Yokogawa Corporation of America

Hoag Ostling
Chief Application Engineer
Field Instruments Business Unit

What is a fieldbus?

- Digital networking technology applied to field device communication
  - FOUNDATION fieldbus
  - Profibus
- Digital process values
- Digital bi-directional communication

Who is the Fieldbus FOUNDATION?

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- Global organization of users, device vendors, and host vendors working together to provide an interoperable international fieldbus.
  - Providing diverse product interoperability
  - Flexibility to choose the best device
  - Supported by device and control system vendors

What is FOUNDATION fieldbus?

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- Digital bus for field devices
- Interoperable Standard
- Utilizes Device Description Technology
- 3rd Party Tested & Registered
- Contains Standard Function Blocks
  - Enable Custom Function Blocks
- Provides Control in the Field

Interoperability:

- Ability to substitute field devices on any host without manufacturer dependence
  - Freedom to choose the best device for an application, or control function
  - Vendor flexibility to innovate and add new and useful features
  - Elimination of proprietary protocols, custom software drivers, and costly upgrades

Device Testing and Registration

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- Device interoperability is assured by the Fieldbus FOUNDATION
  - FF performs device interoperability testing
  - 3rd party objectivity
  - Assures all registered FF devices will work on your system!

Rule of thumb:

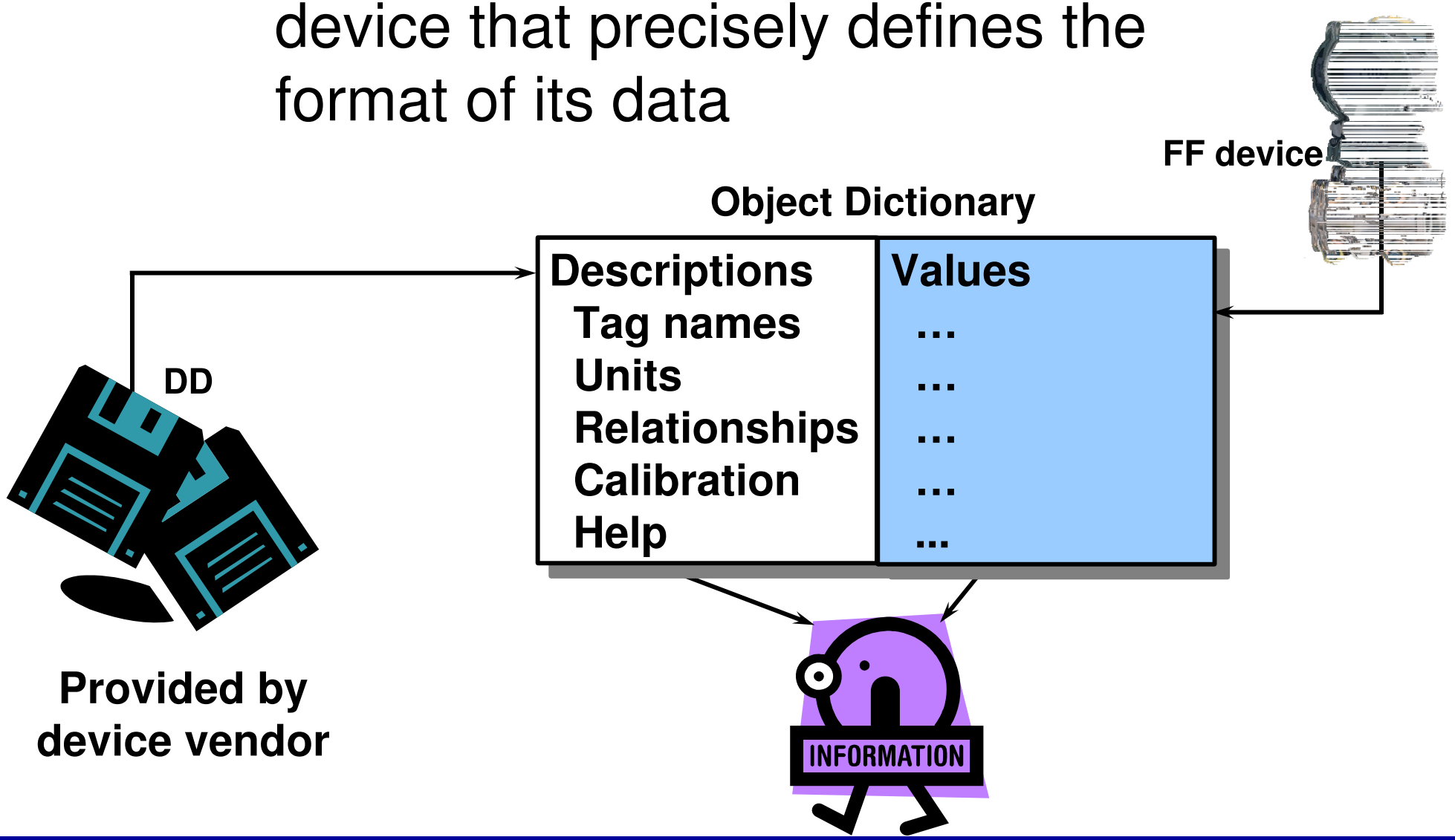
- Make sure your devices have the checkmark!

Device Description Technology

- Device description (DD) files describe all the device capabilities (provided by the device vendor)
- DD services (host side) use the DD file to provide all the device information to the host
- DD Benefits:
  - Common user interface
  - Maintenance needs only one configurator
  - The key to interoperability

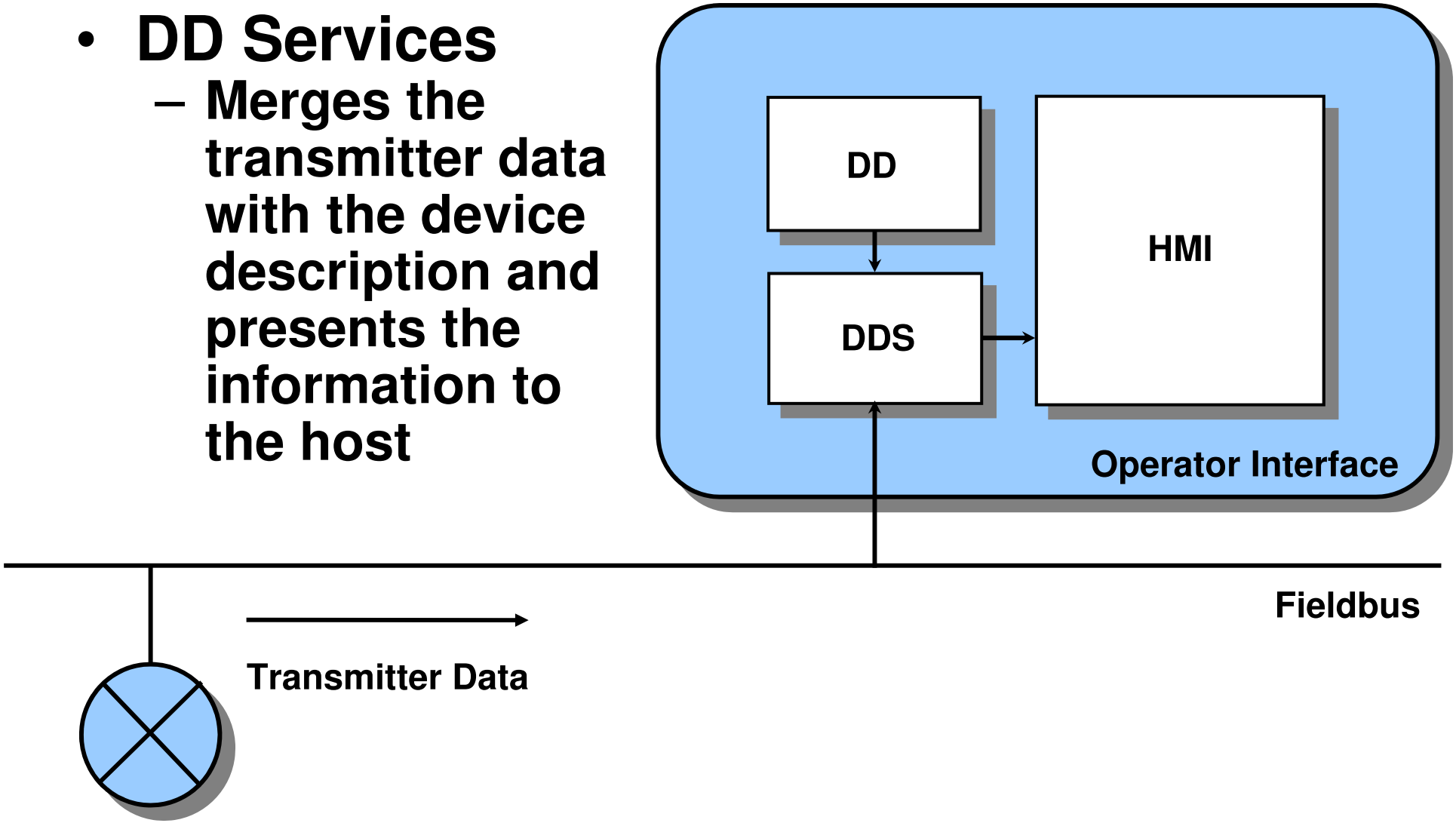
Device Description

- Structured text description for each device that precisely defines the format of its data



Device Description Services

- **DD Services**
  - **Merges the transmitter data with the device description and presents the information to the host**



DD Registration

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Official Fieldbus FOUNDATION registration mark:

Registration mark assures interoperability

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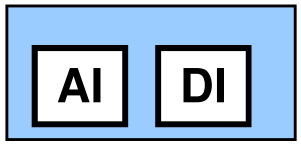
Function Block Introduction

- Standard Function Blocks
  - Execute pre-defined procedures
  - Function Blocks may reside in any device
  - Function Blocks may execute virtually anywhere on the network.
  - Enable true distributed control in field
- Enhanced Function Blocks
  - Enabled by a device vendor to do specialty functions
    - Flow Computer
    - Totalization function

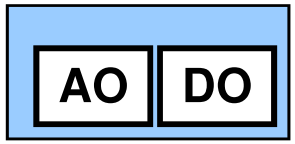
10 Standard Function Blocks

Name	Symbol	Function
Analog Input	AI	Provides AI from Sensor
Analog Output	AO	Accepts MV from control
PID Control	PID	PID control
Control Selector	CS	Override Control
Discrete Input	DI	Provides DI from device
Discrete Output	DO	Accepts DO from control
Manual Loader	ML	Manual Control
PD Control	PD	PD control
Ratio Control	RA	Ratio control
Bias Gain	B	Scaling

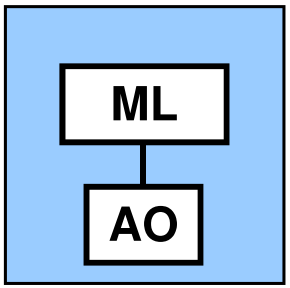
Function Block Applications



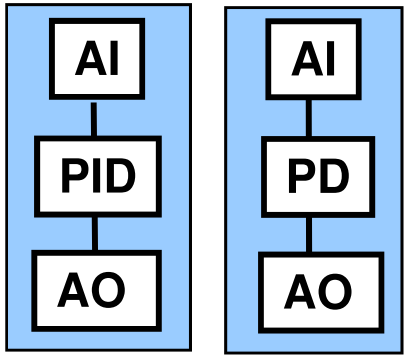
Input



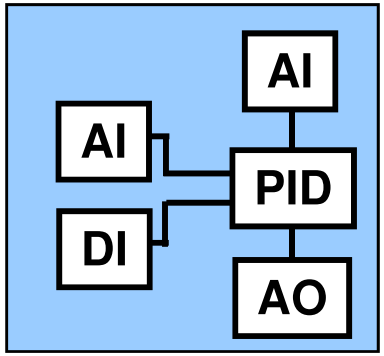
Output



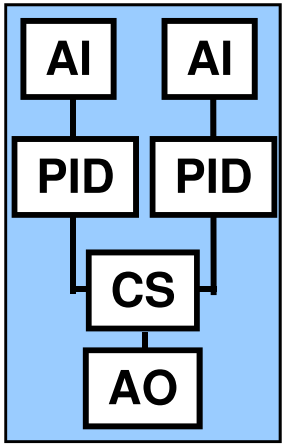
Manual Control



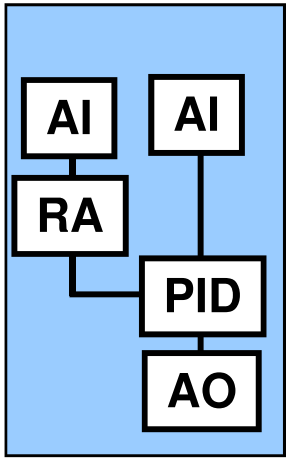
Feedback Control



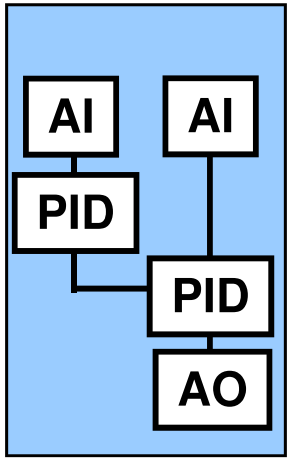
Track, Feedforward Capability in Control



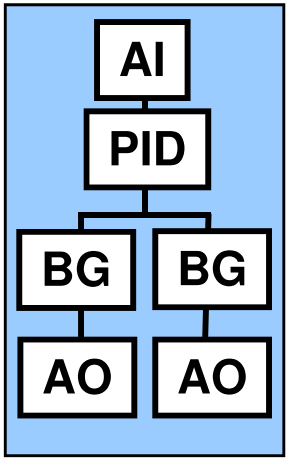
Override Control



Ratio Control



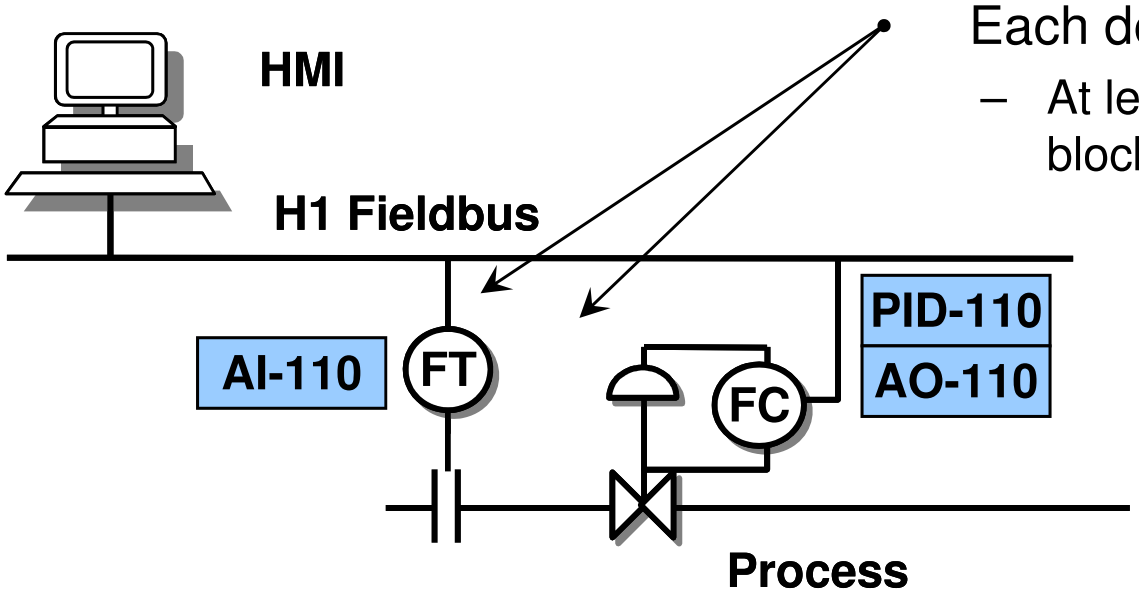
Cascade Control



Split Range Control

Function Blocks

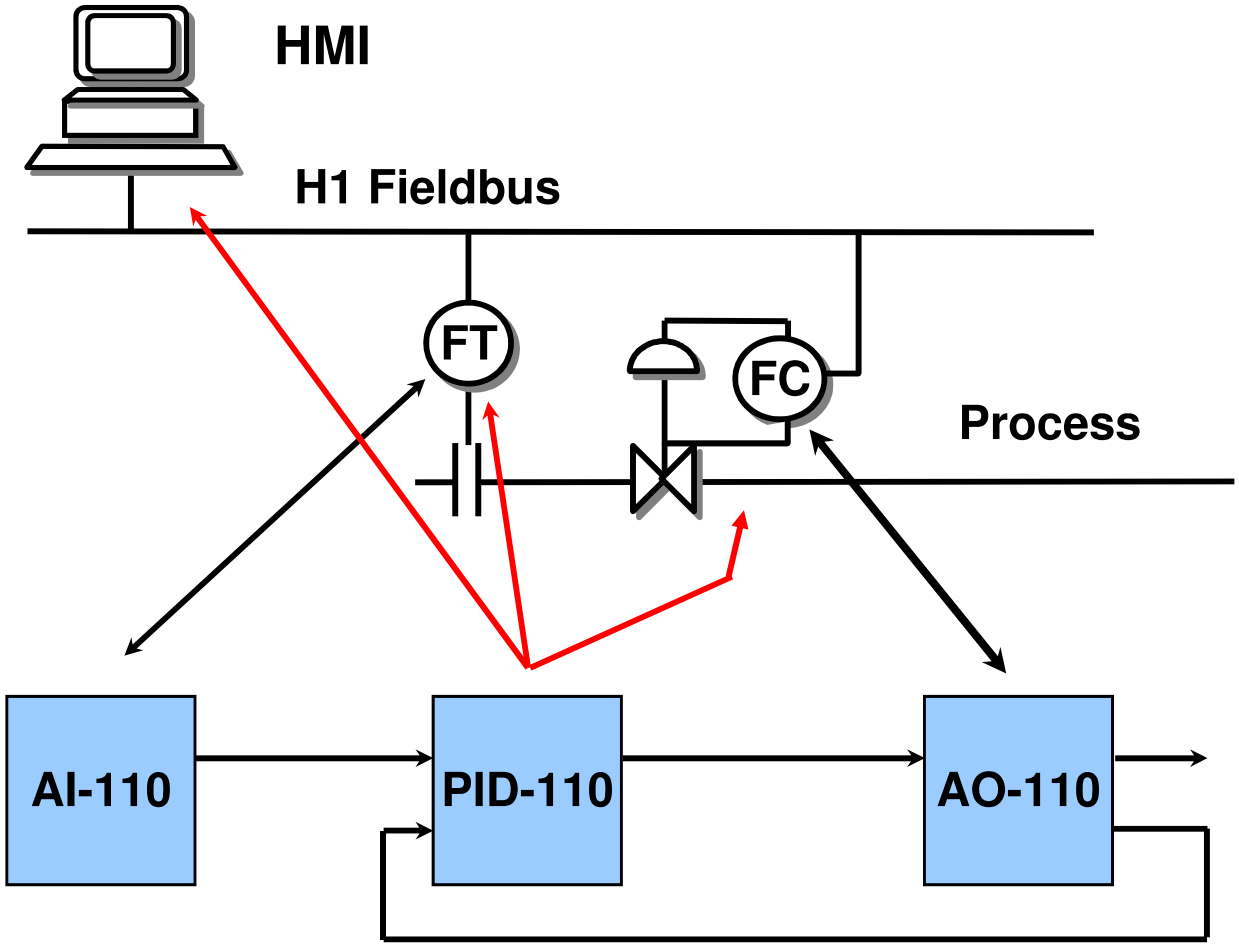
- Function blocks:
  - Encapsulate basic automation functions
  - Reside in device or in host
  - Are connected and provide deterministic control



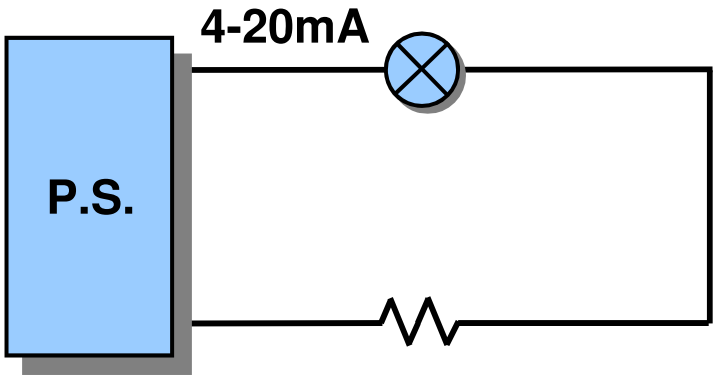
Each device contains
- At least one function block

Function Blocks

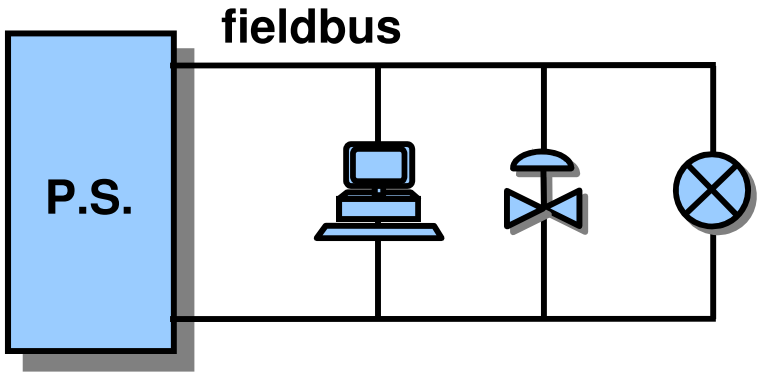
A location-independent model for distributed control



Fieldbus vs. 4-20mA



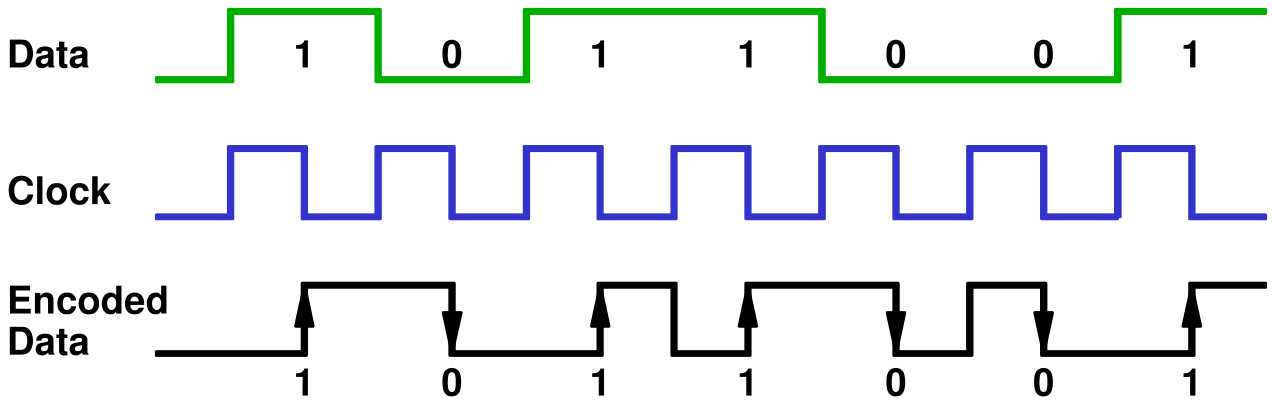
- One pair of wires for each device
- A single analog PV
- Device status unknown



- Parallel connections
- Digital bus
- Multiple PV's per device
- Bi-directional information
- Data available across the network
- Device status insures only good data is used for control

FOUNDATION Fieldbus Benefits

- More Accurate
  - No analog conversion errors
  - Digital communication error correction
- Manchester Bit level encoding
  - puts a time reference on a signal to determine bit boundaries



FOUNDATION Fieldbus Benefits

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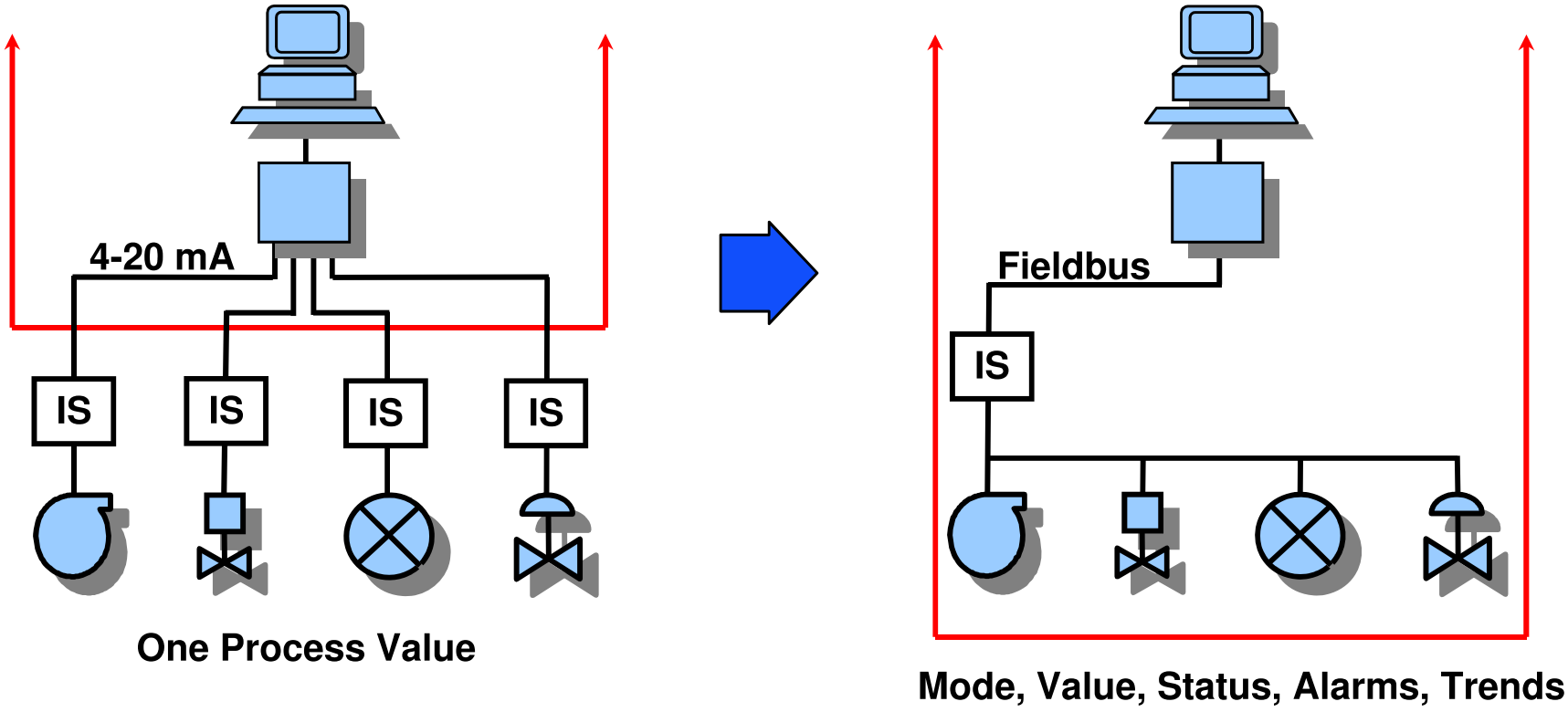
- Reduced wiring and installation costs (CAPEX)



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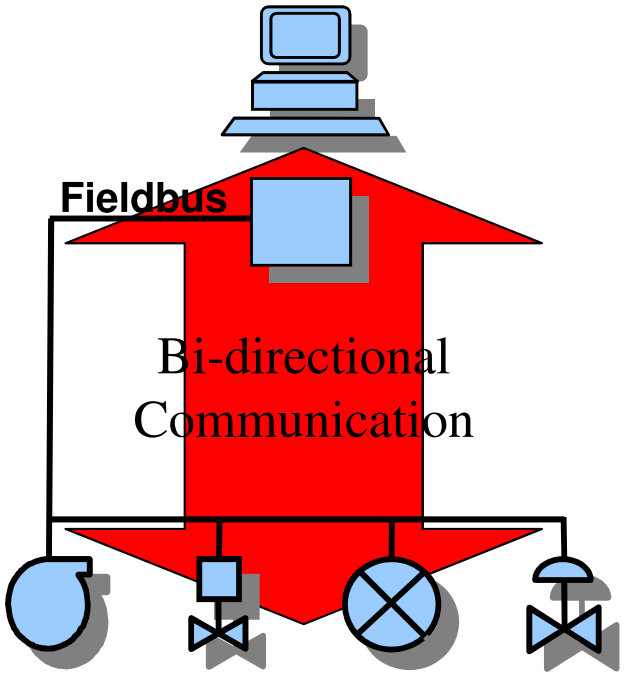
FOUNDATION Fieldbus Benefits

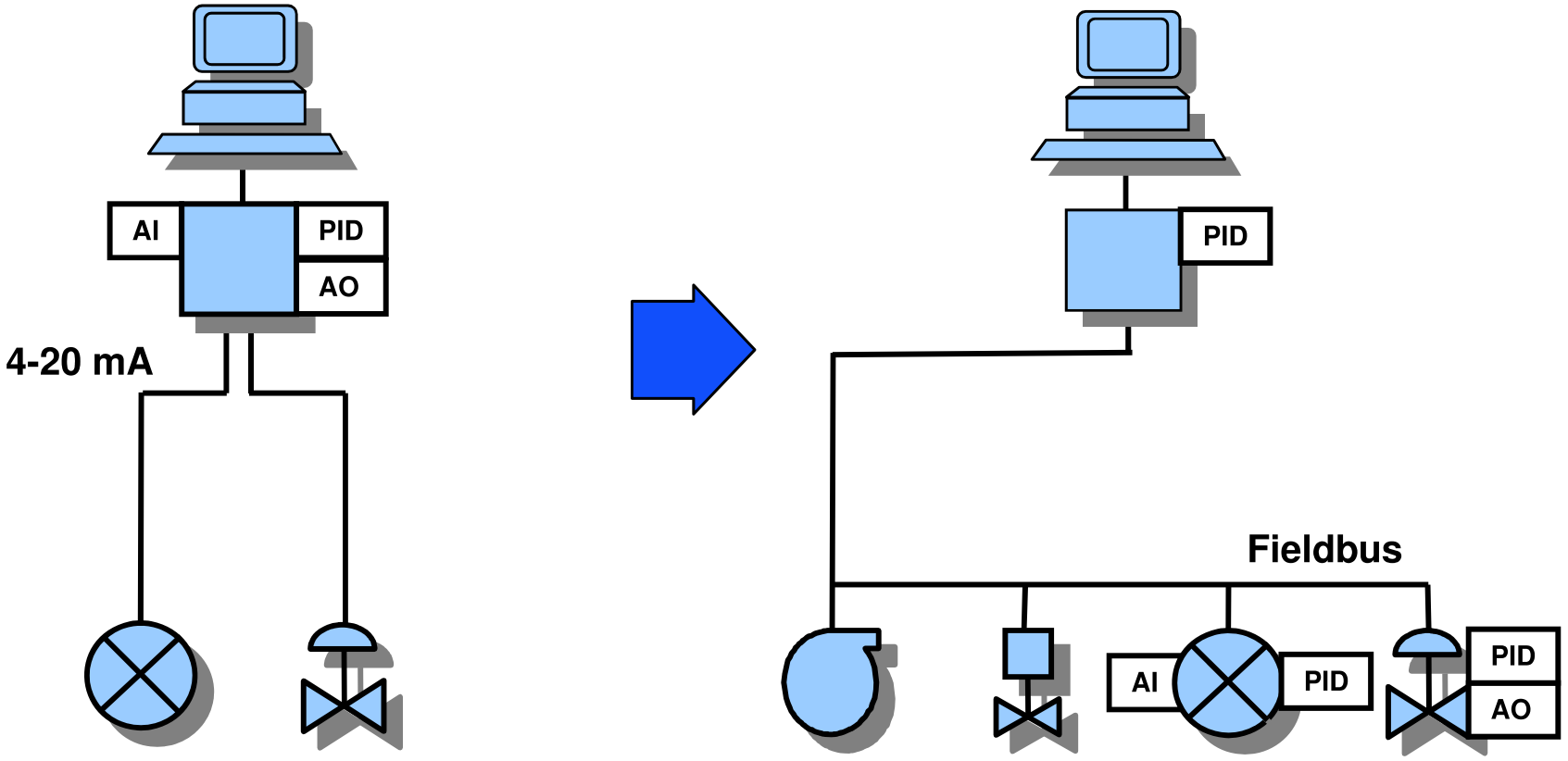
- Reduced engineering and maintenance costs (OPEX)



Mode, Value, Status, Alarms, Trends

FOUNDATION Fieldbus Benefits

- Distribution of functions



Control functions all reside in central controllers.

Fieldbus can be used in the same way, but fieldbus also enables control and I/O functions to be distributed to field instruments.

Physical Connections

- Wire
- Junction Box, Terminal Blocks, Connectors
- Power Supplies
- Power Conditioners
- Terminators
- Intrinsic Safety Barriers
- Polarity
- Grounding
- Lightning protection

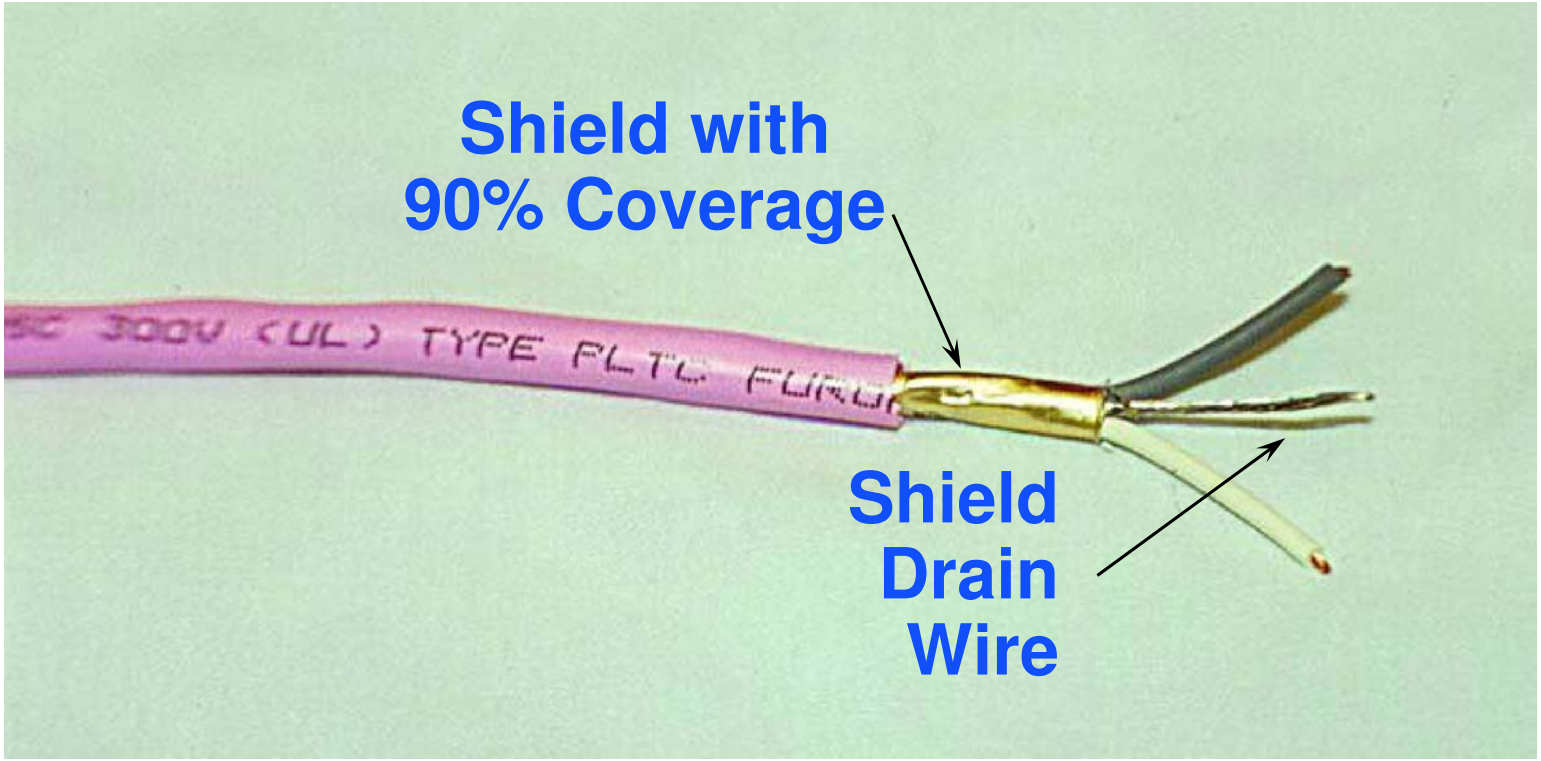
Cable Types / Bus Segment Length

- Fieldbus H1 Segment Cable

Cable Type	Wire Gauge	Max. Length
A. Twisted Shielded Pair	#18 AWG	1900 meters
B. Multi-Pair individually twisted and shielded	#22 AWG	1200 meters
C. Unshielded Twisted Pair	#22 AWG	400 meters

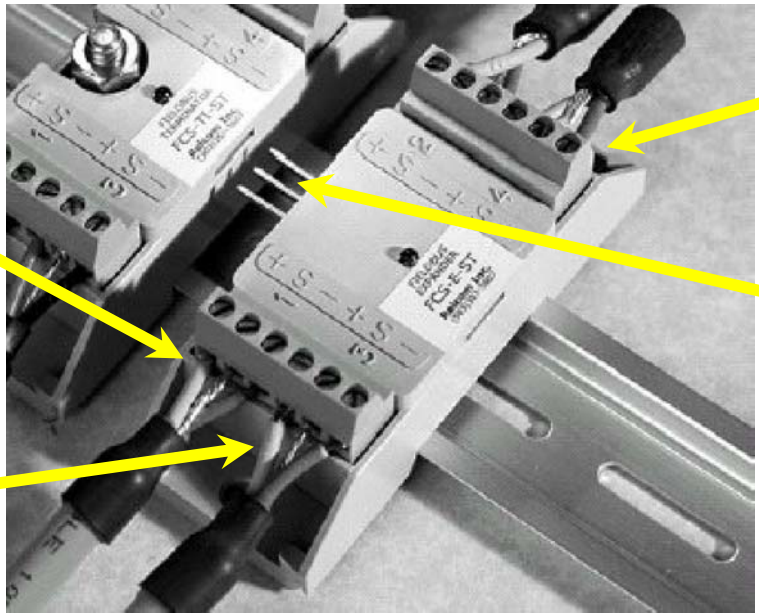
Shielded Twisted Pair Cable

- Typical shielded twisted pair
  - 90% shield
  - Drain wire
  - Color coded



Fieldbus Terminal Blocks

- Screw, plug, or compression terminals
- Color coded terminals
- Options:
  - Terminators
  - Power LED
  - Short circuit protection



Fieldbus in

To single field device

To field device or next junction box

To plug in another terminal block

Fieldbus Terminal Blocks

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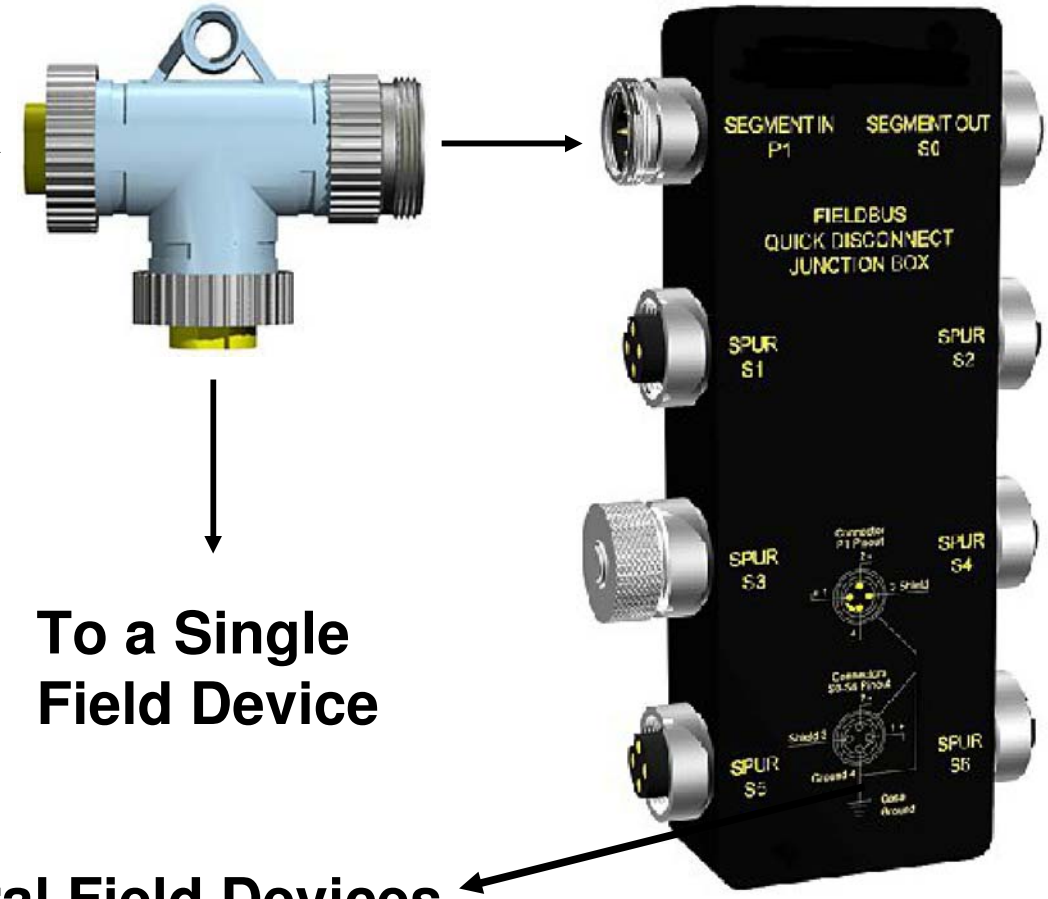
- Plug and Play wiring
  - NEMA 4X – no J-box required!



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Power Supply

- 9 to 30 Vdc
- Power conditioning required
- Power supplies may be redundant

Rule of thumb:

- Select power supply with integral
  - •Terminators and/or conditioners
  - •Switch selectable

Power Conditioner

- A power conditioner:
  - Matches impedance to the network
  - May be integral to the power supply

Terminators

- Impedance matching device used at each end of a fieldbus segment to prevent signal reflection
- Two terminators required per segment (and only two)

Rule of thumb:

- place terminators as far apart as possible

Intrinsic Safety Barriers

- A Fieldbus segment may be used Intrinsic Safety barriers
- Field device must be designed and certified to meet appropriate standards

Polarity

- Fieldbus devices may be sensitive to polarity, confirm with device vendor
- Fieldbus cables require conductor color coding

Rule of thumb:

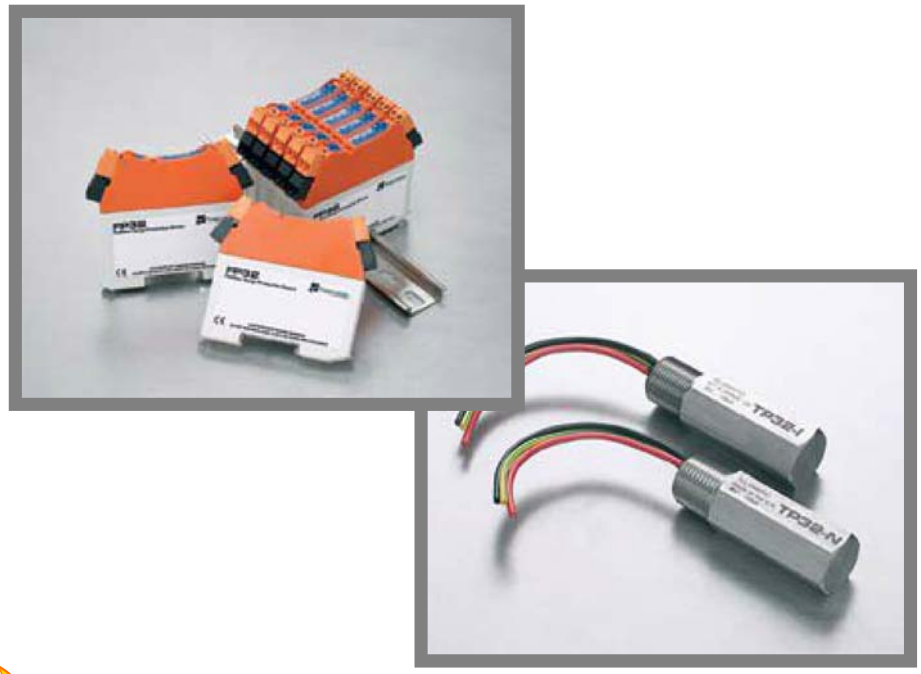
- Assume all FF devices are polarity sensitive
- Maintain consistent wire color coding

Fieldbus Grounding

- Follow current company/plant standard practices and applicable international standards
- Shield grounded at one point only
- Data wires should never be grounded
- Shield never used as a power conductor
- Intrinsically Safe installations have additional specific requirements

Lightning/Surge Protection

- Often taken for granted and not specified!



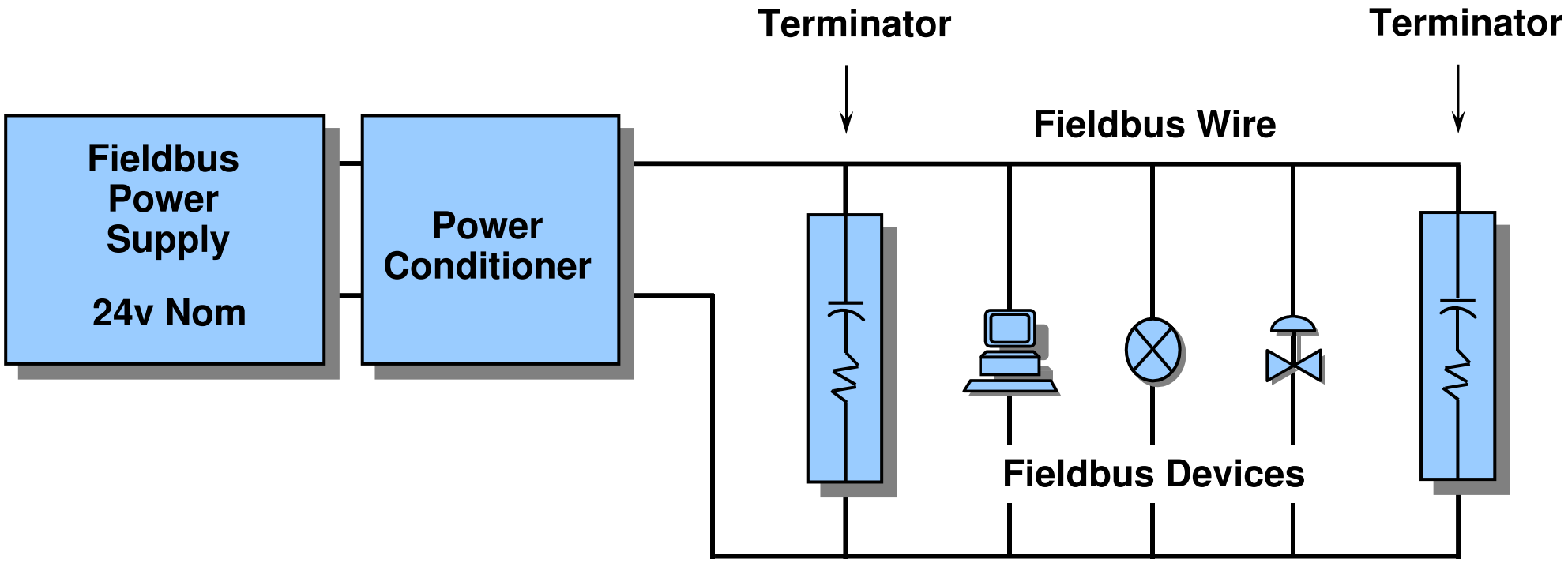
- Surge Protection may be installed at the device or junction box
- Provides a low cost method to reduce Operating Expenses (OPEX)
  - Higher System Integrity
  - Increased Reliability
  - Reduced Downtime
  - Reduced Spares/Inventory

Rule of thumb:

- Specify and install surge protection

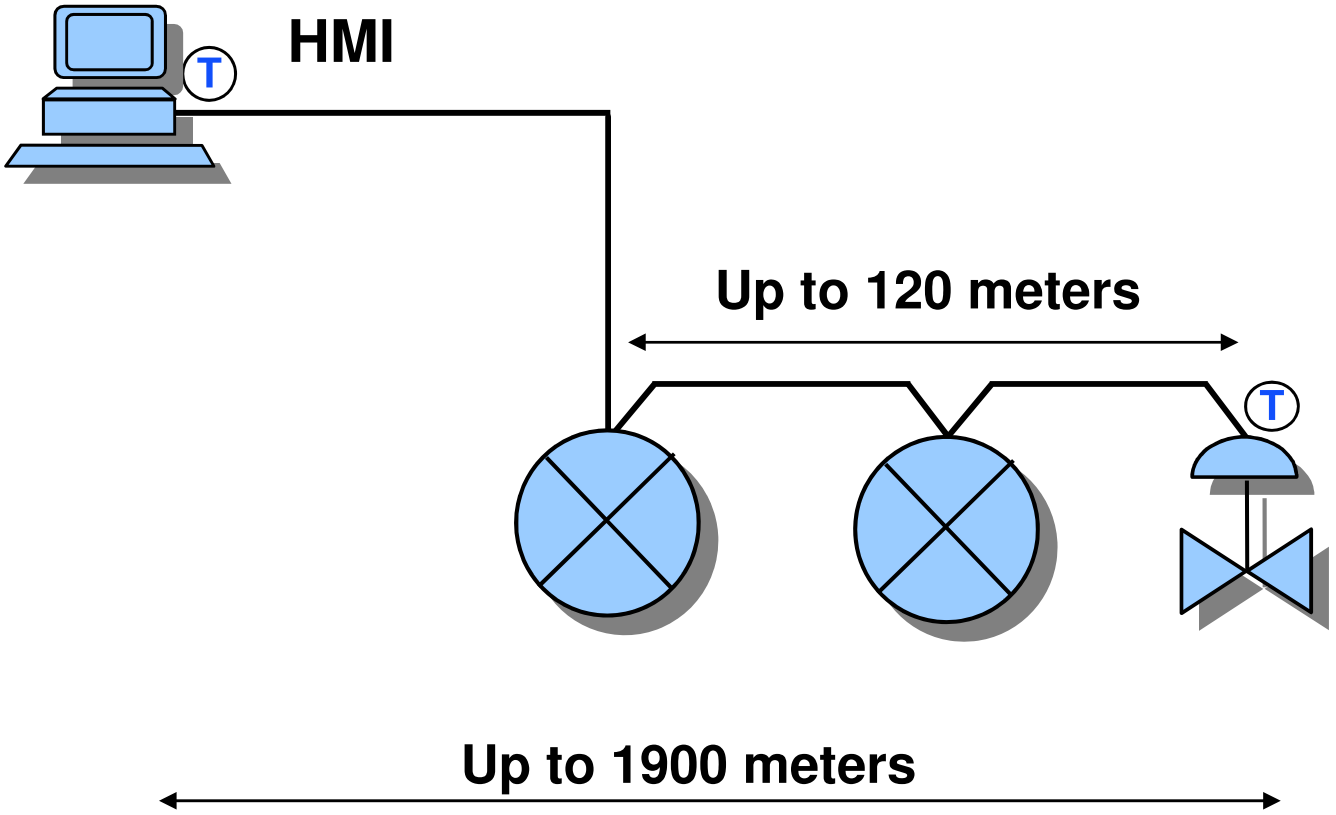
Fieldbus wiring layout

- Typical Fieldbus segment (detail)



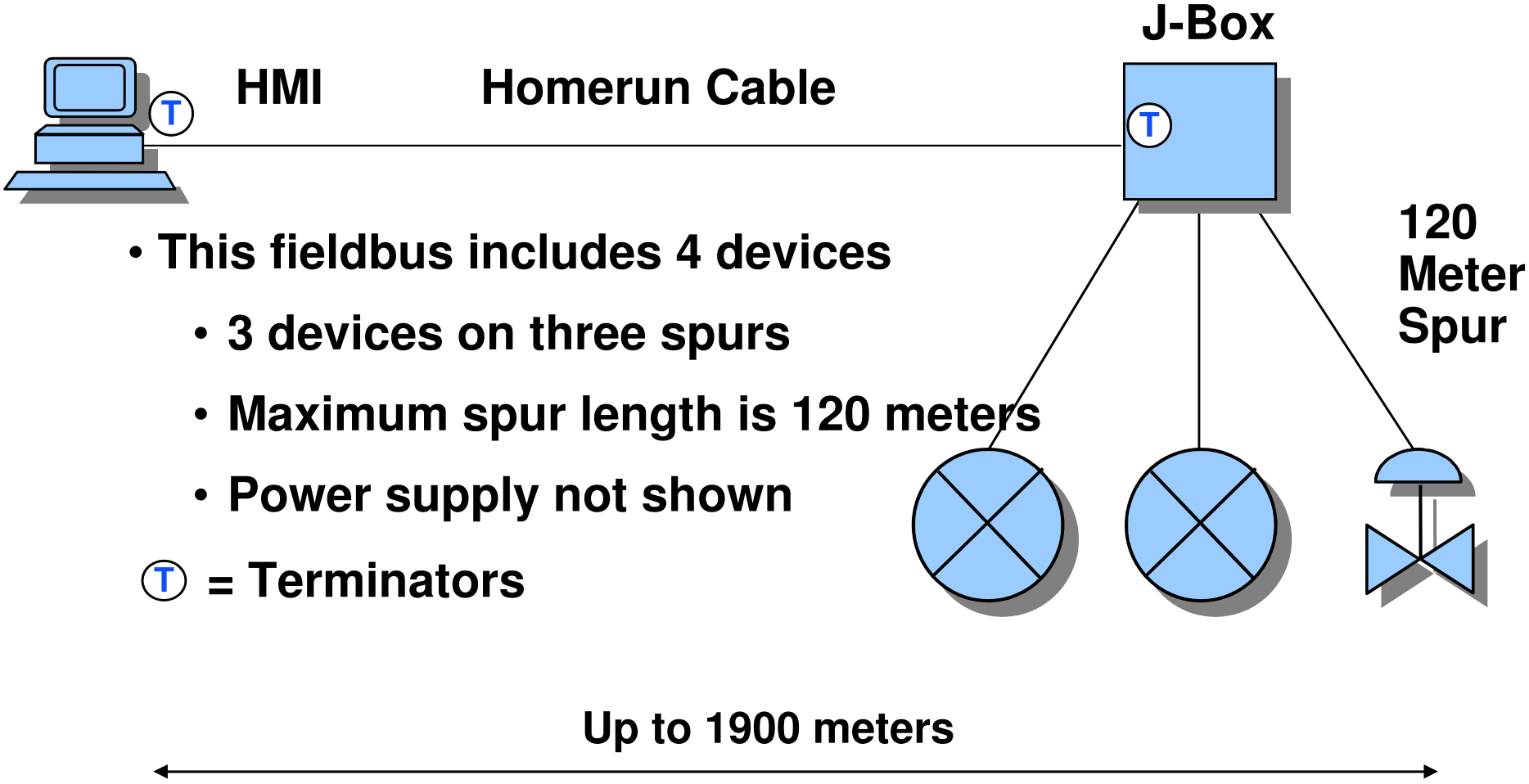
Wiring Topology

- Daisy chain topology



Wiring Topology

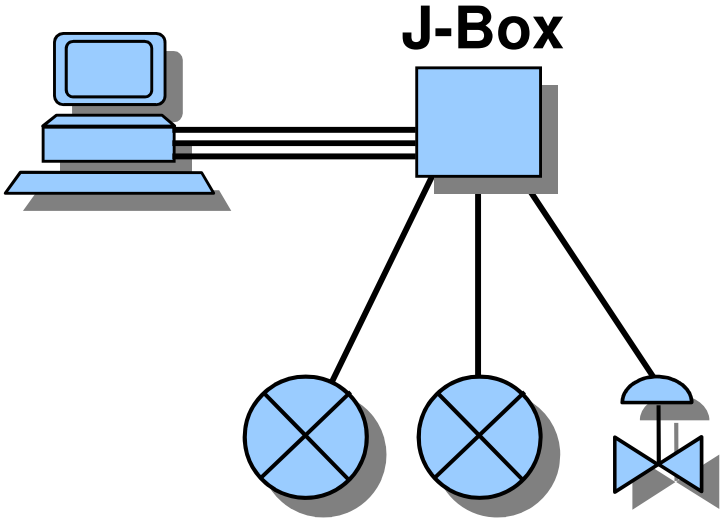
- Tree topology



- This fieldbus includes 4 devices
  - 3 devices on three spurs
  - Maximum spur length is 120 meters
  - Power supply not shown

T = Terminators

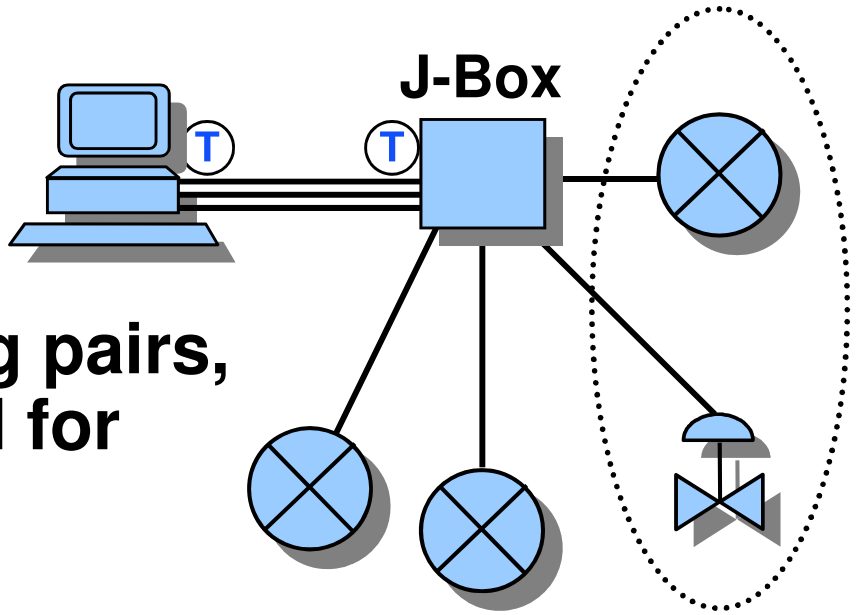
More Control with Installed Wires



3 existing 4-20mA Pairs

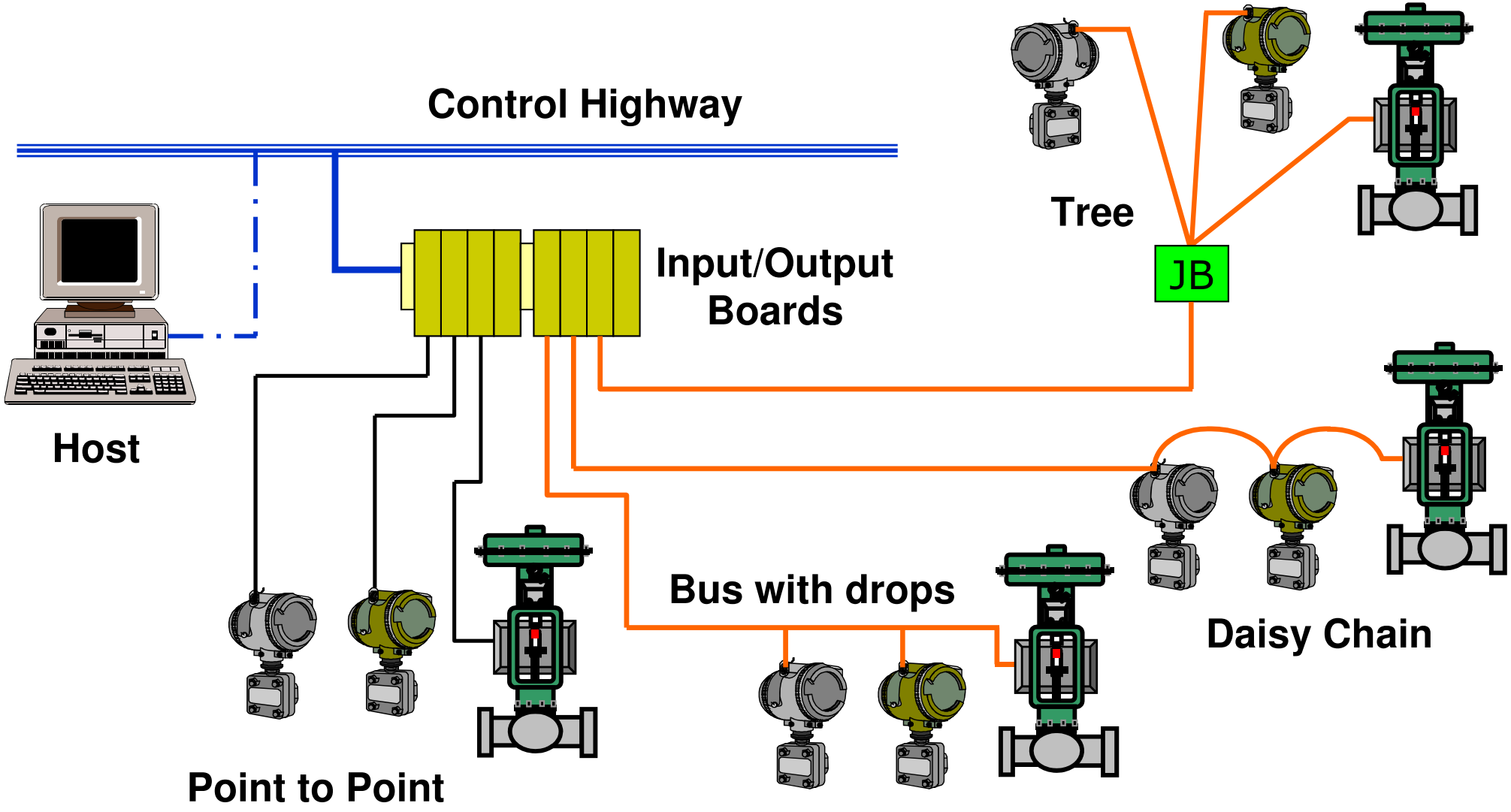
- Expansion flexibility

Fieldbus devices



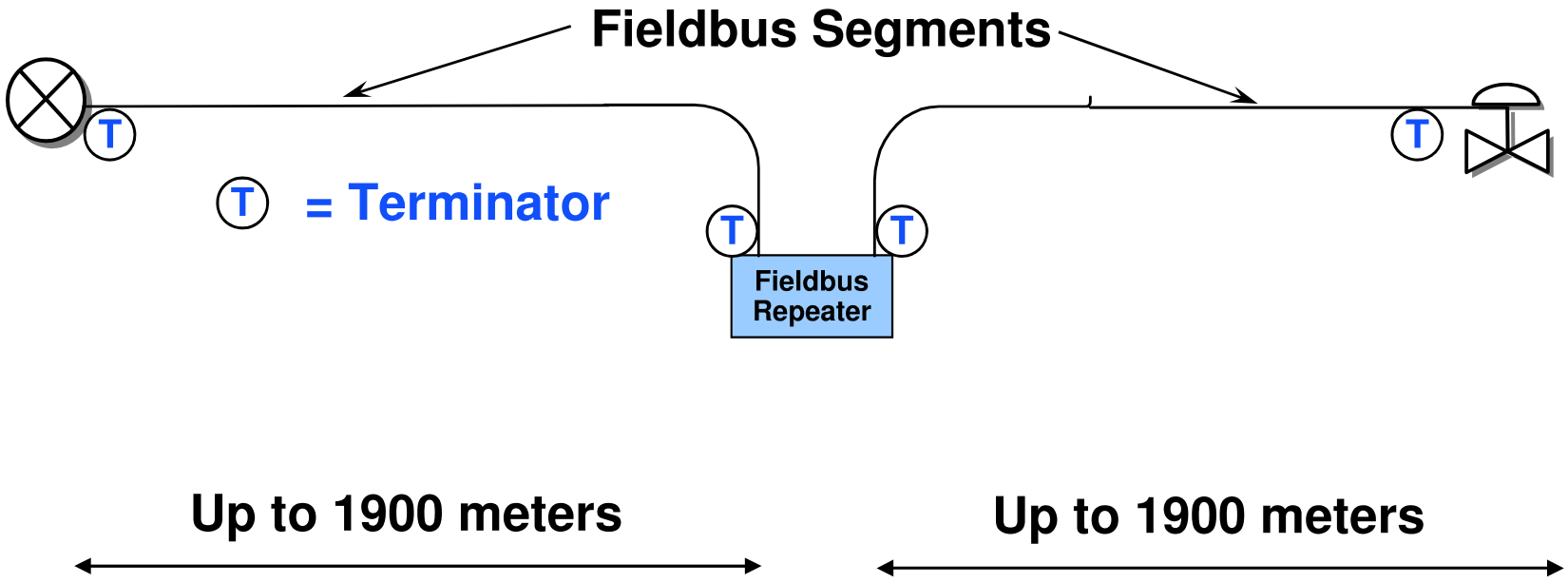
3 existing pairs, one used for fieldbus

Physical Layout Examples



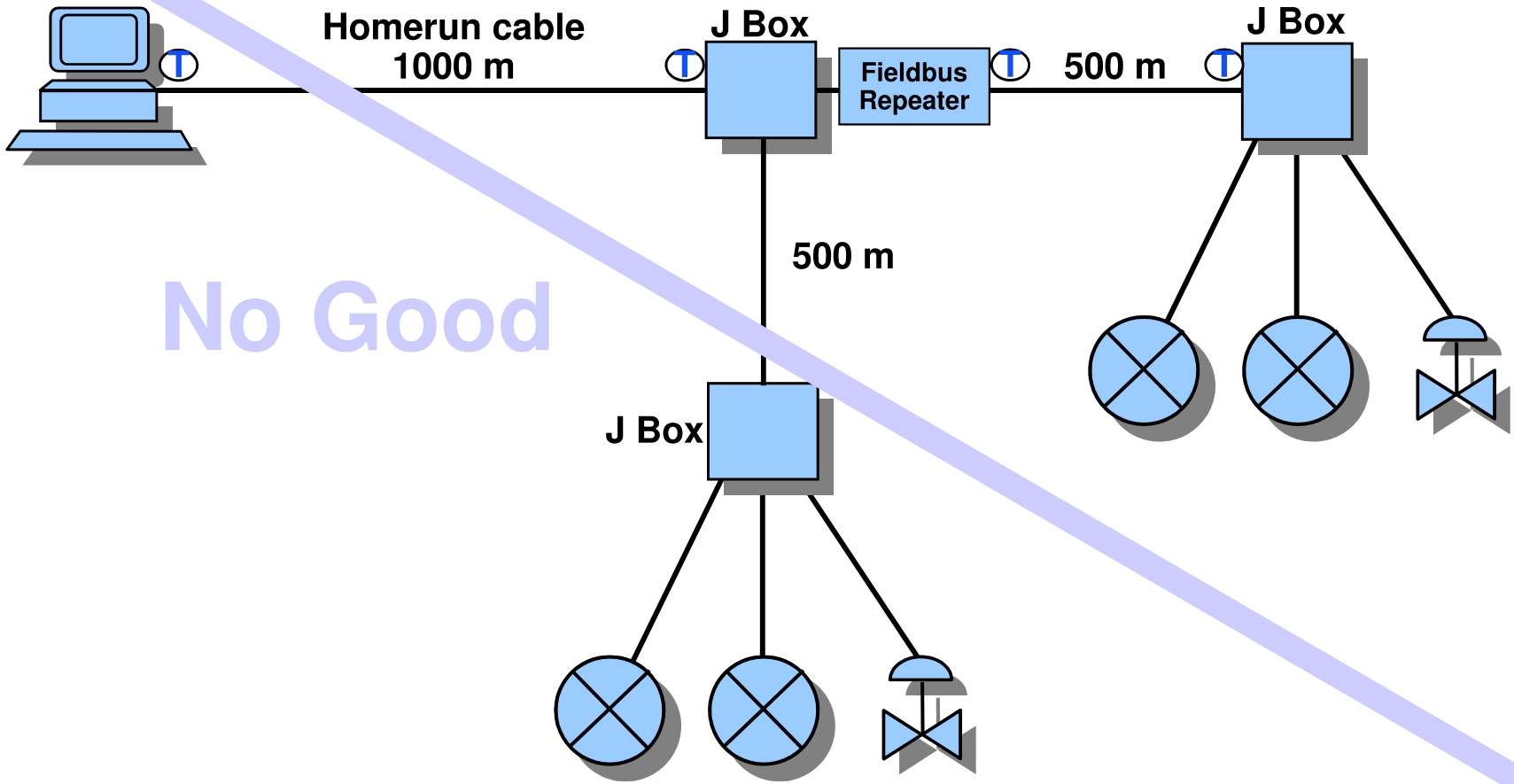
Increasing the Length of a Segment

- A repeater is an active device used to extend the length of a fieldbus



Network Extension

- Spur Length too long (500+ m)



- Repeater resolves excess spur length

Fieldbus Trouble Shooting

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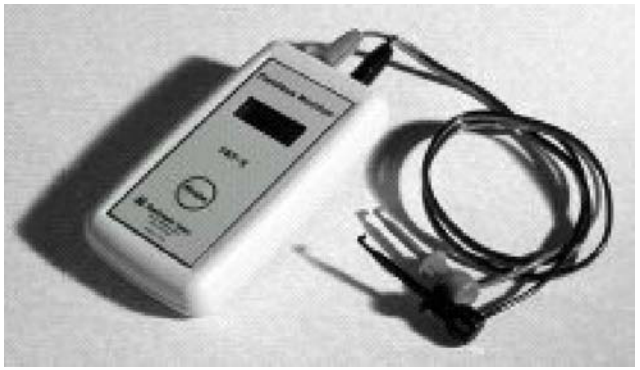
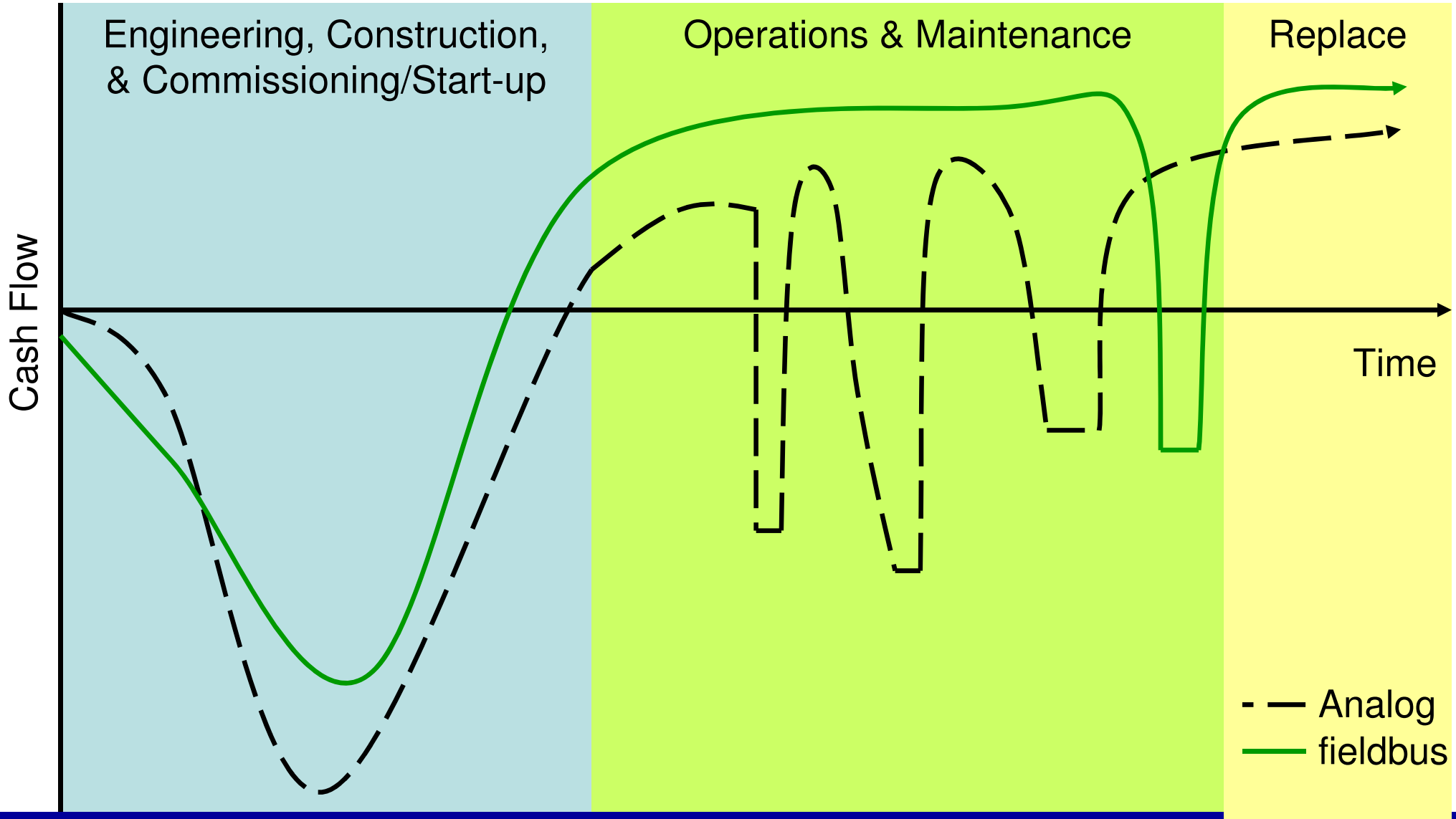
- Power: bus voltage is displayed
- LAS activity: displays LAS signal level
- Device count: displays active device count
- Low: displays device with weakest signal
  - (> 150mV OK)
- Noise: displays average and peak values
  - (< 75 mV OK)



Economic Life Cycle



Operations & Maintenance

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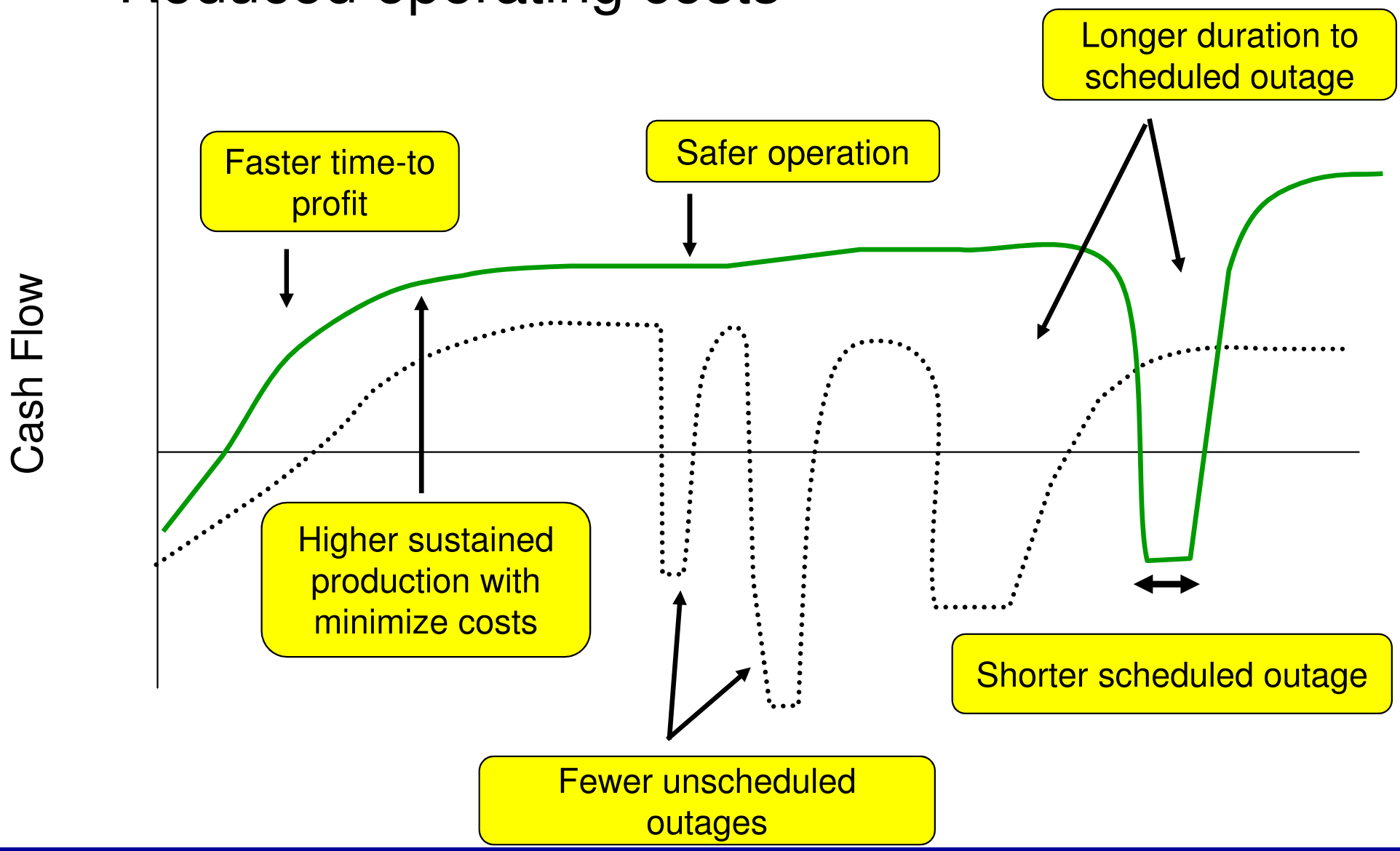
- Reduced operating costs



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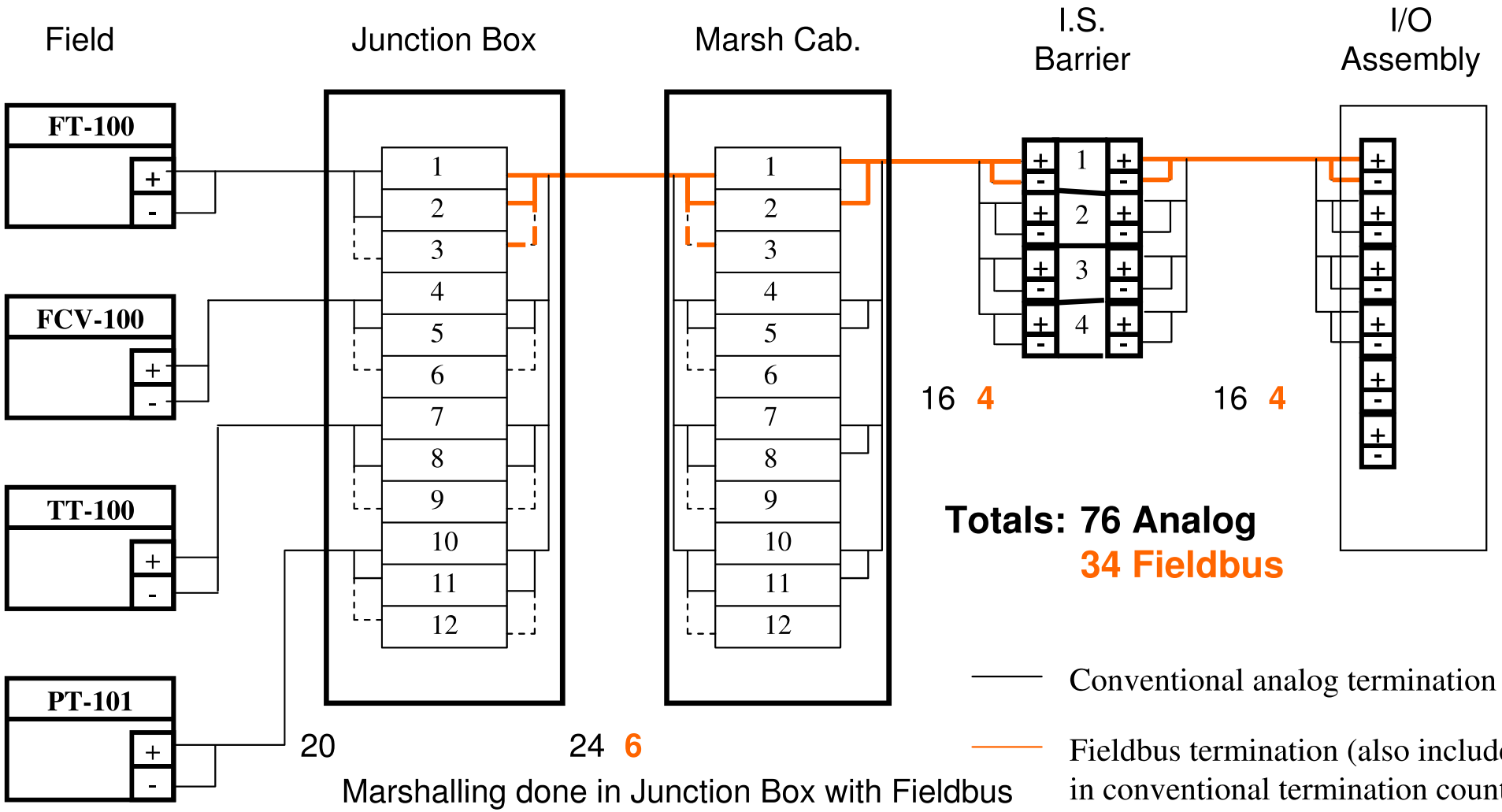
Fieldbus Project Costs

- Estimated Project Savings
  - Materials/Field Devices: Increased +25%
  - Installation Labor: Reduced -50%
  - Commissioning: Reduced -75%
  - Engineering: Reduced -50%

- Overall Capital Savings: **25 – 30%**
  - However savings will only be realized if the project is planned as a fieldbus project

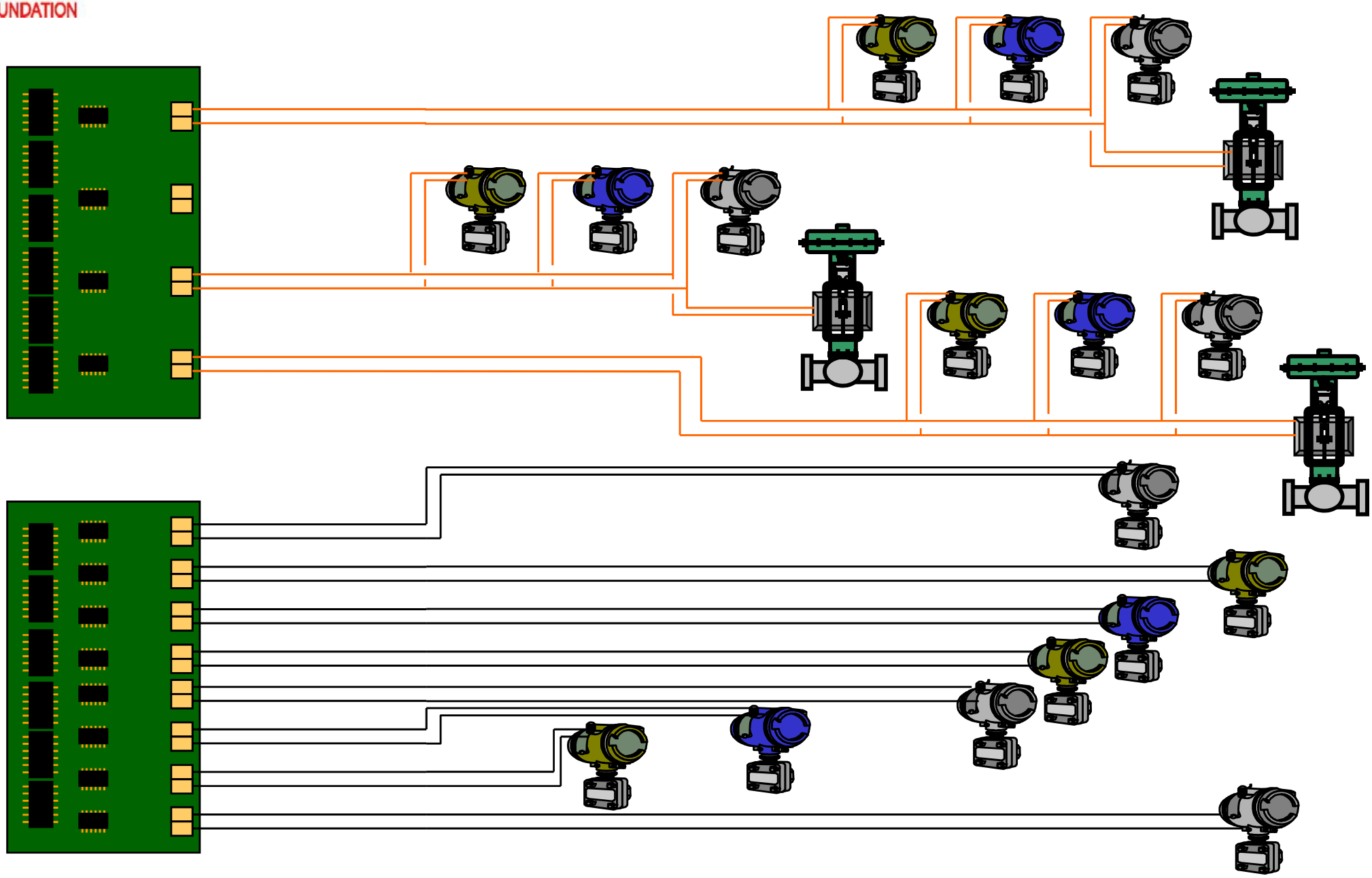
Termination count

- Reduced termination count



Marshalling done in Junction Box with Fieldbus
Therefore Marshalling Cab is optional

I/O Card Savings



Reduced Space Requirements

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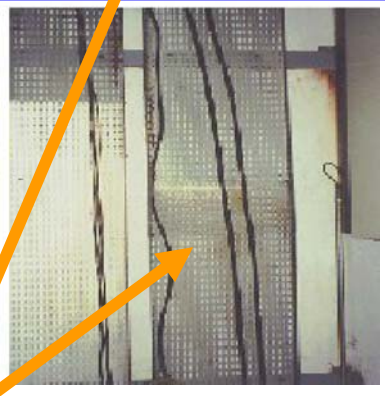
- Wiring & Rack
- Cable cost
- Junction box
- Conduit
- Cable Installation
- Marshalling
- I.S. Barriers

Conventional System

Cabinet

Cable

Fieldbus System



Case of 350 I/O points

Courtesy of Yokogawa Corporation

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Startup Cost Savings

- Commissioning Costs Without fieldbus:

2 hours / device
for 2 technicians

- Individually ring out wiring
- Attach device
- Verify communications
- Verify link to control strategy

Startup Cost Savings

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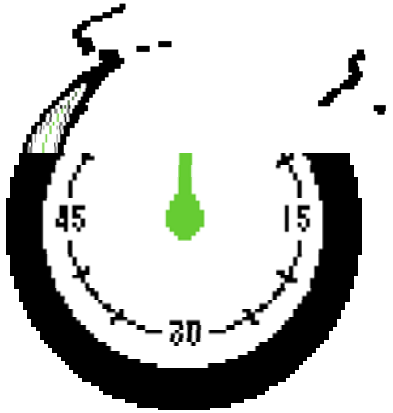
- Commissioning Costs With fieldbus:

25 minutes / device
for 1 technician



- Check segment wiring
- Attach device
- Drag-and-drop commissioning

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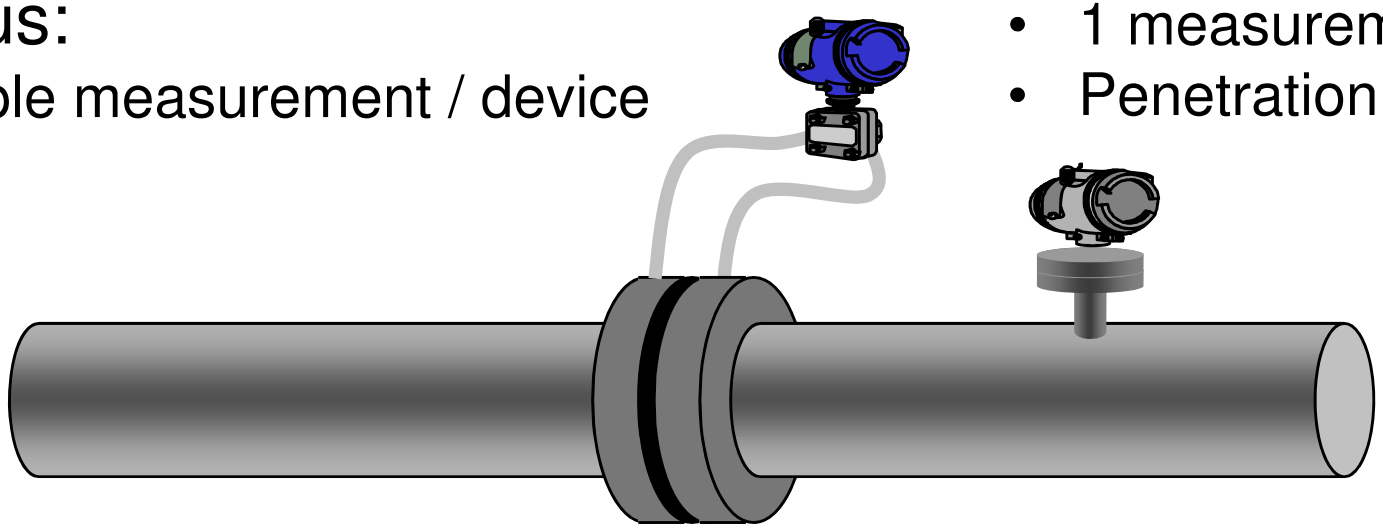
Multivariable Measurements

Fieldbus:
- Multiple measurement / device

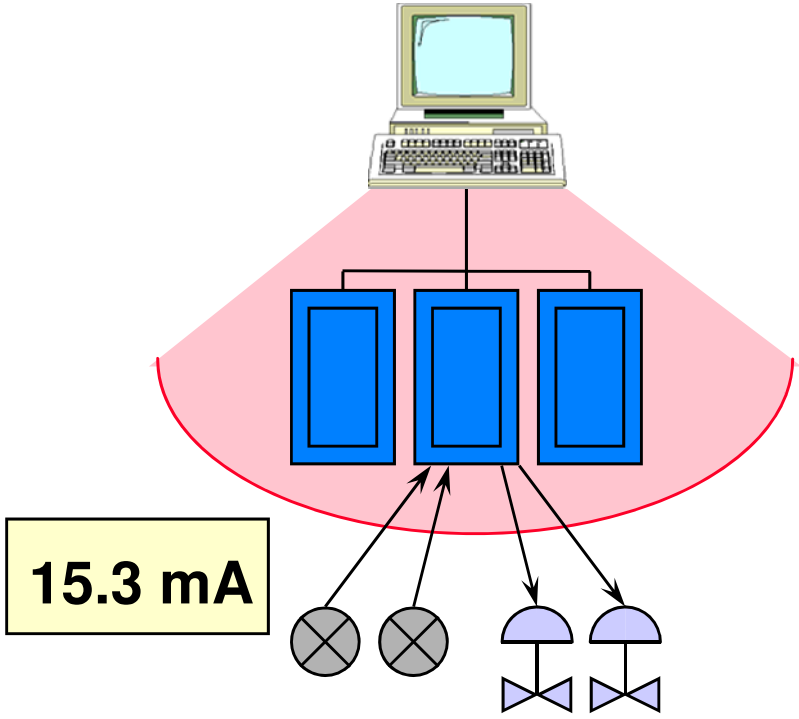
Conventional:
- 1 measurement / device
- Penetration / signal

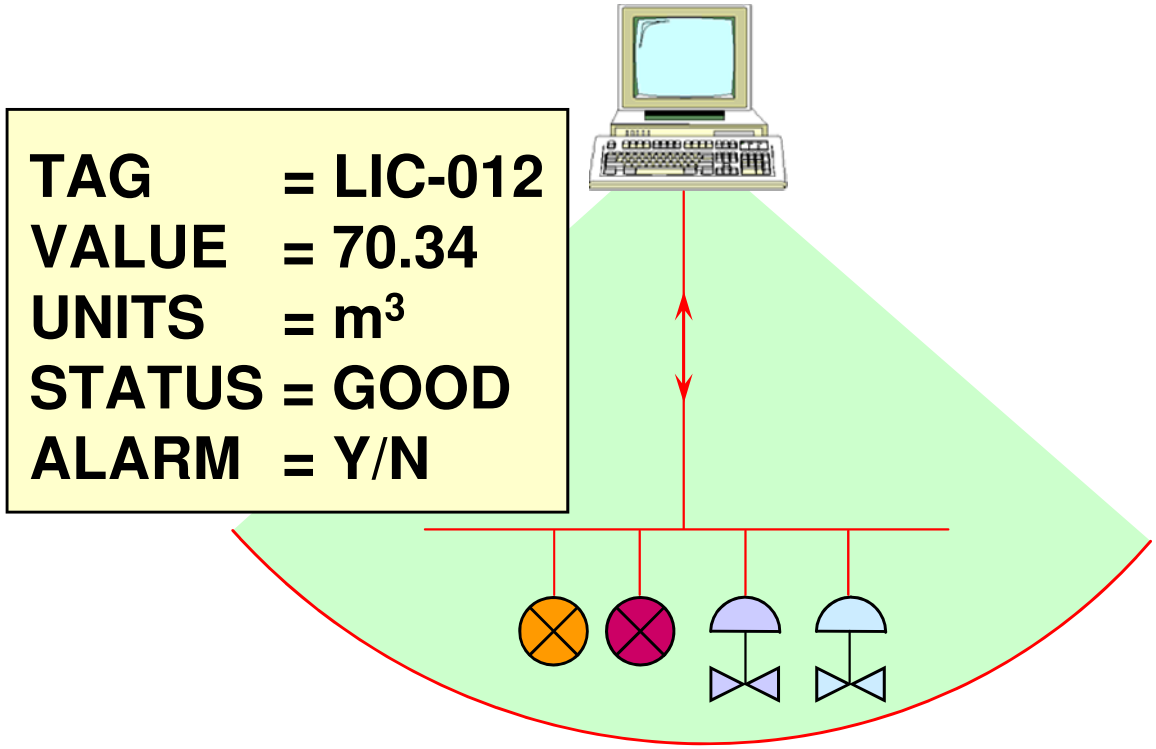


Fieldbus:
- Multiple measurements
  - Pressure
  - Temperature
  - Mass Flow
  - Volumetric Flow

Expanded View

- Expanded device diagnostics



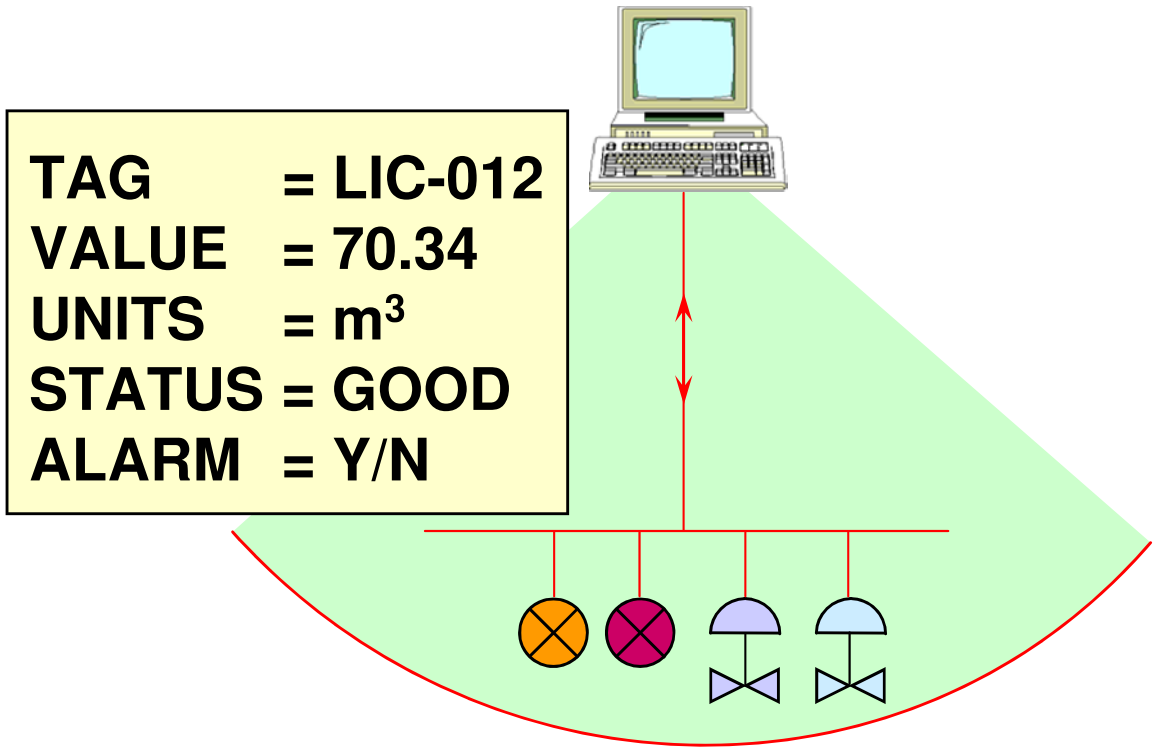


DCS: Limited system view. Does not include diagnostics and other information from field devices.

FCS: Expanded view. Field devices are part of the system.

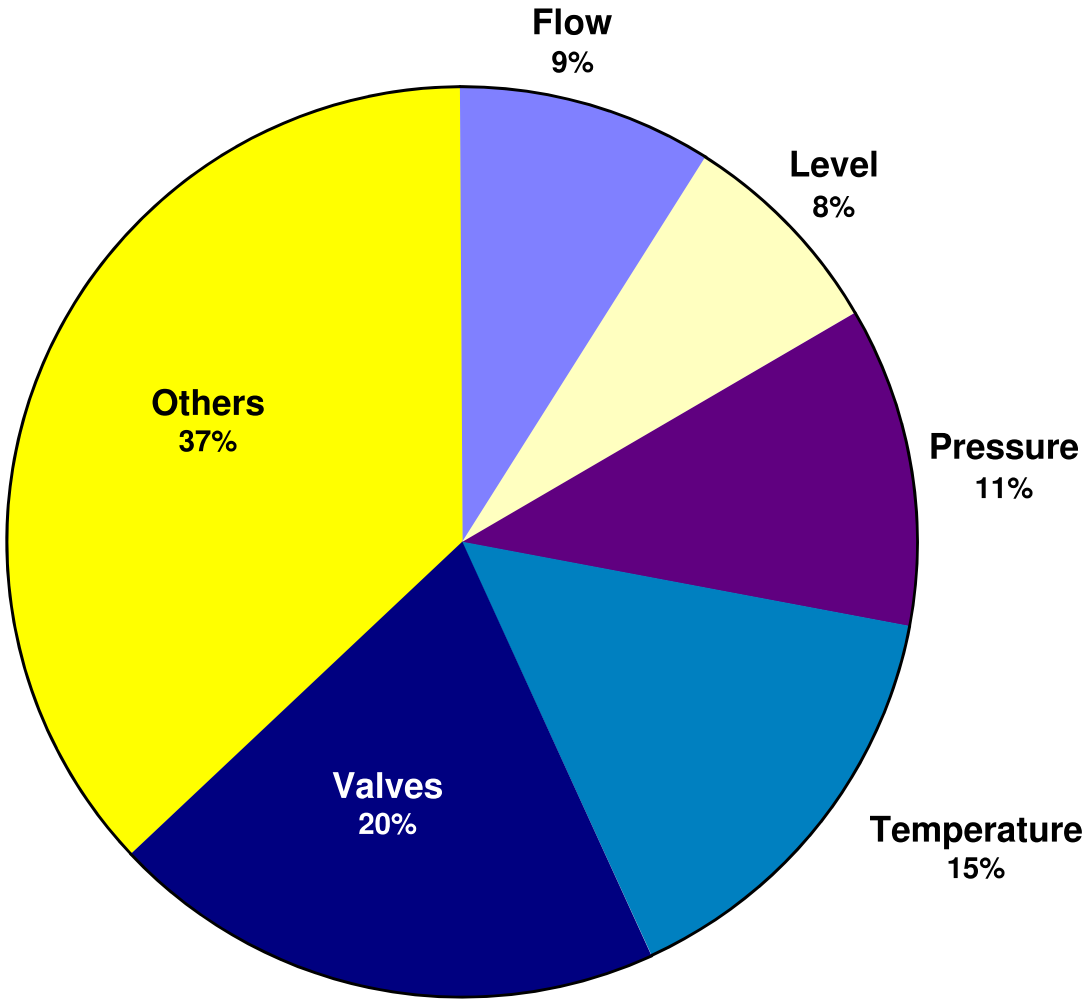
Increased Information

- Analog system
  - PV only
  - 4 - 20 mA has very limited information content
- Fieldbus system
  - Multiple PV's
  - Instrument TAG
  - PV status (health)
  - Ambient conditions
  - Diagnostics
  - Configuration
  - Calibration Record



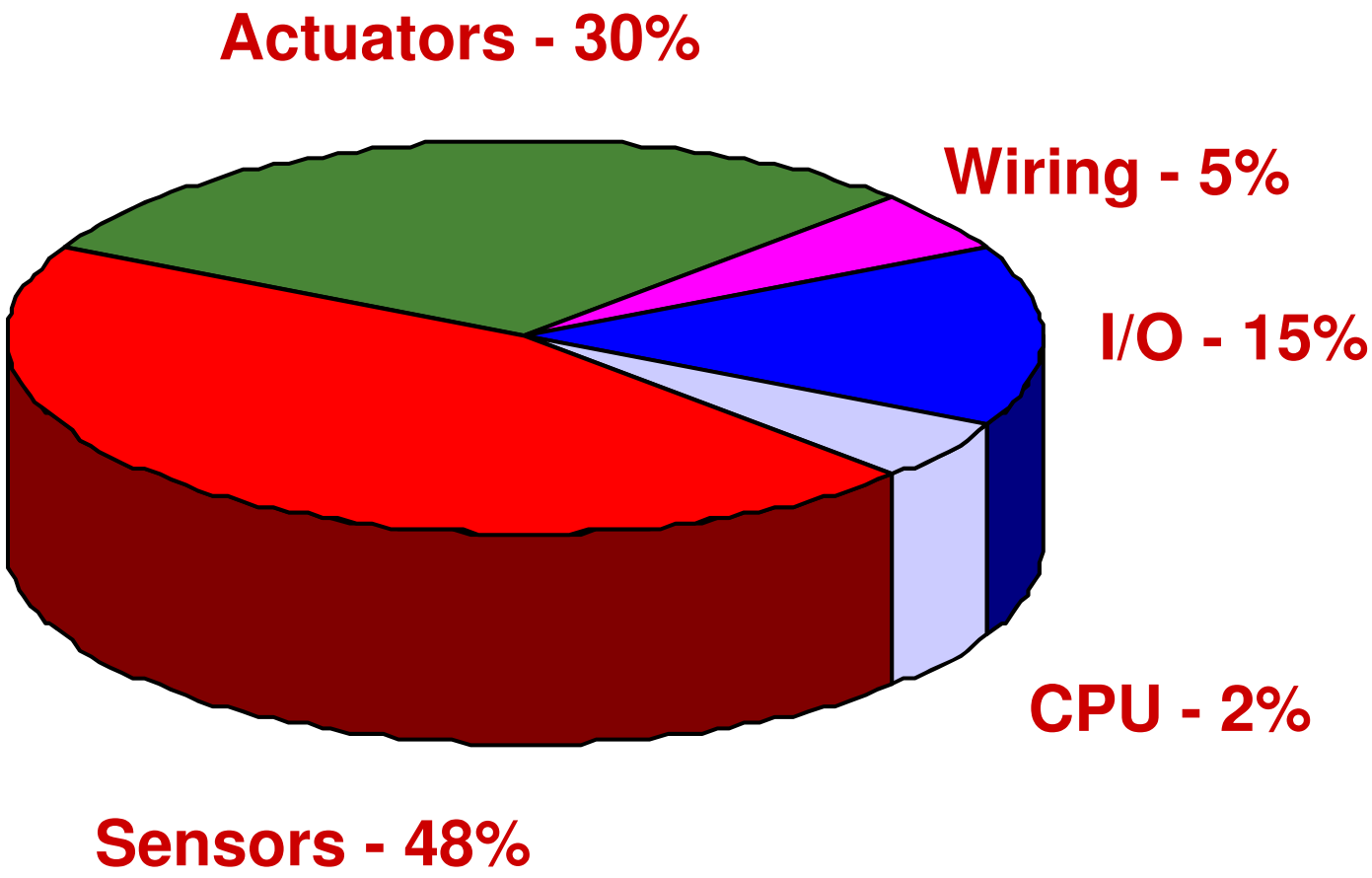
Typical Refinery Instruments Count

- Flow 1100
- Level 950
- Pressure 1400
- Temp. 1900
- Valves 2400
- Others 4600



Areas of failures

- Fieldbus diagnostics give us access to 80% of the failure areas.



Maintenance Savings

- Estimated 10- 20% saving in maintenance
  - Assignment of maintenance tasks to operators / right people to do the task
  - Better field diagnostics
  - Better preventative maintenance data
  - Less false alarms
  - Faster troubleshooting

From ARC Independent Research

Asset Management Benefits

A Yokogawa Commitment to Industry
vigilance™

- Users Need Maintenance Cost Reduction
  - 40% of Mfg. Cost is Maintenance
    - 50% of Maintenance Is Repair
      - 10 times More Costly Than Preventative Maintenance
    - 25% of Maintenance Is Preventative
      - 5 Times More costly Than Predictive Maintenance
      - 60% of Preventative Maintenance is Unnecessary
- Asset Management Tools
  - Identify maintenance waste
  - Create predictive maintenance algorithms

From ARC Independent Research

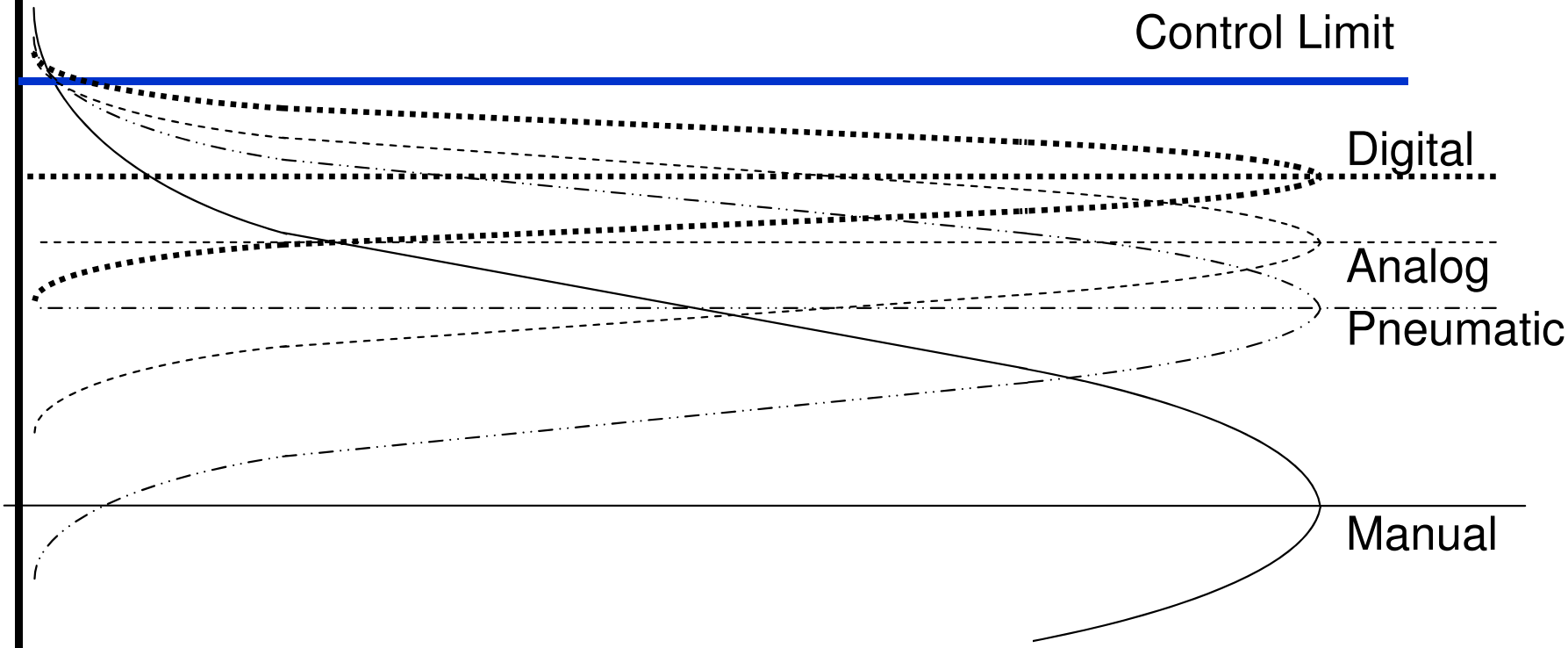
Operational Improvements

- Operational efficiency improved by up to 2%
- Predictive maintenance
  - schedule maintenance based on device diagnostics
  - increase plant availability

- Predictive Maintenance Algorithms
  - Impulse line blockage detection
  - Pump cavitation
  - Heat tracing failure

From ARC Independent Research

Operational Improvements

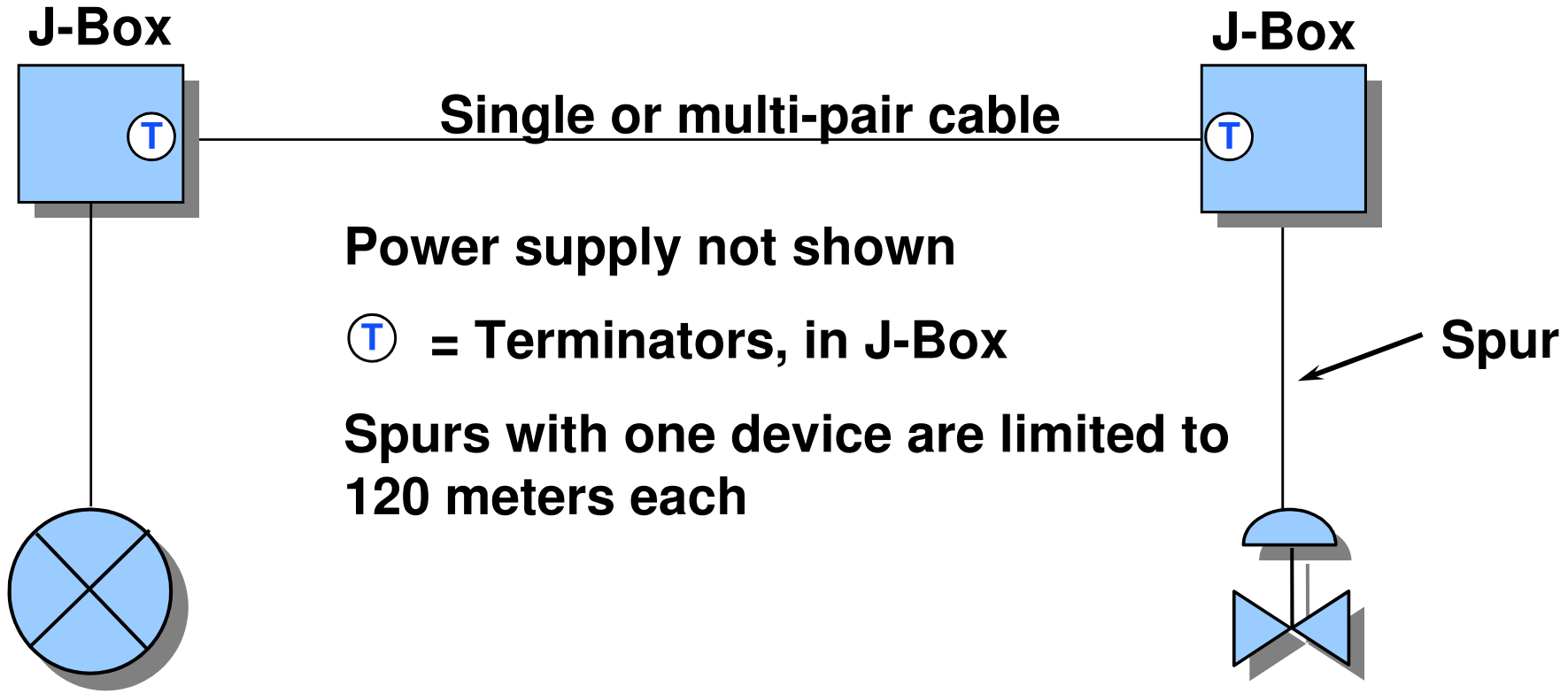


- Tighter Digital Control
  - Controlling closer to ideal set point
    - Better product quality
    - Reduced product cost
    - Increased efficiency
    - Increased safety

Digital
Analog
Pneumatic
Manual

Questions

Wiring Two Devices on a Segment



Fieldbus Waveform