Mark VIe™ NE-DCIS Platform Family

Introducing Networked I/O

- Presenter Joe Wood
- July 26-27, 2006

imagination at work

Mark Family of Controls Evolution

- Mark I Analog Turbine Controls
- Mark II 2nd Generation Analog Turbine Controls
- Mark III 3rd Generation Analog Turbine Controls
- Mark IV Digital Controls
- Mark V 2nd Generation Digital Controls (Structured)
- Mark VI 3rd Generation Digital Controls (Open Architecture)
- Mark VIe 4th Generation Digital Controls (Distributed)

MarkVIe Overview

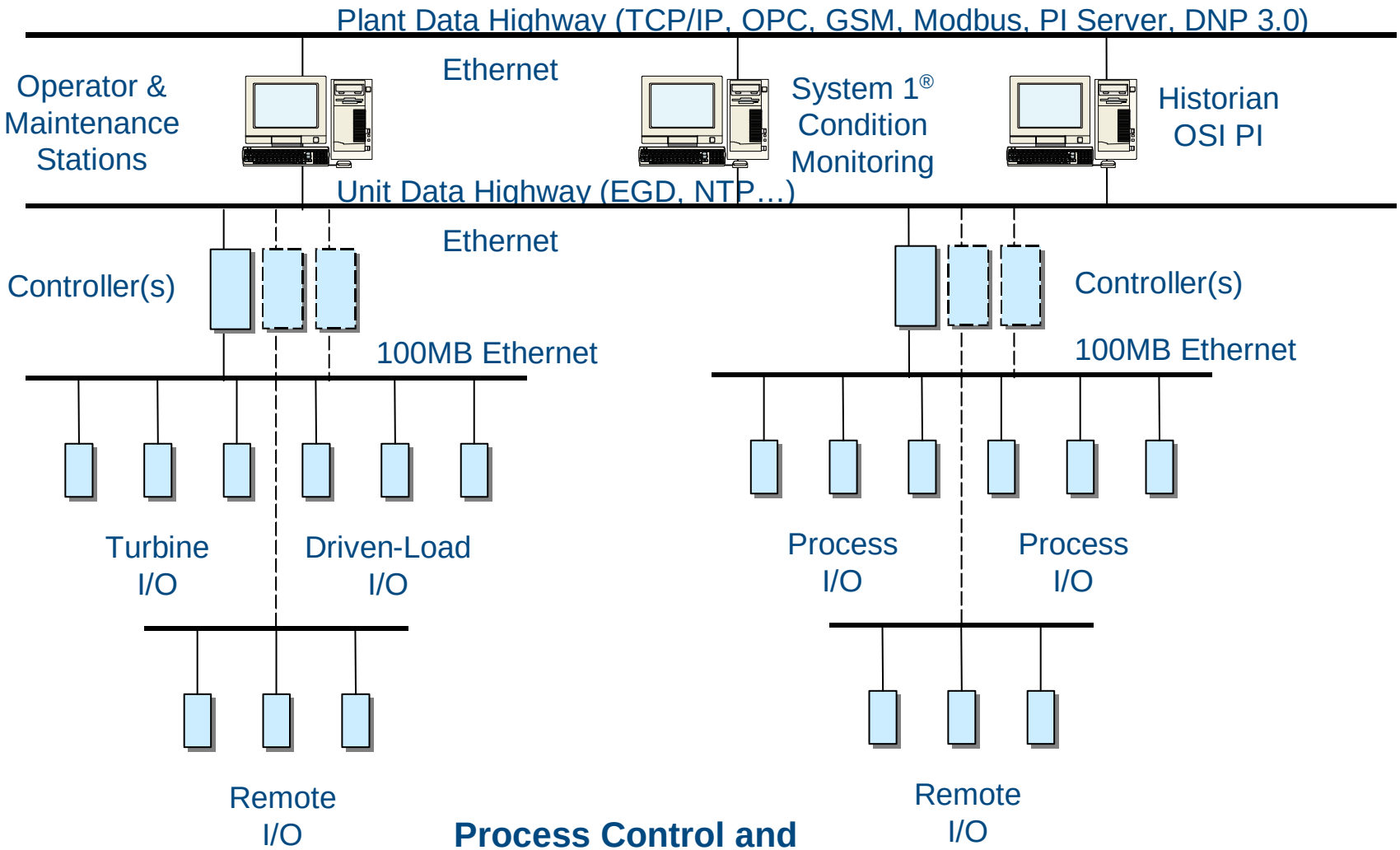
- Flexible Distributed Control Platform
- High Speed Networked I/O for:
  - Simplex
  - Dual
  - Triple Modular Redundant (TMR)
- Industry Standard Ethernet Communications
  - I/O
  - Controllers
  - HMIs
  - Third Party Systems

Architecture

MarkVIe Architecture

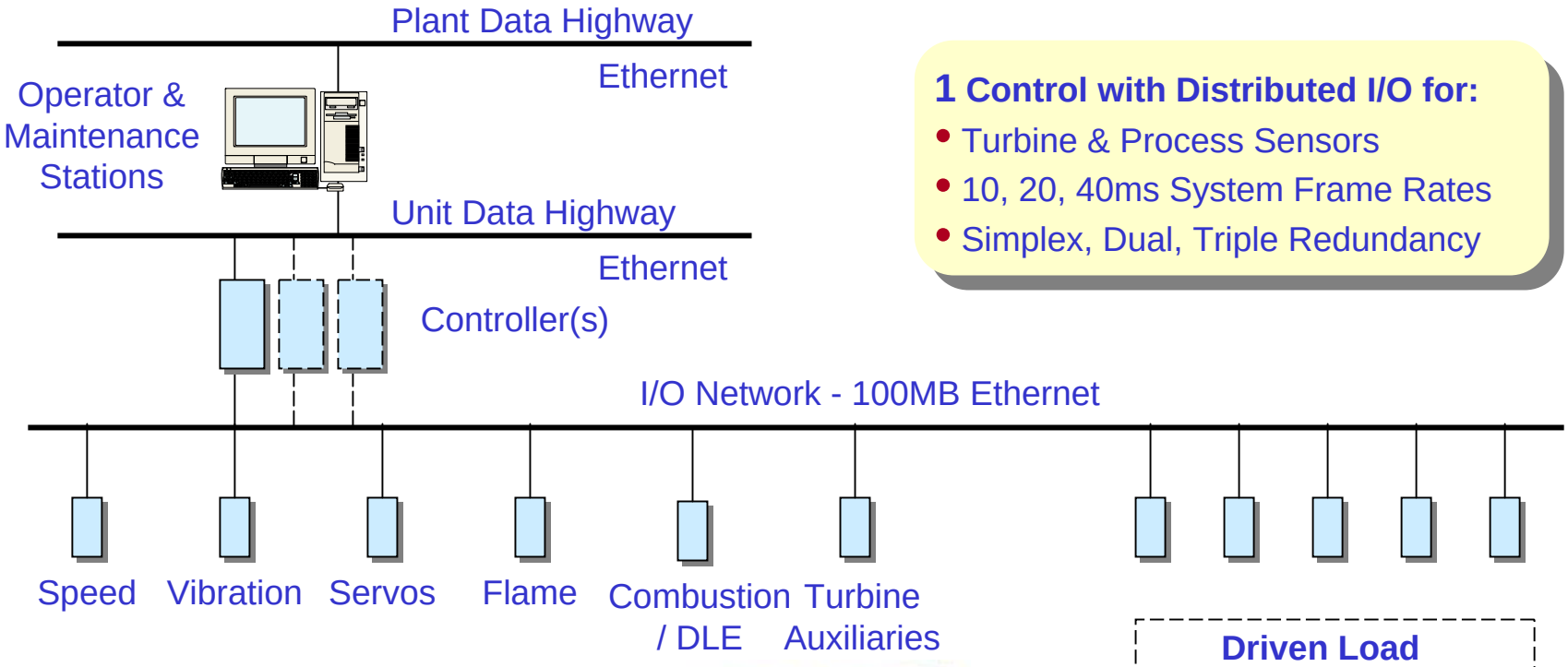
- CompactPCI® (CPCI) Based Controller
- Networked I/O
- QNX Operating System
- Application Software in Non-Volatile Memory
  - Conforms to IEEE- 854, 32 bit floating point
- 100MB Ethernet for Local and Remote I/O
- Distributed I/O
  - Local
  - Remote

Mark VIe Architecture



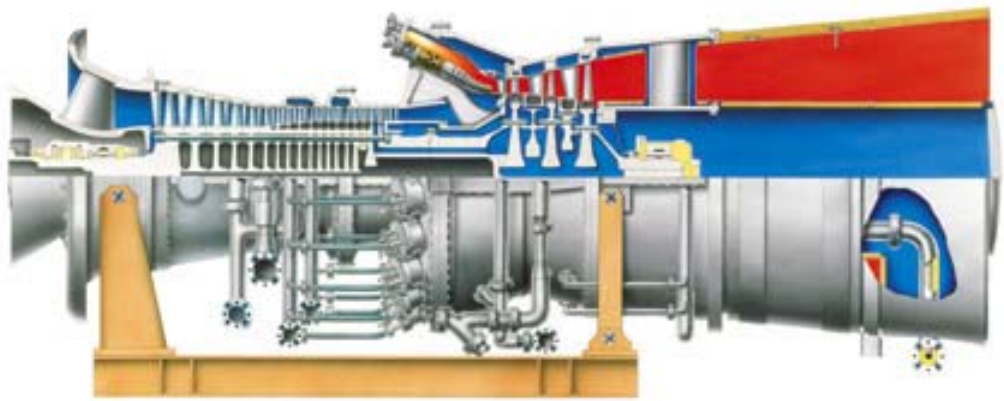
Process Control and Rotating Machinery Control are the same Platform, Tools, & Support

1 Control vs. Integrated Controls



1 Control with Distributed I/O for:

- Turbine & Process Sensors
- 10, 20, 40ms System Frame Rates
- Simplex, Dual, Triple Redundancy



Driven Load

- Generator
- Compressor
- Pump

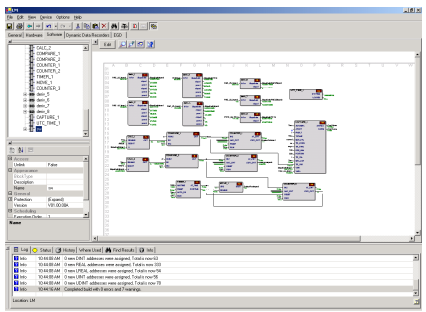
Remaining Process

- Power Island
- Balance of Plant

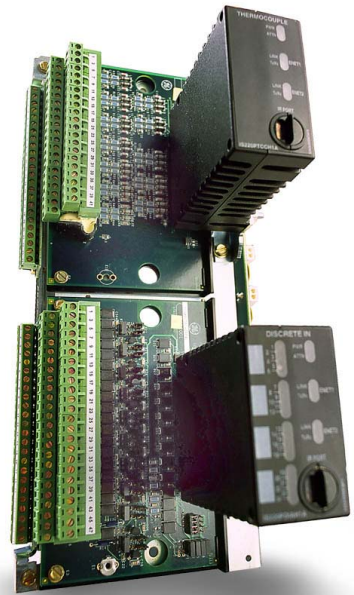
The Building Blocks

The Controllers

The Software



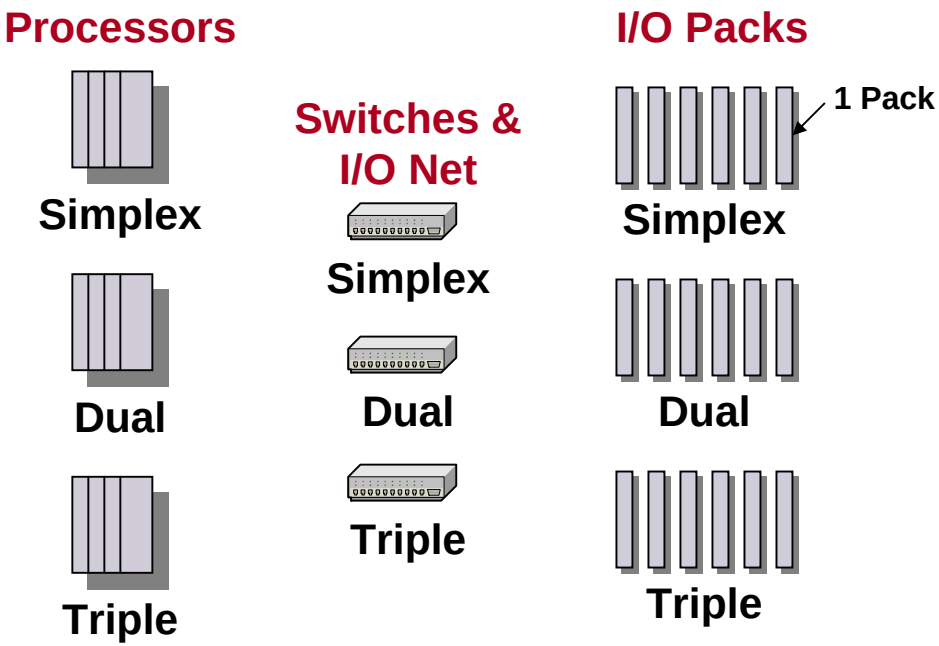
The I/O



The Networks

Flexible Architecture

Mark VI Enhanced



Flexible Redundancy

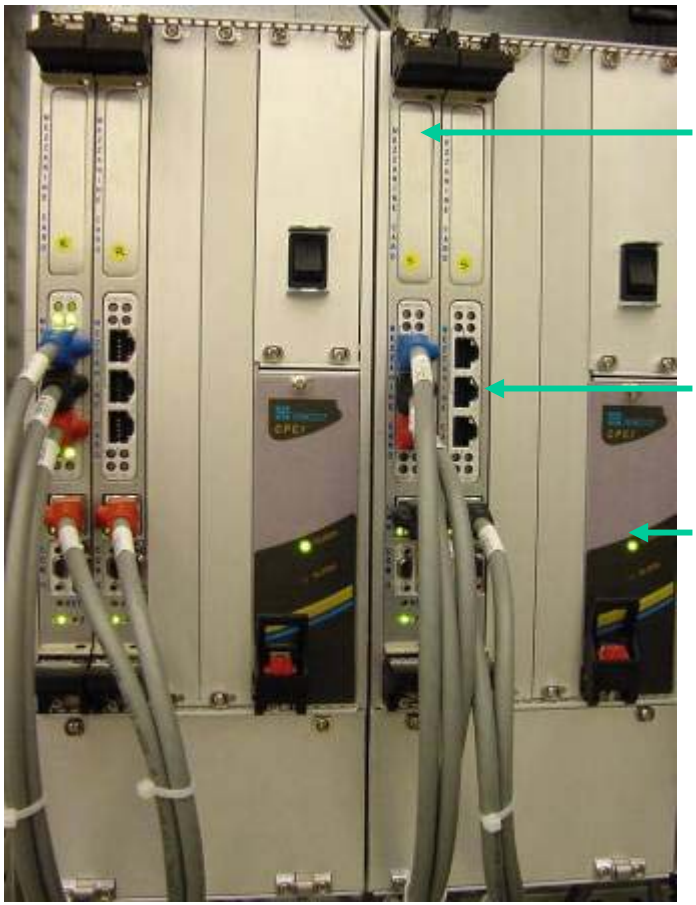
Redundancy
- Dual (Process Runs if Controller Fails)
- Triple (Process Runs if Controller has Partial or Complete Failure)

Distributed / Remote I/O
- Less Installation & Maintenance Cost
- More Flexible Application

On-line Repair / I/O Packs
- Hot Swap in Redundant Systems
- Improved MTTR / Availability

Mark VIe Controller Rack

Redundant Controllers



Main Processor Board
- Compact PCI
- QNX Operating System
- Unit Data Highway, Ethernet
- IONet 100MB Ethernet

Optional Second Processor

Power Supply

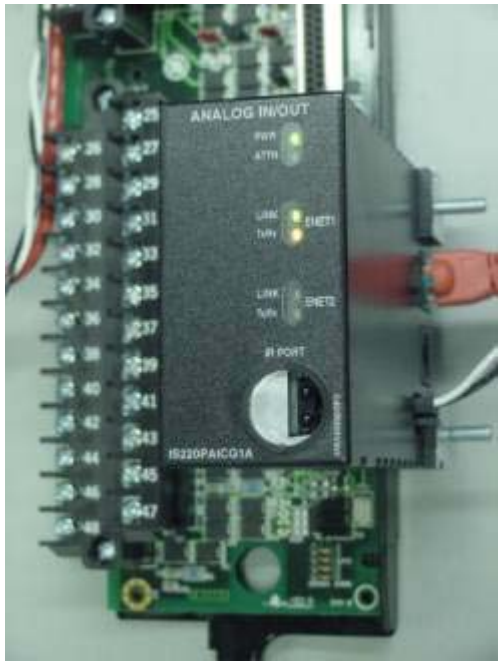
Mark VI Comparison
- Same Control & Protection Strategy
- Same Proven Software Blocks
- Same Maintenance Tools & Diagnostics
- Same QNX Based Operating System

• Processor	650MHz	1.66GHz
• Cache	256k bytes	1M byte
• Ram	128M bytes	256M bytes
• Flash	128M bytes	128M bytes
• Communication	Dual 10/100 Full Duplex Ethernet	
• Power	18 to 32Vdc	

Operation: 0°C to 60°C

NFPA Class 1, Division 2

Mark VIe I/O Packs



- I/O Packs Plug into Mk VI Termination Boards
- Barrier & Box Type TBs

Features

- Dual 100MB Ethernet Ports
- Low I/O Density
- On-line Repair per I/O Block
- Operation -30°C to 65°C
- Accuracy - 30°C to 65°C
- 6W Heat Dissipation / pack (approx.)
- NFPA Class 1, Div 2 with Local Temp Sensor
- Infrared Transceiver for Low Level Diagnostics
  - Monitor I/O Values, Set I/O Pack Host/ Function Names, Error Status
  - Requires Windows Based Diagnostic Tools on Laptop or Handheld PC
  - Ethernet TSM Support

Processor	32 Bit RISC CPU 266MHz
Cache	32k bytes
Ram	32M bytes
Flash	16M bytes
Communication	Dual 10/100 Full Duplex Ethernet
Power	28Vdc

I/O Pack Status LEDs

- Power (PWR): Green
  - Power is present
- Attention (ATTN): Red
  - Off: no fault
  - Solid: critical fault that prevents Pack operation
  - Fast flash: alarm (connected to wrong TB, no TB, SW loading error)
  - Medium flash: Pack is not on line
  - Slow flash: manual request to flash to identify Pack location

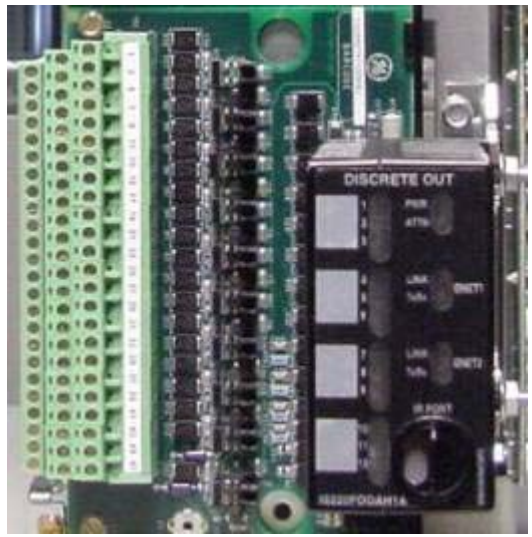
I/O Pack Status LEDs (cont.)

- Link (LINK): Green
  - Ethernet connection is established for IONet (2 per Pack)
- Transmit / Receive (TxRx): Yellow
  - Transmitting or receiving data on IONet (2 per Pack)
- Application Specific LEDs
  - Example: LED for each Contact Input and Relay Output

Terminal Boards

Barrier Terminal Blocks
& 1, 2, or 3 I/O Packs

Box Type Terminal Blocks
1 I/O Pack, but Dual Networks

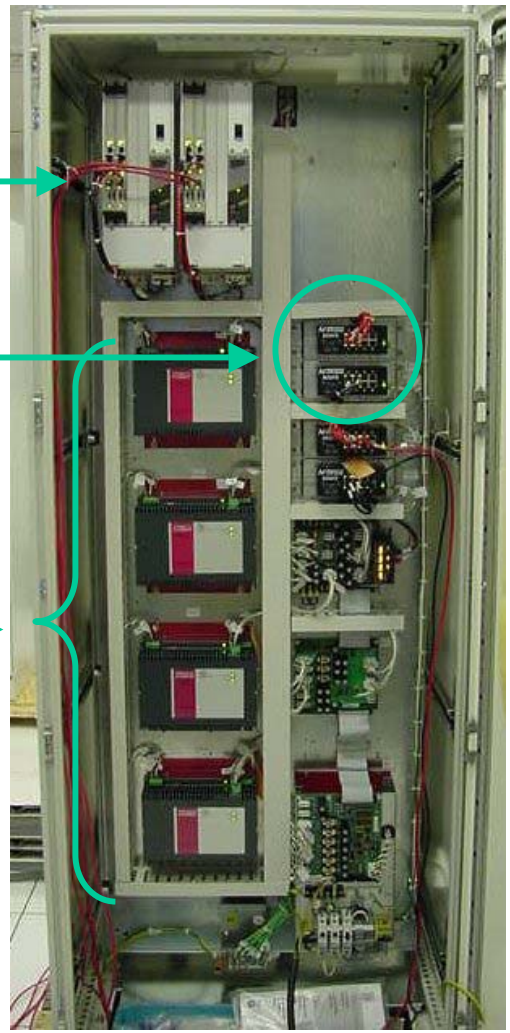


- Barrier Type
  - Derived from Mark VI
  - Full Set of Functionality
  - Simplex, Dual, Triple Redundant
- Box Type
  - Subset of Barrier Type Functionality
  - Simplex or Dual Redundant
- New I/O Types vs. Mark VI (Ex: Solid-State Relays)
  - New I/O Types Backwardly Compatible to Mark VI

Dual Redundant DCS Cabinets

Front View

Back View



Controllers

IONet Switches

Power Supplies

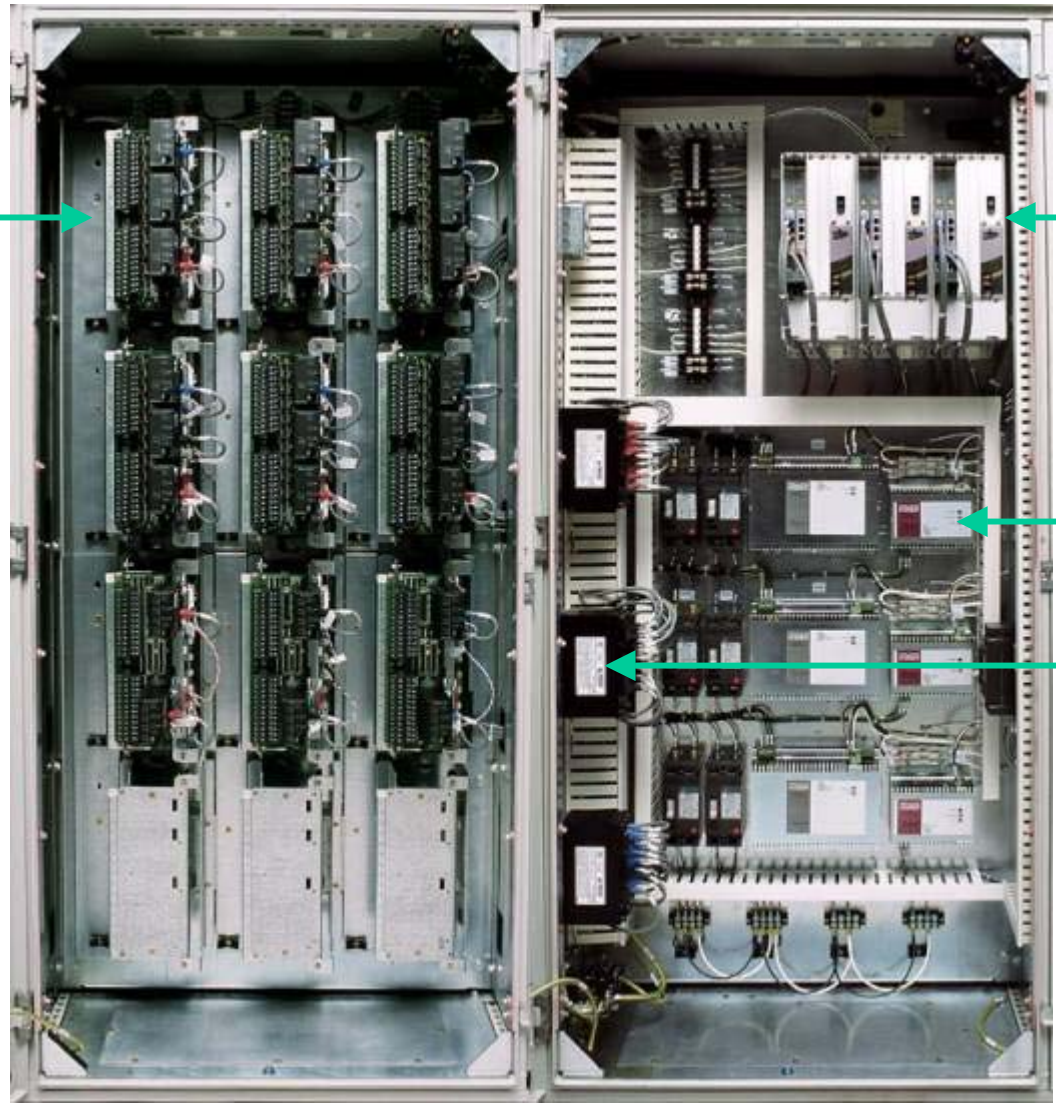
Power Distribution

IONet Switches

I/O Blocks

Triple Redundant Nuclear BOP Cabinets

<u>Field Wiring</u>
- Vertical Channels
- Top & Bottom Cabinet Access
- Barrier Blocks
- Pluggable
- (2) 3.0mm^2 (#12AWG) wires/pt



Controllers

Power Supplies

IONet Switches

I/O Types

- **Process Control**
- **Rotating Machinery** (servos, vibration, etc.)

Process Control I/O - Discrete

Discrete I/O Types - General Purpose	Board	Redundancy Packs/Board
24 DI (125Vdc, group isolated) 1ms SOE	TBCIH1	1 or 2 or 3
24 DI (24Vdc, group isolated) 1ms SOE	TBCIH2	1 or 2 or 3
24 DI (48Vdc, group isolated) 1ms SOE	TBCIH3	1 or 2 or 3
24 DI (115/230Vac, 125Vdc, point isolated) 1ms SOE on 125Vdc	TICIH1	1 or 2 or 3
24 DI (24Vdc, point isolated) 1ms SOE	TICIH2	1 or 2 or 3
24 DI (24Vdc, group isolated) 1ms SOE	STCIH1	1
24 DI (48Vdc, group isolated) 1ms SOE	STCIH4	1
24 DI (125Vdc, group isolated) 1ms SOE	STCIH6	1
12 "C" mech. relays w/6 solenoids, coil diagn. (115/230Vac, 24/125Vdc)	TRLYH1B	1 or 3
12 "C" mech. relays w/6 solenoids, voltage diagn. (115/230Vac, 125Vdc)	TRLYH1C	1 or 3
12 "C" mech. relays w/6 solenoids, voltage diagn. (24Vdc)	TRLYH2C	
6 "A" mech. relays for solenoids, solenoid impedance diagn. (24/125Vdc)	TRLYH1D	1 or 3
12 "A" solid-state relays/inputs (115/230Vac)	TRLYH1E	1 or 3
12 "A" solid-state relays/inputs (125Vdc)	TRLYH2E	1 or 3
12 "A" solid-state relays/inputs (24Vdc)	TRLYH3E	1 or 3
36 mech. relays, 12 voted form "A" outputs	TRLYH1F	3
12 fused branches	WPDFH1A	
36 mech. relays, 12 voted form "B" outputs	TRLYH2F	3
12 fused branches	WPDFH3A	
12 "C" mech. Relays	SRLY	1
6 solenoid circuits	WROB	
12 relay fuses	WROF	
12 field power outputs	WROG	

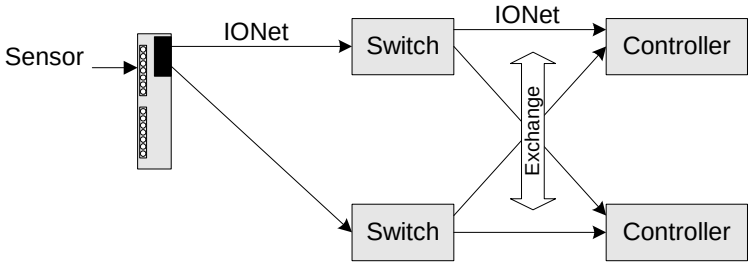
Process Control I/O – Analog & Communications

Analog I/O & Communications - General Purpose	Board	Redundancy Packs/Board
10AI (V/I inputs) & 2AO (4-20/0-200ma outputs)	TBAIH1C	1 or 2 or 3
10AI (V/I inputs) & 2AO (4-20/0-200ma outputs)	STAIH1A	1
16 AO (4-20ma outputs) 8 per I/O Pack	TBAOH1C	1 or 2
8 AO (4-20ma outputs)	STAOH1A	1
12 Thermocouples	TBTCH1B	1 or 2 or 3
24 Thermocouples (12 per I/O Pack)	TBTCH1C	1 or 2
12 Thermocouples	STTCH1A	1
16 RTDs 3 wires /RTD (8 per I/O Pack)	TRTDH1C	1 or 2
8 RTDs 3 wires /RTD	SRTDH1A	1
4 Pulse Rate Inputs	STURH3A	1
I/O Communications		
6 Serial ports for I/O drivers RS232, RS422, RS485	PSCAH1A	1
HART® Communications: 10/2 Analog I/O	SHRAH1A	1
PROFIBUS-DP Communications	SPIDH1A	1

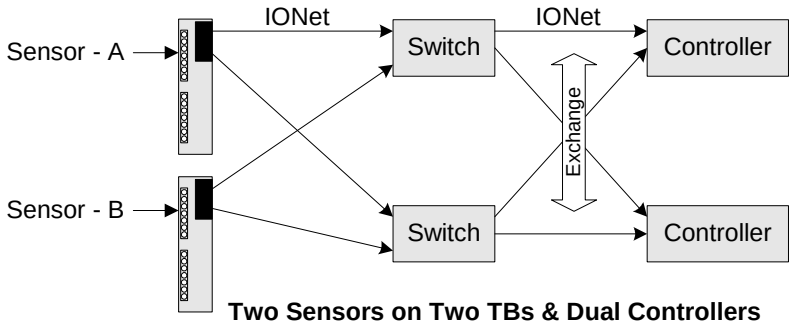
Specifications

- Operation: -30°C to +65°C
- Accuracy: -30°C to +65°C
- I/O Filtering in Firmware

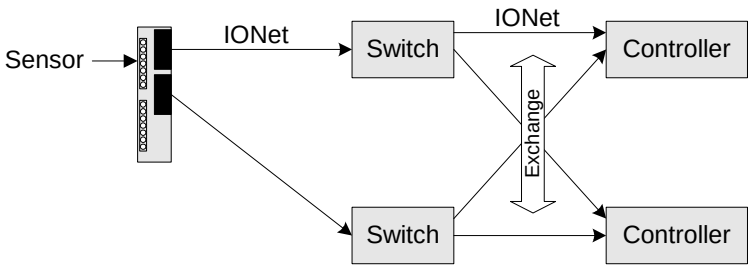
Dual Redundant Input Options



Single Sensor & Dual Controllers

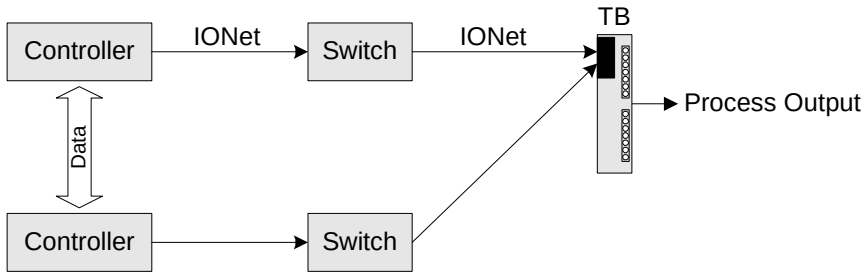


Two Sensors on Two TBs & Dual Controllers

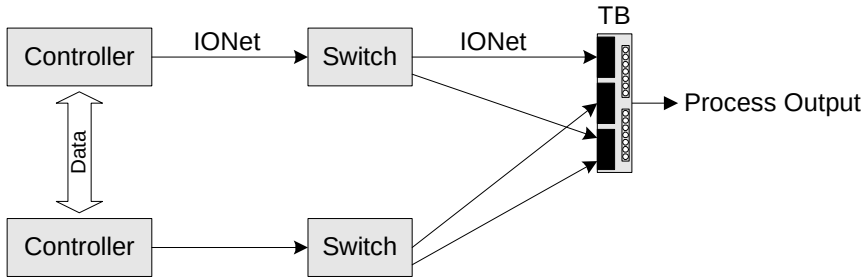


Single Sensor with Two I/O Packs & Dual Controllers

Dual Redundant Output Options

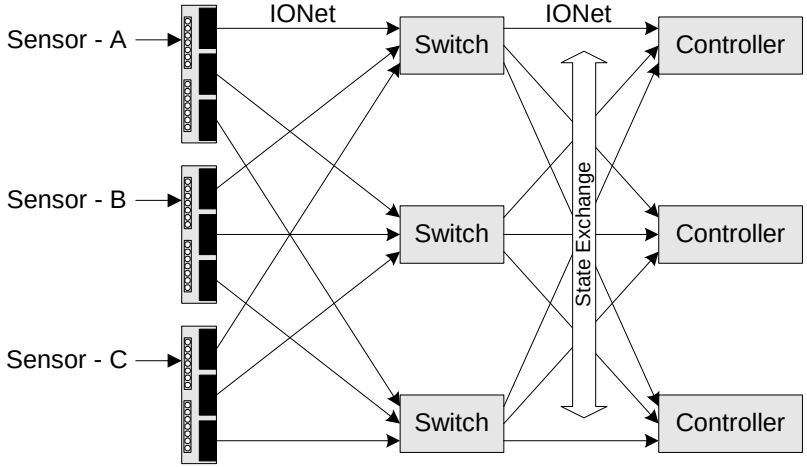


Dual Outputs to a Single I/O Pack

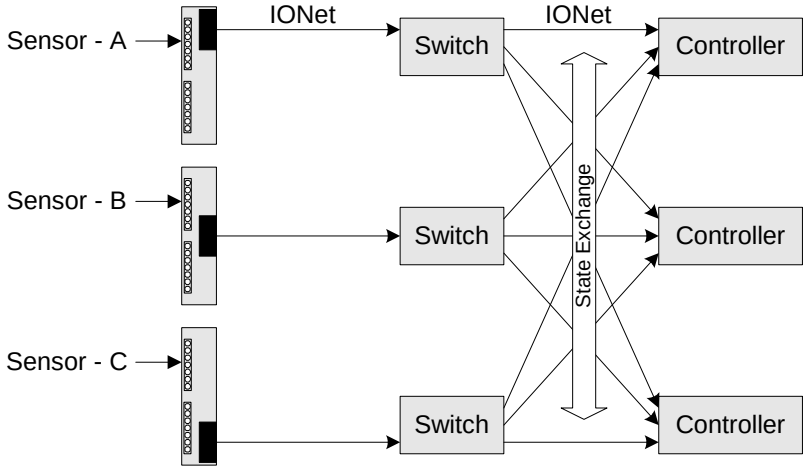


Dual Outputs to Three I/O Packs

Triple Redundant Input Options

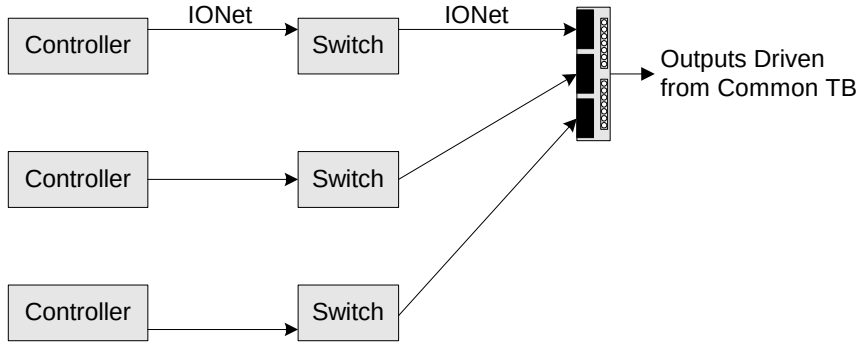


Fanned Inputs to Three Controllers

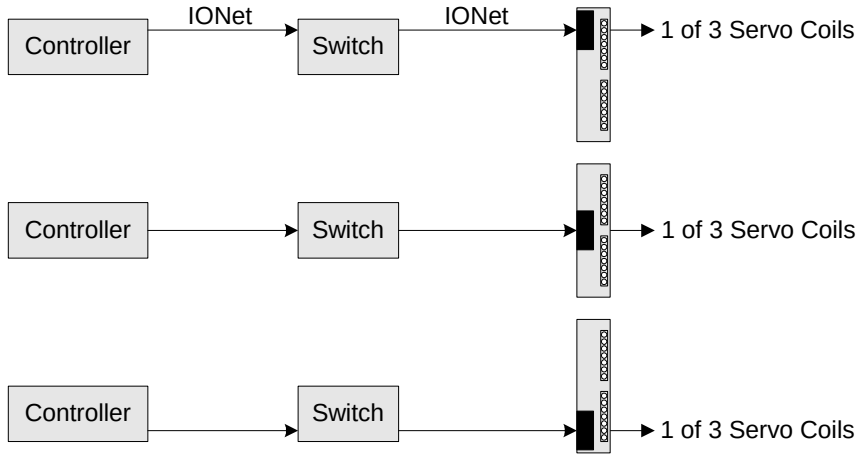


Non-Fanned Inputs to Three Controllers

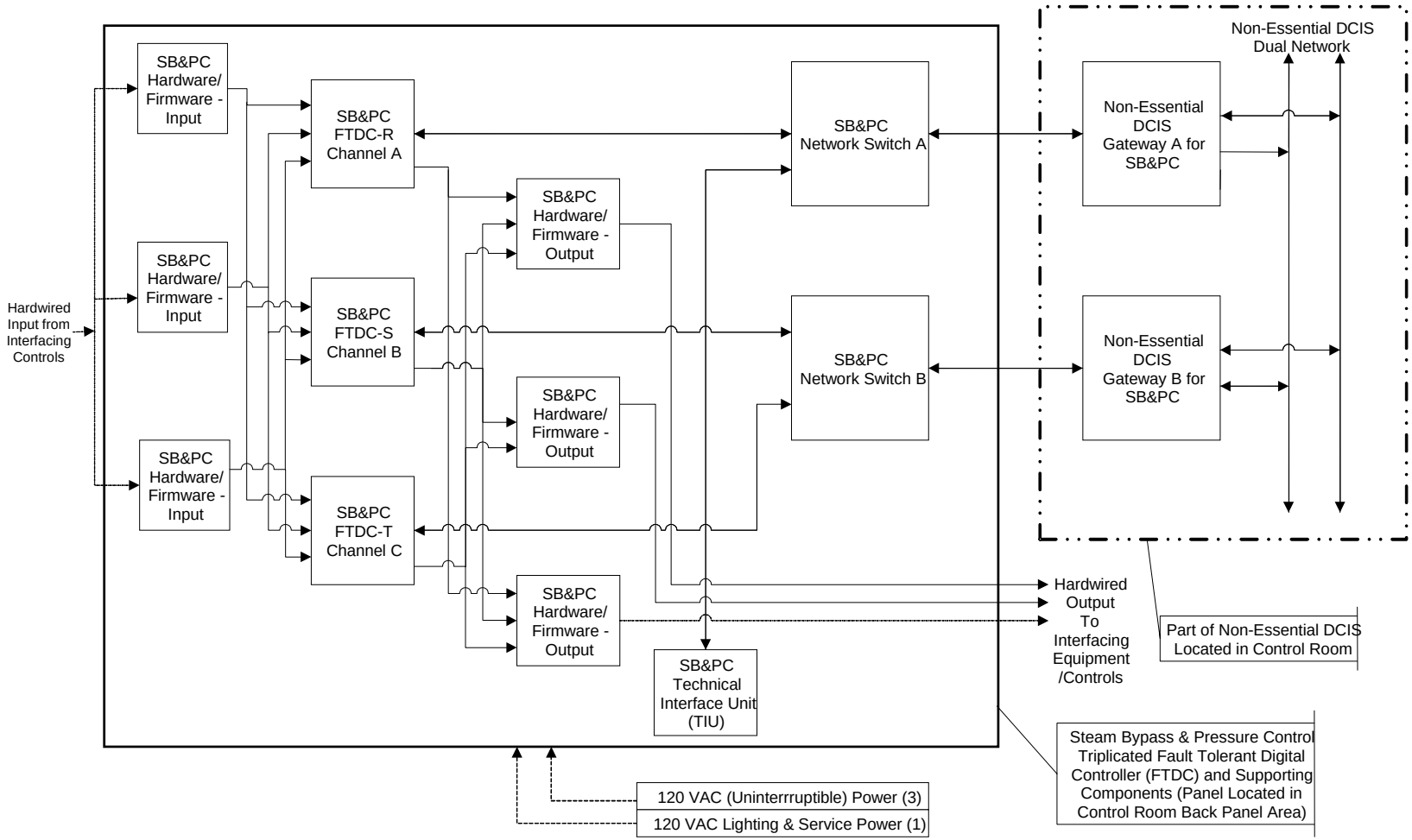
Triple Redundant Output Options



Voting at Termination Board



Extended Voting at Field Device (3 Coil Servo Valve Actuator)


Non-Essential DCIS
Dual Network
SB&PC
Hardware/
Firmware -
Input
SB&PC
Hardware/
Firmware -
Input
SB&PC
Hardware/
Firmware -
Input
Hardwired
Input from
Interfacing
Controls
SB&PC
FTDC-R
Channel A
SB&PC
FTDC-S
Channel B
SB&PC
FTDC-T
Channel C
SB&PC
Hardware/
Firmware -
Output
SB&PC
Hardware/
Firmware -
Output
SB&PC
Hardware/
Firmware -
Output
SB&PC
Network Switch A
SB&PC
Network Switch B
Non-Essential
DCIS
Gateway A for
SB&PC
Non-Essential
DCIS
Gateway B for
SB&PC
Hardwired
Output
To
Interfacing
Equipment
/Controls
SB&PC
Technical
Interface Unit
(TIU)
Part of Non-Essential DCIS
Located in Control Room
Steam Bypass & Pressure Control
Triplicated Fault Tolerant Digital
Controller (FTDC) and Supporting
Components (Panel Located in
Control Room Back Panel Area)
120 VAC (Uninterrruptible) Power (3)
120 VAC Lighting & Service Power (1)

IONet

IONet Switches

Switch Types

- N-TRON 500 Series
- 508TX – 8 10/100 BaseTX RJ-45 Ports
- 516TX – 16 10/100 BaseTX RJ-45 Ports
- 509FX – 8 10/100 BaseTX RJ-45 Ports
  1 100 BaseFX Fiber Port
- 517FX – 16 10/100 BaseTX RJ-45 Ports
  1 100 BaseFX Fiber Port
- 508FX2M – 6 10/100 BaseTX RJ-45 Ports
  2 100 BaseFX Fiber Port

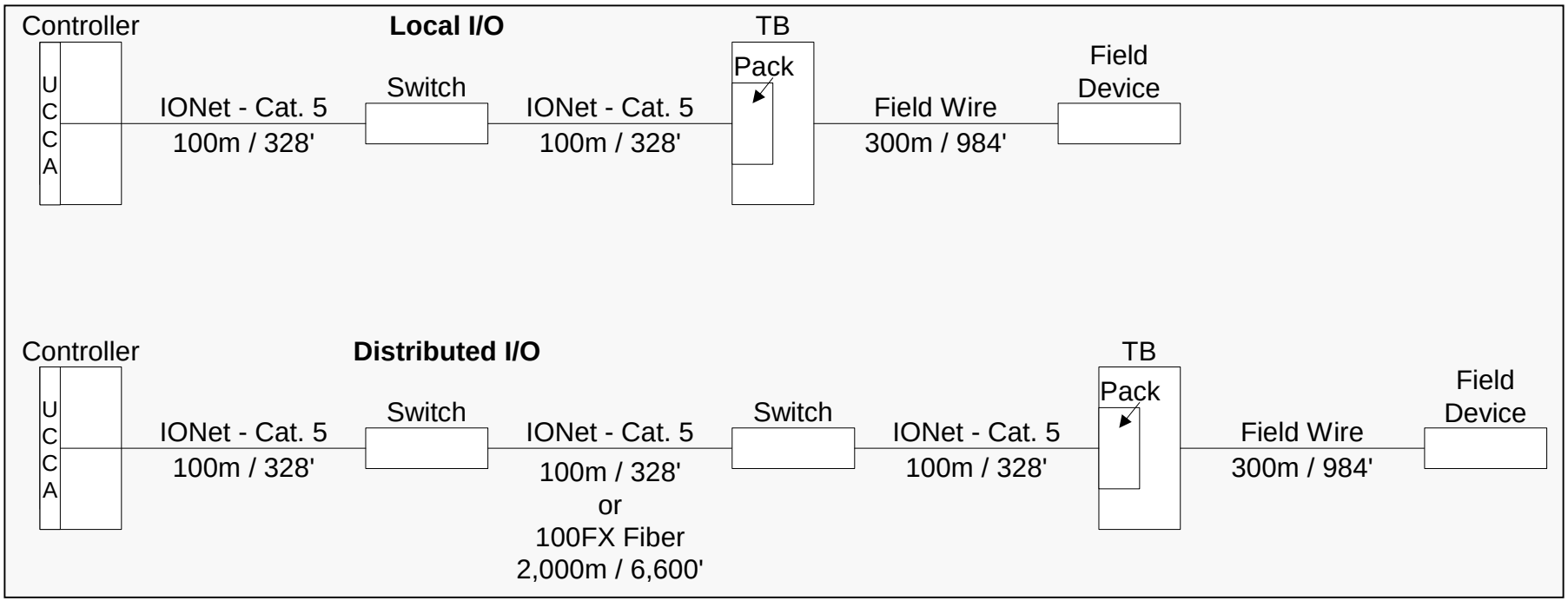
Features

- Operating Temp: -40 to 85C
- Operating Humidity: 10 to 95% Non-Condensing
- Shock: 200g @ 10ms
- Vibration / Seismic: 50g, 5-200Hz, Tri-axial
- MTBF: > 2M hours
- Auto-sensing 10/100 Base TX, Duplex, and MDIX
- Up to 2.6Gb/s, High Speed Backplane
- Steel Enclosure, Prevents EFI and RFI
- DIN-Rail or Rack Mounted
- Redundant Power Inputs 10-30Vdc,
  - 200ma (w/o fiber) 400ma (w fiber) at 24Vdc
- Bi-color LED's for Link, Speed, Activity, and Duplex Status

Emissions and Safety Approvals

- FCC Part 15 Class A
- UL Listed (US & Canada)
- Class 1, Div 2, Groups A, B, C, D, T4A
- CE: EN55011, EN61000-6-2 and –6-4
- EN61000-4-2,3,4,5,6,11, EN61010-1 Class III, Pollution Degree 2

IONet Specifications



	100Base TX	100Base FX
IEEE Specification	802.3u	802.3u
Wire Speed	100Mbps	100Mbps
Cable Type	UTP Cat. 5	Fiber (multi-mode) *
Connector Type	RJ-45	SC
Max I/O Packs / Network	199	199
Topology	Star	Star
Time Synch Protocol	PTP	PTP per IEEE-1588
Distance	100m	2 km

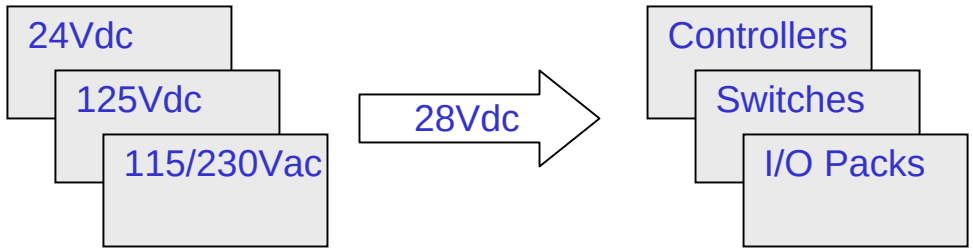
* single-mode: 15km, 40km, 80km

POWER

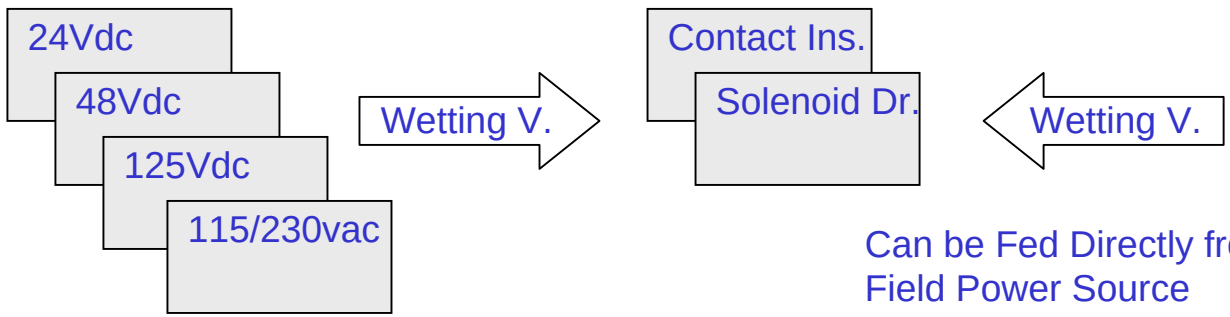
Power Sources, Converters, Supplies

Internal Power Converters
Create 28Vdc for:
- Compact PCI® Controller(s)
- IONet Switches
- I/O Packs

Field Power Sources
- 1 Source
- 2 Sources
- 3 Sources



Field Power Sources
- 1 Source
- 2 Sources
- 3 Sources



Can be Fed Directly from Field Power Source

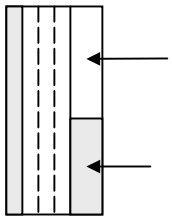
Power Sources and Supplies (cont.)

Incoming Power Sources

- 24Vdc
- 125Vdc
- 115/230Vac
- Any Redundant Combination

Controller Power Supplies

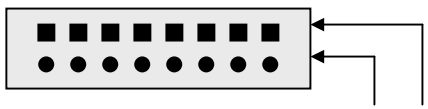
Controller



Second Power Supply

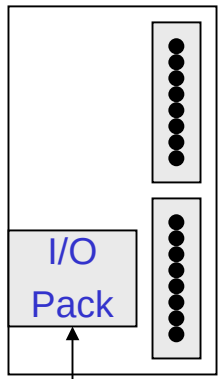
Power Supply 175W
Typically: 24Vdc or
115/230Vac

Switches



(2) Supply Inputs
10-30Vdc, 260ma @ 24V
Industrial Grade

Termination Boards



- Power requirements vary according to the application needs. Example: 125Vdc field solenoids
- Most power for transducers comes “through” the I/O Packs, is current limited per point, and fed to the transducers.

I/O Packs

- Single 16-32Vdc from Local Supply
- Exception: Servo I/O Pack is 26-32Vdc
- Local Supply(s): 24Vdc, 115/230Vac, 125Vdc
- Hot-swap with Solid-state Breaker & Soft-start

Power Options

- Power “Source” Voltage Local & Remote
- Power “Source” Voltage Redundancy
- Redundant Power “Supplies”
  - Local: Controller & Local Switches
  - Remote: I/O Packs & Remote Switches
- UPS Options for Control & Operator Stations

ToolboxST™

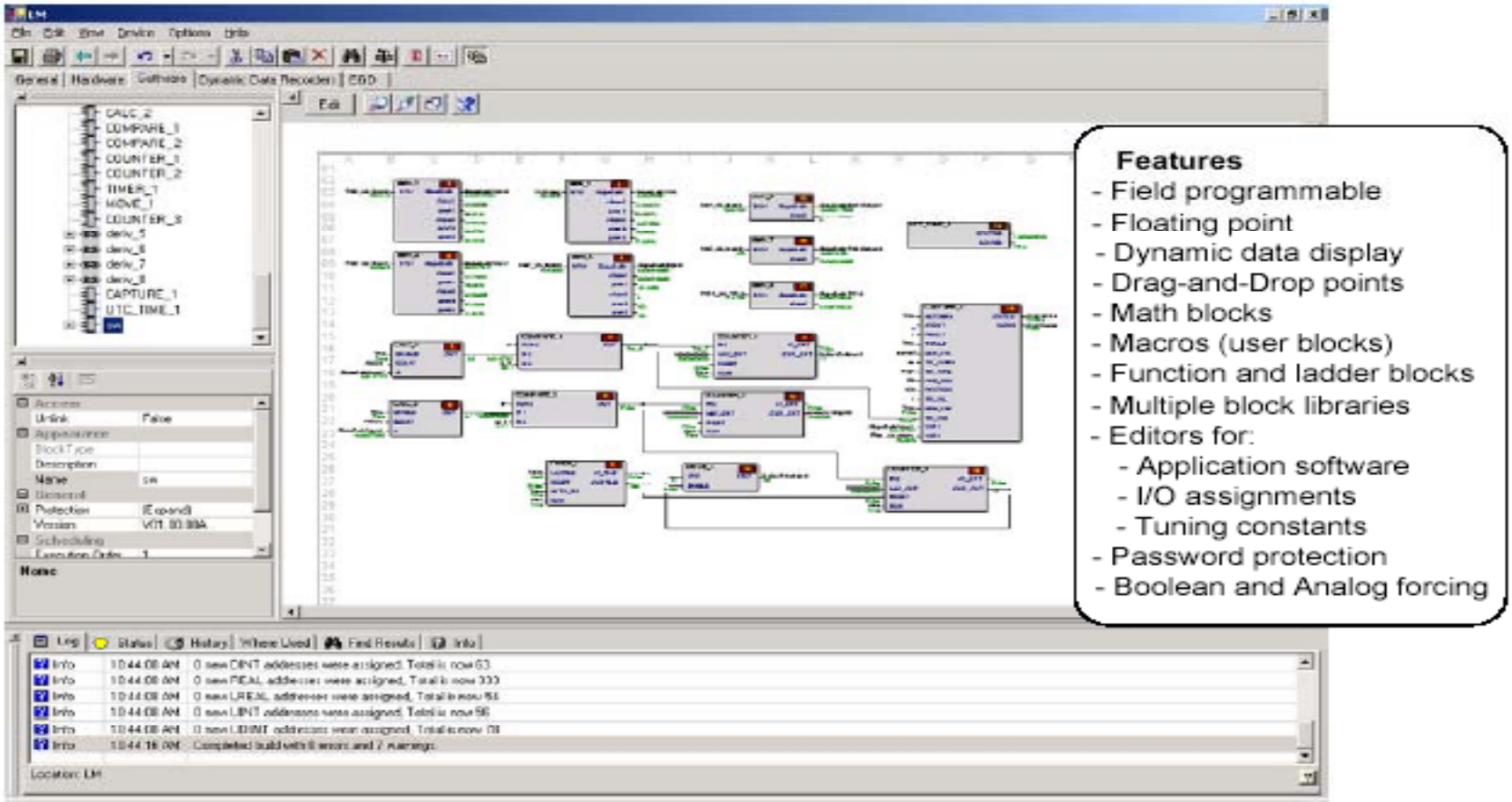
ToolboxST

- Fully Programmable
- Maintained by Factory Software Automation Tools
- Proven GE control and protection algorithms
- Multiple Block Libraries Provided with:
  - General Purpose Blocks
  - Math Blocks
  - Macros (User Blocks)
  - Application Specific Blocks

ToolboxST (cont.)

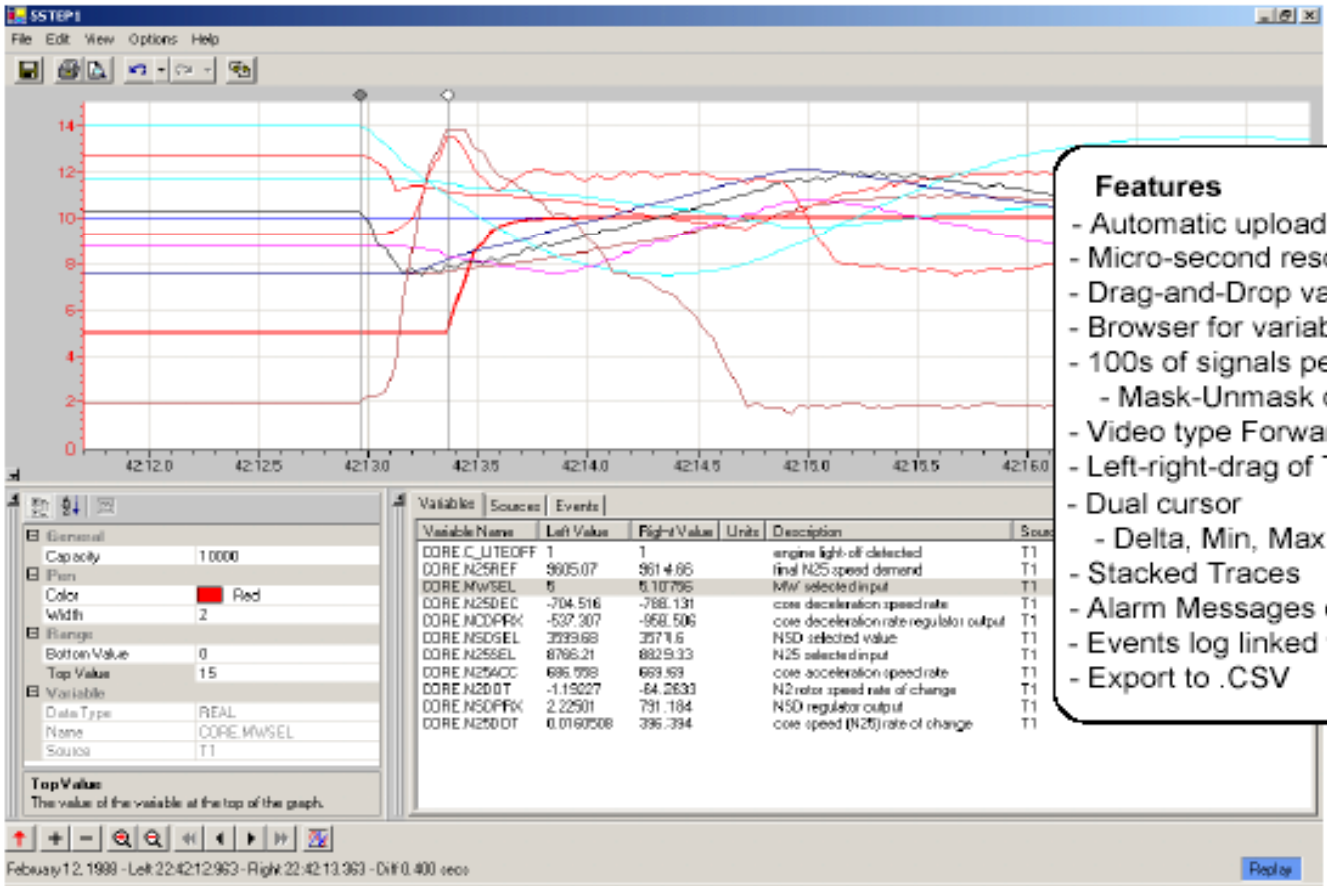
- Multilevel password protection
- On-Line Downloads
- Simplified Editing
  - Drag and Drop
- Trend Recorder
  - Drag and Drop Signals
  - Scaling
- Documentation
  - Application Code can be Printed:
    - Application Software Diagram
    - I/O Assignments
    - Settings of Tuning Constants

ToolboxST (cont.)



ToolboxST Editing Tools

ToolboxST (cont.)



Features

- Automatic upload of Capture Blocks
- Micro-second resolution
- Drag-and-Drop variables to Trender
- Browser for variables selection
- 100s of signals per Trend
  - Mask-Unmask of selected variables
- Video type Forward-reverse
- Left-right-drag of Time Axis
- Dual cursor
  - Delta, Min, Max, Average
- Stacked Traces
- Alarm Messages on Trip Trend
- Events log linked to Trend
- Export to .CSV

ToolboxST Trending Tools

Diagnostics

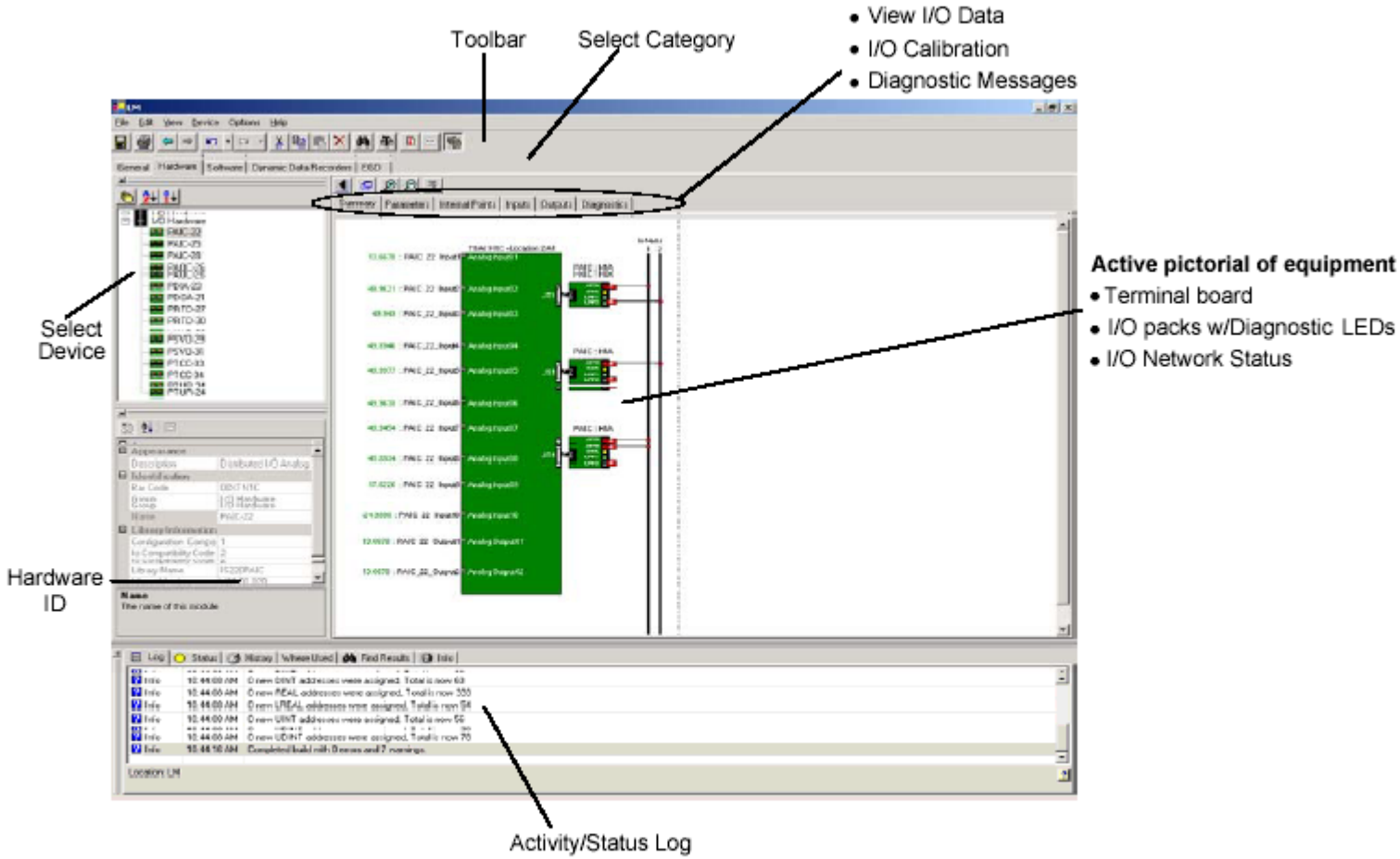
Diagnostics

- Diagnostic LEDs on I/O Packs
  - Power Status
  - Attention (Abnormality Detected)
  - Ethernet Connected
  - Ethernet Communicating
  - Discrete I/O Status Indication

Diagnostics (cont.)

- Hardware Diagnostics
  - High/Low Limits for Analog Signals
  - Composite Diagnostic Alarm State for Each I/O Pack
  - Diagnostic Messages are Assessed Via ToolboxST.
- Diagnostic and System Alarms are Time-Stamped in the Controllers

Diagnostics (cont.)



I/O Pack Diagnostics

Reliability

Reliability

- Dual or Triple Redundancy
- Active Redundancy
  - All components operating Simultaneously
- Flexible design allows for customization to improve reliability

MTBFO Reliability Analysis for Lungmen

The reliabilities of three Lungmen Mark VIe Distributed and Information Control Systems (DCIS)

- Feedwater Control (FWC) System,
- Recirculation Flow Control (RFC) System, and
- Automatic Power Regulator (APR) System

These systems have been analyzed. For each system, the mean time between forced outages (MTBFO) and the failures per million hours and the probability of having forced outages in 40-year (350,640 hours) service have been determined.

MTBFO Reliability Analysis for Lungmen (cont.)

- The estimate of the MTBFO of the FWC System is 75,930,142 hours, or 0.01317 failures per million period hours, and the probability of having forced outages in 40 years of service is about 0.46%.
- The estimate of the MTBFO of the RFC System is 42,111,689 hours, or 0.02375 failures per million period hours, and the probability of having forced outages in 40 years of service is about 0.83%.

MTBFO Reliability Analysis for Lungmen (cont.)

- The estimate of the MTBFO of the APR System is 77,220,075 hours, or 0.01295 failures per million period hours, and the probability of having forced outages in 40 years of service is about 0.45%.

Redundancy

- Power Sources and Supplies
  - Single, Dual or Triple
- Controllers (Main Processors)
  - Single, Dual or Triple
- I/O Net Redundancy
  - Single, Dual or Triple
- I/O Packs per Termination Board
  - One, Two or Three
- Ethernet Ports / I/O Pack
  - Single or Dual