Wireless Sensors: Technology and Cost-Savings for Commercial Buildings

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Overview

- Why wireless in buildings?
- Today's technology
- Technology demonstration projects at PNNL
- Cost-Effectiveness Discussion
- Market transformation
- Future Trends

Wireless Technology in Buildings as Enabler

- Primarily: Cost avoidance of wiring
- Secondarily: Mobility
  - Short-term data logging (e.g., IAQ, temperature)
  - Accommodate constantly changing buildings layout
  - Personalized comfort conditions
- Enable:
  - Better control for EE, demand response
  - Improved comfort
  - Improved life-time of HVAC equipment

Relevant for EE or Demand Responsiveness ONLY if significantly less expensive than wired sensors (x10)

Wireless Technology (RF) Overview for Sensors and Data Acquisition in Buildings

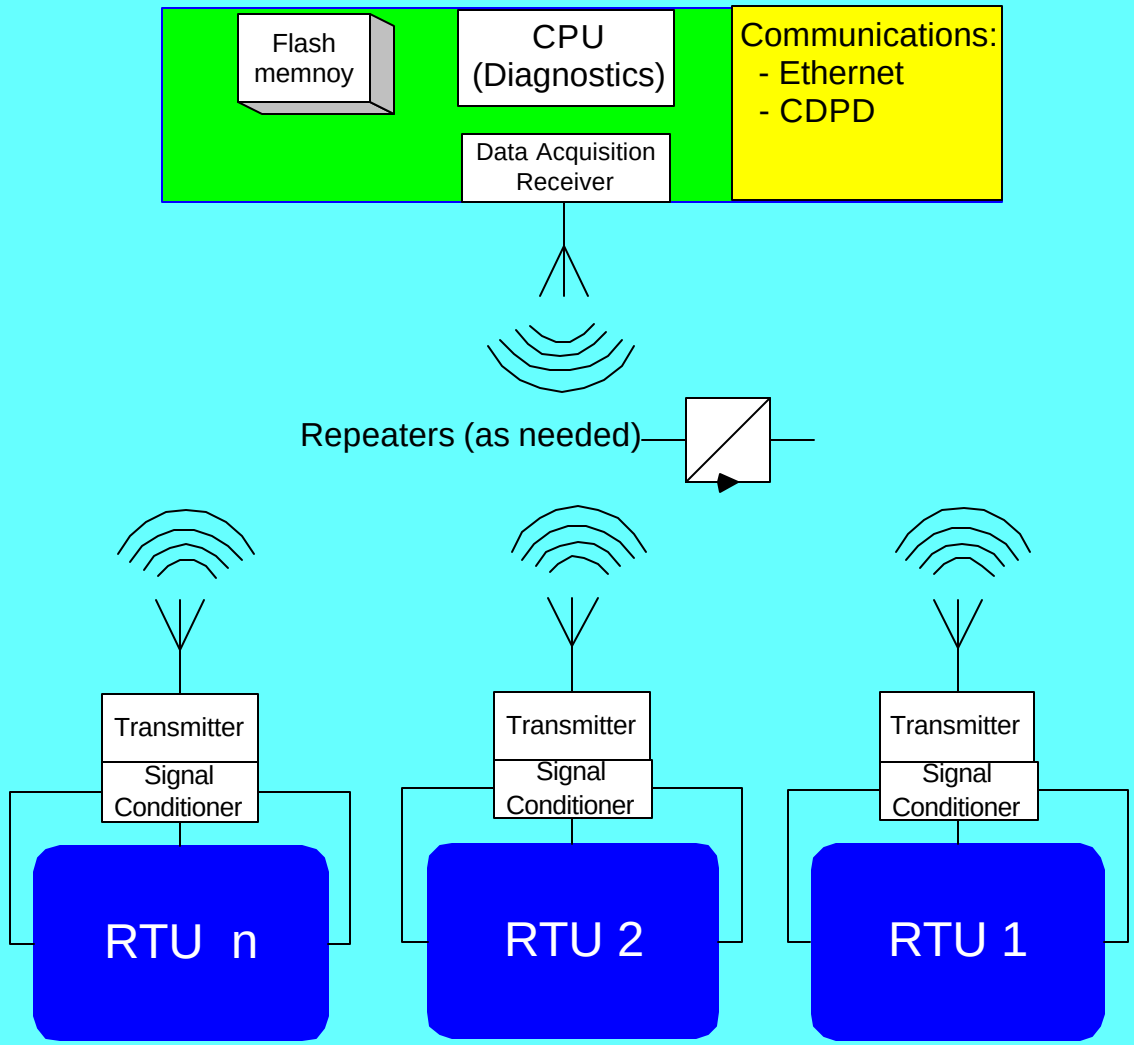
- Unlicensed ISM (industrial, scientific, medical) radio bands (Part 15, FCC): 300, 430, 900 MHz, 2.4 GHz
- Low data rate
  - Radios with proprietary protocols: all ISM
  - Spread-spectrum technology
  - Battery operated
- High data rates
  - Wireless LAN (802.11 family): 2.4GHz, 11Mbs, 30-100m
  - Serial wireless: all ISM bands, 9.6 kbs, 30m to km
  - Bluetooth: 2.4GHz, 720kbs, 10m

Wireless Sensor Demonstrations at PNNL

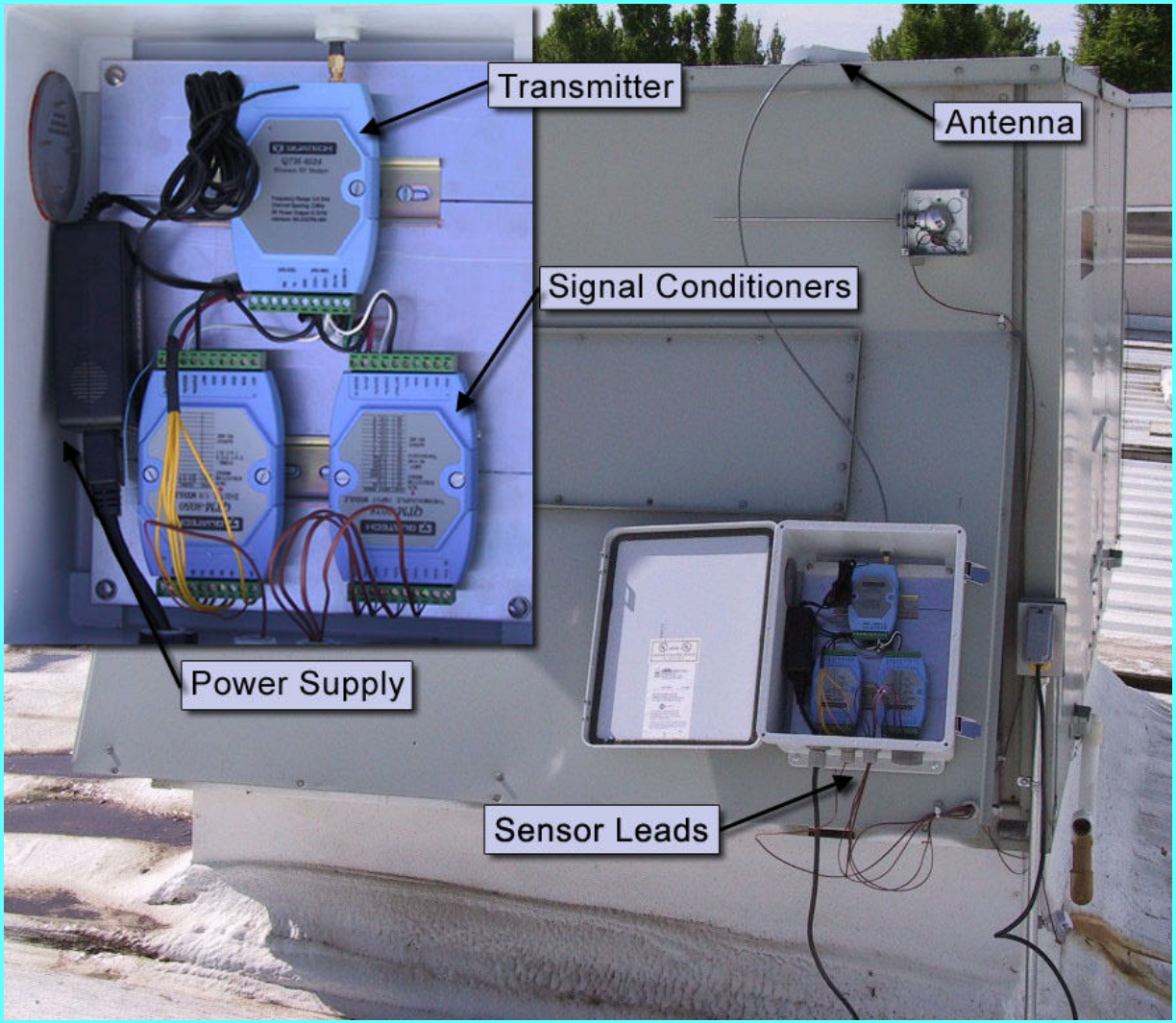
Demonstration: Rooftop Unit (RTU) for Small Commercial Buildings

Application:
- remote monitoring
- diagnostics

Markets:
- small commercial
- chain stores

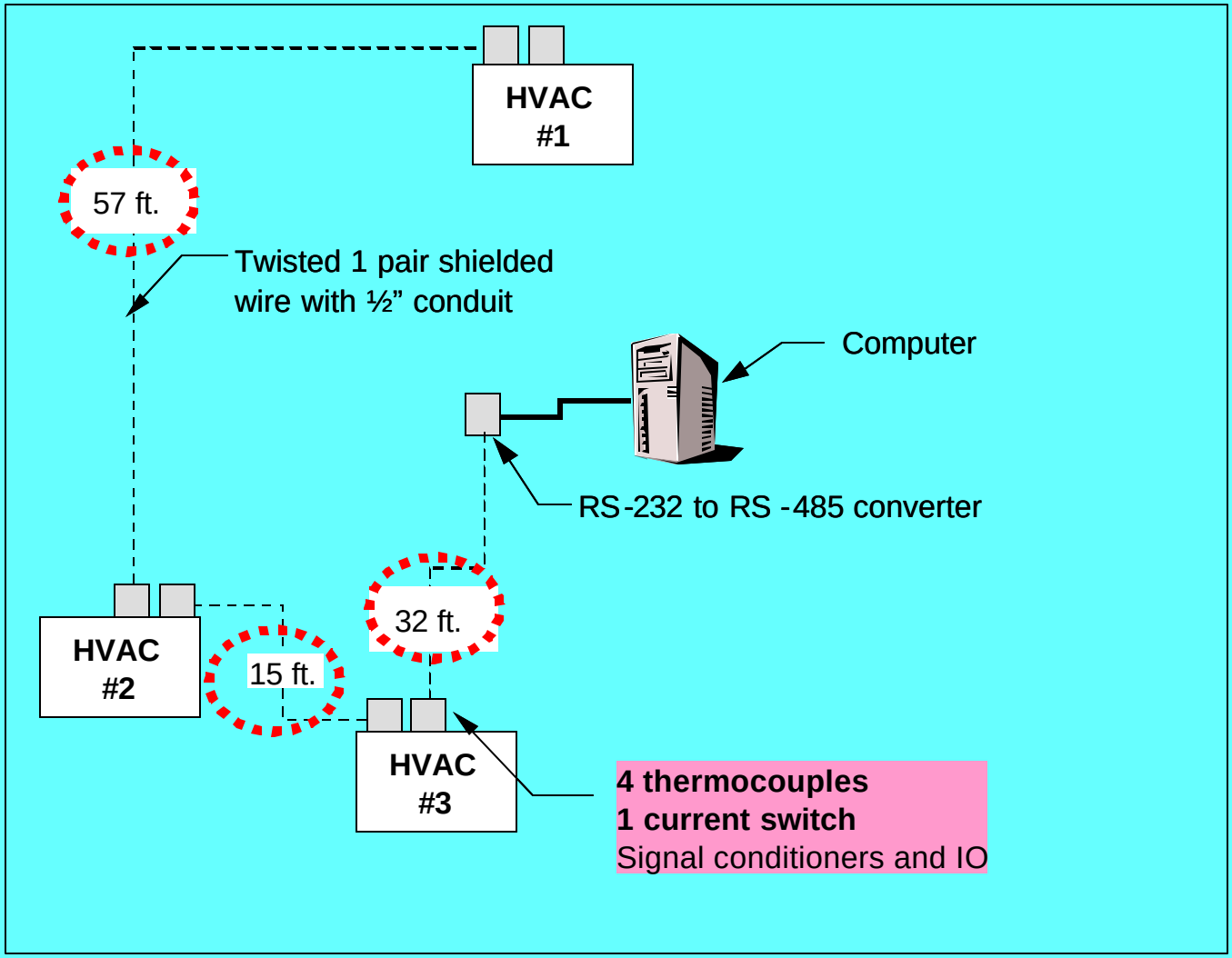


Rooftop Unit Installation at PNNL



Layout for 3 Rooftop Units for Cost Comparison

57ft
+15 ft
+32 ft
104 ft



Cost Comparison for 3 Rooftop Units

Description	Wired System		Low-Cost Wireless		High-Cost Wireless	
	Quantity	Cost	Quantity	Cost	Quantity	Cost
Thermocouple Sensors	12	$516			12	$516
Current Switch	3	$120			3	$120
RS-232 Converter	1	$799				
Thermocouple Signal Conditioner ($239 each)	3	$717				
Digital I/O module ($129 each)	3	$387				$387
Twister pair wiring	104 ft	$13				
½" Conduit	104 ft	$55				
Labor for installing sensors (3 hr per unit)	9 hrs	$450	9 hrs	$450	9 hrs	$450
Labor for installing wire and conduit (at $7 per ft)	104 ft	$729				
R.F. transmitting units with sensors and signal conditioners			3	$900		
R.F. receiver unit			1	$600		
2.4 GHz wireless radio modem ($800 each)					6	$4,800
Thermocouple input transmitter ($239 each)						$717
Total Cost		**$3,785**		**$1,950**		**$7,000**

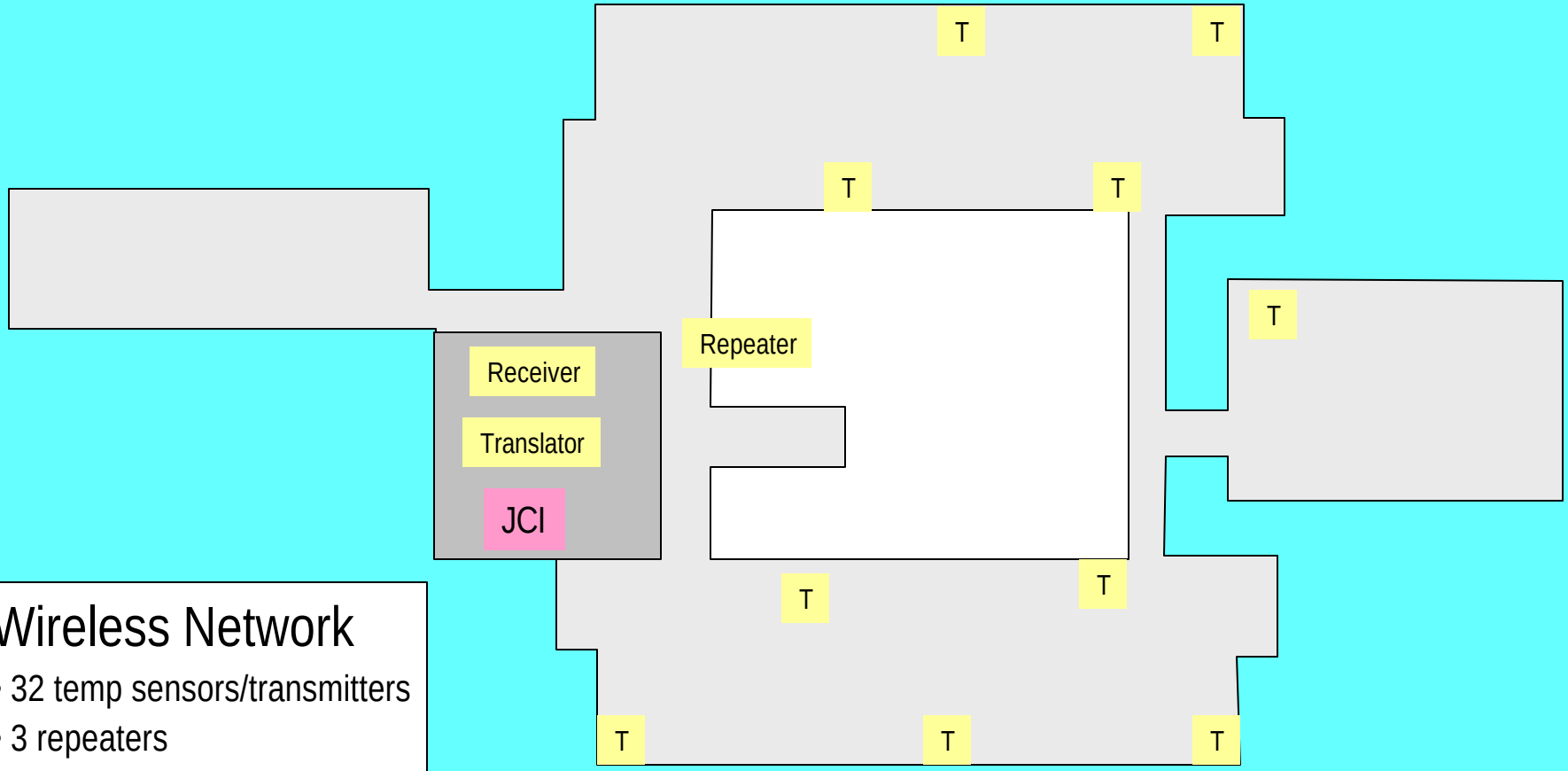
Results:

- wireless can be 50% - 190% of the cost of wired systems
- low cost solution: $133/node

In-Building Wireless Technology Demo at PNNL

- circa 70,000 squft. office space
- steel-concrete construction
- 3 floors,
- Built-up HVAC System
- Chilled water reset using zone temp

Wireless Network Topology



Wireless Network

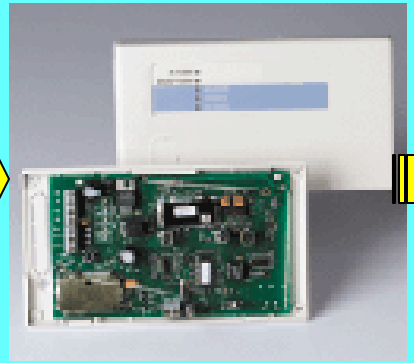
- 32 temp sensors/transmitters
- 3 repeaters
- 1 receiver
- 1 translator

T temperature sensor

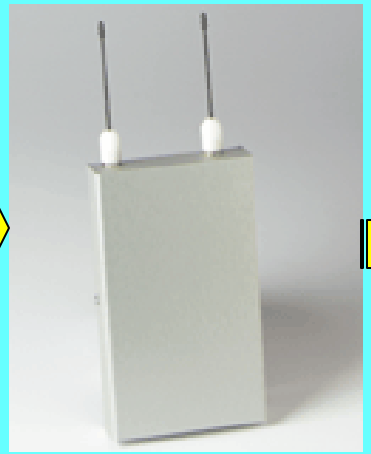
Inovonics Wireless Network at PNNL

Battery-powered
Temperature **sensor**
and **transmitters**

Repeaters



Receiver
1 hundred transmitters



Translator
From wireless to
JCI's N2 bus

Translator

Metasys

JOHNSON CONTROLS

Cost Comparison for In-Building Sensors

	Qty	Wired Design		Wireless Design	
		Cost per Unit	Total Cost	Cost per Unit	Total Cost
Temperature sensor	30	$60	$1,800	$100	$3,000
Wiring	3000 ft	$1.6 per lin. ft	$4,800		
Wireless network gear, inc. repeater, receiver, translator					$2,475
RF surveying	4 hours			$100	$400
Wireless network configuration	4 hours			$100	$400
Total cost			$6,600		$6,275
Cost per sensor			**$220**		**$209**

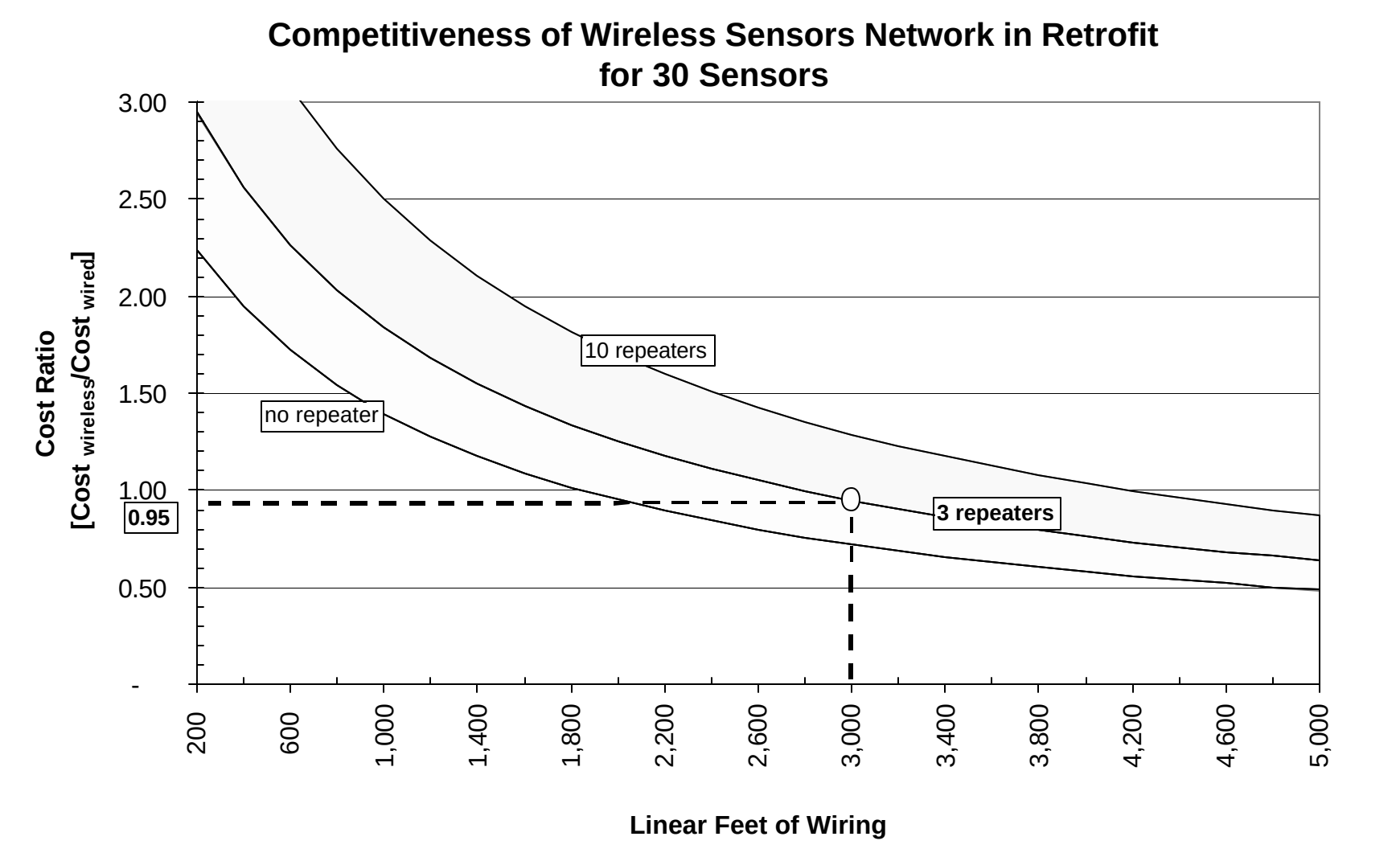
Uncertainties:

- cost estimates for wired system not based on actual bid
- mark-up on wireless products (we assumed 50%)

Results:

- wireless slightly less (5%) expensive than wired
- wireless easily extendable

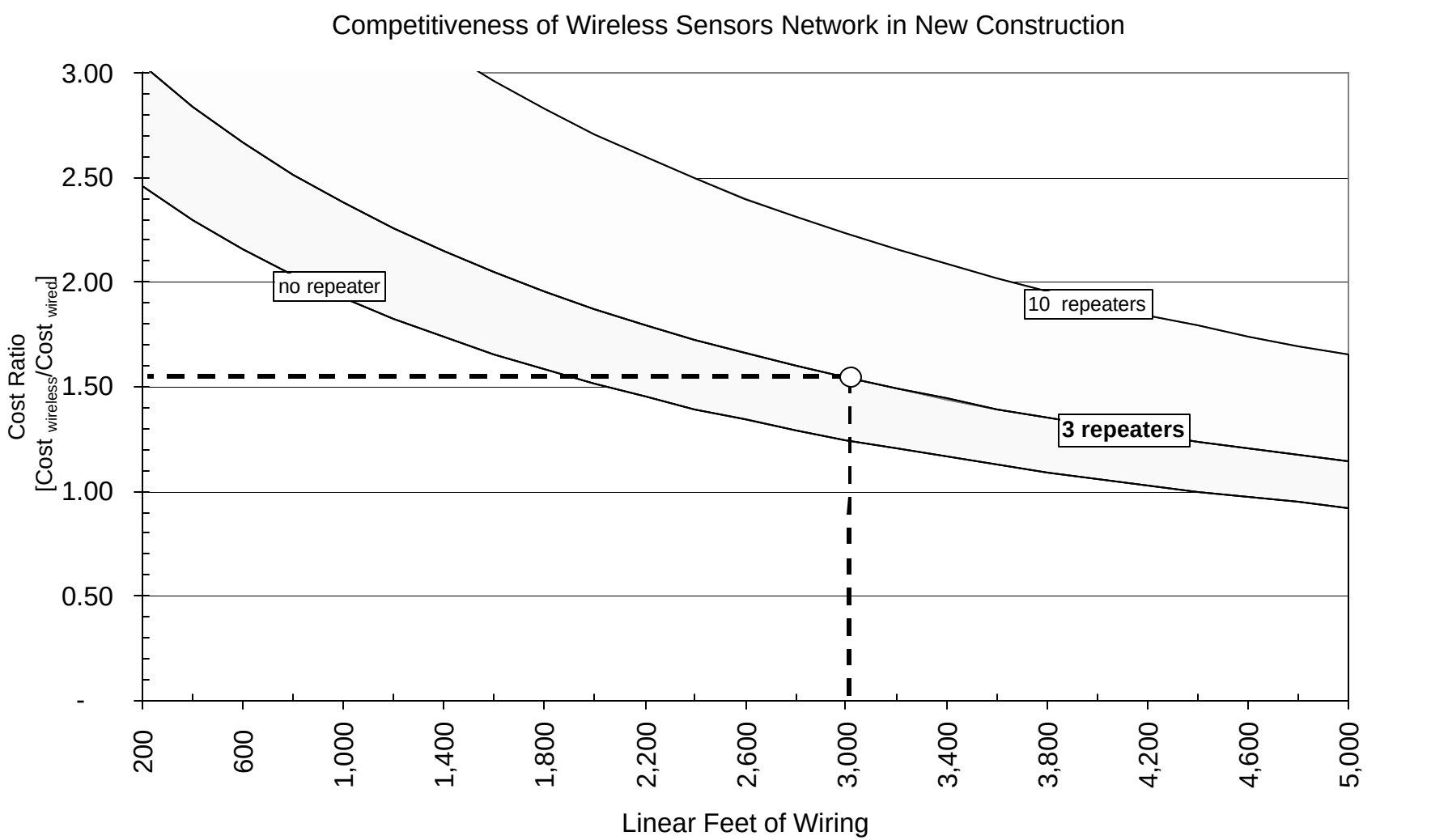
Wireless Cost-Competitiveness - Retrofit



Market Transformation Considerations

- HVAC Control Installer
  - Train installers to perform RF surveys
  - Subcontract wireless installation work
- Facility/Building Owners
  - Integration into existing HVAC control network is a MUST
  - Confidence and trust building
  - If battery operated, adopt battery replacement into O&M plan
- Security
  - In Federal/high security facility, wireless networks may need to be reviewed for vulnerability

Future Trends

- Sensors:
  - Cost reduction from currently $150-200/node to
    - $10-20/node by simplification of transmission -> next 2 years
    - $5/node forecasted by Bluetooth -> next few year ???
    - Sub $1/node using self-configuring networks (DARPA) -> longer term
  - Applications
    - Predominant sensors for open loop control (2-10 min update frequency)
    - Temporary data logging
    - Closed loop control requires high update rates (sec to sub-sec.) more difficult
- Controls:
  - Industrial process control will lead the way
  - HVAC control will follow
    - Light switches
    - Thermostats
    - VAV controllers to retrofit stand-alone pneumatically operated VAV controller

Wireless Cost-Competitiveness – New Construction