

**“Reliable Wireless Connectivity for
Sensing & Control Applications”**

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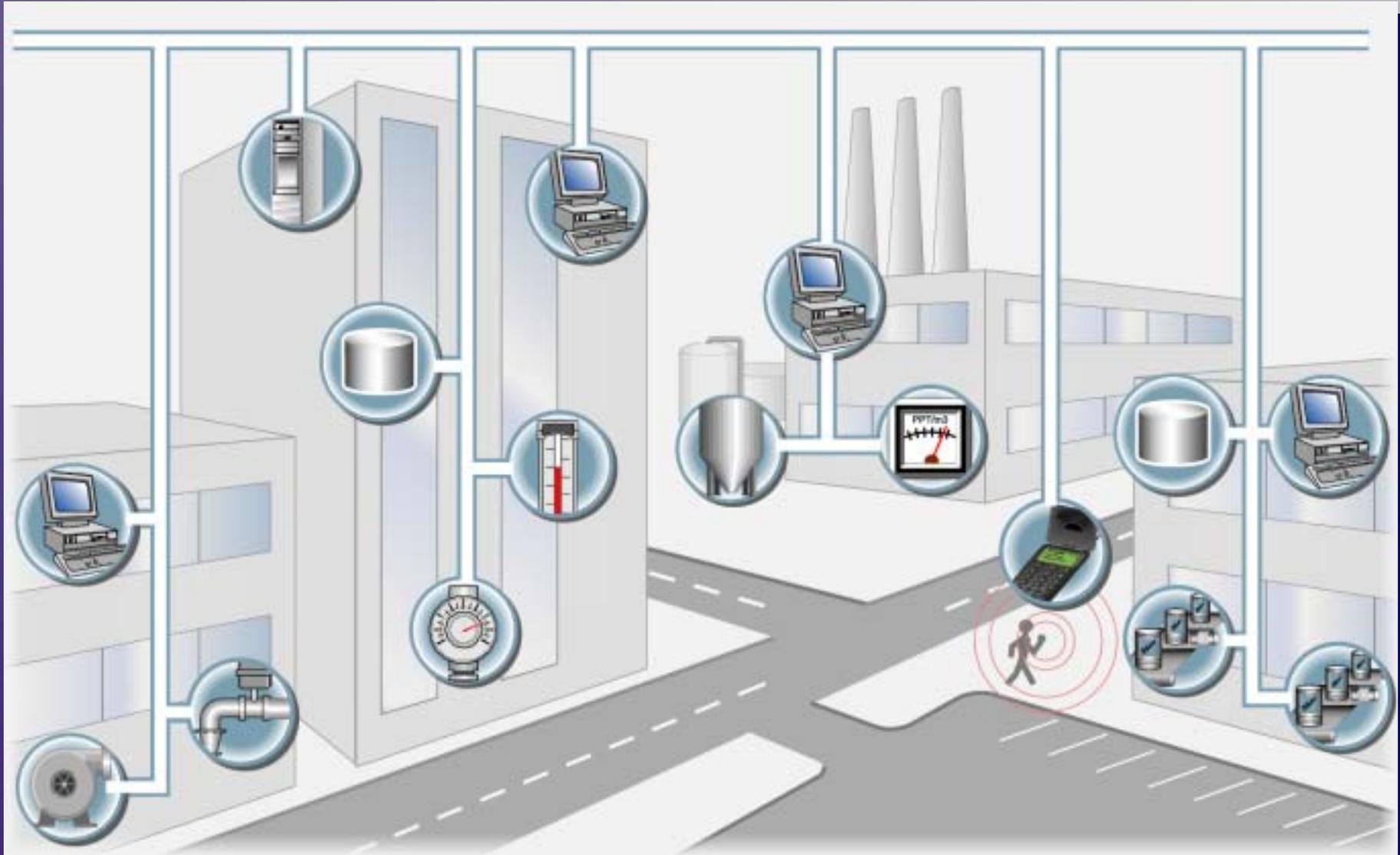


Wireless Sensing Standards Forum

SENSORS EXPO

Philadelphia 10/4/01

Wireless Sensor Connectivity



Industry Quotes

“It’s not going to be people... , it’s going to be sensors, microcontrollers. Trillions of these will be connected to the Internet.”

Scott McNealy, SUN MICROSYSTEMS

“... there will be a day when a person makes use of tens of hundreds of telemetry devices per day without even knowing it.”

THE YANKEE GROUP REPORT



Industry Quotes

“Everyday devices ... will be connected [to the Internet], reporting on their usage and status. Each of these applications of digital information is approaching an inflection point ...”

Bill Gates, MICROSOFT



Wireless sensing: cost benefits

- ▶ **Wire Installation Cost:**
 - \$20-\$50 per foot, more in some environments**
- ▶ **Often too expensive to wire – data is lost, efficiencies are impeded**
- ▶ **Wireless is easy to install**



The harsh reality –

Industrial wireless sensor applications



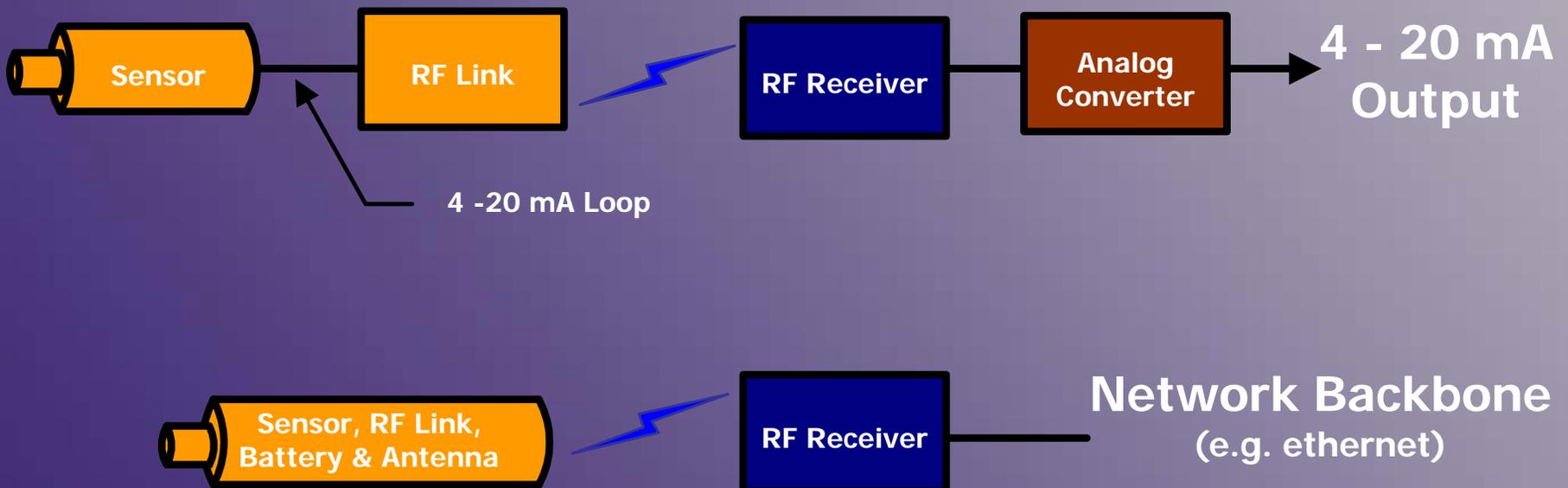
Applications

- ▶ **Process control**
- ▶ **Oil & gas production**
- ▶ **Manufacturing**
- ▶ **Petro-chemical & refineries**
- ▶ **Industrial sensors:
temperature, pressure, flow, level**
- ▶ **Energy management**
- ▶ **Tank level monitoring**
- ▶ **Waste water management**
- ▶ **Utility AMR**

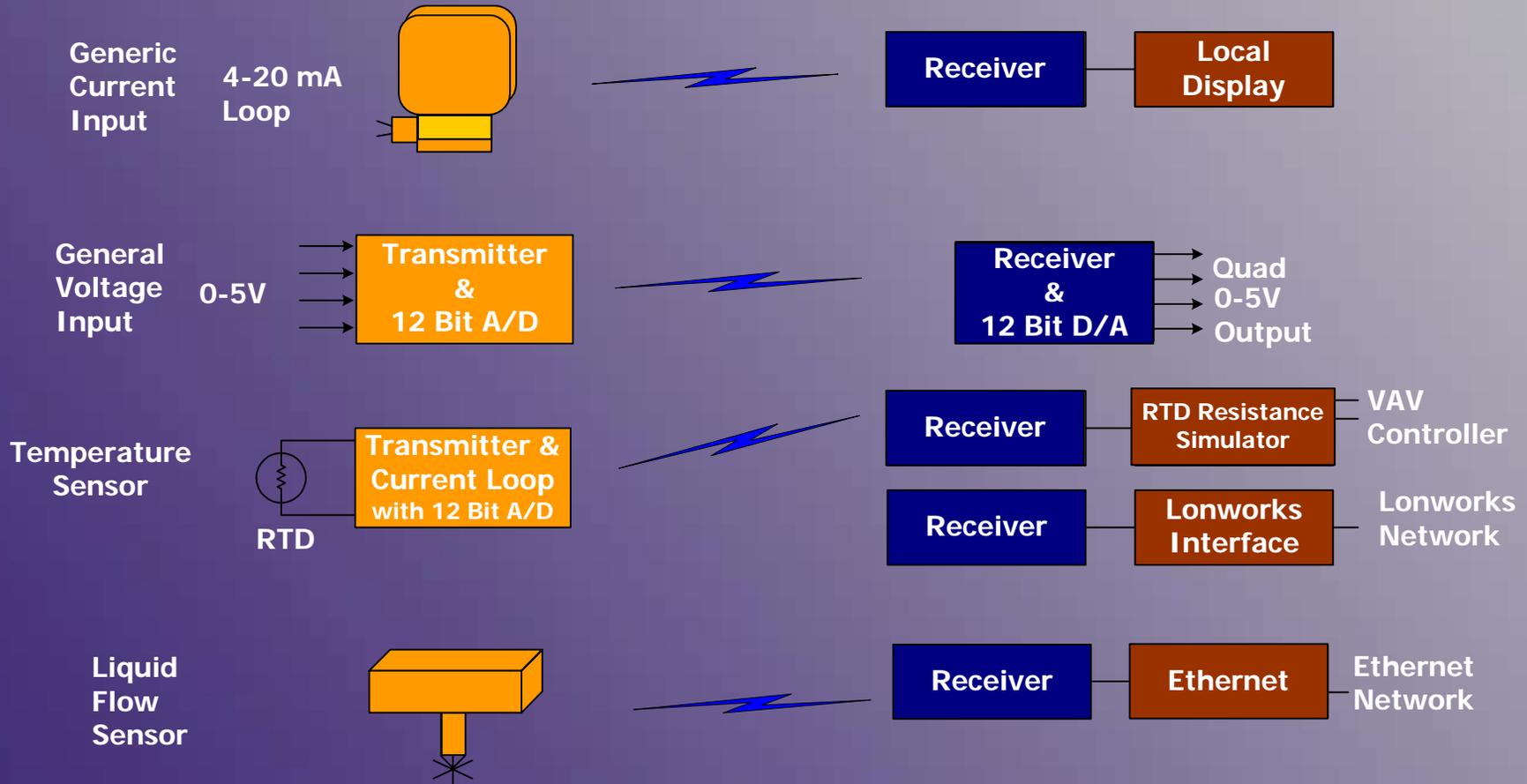


Evolution

Total Turnkey Solutions: Wire Replacement



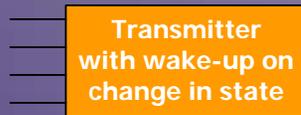
AXONN customer implementations



AXONN customer implementations



Status Contact Inputs



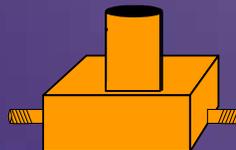
Pulse Accumulator



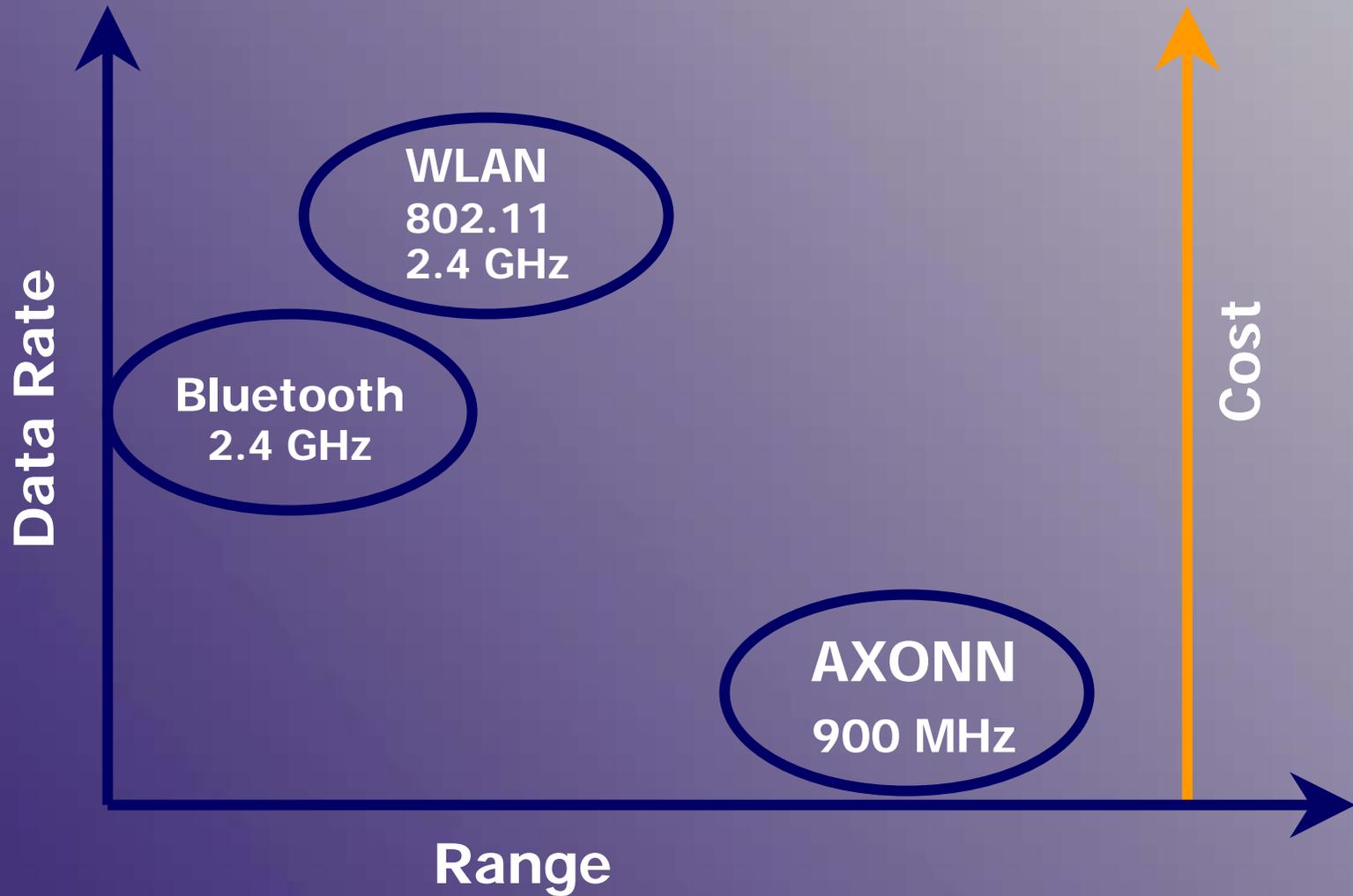
Acoustic Liquid Level Sensor with Integrated Transmitter



Gas meter with integrated intrinsic safe transmitter



Data rate vs. range

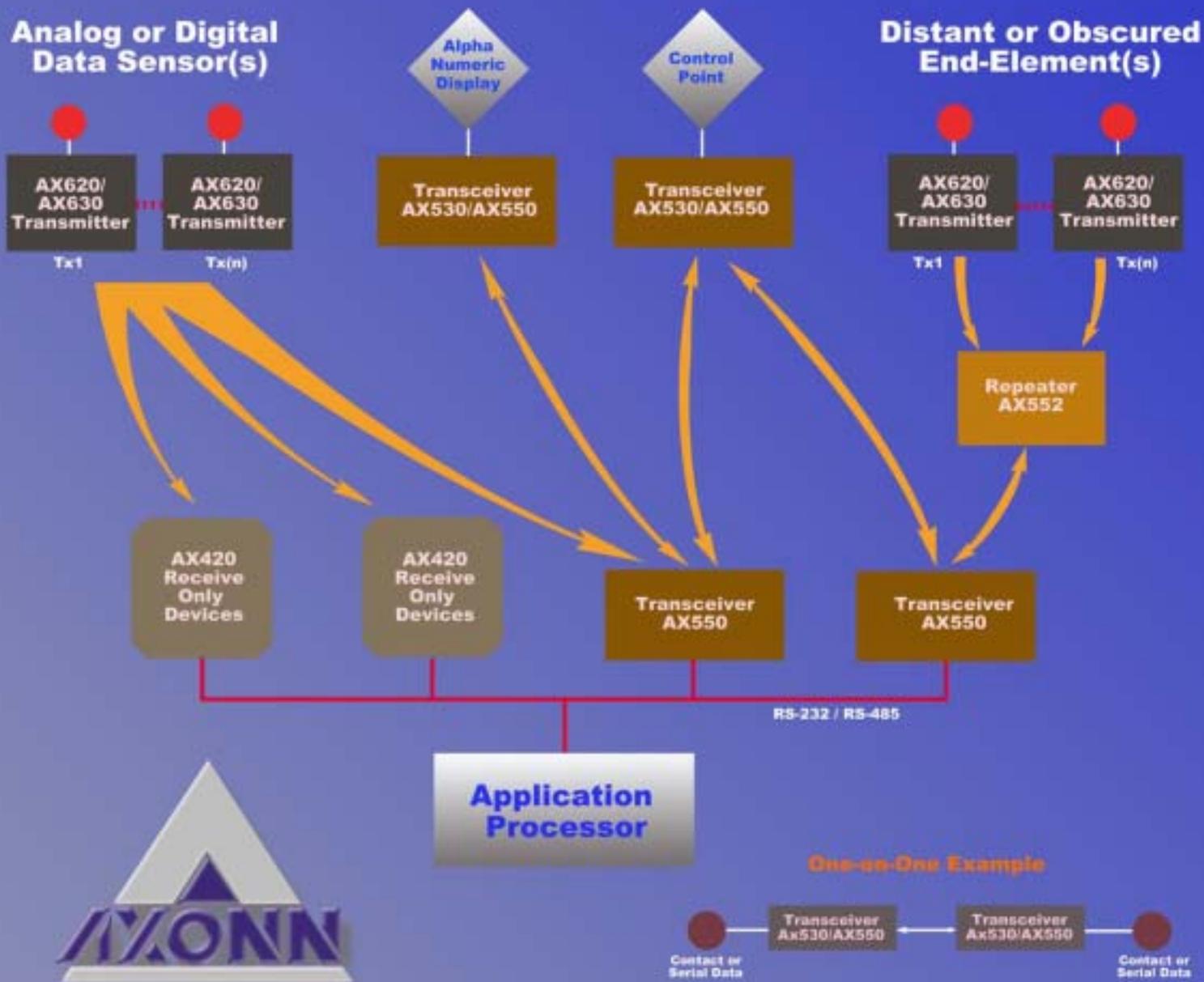


Wireless Sensing: Spread Spectrum Radio Technology Comparison

Technology	WLAN-802.11b	Bluetooth	Axon 900MHz
Frequency	2.4GHz	2.4GHz	900MHz
SS Modulation	DSSS	FHSS	DSSS
Data Rate	High 5-11 Mbps	High 1Mbps	Low 19.2Kbps
Receiver Sensitivity	Various	-70dBm	-110dBm
Radio Range (maximum: RX at 8ft)	100M-300M	10M-100M	1.2mile
Temp Range	N/A	N/A	-40C to +85C
Band Crowding	High*	High*	Medium
Building Penetration & Propagation	Low	Low	Medium
Standardized	Yes	Yes	De-Facto
ISM Band	Yes	Yes	Yes
Multipoint Coexistence Capability	Low	Medium	High
Vendor Diversity	Yes	Yes	Proprietary Multi Sourced
Target Application	Wireless Ethernet	PANs/Mobility	Remote Monitoring

* Hundreds of millions of devices are forecasted to be in use by end 2002 (Source: www.bluetooth.com)

System Architecture Example



900MHz Wireless Technology Highlights

- ▶ 902--928MHz in 8 Channels (programmable 3MHz steps).
- ▶ CDMA & TDMA Operation.
- ▶ Unlicensed ISM Band Operation: Unrestricted Transmission (update) Rate.
- ▶ FCC Approved Now.
- ▶ 868MHz European version: Modular compatibility.
- ▶ 50-250mW Output Power.
- ▶ 1 mile range (LOS).
- ▶ Receive Sensitivity – 110dBm @ 19.2Kbps data rate.
- ▶ DSP Based Anti-Jam & Interference Rejection.
- ▶ Intrinsically Safe RF Transmitter Endpoints: Class I, Div I.
- ▶ Integrated Antenna (external antennae optional)
- ▶ Battery operated transmitters (Life: 7years for 1min supervisory for 3Volt LiMnO2 battery)



900MHz Wireless Technology Highlights

- ▶ Industrial Temperature Range: -40C to +85C.
- ▶ RF communications redundancy options incorporated
- ▶ Modular Radio, or Plug & Play options
- ▶ Conform to NFPA & FAA "Wire Equivalency" Requirements
- ▶ Technology Foundation:
 - 60 patents & Patents Pending.
 - Full Custom Mixed signal ASICS (multi-sourced)
- ▶ Comprehensive System Architecture
- ▶ Proven in the field now



Current high volume installations (roll-out phase)

- ▶ Tank level monitoring
- ▶ Fire & security
- ▶ Utility (AMR & load/distribution control)
- ▶ Energy management & sub-metering
- ▶ Waste water management
- ▶ HVAC control & commercial building controls
- ▶ More than 6,000,000 devices in field operation



Beta Installations

- ▶ Oil & gas production
- ▶ Transportation monitoring (railcar)
- ▶ Pressure sensing
- ▶ Parking meters
- ▶ Fleet monitoring (asset tracking)
- ▶ Vending





End products in use

End Products: Industrial wireless sensor applications



4-20mA
Pulse Counter
Contact Relay



End Products: Industrial wireless sensor applications



Wireless
pH/ORP Sensor



Wireless
Acoustic Level Sensor

End Products: Utility & energy management applications



Battery life & power consumption

3uA sleep current (still operating oscillator and monitoring inputs)

Uses small (2/3A size) cheap camera batteries

No external power required for transmitters

Battery status is sent in each transmitted message

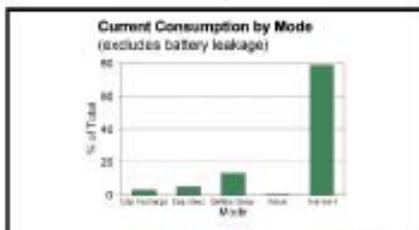


ESTIMATION OF TYPICAL BATTERY LIFE WITH ALPHA CALCULATIONS

Wake up interval (no transmission) =	20 minutes
Supervisory Transmission interval =	1 minutes
Transmissions per supervisory interval =	1
Alarm Transmission interval =	1E+02 minutes
Transmissions per alarm interval =	3
Average wake up interval =	00 50 seconds
Resistor value in series with battery =	0 ohms

CAUTION: ESTIMATED LIFE = SHELF LIFE!

Average battery current consumption =	20.05 <i>uA</i>
Battery leakage current =	1.00 <i>uA</i>
Battery series resistor average current =	0.00 <i>uA</i>
Total average current consumption =	21.05 <i>uA</i>
Usable Battery capacity =	1.33 <i>Amp Hours</i>
Estimated Battery Life =	7.01 <i>Years</i>



AX002 Sleep current =	2.5 <i>uA</i>
EE ROM Sleep current =	0.3 <i>uA</i>
Capacitor Leakage current =	0.3 <i>uA</i>
CPU Sleep current =	0.4 <i>uA</i>
Total Sleep current =	3.5 <i>uA</i>

Equivalent Battery Leakage Current = **1.00** *uA*

Maximum sleep time on capacitor alone =	00 10 seconds
Remaining sleep time on battery =	40 44 seconds
Capacitor Sleep Mode Duty Cycle =	27 20 %
Battery Sleep mode Duty Cycle =	72 81 %

Capacitor discharge due sleep =	0.0 Volts
Capacitor recharge current from V-pump =	54 40 <i>mA</i>
Capacitor recharge current from battery =	05 00 <i>mA</i>
Capacitor Recharge Duty Cycle =	1 00-03 %
Average Capacitor recharge current =	1 55 <i>uA</i>

% of above used which is used for sleep = **03 28** %
which is equivalent to **0 88** *uA*

Average Battery Sleep mode current = **2 52** *uA*

AX002 active mode current =	3 <i>mA</i> @ V of V-pump
RF Multiplier current =	0 <i>mA</i> @ V of V-pump
Additional Vpump drive current =	0 71 <i>mA</i> @ V of V-pump
Additional Microprocessor current =	0 8 <i>mA</i> @ V of V-pump
Average EE ROM current =	0 30 <i>mA</i> @ V of V-pump
CPU Current =	4 <i>mA</i> @ V of V-pump
Total Digital Active mode current =	7 30 <i>mA</i> @ V of V-pump
Battery digital active mode current =	11 13 <i>mA</i>
Active Mode Duty Cycle (%) =	4 00-04 %
Average Active Mode current =	0 30 <i>uA</i>

FOR THE AX-420 TRANSMITTER

ALPHA CALCULATIONS

Number of Transmissions =	200
Reception is required every =	5 minutes (Guaranteed Interval)
Effective redundancy =	5 10
Unsuccessful Guaranteed Interval =	2 04 per year
One Guaranteed Interval failure per =	100 000 15 Minutes
Probability of Success =	00 0000007 1%
Probability of Collision =	0 00001022%

Battery storage =	2 9 Volts typical
Battery capacity =	1 4 <i>Amp-Hours</i>
Usable Battery Capacity =	90 %
Battery capacity loss =	1 % per year (based on new battery)
Battery Shelf Life =	7 Years
V Pump output =	3 7 Volts
V Pump efficiency (%) =	04 (Transmit Mode)
Low current V Pump efficiency (%) =	06 (Active Mode)
V pump efficiency at start up (%) =	12 (Start up Mode)
Active mode Vpump drive DC =	10%
Transmit mode Vpump drive DC =	32%
V pump capacitor =	68 <i>uF</i>
V pump resistor =	300 ohms
V pump transistor voltage drop =	0 7 volts
Capacitor charge voltage =	3 7 volts
Capacitor minimum voltage =	2 9 volts
EE ROM current consumption =	1 <i>uA</i>
EE ROM transmit mode activity (%) =	0 1 %
EE ROM active mode activity (%) =	0 %

Digital start up time = **1** milliseconds
Active Mode wake up duration = **1 5** milliseconds (digital is active for this period for non-transmission active re)
Active time > length of transmission = **1** milliseconds (digital is active for this period longer during XMSN mode)

Length of transmission = **10 02** milliseconds (see page B for Message parameters)
% of RF period equal to one = **72 85** % of the packet will output R1 (based on 50% of data equal to one)

← BATTERY LEAKAGE CURRENT

← SLEEP MODE DURATIONS

Accom Corporation
101 West Robert E. Lee Boulevard
Suite 202
New Orleans, LA 70124
PH: (504) 282-0113
FAX: (504) 282-0106

← CAPACITOR SLEEP MODE CURRENT USAGE

← BATTERY SLEEP MODE CURRENT USAGE

← ACTIVE MODE (DIGITAL) CURRENT USAGE

(No transmissions take place during Active mode)
RF KEY enabled circuitry current = **32** *mA* @ V of V-pump
RF CHWILE enabled circuitry current = **20** *mA* @ V of V-pump
RF KEY current - data duty cycle = **23 2100000275** *mA* @ V of V-pump
Effective Digital Active current = **8 21** *mA* @ V of V-pump (includes time digital is active beyond transmit packet length)
Additional Microprocessor current = **4 00** *mA* @ V of V-pump
Additional Vpump drive current = **2 29** *mA* @ V of V-pump
Average EE ROM current = **0 30** *mA*

← TRANSMIT MODE (RF) CURRENT USAGE

(includes current required for digital circuits during transmission)

Total Average Current = **20 051000071** *uA*

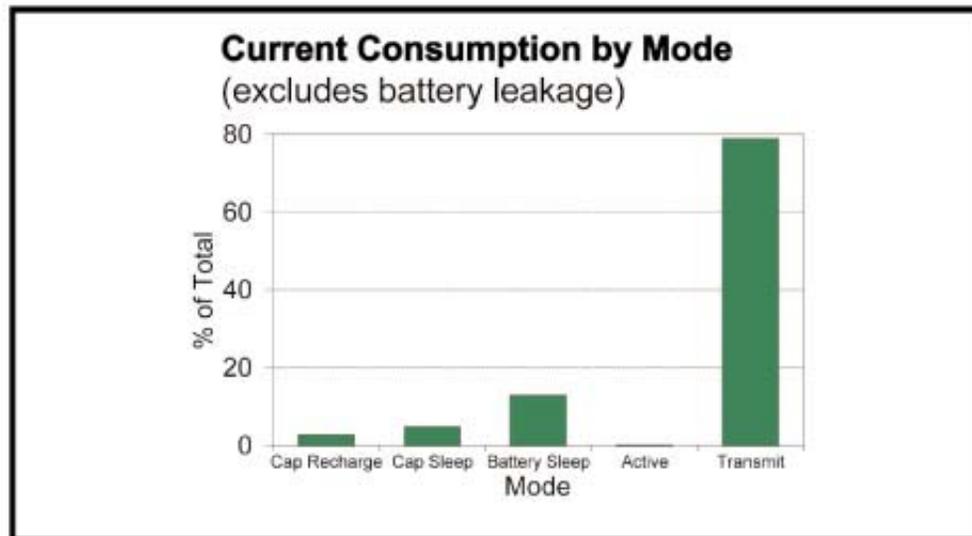
← TOTAL AVERAGE CURRENT

ESTIMATION OF TYPICAL BATTERY LIFE WITH ALOHA CALCULATIONS

Wake up interval (no transmission)=	20 minutes
Supervisory Transmission interval =	1 minutes
Transmissions per supervisory interval =	1
Alarm Transmission interval =	1E+02 minutes
Transmissions per alarm interval =	3
Average wake-up interval=	55.56 seconds
Resistor value in series with battery=	0 ohms

CAUTION: ESTIMATED LIFE > SHELF LIFE!!

<i>Average battery current consumption =</i>	20.05 μA
<i>Battery leakage current =</i>	1.60 μA
<i>Battery series resistor average current =</i>	0.00 μA
<i>Total average current consumption =</i>	21.65 μA
<i>Usable Battery capacity =</i>	1.33 Amp Hours
<i>Estimated Battery Life =</i>	7.01 Years



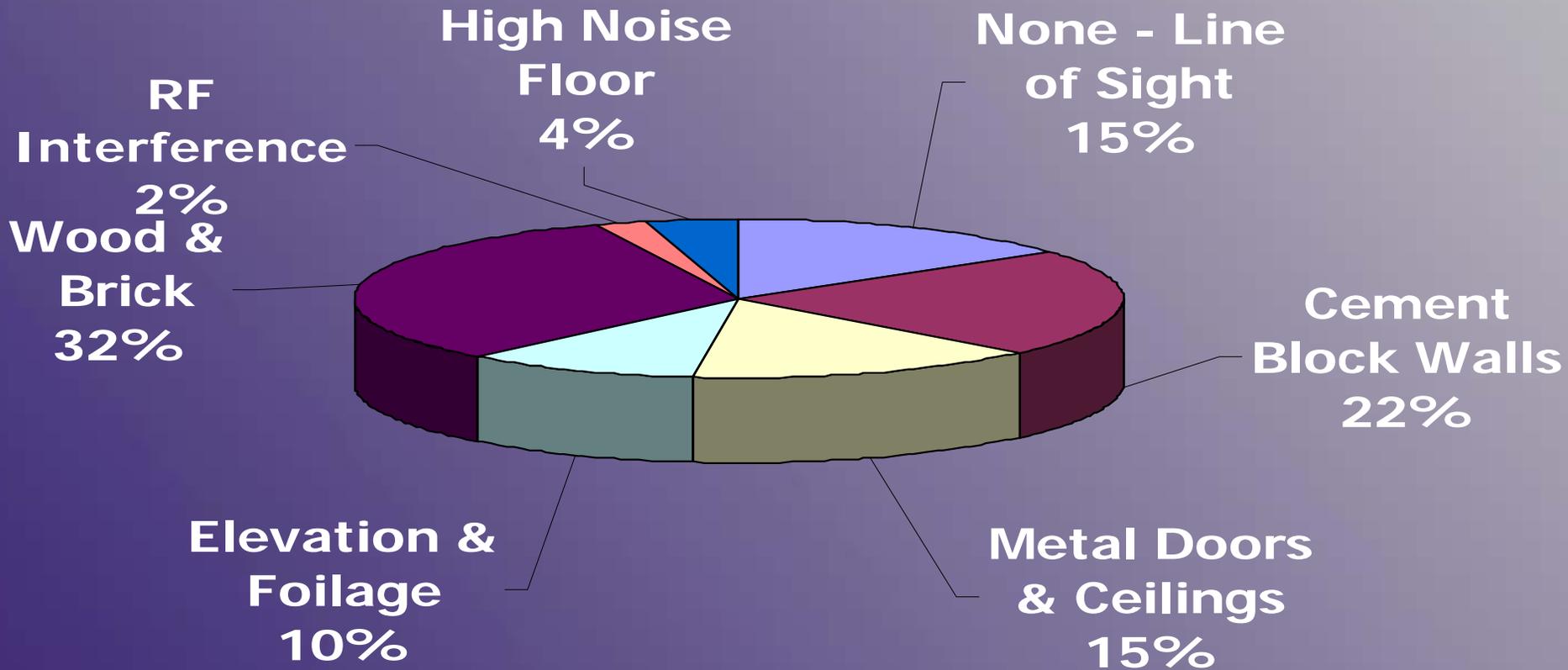
The harsh reality –

Industrial wireless sensor applications



Environmental Obstacles

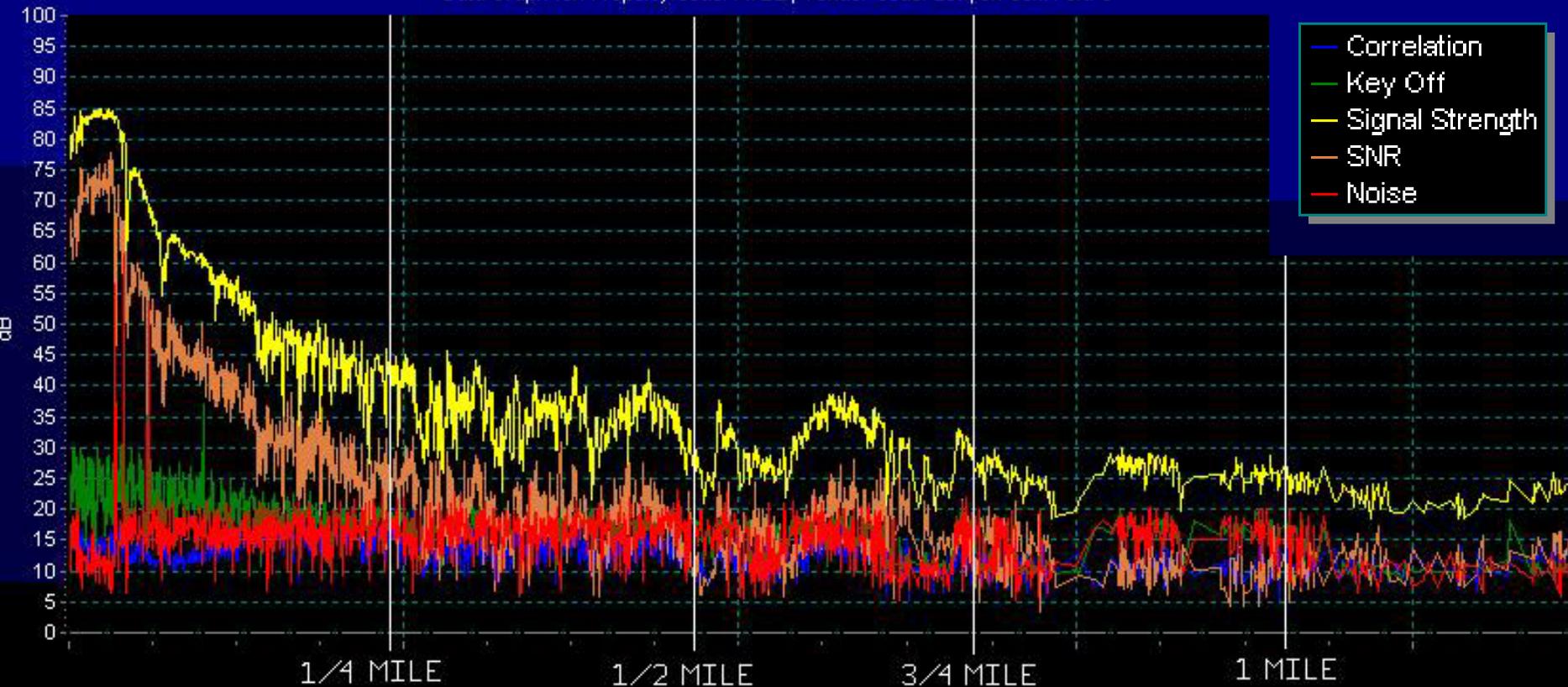
Industrial Wireless Sensor Applications



Range - Outdoors



Data Graph for: Property Code: A721 , Vendor Code: 207 , on Com Port: 0

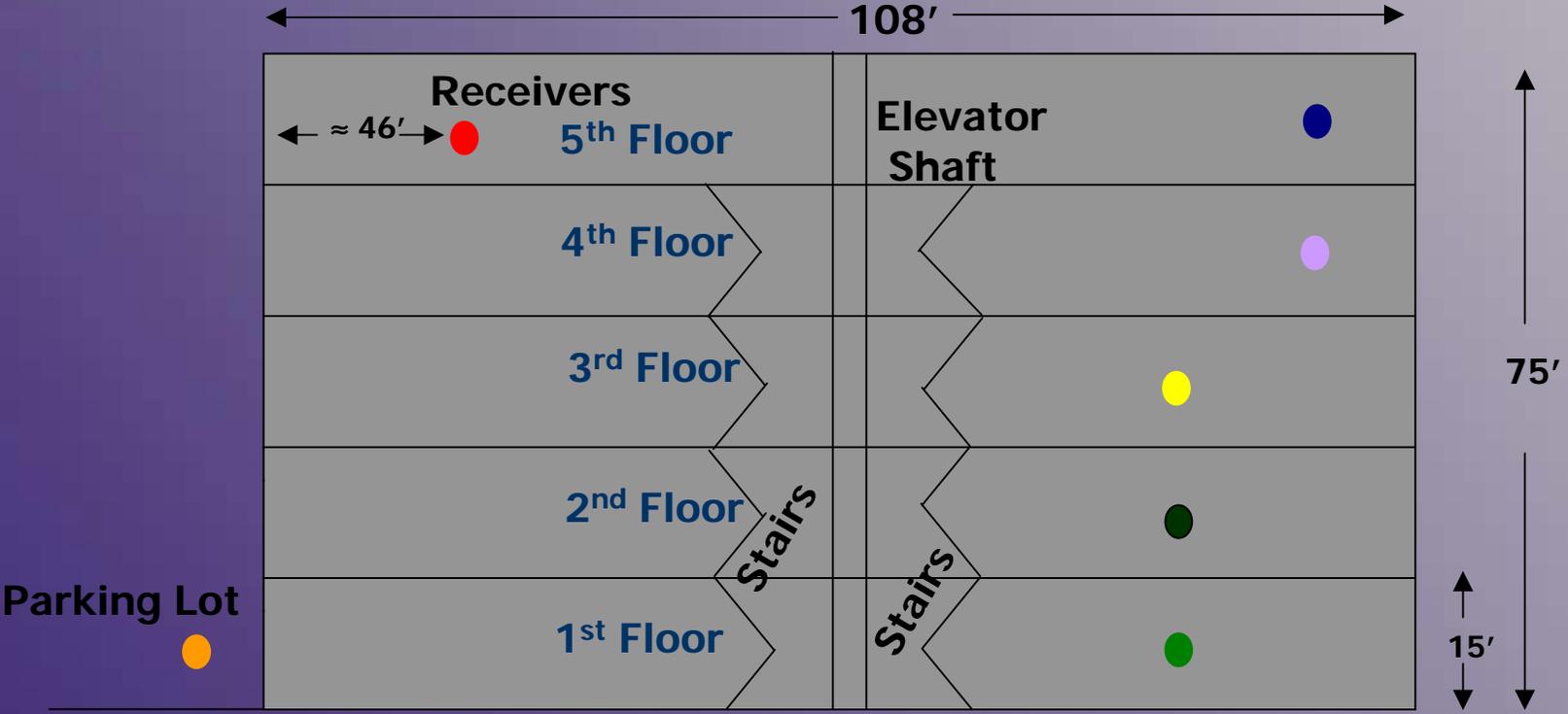


6/11/01 Slightly Undulating Terrain LOS



Construction 2000

Range Indoors



Reliability: Operation

- ▶ **Operating Temperature Range**
-40C to +85C

- ▶ **Intrinsic Safety: Class I, DIV I**
**Needed for many sensing
end-point applications**



Reliability: RF Communication

Multiple redundancy approaches used for RF communication reliability.

- ✓ Redundant transmissions:

 - Burst of transmissions randomly spaced in time

- ✓ Redundant receivers:

 - Overlapping coverage

- ✓ Antenna Diversity:

 - Reduce fading effects

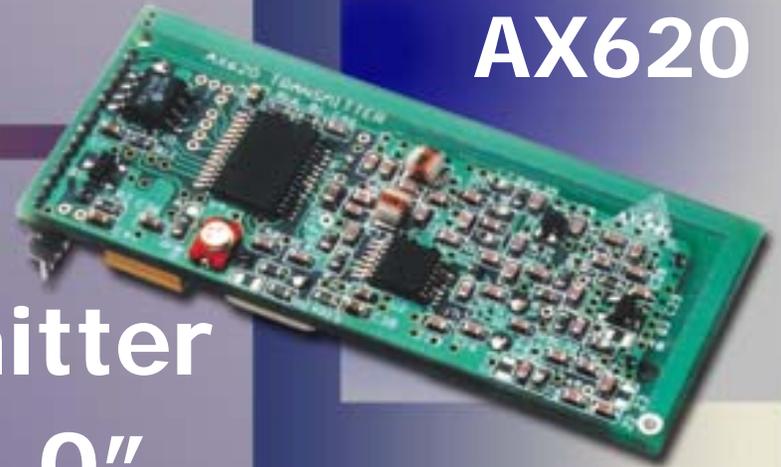
- ✓ Frequency Diversity:

 - Multiple frequencies to circumvent jamming sources



Transmitters

AX620



Digital Input Transmitter
Dimensions: 2.3" X 1.0"

AX630



Analog Input Transmitter
Dimensions: 2.37" X 1.2"



Receivers, Transceivers & Repeaters

8 channel 900MHz
2.2" X 3.4" X 0.8"



AX550/AX552



AX420



Plug & Play RF Sensor Endpoints:

900MHz Spread Spectrum CDMA & TDMA

Inputs:

- 4-20mA
- 0/1-5Volts
- 0-10Volts
- Thermocouples (J, K, E, T)
- Pulse
- Contact Closure

Intrinsically Safe: Class I, Div I

NEMA 4 Enclosure/ Custom enclosure

Integrated Antenna (external optional)

Battery Operated

Industrial Temperature Range: -40C to +85C

Compatible with RF communications redundancy options

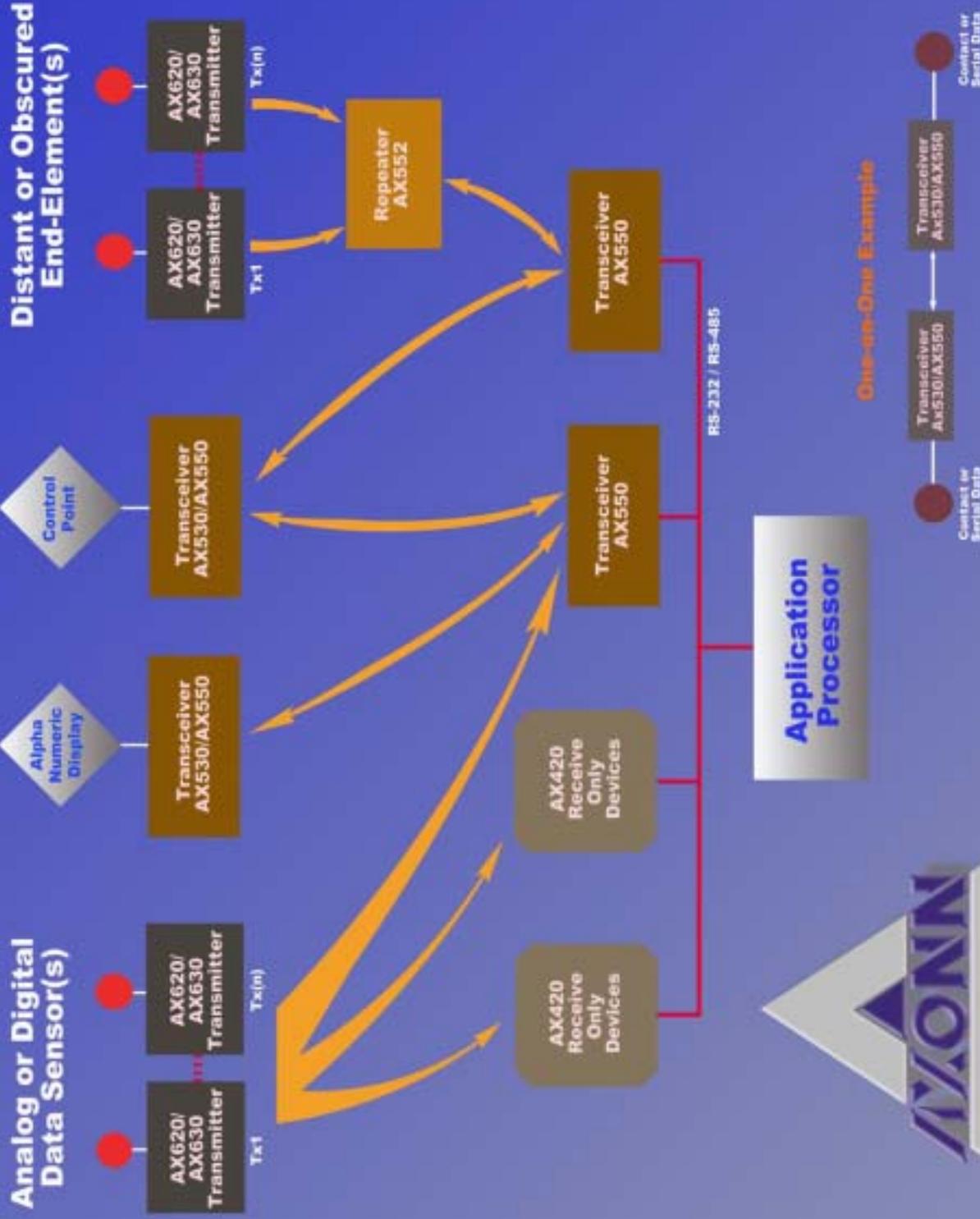
Standard Receiver & Repeater compatibility in

system architecture

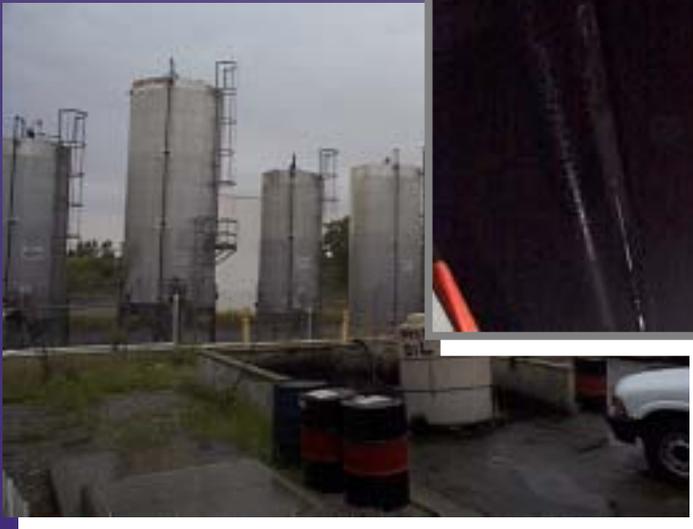
Available Q4/01.



System Architecture Example



The harsh reality – Industrial wireless sensor applications



900MHz

- ▶ **Leading provider of low cost spread spectrum RF technology**
- ▶ **Developed portfolio of 60 patents & patents pending**
- ▶ **Placed over 6 million devices in the field**
- ▶ **Founded in 1985**



Key considerations in choosing a wireless solution for sensing and control applications

- ▶ **Wireless telemetry works – 6 million times and counting**
- ▶ **Wireless connectivity technology must be matched to application**
- ▶ **Economics will force pervasive wireless sensing in SCADA segments**
- ▶ **Wireless will ultimately drive into traditionally hard-wired solutions**
- ▶ **It's more than margin enhancement: wireless will cause transitions in traditional business practices (from fighting commoditization to winning customer loyalty)**



Wireless

data solutions

that work[®]

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