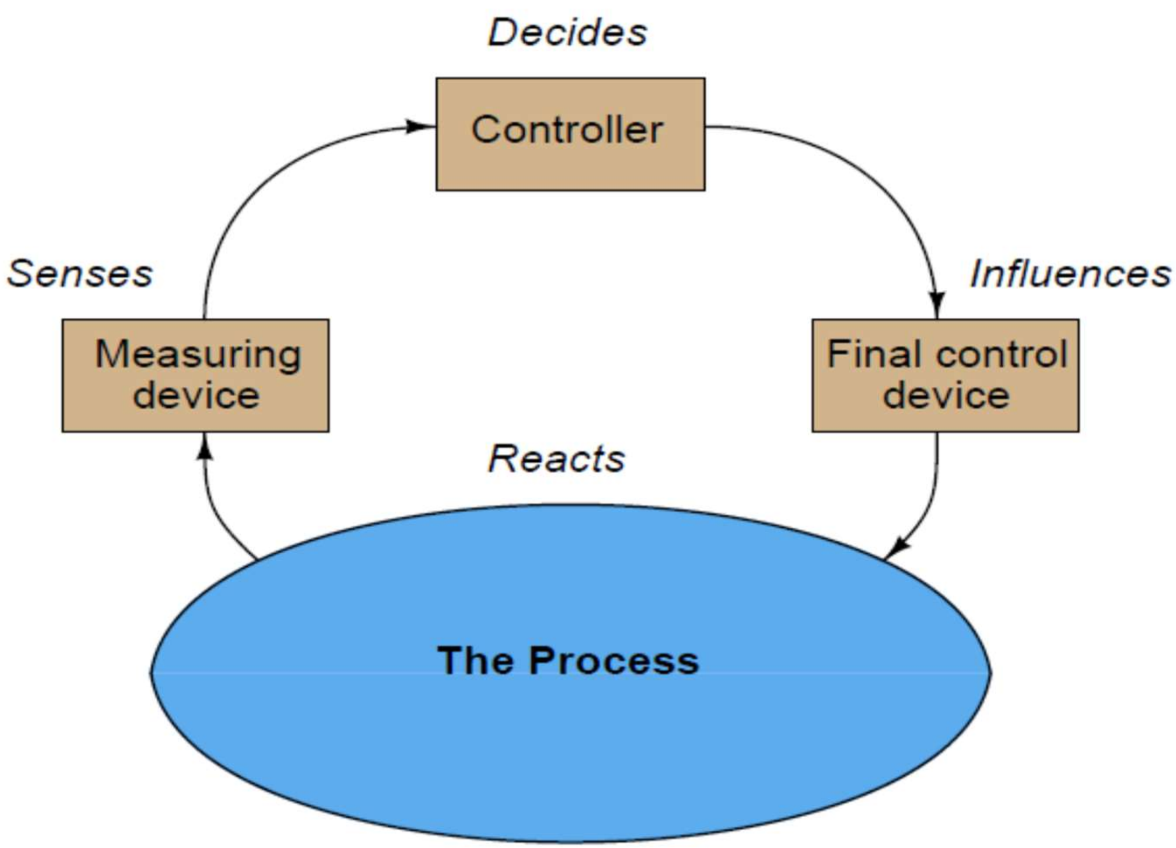
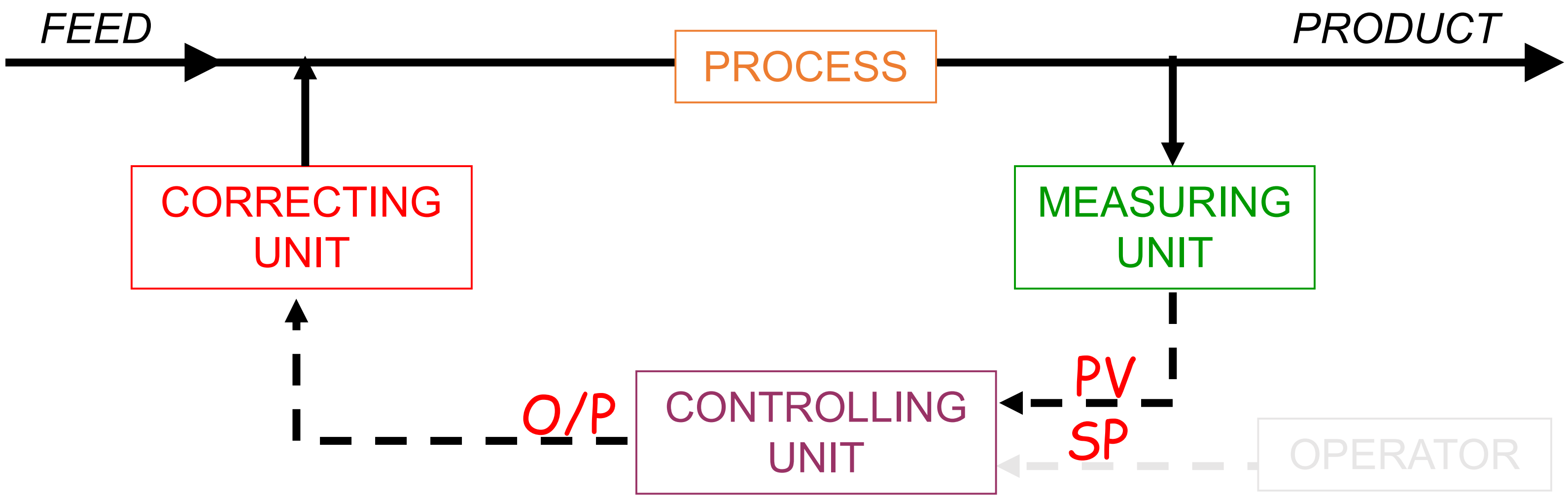
Sensors, Wireless & IIoT

Murali Krishnan T

OVERVIEW OF A PROCESS CONTROL LOOP



Control Principle



Control theory can be encapsulated as the matching of a measured variable (PV) to the plant requirement (SP).

MEASURING ELEMENTS (SENSORS):

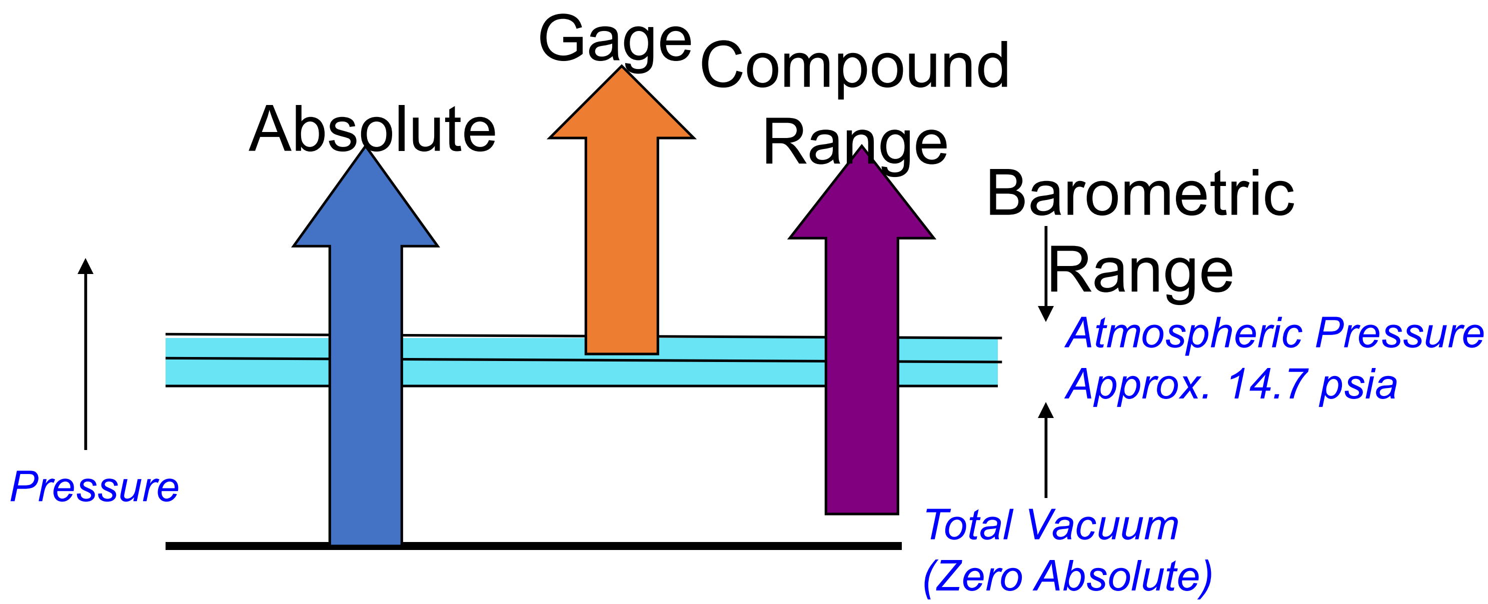
- PRESSURE
- LEVEL (DP, RADAR)
- FLOW (Orifice DP, Coriolis, Vortex, Magnetic, Annubar DP, Venturi DP)
- TEMPERATURE (Thermocouple, RTD)
- MACHINE POSITION, MOTION or ACCELERATION
- CHEMICAL CONCENTRATION SUCH AS pH, CONDUCTIVITY, O2, CO2, HC MEASUREMENT

FINAL CONTROL ELEMENTS:

- CONTROL VALVES (Globe, Rotary, Ball)
- ON/OFF VALVES (Ball, Butterfly)
- MOVs
- ELECTRIC MOTORS
- ELECTRIC HEATERS, COOLERS ETC

Pressure terminology

Reference Pressure



Gage(psig) - Level of pressure relative to atmospheric

- *Positive or negative in magnitude*

Absolute(psia) - based from zero absolute pressure - no mass

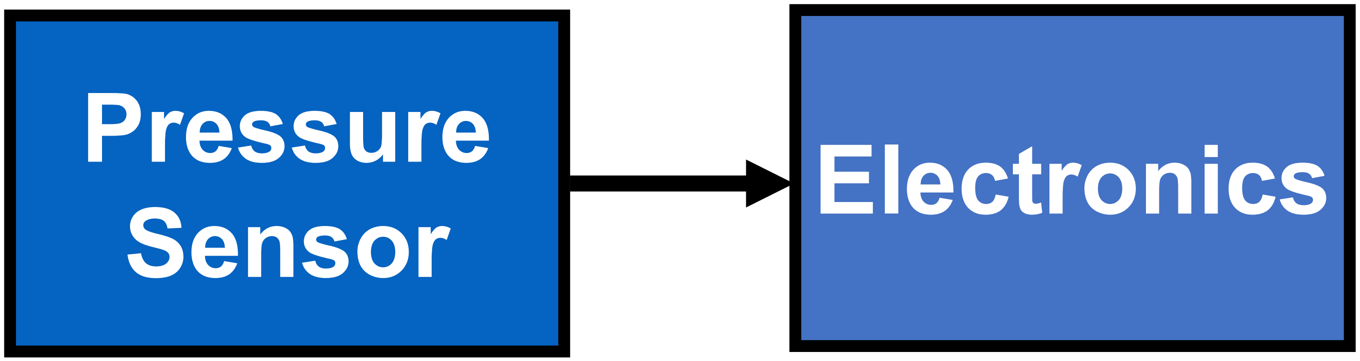
Typical atm reference: 14.73 psia

Compound Range (psig) - Gage reading vacuum as negative value

Differential(psid) - difference in pressure between two points

Basic Pressure/DP Transmitter Block Diagram

- Sensor
- Electronics

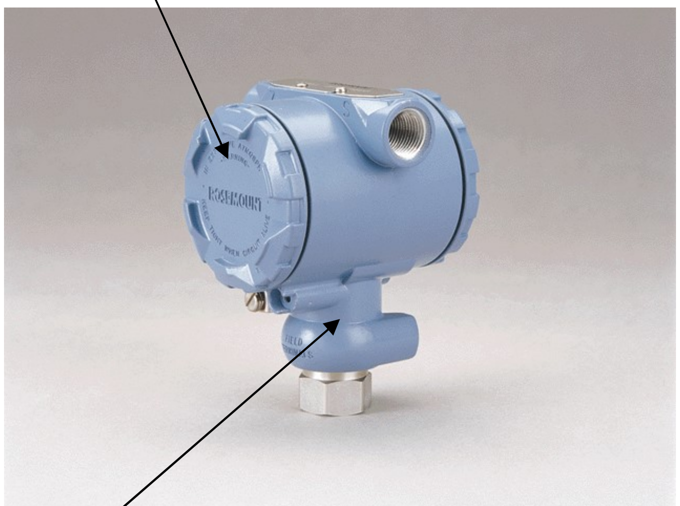


Measure Pressure

Give Transmitter Output
Analog
Smart/HART
Fieldbus

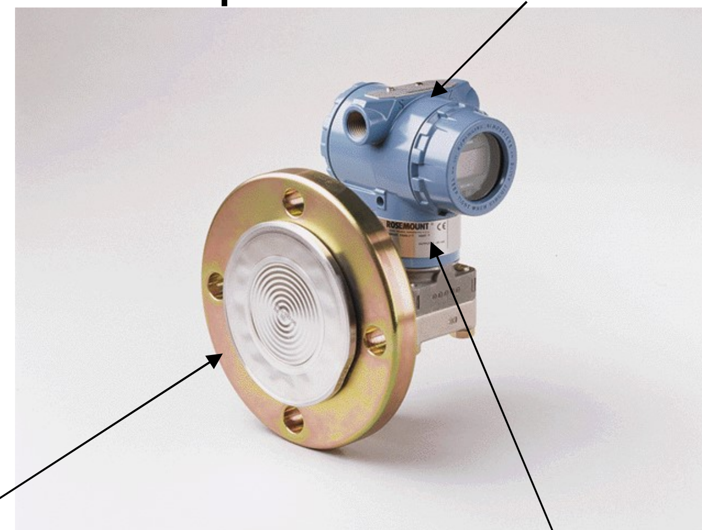
Pressure Transmitter

Output Electronics



Sensor Module

Output Electronics



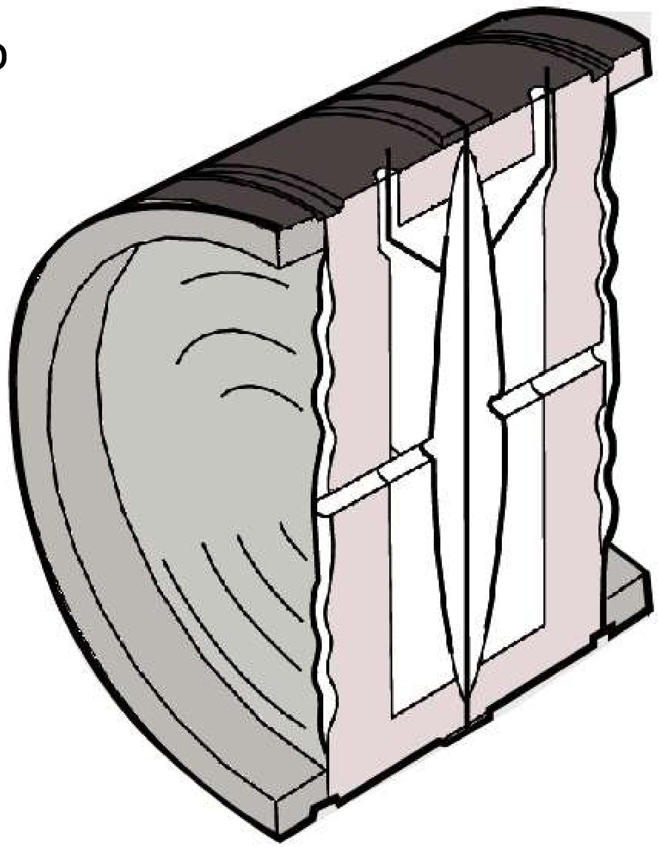
Diaphragm Seal

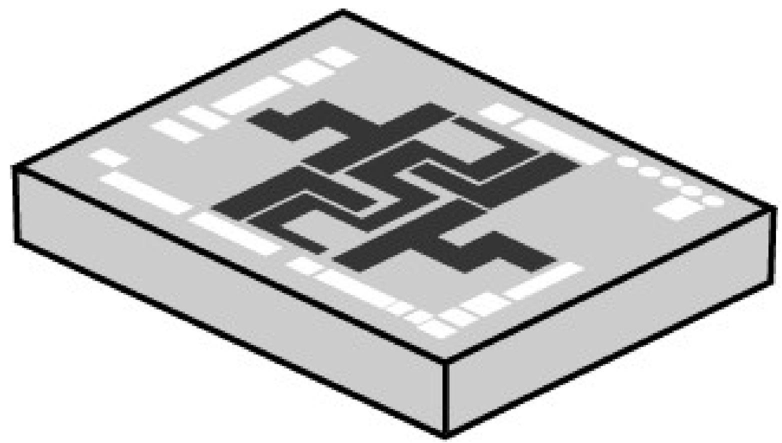
Sensor Module

- Sensor (transducer) module is part of the transmitter.
- Output Electronics in the transmitter translates the useable electrical signal from the sensor into a standard output signal.

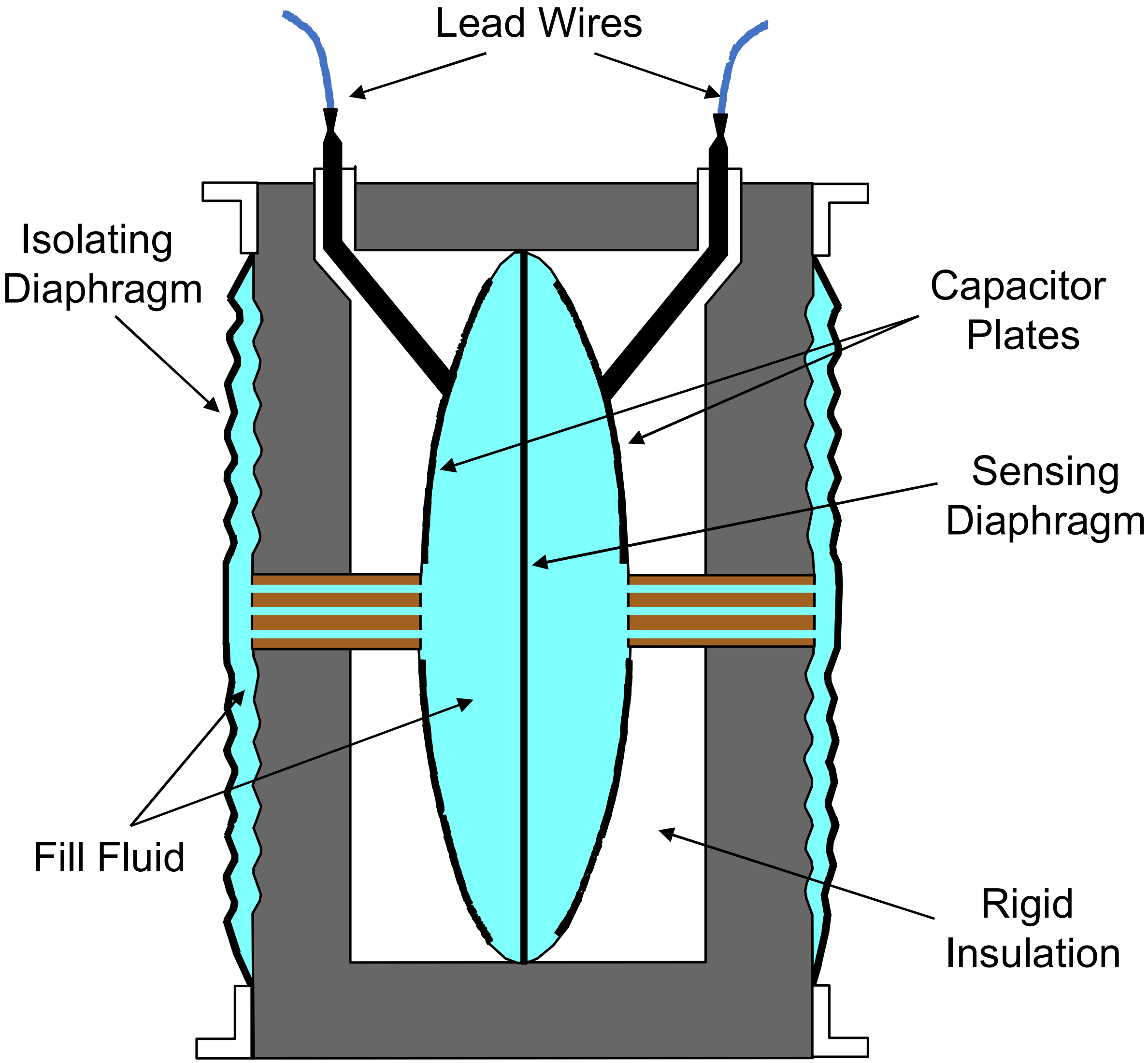
Available Sensor Technology

- Capacitance
- Piezo





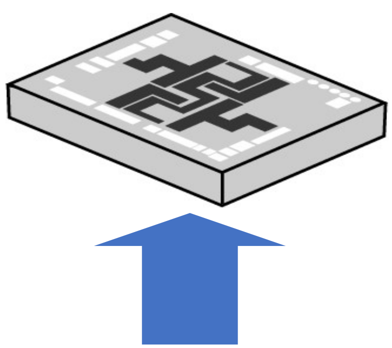
Capacitive Sensing



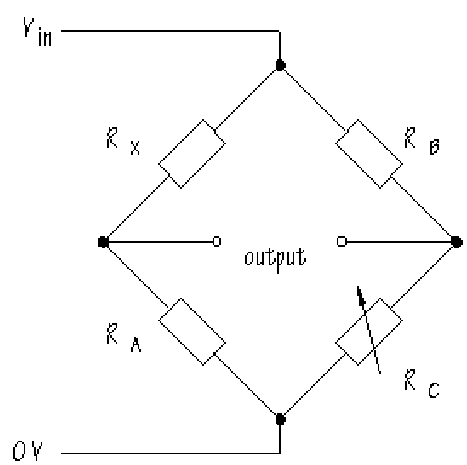
- Sensing element is really two capacitor plates with a common sensing diaphragm
- Process pressure transmitted through fill fluid to center of sensor
- Sensing Diaphragm deflects proportional to differential pressure
- Differential capacitance is measured electrically through leads inside sensor
- Inherent overpressure protection

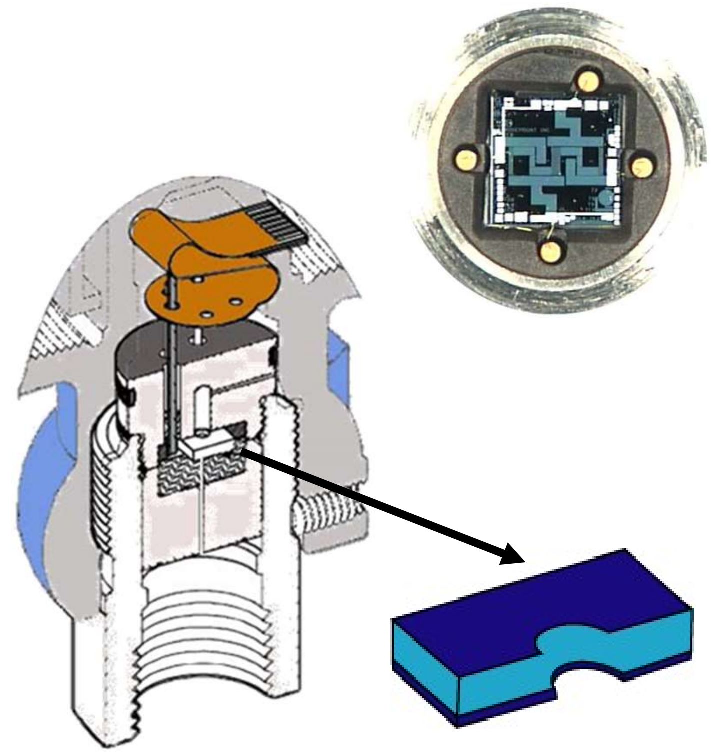
Silicon Sensing Technology

- A Wheatstone Bridge fabricated to silicon substrate
- Applied Pressure cause stress on silicon
- Stress deflects silicon which causes a change Resistance
- Measure the output of the bridge

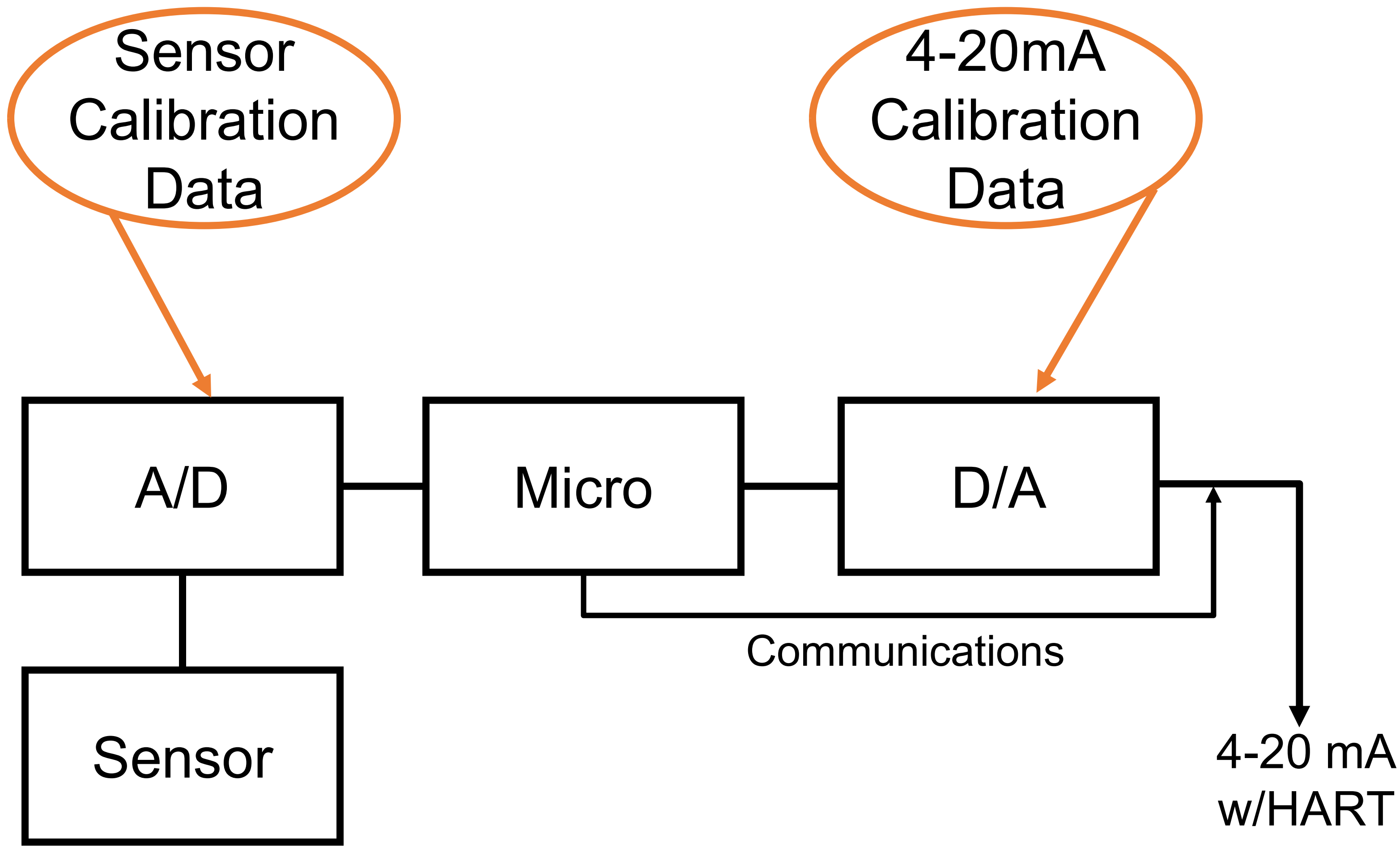


Pressure

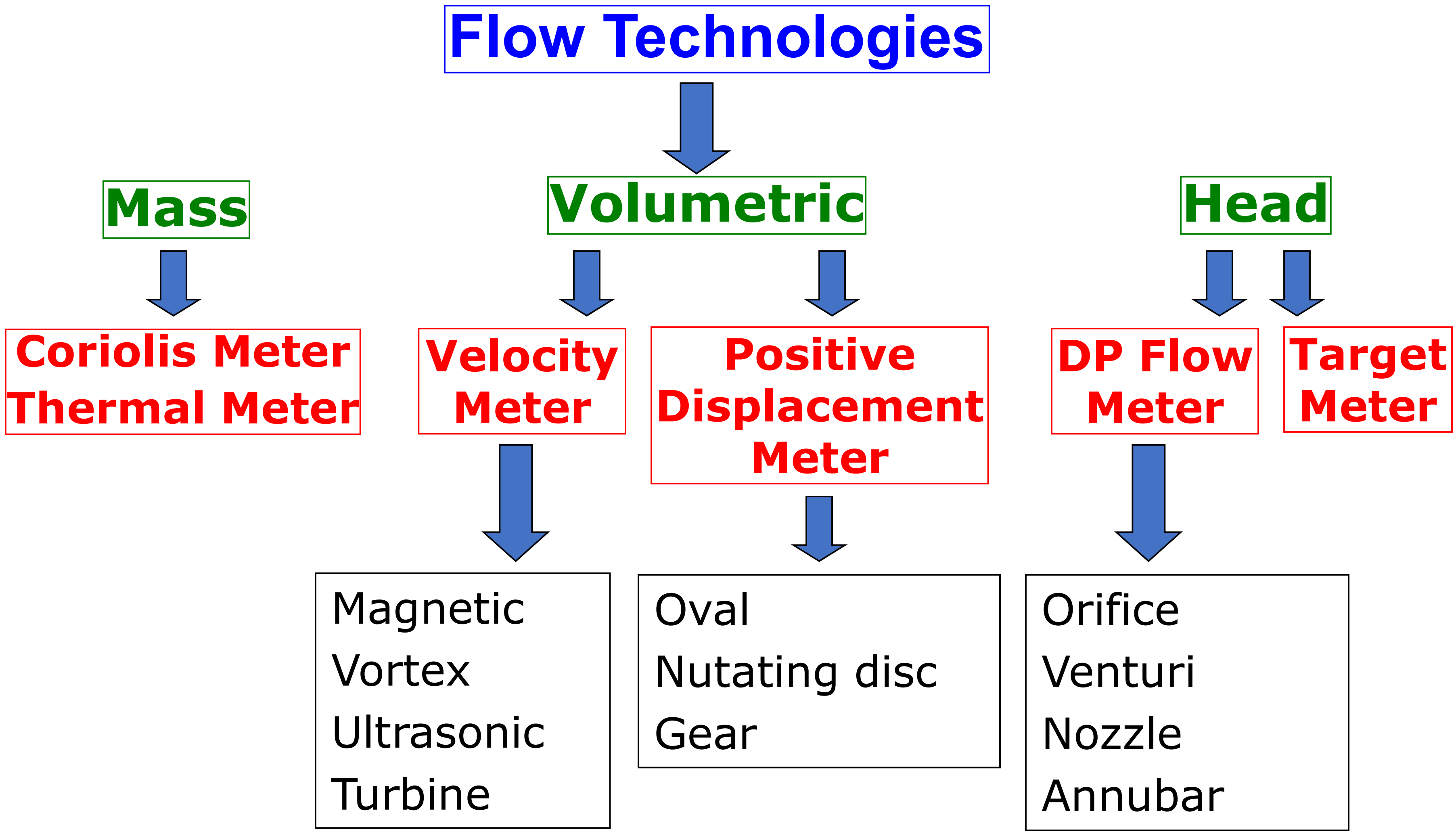




Typical Smart/Hart Transmitter Block Diagram

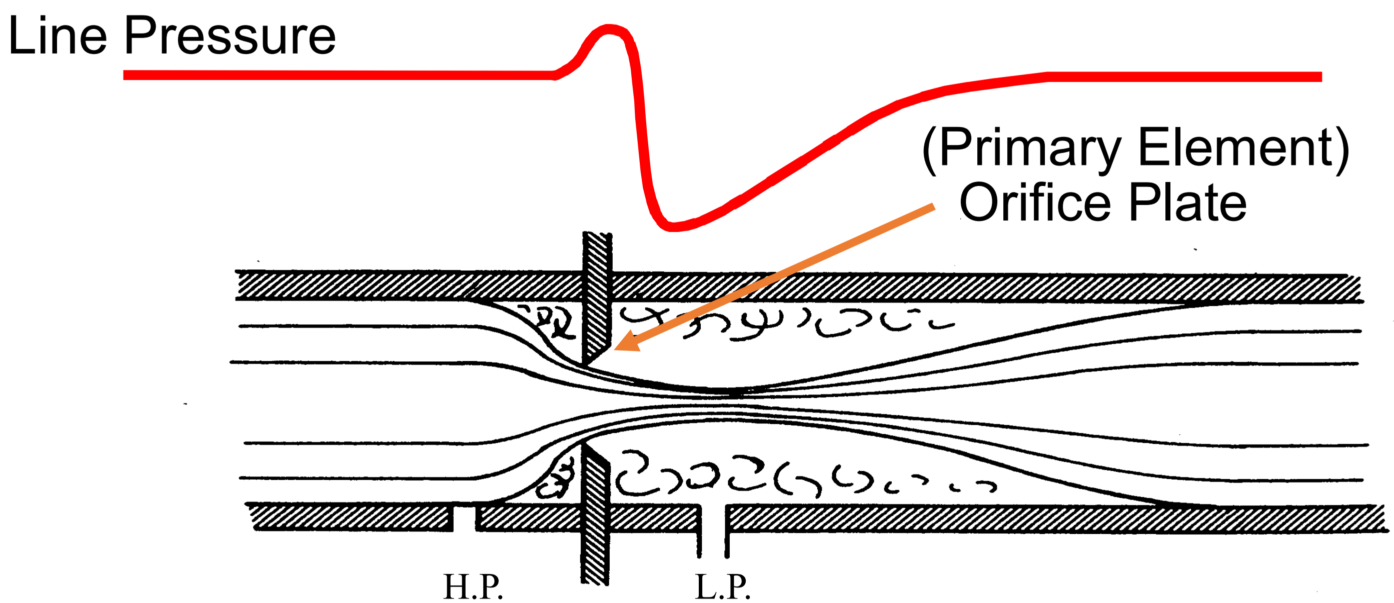


Flow Technologies



DP flowmeter

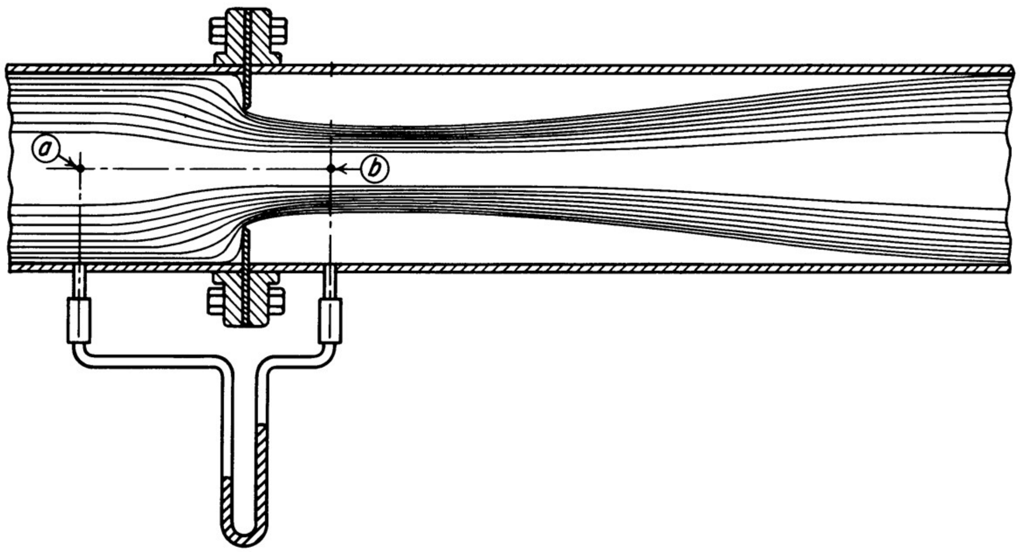
Flow Restriction in Line cause a differential Pressure



$$Q_V = K \sqrt{DP}$$

Constant

Orifice Meter



The orifice meter consists of an accurately machined and drilled plate concentrically mounted between two flanges. The position of the pressure taps is somewhat arbitrary.

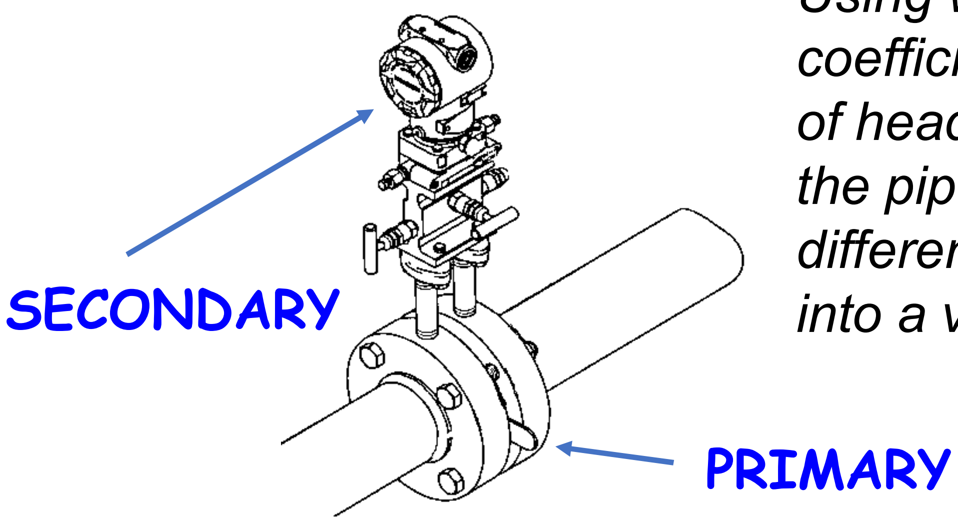
DP flowmeter

DP Flow Meters consist of two main components:

Primary - placed in the pipe to restrict the flow.

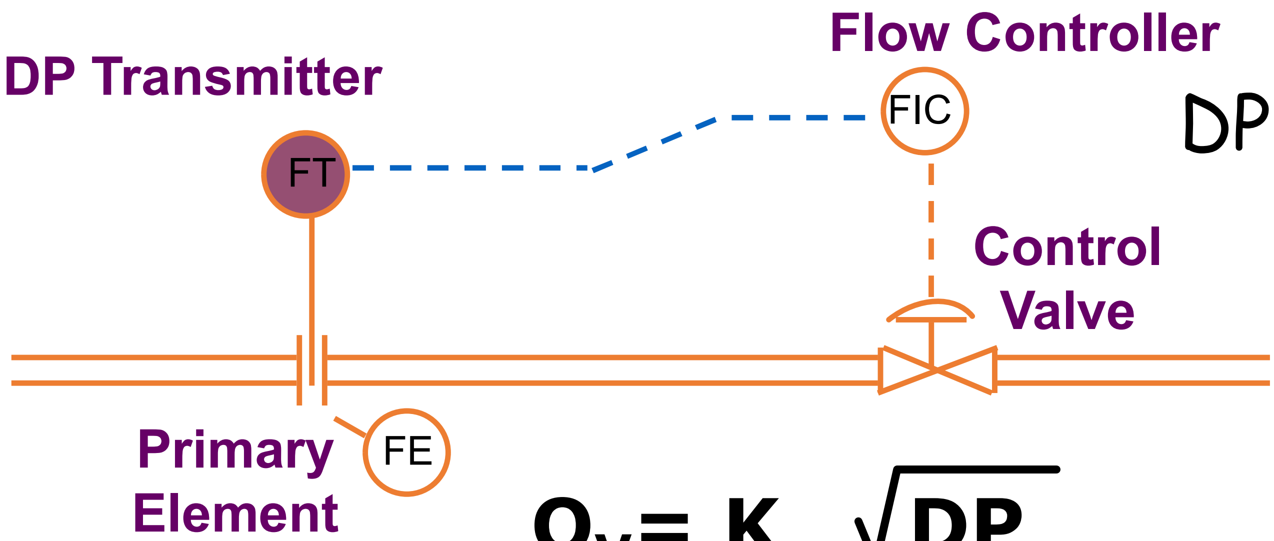
Orifice, Venturi, nozzle, Pitot-static tube, elbow, and wedge.

Secondary - measures the differential pressure.



Using well-established conversion coefficients which depends on the type of head meter used and the diameter of the pipe, a measurement of the differential pressure may be translated into a volume rate.

DP flowmeter



DP volumetric flow

$$Q_V = K \sqrt{DP}$$

- Outputs represent true flow only under specified conditions.

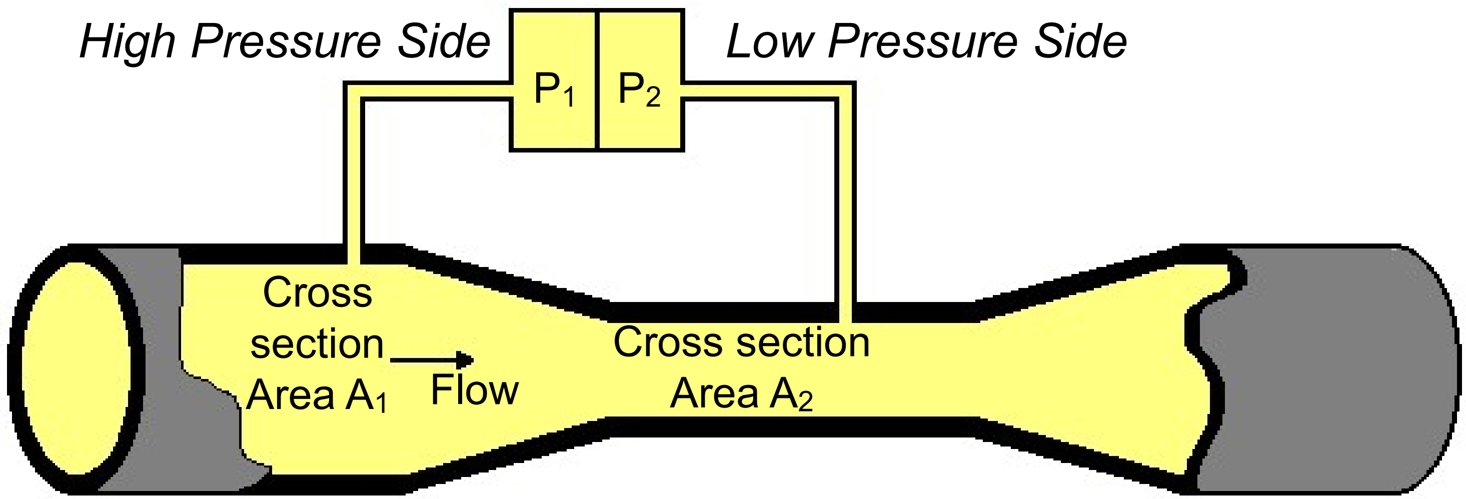
  Using "constants" in flow equations assumes a static flow environment.

- For DP flowmeter output to represent *true flow*, the following fluid properties must be constant:
  - Fluid density
  - Fluid viscosity,

DP flowmeter

Venturi Tube

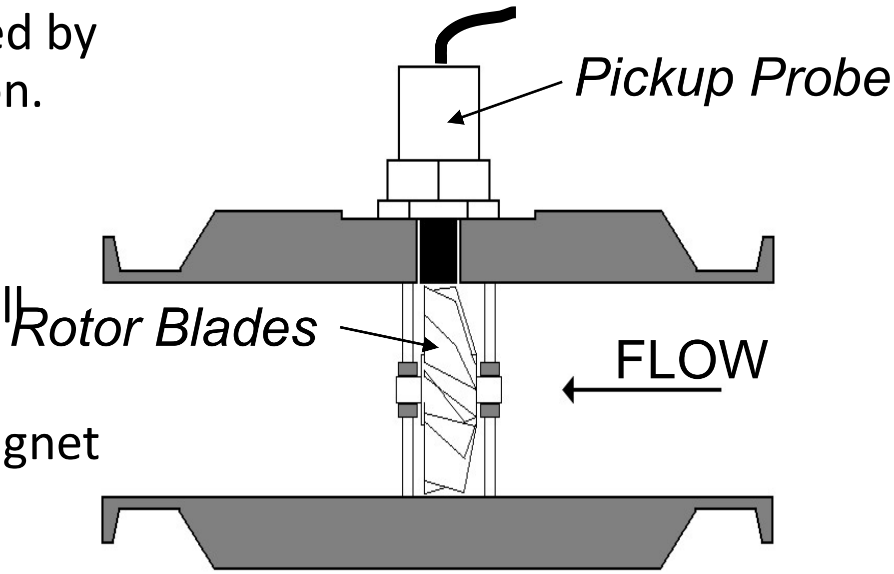
- Gradually narrows the diameter of pipe.
- Resultant drop in pressure is measured.
- Pressure recovers at the expanding section of the meter.
- For low pressure drop and high accuracy reading applications
- Widely used in large diameter pipes.



$$Q\ (\text{Actual}) = C \times A_1 \times A_2 \sqrt{\frac{2 \times (P_1 - P_2)}{(A_1^2 - A_2^2)\ \rho}}$$

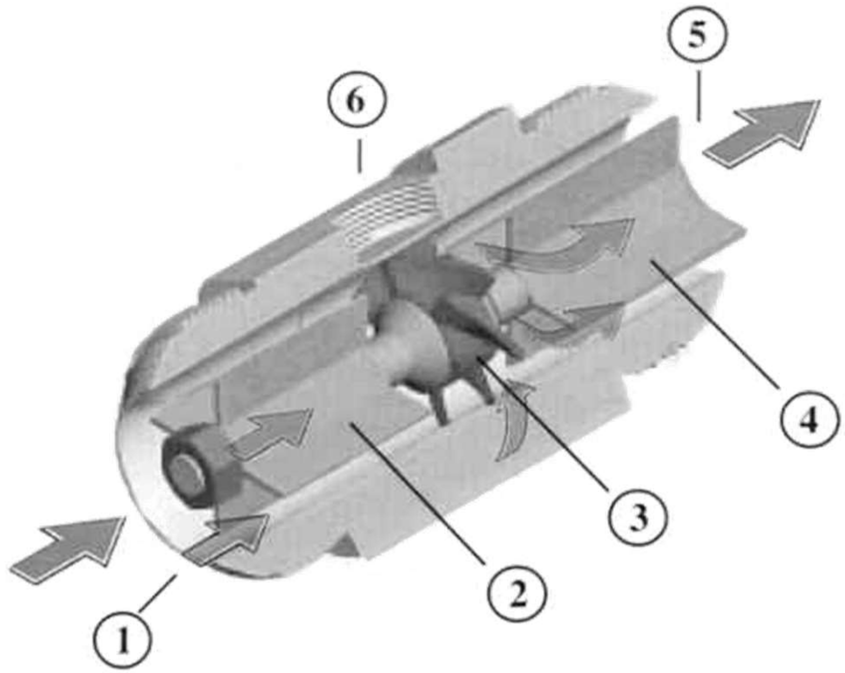
Turbine Meter

- Consist of multi-blade rotors supported by bearings and enclosed in a pipe section. perpendicular to fluid flow.
- Fluid flow drives the rotor.
- Rotor velocity is proportional to overall volume flow rate.
- Magnetic lines of flux created by a magnet coil outside the meter.



An alternating voltage is produced as each blades cuts the magnetic lines of flux. Each pulse represents a discrete volume of liquid.

Turbine Meter



Measure by determining RPM of turbine (3) via sensor (6).
Turbine meters are accurate but fragile.

Turbine Meter

Advantages:

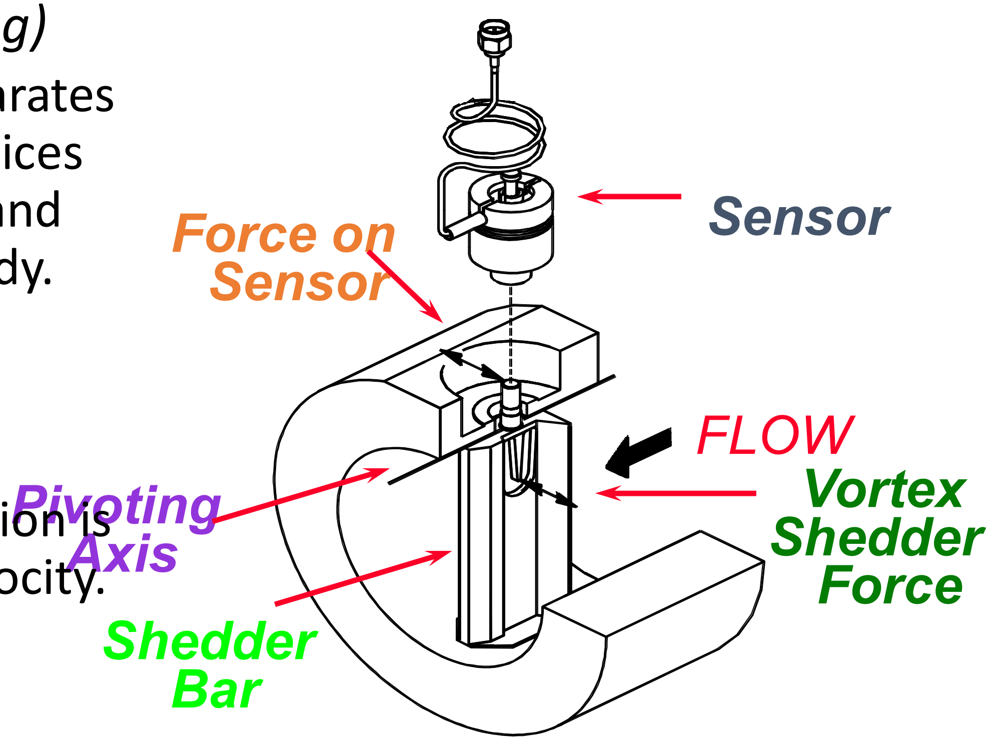
- High accuracy
- Rangeability 10:1
- Very good repeatability
- Low pressure drops
- Can be used on high viscosity fluids (but with lower turndowns)

Disadvantages:

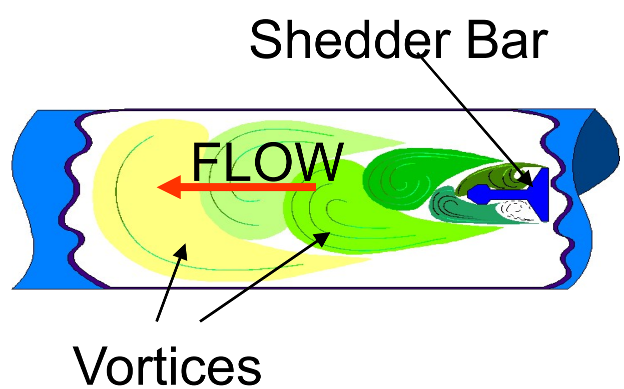
- Moving parts subject to wear
- Can be damaged by overspeeding
- High temperature, overspeeding, corrosion, abrasion and pressure transient can shorten bearing life
- Rather expensive
- Filtration required in dirty fluids

Vortex Meter

- *von karman effect (vortex shedding)*
  - As fluid pass a bluff body, it separates and generates small eddies/vortices that are shed alternately along and behind each side of the bluff body.
  - This vortices cause areas of fluctuating pressure that are detected by a sensor.
  - The frequency of vortex generation is directly proportional to fluid velocity.



$$\text{Fluid Velocity} = \frac{\text{Vortex Frequency}}{\text{K-factor}}$$



Vortex Meter

Advantages

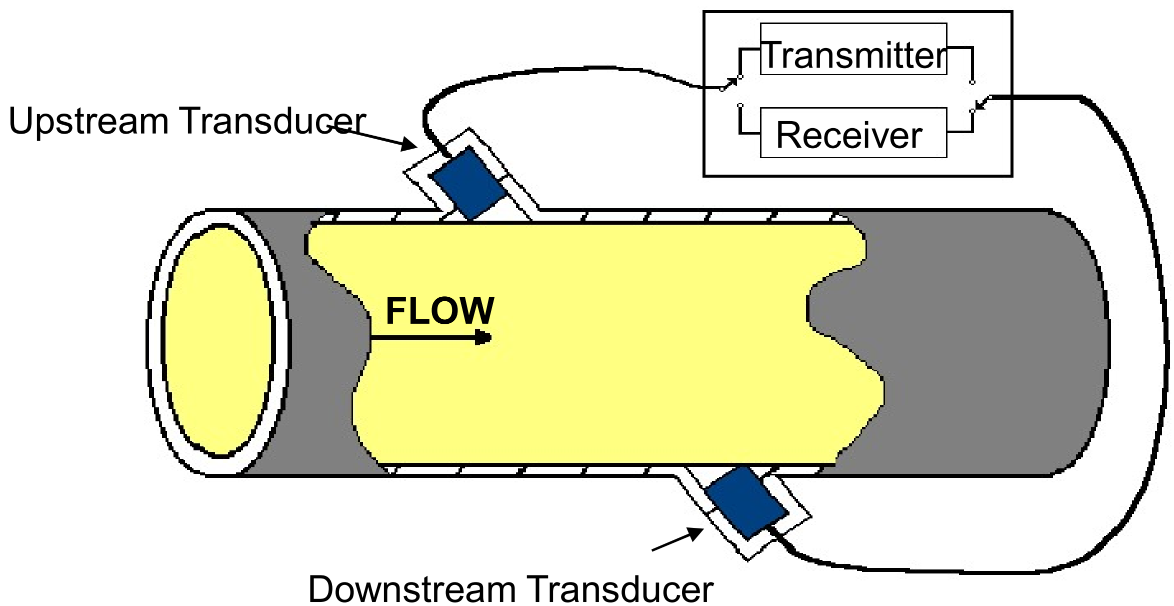
- Good accuracy
- Usually wide flow range
- Used with liquids, gases and steam
- Minimal maintenance (no moving parts)
- Good linearity over the working range

Disadvantages

- Not suitable for abrasive or dirty fluids
- Straight upstream pipe required equal to 30 times pipe diameter or longer
- Limited by low velocity (RD < 10,000)

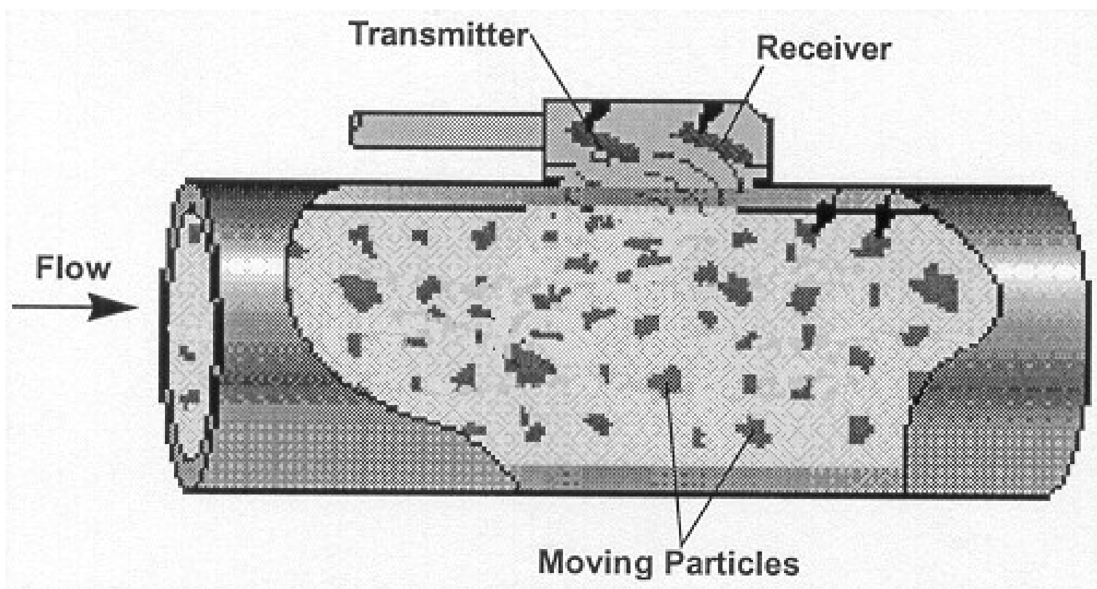
Ultrasonic Flowmeter

- uses sound waves to determine flow rates of fluids.
  - Transit-Time Method
    - 2 piezoelectric transducers mounted opposing, to focus sound waves between them at 45° angle to the direction of flow within a pipe. In a simultaneous measurement in the opposite direction to fluid flow, a value (determined electronically) is linearly proportional to the flow rate.



Ultrasonic Flowmeter

- Uses sound waves to determine flow rates of fluids.
  - Doppler Effect Method
    - One of the 2 transducer mounted in the same case on one side of the pipe transmits sound waves (constant frequency) into the fluid. Solids or bubbles within the fluid reflect the sound back to the receiver element. Frequency difference is directly proportional to the flow velocity in the pipe.



Ultrasonic Flowmeter

Advantages:

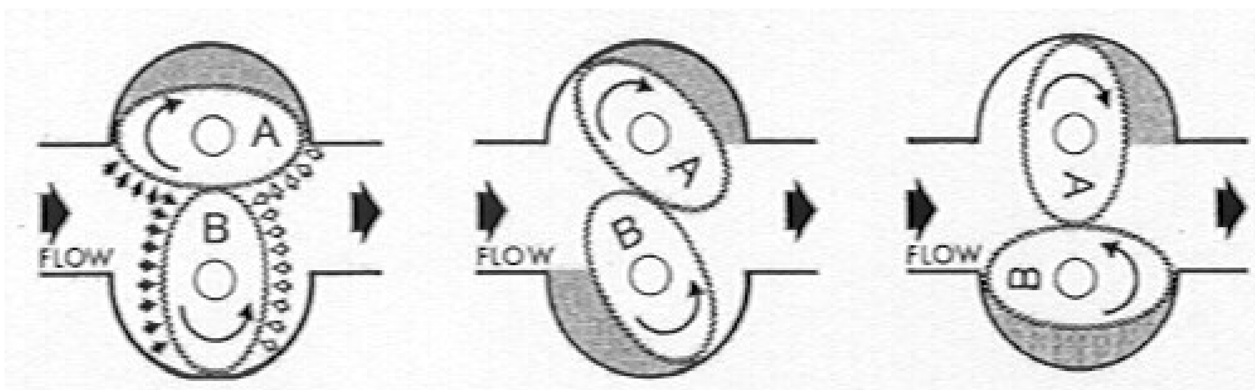
- Non-intrusive, obstructionless
- Wide rangeability (10:1)
- Easy to install (especially for clamp-on version)
- Cost virtually independent of pipe size
- The flow measurement is bi-directional

Disadvantages

- Maximum temperature 150°C
- Particular fluid conditions are required (TOF-type: clean liquids; Doppler-type: particles or impurities in the stream)
- Not very high accuracy (about ±2%)
- Doppler flowmeter clamp-on type requires a pipe of homogeneous material (cement or fibreglass linings must be avoided)

Positive Displacement Flowmeter
Oval Gear Meter

- An example of positive displacement meter
  - Two meshing oval gears rotate as fluid flows through them
  - Gears trap a known quantity of fluid as they rotate
  - Each complete revolution of both the gears = 4 * amount of fluid that fills the space between the gear and the meter body
  - volumetric flow rate is directly proportional to the rotational velocity of the gears



Effects on Volumetric Measurement

Changes in Process Conditions

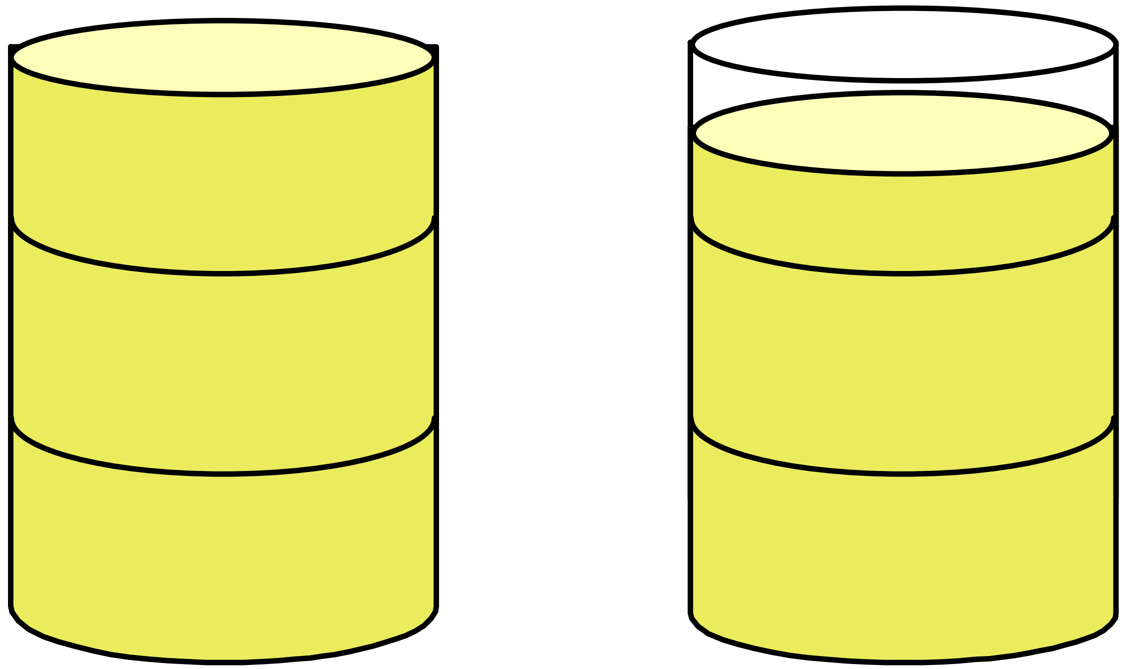
- Temperature
- Pressure

Changes in Fluid Properties

- Density
- Viscosity

Temperature Effect on Volume

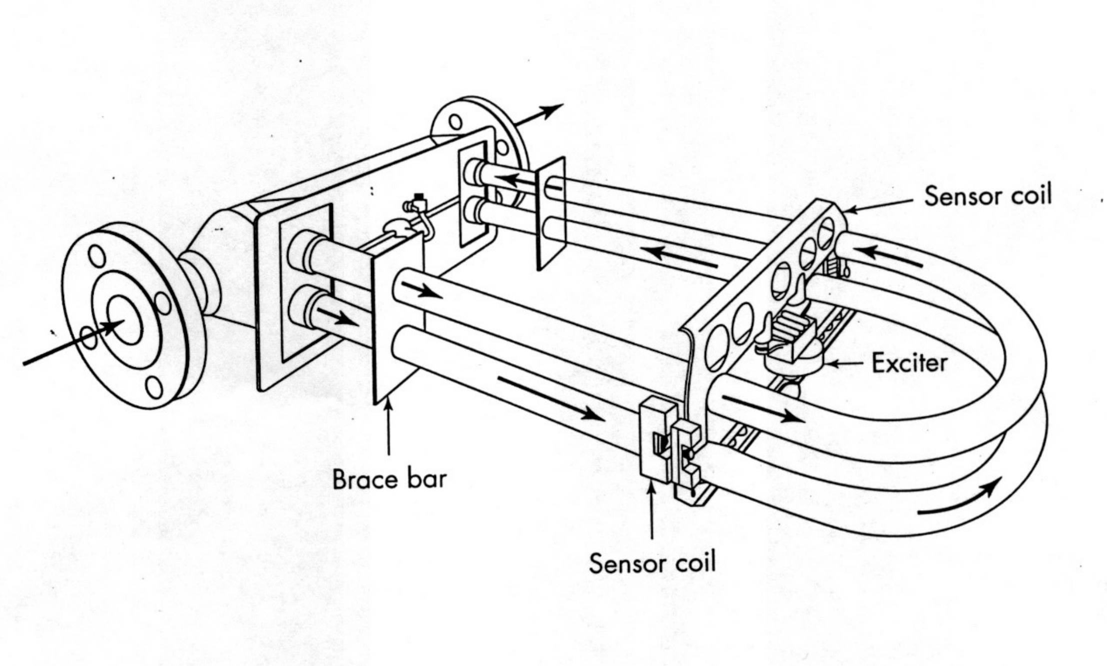
Gasoline at 16^{0} C



Gasoline at 5^{0} C

			Error
Volume:	159.0 liters	155.2 liters	2.45%
Mass:	119.5 kg	119.5 kg	0.00%

Coriolis Meters



When fluid is passed through a U-bend, it imposes a force on the tube wall perpendicular to the flow direction (Coriolis force). The deformation of the U-tube is proportional to the flow rate. Coriolis meters are expensive but highly accurate.

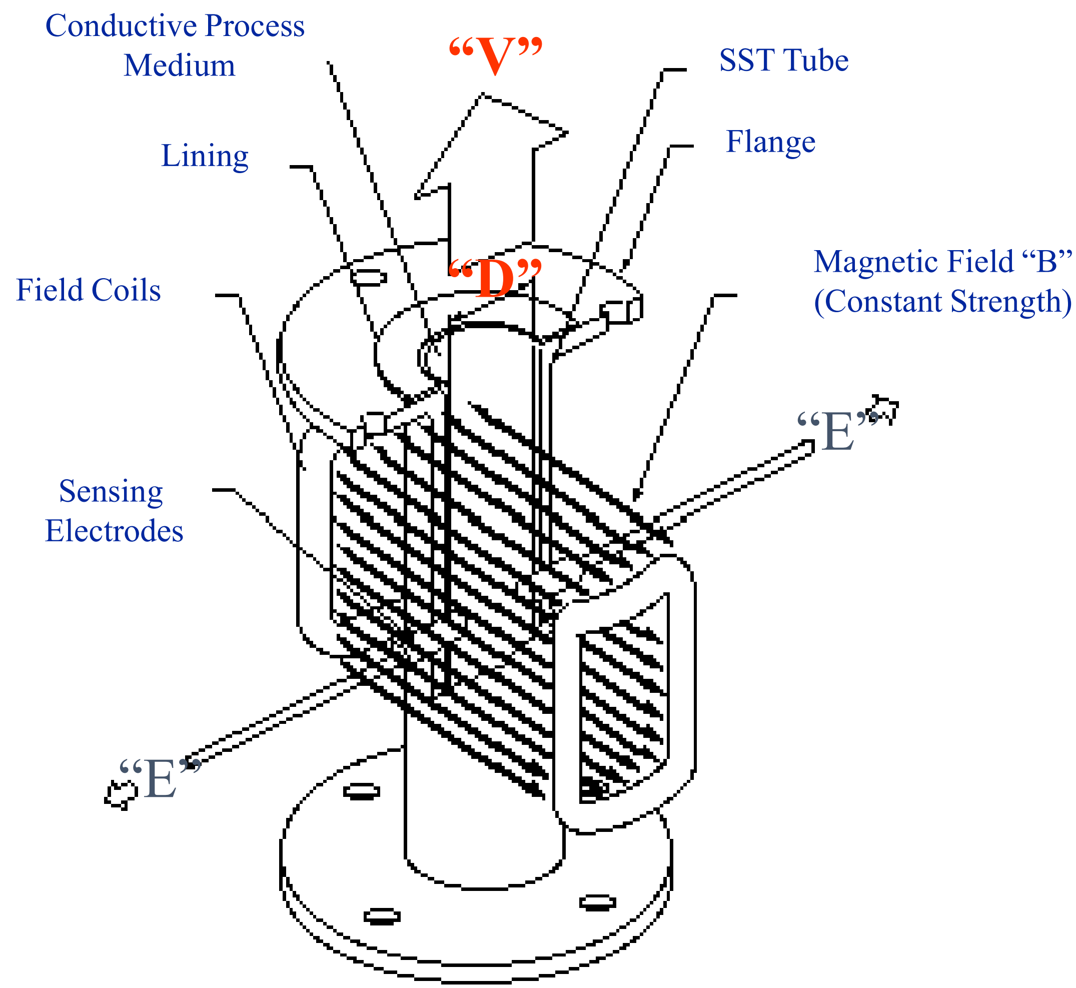
Benefits of Coriolis Technology

- Direct mass
- Simultaneous density
- Highly accurate
- Non-intrusive
- Low maintenance

Magnetic Flowmeter

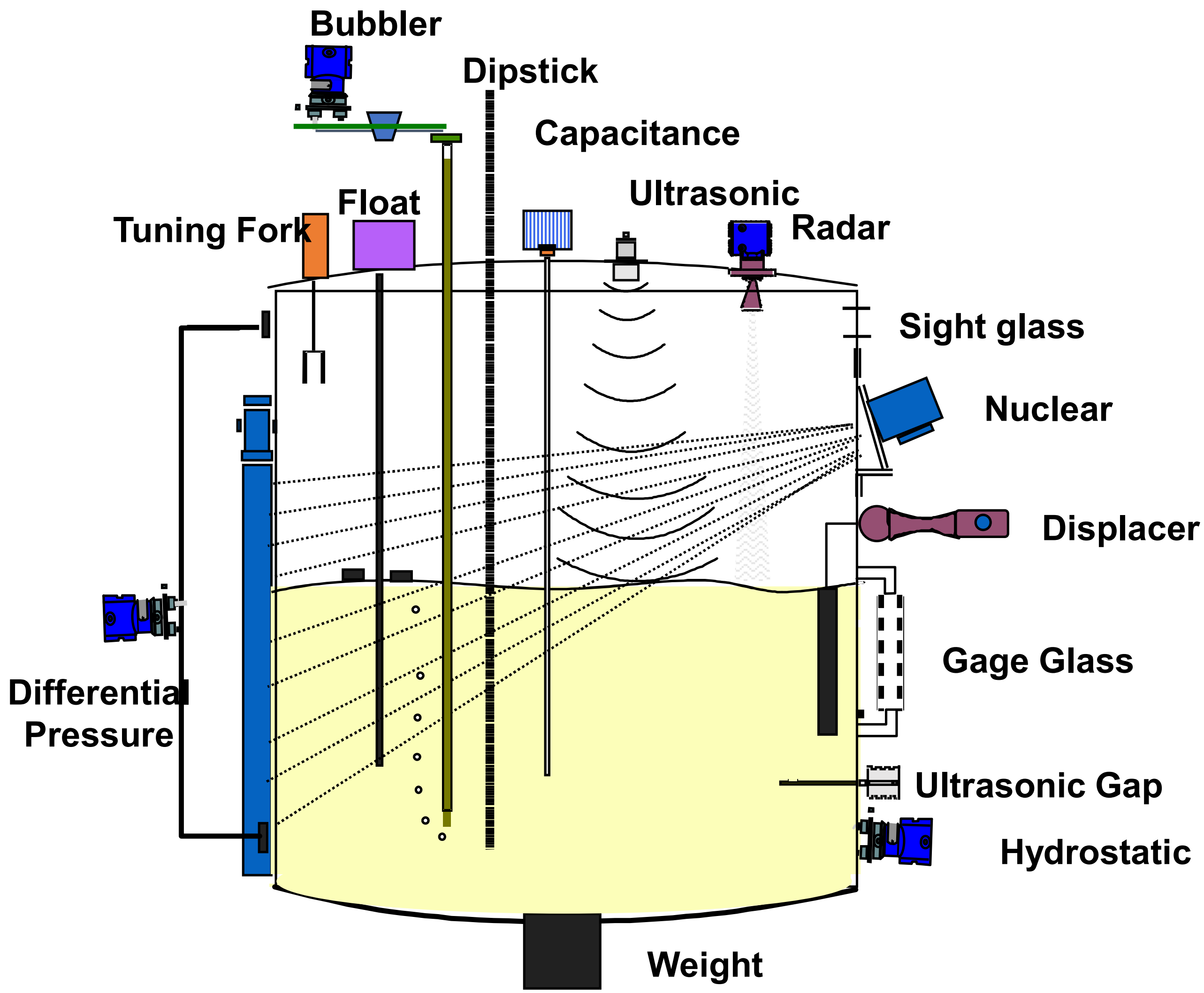
Variable Flow Rate
(Feet Per Second)

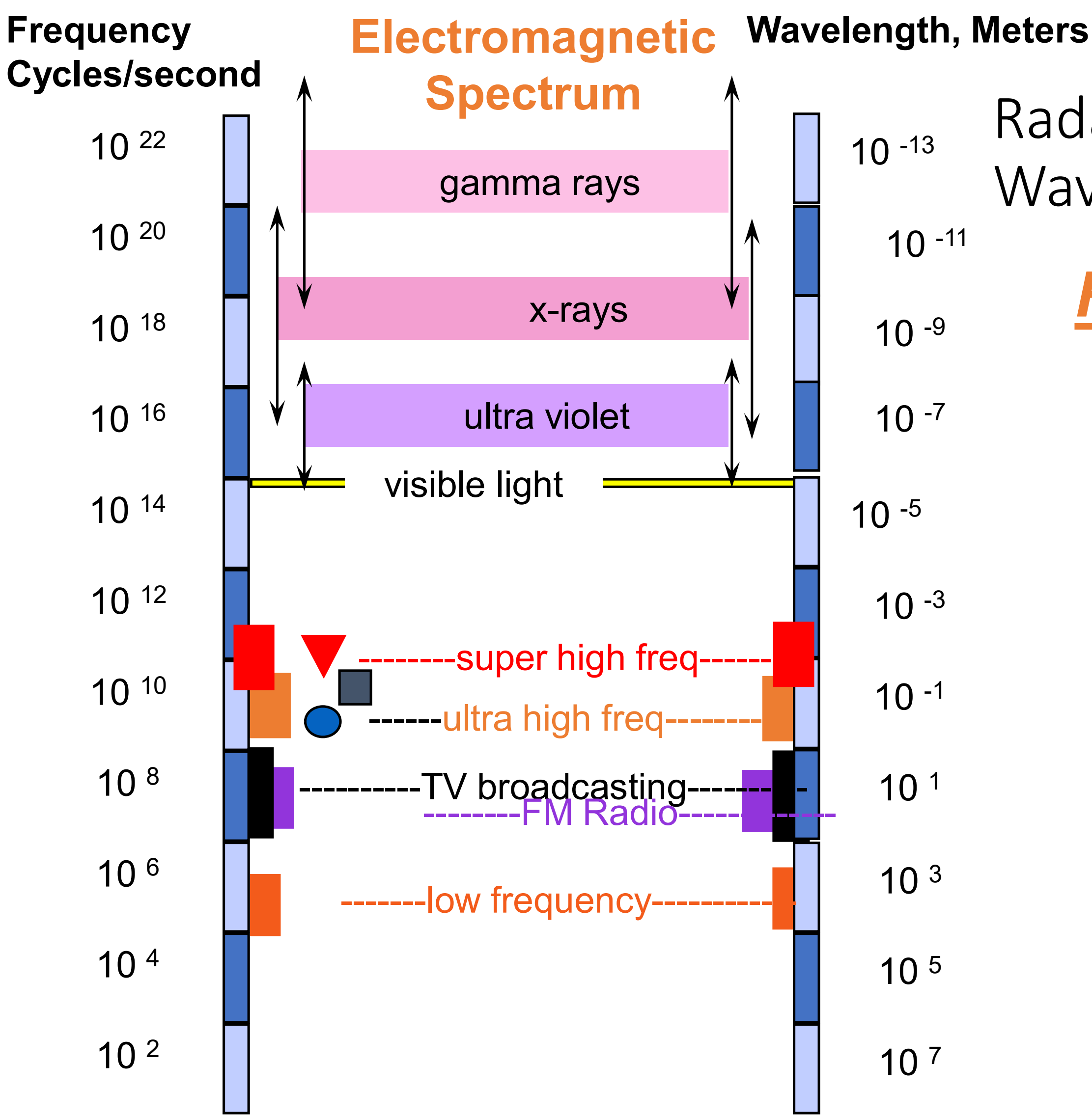
Faraday's Law



$$E = kBDV$$

Level Measurement Technologies





Radar is an Electromagnetic Wave

***Ra**dio **D**etection **A**nd **R**anging*

Radar,

3-30 GHz

Microwave oven,

2 - 10 GHz

Cellular, pager,

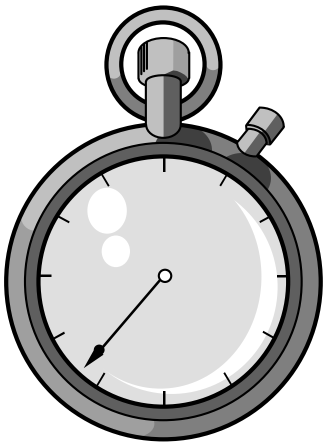
300-3000 MHz

Rosemount technologies

Radar Gauge

Radar Techniques

- *Pulse*
  - » Measures range (distance)
  - » Transmits a pulse and measure *time* until echo is received
  - » Accuracy depends on ability to measure time
    - Radar signals travel at the speed of light.
    - Must measure in picoseconds (x10^{-12}) !
    - Cost-effective electronics do not exist to do this accurately !

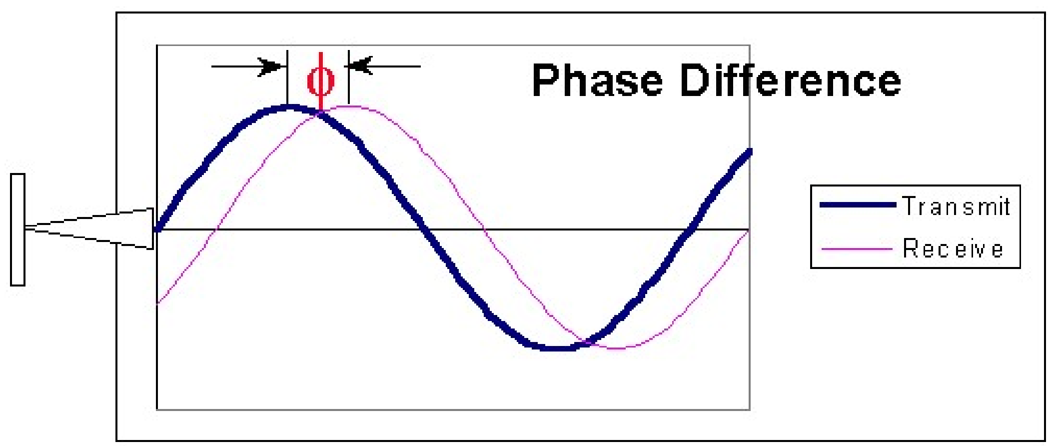


Rosemount technologies

Radar Gauge

Radar Techniques

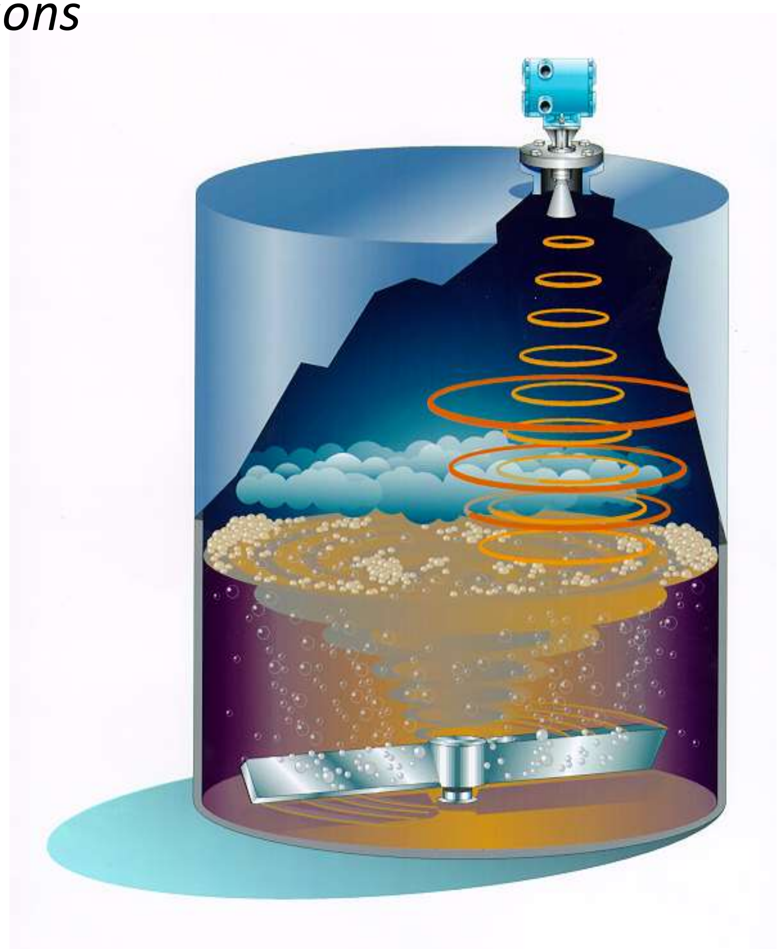
- *FMCW: Frequency Modulated Continuous Wave*
  - » Does NOT calculate time-of-flight
  - » Evaluates the *phase difference* between the transmitted and return signal
  - » Plotting these phase differences against the transmitted signal yields a result proportional to distance



Rosemount technologies

Radar Gauge

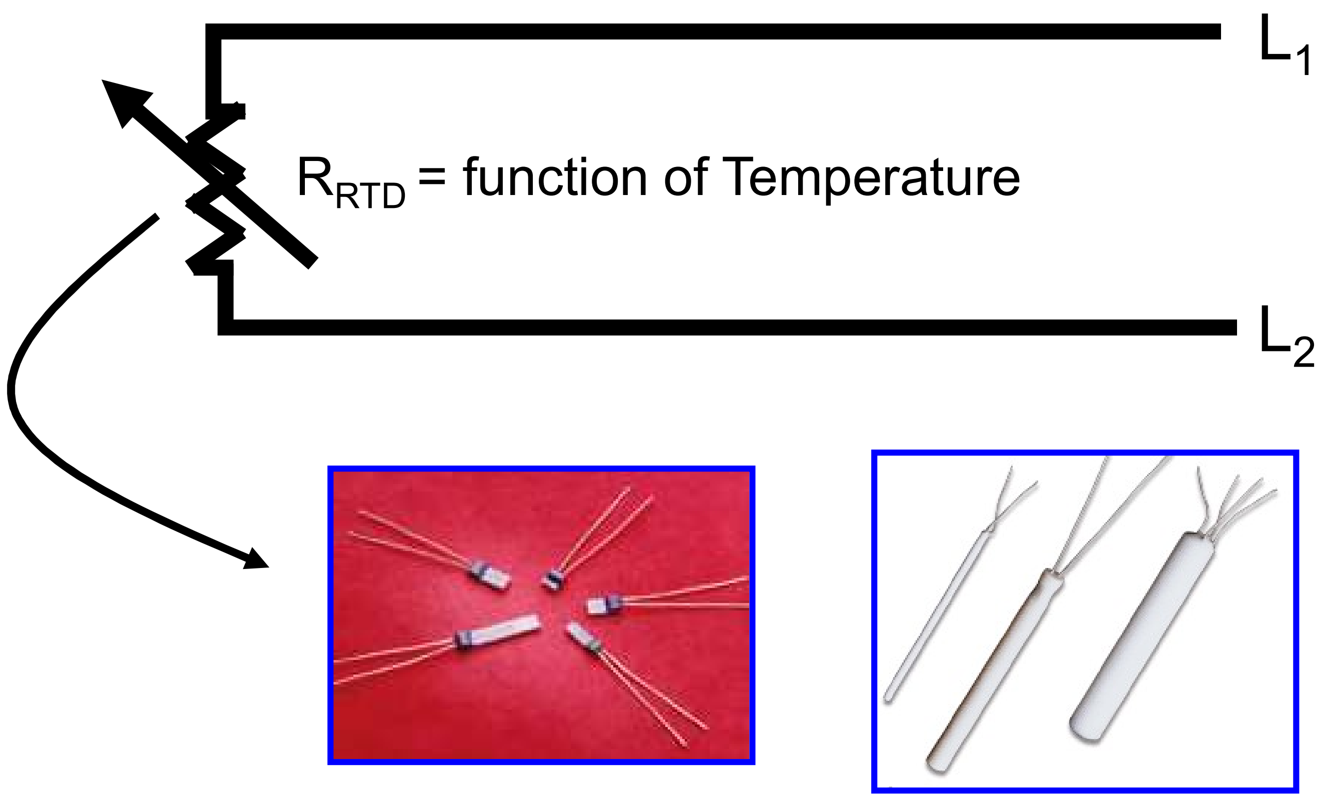
- *Non Contact, Non Intrusive*
- *Tolerates Wide Range of Process Conditions*
  - » Corrosive Processes
  - » High Temperatures
  - » Changes in Vapor Space
  - » Variable Density
  - » Variable Dielectric
  - » Viscous or Sticky Products
- *Low Maintenance*
- *No Special Licenses Required*
- *Can measure long distances*
- *Liquids, pastes, solids*



Temperature Sensors: RTDs

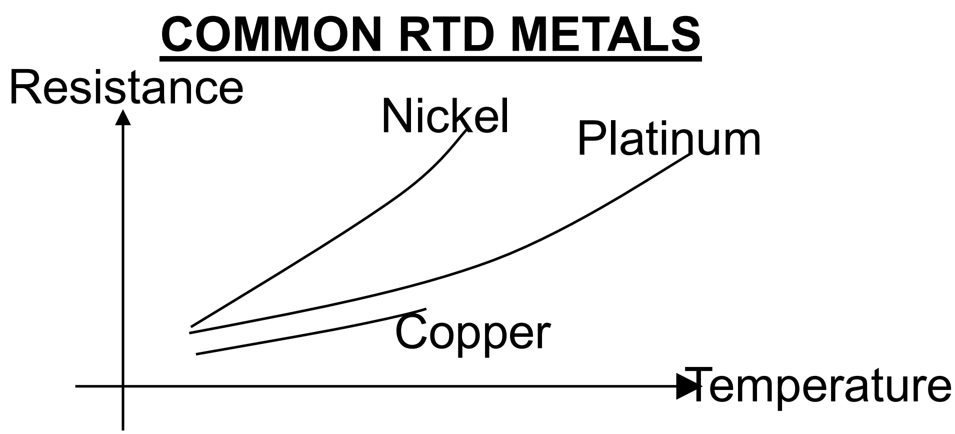
Operating Principle: Resistance increases as temperature increases.

RTD = Resistance Temperature Detector



Temperature Sensor Fundamentals

- RTD Operating Principle
  - Electrical resistance of a metal changes as temperature changes, also called thermo-resistivity



  - Many RTD metals are in existence, but Platinum is the most common due to its relatively large temperature range and linearity

Industry Standard RTDs

- Thin Film
  - Usually Class B tolerance
  - Range: -50 to 450°C

- Wire-wound
  - Usually Class A tolerance for range –50 to 450 °C
  - Only Class B for High Range: -200 to 600°C

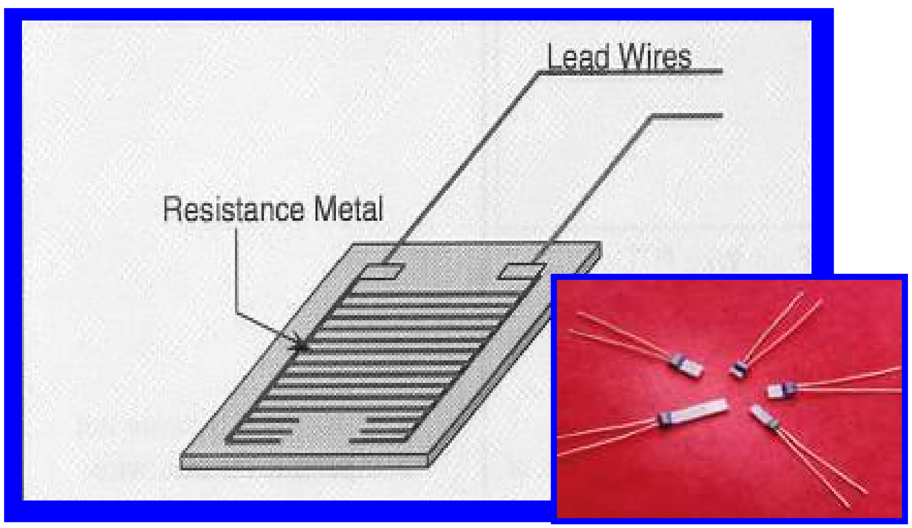


Fig A: Platinum metal is deposited on a ceramic substrate.

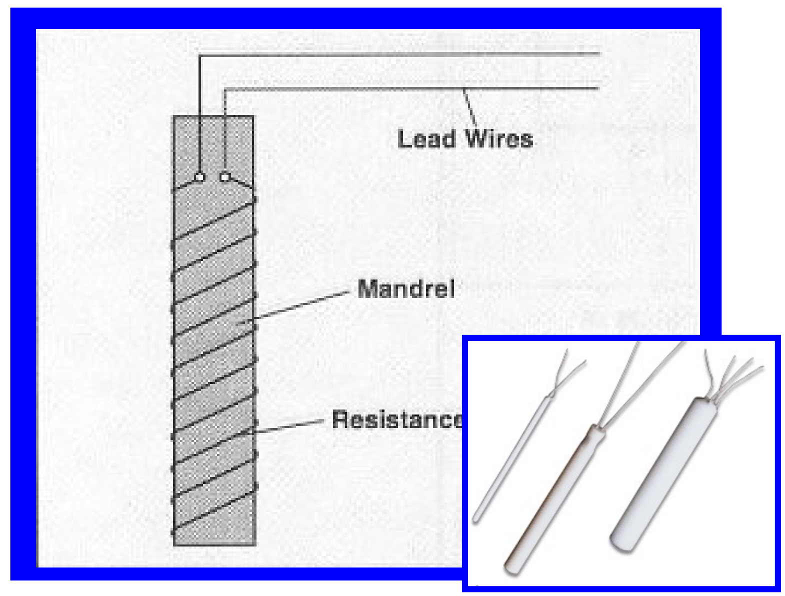


Fig B: Platinum wire is wound on or inside a ceramic mandrel.

Temperature Sensors

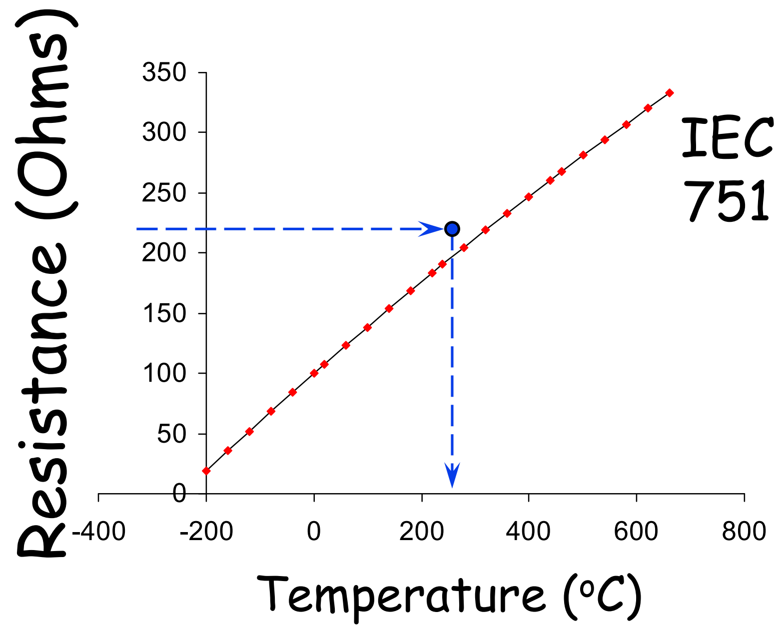
RTDs

- How does a RTD work?
  - Resistance changes are Repeatable
  - The resistance changes of the platinum wiring can be approximated by an ideal curve -- the IEC 751

International Resistance vs. Temperature Chart:

°C	Ohms
0	100.00
10	103.90
20	107.79
30	111.67

IEC 751

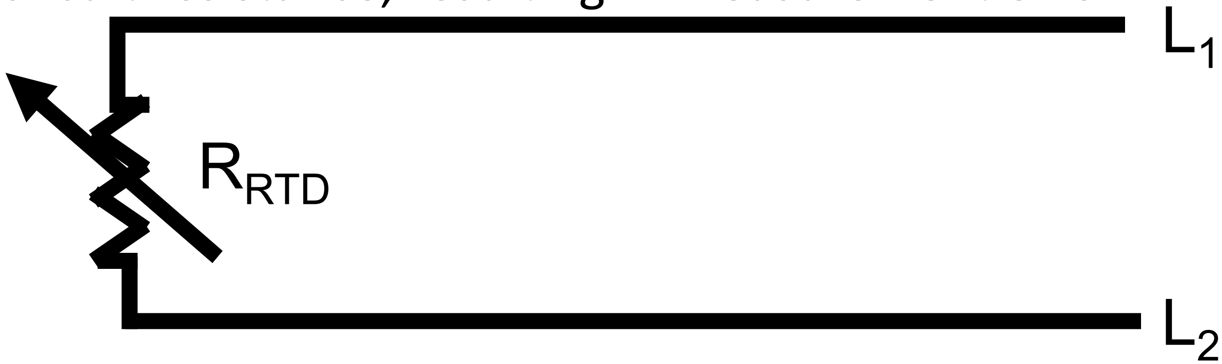


IEC 751 Constants are :- A = 0.0039083, B = - 5.775 x 10 $^{-7}$,
If t>=0°C, C=0, If t<0, C = - 4.183 x 10 $^{-12}$

Example: $R_T = R_0 [1 + At + Bt^2 + C(t-100)t^3]$
$= 103.90$

RTDs: 2-Wire Configuration

- Circuit is uncompensated so leadwire resistances are additive to the total circuit resistance, resulting in measurement error.

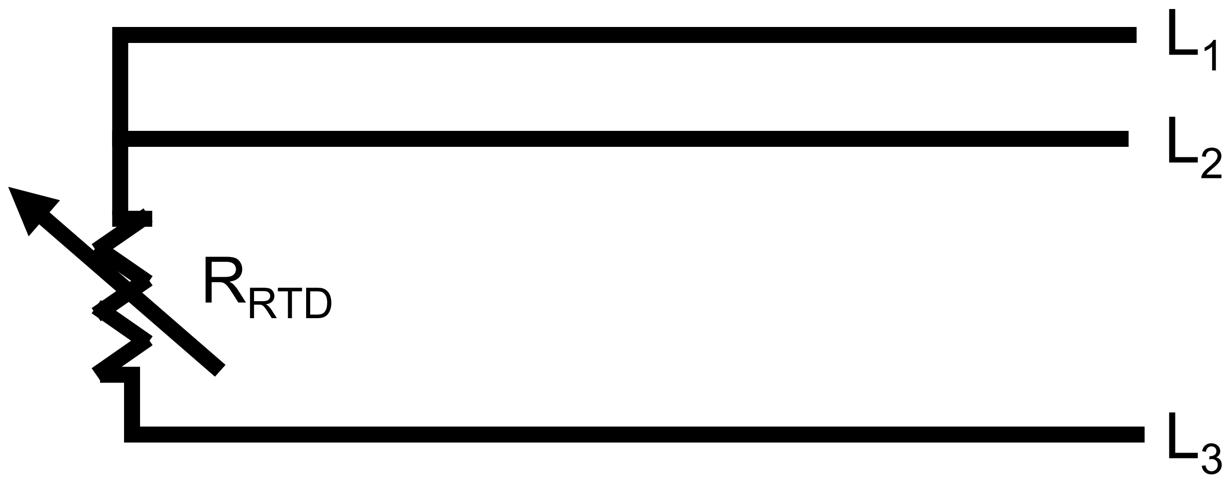


Resistance Reading = $R_{RTD} + L_1 + L_2$

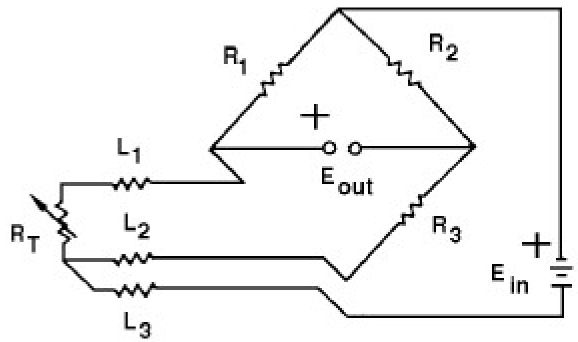
NOT RECOMMENDED!!

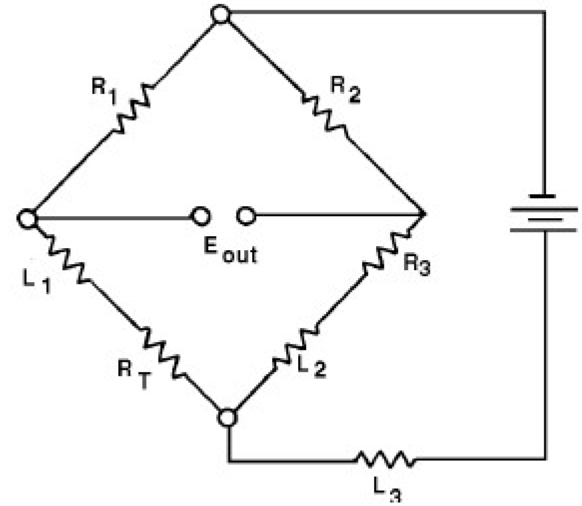
RTD 3-Wire Configuration

- L_1 / L_2 is subtracted from L_2 / L_3 in order to compensate for leadwire resistance.
- Assumes that leadwire resistances L_1 / L_2 and L_2 / L_3 are the same. Usually correct within 5%.



RTD 3-Wire Configuration





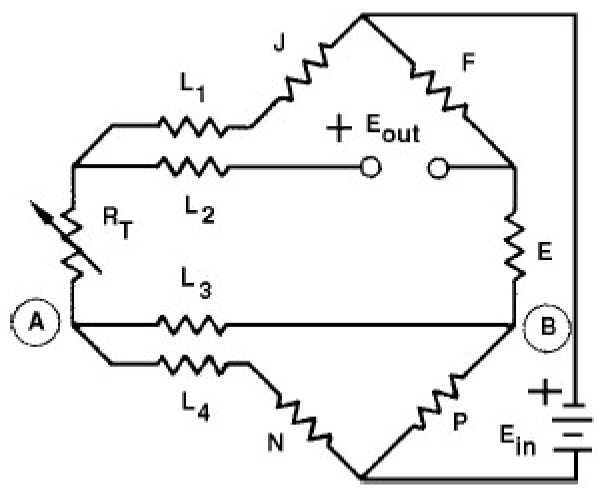
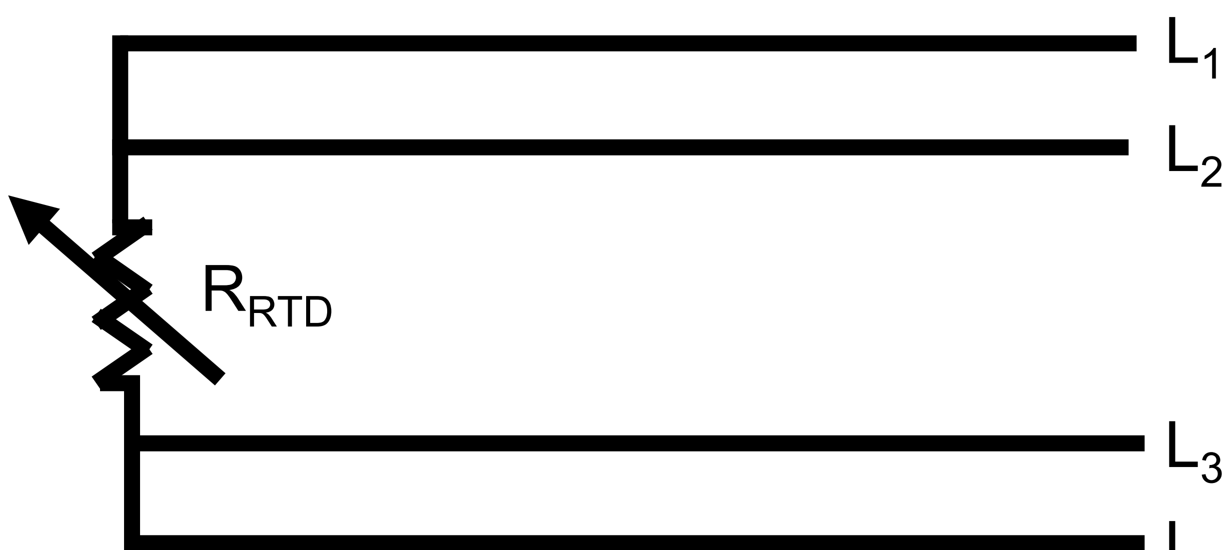


Fig. 5.38 The four-wire bridge

RTD 4-Wire Configuration

- L_1 / L_4 is used to source a precise electrical current
- L_2 / L_3 is used to precisely measure the voltage drop across the RTD sensor element
- The exact RTD resistance (without any leadwire effects) can then be calculated

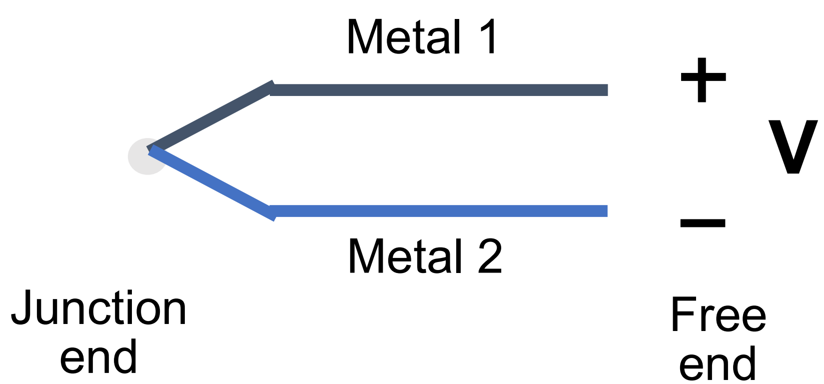


RTD Wiring Configuration Recommendations

- 2-, 3-, and 4-wire configurations available
- In general, only 3- and 4-wire configurations should be used
- 4-wire configurations are recommended for high accuracy applications and for longer leadwire distances
    - Measurement independent of the properties of the leadwires or their variation

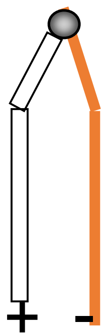
Thermocouple Operating Principle

- 2 wires of dissimilar metals joined at a junction will create a voltage that is proportional to the **temperature difference** between the junction end and the free end, also called the Seebeck Effect.

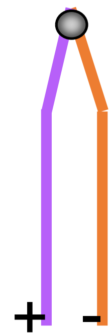


- Many thermocouple metals are in existence but the most common consist of pairings of Iron, Constantan (Copper/Nickel), Chromel(Nickel/Chromium), Alumel (Nickel/Aluminum) and Copper

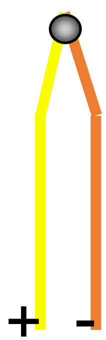
Thermocouples:
Metallic Types and Leadwire Colors

- Type J


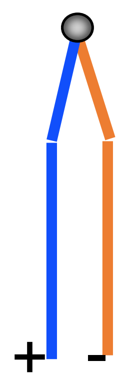
  - Iron / Constantan
    - White, Red
    - 0 to 760 °C
    - Most common

- Type E


  - Chromel / Constantan
    - Purple, Red
    - 0 to 900 °C
    - Most sensitive

- **Type K**


  - Chromel / Alumel
    - » Yellow, Red
    - » 0 to 1150 °C
    - » **Most Linear output**

- **Type T**


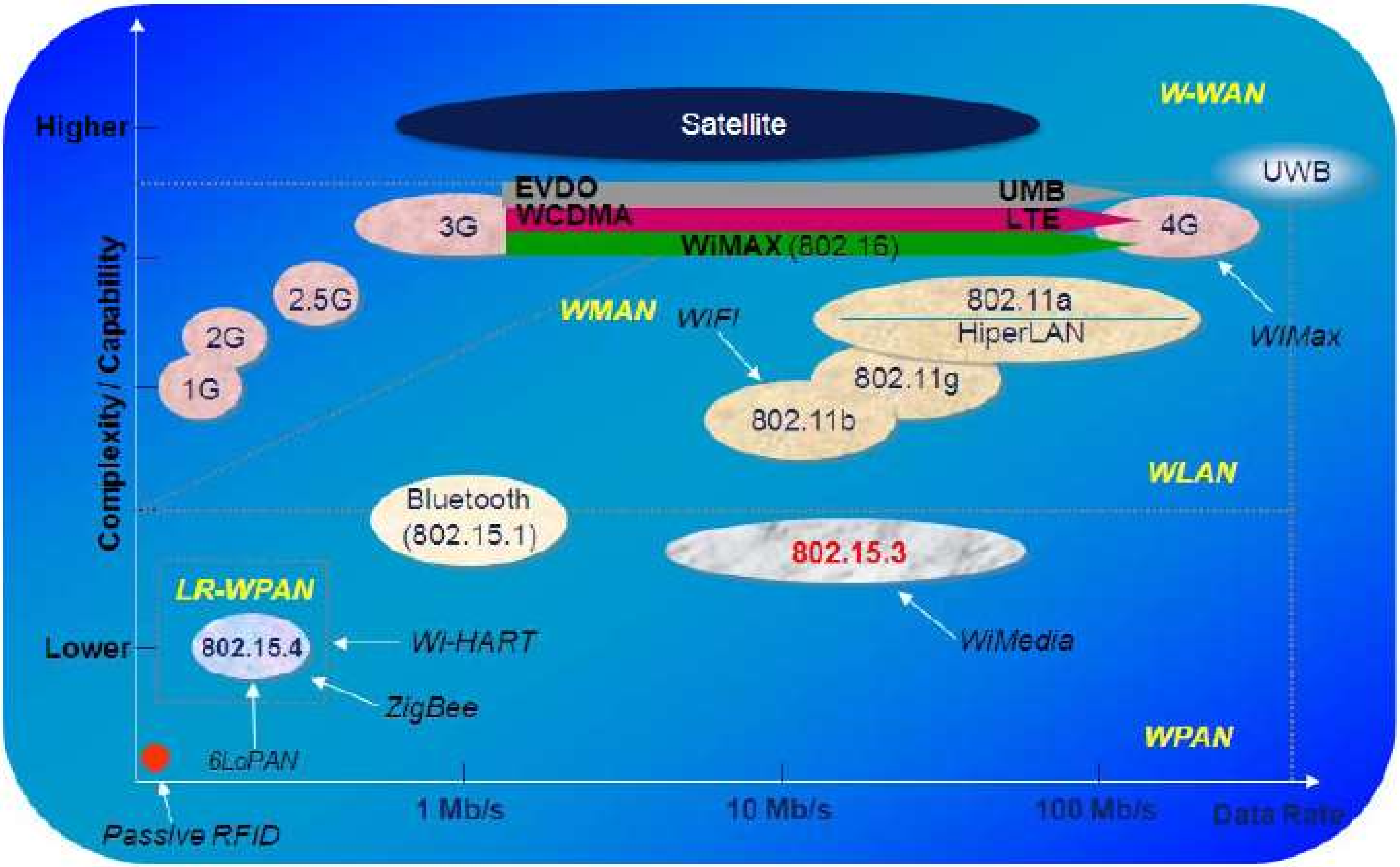
  - Copper / Constantan
    - » Blue, Red
    - » -180 to 371 °C
    - » **Highly resistant to corrosion from moisture**

Technologies:
RTD's versus Thermocouples

- Why use an RTD?
  - When accuracy is important
    - Sensor accuracy
    - System accuracy
  - More linear output
  - More stable
  - Lower installation cost
  - Less susceptible to EMI

- Why use a Thermocouple?
  - Less expensive sensor cost
  - Greater temperature range
  - More flexible configurations
  - Faster response
  - Simple rugged design

Standard Wireless Landscape



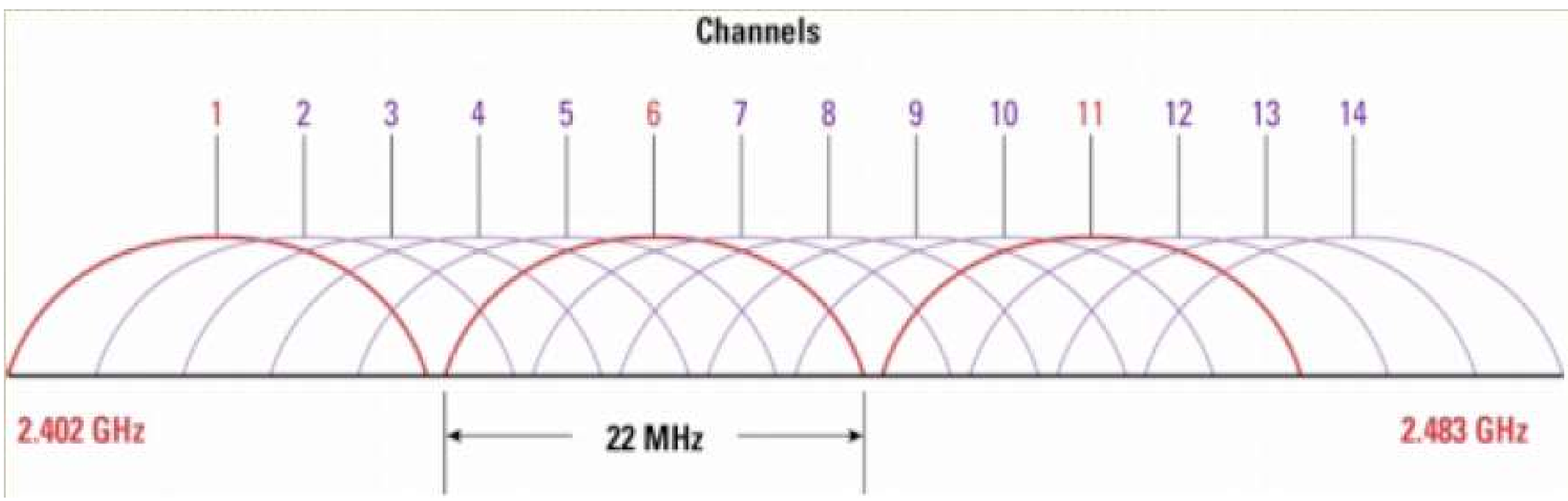
IEEE 802.15.4 Characteristics

- Data rate of 250kbps in 2.4 GHz Band
  - 16 Radio Channels
  - Digital Modulation based on Direct Signal Spread Spectrum(DSSS)
- Peer to Peer operation to enable Mesh network formations
- Support for low latency and latency controlled devices
- “Listen Before Talk” channel access (CSMA-CA)
- Dynamic device addressing
- Full handshake protocol for transfer reliability
- Low Power Consumption
- Designed with 802.11 Coexistence in mind

IEEE 802.11 (aka WiFi or Wireless Ethernet)

Protocol	Release	Frequency	Throughput	Max Rate
Legacy	1997	2.4 GHz	0.9 Mbps	2 Mbps
802.11a	1999	5 GHz	23 Mbps	54 Mbps
802.11b	1999	2.4 GHz	4.3 Mbps	11 Mbps
802.11g	2003	2.4 GHz	19 Mbps	54 Mbps
802.11n	2009	2.4 GHz; 5 GHz	74 Mbps	248 Mbps

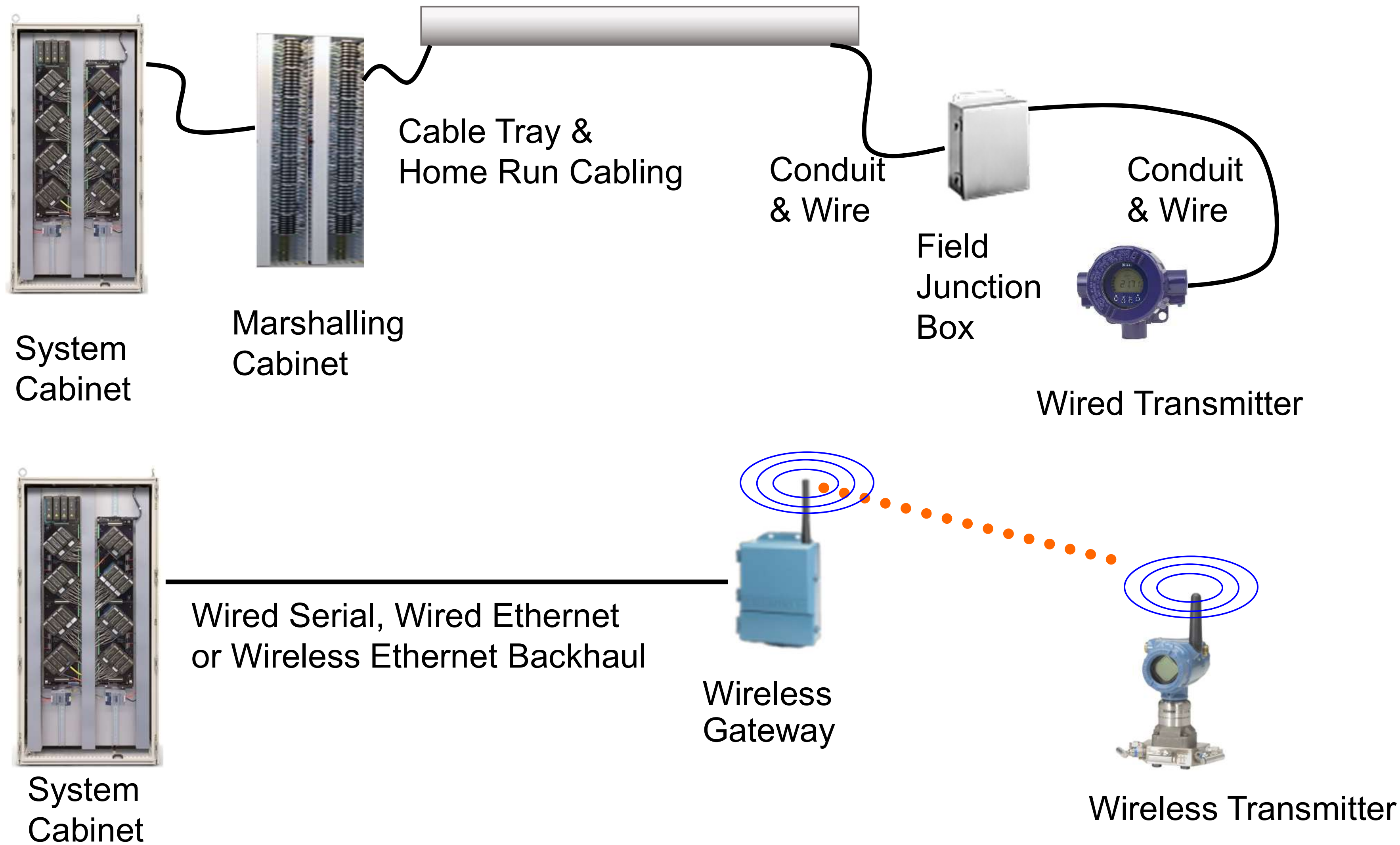
- IEEE 802.11e – QoS Extenstion
- IEEE 802.11i – Enhanced security
- IEEE 802.11s – Mesh networking



Wireless Networks Table

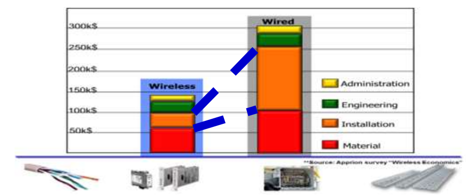
Network 'Standard'	802.11b/g (WiFi)	802.11a (Wireless A)	802.15.1 (Bluetooth)	802.15.3 WiMEDIA	802.15.4 ZigBee SP100 Wireless HART	802.16 WiMAX	Control Channel (AERIS)	2.5G/3G WCDMA EDGE	Satellite
Frequency	2.4GHz	5.8GHz	2.4GHz	2.4GHz	2.4GHz 915/868MHz	2 – 11 GHz 10 – 66 GHz	900MHz	2.4GHz	137 – 150 MHz
Network Type	LAN	LAN	PAN	PAN	PAN	MAN	WAN	WAN	WAN
Transmission Method	DSSS	OFDM	FHSS	OFDM	DSSS	OFDM	AMPS CC (*)	3G	SAT
Distance	300 feet (*)	300 feet (*)	30 feet	30 feet	100's of ft.	30 miles	Mobile	Mobile	Global
Bandwidth	11Mbps 55Mbps	55Mbps	1Mbps	55Mbps	250Kbps	75Mbps	50-100bps	64K – 384Kbps	2.4Kbps (up) 57Kbps (down)
Power Consumption	High	High	Low	Low	Very Low	High	Low	Low	Low
Device Availability	Mainstream	Mainstream	Mainstream	Gestation	Mainstream	Infancy	Mature	Infancy	Mainstream
Primary Application Areas	Email Data entry, Client Access	Large File Transfer, Backhaul	Device Interface	Video	Industrial Sensors & Switches	Wireless Backhaul	Remote Monitoring	Mobile Applications	Sparse Apps.

Wired and Wireless Communication Methods Overview



Benefits of Field Wireless

- Reduce Capital Savings
  - Wire material, Labor, Conduit, Junction boxes, Drawings, etc.



- Reduce Operational Expenses
  - Less maintenance, less downtime, higher productivity, easy modification/expansion

- Improve Safety and Production quality
  - Easy to increase or move monitoring points
  - Reduce difficult or impossible monitoring points like limited space, long distance, dangerous atmosphere

Technical Considerations for Field and Plant Networks

Wireless **Field Networks**

Bandwidth: Lower - Short, high priority communications

Security/Reliability: We cannot 'drop a call'…Must coexist and perform in dynamic, harsh plant environment

Power: LOW…lots of devices, widely distributed in harsh environments, batteries must last 5-10 years

Standards: Driven by Process community (WirelessHART/ISA100.11a)

Wireless **Plant Networks**

Bandwidth: High – Multiple applications must share the same wireless infrastructure

Security/Reliability: Industrial security and robust coexistence essential… Must pass IT muster

Power: Devices can be line powered or recharged daily

Standards: Driven by IT Community (802.11)

Wireless Typical Applications

Wireless **Field Networks**

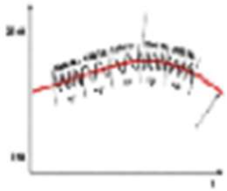
Typical Applications:

1. Difficult Process Monitoring
2. Rotating Equipment
3. Environmental
4. Auxiliary Systems (Pump, HE)
5. Operator Safety
6. On/Off Valve Position
7. Process Startup
8. Temporary Installations
9. Wired Alternative

Wireless **Plant Networks**

Typical Applications:

1. Field Data Backhaul
2. Mobile Worker
3. Video - Security
4. Video - Process
5. Location Tracking
6. Safety Mustering



1986

HART became an open standard.

1993

The HART Communication Foundation was formed to manage the standard.

1999

The HART Server, an easy to use, OPC compliant software application for accessing real time process and diagnostic information was released

2001

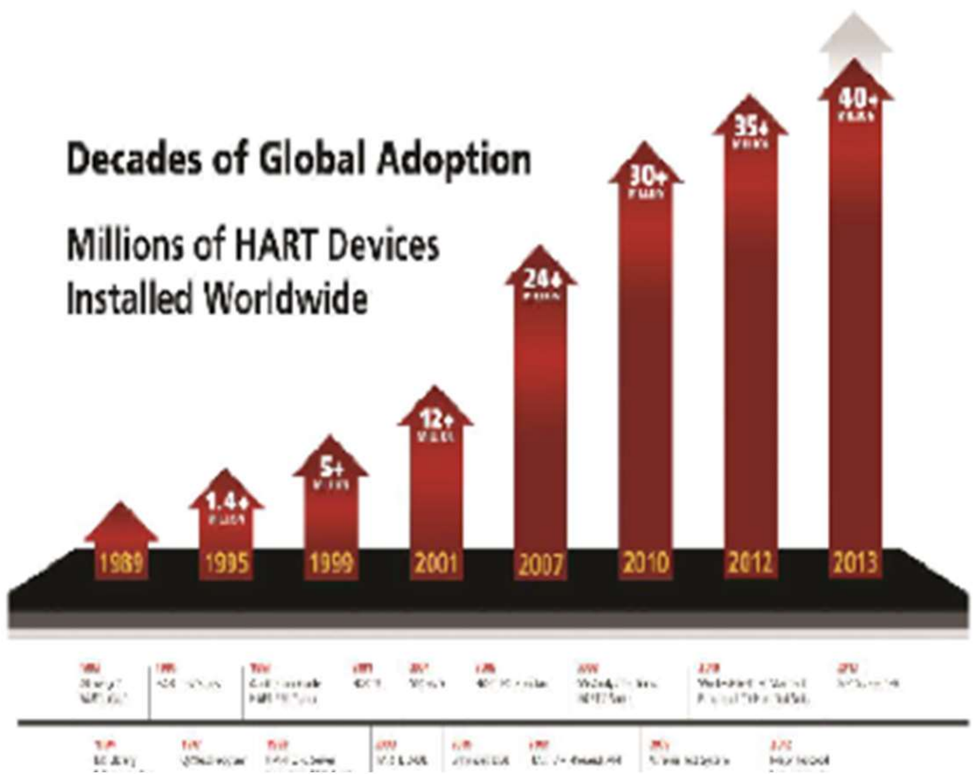
HART 6 was released, including features to enable AMS (Asset Management System) integration.

2007

HART 7 was released, and included the WirelessHART standard.

2012

HART 7 was enhanced with additional functionality, including HART IP.



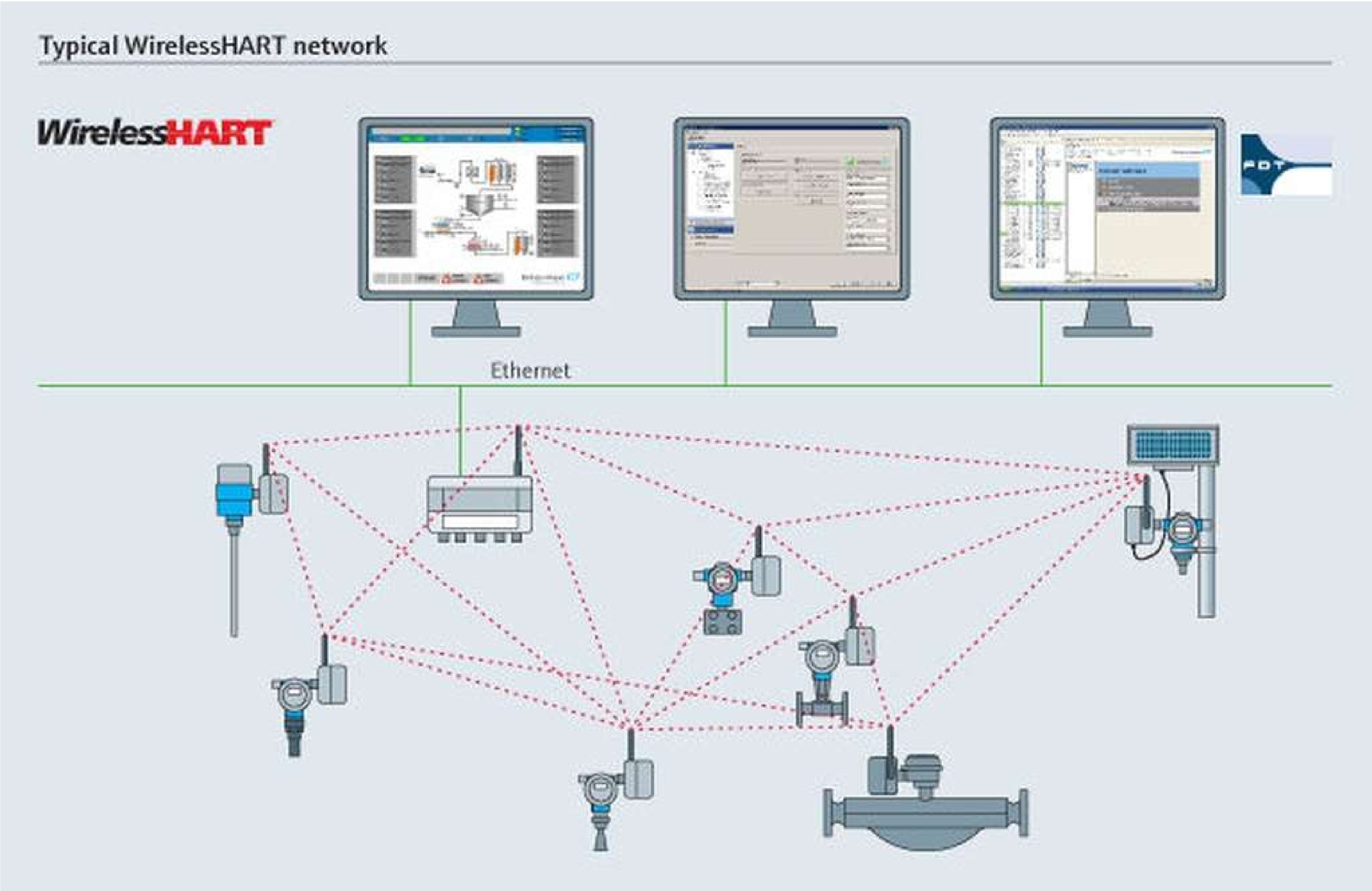
What to Expect from a Wireless Solution

- Make it **Simple**
  - As simple as 4-20mA
  - Technology not technicians
- Make it **Reliable**
  - Process plants change
  - Need to coexist
- Make it **Secure**
  - Secure the data and network
  - Authenticate data and devices

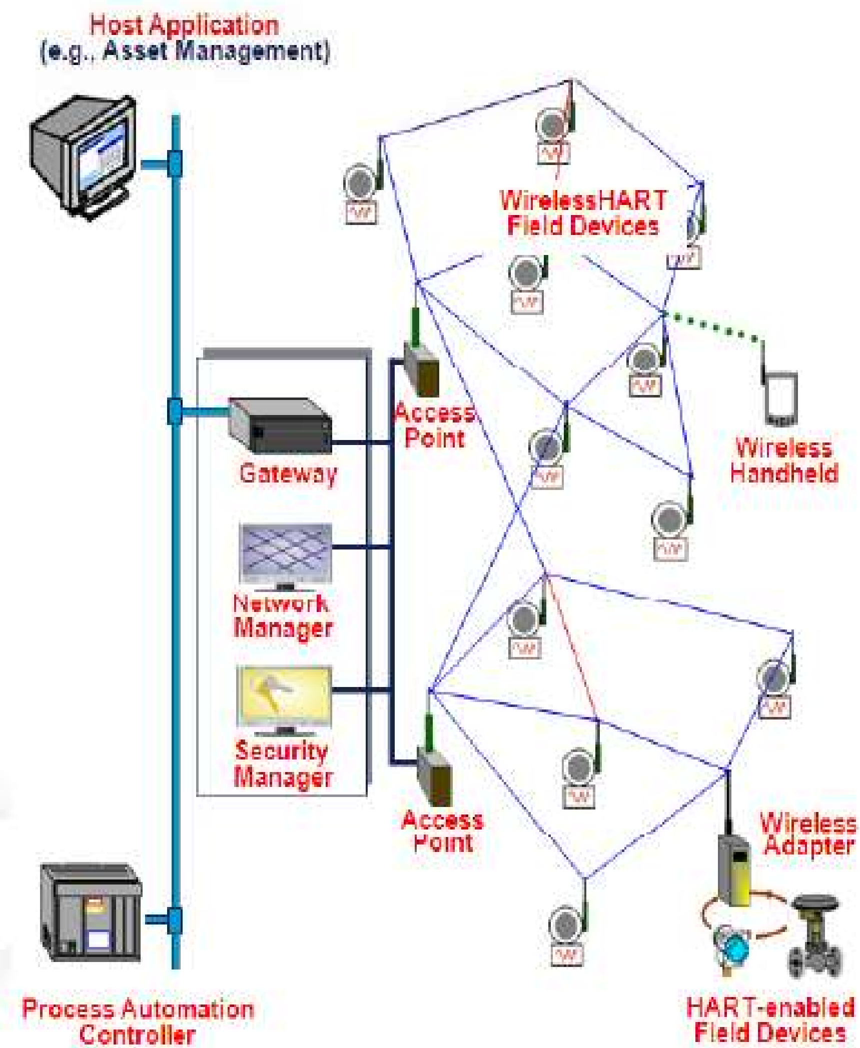
Simple. Reliable. Secure.

WirelessHART

HART Without Wires!


Typical WirelessHART network
WirelessHART
FDT
Ethernet

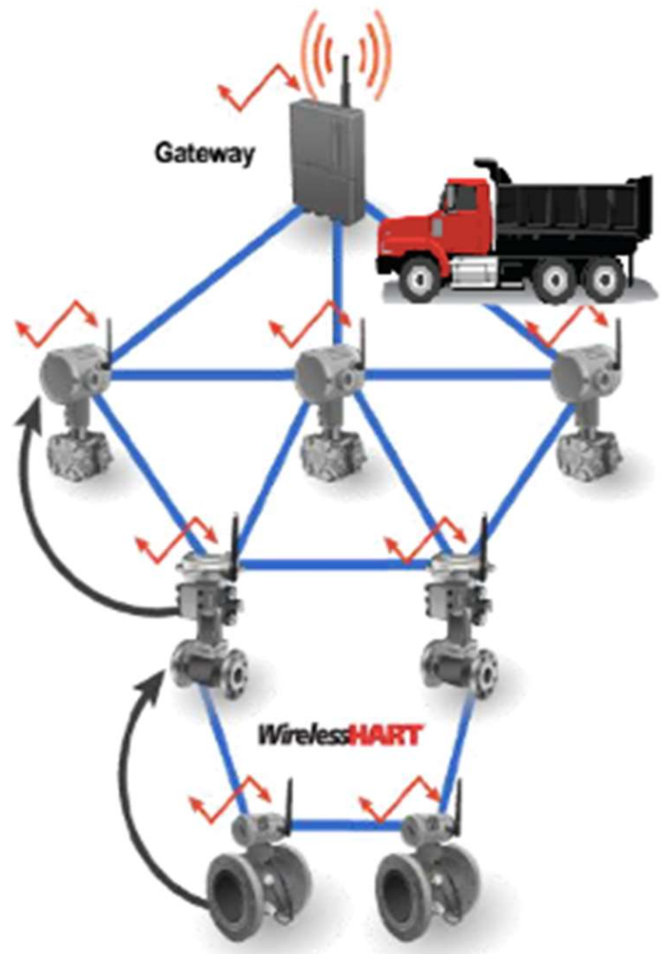
WirelessHART - Self Organizing, Self Healing Interoperable Wireless Mesh Network



- **Simple -** Same wireless capabilities for all field devices
- **Reliable** - Messages routed around interference, obstacles
- **Secure** - AES-128 bit Encryption & Keys
- **Flexible** - User chooses topology, speed, application
- **Built on Standards - IEEE802.15.4** 2.4GHz DSSS w Channel Hopping
- **Monitoring** and control applications
- **Same HART User Experience** – Same tools and practices as wired HART
- **Same HART Command structure -** Compatible with HART-enabled control systems and EDDL
- **Power**: long life batteries, power scavenging, loop and/or mains power.
- **Backwards Compatible**

WirelessHART Mesh Network

- Self-building mesh
  - Simplifies commissioning
  - Automatic features
    - Scheduling
    - Communication links
- Self-healing network
  - Redundant communication paths
  - More instruments = more redundant pathways



Interoperability

EATON
EMERSON Process Management
Endress+Hauser
MICROCYBER
PEPPERL+FUCHS
PHOENIX CONTACT

Devices and Adapters - *Wireless*HART

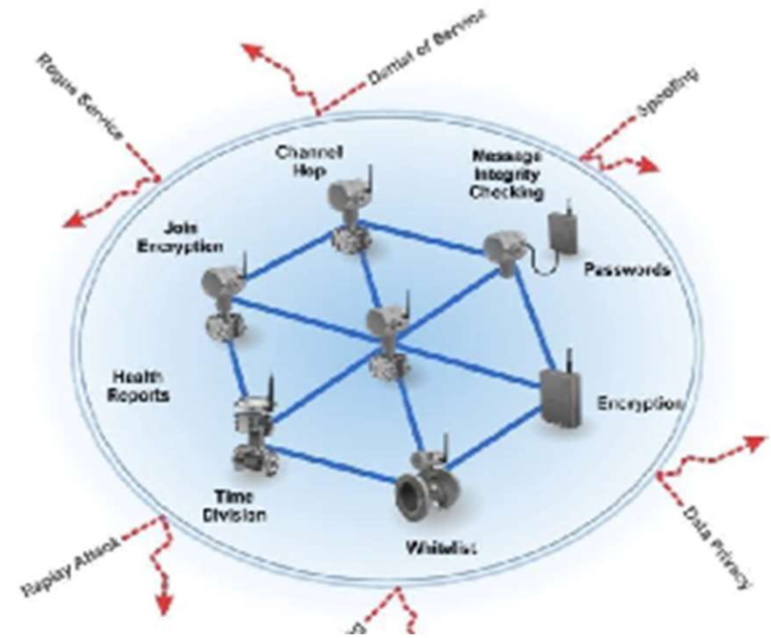
*Wireless*HART Adapters

- Adds wireless connectivity to a 4-20MA device
- 1 adapter to a device or multiple devices using multi-drop
- Connect on or near a device or anywhere on the 4-20mA loop
- Battery or line power options

Make it Secure – Always On Security

_Wireless_HART ensures secure communications

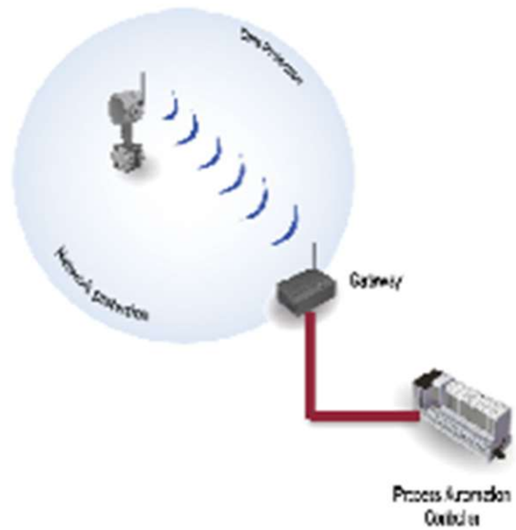
- Security is "built-in" and cannot be disabled
- Uses standard AES-128 bit encryption
- Ease of use (automatic functions)
- Only the final device can decrypt and utilize the data



Make it Secure - Risk Assessment / Reduction

***Wireless*HART networks have two main categories of protection:**

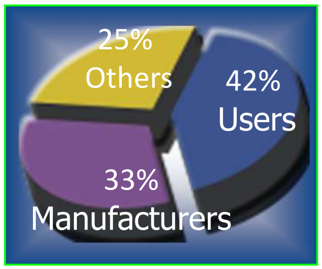
- **Data Protection**
  - Confidentiality
  - Integrity
- **Network Protection**
  - Availability



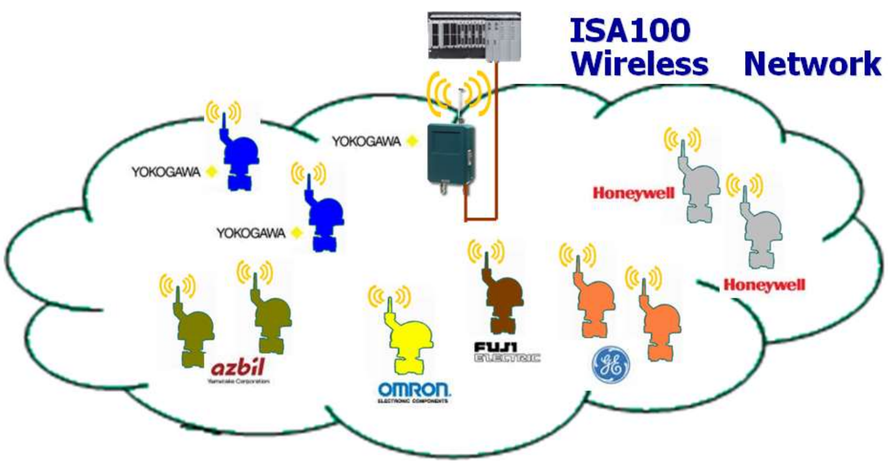
ISA100 Wireless

- End-user driven standard

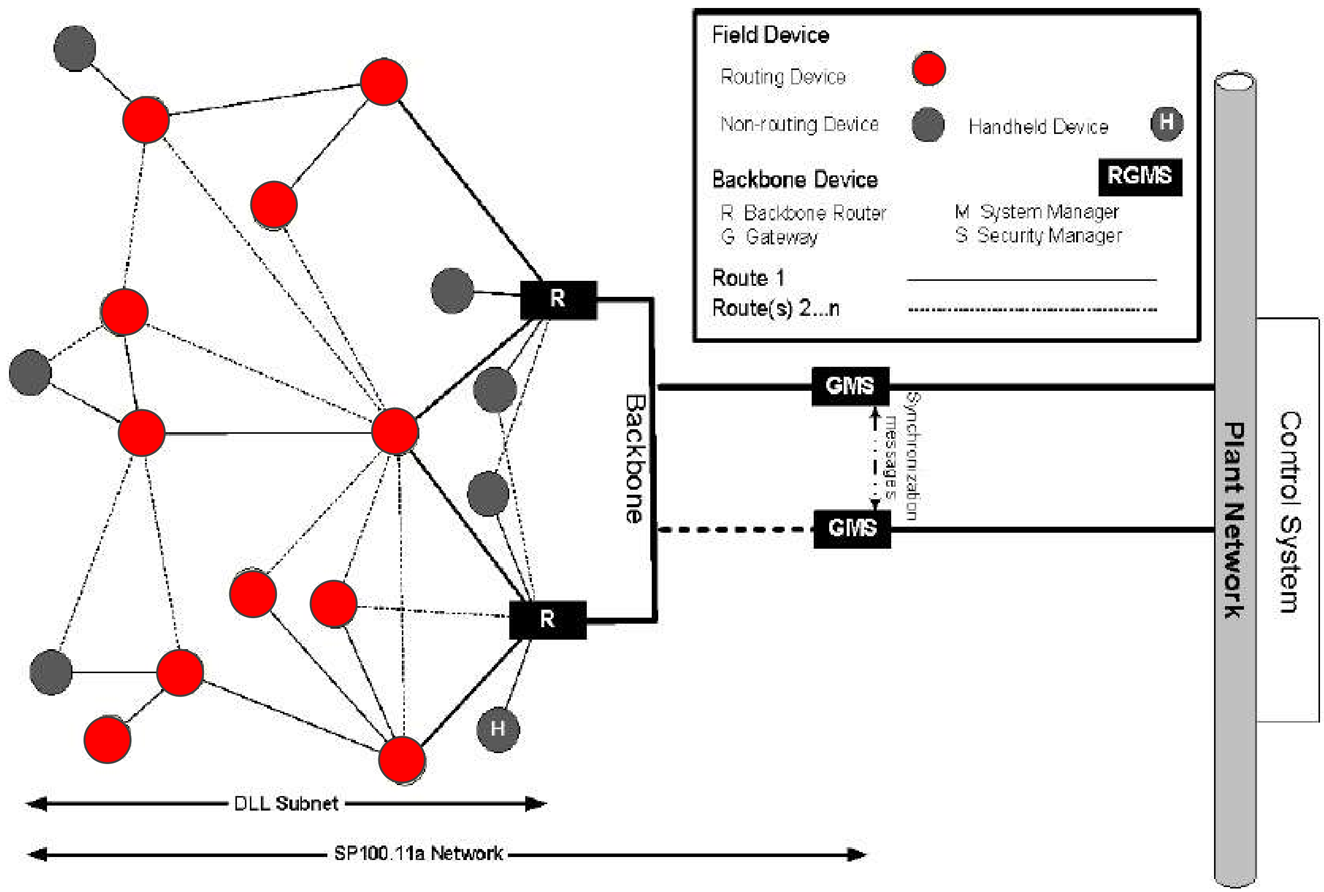
- Multi-vender interoperability



WCI: ISA100 Wireless Compliance Institute
www.isa100wci.org/



ISA100.11a Architecture



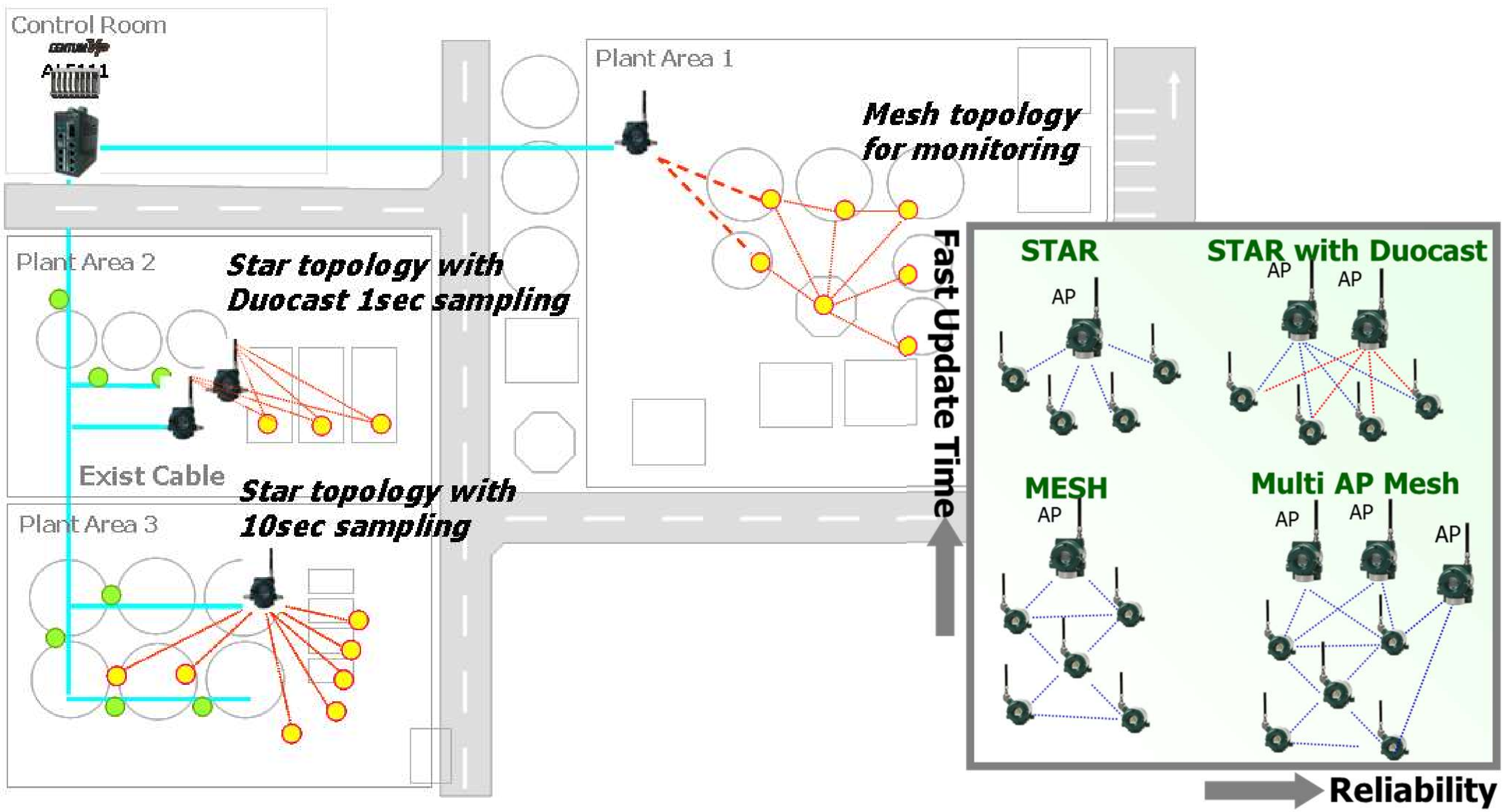
A Robust, Flexible, and Scalable Architecture to Meet Various Plant Needs

Feature of ISA100 Wireless System

Keywords	Feature of R2 System	Advantages (using our system)
System Scalability	**500 devices**	**"Simple"** System
Communication Range (1hop)	**600m**[*1](Standard Antenna) **5km**[*2](High gain antenna)	
Numbers of Hops	**4 hops** max.	
Reliable Radio	**Robustness against Interference**	**"Reliable"** System
Reliable Network	**Skymesh** (Installation Concept)	
Reliable Application	**Full Redundant System** Device (MS[**<=1sec**], AP, Router), Networks	
Update Time	**0.5sec** (Pressure: EJX) ,**1sec** (Temp: YTA,YTMX)	**"Fast"** Application
Low Latency	**Fixed Path**, Software Algorism**,** Duocast	
Battery Life	ex) More than **10years** (YTA510@10sec)	**"Easy"** Engineering & Maintenance
Antenna Option	**High Gain Antenna**(6/9/15dBi), **Remote Cable**	
GW Application Interfaces	Modbus/TCP, RTU, PRM, DCS, OPC	
Communication Port	Field Network: x3 , Backbone Network: x4	

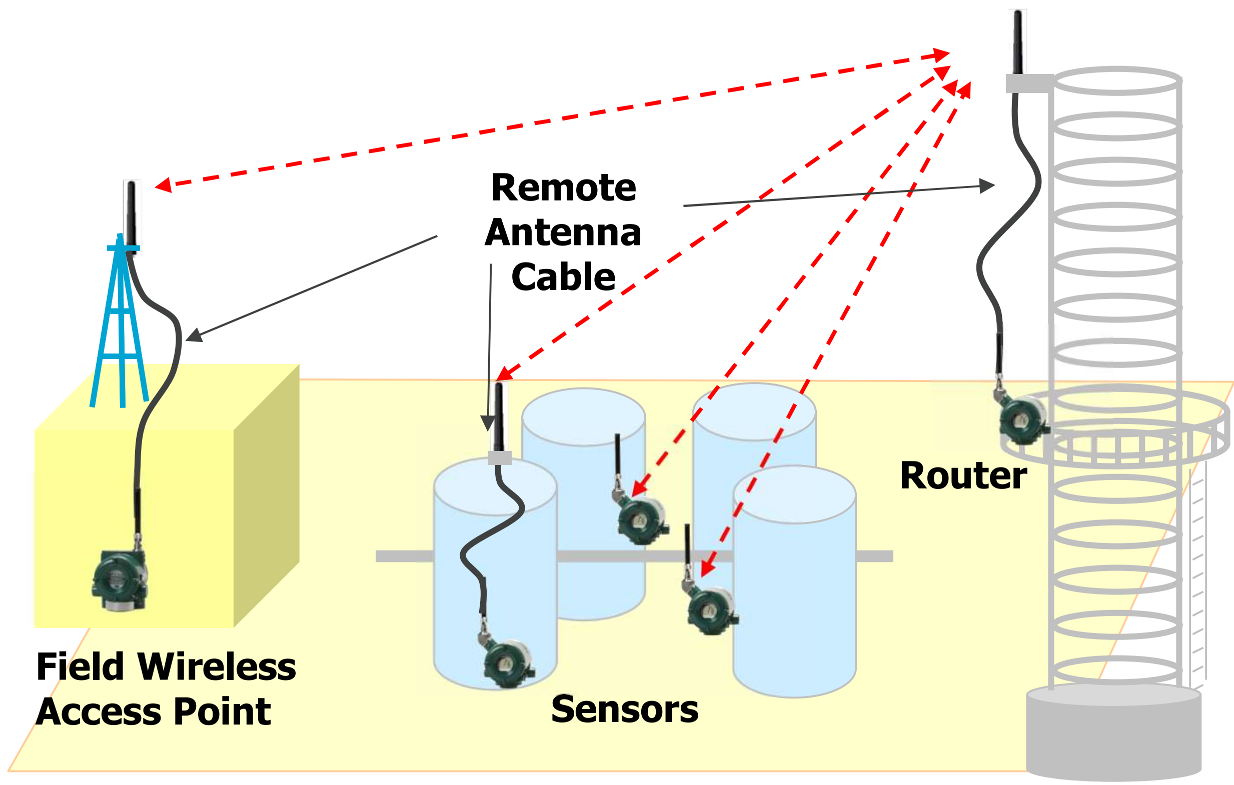
[*1] 500m in General specification
[*2] Actual test result

Various topology types



Easy engineering (Remote antenna cable)

- Remote antenna with extension cable is available for Sensors, Repeaters & APs
  - Flexibility in monitoring points, less blind spots…



OneWireless Network is made up of the following components

- **Honeywell OneWireless Field Device Access Point (FDAP):** An industrial meshing access point for ISA100 Wireless and WirelessHART field instruments
- **Honeywell OneWireless Wireless Device Manager:** Manages the wireless field instrument network and all wireless field devices, including ISA100 Wireless and WirelessHART field instruments, FDAPs, the field instrument radio embedded in the access points and any wired field devices with a wireless adapter
- **Cisco® Aironet® 1552S Access Point:** An industrial meshing access point for IEEE 802.11 devices and ISA100 Wireless and WirelessHART field instruments
- **Cisco Wireless Controller:** Manages the IEEE 802.11 network and all IEEE 802.11 devices connected to the network.

Honeywell_FieldDeviceAccessPoint.webp

Honeywell_Cisco-Aironet-1552S-Access-Point.webp

OneWireless Network offers the following features

- Flexibility and scalability: Honeywell meets a site's specific wireless network needs with a rich portfolio of industrial access points and wireless field instruments
- Wired-like performance with 250 ms latency
- Best-in-class data availability with wall-to-wall dual paths between ISA100 Wireless / WirelessHART field instruments and host applications
- Superior wireless security with end-to-end AES-128-bit encryption, unique join keys and rotating session keys
- Great user experience with no software to install, an intuitive user interface, and over-the-air firmware upgrade and secure provisioning
- Easy integration with the richest portfolio of interfaces, including Modbus, OPC, HART, Experion® CDA, GCI and Honeywell Enraf

What Problems Does It Solve?

- The OneWireless Network allows users to:
- Achieve lowest total cost of ownership and maximum flexibility for wireless instruments by virtue of supporting ISA100 Wireless WirelessHART Wi-Fi and Ethernet devices on single network infrastructure
- Cost-effectively and quickly roll-out battery-powered wireless transmitters
- Collect additional process data and meet HSE regulations at lower costs
- Empower their mobile-workforce with remote access to process data and other plant-related information
- Enhance plant security by cost-effectively implementing wireless CCTV cameras
- Improve personnel safety with portable wireless and fixed gas detectors
- Easily connect remote controllers to the central control system

Safety

PORTABLE GAS MONITORING

SAFETY SHOWER

GAS MONITORING

Mobile/Portable

BOILER
EFFICIENCY

RAIL CAR

BATCH
PROCESSING

TRUCKING

PORTABLE
MEASUREMENTS

Rotating Equipment

Remote



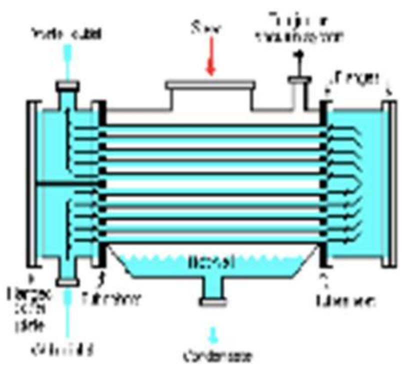




Increase Heat Exchanger Efficiency

Heat Exchanger Efficiency

Increase efficiency of heat exchangers and surface condensers with real time continuous monitoring



SOLUTION

Automation & Wireless Infrastructure

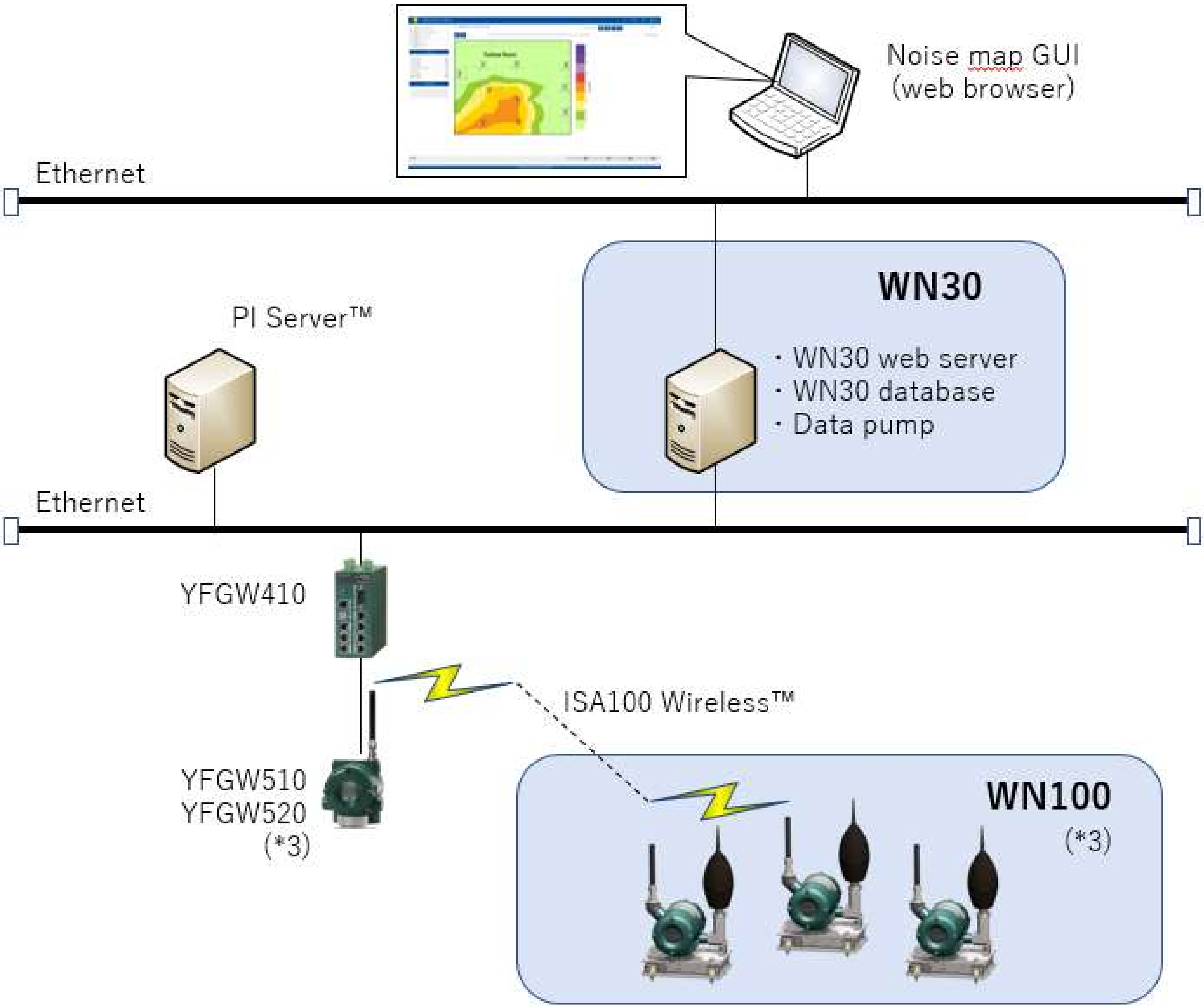
Better manage condenser cooling to maximize steam turbine output

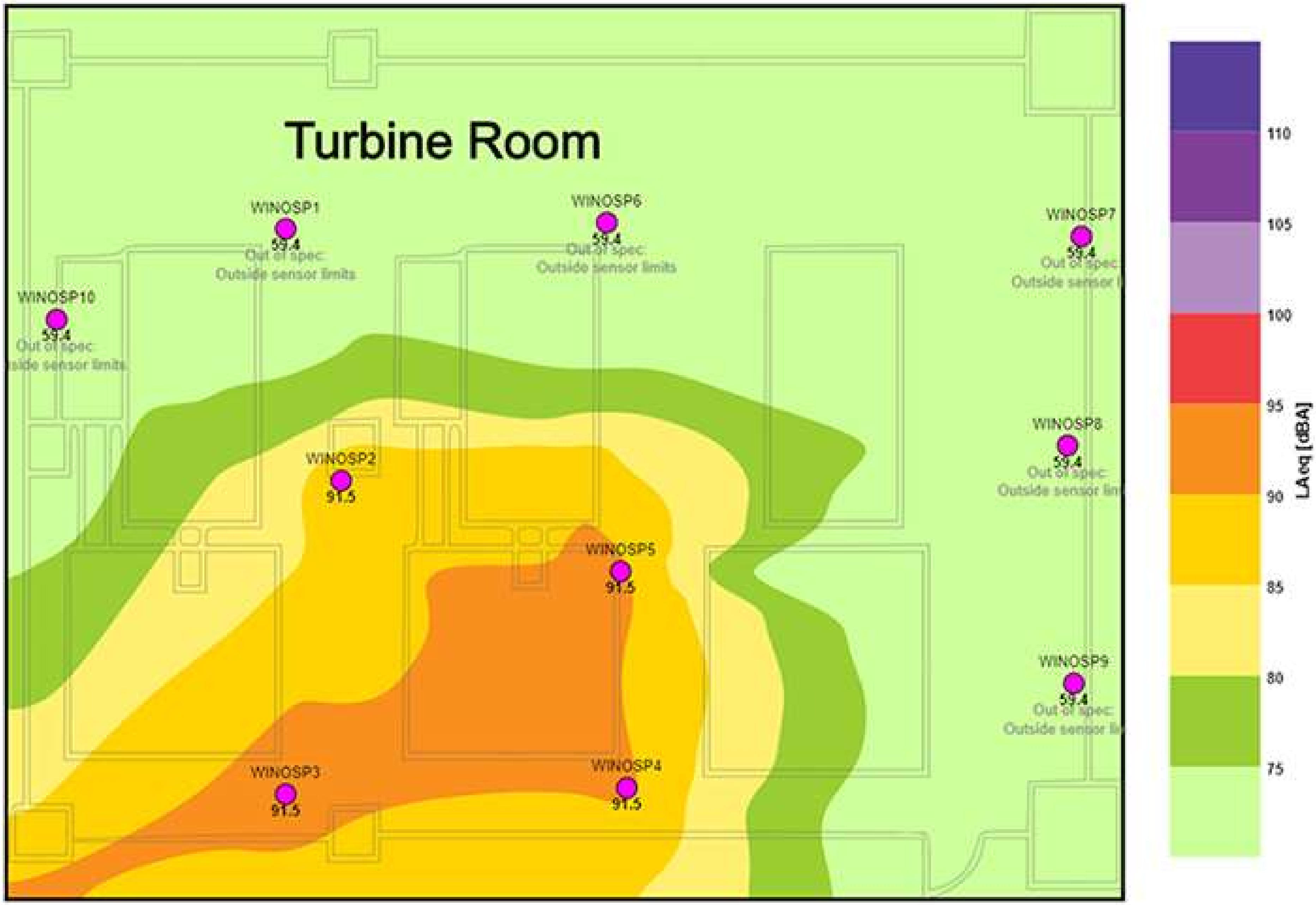
Prevent outages by providing operations and maintenance workers with advanced information about developing problems

Business Result

Minimize energy loss and cost from fouling

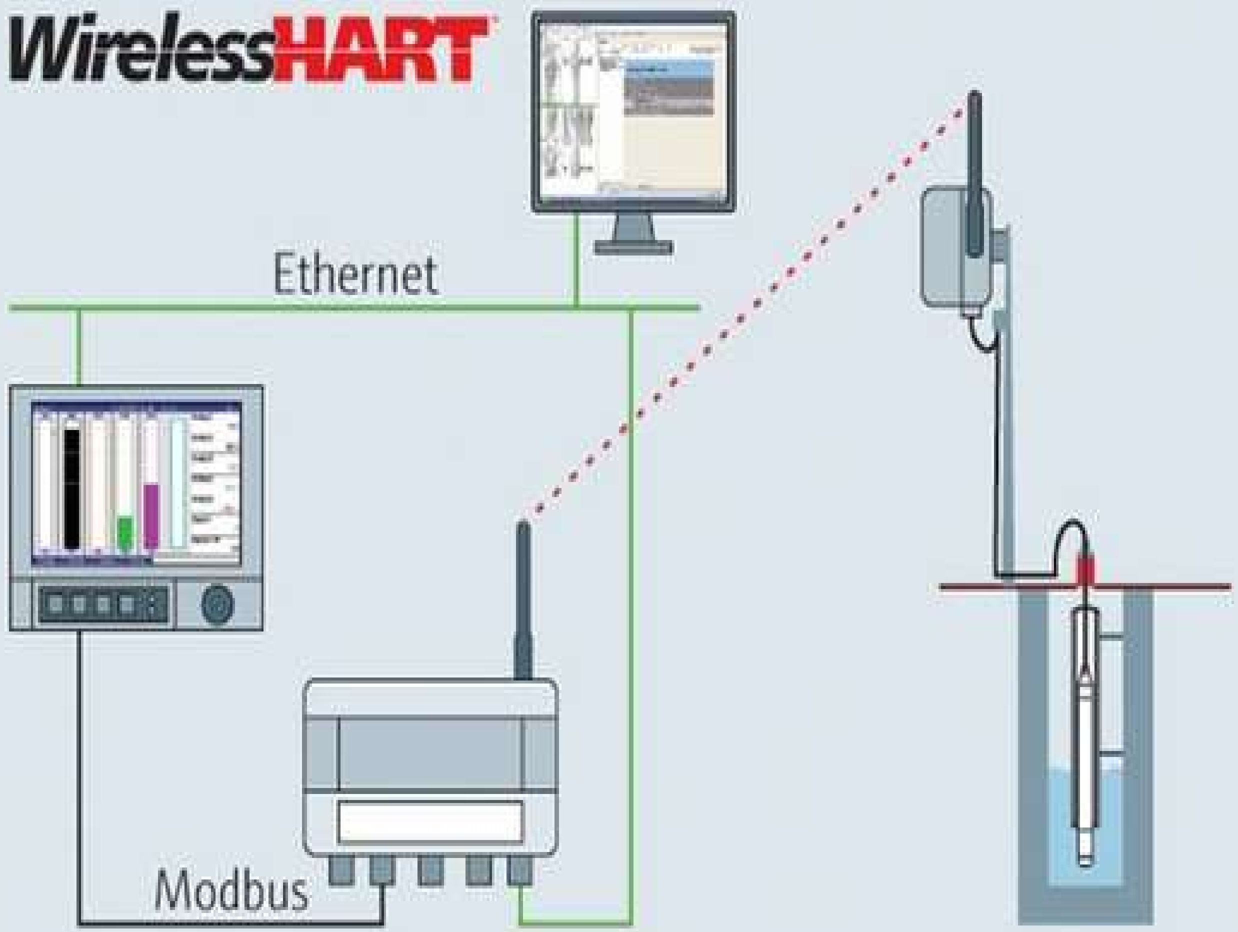

OpreX™ Measurement:
Wireless Noise Surveillance System


Noise map GUI
(web browser)
Ethernet
WN30
PI Server™
・WN30 web server
・WN30 database
・Data pump
Ethernet
YFGW410
ISA100 Wireless™
YFGW510
YFGW520
(*3)
WN100
(*3)



Turbine Room
WINOSP1
59.4
Out of spec:
Outside sensor limits
WINOSP6
59.4
Out of spec:
Outside sensor limits
WINOSP7
59.4
WINOSP10
59.4
WINOSP2
91.5
WINOSP8
59.4
WINOSP5
91.5
WINOSP9
59.4
WINOSP3
91.5
WINOSP4
91.5
110
105
100
95
90
85
80
75
LAeq [dBA]

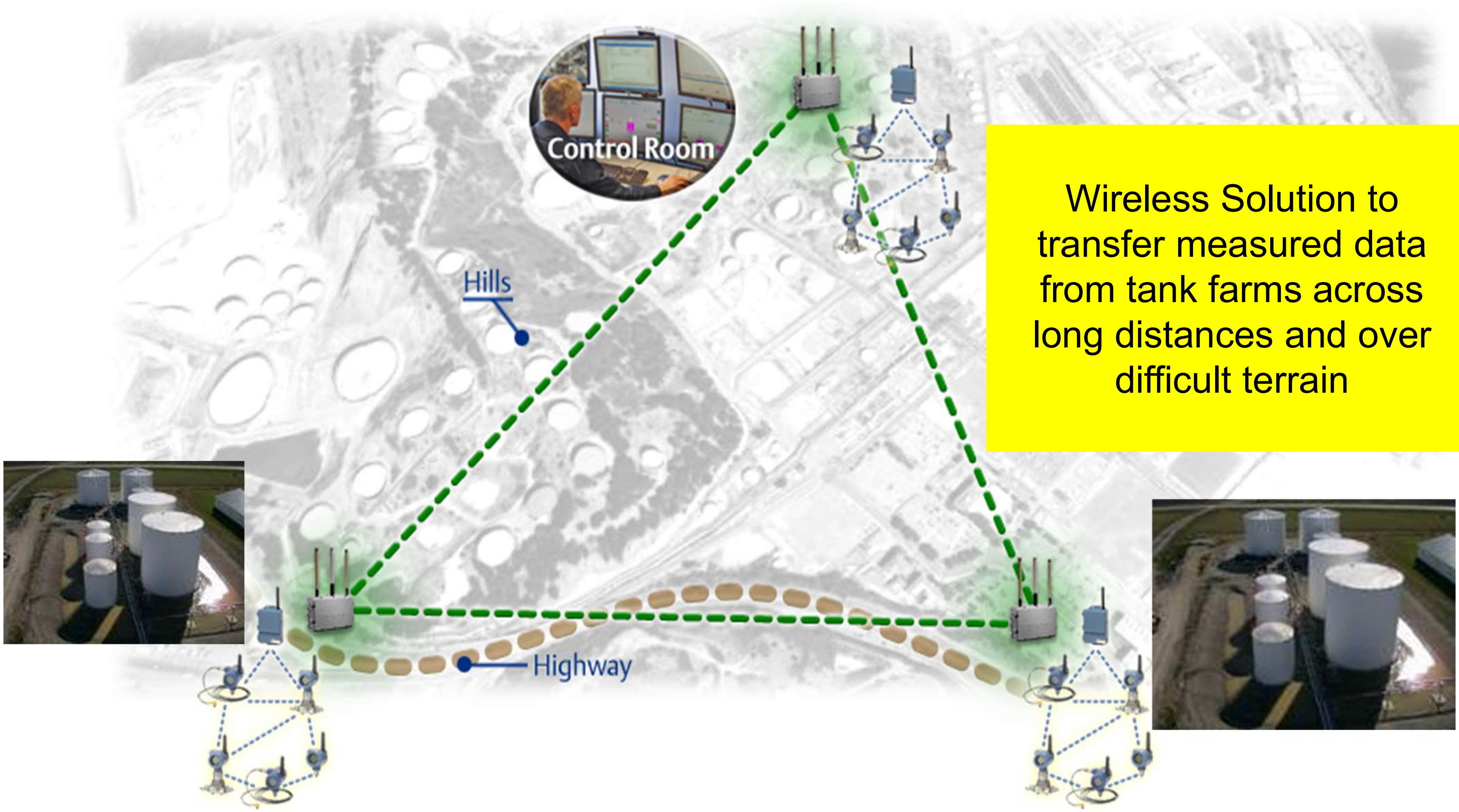
WirelessHART for groundwater monitoring



WPN Main Components

- **Mesh Access Point**
  - Connects to a Smart Wireless Gateway to backhaul field sensor data wirelessly to the central control room
- **Wireless LAN Controller**
  - Provides a centralized control of Access Points
- **Wireless Control System (optional)**
  - Provides a visualized system view of the network for RF planning and management.

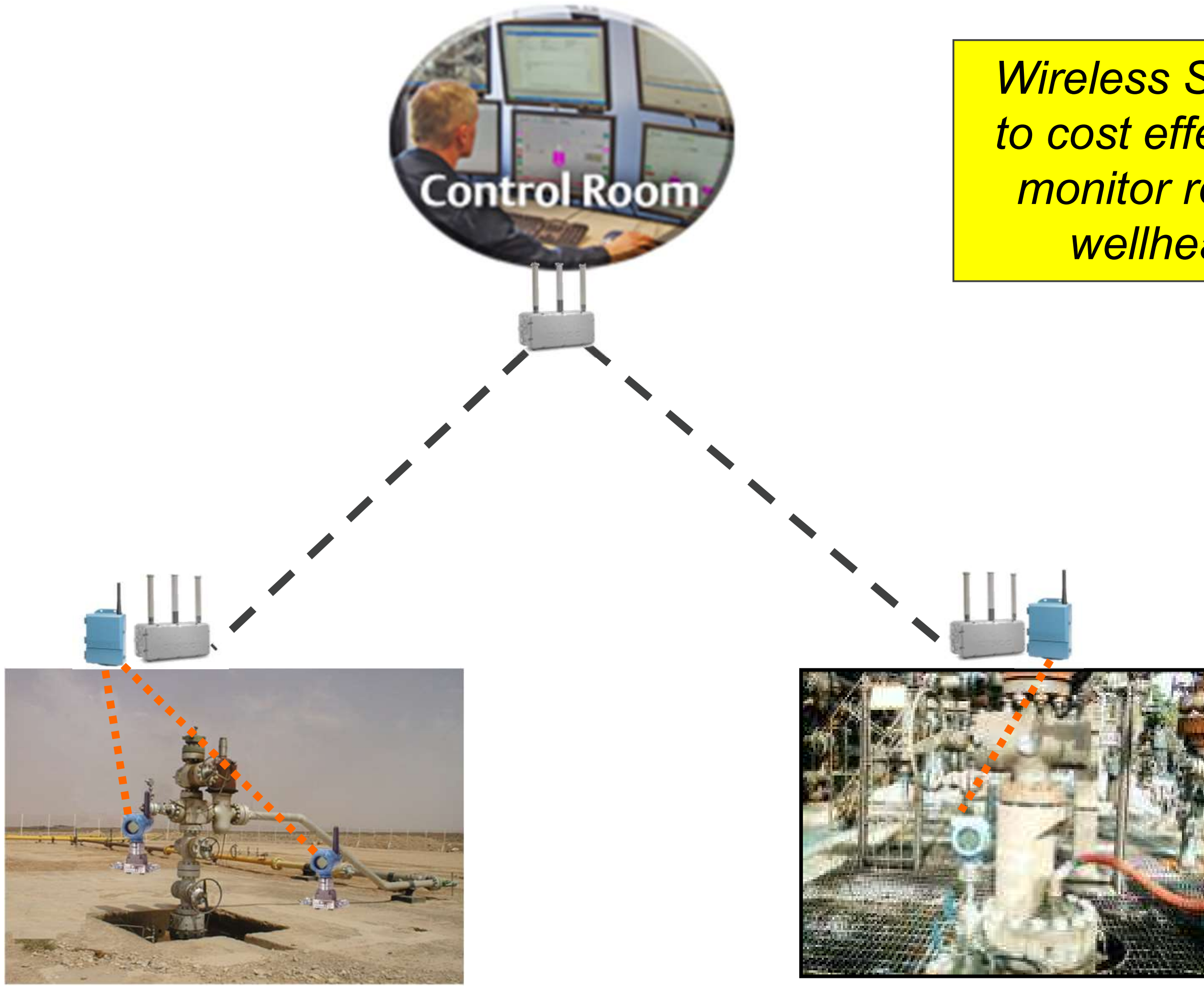
Wireless Backhaul Solutions – Enable New Cost-Effective Data Acquisitions



Wireless Solution to transfer measured data from tank farms across long distances and over difficult terrain

Continuously Monitor Remote Wellheads

Wireless Solution to cost effectively monitor remote wellheads



Wellhead

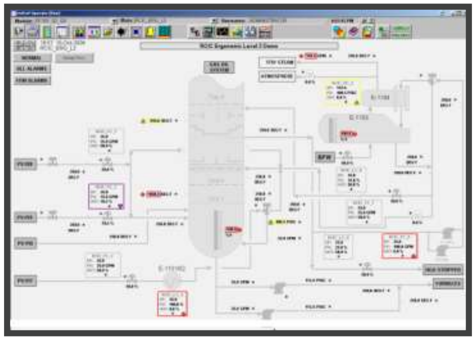
Wellhead

Extending the Control Room to the Field

- Access process control and operations data in real time

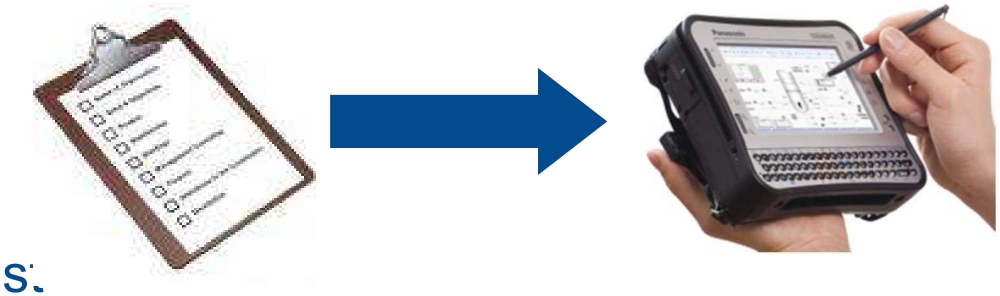
Mobile Operators - Accessing Control Data in the Field

- Utilize operator control displays on mobile devices
- Access operational data and reports in the field
- Receive process alarms outside the central control room
- View historical trends while anywhere in the plant



Mobile Operator Rounds – Real-time Data Collection and Work Requests

- Real-time mobile applications replace clipboard for data acquisition
- Electronic workflow to enable best practices
- Issue electronic work orders in the field



Wireless Enables Cost-Effective Video Monitoring

- Significantly reduce cost of remote video monitoring
- Add extra “eyes” in remote sites and hazardous areas

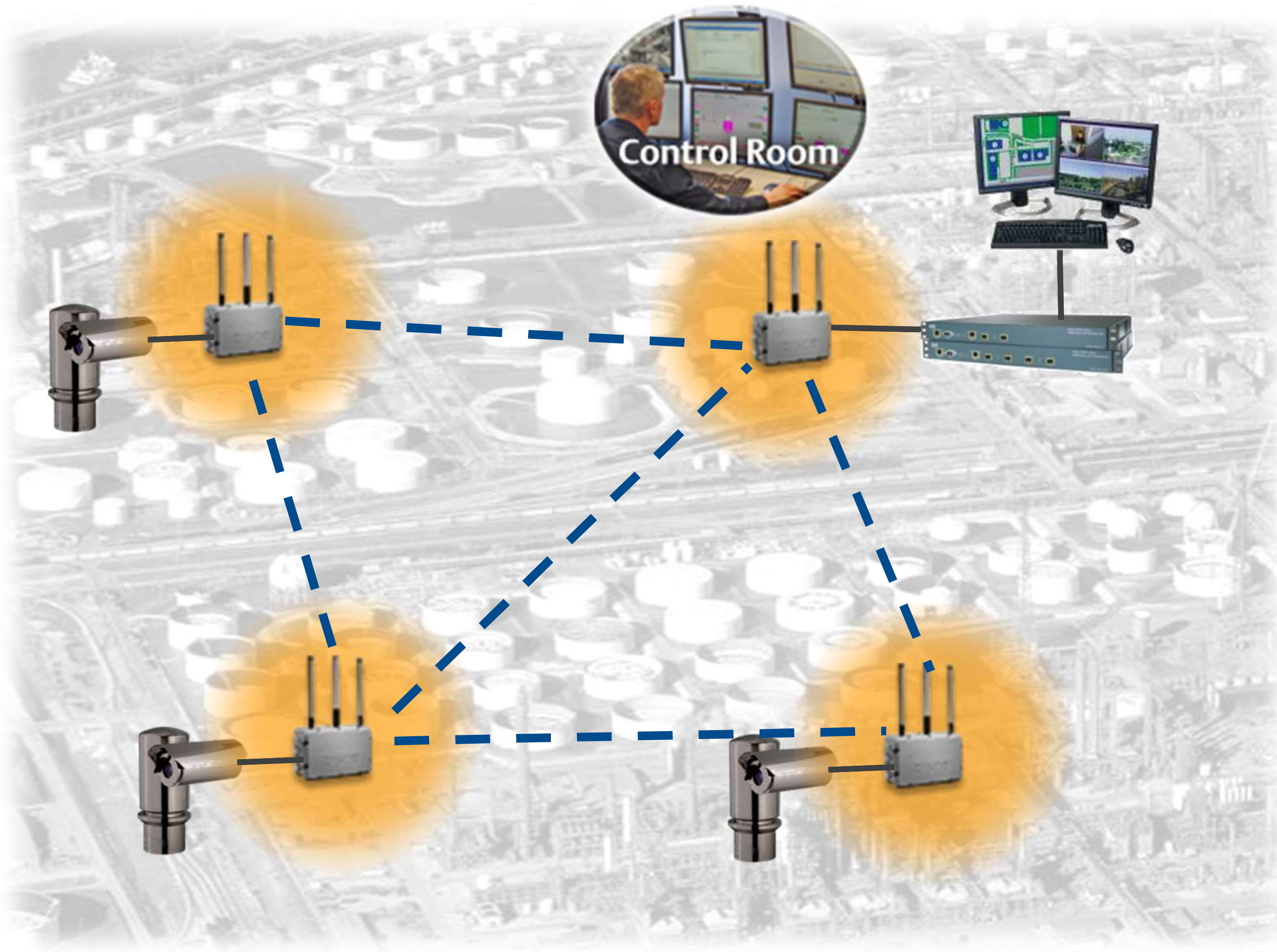
Monitoring Hazardous Areas

- Monitor hazardous area, such as an oil truck loading bay
- Report spills or man-down incidents

Monitoring for Security

- Monitor plant perimeter and remote tank farms to improve security and comply with security regulations

Video over a Wireless Mesh Network



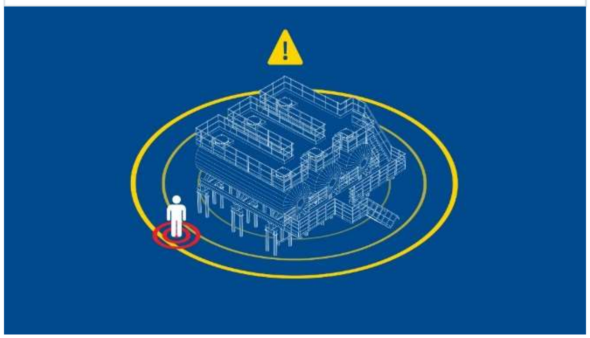
Safety Challenges

- Regulatory compliance and accountability for the mustering of all personnel
- Mustering progress needs to be controlled and monitored in real-time
- Remote alerting on safety of people in isolated areas
- Employees, visitors and contractors wandering to restricted areas

Location Awareness for a Safe and Secure Environment

People Tracking

Keep contractors safe and efficient with designated work zones and keep workers safe by creating zones of known hazardous locations

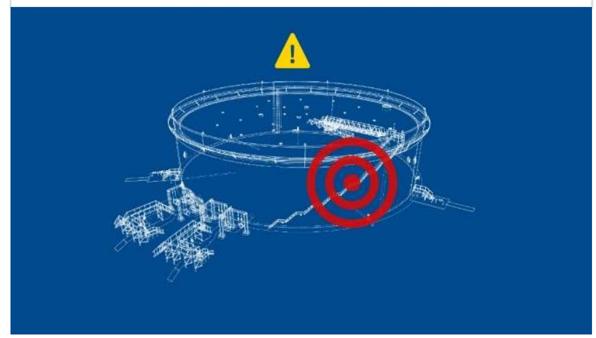


Safety Mustering

In an emergency, know that your personnel are safe and accounted for at designated muster points

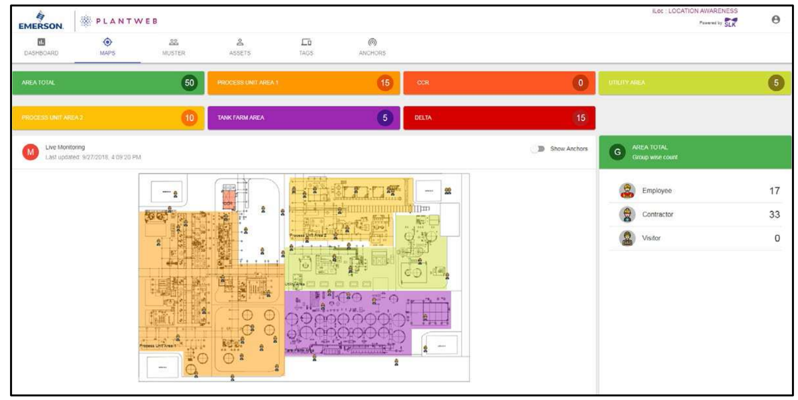
Location Alerts

Know where fallen personnel are located to quickly dispatch emergency responders



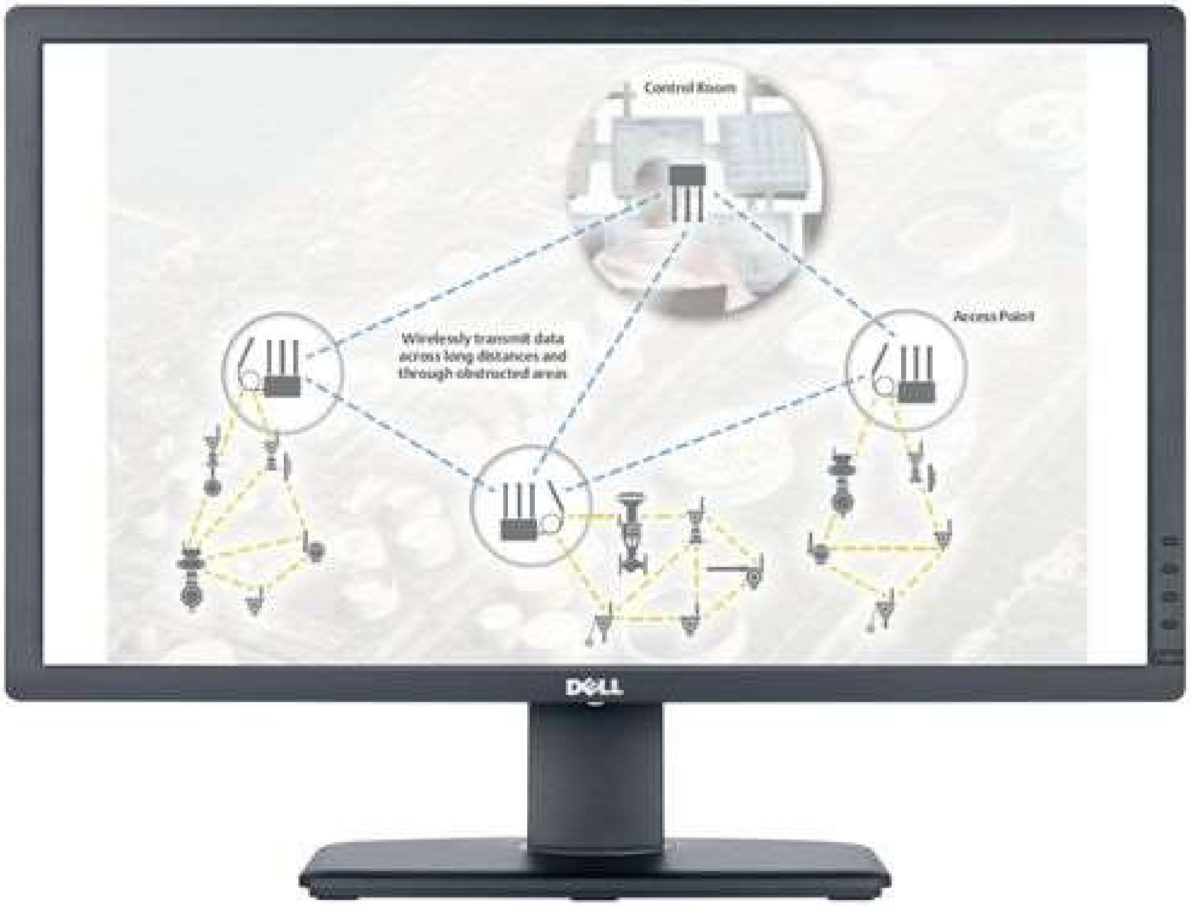
Location Awareness - RTLS (Real Time Locating System) - Combining Rich Plant Information with Personnel Location

"Digital PPE"

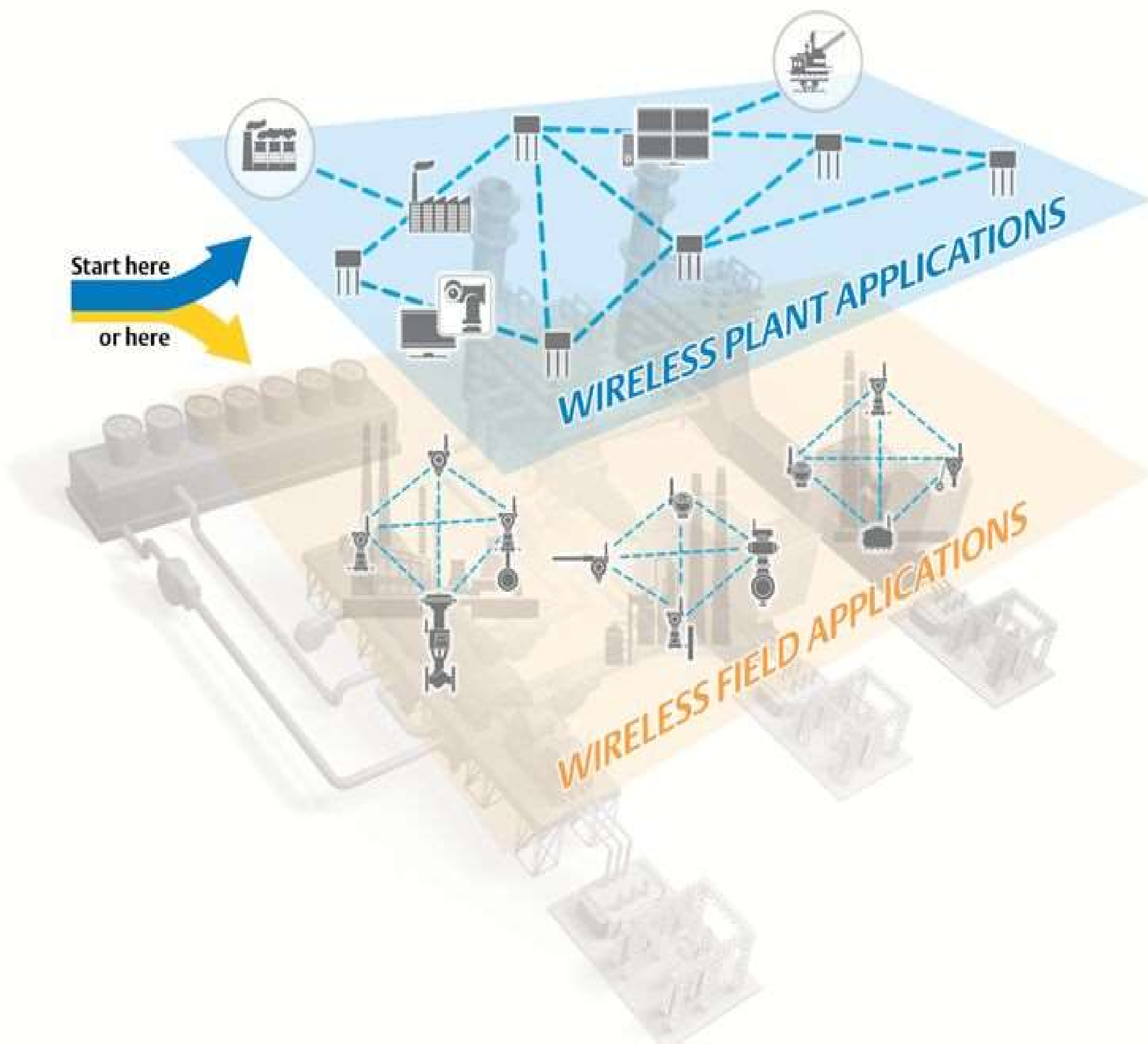


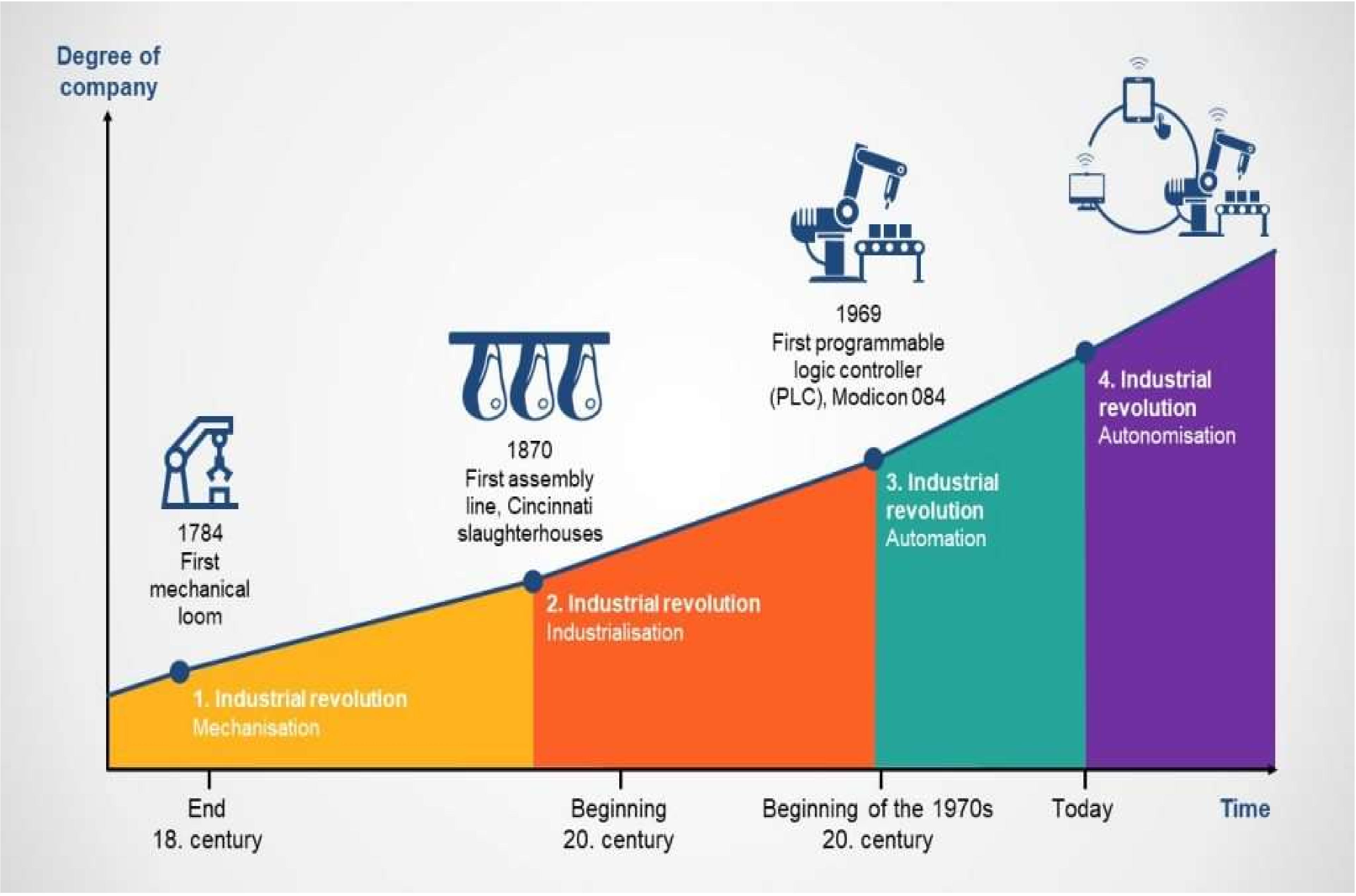
- Mustering headcount
- Rescue locating
- Geofencing; stray into high-risk areas
- Contractor management
- Fatigue management / insufficient rest (API 755)

- The Smart Wireless Gateway 1552WU combines WirelessHART (IEC62591) and Wi-Fi (IEEE802.11 a/b/g/n) in a single device.
- The Smart Wireless Gateway 1552WU makes possible a full-featured wireless solution comprising plant and field networks into a seamless architecture enabling pervasive sensing along with Wi-Fi solutions in a more straightforward and economical manner.
- The solution is self-organizing and adaptive to mesh routing.



Control Room
Access Point
Wirelessly transmit data
across long distances and
through obstructed areas
DELL


Start here
or here
WIRELESS PLANT APPLICATIONS
WIRELESS FIELD APPLICATIONS


Degree of company
1784
First mechanical loom
1870
First assembly line, Cincinnati slaughterhouses
1969
First programmable logic controller (PLC), Modicon 084
1. Industrial revolution
Mechanisation
2. Industrial revolution
Industrialisation
3. Industrial revolution
Automation
4. Industrial revolution
Autonomisation
End 18. century
Beginning 20. century
Beginning of the 1970s 20. century
Today
Time

"Digital transformation is about reimagining how you bring together people, data, and processes to create value and maintain a competitive advantage in a digital-first world."

Satya Nadella, CEO Microsoft

SAFETY

Zero injuries. Zero incidents.

- Employees removed from hazardous activities
- Constant monitoring of worker and plant health
- Threat prevention and response – cyber, physical – is automated, part of culture

RELIABILITY

No unplanned downtime at minimal cost

- Analytics predict health of all equipment
- No reactive repair: pre-failure corrective action by automated closed-loop systems
- 'Avatars' perform field tasks

DIGITAL TRANSFORMATION ROADMAP

PRODUCTION

Production optimized to market conditions

- Continuous visibility enables active business management
- Business areas optimized in real-time across interconnected systems
- Predictive digital twins enable exception management along entire value chain

ENERGY & EMISSIONS

Recognized sustainability leader

- Continuous analytics predict and prevent releases
- Energy consumption measured and dynamically optimized with production
- Energy sources balance business and shared community goals

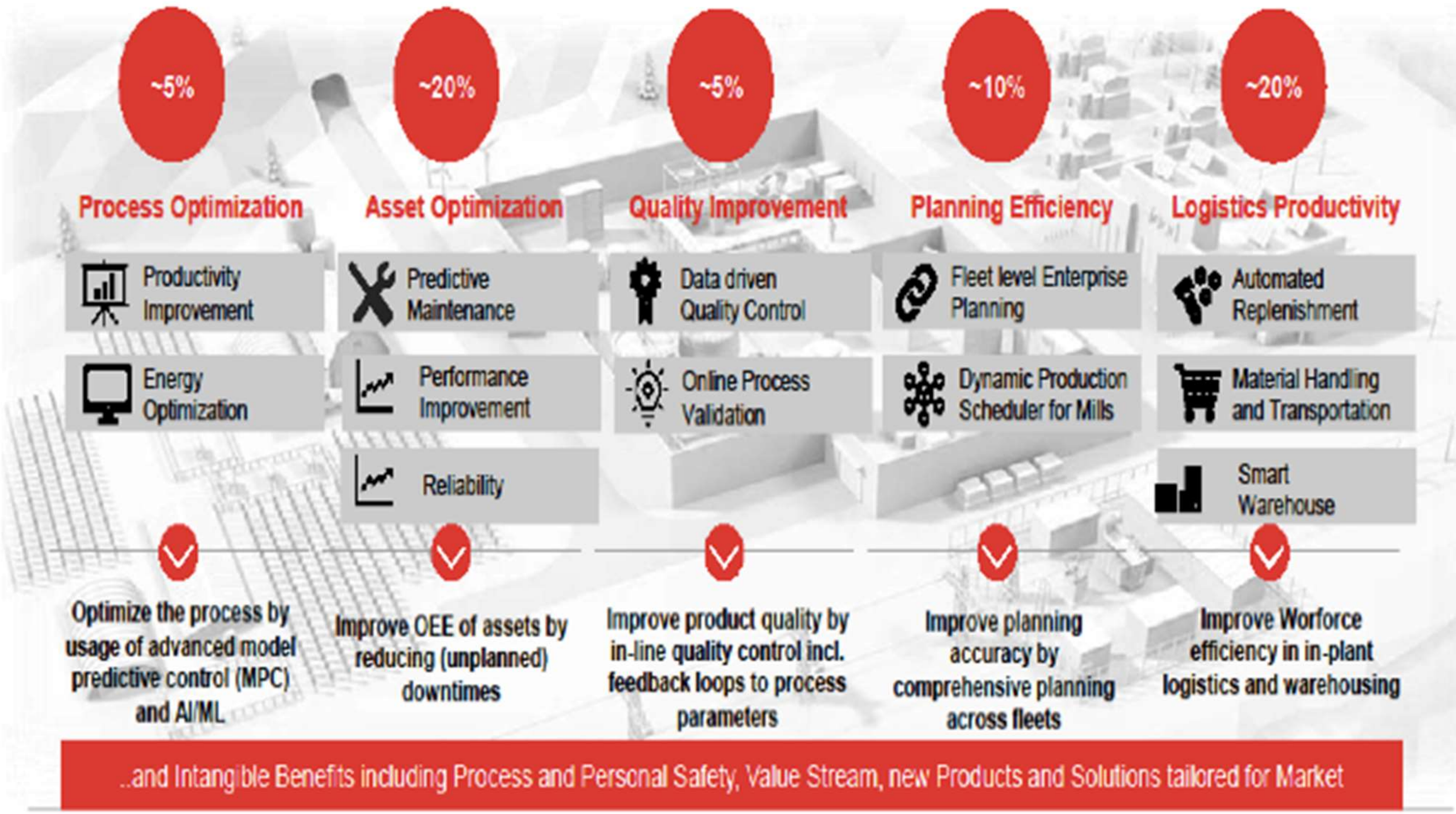
WORKFORCE

Empowered workers drive even more value

- All routine tasks automated: staff takes larger role in meeting KPIs
- Collaboration embedded in culture and work processes
- Faster, better decisions supported by analytics and on demand expertise
- Career-long development and certification through virtual tools

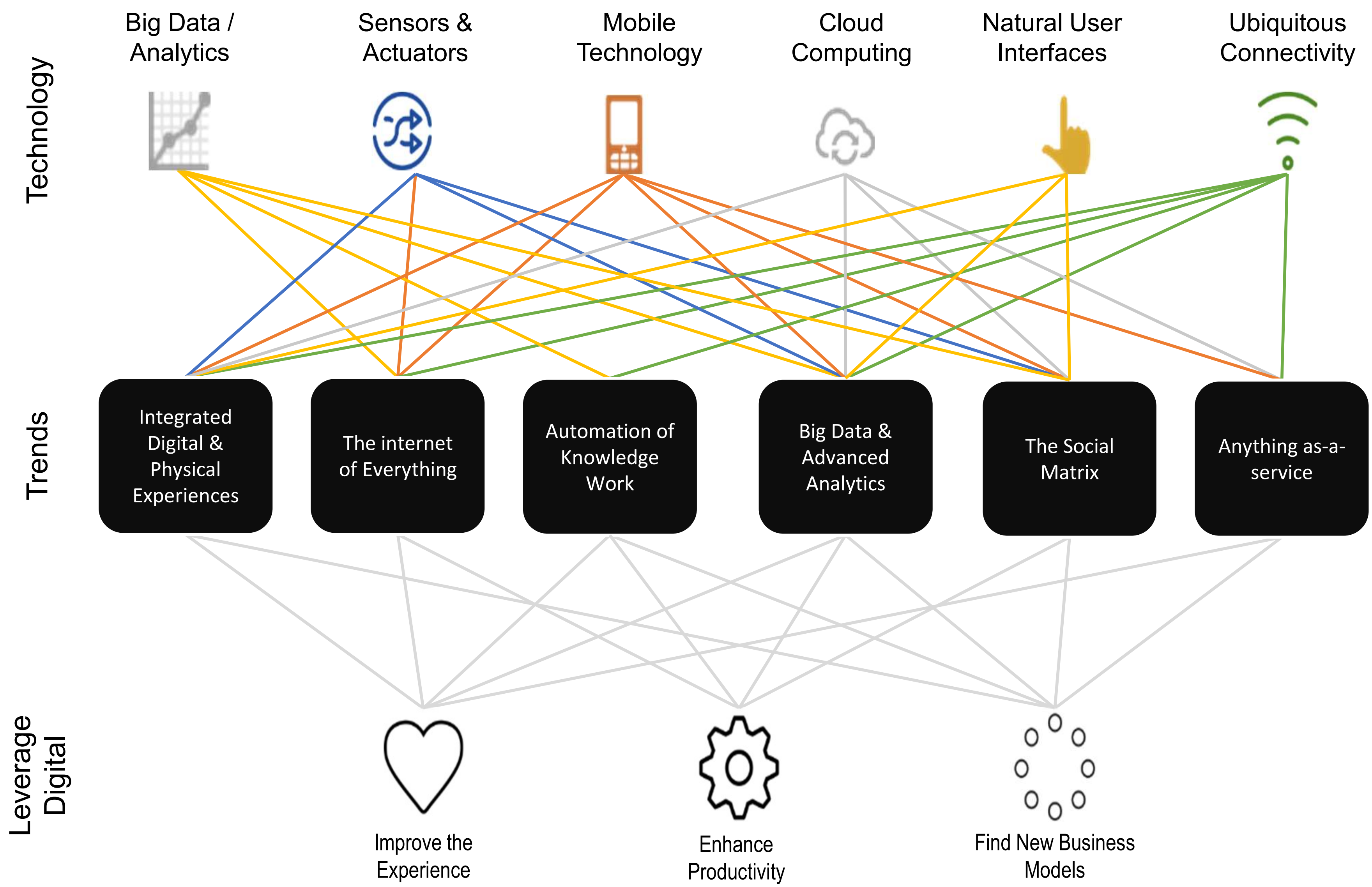
Typical Business Benefits of Digital Transformation in Process Industries

Bottom line and Top line Impact



The Perfect Storm

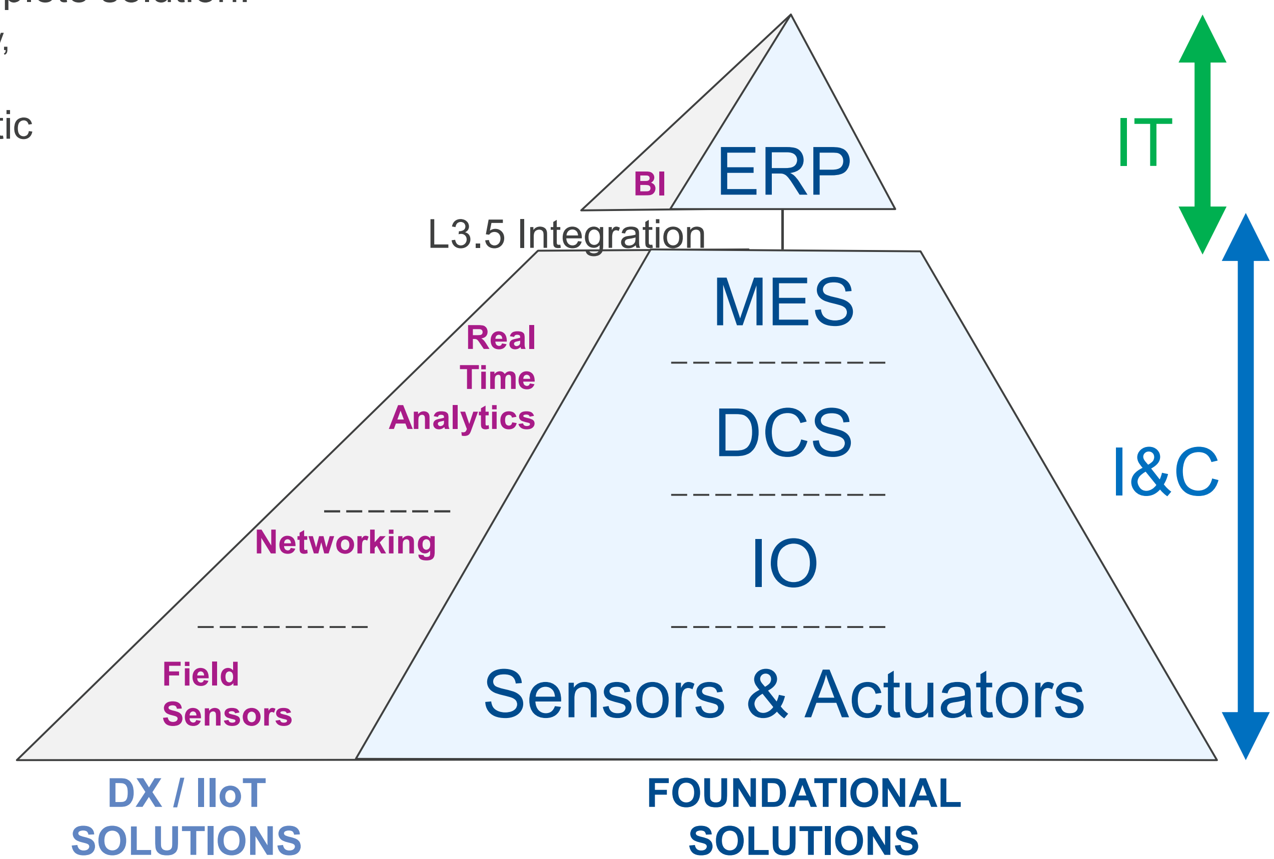
Exponential Technologies are fuelling this storm



Adapted from McKinsey Global Institute – Ten IT enabled Trends for the decade ahead – May & Zensar Analysis

Second Layer of Automation Integrated with Existing Operational Infrastructure and IT Infrastructure in a Digital Plant

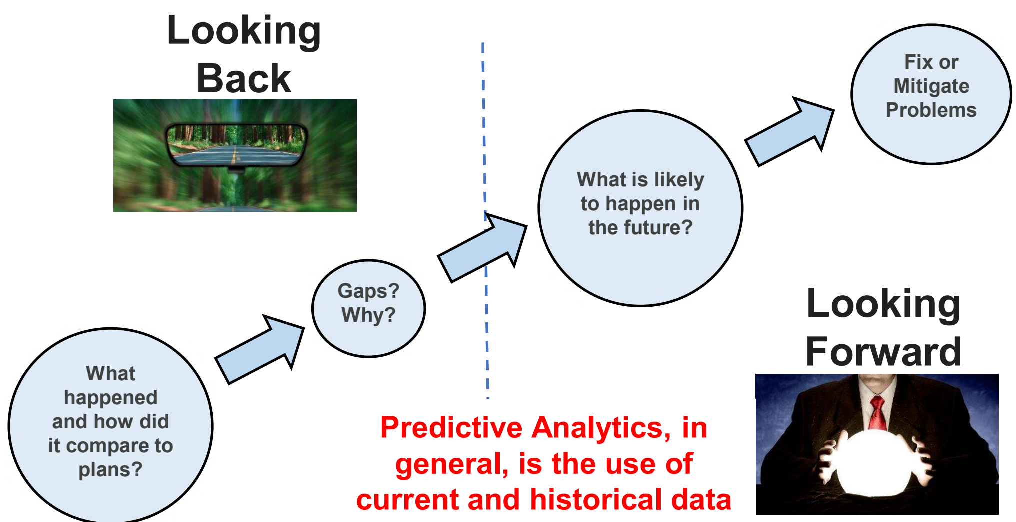
- Built-for-purpose readymade building blocks
- Not just a software platform; complete solution:
  - Sensors, analytics, mobility, security, and connected services.
- Open standards; platform-agnostic
  - Works with control system, historian, machinery protection etc.
- Integrates with ERP system



Solving New Challenges with Wireless Devices

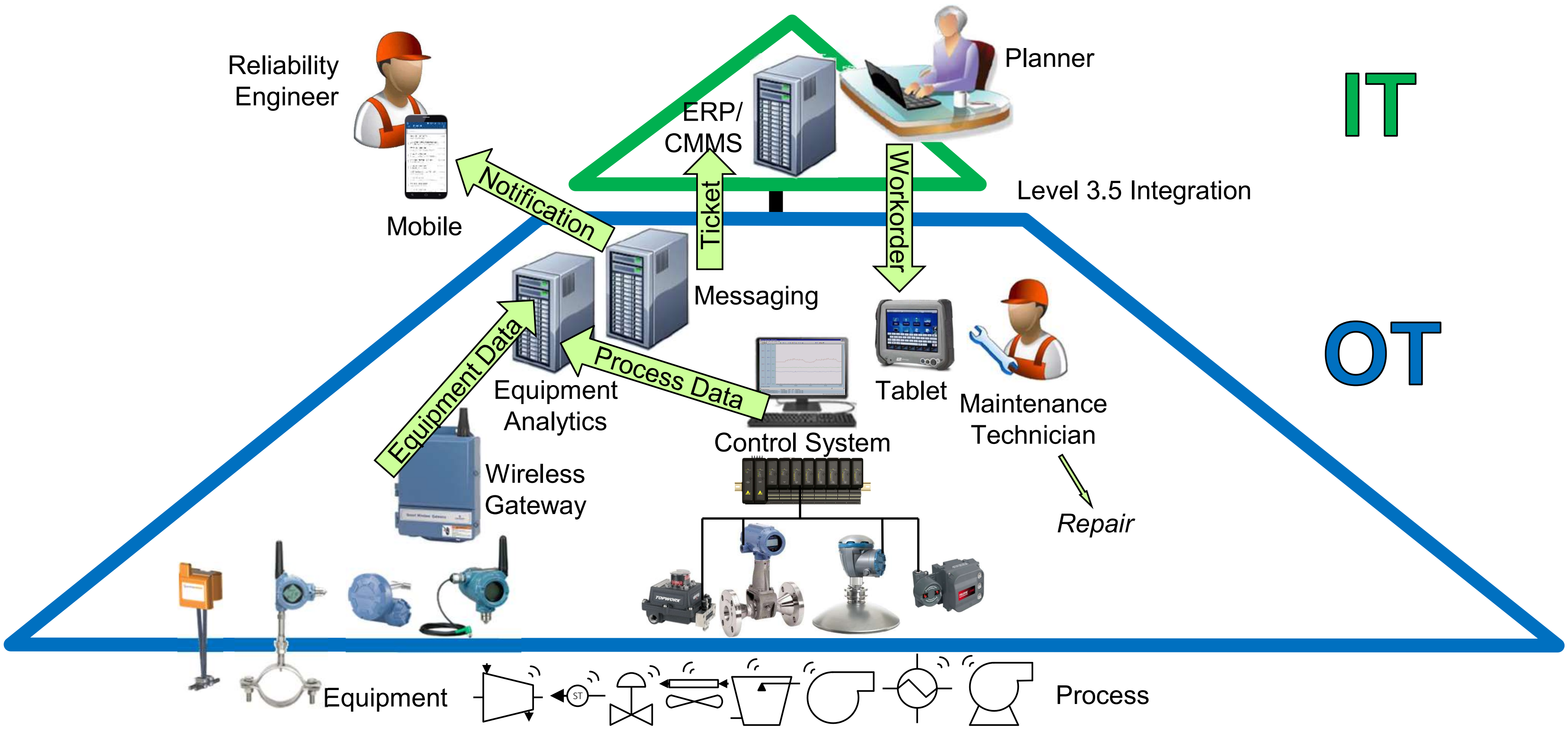
- Pressure gauge
  - Safer, more reliable, continuous wireless output
- Non-intrusive corrosion monitoring
  - Continuous wall thickness measurement
- Electrical equipment monitoring
  - Continuous temperature readings of switchgear
- Non intrusive temperature measurement
  - Add new temperature readings without penetrations
- Power meter
  - Continuous measurement of power consumption for energy and health
- Gas Detector for Toxic Combustible Gases
- Vibration Sensor

Creating Value From Digitalization - Looking Forward

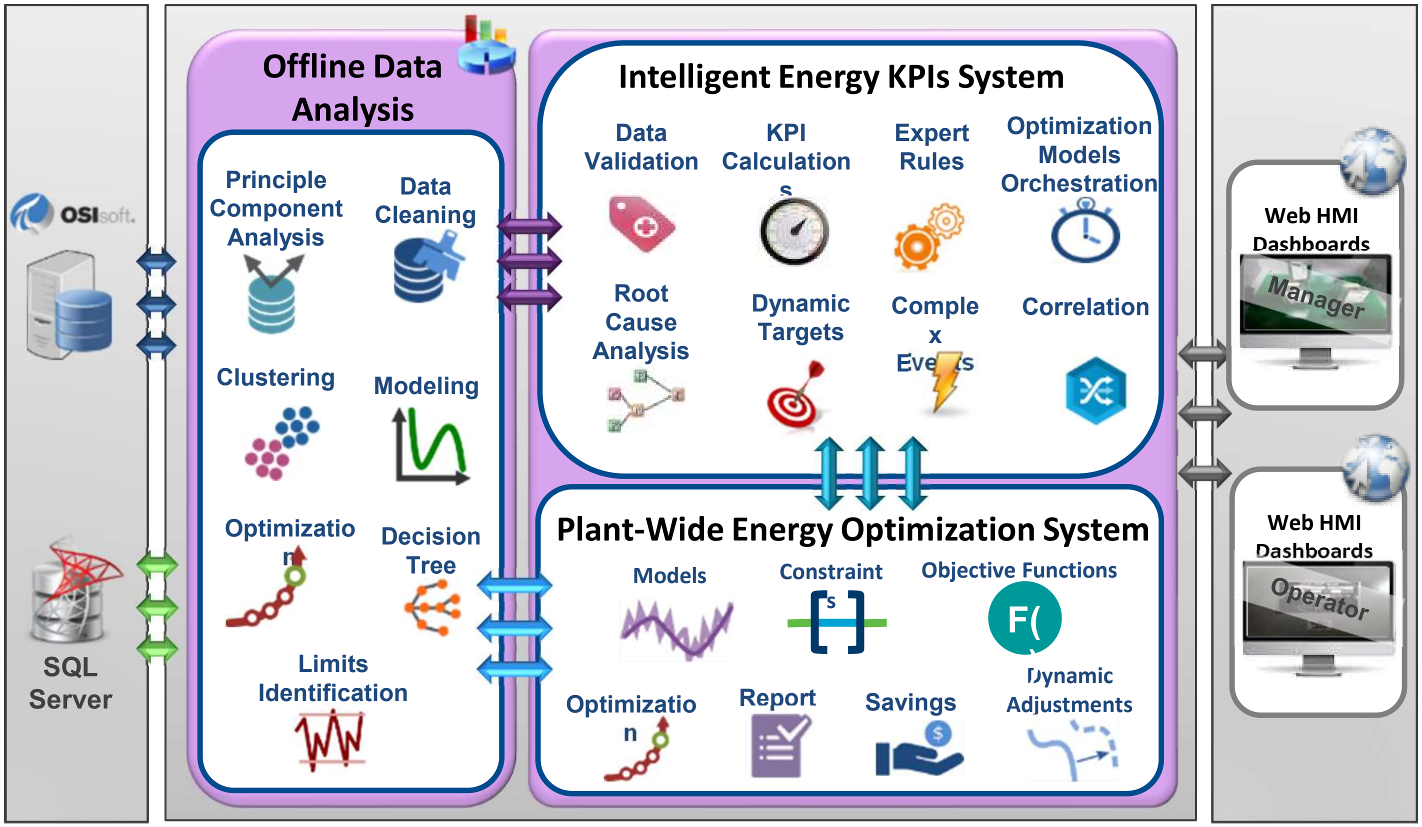


Predictive Analytics, in general, is the use of current and historical data in conjunction with system models to predict future trends in real-time (near).

Digital Workflow Integration



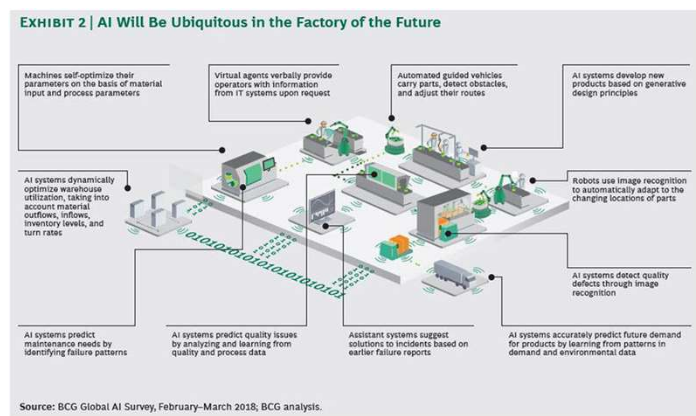
AI/ML Analytics based Energy Solution Data Flow



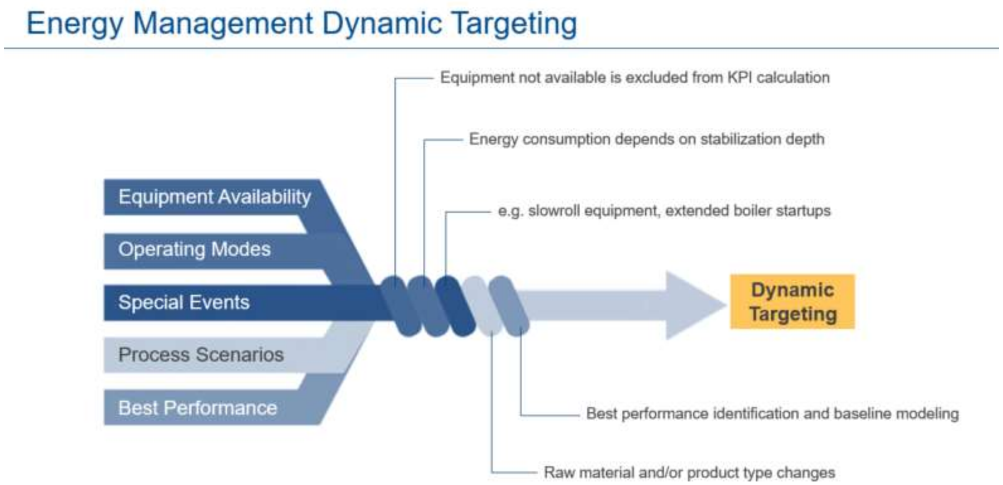
The use of AI and Machine Learning in Process Industry

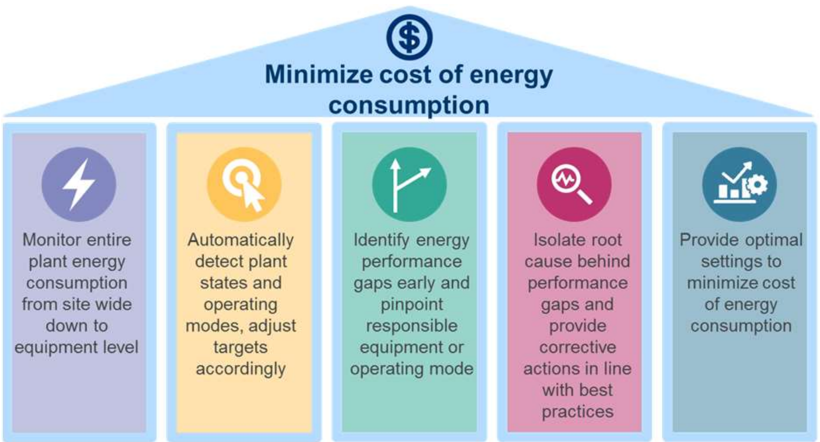
- Energy Management
  - ISO 50001
  - Cost Management:
    - Raw Mat, People, Energy
  - Good PR
  - AI/ML has been proven to be effective
- Process Optimization and Advanced Control
  - Small scale use of Fuzzy Logic, Neural Net, MPC since 1990
  - Proven in Process Analytics, Quality Prediction etc
  - Larger Scale use of AI/ML in Process Optimization of large units has not been easy
    - Good application knowledge needed
    - Constant tuning/re-modelling

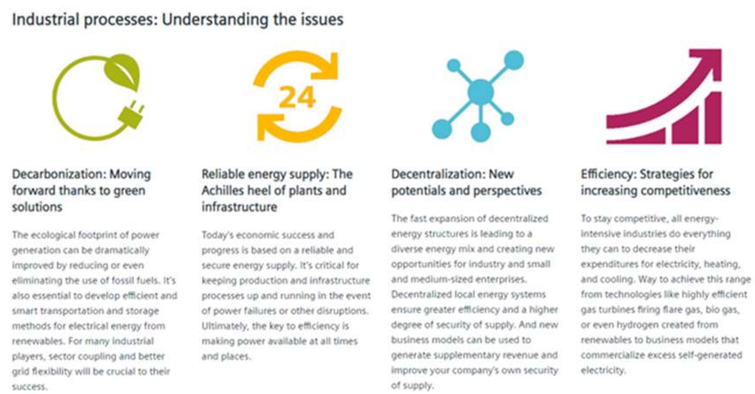
- Asset Performance and Management
  - Adv Diagnostics and Expert System in use since 1990
  - More recent expanded use
    - Equipment Useful Life Prediction
    - FMEA and Failure Prediction
    - Criticality Analysis
    - Maintenance and Shutdown Scheduling Optimization



Energy Management







What for? Just like the flight simulator – Familiarization and training…

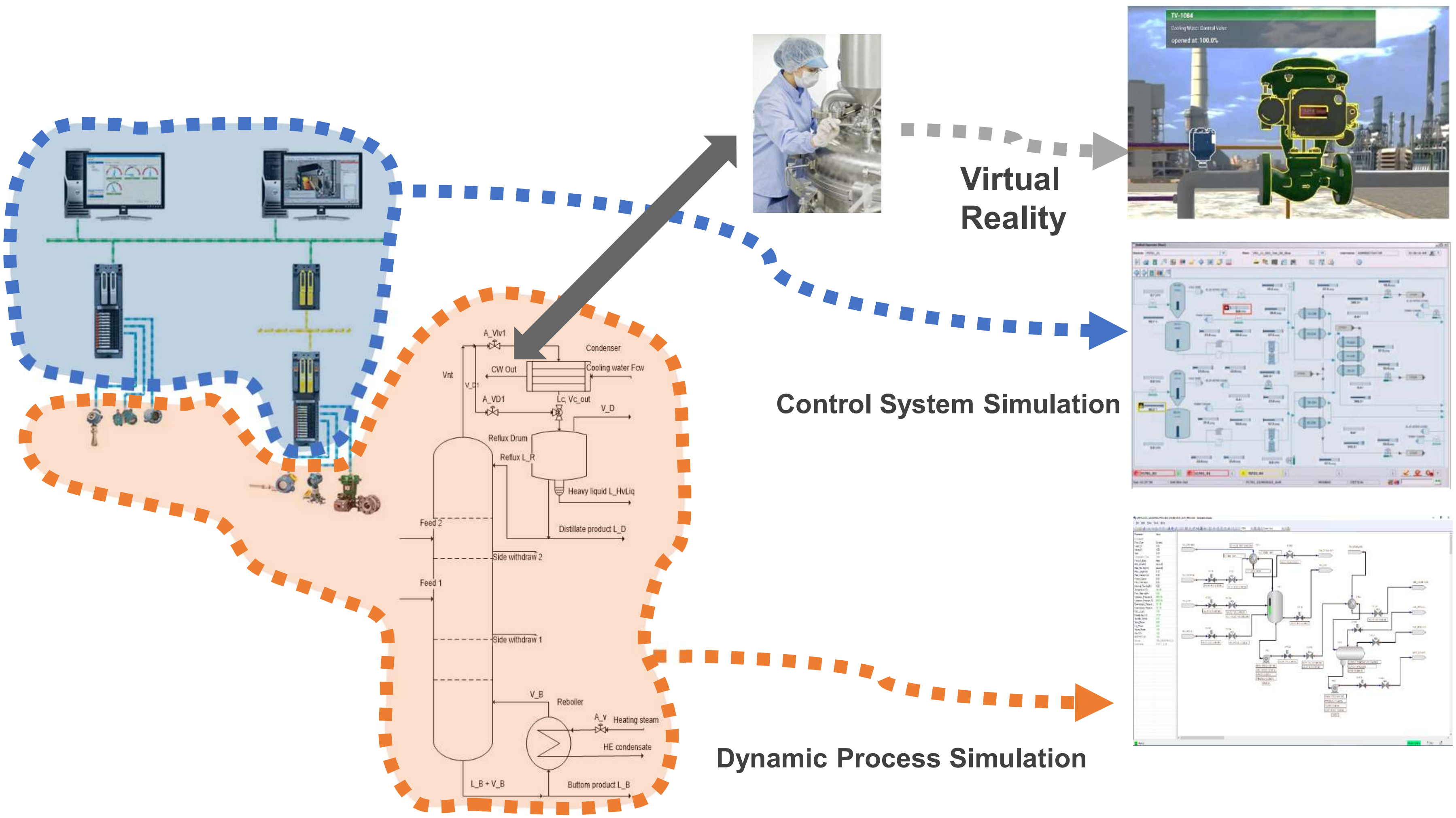
Pilot – over 100 variables

Operator – over 1000 variables

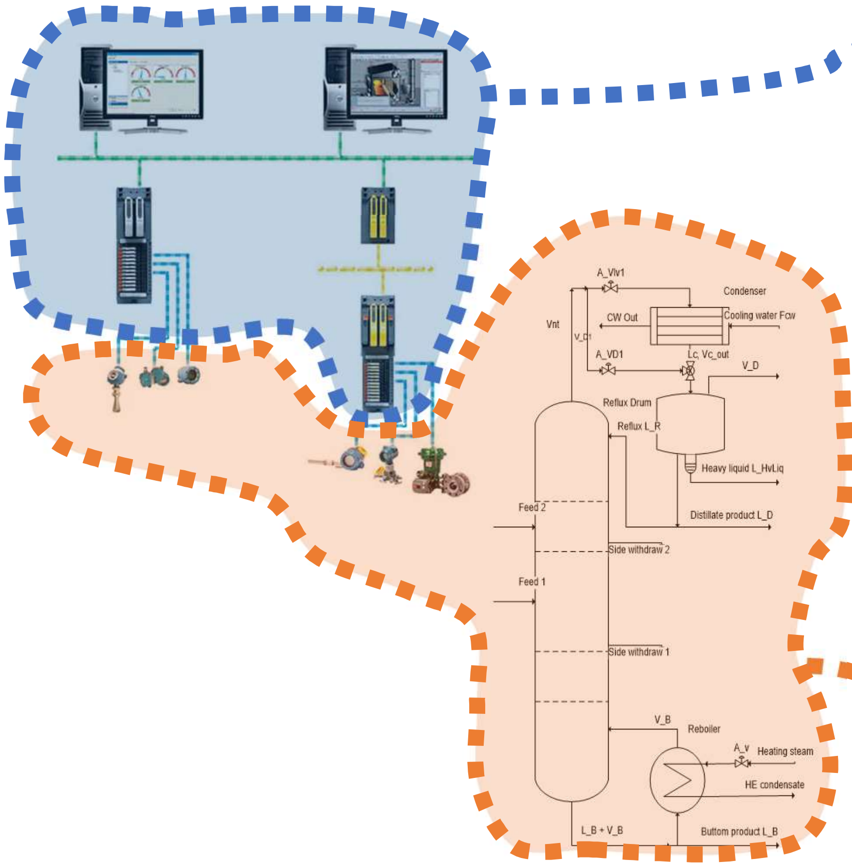
But not everything can be done within the control room. What if you need to:

1. Control Room needs to co-ordinate some manual intervention in the field
2. Abnormal situation – emergency diversion, shutdown
3. Manual addition of raw material

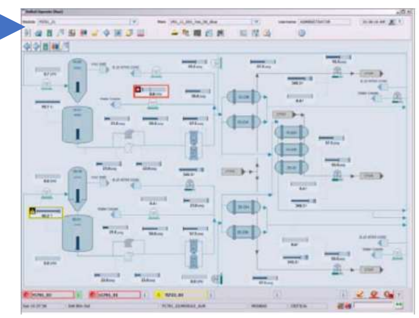
How do you have simulation training for those?


Virtual Reality
Control System Simulation
Dynamic Process Simulation
TV-1084
A_Vlv1
Condenser
Vnt
CW Out
Cooling water Fcw
V_D1
A_VD1
Lc, Vc_out
V_D
Reflux Drum
Reflux L_R
Heavy liquid L_HvLiq
Feed 2
Distillate product L_D
Side withdraw 2
Feed 1
Side withdraw 1
V_B
Reboiler
A_V
Heating steam
HE condensate
L_B + V_B
Buttom product L_B

Simulation Systems: two parts…

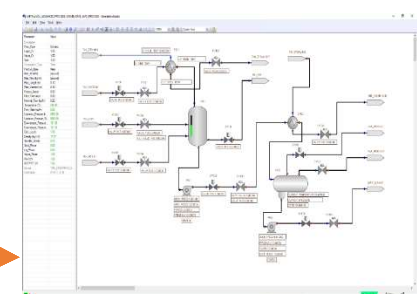


Control System Simulation
Virtual Controller:
“Fake” Prahics HMI, PID loops, logics, Production control sequence etc



OPC link

Dynamic Process Simulation
Virtual Plant:
“ Fake” pipes, tanks, reactors
Giving temperature, flow, pressure changes, raw material movement etc



Virtual Reality (VR) For Field Operator Training

- Digital Twin for simulated environment and process data
- Ideal for learning of scenarios eg: Abnormal Situation Management, Operator Field Intervention, Collaboration with Control Room

Augmented Reality is not just for Games and Fun

Shopping Experience TODAY

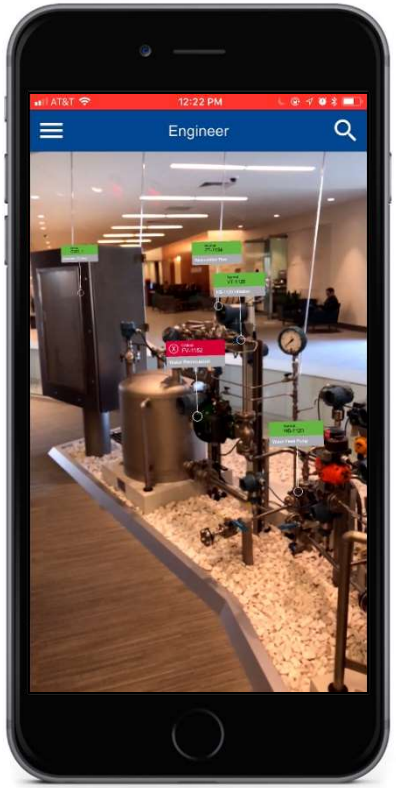
- Decisions on the move
- Supported by relevant instant info and data
- Augmented Reality!

Workforce Empowerment TOMORROW:

- Decisions on the move
- Supported by relevant instant info and data
- Augmented Reality!

AR –
Guidance and Decision Support for your workforce

Overlay Digital Information on Top of the Physical World for increased Productivity, Safety, and Insight



- Equipment Location
- Connectivity and Wiring info
- Asset Health and Diagnostics
- Recommended actions / fixes
- Process values and history
- Access to remote experts
- Digital workflows
- Documentation
- Educational content
- Spare parts lists

Considerations:
1. Wireless Infrastructure
2. Explosion proofing of tablet and phones
3. Overloading the Operator – change the SOP
4. Cloud or On-prem? IP and cybersecurity…

Barriers to digital transformation

PEOPLE

Organizational siloes and skill gaps

Requires collaboration across LoB, IT and ecosystems like never before

PROCESS

Business processes and transactions span multiple environments

Demands security, visibility and control at each touch point to mitigate new risks

TECHNOLOGY

Fast, secure, controlled access to data

Identifying, integrating, and analyzing the right data across diverse ecosystems

Flexibility for the future

To use any data, applications, services and devices