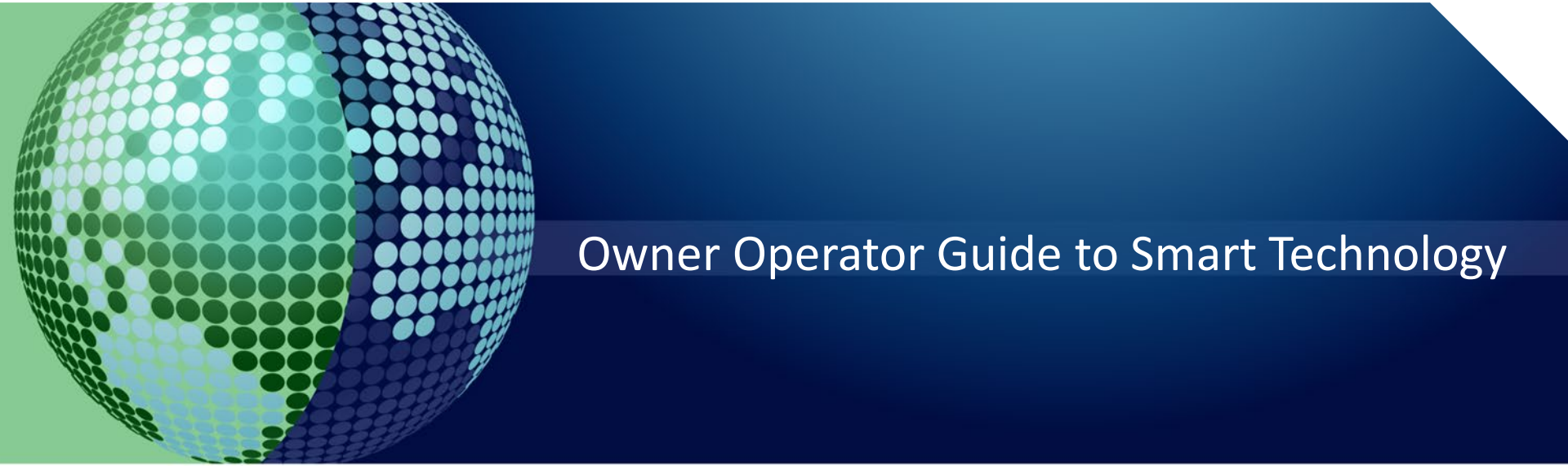
Emerging Smart Control Systems Technology



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John Dressel, Fluor
Control Systems Fellow

Data Centric Instrument Technological Revolution

- Owner Operator Guide to **Data Centric** Emerging Smart Technology
- New Process Measurement and Control Technologies are Increasing and Emerging at an alarming rate and most are **Data** driven
- New and Emerging Smart Technologies:
  - Measurement Chip Sets = Smart = Data
  - HART Instrument Protocol = Smart = Data
  - Instrument Bus Networks = Digital = Data
  - Wireless Instrumentation = Networks = Data
  - Web Centric Applications = Cloud = Data
  - Plant Operating Networks = Systems = Data
  - Bluetooth Instrumentation = Connectivity = Data
  - Remote Programmable I/O = Networks = Data
  - Electronic Instrument Marshalling = Data

Data Centric Instrument Technological Revolution

- The Emergence of Data Centric Instrument Systems has caused the decline of some Technologies
- Outdated Instrument Technologies:
  - Pneumatic Instrumentation
  - 4-20 mA Analog Signals
  - Hardware Based BPCS
  - Dedicated DCS Consoles
  - I/O Buildings and Rooms
  - Multi-core Homerun Cables
  - Switch and Hardwired Logic
  - Discrete Field Switches

Obstacles to acceptance of Smart Instrumentation

- Outdated or Ignored Instrument Standards
- Capability of CAE Software to Document New Tech
- Under Trained or Uninformed Engineering User Base
- Owner Operator Acceptance of New Technologies
- Obstructive **Paradigms** to New Technologies:
  - “This is the way we’ve always done it”
  - “It is not secure enough for our use”
  - “We don’t know how to maintain it”
  - “This technology is too complex”
  - “This technology is not proven”
  - “It will confuse our Operators”

Updated Instrument Standards for Owner Operators

- **ANSI/ISA 5.1-2022 - Instrumentation Symbols and Identification** has significant changes over the previous versions ANSI/ ISA-5.1- 2009 or ISA-5.1-1984 (R1992)
- This standard has been updated to include New and Evolving Instrument Technology, Control Systems and Computer Networks
- Instrument Types and Naming Conventions as defined on the P&ID dictate the Instrument Types used by Smart Instrumentation

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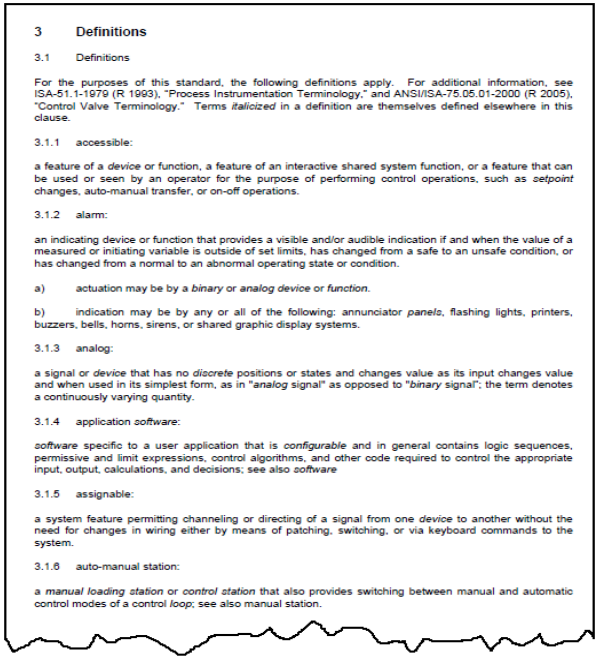
ANSI/ISA-5.1-2022 – Added Definitions for P&IDs

- Analog vs Digital Instrument Systems
- Application Software for Graphics and Data
- BPCS – Basic Process Control System
- HLCS – High Level Control System
- SIS – Safety Instrumented Systems
- Communications Protocols
- Computer Control System
- Data Link – TCP/IP Protocols
- Detector – Process Function signal converter
- Discrete Signal (it is not Digital any longer)
- Field Instrument - Hardware vs Software



3 **Definitions**

3.1 Definitions

For the purposes of this standard, the following definitions apply. For additional information, see ISA-51.1-1979 (R 1993), "Process Instrumentation Terminology," and ANSI/ISA-75.05.01-2000 (R 2005), "Control Valve Terminology." Terms *italicized* in a definition are themselves defined elsewhere in this clause.

3.1.1 accessible:

a feature of a *device* or function, a feature of an interactive shared system function, or a feature that can be used or seen by an operator for the purpose of performing control operations, such as *setpoint* changes, auto-manual transfer, or on-off operations.

3.1.2 alarm:

an indicating device or function that provides a visible and/or audible indication if and when the value of a measured or initiating variable is outside of set limits, has changed from a safe to an unsafe condition, or has changed from a normal to an abnormal operating state or condition.

a) actuation may be by a *binary* or *analog device* or *function*.

b) indication may be by any or all of the following: annunciator *panels*, flashing lights, printers, buzzers, bells, horns, sirens, or shared graphic display systems.

3.1.3 analog:

a signal or *device* that has no *discrete* positions or states and changes value as its input changes value and when used in its simplest form, as in "*analog* signal" as opposed to "*binary* signal"; the term denotes a continuously varying quantity.

3.1.4 application *software*:

software specific to a user application that is *configurable* and in general contains logic sequences, permissive and limit expressions, control algorithms, and other code required to control the appropriate input, output, calculations, and decisions; see also *software*

3.1.5 assignable:

a system feature permitting channeling or directing of a signal from one *device* to another without the need for changes in wiring either by means of patching, switching, or via keyboard commands to the system.

3.1.6 auto-manual station:

a *manual loading station* or *control station* that also provides switching between manual and automatic control modes of a control *loop*; see also manual station.

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ANSI/ISA-5.1-2022 – Table 4.1 Identifier Letters

- Added Identification letters to Table 4.1
  - C – “Close” Modifier
  - D – “Deviation” Modifier
  - G – “Gauge” Function
  - O – “Open” Modifier
  - R – “Run” Modifier
  - S – “Stop” Modifier
  - W – “Probe” Function
  - X – “Accessory Device”
  - Z – “SIS” Variable Modifier

Table 4.1 — Identification letters

Note: Numbers in parentheses refer to the preceding explanatory notes in Clause 4.2.

	First letters (1)		Succeeding letters (15)		
	Column 1	Column 2	Column 3	Column 4	Column 5
	Measured/Initiating Variable	Variable Modifier (10)	Readout/Passive Function	Output/Active Function	Function Modifier
A	Analysis (2)(3)(4)		Alarm		
B	Burner, Combustion (2)		User's Choice (5)	User's Choice (5)	User's Choice (5)
C	User's Choice (3a)(5)			Control (23a)(23e)	Close (27b)
D	User's Choice (3a)(5)	Difference, Differential, (11a)(12a)			Deviation (28)
E	Voltage (2)		Sensor, Primary Element		
F	Flow, Flow Rate (2)	Ratio (12b)			
G	User's Choice		Glass, Gauge, Viewing Device (16)		
H	Hand (2)				High (27a)(28a)(29)
I	Current (2)		Indicate (17)		
J	Power (2)		Scan (18)		
K	Time, Schedule (2)	Time Rate of Change (12c)(13)		Control Station (24)	
L	Level (2)		Light (19)		Low (27b)(28)(29)
M	User's Choice (3a)(5)				Middle, Intermediate (27c)(28) (29)
N	User's Choice (5)		User's Choice (5)	User's Choice (5)	User's Choice (5)
O	User's Choice (5)		Orifice, Restriction		Open (27a)
P	Pressure (2)		Point (Test Connection)		
Q	Quantity (2)	Integrate, Totalize (11b)	Integrate, Totalize		
R	Radiation (2)		Record (20)		Run
S	Speed, Frequency (2)	Safety(14)		Switch (23b)	Stop
T	Temperature (2)			Transmit	
U	Multivariable (2)(6)		Multifunction (21)	Multifunction (21)	
V	Vibration, Mechanical Analysis (2)(4)(7)			Valve, Damper, Louver (23c)(23e)	
W	Weight, Force (2)		Well, Probe		
X	Unclassified (8)	X-axis (11c)	Accessory Devices (22), Unclassified (8)	Unclassified (8)	Unclassified (8)
Y	Event, State, Presence (2)(9)	Y-axis (11c)		Auxiliary Devices (23d)(25)(26)	
Z	Position, Dimension (2)	Z-axis (11c), Safety Instrumented System (30)		Driver, Actuator, Unclassified final control element	

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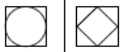
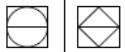
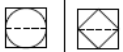
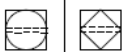
ANSI/ISA-5.1-2022 – Table 5.1.1 Symbols

- **Column A - DCS - BPCS**
  - Primary Shared Control System (DCS)
  - Basic Process Control System (BPCS)
- **Column B - PLC - SIS**
  - Alternate Shared Control System (PLC).
  - Safety Instrumented System (SIS)
- **Column C - Software**
  - Computer Functions and Software
  - High Level Control System (HLCS)
- **Column D - Hardware**
  - Discrete Primary Elements, Transmitters and Indicators
  - Discrete Final Control Elements and Control Valves

Table 5.1.1 — Instrumentation device and function symbols

Note: Numbers in parentheses refer to explanatory notes in Clause 5.3.1.

No.	Shared display, shared control (1)		C	D	Location & accessibility (6)
	A	B			
	Primary Choice or Basic Process Control System (2)	Alternate Choice or Safety Instrumented System (3)	Computer Systems and Software (4)	Discrete (5)	
1					• Located in field. • Not panel, cabinet, or console mounted. • Visible at field location. • Normally operator accessible.
2					• Located in or on front of central or main panel or console. • Visible on front of panel or on video display. • Normally operator accessible at panel front or console.
3					• Located in rear of central or main panel. • Located in cabinet behind panel. • Not visible on front of panel or on video display. • Not normally operator accessible at panel or console.
4					• Located in or on front of secondary or local panel or console. • Visible on front of panel or on video display. • Normally operator accessible at panel front or console.
5					• Located in rear of secondary or local panel. • Located in field cabinet. • Not visible on front of panel or on video display. • Not normally operator accessible at panel or console.

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ANSI/ISA-5.1-2022 – Table 5.2.2 Notations

- Table 5.2. is a new table for Measurement Notations and has added several New Technology Functions and descriptions

Table 5.2.2 — Measurement symbols: measurement notations (4)

Note: Numbers in parentheses refer to explanatory notes in Clause 5.3.2

Flow											
CFR	=	Constant flow regulator	OP	=	Orifice plate	PT	=	Pitot tube	VENT	=	Venturi tube
CONE	=	Cone	OP-CT	=	Corner taps	PV	=	Pitot venturi	VOR	=	Vortex Shedding
COR	=	Coriolis	OP-CQ	=	Circle quadrant	SNR	=	Sonar	WDG	=	Wedge
DOP	=	Doppler	OP-E	=	Eccentric	SON		Sonic			
DSON	=	Doppler sonic	OP-FT	=	Flange taps	TAR	=	Target			
FLN	=	Flow nozzle	OP-MH	=	Multi-hole	THER	=	Thermal			
FLT	=	Flow tube	OP-P	=	Pipe taps	TTS	=	Transit time sonic			
LAM	=	Laminar	OP-VC	=	Vena contracta taps	TUR	=	Turbine			
MAG	=	Magnetic	PD	=	Positive displacement	US	=	Ultrasonic			
Level											
ABS	=	Absolute			Manometer	VAC	=	Vacuum			
AVG	=	Average									

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ANSI/ISA-5.1-2022 – Table 5.2.3 Symbols

- Primary element symbols with several new symbols for special Orifices and Measurement Technology

Table 5.2.3 — Measurement symbols: primary elements

Note: Numbers in parentheses refer to explanatory notes in Clause 5.3.2.

	No	Symbol (4)	Description
Flow	10		• Circle quadrant orifice plate.
Flow	11		• Multi-hole orifice plate
			• Generic venturi tube, flow nozzle, or flow tube.

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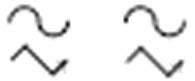
ANSI/ISA-5.1-2022 – Table 5.3.2 Signal Symbols

- Added Line symbols with new symbols and signal types for Wireless, Fieldbus, Smart and Serial Communications

Table 5.3.2 — Line symbols: instrument-to-instrument connections

Note: Numbers in parentheses refer to explanatory notes in Clause 5.3.3.

No	Symbol	Application
11	(3) a) b) 	• Unguided electromagnetic signals, light, radiation, radio, sound, wireless, etc. • Wireless instrumentation signal. • Wireless communication link.
12	(4) 	• Communication link and system bus, between devices and functions of a shared display, shared control system. • DCS, PLC, or PC communication link and system bus.

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ANSI/ISA-5.1-2022 – Table 5.3.4 Final Elements

- Final control element actuator symbols with new Valves with positioners and partial stroke testing device symbols

Table 5.4.2 — Final control element actuator symbols

Note: Numbers in parentheses refer to explanatory notes in Clause 5.3.4

No	Symbol	Description
1	(7) 	• Generic actuator. • Spring-diaphragm actuator.
2	(7) 	• Spring-diaphragm actuator with positioner.

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ANSI/ISA-5.1-2022 – Annex A Identification system

- Annex A has expanded Tables for Allowable Loop, Tag & succeeding letter combinations for instrument type functions

Table A.3.2 — Allowable succeeding letter combinations for output/active function letters (1) (4b2)

Note: Numbers in parentheses refer to explanatory notes in A.16.3.

First Letters		B	C				K	N	S		T			U	V	X	Y	Z
Measured/Initiating Variables w/ and w/o Modifiers		User's Choice (4a)	Control C (7)	Indicate Control IC (8)	Record Control RC (8)	Control Valve CV (9)	Control Station	User's Choice (4a)	Switch S	Function Modifier [*] (3) (4d)	Transmit T	Indicating Transmit IT	Recording Transmit RT	Multi-function	Valve Damper Louver	Unclass-ified	Compute, Convert Relay	Actuator, Drive
SZ	Speed(SIS)		SZC	SZIC	SZRC	SZCV	NA		SZS[*]		SZT	NA	NA	SZU	SZV	SZX	SZY	SZZ
T	Temperature		TC	TIC	TRC	TCV	TK		TS[*]]		TT	TIT	TRT	TU	TV	TX	TY	TZ
TD	Temperature Differential		TDC	TDIC	TDRC	NA	TDK		TDS[*]		TDT	TDIT	TDRT	TDU	TDV	TDX	TDY	TDZ
TF	Temperature Ratio		TFC	TFIC	TFRC	NA	TFK		TFS[*]		NA	NA	NA	TFU	TFV	TFX	TFY	TFZ
TJ	Temperature Scan		NA	NA	NA	NA	NA		TJS[*]		TJT	NA	NA	NA	NA	NA	NA	NA
TK			TKC	TKIC			TKK		TKS[*]			NA		TKU	TKV	TKX	TKY	

- Added Function modifiers PF = Ratio, PQ = Total, PS = Safety & PZ = SIS - ISA now recognizes over unique 1000 Instrument Type identifiers

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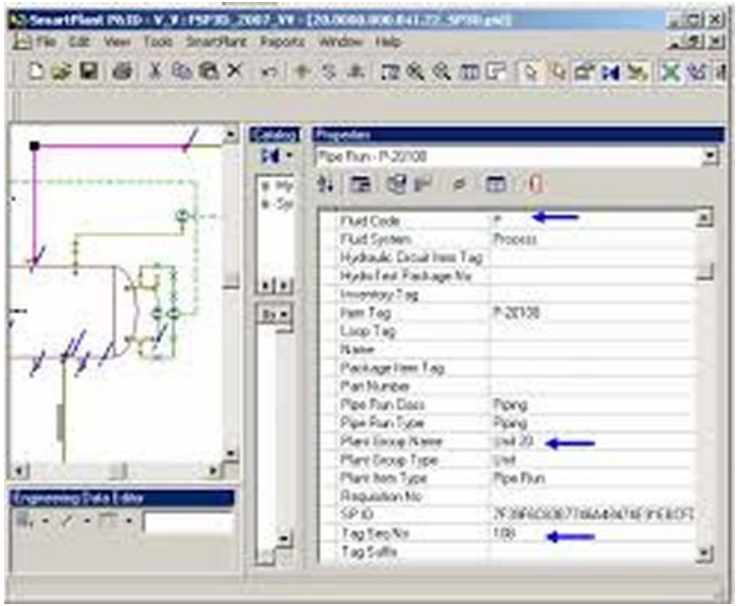
Documenting New Technology in Smart P&ID

- The P&ID Defines all Elements of the Instrument Technology
  - Use the Latest Instrument Symbols
    - (ANSI/ISA-5.1-2022)
  - Show Every Bubble, Tag and Valve
    - (No “Implied” Tags)
  - Show the Signal Type and Technology of Every Element
  - Be Mindful of the Smart P&ID Data Properties, Integrity and Quality
  - Expect and Use Data Integration to other Smart Software Applications



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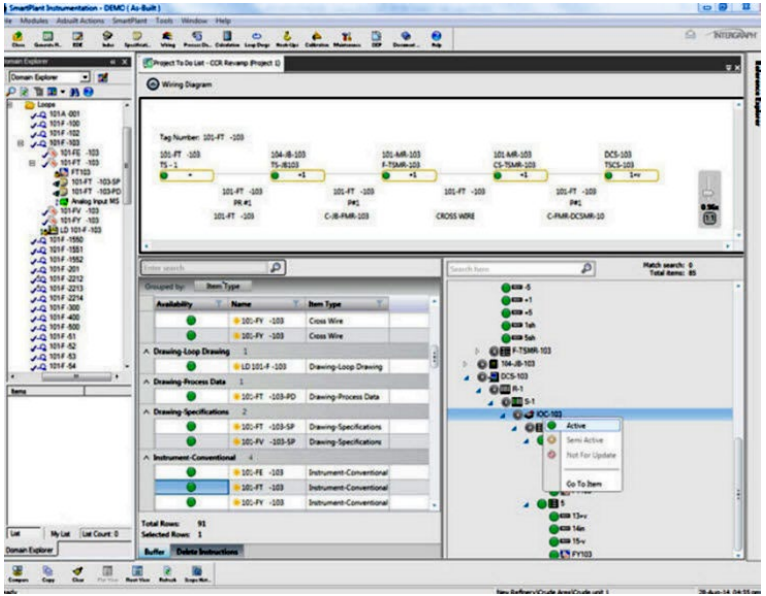
Documenting New Technology in Smart Instrumentation

- Smart Instrumentation has the Ability to Document any New Technologies with Minimal Modifications
  - Define New Instrument Types for Emerging Technologies
  - Develop New Spec Forms for New Tech Devices
  - Document Fieldbus and Profibus with the Wiring Module
  - Document Networks using the Telecommunications Module



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How Engineers Cope with New Technology

- Because Emerging Technologies are developing at such a rapid pace it is necessary for Control Systems Engineers to:
  - Get Additional Training on New or Emerging Technologies
  - Attend User and Vendor Conferences and Seminars
  - Attend Lunch & Learns on New Products and Technologies
  - Use Knowledge Management Systems for Collaboration
  - Become Subject Mater Experts centered on New Tech
  - Work directly with Vendors to develop New Technology
  - Join Standards Organizations and Serve on Committees

- **Control Systems Engineers need to bring Answers about New Technology to the Owner Operator Clients – Not Questions!**

Owner Operator Acceptance of New Technology

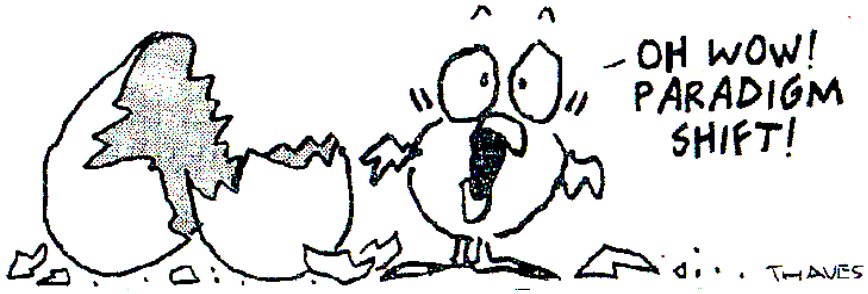
- When it comes to New and Emerging Technologies –

  “The Customer is Not Always Right!”

- It is the Engineering Companies responsibility to keep up with New Technologies and Advise Clients Accordingly
- Operating Companies hire EPC’s to do the engineering expecting the companies to engage current Best Practices
- Clinging to Existing Technologies will Create Built-in Obsolescence when Developing New or Updated Facilities
- Owner Operators and Engineering Companies Share the Risk when the latest Standards are not followed

Owner Operator Acceptance of New Technology

- Accepting New or Emerging Technology may require a **Paradigm Shift** by the Control System Engineers and Owner Operators
  - **Self Knowledge** – Educate Yourself about New Tech
  - **Interaction** – Work with Engineers and Vendors on New Tech
  - **Adaptive Thinking** – Accept Change when Using New Tech
  - **Digital Literacies** – Embrace Data Centric Instrumentation



Owner Operator Acceptance of New Technology

- **Paradigm - “This is the way we’ve always done it”**
  - Most Existing Plants are more that 10 Years Old and the Measurement and Control Technology is long outdated
  - Digital Technologies are more accurate and dependable
  - Digital Technologies are more efficient than 4-20 mA Analog and high demand instrument air supplied technologies
  - Emerging Technologies of today will be “the way we’ve always done it” of the future

"Consistency is the last refuge of the unimaginative"

~ Oscar Wilde

Owner Operator Acceptance of New Technology

- **Paradigm - “We don’t know how to maintain it”**
  - Almost all obsolete, and difficult-to-maintain analog technology for Measurement and Control systems in the U.S. have been replaced with digital systems aver the last 10 to 20 years
  - The advantages of digital technology is improved diagnostics capability and system reliability requiring less maintenance
  - Digital instrumentation has been in place in some installations for over 20 years and current calibration and maintenance equipment are designed to be used with it

"I'm a visionary. I'm not a maintenance person"

~ John Catsimatidis

Owner Operator Acceptance of New Technology

- **Paradigm - “It is not secure enough for our use”**
  - Cyber Security and Digital Information networks are much more secure than previous generation technology
  - Most concern about security is around wireless and networks:
    - WirelessHART and ISA100.11a meets the Federal Information Processing Standard 197 (FIPS-179) and both are AES-128 encryption (NIST/IEEE 802.15.4) compliant
    - Industrial Automation and Control Systems Network manufactures, Integrators and end-users comply with the ISA/IEC-62443 (Formerly ISA-99) set of Standard Documents

"We spend our time searching for security and hate it when we get it" ~ John Steinbeck

Owner Operator Acceptance of New Technology

- **Paradigm - “This technology is not proven”**
  - Proven technology has a documented track record for use in a defined environment to meet the specified requirements
    - Current Standards support Digital Technology
    - Current Best Practices are based on Latest Tech
    - Digital Instrument Systems are Proven in Use
    - Equipment is Certified as Fit for Purpose
    - Technology must be Competitive to Market

"In science, nothing is ever 100% proven"

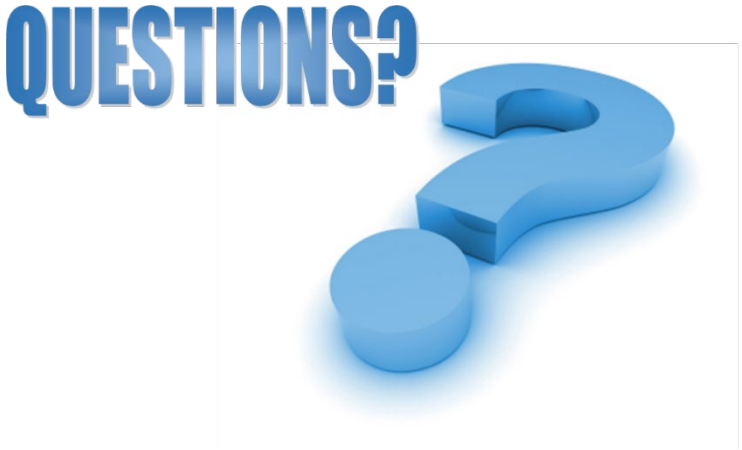
~ Michio Kaku

Owner Operator Acceptance of New Technology

- **Paradigm - “It will confuse our Operators”**
  - Operators have more information at their disposal when using a modern HART or Bus based digital control system
  - Applied Digital DCS, BPCS and HMI advances simplify operations
  - The Equipment and Technology used to gather and connect the components of a modern instrument system are transparent to the Operators

"Many people find the universe confusing – it's not”

~ Stephen Hawking



“Do you realize if it weren't for Edison, we'd be watching TV by candlelight?”

~ Al Boliska