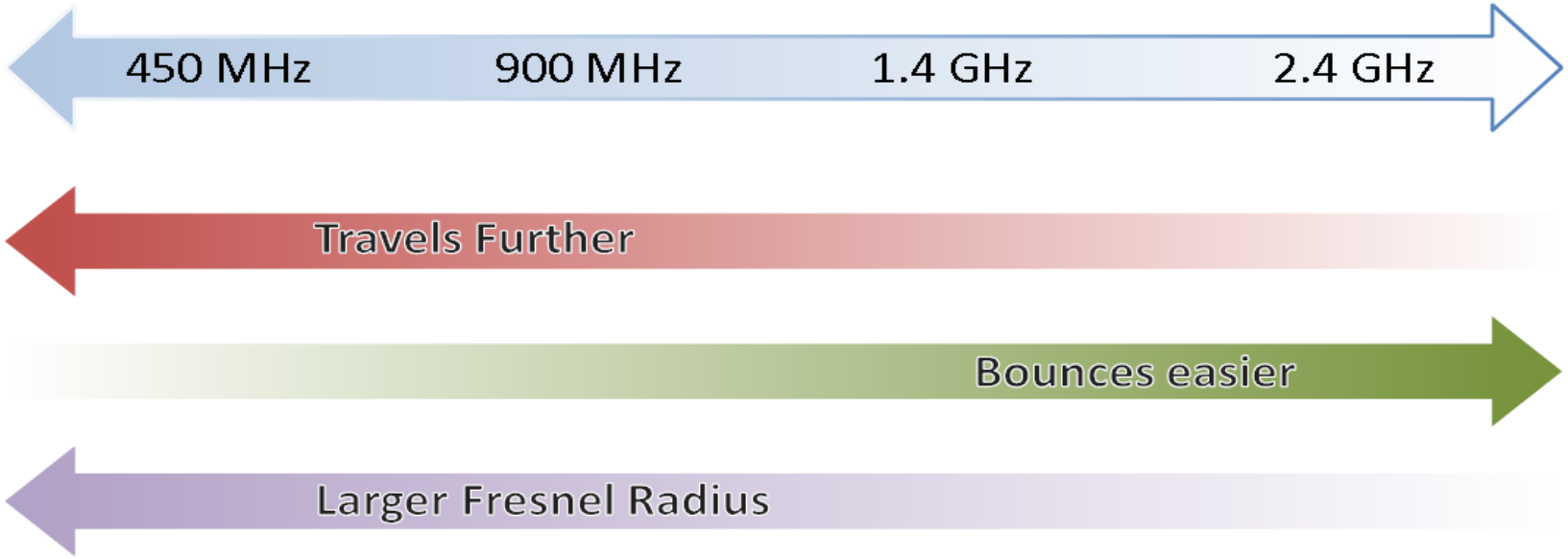
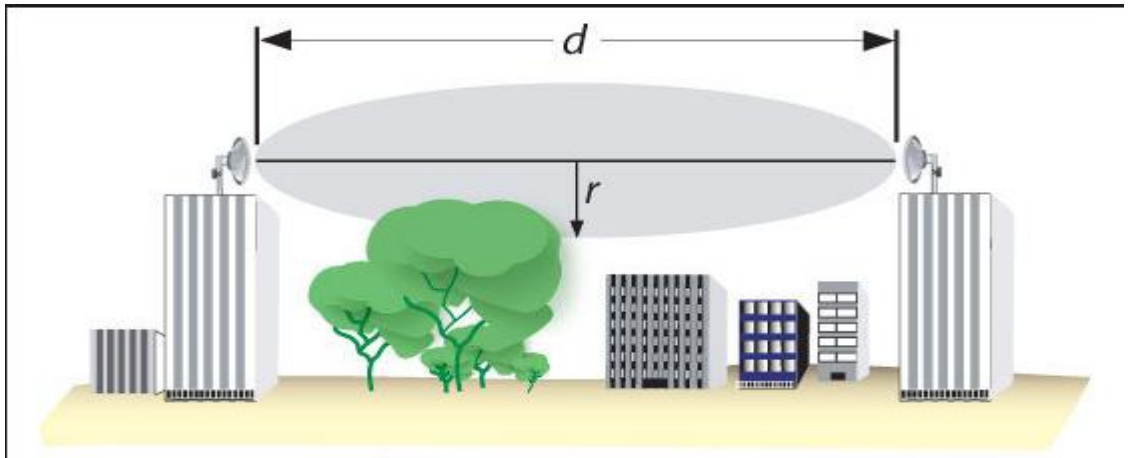
Frequency-hopping spread spectrum (**FHSS**)
Available Frequencies

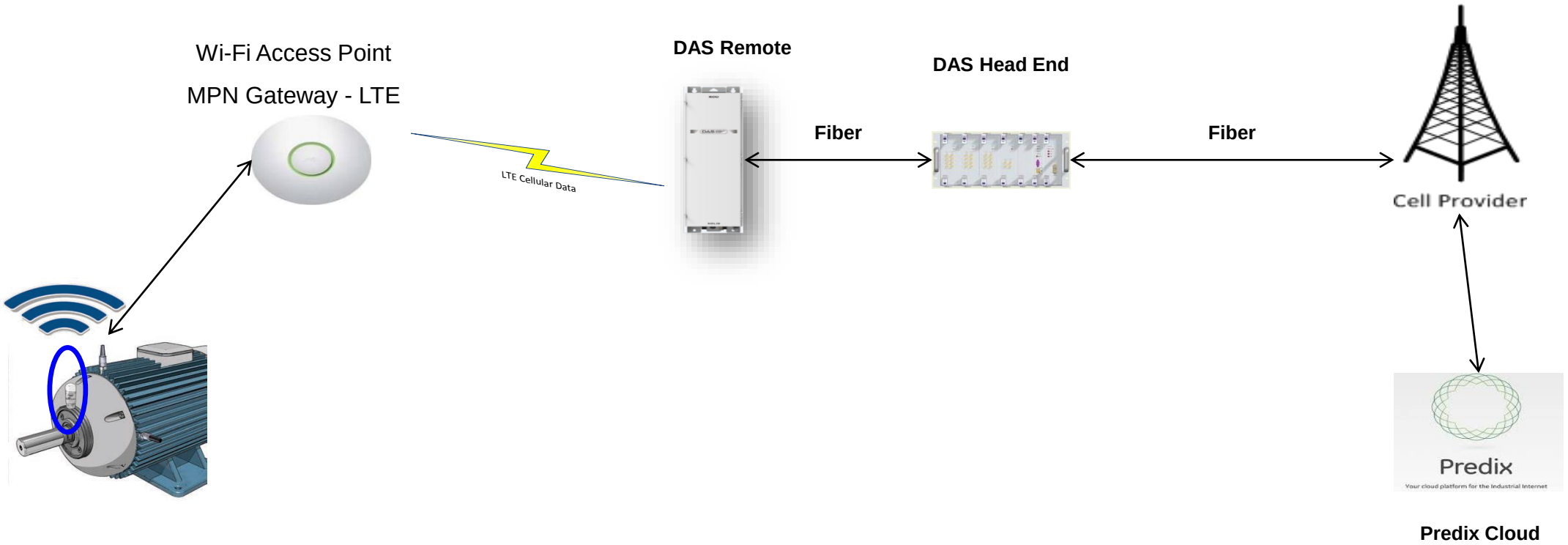




$$r_{(\text{in mts})} = 17.32 \times \sqrt{\frac{d}{4f}}_{(\text{in Km})\,(\text{in GHz})} \qquad r_{(\text{in ft})} = 72.05 \times \sqrt{\frac{d}{4f}}_{(\text{in miles})\,(\text{in GHz})}$$

Exelon.

DAS – LTE on MPN



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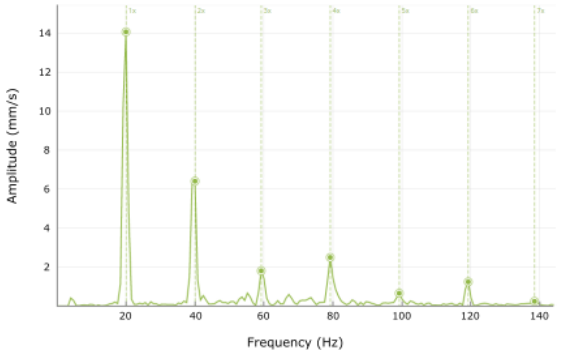
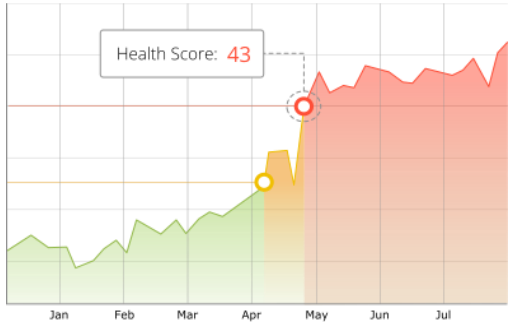
Wireless Sensors – Petasense

- Petasense, Inc. manufactures and sells self-contained battery powered wireless devices to monitor rotational machinery.

- Using various on-board sensors, the devices collect raw data, process, and feed it to cloud services for examination.



- The processed data is then examined with machine learning for patterns and anomalies to help determine future failures and equipment wear and tear.



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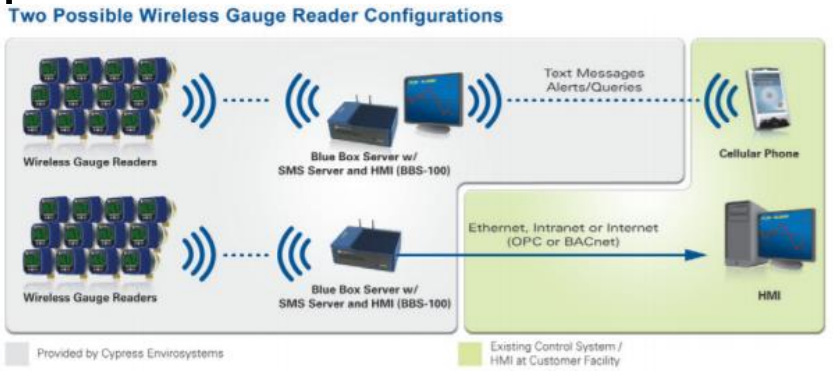
Cypress Gauge readers (900 MHz) project

- Leaky Wire/Distributed Antenna System (DAS) 900 MHz Network
- Wireless Gauge, Pressure & Temperatures Sensors and other innovative monitoring technologies – good for one way communication
- Site & Centralized monitoring
  - GE Predix Dashboard
  - GE Predix – APM/Analytics Implementation (2017 to 2018)



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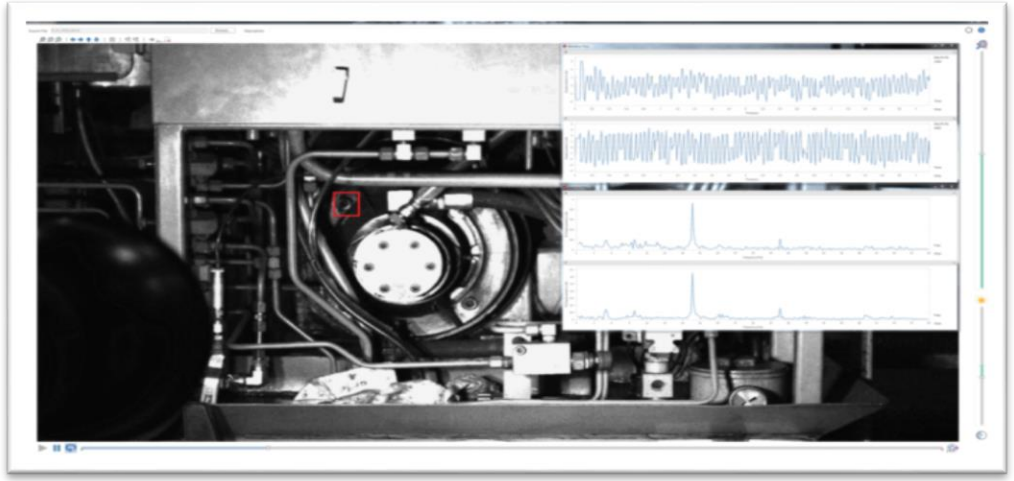
Innovative Technologies

Non-Contact Vibration (IRIS M)

- Measurement taken without contact (Video camera)
- Displacement and motion of every pixel in the image are measured
- Custom image processing software generates vibragrams or waveforms.
- Software measures subtle motion and amplifies to be visible by the naked eye



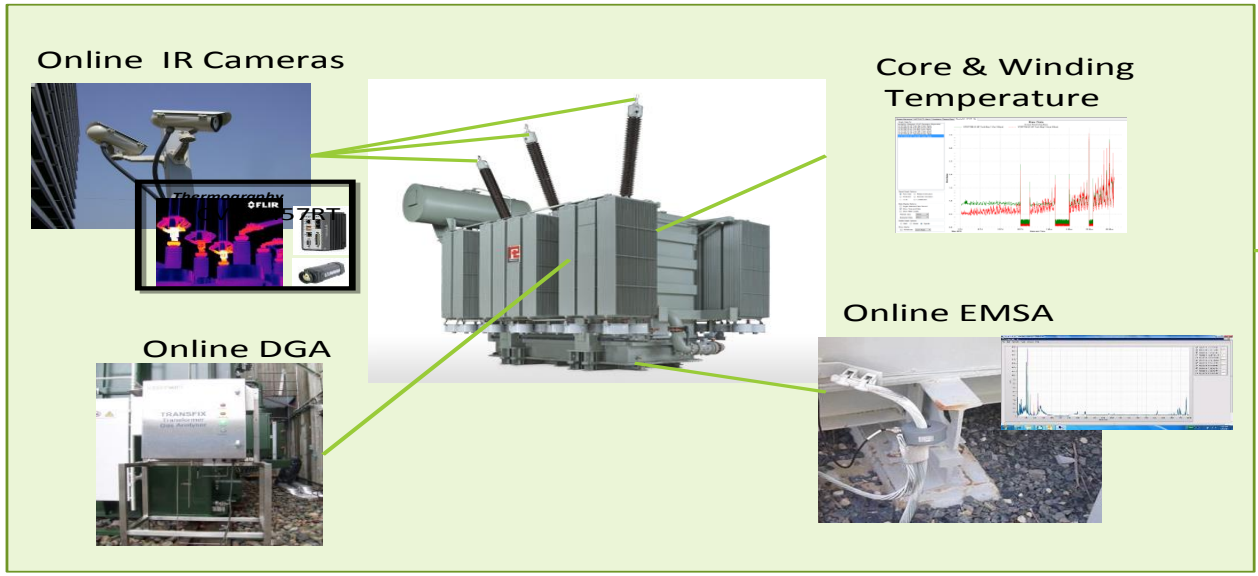
On-Line Thermography

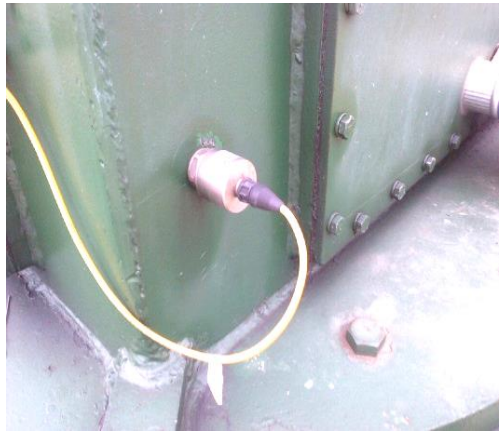
- Enables Thermography 24/7
- Remote Fault detection and Alarm Generation
- Remotely Monitor Multiple Critical Substation Assets from One Central Controller
- Automated Monitoring Tours and Full Manual Directed Control

New Sensor Technology for Advancing OLM

Wired or Wireless Vibration Sensors

Online Transformer Monitoring Using IR Cameras, EMSA, DGA and Core & Winding Temperature





On-line Oil Particle Counter

Wireless Gauge Reader

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Cycle Isolation Sensors

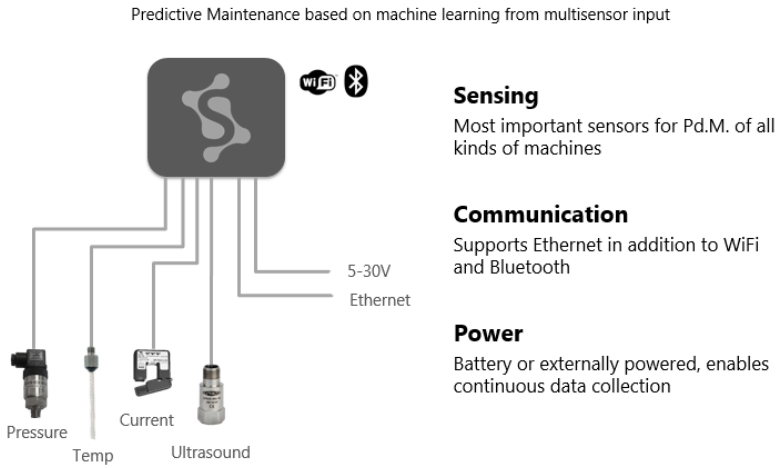
Petasense

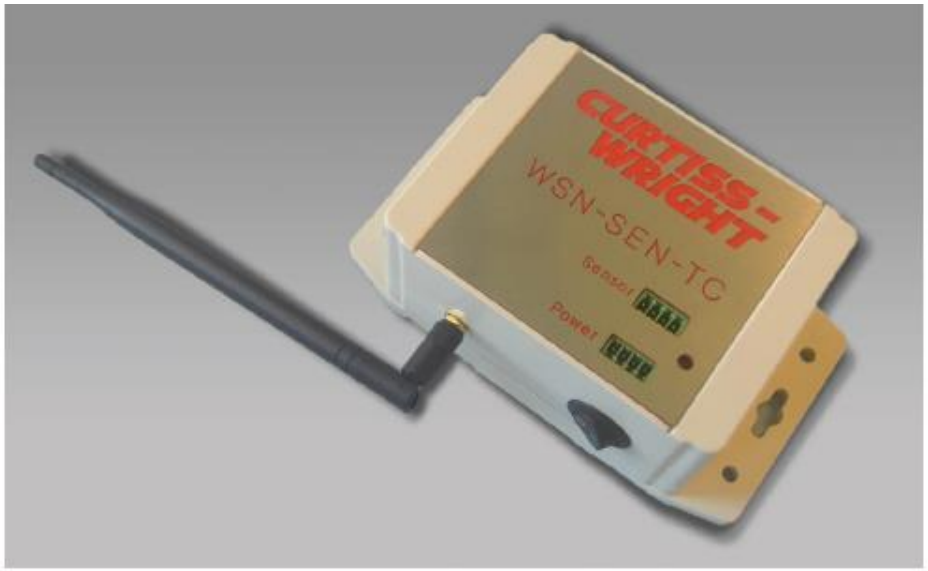
- Sensors are Wi-Fi
- Purchased 10 sensors for POC

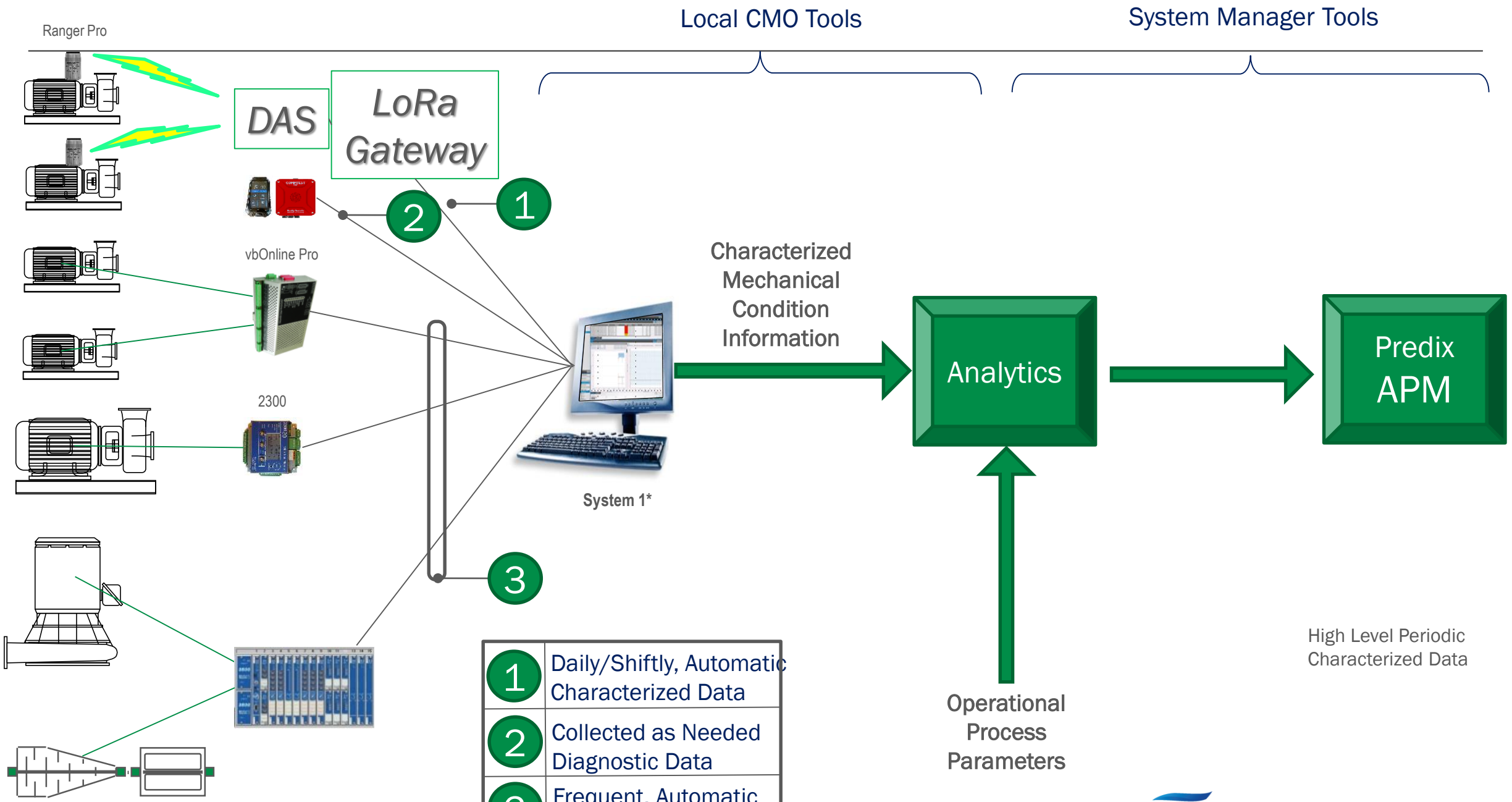
Cutis Wright :

- 900 MHz sensor will work on the DAS at NMP

Petasense Transmitter*






Ranger Pro
Local CMO Tools
System Manager Tools
DAS
LoRa Gateway
1
2
3
vbOnline Pro
2300
System 1*
Characterized Mechanical Condition Information
Analytics
Predix APM
Operational Process Parameters
High Level Periodic Characterized Data
1 Daily/Shiftly, Automatic Characterized Data
2 Collected as Needed Diagnostic Data
3 Frequent, Automatic Diagnostic Data

Questions?