An Energy-Efficiency Workshop and Exposition
Orlando, Florida

Emerging Technologies for Building Operation and Facility Management

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PNNL-SA-39225

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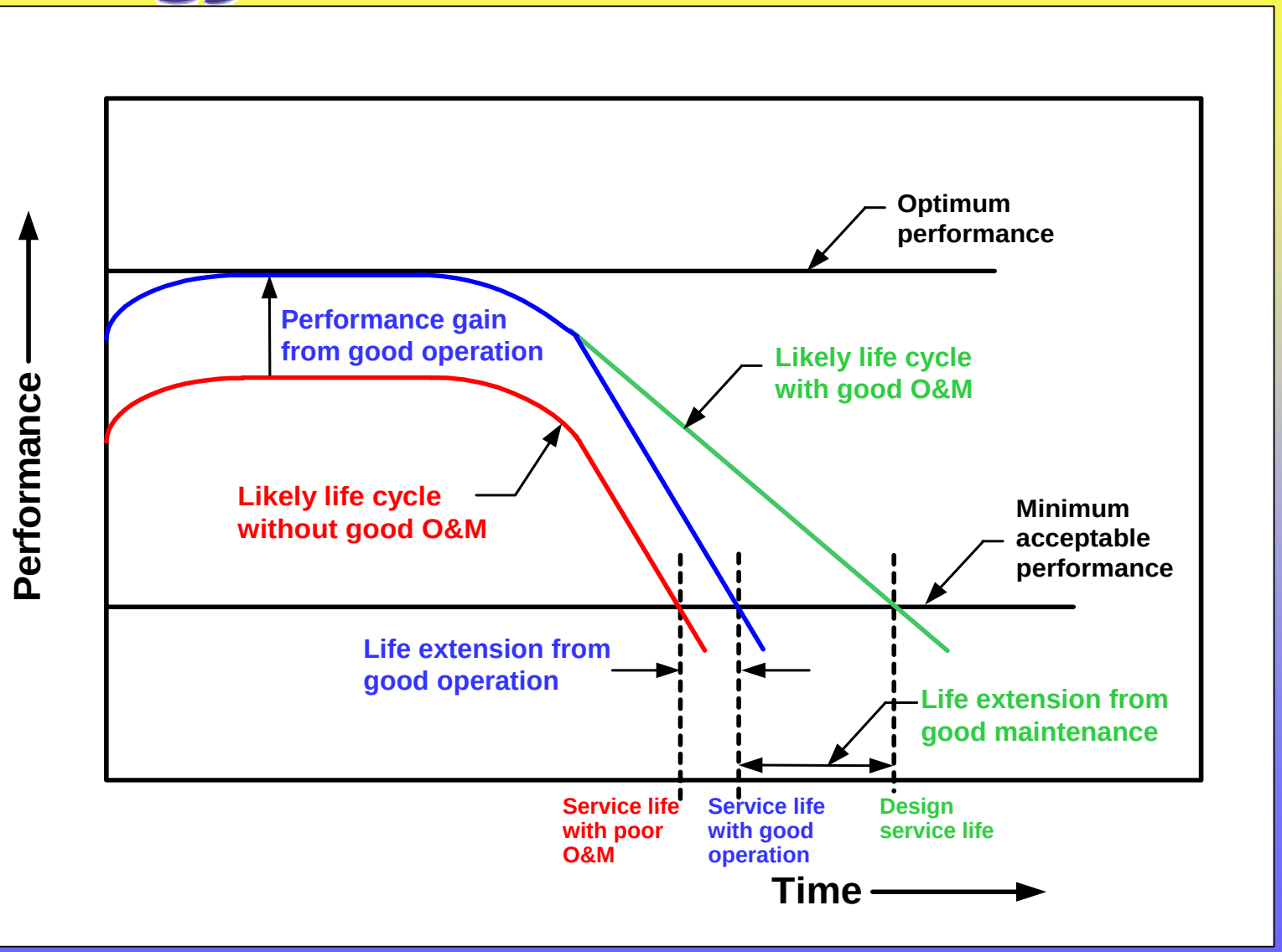
Please be courteous to our speakers

Turn off all cell phones
and
Set pagers to vibrate

Overview

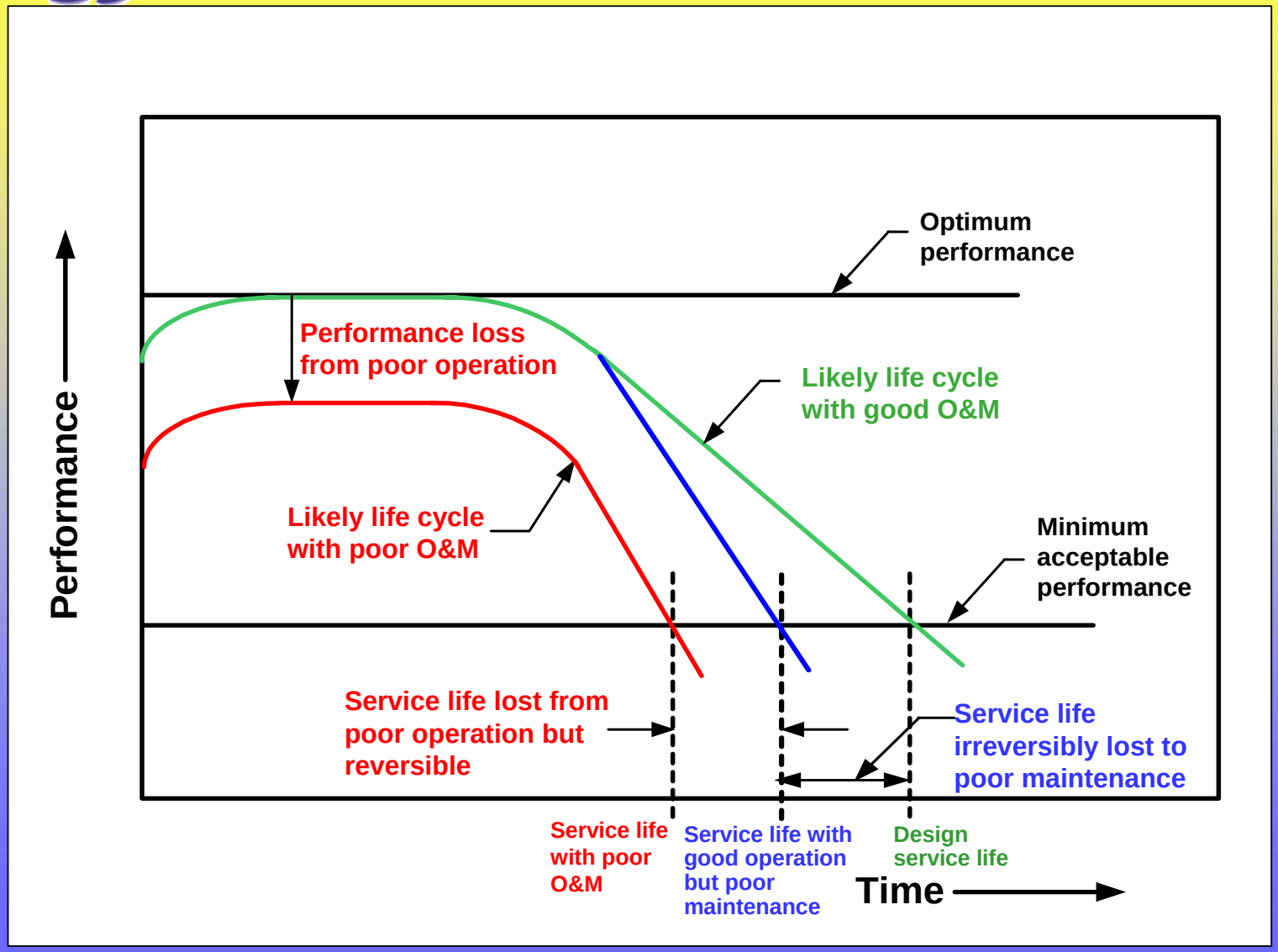
- Why O&M
- Wireless sensing
- Wireless power meter
- Automated diagnostics – Whole Building Diagnostician (WBD)
- Facility management via your web browser (Patrick O'Neill, NorthWrite Inc.)

Benefits of Good O&M



Adapted from Ab Ream, Federal Energy Management Program, Presentation "Federal Energy Efficiency through Improved Operation and Maintenance."

Losses from Poor O&M



Wireless Radio Frequency Sensing

- Two generic building applications
  - In-building
    - Many physical obstacles to rf communication
    - Indoor environmental sensing
    - Sensors for equipment
  - Rooftop
    - Line of sight can be achieved
    - Electromagnetic noise from equipment
    - Sensors primarily for equipment

PNNL Test Sites

PNNL 337 Building

- about 70,000 sq. ft. office space
- 3 floors
- steel-concrete construction
- built-up HVAC system
- wireless temperature sensors 1

PNNL EMSL Building

- one wing is instrumented
- about 15,000 sq. ft. office space
- 2 floors
- steel-concrete construction
- wireless temperature sensors 1 2

337 Building

- Federally owned
- operated by Battelle
- about 70,000 sq. ft. office space
- U-shaped with courtyard between wings
- steel-concrete construction
- built-up central HVAC system

Wireless Network
32 temperature transmitters
3 repeaters, 1 per floor
1 receiver/translator

Wireless Sensor Network Technology 1

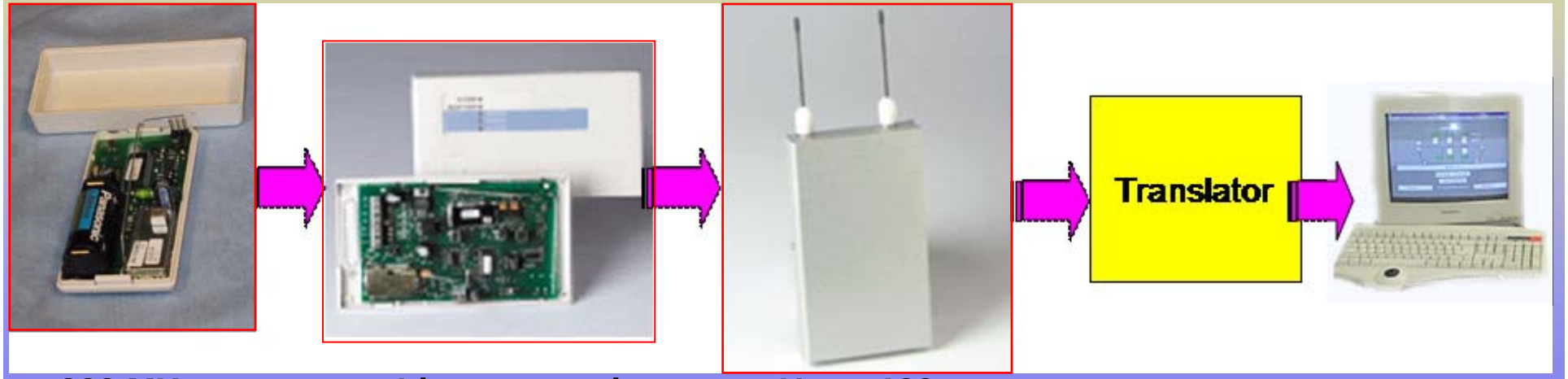
Battery-powered temperature **sensors** and **transmitters**

Repeater

Receiver

Translator
From wireless to JCI Metasys

Building Automation System



- **900 MHz**
- **FHSS**
- **Range: 2500 ft.**
- **Battery life: 3 years**
- **Sensor: RTD**

- **Line powered**
- **Range: 4 miles**

- **Up to 100 transmitters**

PNNL EMSL Building

- 15,000 sq. ft. in wing
- 2 floors
- Central open atrium space
- 56 offices on two corridors
- Walls
  - Metal studs
  - Gypsum wall board
- Ceiling:
  - Metal sheeting
  - Concrete floor

Wireless Sensor Network Technology 2

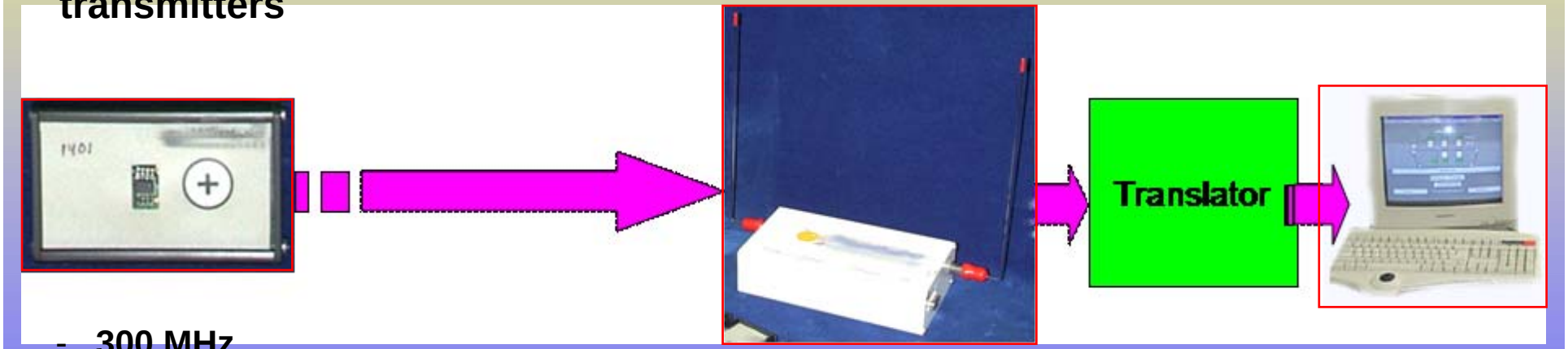
Battery-powered temperature **sensors** and **transmitters**

No repeater

Receiver transmitters

Translator from wireless to Johnson N2 bus

Building Automation System



- **300 MHz**
- **Range: 300 ft.**
- **Battery life: 5 years**
- **Sensor: IC**

In Building Wireless: Findings and Lessons Learned (slide 1)

- Installation and setup was straight forward
- Wireless network in 337 Building has worked nearly flawlessly since Spring 2002
- Facility staff fully embraced wireless technology as enabling technology
  - Control of space conditioning in bay area – turned off automatically when garage door opened
  - Diagnostics:
    - Heat buildup in kitchen
    - Cold spots in zones led to reset of the entire building temperature, thus avoiding overcooling and use of space heaters
  - Working on monitoring emergency lighting ballasts – implementation will reduce cost per point for all sensors
  - Considering adding occupancy-based demand-controlled ventilation in EMSL

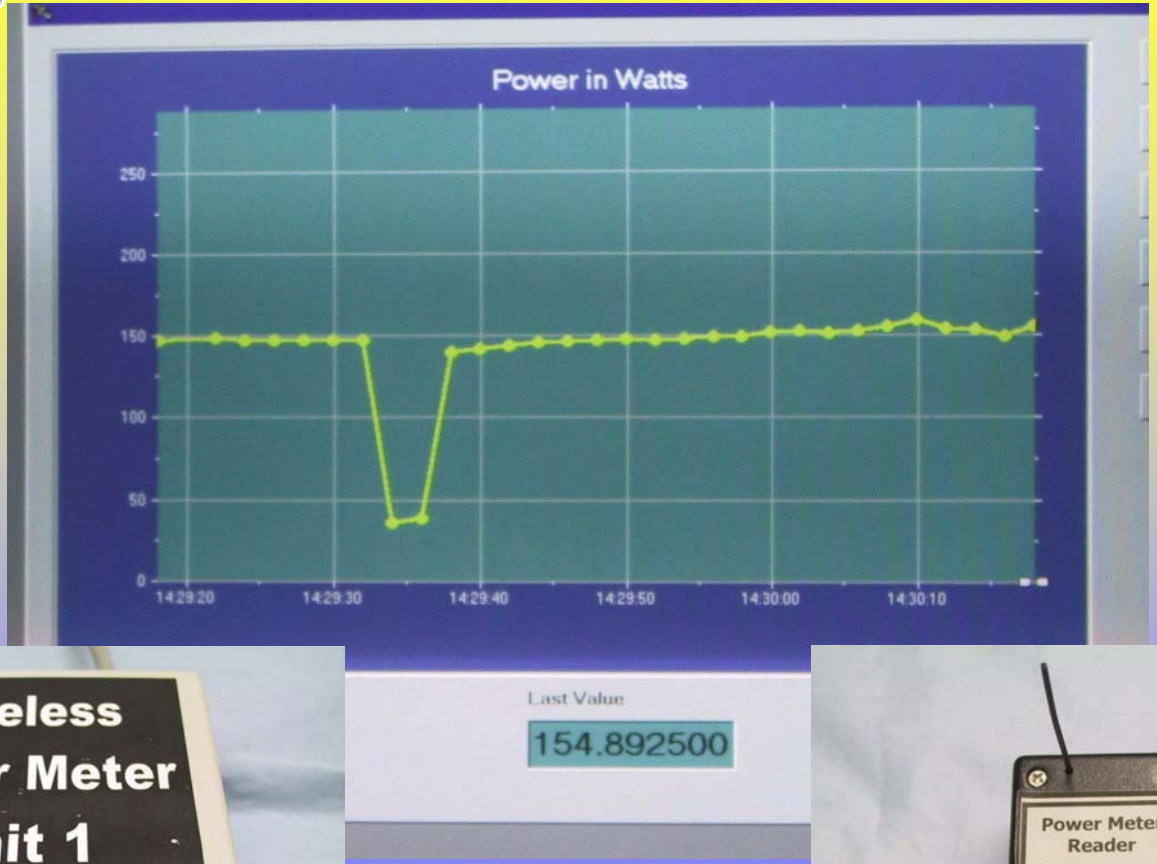
In Building Wireless: Findings and Lessons Learned (slide 2)

- Directly quantifiable benefits:
  - Chilled water reset strategy based on averaged zone temperatures as proxy for meeting load.
  - $6000 cost savings per year
  - Payback: 6 – 12 months
- Communication to occupants was necessary to explain new technology.
- RF-surveying for locating receivers and repeaters - Requires training. Now done by controls specialists

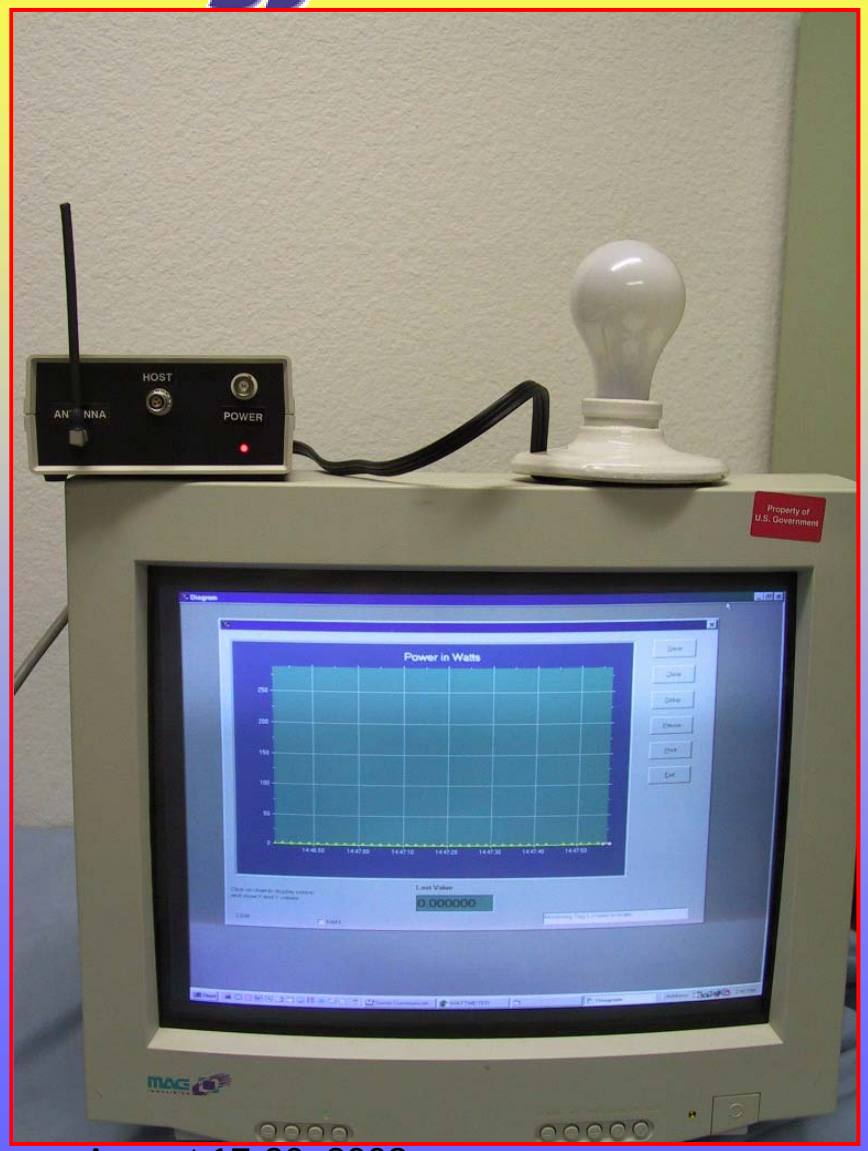
Wireless Power Meter

- Objective: Provide power meter for end-use monitoring that is:
  - Low cost – under $100
  - Easy to install
  - Convenient to use – monitor meters from office or control room
  - Reliable
- Single-phase power meter completed (ready for field testing)
- Three-phase meter planned for development in Fall 2003

Wireless Power Meter



Wireless Power Meter



Wireless Sensing for Rooftop HVAC Units

- Objectives
  - Assist service technicians in targeting service while on site
  - Provide for central monitoring by building staff or service providers for condition-based maintenance
  - Provide real-time feedback to operators
  - Thereby, change the dismal condition in which most rooftop units are operated and maintained

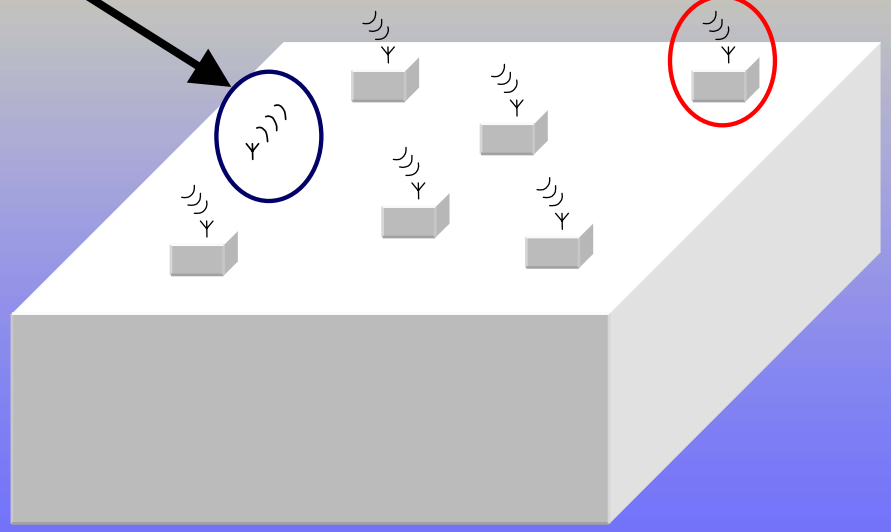
Wireless Monitoring of Rooftop Units

Envisioned System

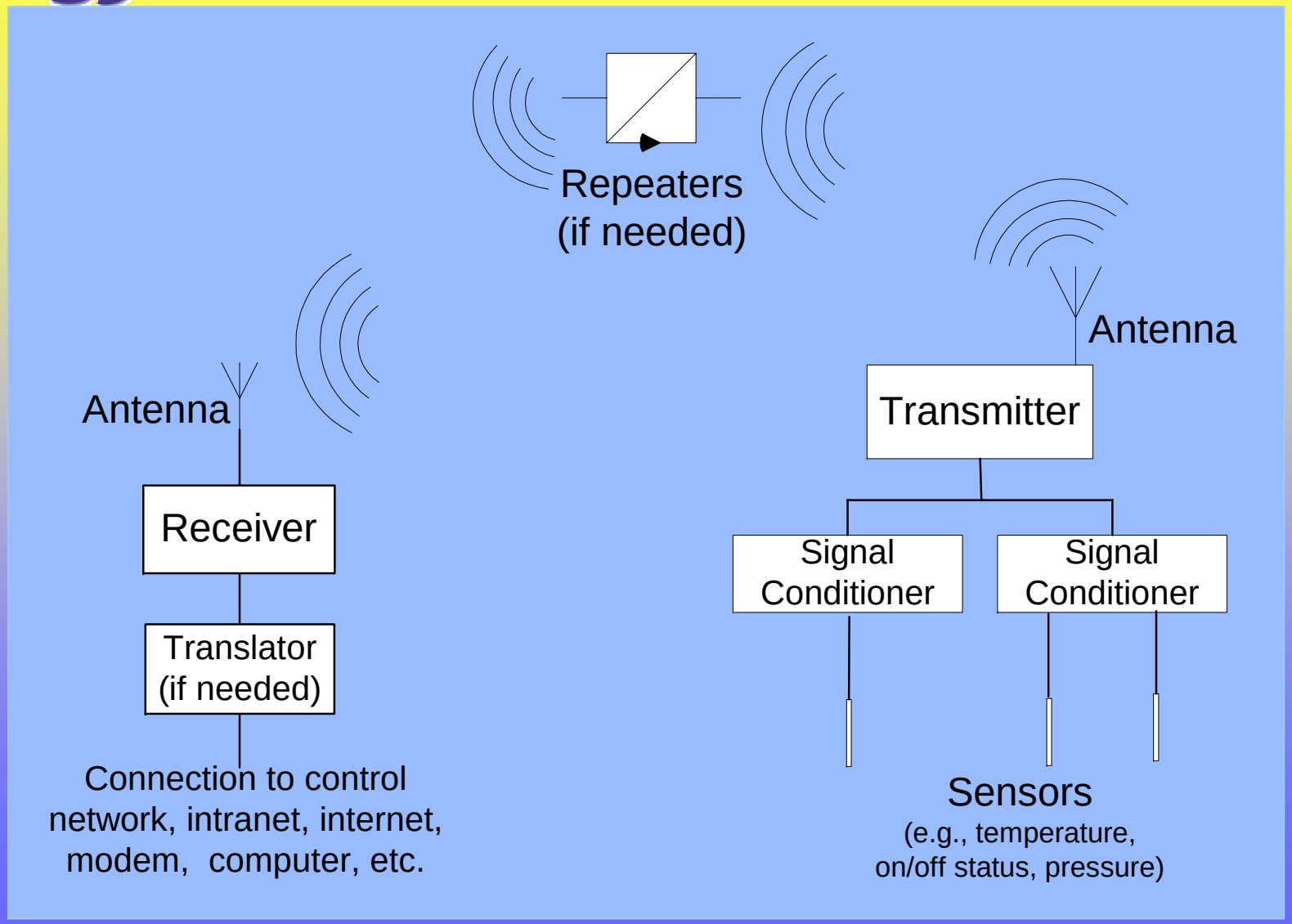
Each rooftop unit with sensors, one rf transmitter, and one antenna

Rooftop rf receiver with connection to:

- computer in building
- intranet
- Internet
- long-distance wireless
- wireless to personal digital assistant
- wired telephone modem

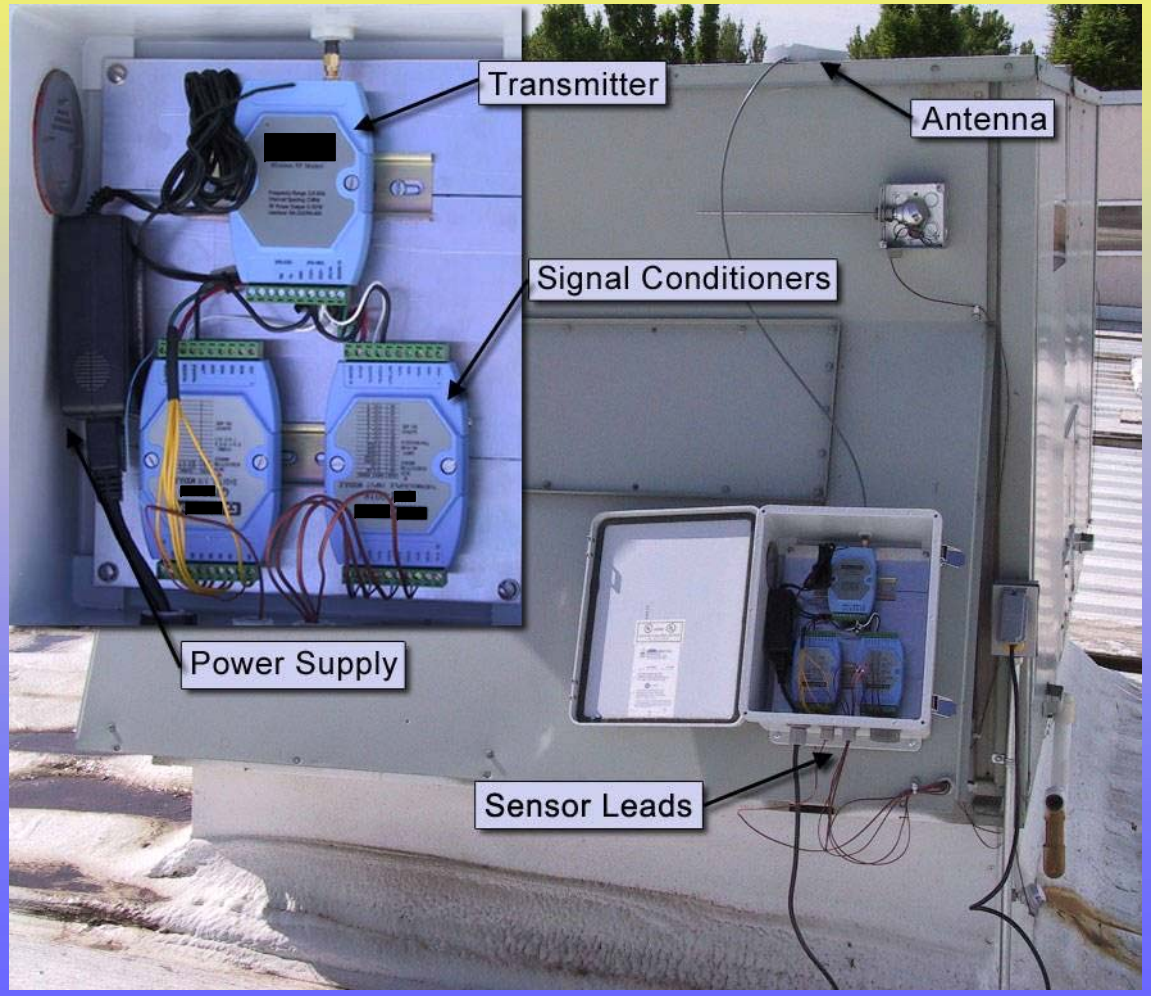


A Closer Look



System Types Tested (slide 1)

- System configured from generic components – applied to one unit

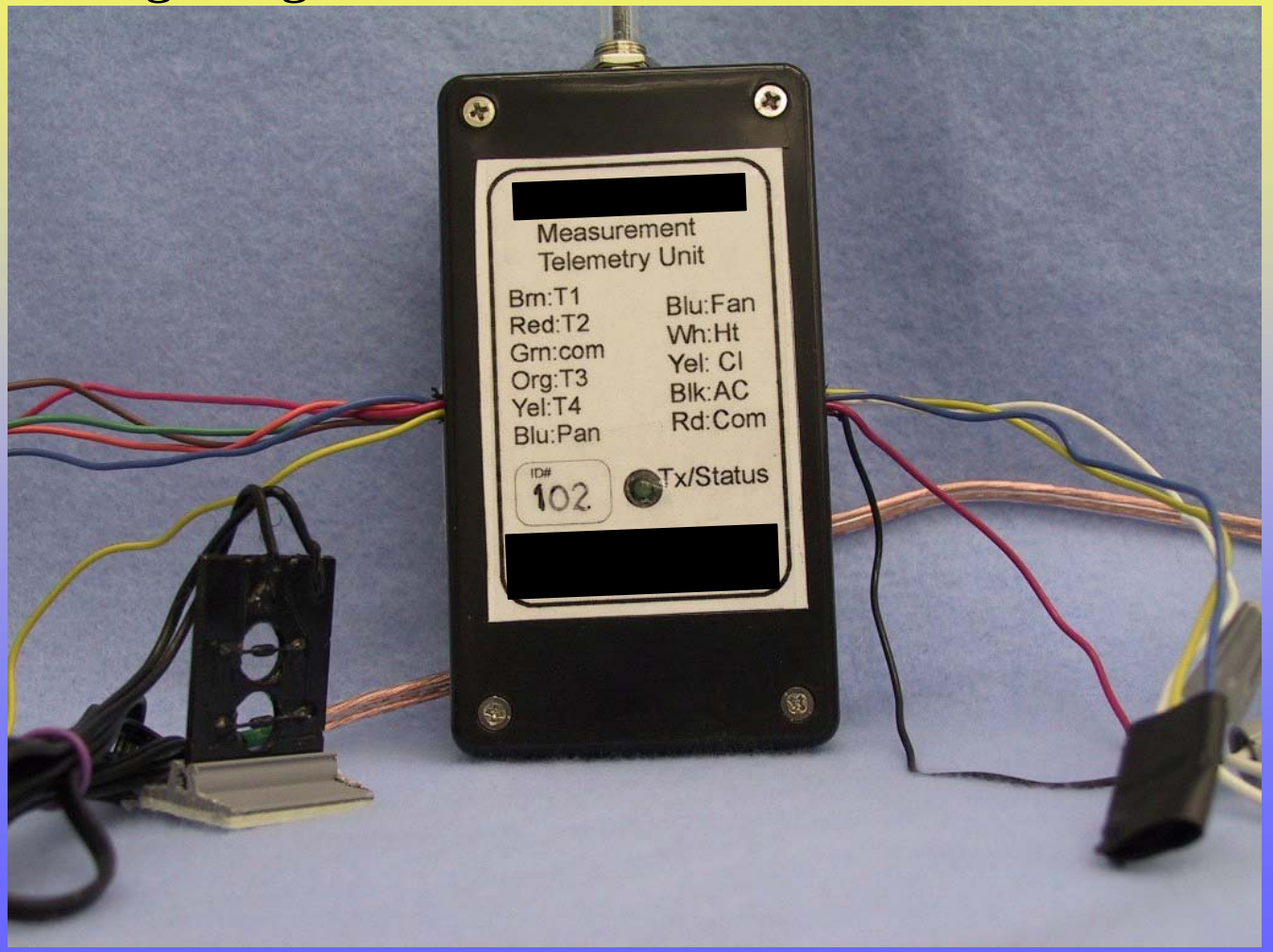


System Types Tested (slide 2)

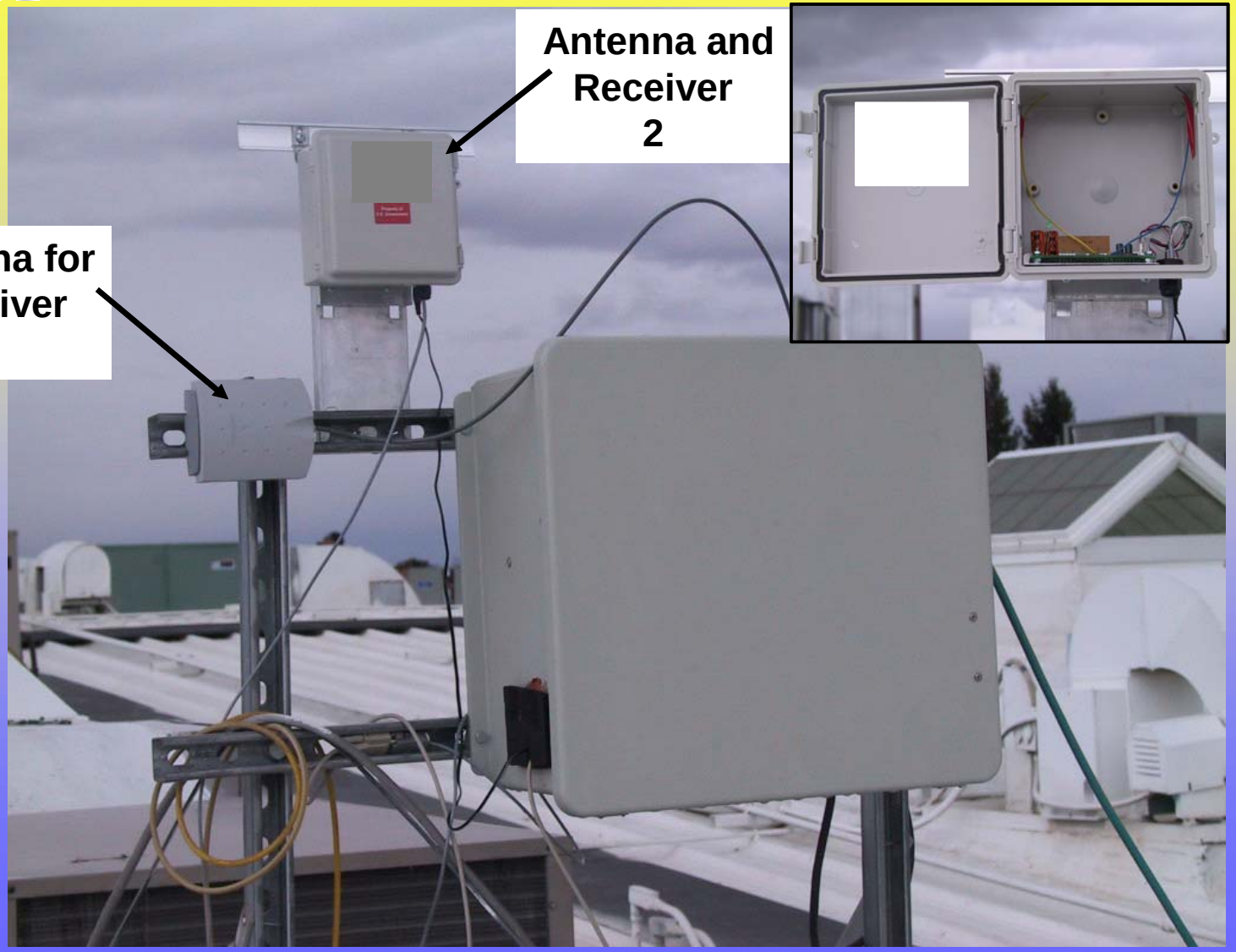
- System specifically manufactured for package unit monitoring – applied to 4 units

System Types Tested (slide 3)

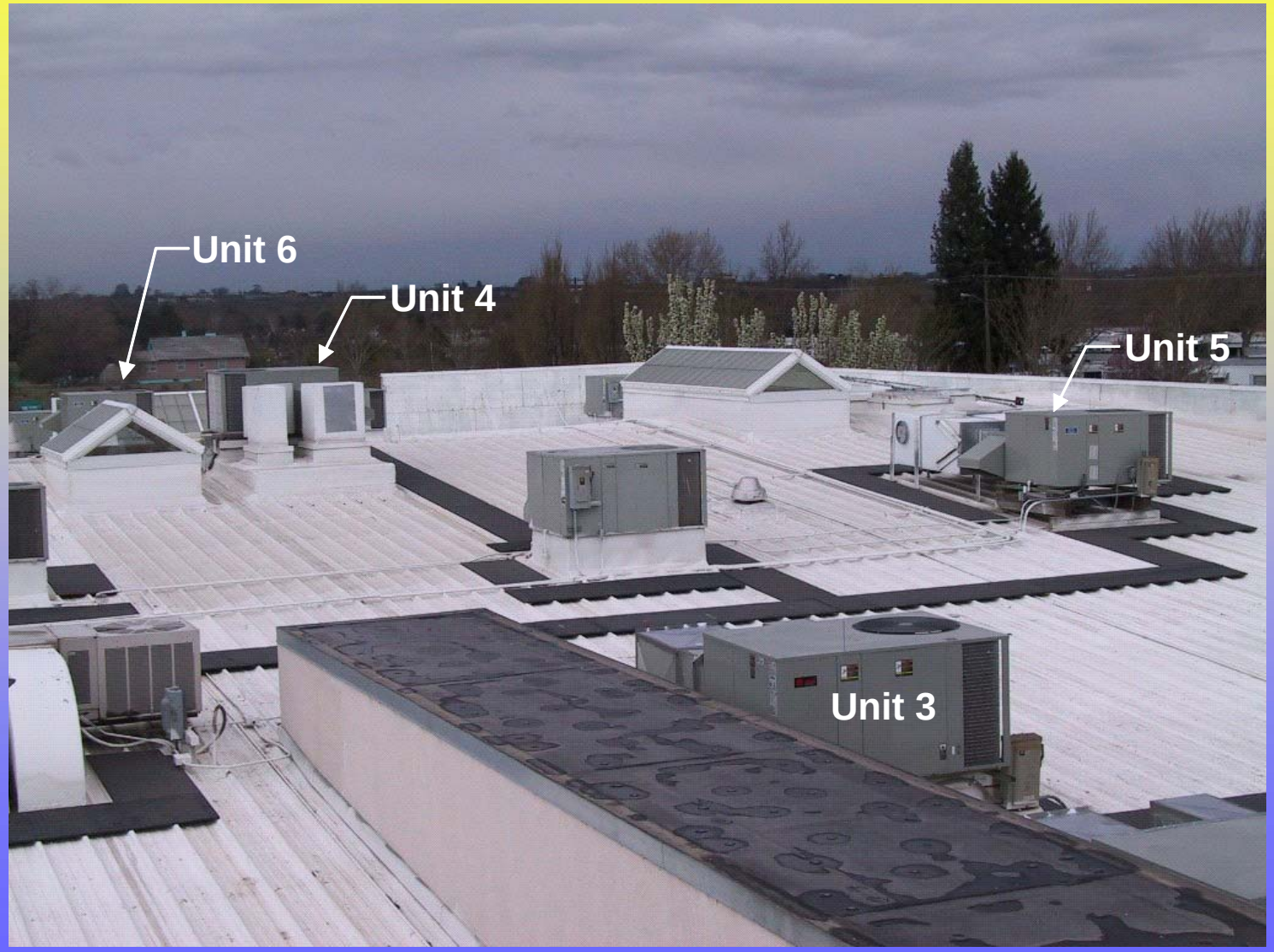
- Close up of wireless transmitting unit with signal conditioning integrated into it



Receiver Stations



Test Environment



Rooftop Wireless Monitoring Cost Competitiveness

Cost Component	Cost	
	Monitoring System for Three Packaged HVAC Units	
	Wired Design	Wireless Design
Sensors	$636	$636
Wiring	$68 [1]	---
Communication and signal-conditioning hardware	$1903	$1500
Labor	$1179 [2]	$450
Total cost	$3786	$1950
Average cost per sensor	**$316**	**$163**

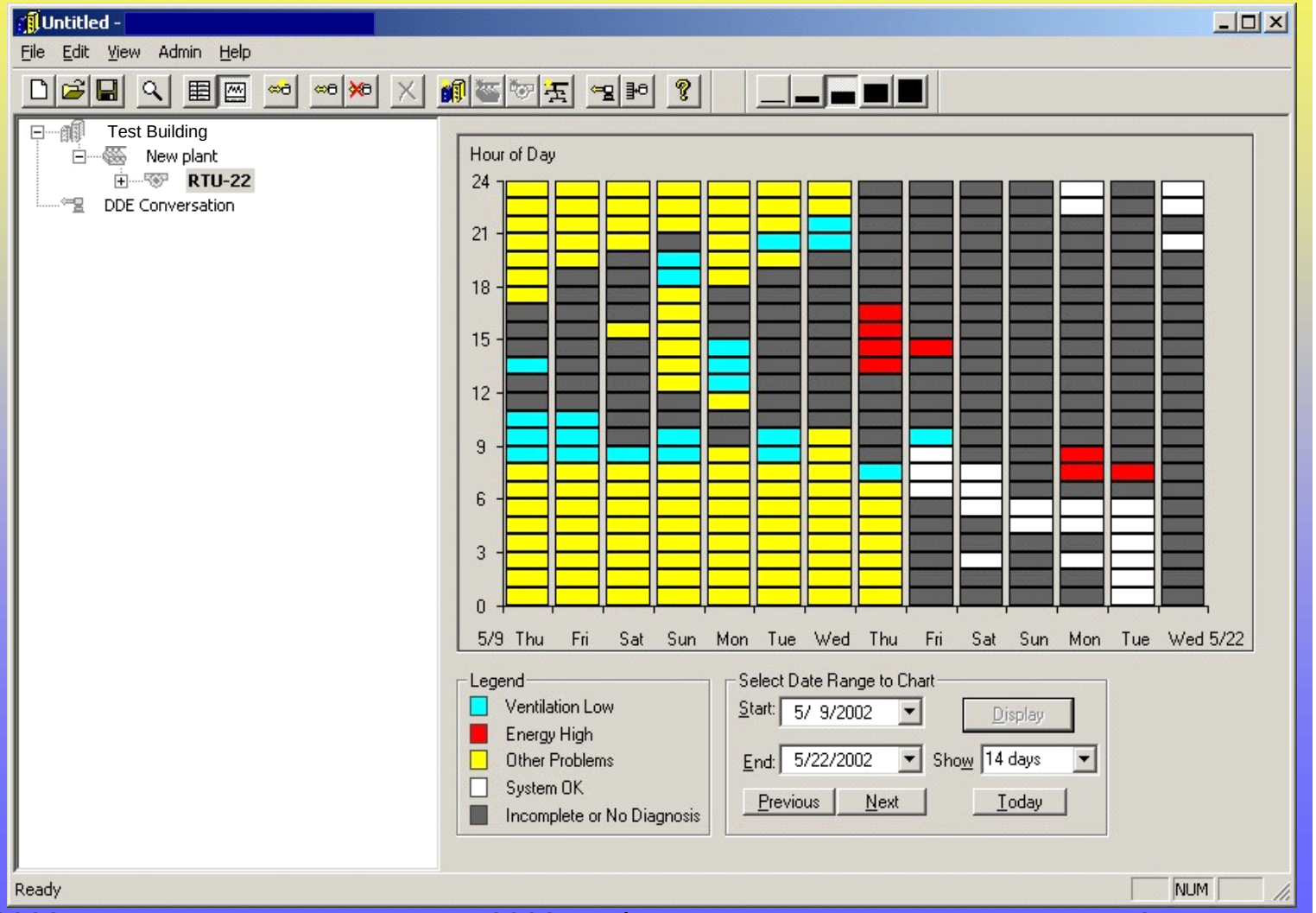
Rooftop Wireless Monitoring Data

SystemId	PollDate	FanOnFraction	Tmix	Tout	Tret	Tsupply
3	29-Mar-02	1	68.7	56.42	68.18	65.17
3	29-Mar-02	1	69.06	58.8	68.73	62.94
3	29-Mar-02	1	69.04	60.78	68.7	62.63
3	29-Mar-02	1	69.71	62.81	69.2	62.15
3	29-Mar-02	1	70.82	64.79	70.23	62.31
3	29-Mar-02	1	71.2	65.42	70.59	62.56
3	29-Mar-02	1	69.13	59.7	68.09	60.62
3	29-Mar-02	1	70.8	56.73	69.98	71.25
3	29-Mar-02	1	70.28	54.57	69.2	68.28
3	29-Mar-02	1	70.08	51.94	68.79	68.28
3	29-Mar-02	1	70.26	50.34	68.88	69.94
3	29-Mar-02	1	70.41	49.37	68.93	69.22
3	29-Mar-02	1	70.46	47.78	68.9	69.22
3	30-Mar-02	1	70.05	46.54	68.41	69.78
3	30-Mar-02	1	70.21	47.17	68.55	69.98
3	30-Mar-02	1	69.71	46.56	67.96	68.34
3	30-Mar-02	1	69.83	46.31	68.1	69.53
3	30-Mar-02	1	69.96	45.86	68.19	69.62
3	30-Mar-02	1	69.98	44.78	68.12	69.54
3	30-Mar-02	1	70.03	43.59	68.09	69.49
3	30-Mar-02	1	71.56	48.81	70.28	71.43

Automated Diagnostics
Making Information out of Data

Whole-Building Diagnostician (WBD)

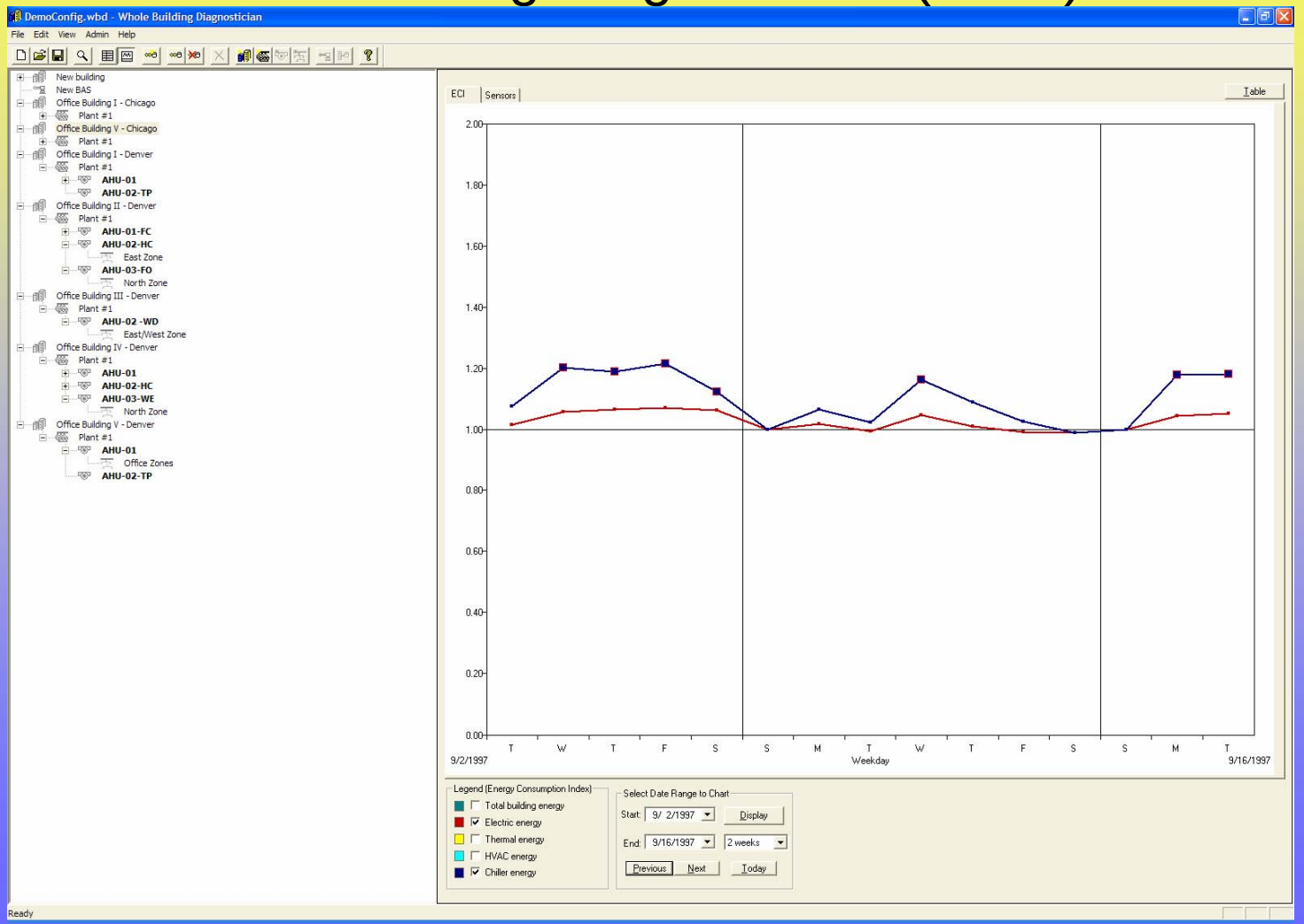
Outdoor-Air Economizer Diagnostic (OAE) Tool



Automated Diagnostics
Making Information out of Data

Whole-Building Diagnostician (WBD)

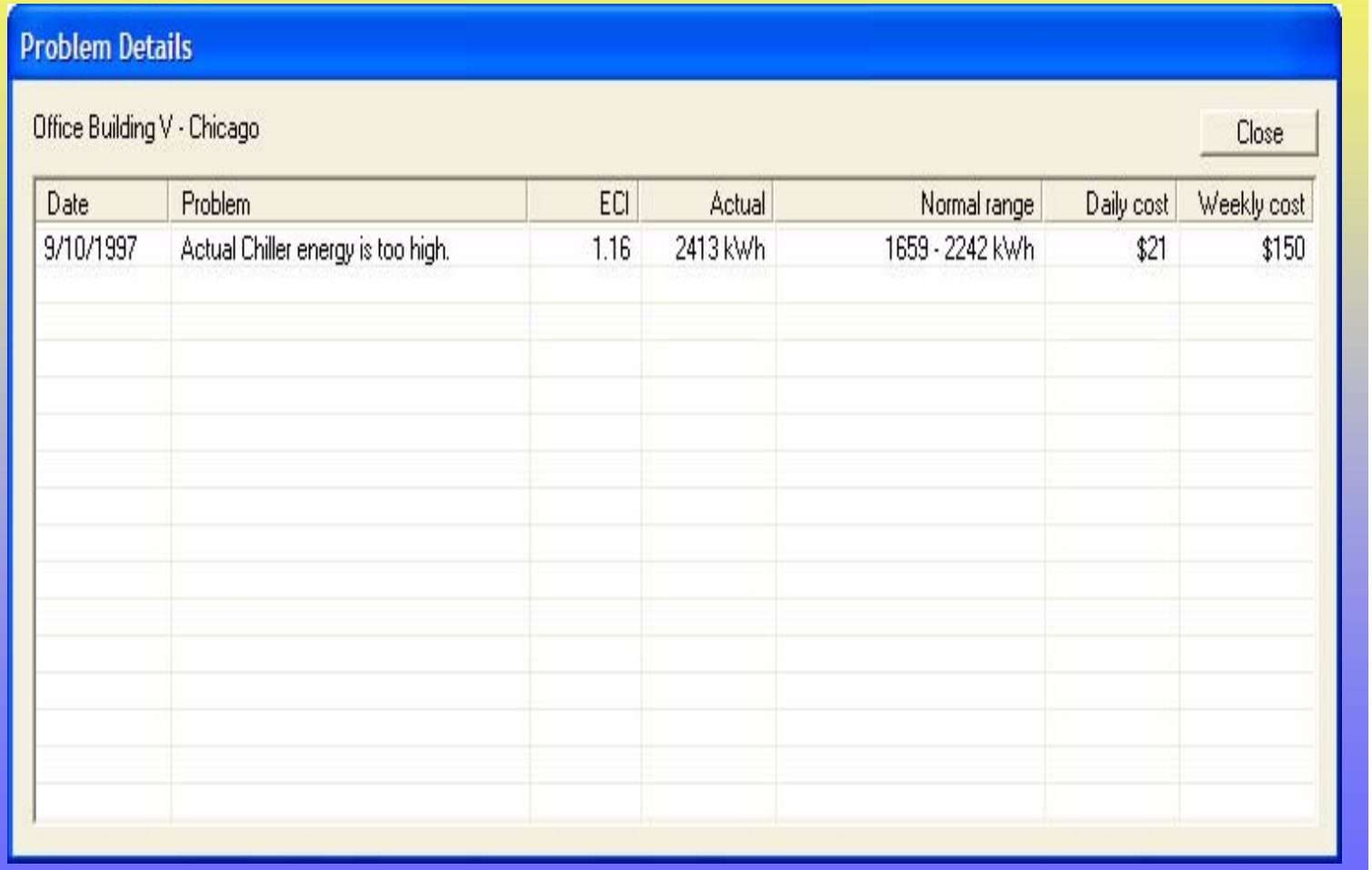
Whole-Building Energy Tool (WBE) - 1



Automated Diagnostics
Making Information out of Data

Whole-Building Diagnostician (WBD)

Whole-Building Energy Tool (WBE) - 2



Date	Problem	ECI	Actual	Normal range	Daily cost	Weekly cost
9/10/1997	Actual Chiller energy is too high.	1.16	2413 kWh	1659 - 2242 kWh	$21	$150

Web-Based Facility Management

Patrick O'Neill, NorthWrite Inc.

The Facility Manager

"I need a simple way to streamline communications between employees, customers, suppliers, contractors, and staff".

Larry Kapustka
Director of Facilities
Honeywell Labs

What Facility Manager's Are Saying

200+ Direct Interviews

- ✓**Facilities are viewed as a cost function which is thinly resourced.**
- ✓**Facility costs/operations are globally competitive**
- ✓**More facilities to manage without increase in headcount.**
- ✓**Internal competition for capital investments.**
- ✓**Need to know more about energy savings and operational saving opportunities.**
- ✓**Difficult keeping pace with technology**

Are Federal facilities any different?

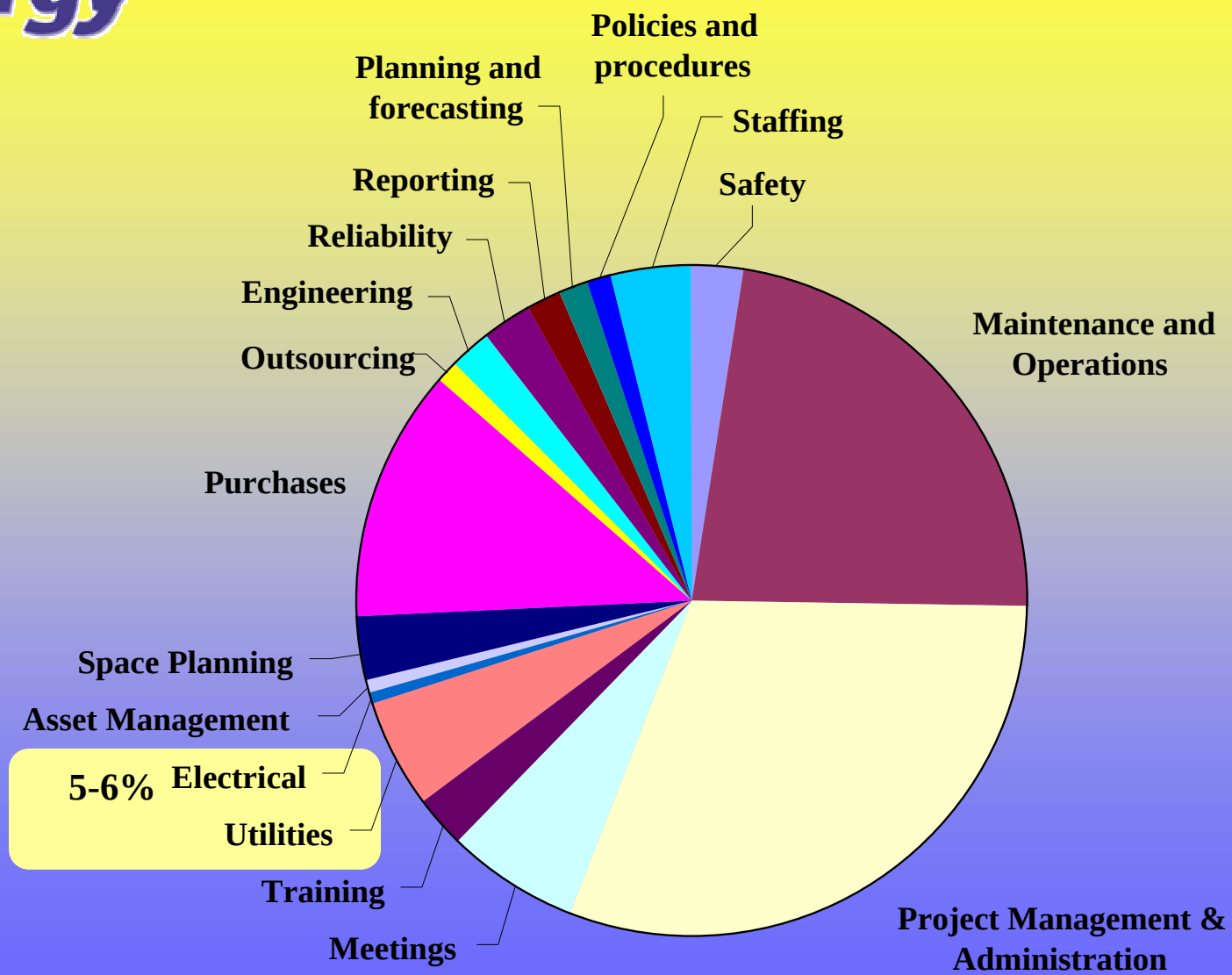
Top 10 Worker Complaints

According to the International Facility Management Association the top 10 worker complaints are as follows:

- ✓ **It's too cold**
- ✓ **It's too hot**
- ✓ **Poor janitorial service**
- ✓ **Not enough conference rooms**
- ✓ **Not enough storage/filing space in workstation**
- ✓ **Poor indoor air quality**
- ✓ **No privacy in workstation/office**
- ✓ **Inadequate parking**
- ✓ **Computer problems**
- ✓ **Noise level/too noisy**

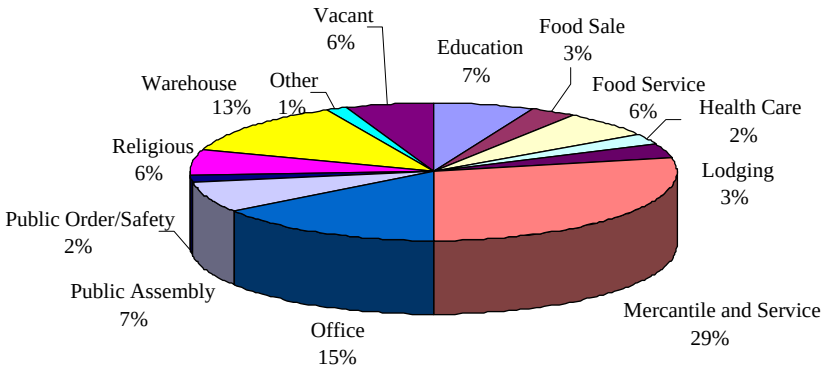
Incidentally, the survey also indicated that the most common complaint that the facility managers get from their manager is that the cost of operations is too high!

Proportion of Time Dedicated to FM Tasks

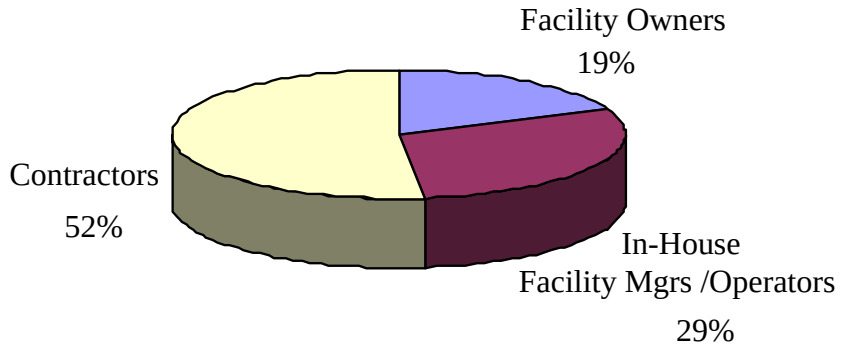


Global Market Sizing and Potential

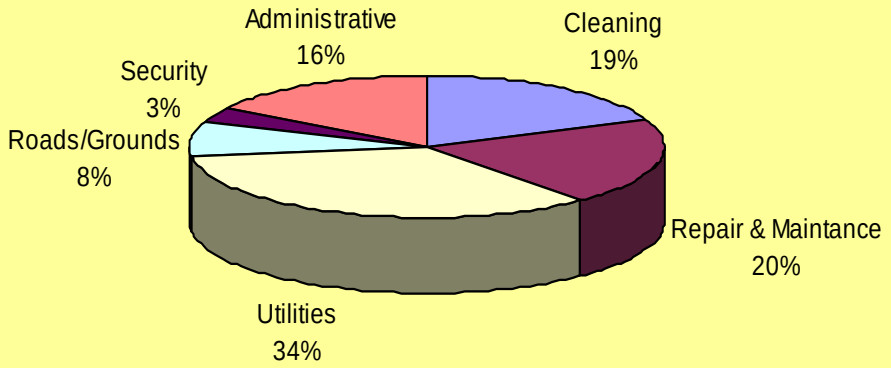
18 Million Existing Buildings



56 Million Facilities Professional



$1.2 Trillion Annual Purchases



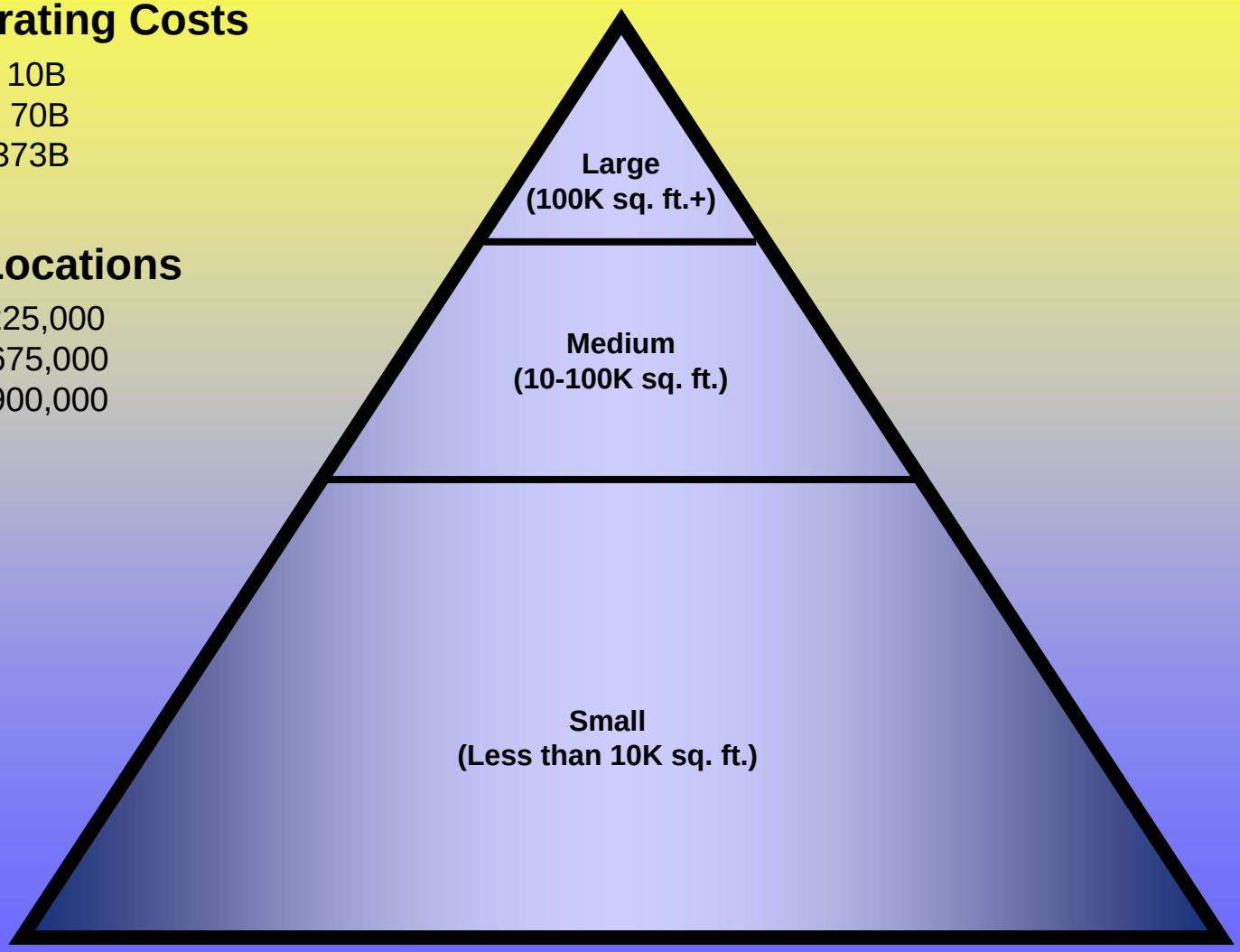
USA Building Population

Annual Operating Costs

Large	$ 10B
Medium	$ 70B
Small	$ 373B

Number of Locations

Large	225,000
Medium	675,000
Small	3,900,000



Customer Value Proposition

A.K.A: Where's the Money?

Applications Area	EQUIPMENT	OPERATIONS	ENERGY	PURCHASING
Information	•Alarms •Schedules •PM History •Trending and Modeling	•Service call tracking •Assets •Project History •Warranty Tracking	• Metering (KWH/ Demand & Amps • Utility Bills • Rate Agreements • Monitoring	• Pricing • Quantities • Vendor Performance • Bidding
Analysis	• Equipment Uptime • Reduced repairs • Predictive Alarms	• Service Call Validation • Vendor Report Card • Project Management	• Usage analysis • Rate Validation • Operational efficiencies	• Supplier Leverage • Purchase Aggregation • Cost Comparisons
Savings	Utility 2% - 5% Repair G&A Reduce Downtime	Utility 2% - 5% Repair G&A Reduce Downtime	Utility 1% - 2% G&A	G&A 1% - 4%

4% - 10% Combined Potential

5% - 12% Combined Potential

6% - 16% Combined Potential

The Service Provider

"I need productivity tools that are simple to understand, simple to use and are within my budget".

Jim Ronglie
President
Building Maintenance Management

What Service Providers are Saying

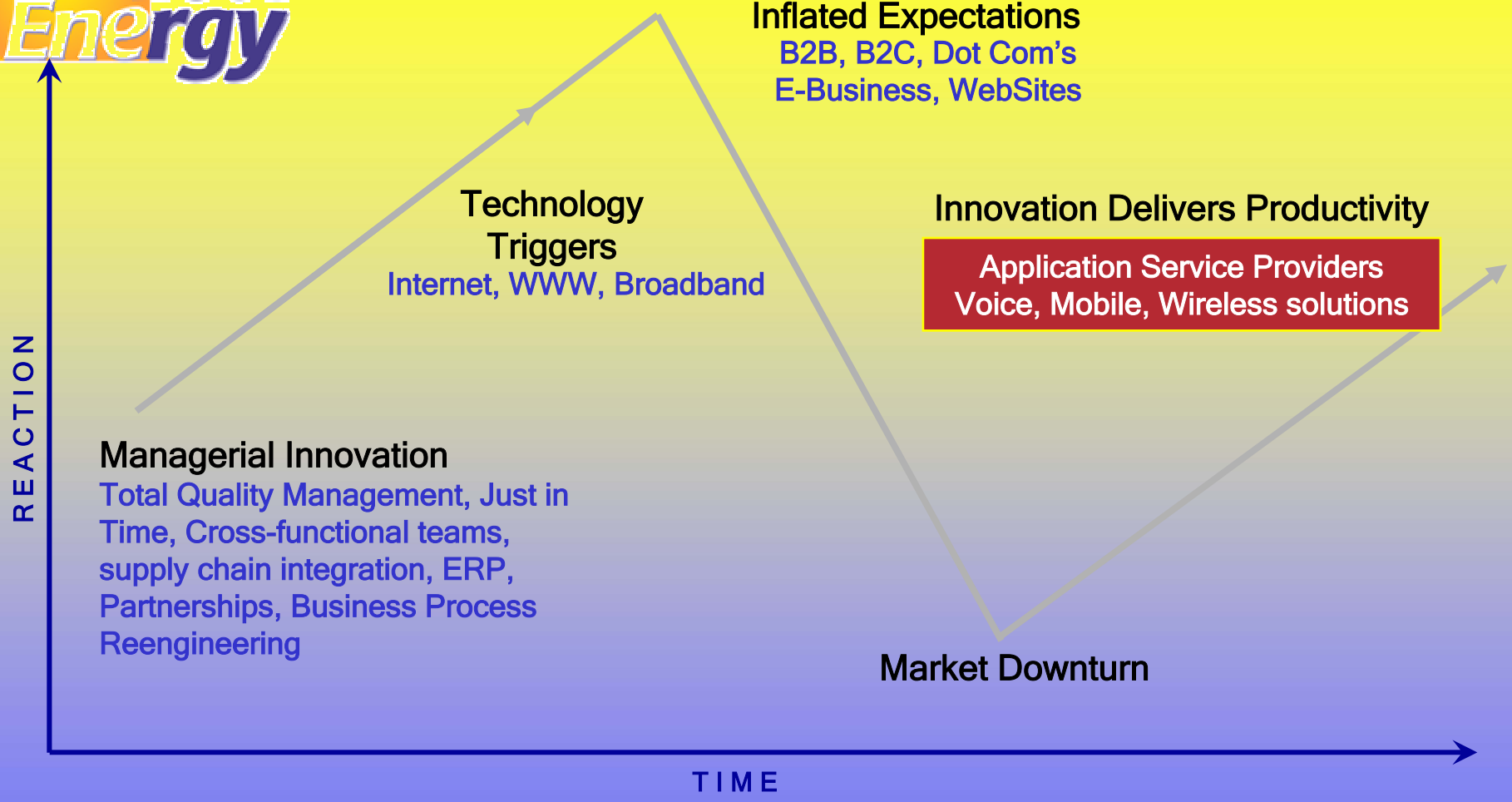
Statements:

- ✓**Logistics/work planning, growth, labor shortages, and cash flow:**
  - **"We never do enough preventative maintenance, even though we know it is important. We're too busy fighting fires."**
- ✓**Extremely cost-conscious industry:**
  - **"A big part of my job is to look for ways to decrease costs. When I can reduce energy costs, it is money in both my and my client's pocket."**
- ✓**Service is still important at the local supplier level.**
- ✓**The industry is not highly automated; mix of home grown and off-the-shelf solutions.**

Observations:

- ✓**Trend towards outsourcing increases their importance**
- ✓**One of more difficult management challenges for facility managers.**
- ✓**Role increases in small- to medium-sized facilities**
  - → **De facto facility manager**
- ✓**Any technology solutions brought to facility O&M must include service providers**
- ✓**Outsourcing trends in Federal facilities support these observations**

Historical Perspective

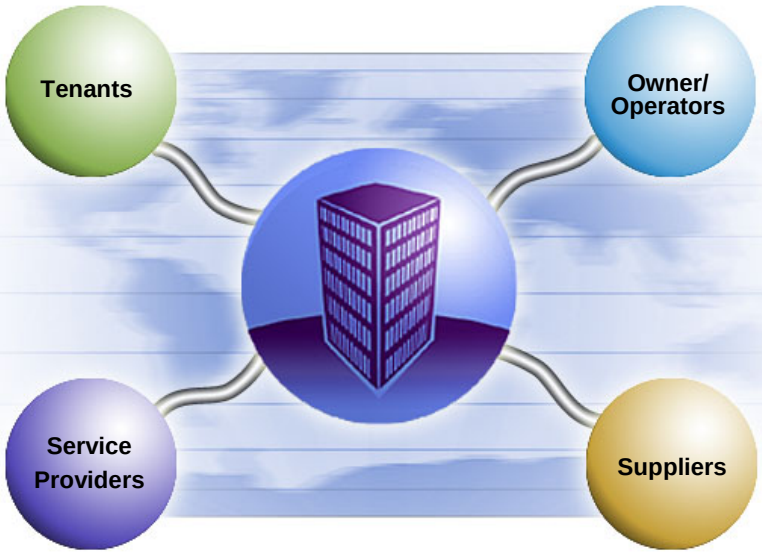


Innovation and Technology Set The Foundation For Growth

Technology Imperatives

Tenants
- Efficient facility services
- Convenience
- Productivity
- Low cost

Owners and Operators
- Efficient operations
- Tenant responsiveness
- Tighter budgets
- Increased revenues



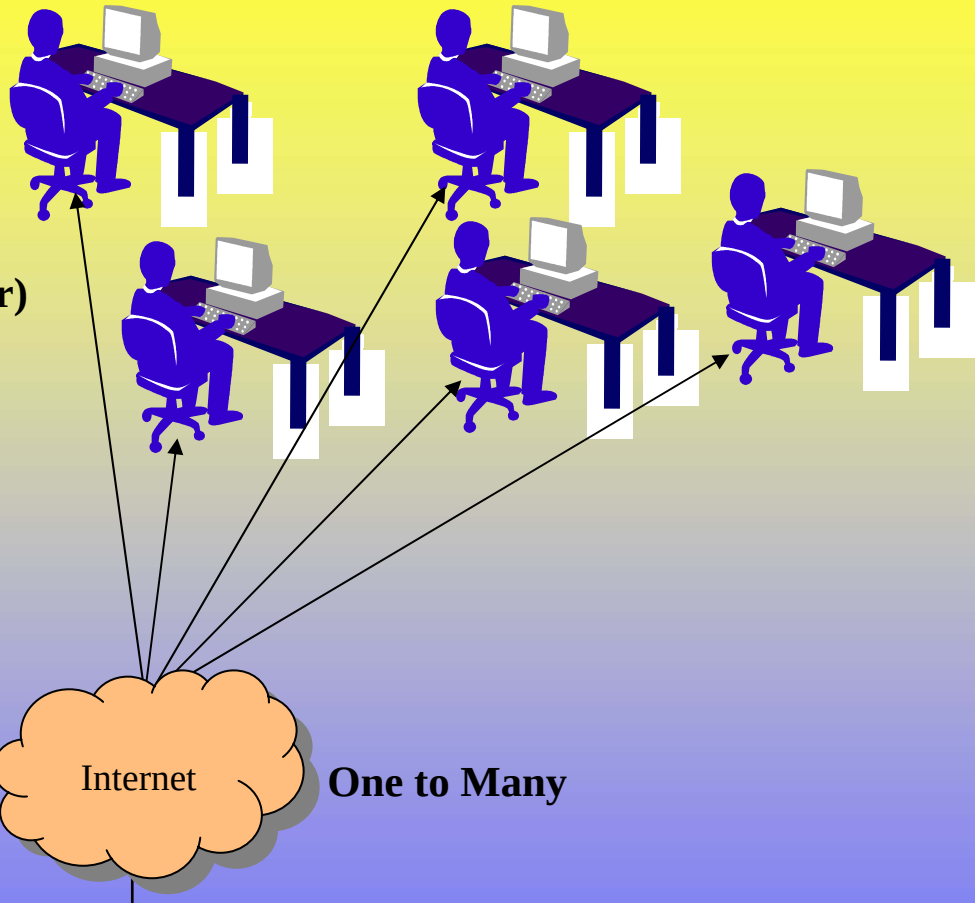
Service Providers
- Operational productivity
- Increased customer value
- Small business economics

Suppliers
- Customer access
- Efficient supply chain
- Differentiated offerings

Applications Service Providers

Advantages of ASP

- ✓ Continuous updates of software
- ✓ Everyone uses same software
- ✓ Economies of Scale (Much Cheaper)
- ✓ All users get all applications
- ✓ Pay only as long as you need it
- ✓ Infrastructure Requirements:
  - ➢ Internet Connection
  - ➢ PC with a Browser (Modem)
  - ➢ Minimal IT Support Required

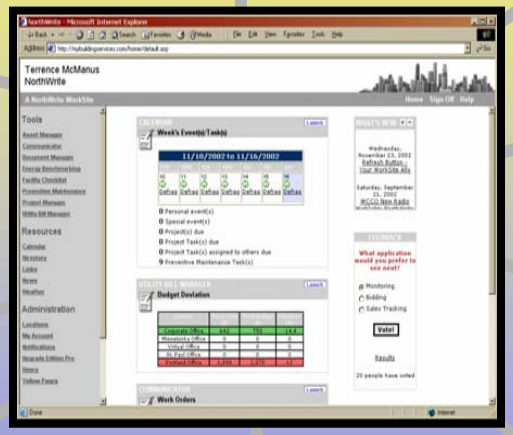


ASP Software

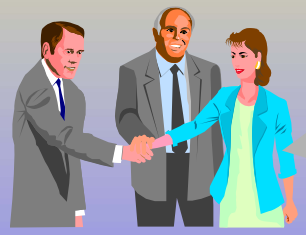
Maintenance Mgt.

Energy Data Analysis

Monitoring

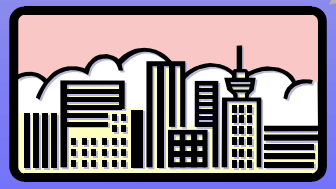


Communications



Project Mgt.

Mobile Delivery



Asset Mgt.

Utility Bill Mgt.

Document Mgt.

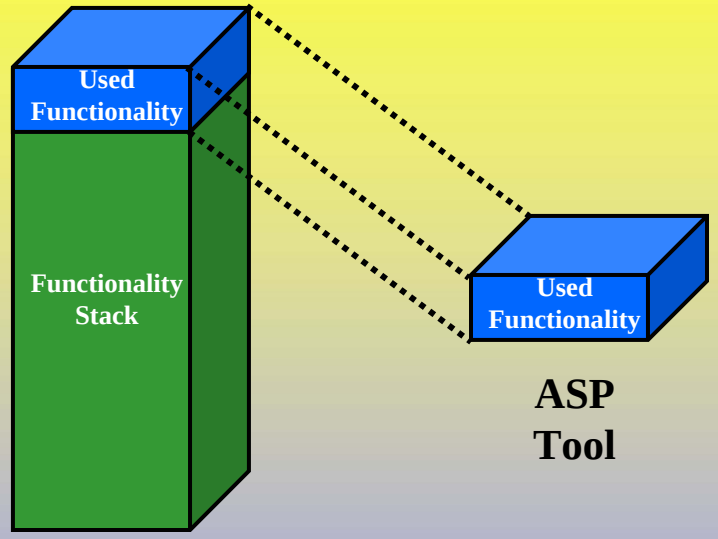
ASP Tools: "The 10% Solution"

Enterprise Software

- ✓Extremely Complex
- ✓Lots of Training
- ✓Very Expensive
  - License
  - Maintenance
- ✓Often vastly underutilized

ASP Tools

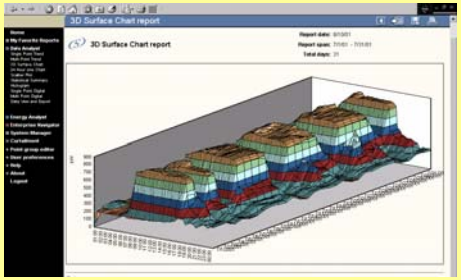
- ✓Simple to use
- ✓Minimal Training
- ✓10-100x less expensive



Enterprise Applications

Project Management (Microsoft Project)

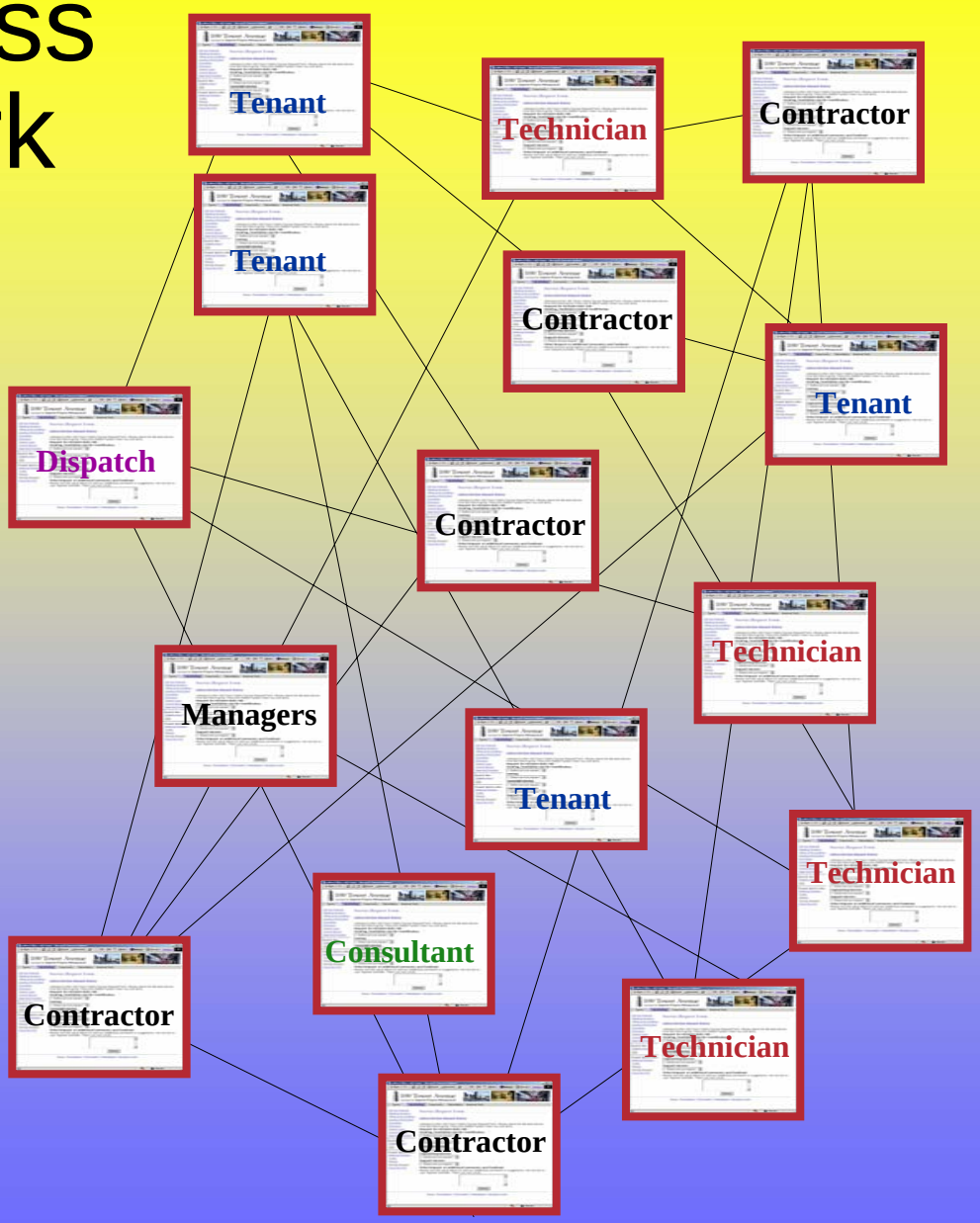
Maintenance Mgt. System (MP2/Maximo)



Enterprise Energy Management (Silicon Energy)

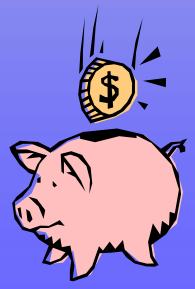
Business Network

One to Many



Key Benefits of ASP's

1) **Speed**
   - ✓ You can be up and running in minutes
   - ✓ Can be rolled-out to large number of users
2) **Cost**
   - ✓ Costs a fraction of stand-alone applications
   - ✓ Typically not a capital procurement
3) **Quality**
   - ✓ Software is continuously monitored
   - ✓ On-line and phone support provided
4) **Innovation**
   - ✓ New features added continuously
   - ✓ No upgrade or maintenance costs



5) **Simplicity**
   - ✓ Use only those applications you want
   - ✓ Minimizes training
6) **Security**
   - ✓ Typically password protected
   - ✓ Users see only information they need
   - ✓ n+1 Data Backup
7) **Communications**
   - ✓ Network with all key stakeholders
   - ✓ Accountability of vendors
   - ✓ Management visibility

ASP-Delivered Facility Management Tools

For Federal Facilities →

- ✓**Web-based delivery ensures rapid implementation**
- ✓**Ideal platforms for managing outsourced vendors (contractor performance)**
- ✓**Increase communications among all participants/stakeholders in facility management**
- ✓**Mechanism for delivering energy-related tools to target users (like WBD)**
- ✓**Monitoring and tracking platform**
  - **Within agencies**
  - **Across all Federal facilities**
- ✓**Potential training delivery platforms**
- ✓**Ensure consistency and common practices across facilities**