DOE Sensors & Automation
2006 Annual Portfolio Review

Wireless Network for Secure Industrial Applications

DOE Contract: Wireless and Sensing Solutions for Improved Industrial Efficiency
Task A: *Development of a Pervasive Wireless Industrial Sensing Infrastructure*

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Honeywell

Wireless & Sensing Solutions for Improved Industrial Efficiency

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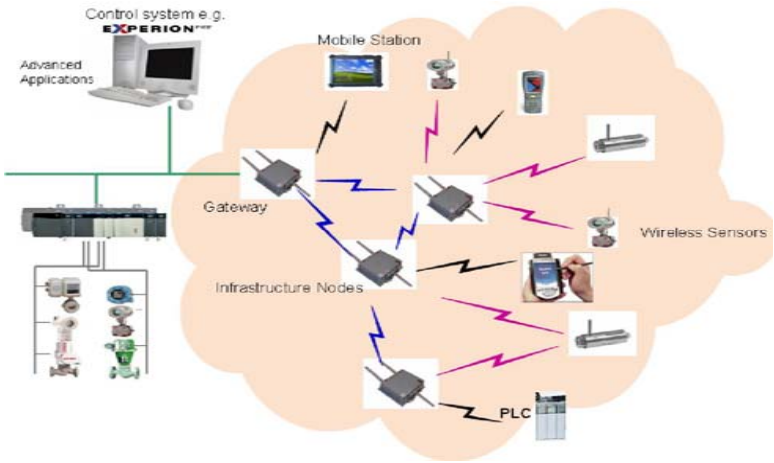
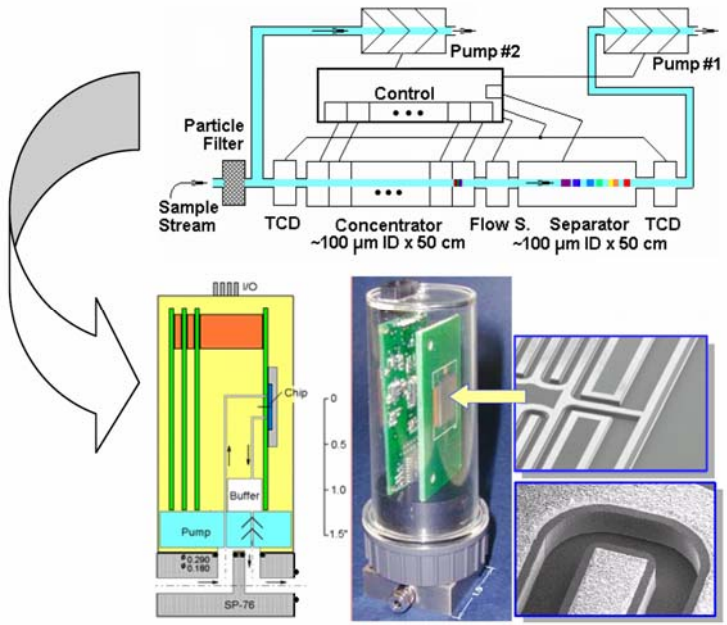


Task A: Wireless Network for Secure Industrial Applications

- Robust industrial wireless infrastructure
- High data security
- Lowest total cost of ownership
- Low power requirements and extended battery life
- Enhanced availability and coexisting with other RF systems

Task B: PHASED Gas Composition MicroAnalyzer

- MEMS based micro gas chromatograph
- Real-Time, on-/by-line measurement of process streams
- High-Speed, 1-10 seconds analysis time
- 20-50-Stage, sub-second pre-concentration
- NeSSI-Compatible Microanalytics
- Low-Power requirements
- Affordable



Project Description: Industrial Wireless Sensing

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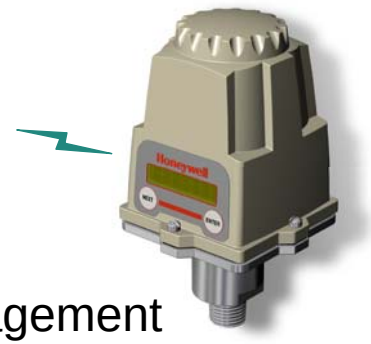
- **Need:**
  - A low cost, reliable and secure wireless sensor network for industrial applications that offers significantly improved monitoring and control, reduced energy consumption, and reduced environmental emissions.
- **Core Technology:**
  - Highly robust radio communications
  - Scalable latency-controlled multi-hop mesh network
  - Secure wireless communications with convenient key management
  - Very long battery life



Wireless sensors will become the obvious choice for industrial process monitoring and non-critical control

Project Description: Industrial Wireless Sensing

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- **Novel Elements**
  - Robust radio design supporting 5+ year battery lifetime
  - Space / time / frequency diversity for interference management
  - Low power cryptographic authentication and privacy
  - Latency controlled message delivery
- **Key Project Deliverables**
  - Voice of the customer interviews
  - Industrial wireless requirements documents
  - Radio performance test results and trade-off assessments
  - Unique system architecture to meet requirements
  - Operational factory deployment testing results for the wireless network

Design, development, and field testing of a robust, scalable, secure wireless network at two industrial plant sites

Project Description: Cross-cutting Applicability

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Designates initial industries of application

Industries	Wireless Applications: people / asset tracking	safety shower monitoring	equipment health monitoring	automated field operator rounds	emissions monitoring	leak detection	process optimization via more I/O	process diagnostics
-Petrochemical refining	x	x	x	x	x	x	x	x
-Pulp and paper manufacturing	x	x	x				x	
-Continuous process industries	x	x	x		x	x	x	x
-Power generation and distribution	x		x	x	x		x	x
-Pharma industries		x	x			x	x	
-Aluminum	x		x	x	x		x	x
-Chemicals	x	x	x	x	x	x	x	x
-Glass			x	x	x		x	
-Metal casting	x		x				x	
-Mining	x		x				x	
-Steel	x		x	x	x		x	x

Barriers and Pathways

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Key challenges:

- Industrial wireless devices can not have batteries recharged as with traditional mobile devices
- Unreliable (intermittent) communications, as in conventional RF devices, is unacceptable
- Existing systems suffer significant message latency or packet loss problems on scale-up
- Lack of user interface for security key deployment on wireless sensor devices
- A *standard* industrial sensing solution that meets customer requirements

Elements of the solution:

- Extensive voice-of-the-customer (VOC) assessment to determine critical unmet needs
- Develop Industrial wireless requirements specification
- Assess and test existing wireless alternatives
- Design an innovative network architecture addressing identified industrial wireless requirements:
  - Low power wireless sensors
  - Low power / convenient cryptography
  - Robust wireless architecture
- Active participation in industrial wireless standards bodies, i.e. ISA-SP100, etc

Continued investment and participation of DOE and industrial partners will overcome the key challenges

Important Metrics: Architecture Challenge

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- **Wireless Networks**
  - Ability to scale system up to 1000's of wireless devices in a single factory area with high sensor reporting rates.
  - QoS including controlled message latency of less than one half the sample time
  - Reliable (> 95%) delivery of latency controlled messages
    - Robustness to single point of failure, resistance to interference
  - Highly secure wireless communications with simple key deployment
  - Global solution capable of coexisting with common wireless devices (e.g. Wi-Fi)
- **Wireless Sensors**
  - Battery life in excess of 5 years for untethered devices
  - Low installed cost (less than 1/10th that of wired sensors)
- **Wireless Standards**
  - Strong participation in ISA-SP100, etc

A solution addressing ***all*** requirements is needed for industry acceptance

Project Status

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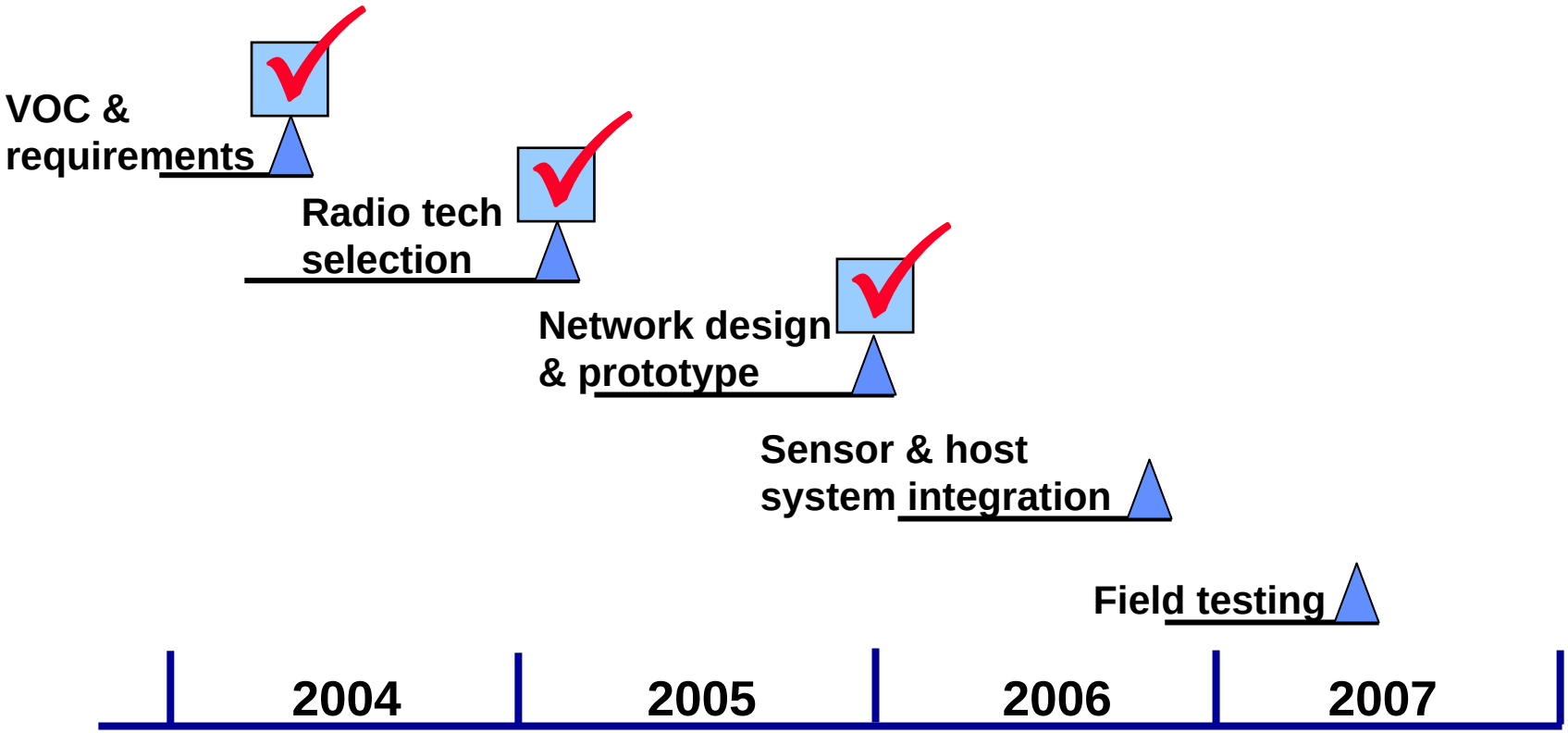
- ✓ Major technical risk items and challenges have been addressed in the architecture – scalability, security, battery life, reliability, latency-control, etc
- ✓ All components of the architecture implemented – robust FHSS low-power wireless, low-power sensing, system-wide wireless security, highly scalable mesh
- ➢ System integration underway



Project on track for field tests

Accomplishments: Requirements & Architecture Concept

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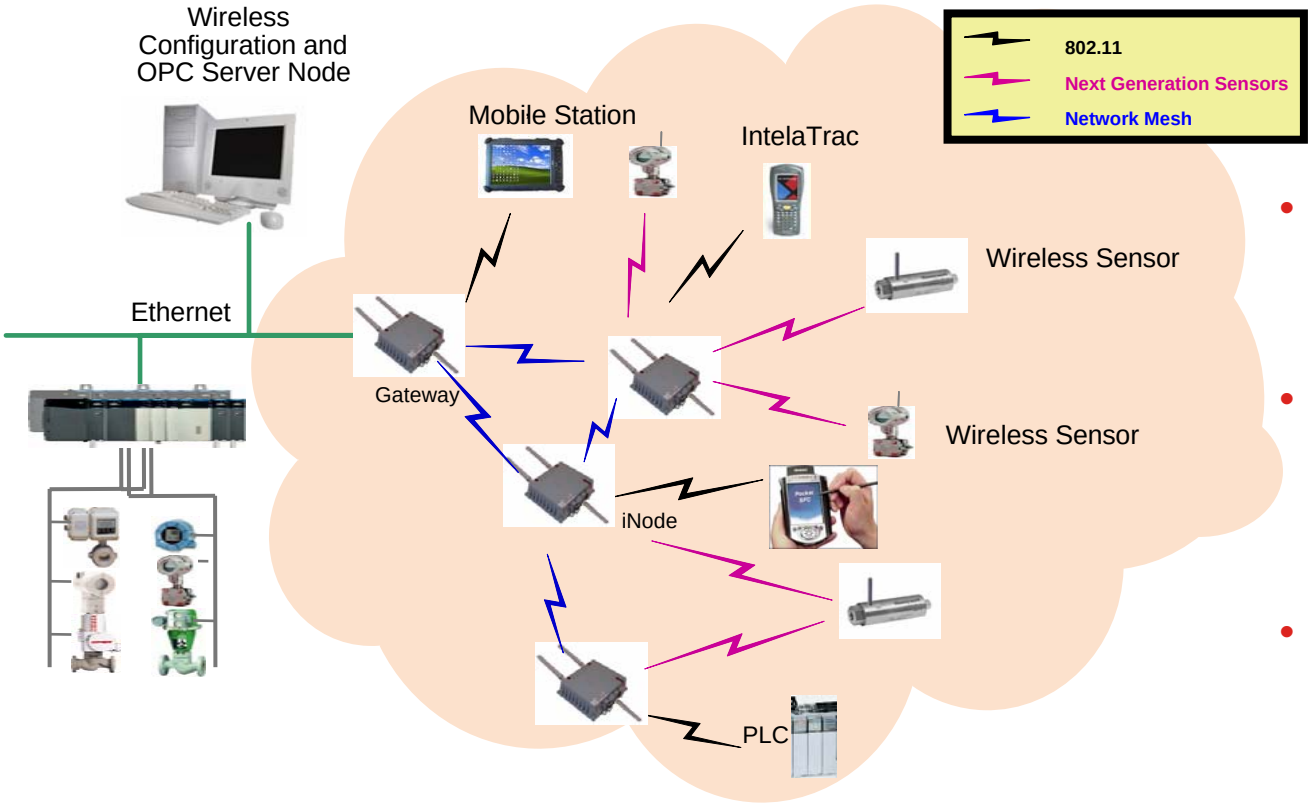

- **Established industrial wireless requirements through voice-of-the-customer (VOC) interviews**
- **Evaluated performance of FHSS and DSSS wireless technologies against industrial process requirements**
- **Evaluated performance of COTS mesh networks against industrial process requirements**

Developed robust industrial wireless architecture concept

Accomplishments: FHSS Software and Hardware

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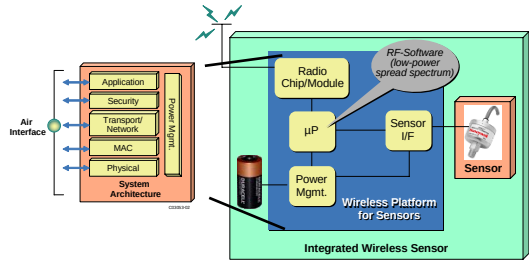
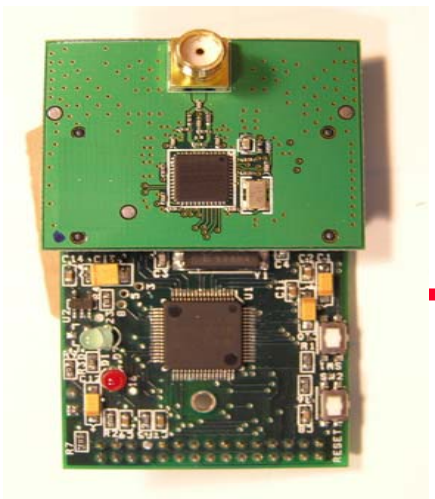
- **Reliable comm. between sensor and infrastructure – Developed robust FHSS communication protocol for battery-powered sensors**
  - **including QoS: latency controlled, high throughput, immediate, and low importance traffic classes**

- **Radio pair hardware development activities:**
  - Completed multiple prototypes of radio modules: including revised form factor to fit industrial sensor packaging
  - Performance measurements: open field LOS range, blocking, sensitivity, adjacent channel rejection, power consumption, output power
    - over industrial temperature range
  - **FHSS radio module for low-power sensors**
  - **FHSS radio module for infrastructure nodes**



Wireless Platform for Sensors



Rev 1

Rev 2a

Rev 2b

Rev 3

Robust FHSS communication protocol for battery powered sensors

Accomplishments: Battery Power Management

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Battery life is a complex function of: Sensor Type, Ambient Temperature, Analog Conversion Rate, RF Transmit Rate, Number of Analog Inputs

Estimated Battery Life for Sensors Transmitting One Analog Measurement With Honeywell Technology

Ambient Temperature	Measurement Rate (seconds)			
	1	5	10	30
0ºC (32ºF)	4.9 yrs	10 yrs	10 yrs	10 yrs
25ºC (77ºF)	4.5 yrs	10 yrs	10 yrs	10 yrs
50ºC (122ºF)	4.0 yrs	10 yrs	10 yrs	10 yrs
72ºC (162ºF)	3.3 yrs	8.1 yrs	9.3 yrs	10 yrs

3 - 10 Year Battery Life - *Rain or Shine*

Accomplishments: Infrastructure Development

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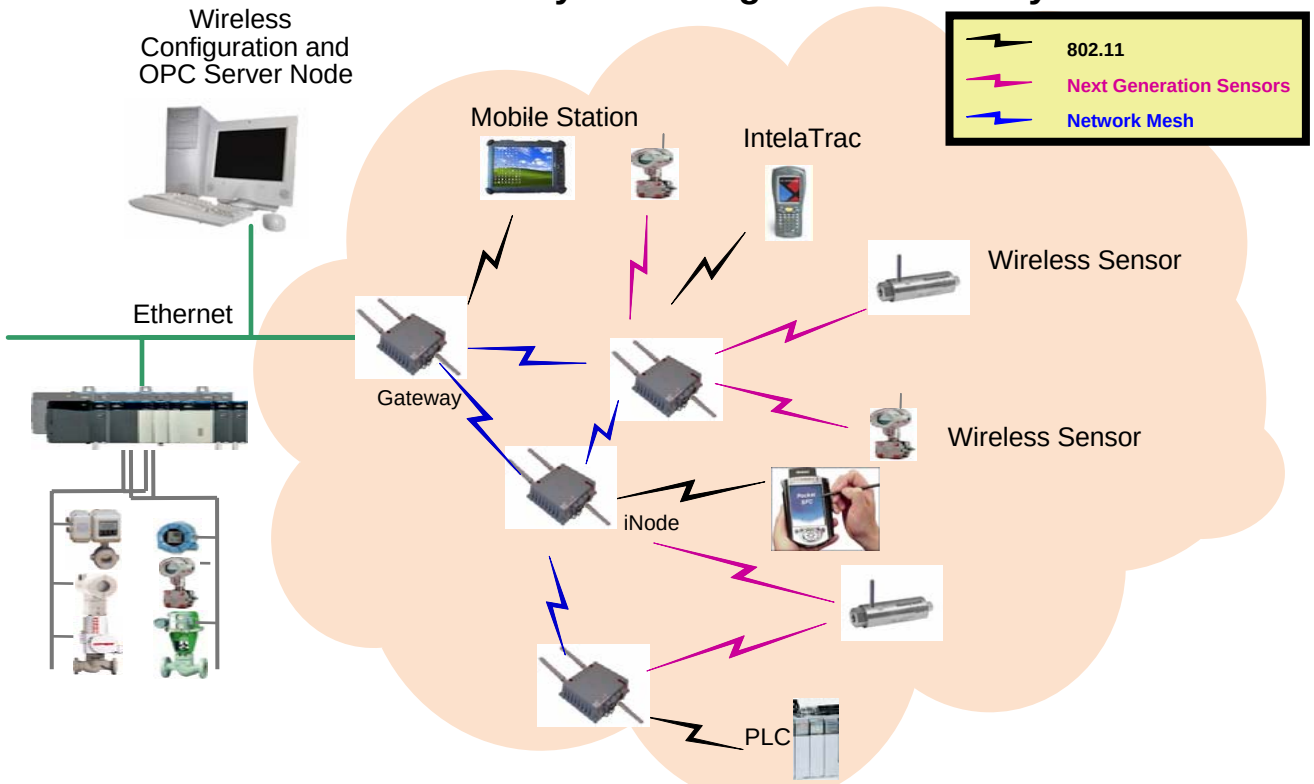
- **Developed multi-functional mesh infrastructure:**
  - **Supports wireless sensors**
  - **High speed mesh**
  - **Flexible to support 802.11 version of 1451.5**
  - **Supports wireless worker via Wi-Fi**
- **Software methods for host system integration underway**



Highly scalable, secure, reliable wireless network supporting latency control and low-power sensors

Accomplishments: Secure Wireless Architecture

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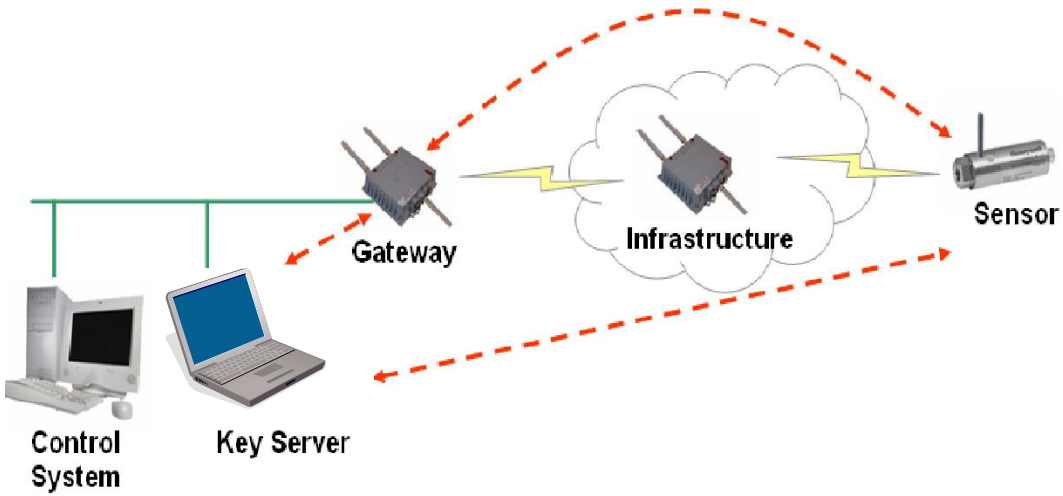
- Developed comprehensive end-to-end security architecture maintaining low power consumption:
  - Confidentiality
  - Integrity
  - Source authentication
  - Replay protection
  - Resistance to denial-of-service attacks
  - Convenient key management
- Completed three external security reviews
- Completed initial system-wide integration



Accomplishments: System Performance Evaluation

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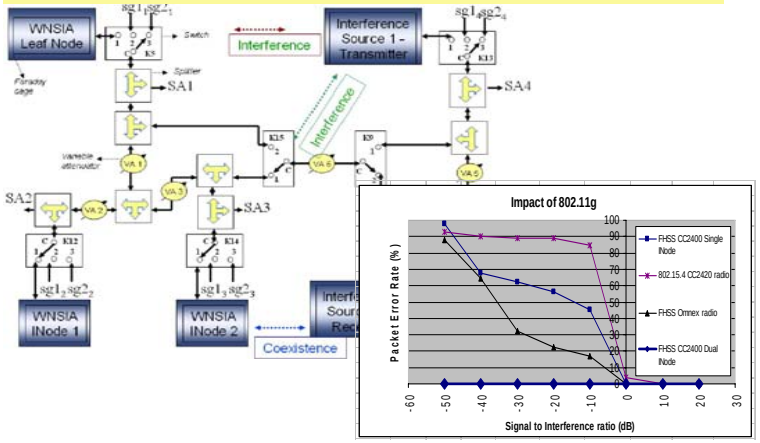
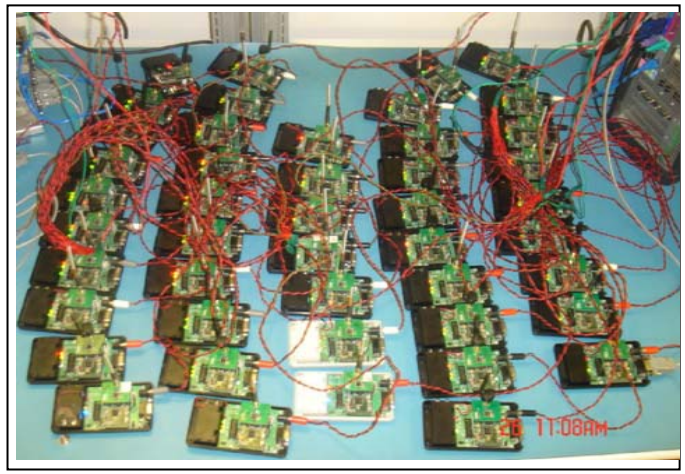
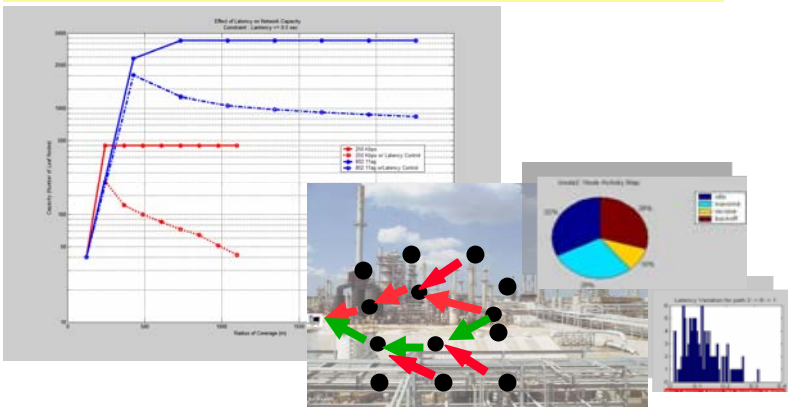
Interference & Coexistence testing



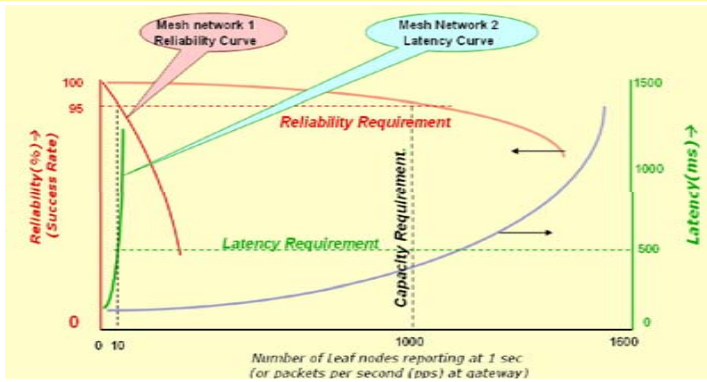
Scalability testing



Modeling & Simulation



Mesh network testing



Lab tests and modeling to evaluate interference-resistance, co-existence, scalability, reliability, and latency

Accomplishments: Field Measurements

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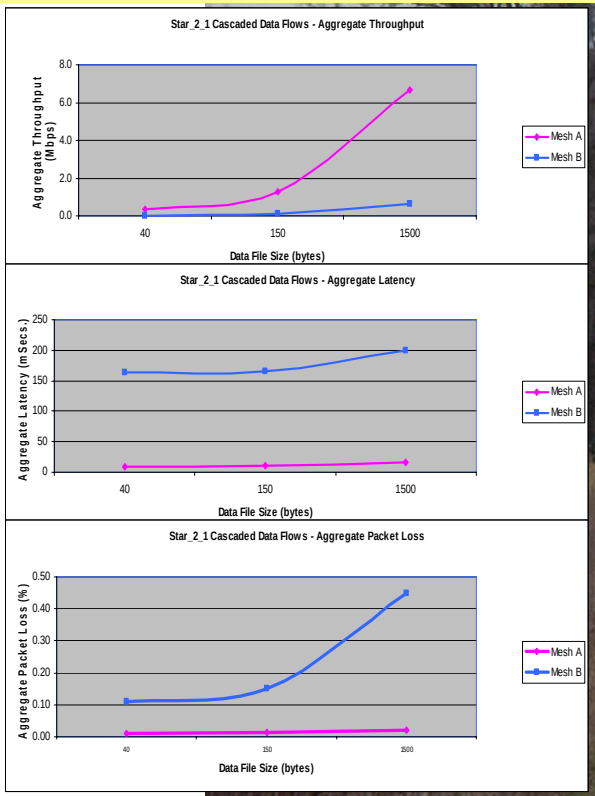
Mesh network testing



Point-to-point range testing

Field tests to measure throughput, latency, packet loss, and LOS range

Next Project Steps and Future Milestones

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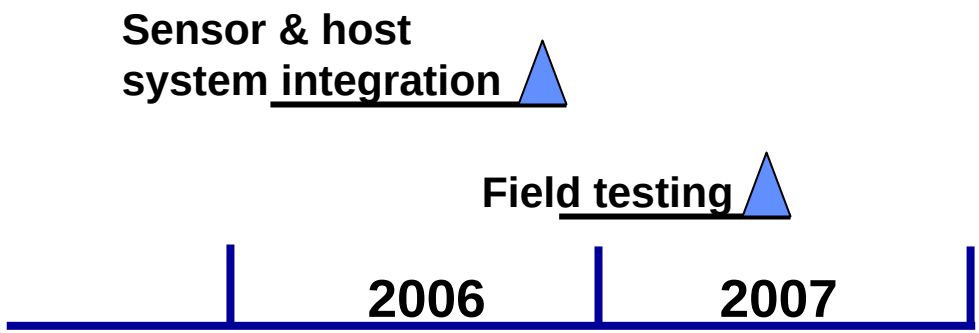
- **Integrate sensors, wireless network, and host system into field deployable prototype by 4Q 2006**
- **Install and complete performance testing in two industrial plants by 2Q 2007**



Project success dependent on deployment and performance testing of wireless network at two plant sites

Anticipated Economic Impact

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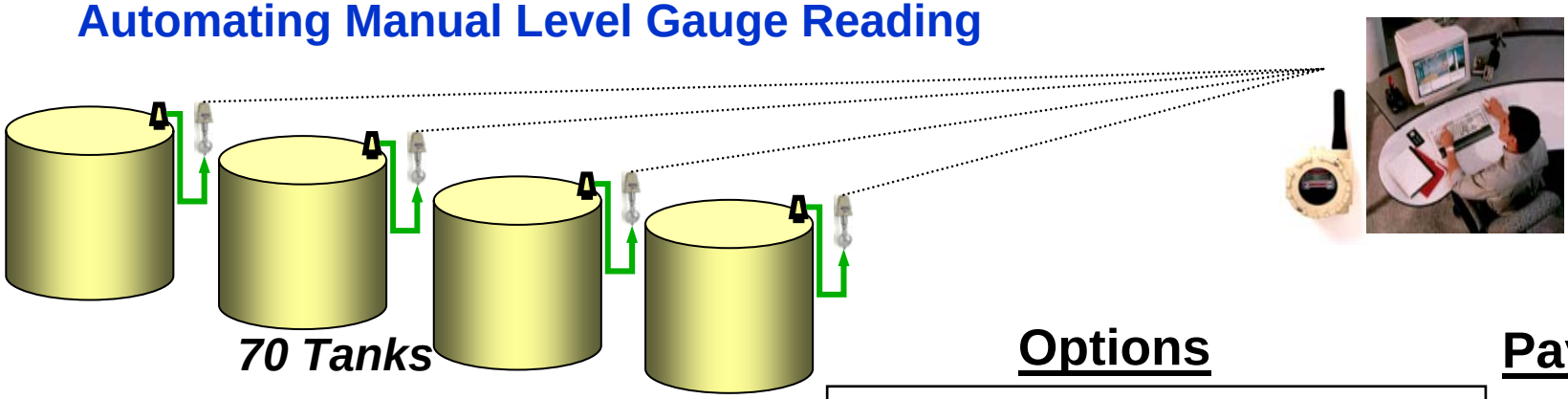
- Inventory Management Example:

Automating Manual Level Gauge Reading



Project Savings

	Annual Savings ($)
Level Readings Labor*1	196,000
Calibration Costs*2	3,500
Increase Safety & Environmental Compliance*3	75,000
Total	274,500

*1 - 70 gauges/round read @ 5 min/gauge, 1hr/60 min, 3 rounds/day for 350days/year @ $32/hr
*2 - 70 gauges calibrated/3years @ 3 hrs/gauge, @ $50/hr
*3 - 1 minor incident (1k-10k gallon spill) every 2 years that costs $150K paperwork, fines, clean-up.

Options

1. Wired Automation Investment

	Initial ($)	Annual ($)
Wired Installation Cost*:	385,000	
Wire inspections 70k/year	70,000	70,000
Wired Total	455,000	70,000

* Includes Infrastructure, sensors, drawings, and all labor costs.

2. Wireless Automation Investment

	Initial ($)	Annual ($)
Sensors & Wireless System*	121,000	
Average annual maintenance	14,000	14,000
Wireless Total	135,000	14,000

* Includes Infrastructure, sensors, drawings, and all labor costs.

Payback

23 Months

6.1 Months

Wireless Offers 6.1 Month Payback with ~4x Impact

Anticipated Economic Impact (cont'd)

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Examples:

- Remote Safety Shower Monitoring:
  - Required by OSHA First Alert Response guidelines
  - Estimated wired system installed cost $1.5M
  - Estimated wireless system installed cost $50K
- Pipeline Pressure Monitoring:
  - Wireless provides 37% cost savings over wired system
  - 50% reduction in maintenance costs
  - Increased data and measurement reliability with the elimination of data transmission faults
- Bearing Temperature Monitoring:
  - Temp monitoring critical to predict compressor bearing failure
  - Wireless eliminates thermocouple failure previously present due to moisture in wiring conduits
  - Reduces process downtime and prevents possible employee injury
- Rotating Equipment Temp Monitoring:
  - Temp monitoring inside rotating lime tunnel kilns needed for product quality
  - 60-80 rotations / hour, 500degF – significant time and energy cost savings possible
  - Wireless helps avoid scrap product

Wireless Value Proposition to End User

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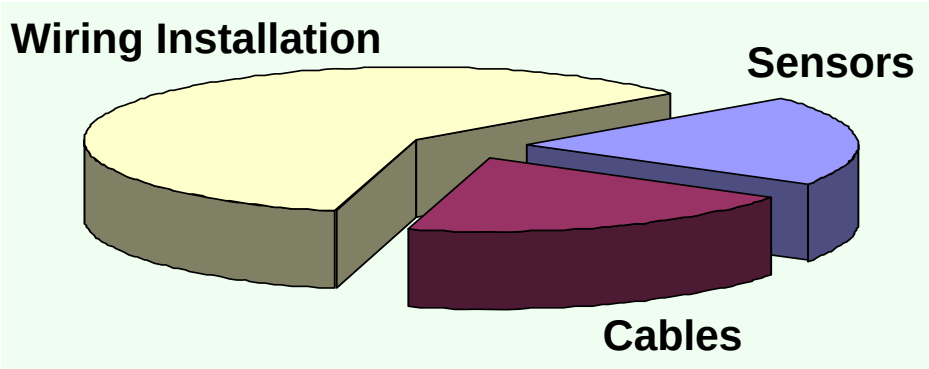
- **Up to 10:1 reduction in capital expenditure**
  - No signal wiring or conduit for new points
  - No marshalling area space or termination assemblies
  - No additional I/O cabling into automation system
  - No I&E documentation for wiring and termination interconnect
- **Modest reduction in operational expenditure**
  - No budget for wiring and conduit maintenance
  - No spares for termination assemblies
- **Easy addition of more sensors**
  - Significantly improved process operations
  - Additional coverage when primary sensors fail
  - Better process diagnostics
  - Suitable for temporary placement during unit troubleshooting

- **Usable where wired connections are infeasible**
  - due to long distance (e.g., piers and quays, pump houses)
  - due to large common-mode voltage differences (e.g., motors, tank farms)
  - over water or non-owned obstructions (e.g., roadways)
  - on vibrating, rotating, or moving machinery (e.g., large motors, fans, cranes)
  - great height: stacks, towers, tanks (e.g., for monitoring emissions)



Industrial Sensor Installation Costs

Eliminating wiring costs opens the opportunity for pervasive sensing

Commercialization Plan

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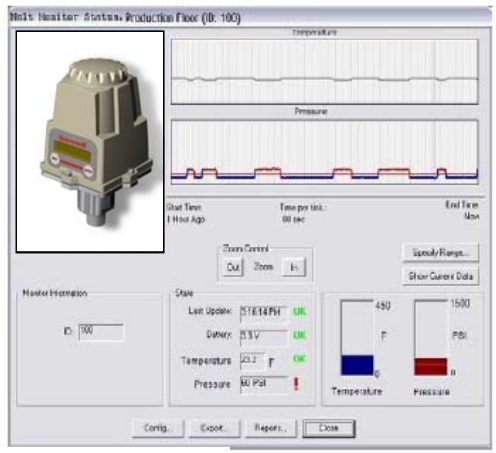
Wireless Transmitters

Bi-directional Wireless Link
900 MHz FHSS

Base Radio



Wireless Management Toolkit
RS232 interface

Modbus or
4-20mA
interface

Current Industrial Wireless Sensing System –
First Generation Product “XYR 5000”

Commercialization Plan

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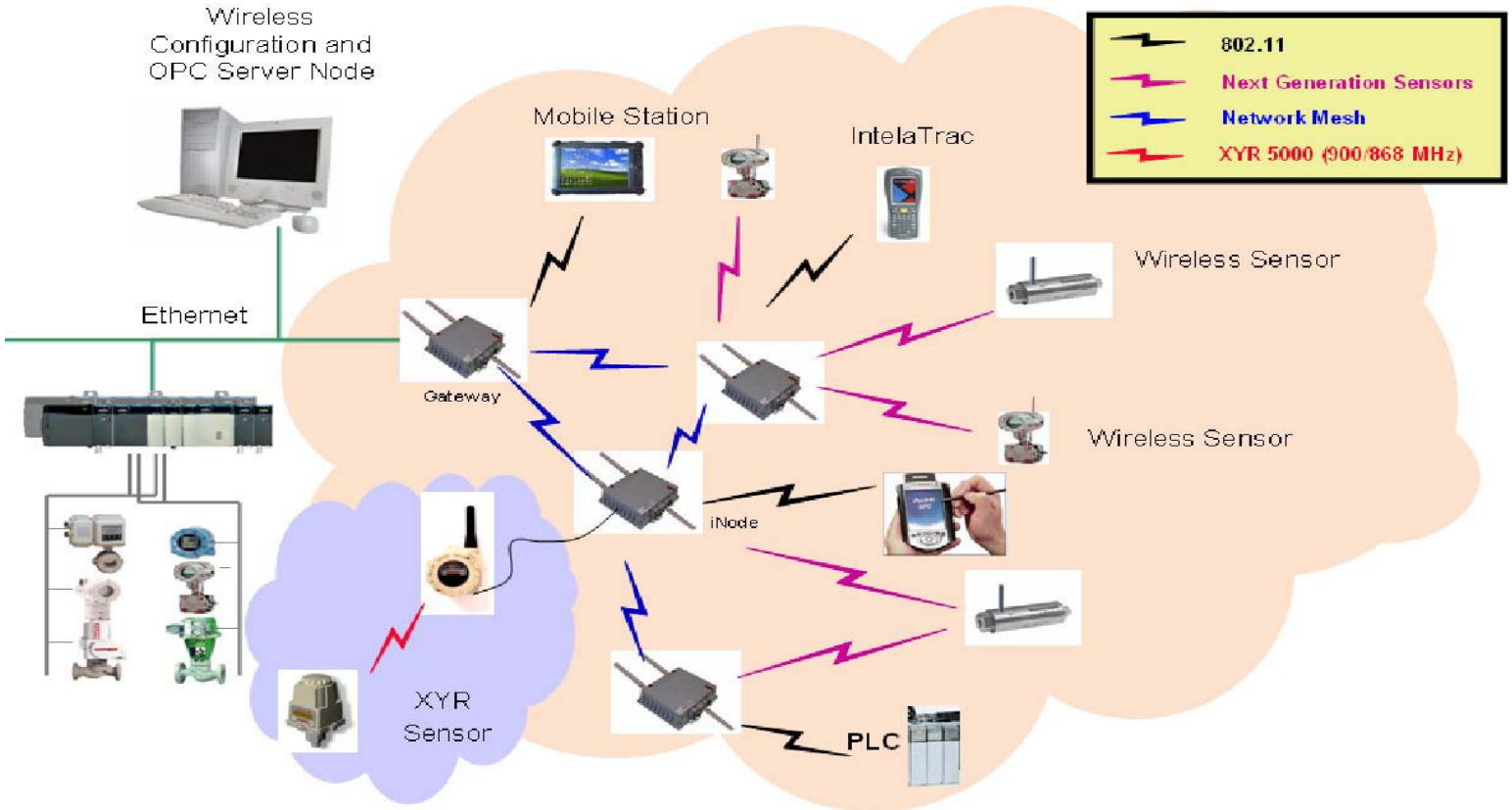

Next Generation Industrial Wireless Sensing System – Multi-functional Scalable Architecture

Continuation after ITP-Sponsored Project

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- Continue to support industrial wireless standards
- Aggressively introduce and promote industrial wireless sensors and networks – 2nd generation wireless system products based on DOE funded technology
- Support collaborators and partners to enable effective industrial wireless solutions and corresponding wireless market development
- Pursue tight integration with industrial host systems
- Develop advanced wireless network support tools and device installation tools

Honeywell is a leading supplier of industrial wireless systems and will aggressively support industry development

Commercial/Technical Risks Remaining

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- **Technical Risks**
  - System integration challenges
  - Impact of unknown field environment
- **Commercial Risks**
  - Market confusion regarding expected wireless network performance results in low adoption rates
  - Lack of standards to unify market space
  - Aggressive marketing of poorly developed wireless networks can damage the industry perception of value

Growth of the industry and benefits derived depend on systematic development and introduction of solutions that address key requirements of reliability, scalability, security, and battery life

Energy Savings

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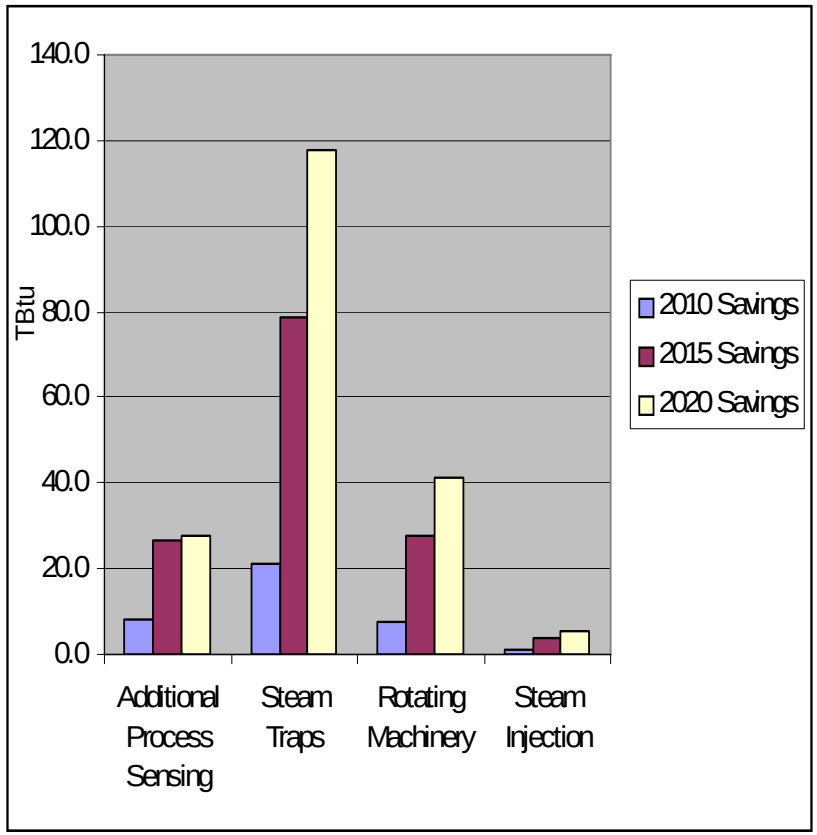
- **How will energy be saved?**
  - Improved industrial process control leading to improved product quality and fewer process upsets
  - Monitoring of steam traps in industrial processes
  - Monitoring steam injection devices used in oil production
  - Monitoring electric motors used in industrial processes
  - Faster introduction of new sensor and analytical technology
  - Condition-based diagnostics and maintenance resulting in fewer unexpected shutdowns
  - Ability to deploy temporary sensing to solve in efficient control problems

- **How much energy will be saved?**



Estimated Energy Savings