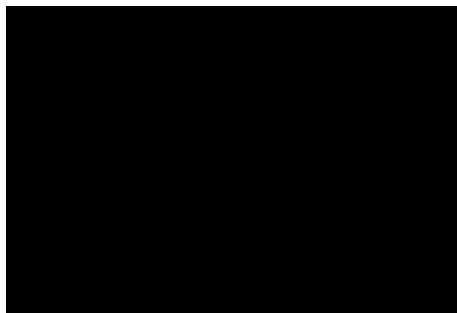
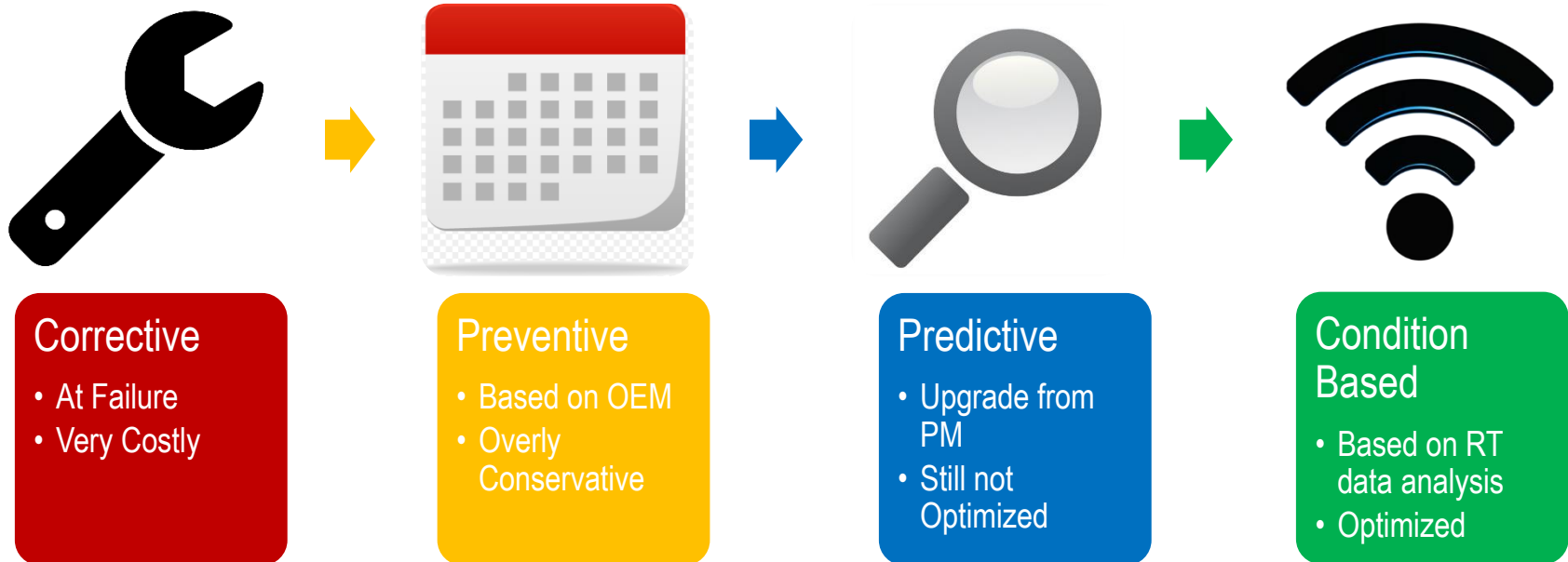


# CW Wireless Network, Adv Analytics, and CBM

## Product Overview



# Maintenance Types



# Condition Based Maintenance

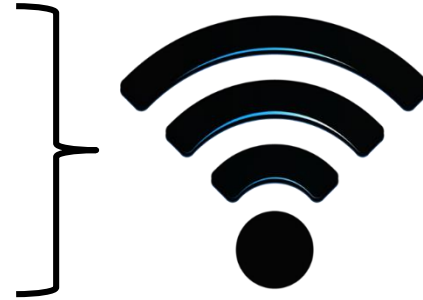
- **Most cost effective form of maintenance**
  - Only performed when real-time data provides indication of future failure
    - Scheduling of maintenance can be planned around next expected outage and parts procured in advance
  - Removal of time-based PMs
    - Less potential for human error
    - Only touch equipment when directed by data
  - Adjusts for variations in operating and seasonal conditions

# Why haven't we done Condition Based Maintenance Before?

- **More costly than PMs to set up**
- **Need additional data that was not easily available / costly to obtain**
- **Advanced Analytical tools required too much information and were difficult to perform in real time**
- **Integration of data with maintenance, operations and engineering to allow for a controlled approach was difficult**

# How do we overcome these barriers?

- **Collect more data**
  - Additional sensors
  - Continuous Monitoring
  - Additional Sensor types



# Wireless – Collecting More Data

- **Removes the costs of running wires throughout the site**
- **Allows for real time monitoring of systems that were previously intermittently monitored**
  - Operator Rounds
  - System Engineering Walkdowns
  - Localized recorder data
- **Additional Sensor types can be deployed in the field that were not originally installed**
- **Short term or Fix-It-Now data collection and analysis can now be done cost effectively**

# Curtiss-Wright Wireless Sensor Network Product

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## ■ Power Consumption

- Ultra low power consumption enables battery only operation for greater than 2 years
- Low power consumption enables energy harvesters to sustain battery for essentially unlimited periods

## ■ EMI / RFI Interference

- Low Susceptibility / Ability to operate in noisy RF and EM environments
- Controlled Emissions / Ability to operate without affecting other nearby electronic equipment

# Curtiss-Wright Wireless Sensor Network Product

- **Cyber Security**

- Continuous online communication diagnostics
- 256-bit encryption
- One way data transfer
- Configuration by secure plant tools

- **Product managed to industry requirements**

- Implement standard COTS components
- Configure to support current and future power generation standards
- Design for operation in typical power generation physical environments



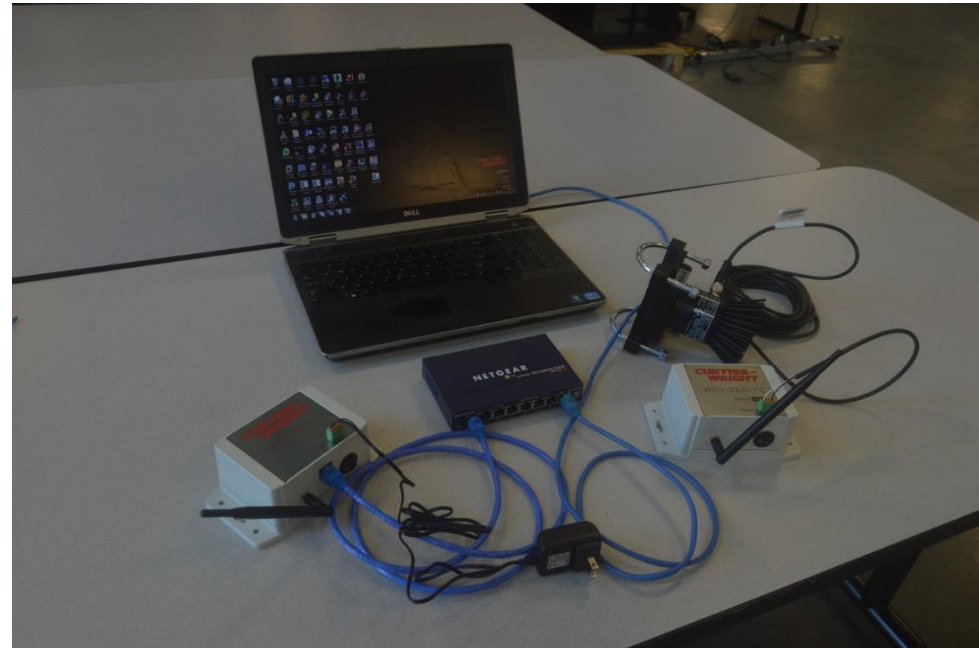
# Curtiss-Wright Wireless Sensor Network Configurations

## ■ Typical use

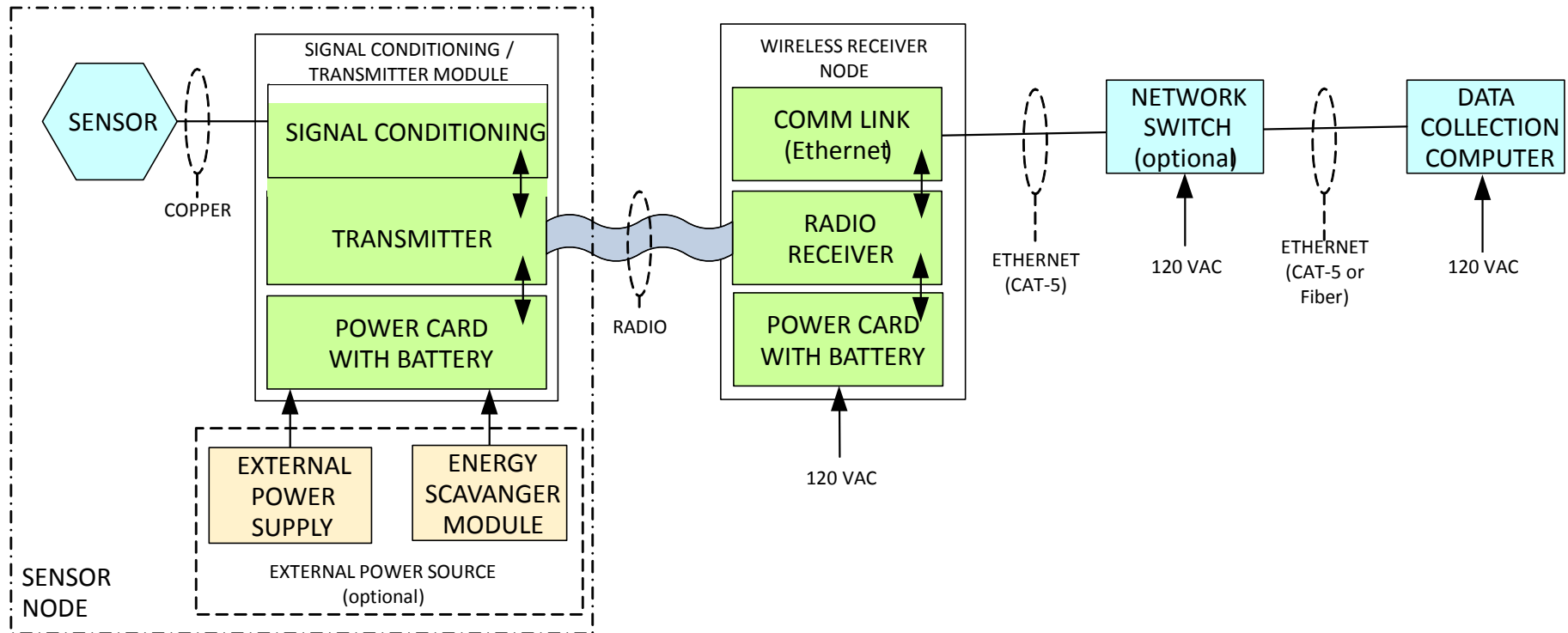
- Permanent and temporary deployment
- Balance of Plant networked monitoring
- Standalone monitoring
- Integrated wide area plant asset monitoring
- Performance/efficiency management
- Condition based maintenance enabler

# Curtiss-Wright Wireless Sensor Network Product

- **Composed of 3 major components**
  - Wireless Sensor Node (WSN)
  - Wireless Receiver Node (WRN)
  - Data Collection Computer (DCC)



# Curtiss-Wright Wireless Sensor Network Overview



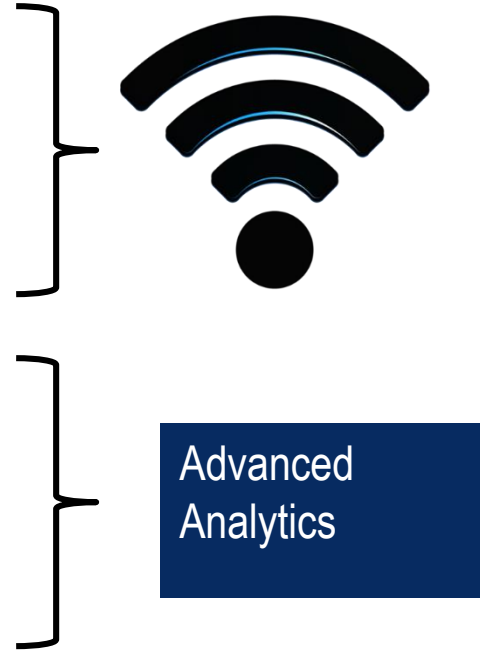
# How do we overcome these barriers?

## ■ Collect more data

- Additional sensors
- Continuous Monitoring
- Additional Sensor types

## ■ Utilize Advanced Analytics

- APR
- Thermal Performance
- Fault Tree Analysis



- **PdP – Advanced Pattern Recognition**

- Compares current state to learned or referenced states based upon related historical information
- Can determine very subtle condition changes

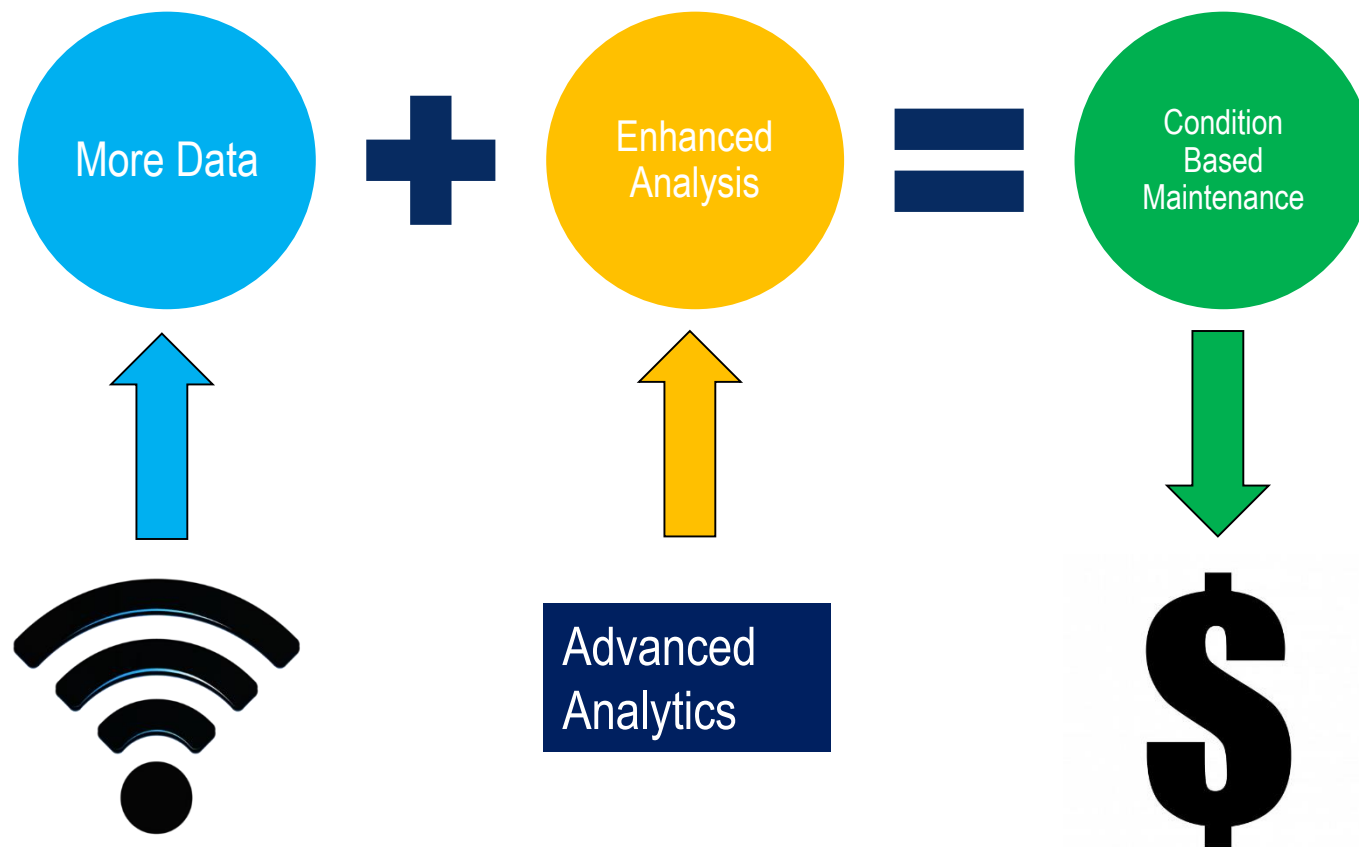
- **PMAX and PEPSE**

- MW Accounting
- Best Achievable vs Nameplate
- Allows for lost MW costs to be constructed into system

- **Rules Engine**

- Dynamic real time decision tree analysis processing

# Condition Based Maintenance





# Conclusion

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- **Wireless**

- Removes the costs of running wires through out the site
- Allows for real time monitoring of systems that were previously intermittently monitored

- **Advanced Analytics**

- Allows for real-time analysis and trending of plant components and systems

- **Condition Based Maintenance**

- Combines additional real-time data provided by wireless with advanced analytics to provide a powerful tool for performing the right maintenance at the right time.



# Questions

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**Tony Paletta**

***Director, Sales and Marketing***

***Curtiss-Wright***

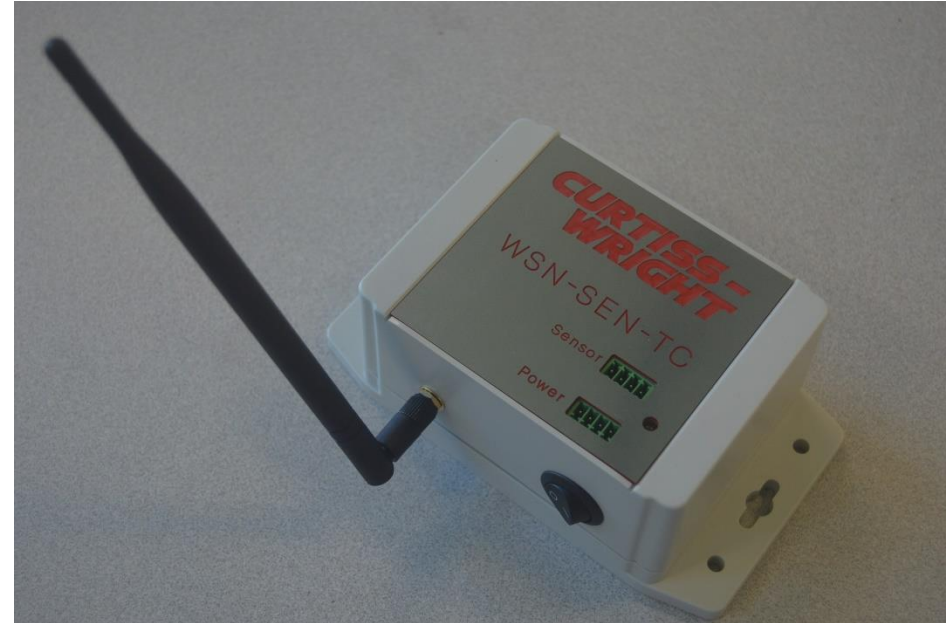
**304.670.5690**

**tpaletta@curtisswright.com**



# Wireless Sensor Node

- **Node is built around three basic circuit boards**
  - Wireless Transceiver Board (same as WRN)
  - Power / Battery Board (same as WRN)
  - Sensor Conditioning Board
    - Thermocouple
    - RTD
    - Radiation
    - Voltage
    - (more in later product versions)
  - One sensor per sensor node
    - Multi sensor nodes in future product versions



# Sensor Types

## ■ Thermocouple

- Type K, J, N, R, S, T, E, and B
- Open Thermocouple Detection
- Low level voltage inputs (0-80 mV)
- Cold Junction Compensation
- External thermocouple
- Either raw voltage or temperature provided to the Data Collection Computer

## ■ RTD

- 100 Ohm or 1000 Ohm Platinum
- 2, 3 or 4-wire configuration
- External RTD
- Resistance provided to the Data Collection Computer (converted to temperature on DCC)

# Sensor Types

## ■ Radiation

- Counts pulses from internal sensor
- Counts per time interval provided to the Data Collection Computer (converted to radiation rate on DCC)

## ■ Voltage

- -10VDC to +10VDC input range
  - Measure current loop inputs by converting current to voltage using an external resistor
- Raw voltage provided to the Data Collection Computer (converted to EU value on DCC)

## ■ New Sensors

- As defined by customer requirements
  - Vibration
  - Stresswave
  - Others?

# Wireless Radio

- **EMI / RFI Design Considerations (Susceptibility and Emissions)**
  - Operates in the 915 MHz band
    - Better penetration, lower power
  - Frequency band supports 50 channels (USA)
    - Channels can be user assigned individually or in groups of channels
    - All WSNs and WRNs in a Wireless Sensor Subnet use the same channel assignments
  - Configurable Transmit Power Level
    - 1 mW – 100 mW
      - User configurable
      - As installed 10 mW or 20 mW (~50 to 100 m range)
    - Less than 12 inch exclusion zone at 20 mW

# Sensor Inputs

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- **Process inputs suitable for low frequency periodic sampling**
  - Input sensor sampling rate user configurable
    - Default is sample rate every 10 min
    - Default transmission rate is once per hour
    - Higher rates may require external power source
      - Scavenging or AC

# Power / Battery Board

- **Power / Battery Board supports 3 battery configurations**
  - 2200 mAh (size of 1 AA battery)
    - Default for AC or energy harvesters
  - 6600 mAh (size of 3 AA batteries)
    - Default for battery only sensor nodes
- **Optional power modules**
  - Thermal Energy Harvester
  - External 120 VAC transformer



# Wireless Receiver Node

- **Node is built around three basic circuit boards**
  - Wireless Transceiver Board (same as WSN)
  - Power / Battery Board (same as WSN)
  - Communication Link Board
    - RJ-45 Ethernet
    - RS-485 Serial
  - External 120 VAC transformer required for power





# Wireless Sensor Subnet

- **Composed of**
  - One Wireless Receiver Node (functioning as receiver)
  - Zero or more Wireless Receiver Nodes (functioning as multi-hop repeater nodes)
  - 1 to 16 Wireless Sensor Nodes (additional nodes for future revision)
- **Each Wireless Sensor Network installation can have an unlimited number Wireless Sensor Subnets**
  - One Data Collection Computer services any number of Wireless Sensor Subnets

# Data Collection Computer

- **Data Collection Computer is composed of**
  - Dell / HP / other laptop, desktop or server computer
  - R\*TIME Server and R\*TIME Viewer software (standard R\*TIME software)
  - Wireless Sensor Network Interface software for R\*TIME
  - External interface software to OSI-PI, eDNA, etc. (optional)
- **The Wireless Receiver Node for each Wireless Sensor Subnet interfaces to the Data Collection Computer**
  - RS-485 serial
    - Converted to Ethernet via a separate serial hub device
  - RJ-45 Ethernet
    - Wireless Receiver Node interface is RJ-45 Ethernet, can be converted to fiber via additional transceivers or networking equipment

## ■ Cyber Security Design Considerations

- Devices not field configurable, only configurable in I&C shop
- Network ID and Preamble ID Configurable
  - User configurable for each Wireless Sensor Subnet
- All Communications Encrypted
  - User defined 256-bit AES encryption key
  - Symmetric encryption
  - Encrypts the entire transmission
- Initially only used for Cyber Security Layer 2 data (NEI 08-09 Cyber Security Model)
  - Meets requirements for Cyber Security Layer 3 data
- Sensor values used for maintenance decisions not operational decisions.

## ■ Low Power Design Considerations

- User defined scan rate
  - Default is 10 min
- User defined transmission rate
  - Default is 1 hour
- Microcontroller sleep mode when not executing
- Radio sleep mode when not transmitting
  - Sleep mode for Wireless Sensor Nodes only
  - Wireless Receiver Nodes (including repeater nodes) require external power because radio and microcontroller are constantly energized

## ■ Low Power Design Considerations

- Sensor chips scan only when enabled by the microcontroller at the scan rate
- Low data volume transmitted
- Power / Battery Board supports 2 battery configurations
  - 2200 mAh (size of 1 AA battery)
  - 6600 mAh (size of 3 AA batteries)
- > 2 year battery life for Wireless Sensor Nodes that do not have external power (at default scan and transmission rates)

# Wireless Radio

## ■ Reliability Design Considerations

- 16 Wireless Sensor Nodes per Wireless Sensor Subnet (additional nodes in future version)
  - Can separate different wireless subnets into different frequency channels
- Radio transmissions from the Wireless Sensor Node are acknowledged by the Wireless Receiver Node
  - Lack of acknowledgement causes transmission retry
  - Multiple retries are logged
- Acquired data is buffered on the Wireless Sensor Node
  - Able to withstand limited, periodic interference by buffering data
- In each time slot, the WSN tries transmission up to 3 times (retries twice per time slot)
- Communication timeouts are logged on the Data Collection Computer

- **Will this product support safety-related applications?**
  - This product is being provided as COTS equipment and is not being developed or manufactured under either Augmented Quality or NQA-1.
- **Is the product seismically qualified?**
  - The base product is not being seismically qualified. However, seismic testing can be performed for a customer under a T&M basis.
- **Is the product EMI / RFI qualified?**
  - Even though the product has been designed to be EMI / RFI friendly, it has not been tested under EPRI TR-102323. However, EMI / RFI testing can be performed for a customer under a T&M basis.

- **Is installation and commissioning support provided with the base system?**
  - Installation and commissioning can be provided by Curtiss-Wright.
- **Is the list of sensor provided in the presentation the only supported sensors?**
  - Yes, for the first release of the product. Subsequent product versions may include additional sensor types based upon customer demand.
- **Does the base system include networking equipment required to connect the Wireless Receiver Node to the Data Collection Computer?**
  - The Wireless Receiver Node includes either an RJ-45 Ethernet connection or RS-485 connection to connect to the customers network. Any additional equipment required can be provided by Curtiss-Wright but is not included in the base system.
- **Does the base system include design documentation?**
  - Yes, the base system includes complete design documentation on the system including a Design and Installation Manual.



- **Does the base system include the Data Collection Computer?**
  - The Data Collection Computer is not included in the base system. A Data Collection Computer can be provided by Curtiss-Wright or a customer provided system utilized.
- **Does the base system include the Thermocouples and RTDs?**
  - The sensors are plant equipment, Thermocouples and RTDs are customer provided and installed.
- **Can the Wireless Sensor Network be installed and configured by the customer?**
  - Yes, Curtiss-Wright recommends either Curtiss-Wright provided system training or installation and configuration services for the first installation at a customer site.

- **Is source code provided for the system?**
  - Source code of the R\*TIME based Wireless Sensor Node Interface software is provided. Source code for the Wireless Sensor Node and Wireless Receiver Node embedded software are not provided.
- **How many inputs does each sensor node support?**
  - The initial product version only supports one physical sensor per sensor node. Subsequent product versions may support multiple sensors for each sensor node for some sensor types.
- **Can the product be used for Cyber Security Layer 3 (PPC) or Cyber Security Layer 4 (Control System) systems?**
  - There is no technical reason the product cannot support these environments. However, because of the uncertainty surrounding the NRC acceptability of wireless solutions associated with plant operational systems, Curtiss-Wright is recommending the product for Cyber Security Layer 2 systems for the initial installations at a plant.

# Questions?

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The Curtiss-Wright logo, featuring the company name in a bold, italicized, sans-serif font. The text is white and set against a solid red rectangular background.

***CURTISS -  
WRIGHT***

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**Director, Sales and Marketing**  
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