Gas Turbine Automation & Control
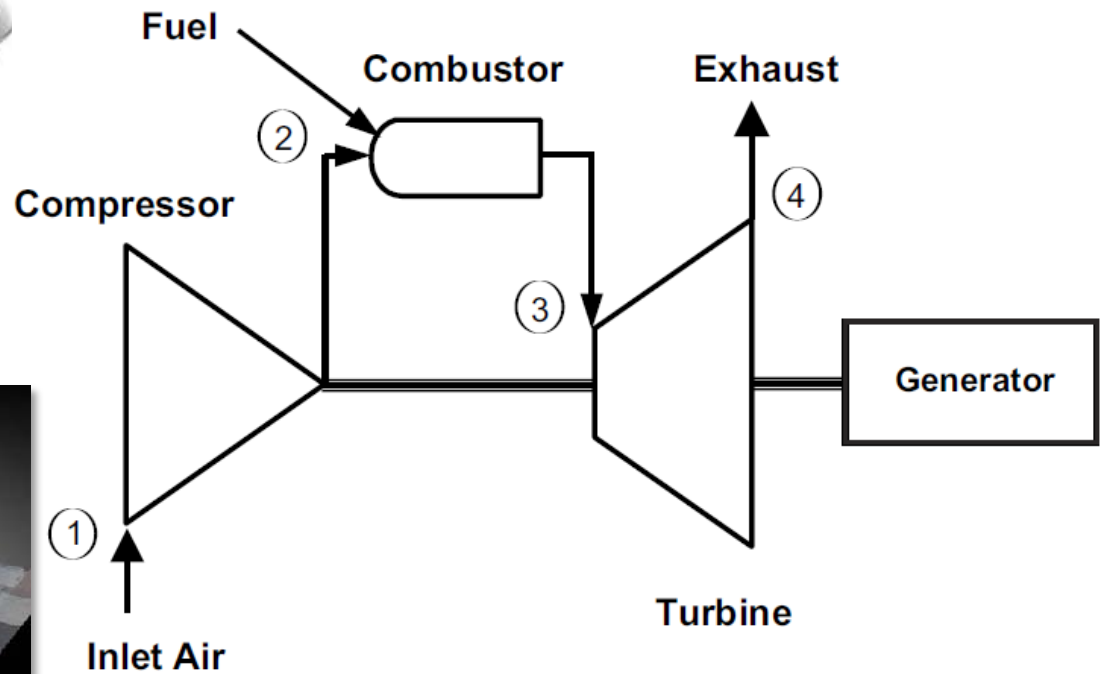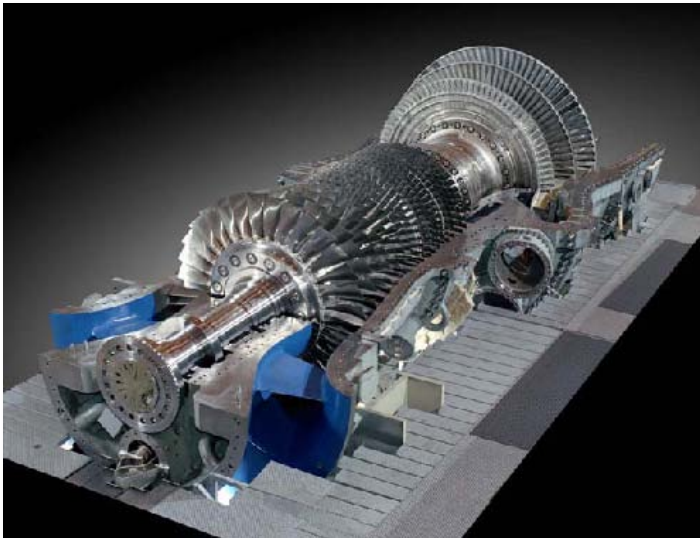

Uranquinty Power Station, New South Wales

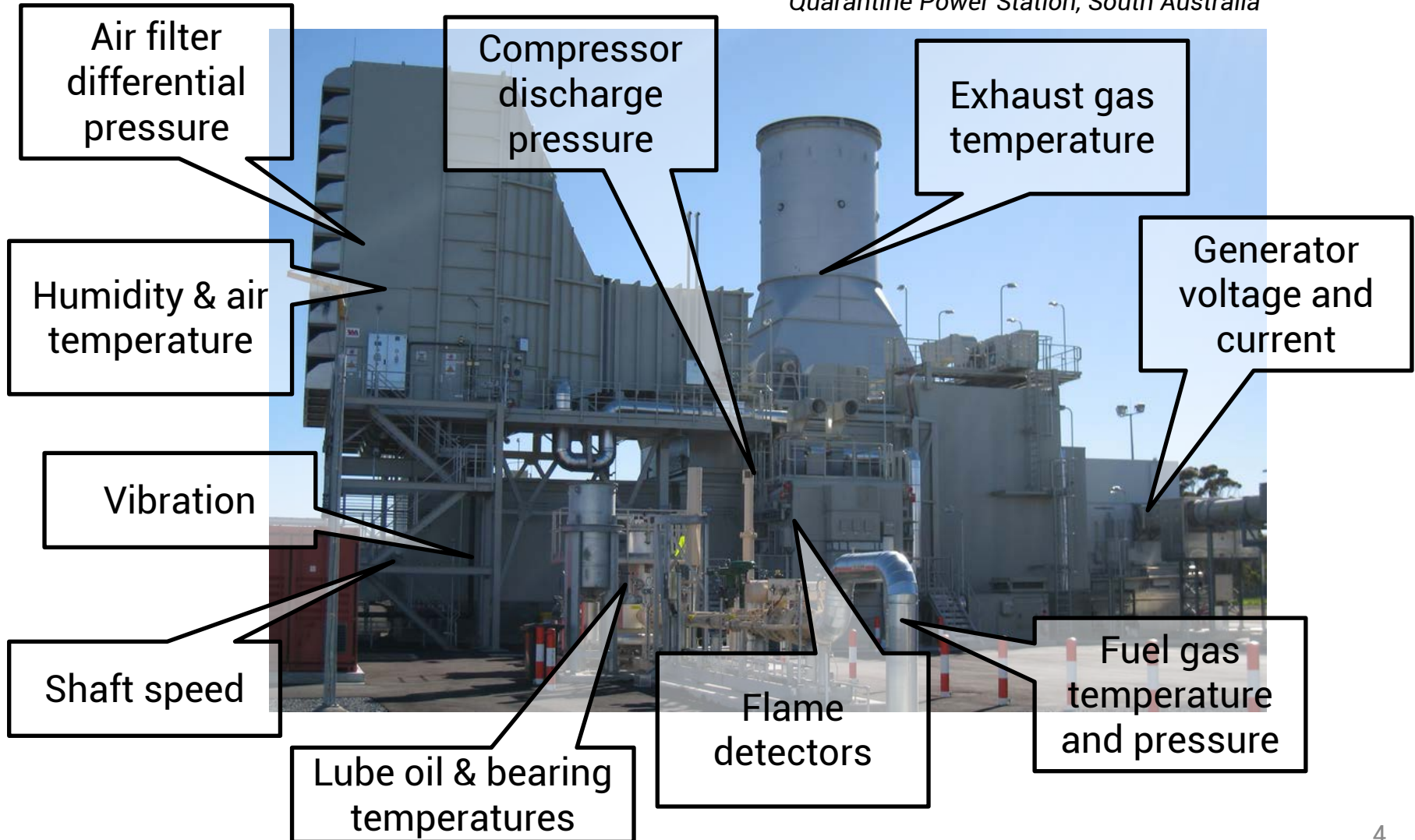## Dr David Ingram

13 August 2013

Content

- Introduction to gas turbines
- Distributed control and its functions
- Turbine control
- Instrumentation networks
- Operator interfaces
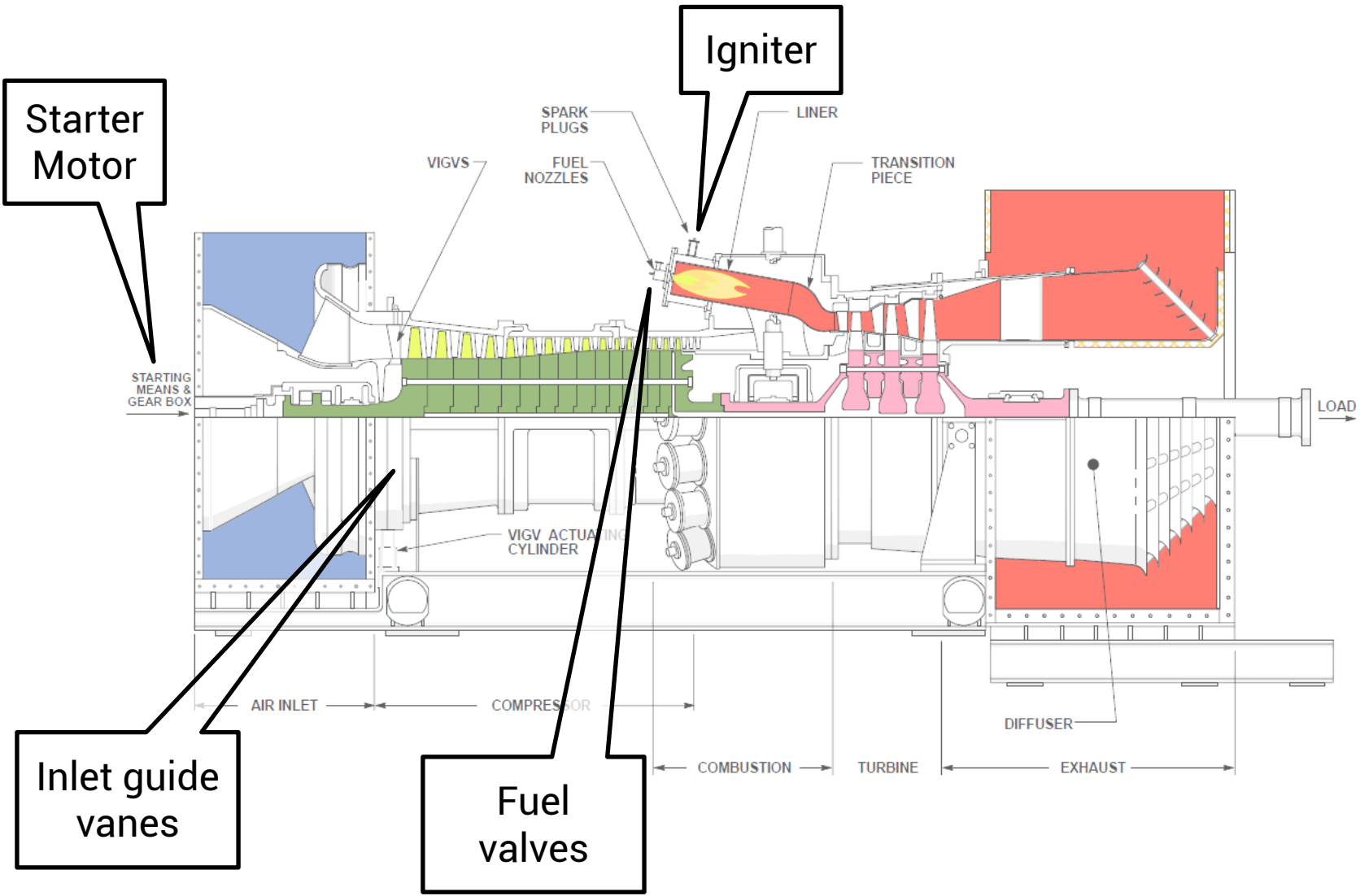- Functional safety

The Gas Turbine

Gas Turbine Package Instruments

Quarantine Power Station, South Australia

Air filter differential pressure

Compressor discharge pressure

Exhaust gas temperature

Generator voltage and current

Humidity & air temperature

Vibration

Shaft speed

Lube oil & bearing temperatures

Flame detectors
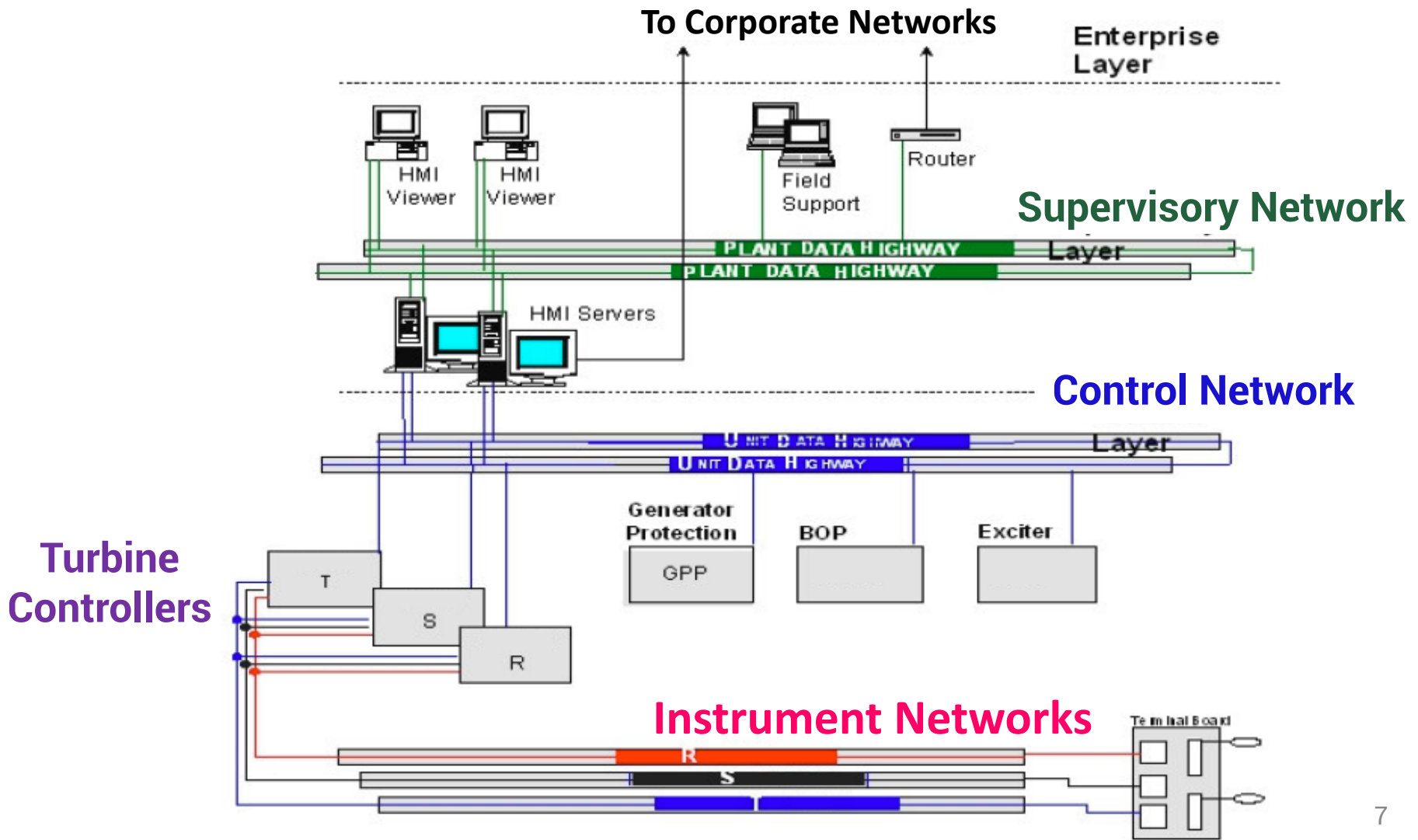
Fuel gas temperature and pressure

4

Gas Turbine Actuators

Distributed Control System Functions

- Regulate exhaust temperature to get maximum output without damage to plant
  - Control fuel flow
  - Control intake air
- Monitor safety and condition
  - Temperatures
  - Vibration
  - Pressures
  - Manual trips (big red buttons)

Typical DCS Architecture

To Corporate Networks

Enterprise Layer

HMI Viewer

HMI Viewer

Field Support

Router

Supervisory Network

PLANT DATA HIGHWAY   Layer
PLANT DATA HIGHWAY

HMI Servers

Control Network

UNIT DATA HIGHWAY   Layer
UNIT DATA HIGHWAY

Generator Protection
GPP

BOP

Exciter

Turbine Controllers

T

S

R

Instrument Networks   Terminal Board

R

S

Redundancy

- ## Simplex
  - A single controller
- ## Duplex
  - Two controller looking after the same functions.
  - If one fails, the other takes over
- ## Triplex
  - Three controllers.
  - 2 of 3 voting for most functions
 - 1 of 3 tripping for critical functions

Turbine Control

- Many suppliers
  - Woodward MicroNet
  - GE Mark VIe
  - Invensys Triconex
  - Siemens T3000
- Implement the control algorithms
  - Governor
  - Firing temperature
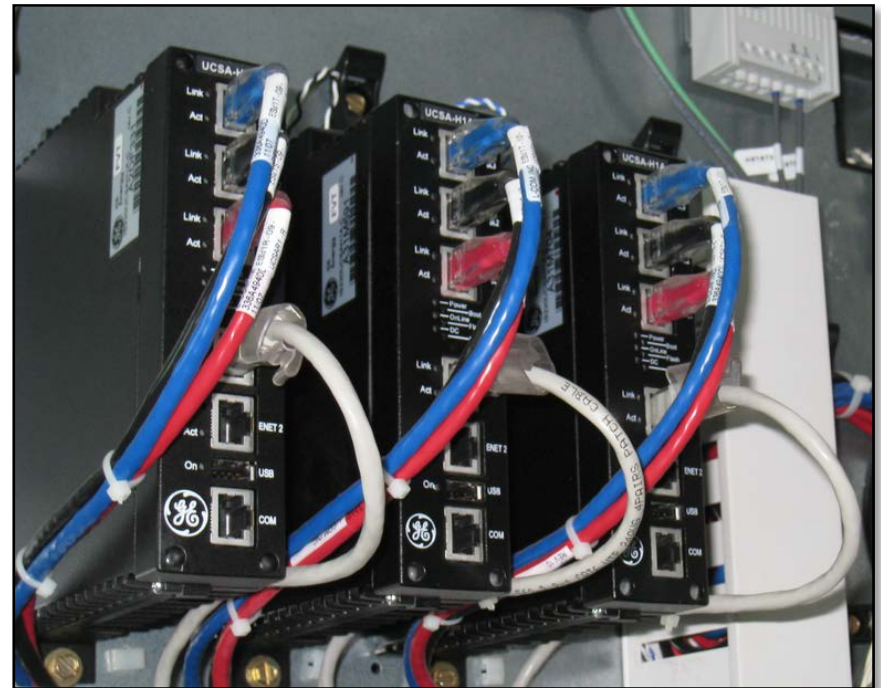
*GE Mark VIe Controllers*

Instrument Network

- Ethernet, ProfiBus & CAN common

- IO packs connect to terminal boards.

- Sensor specific packs
  - Thermocouple
  - Vibration
  - LVDT
  - Pressure
  - Relay I/O
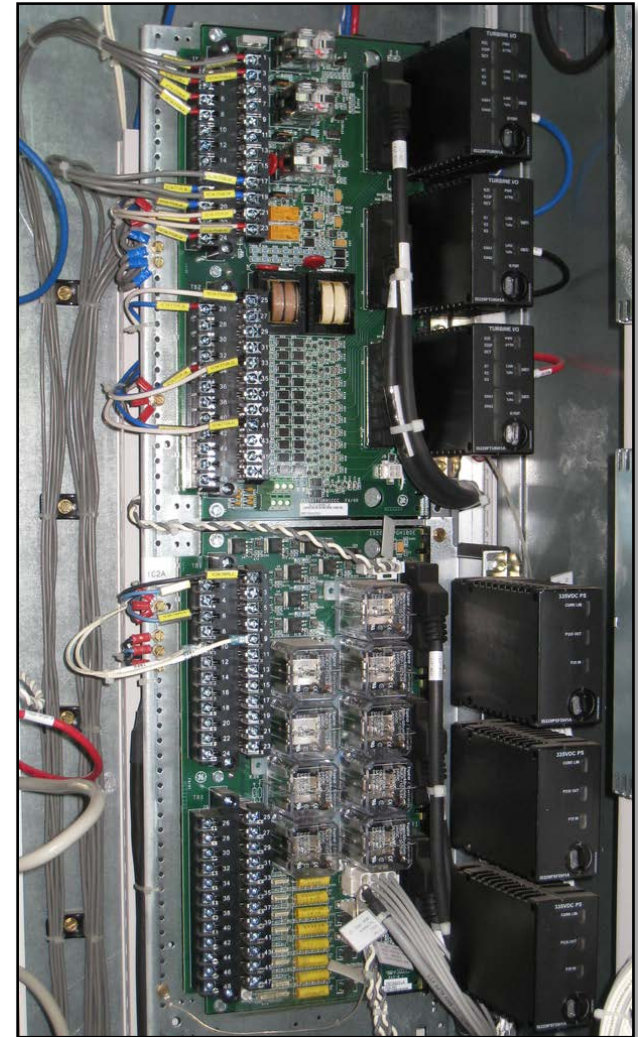
*GE Mark VIe Interface Cards*

TMR Instrument Network

- Some sensors replicated three times, others once or twice.

- More critical functions have more redundancy.

- Modules can be separated from controllers, or may be in adjoining cubicle.
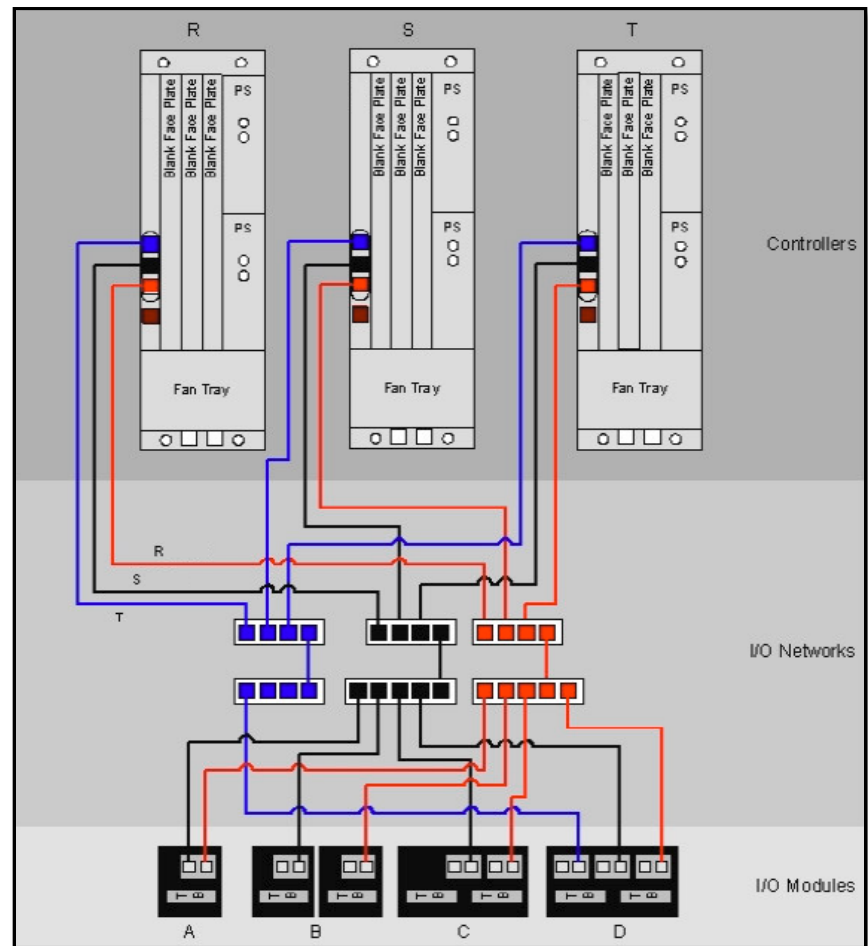
Control Layer

- Information passed between different controllers.
  - Turbine controllers
  - Balance of plant controllers or PLCs
  - Generator excitation systems
  - 'Whole of station' controller
  - "SIL" safety controllers
- Interface to the operators' consoles/HMIs
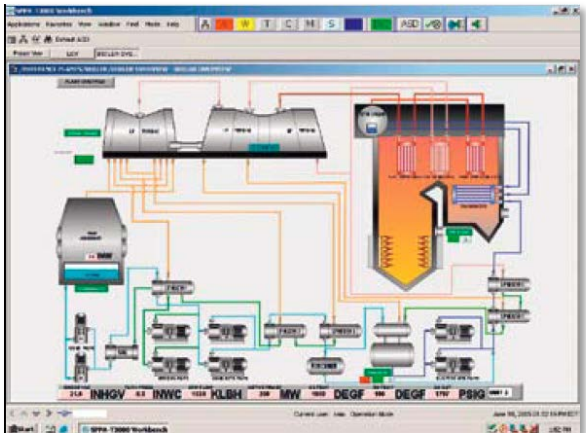- Time critical network

Example Networks
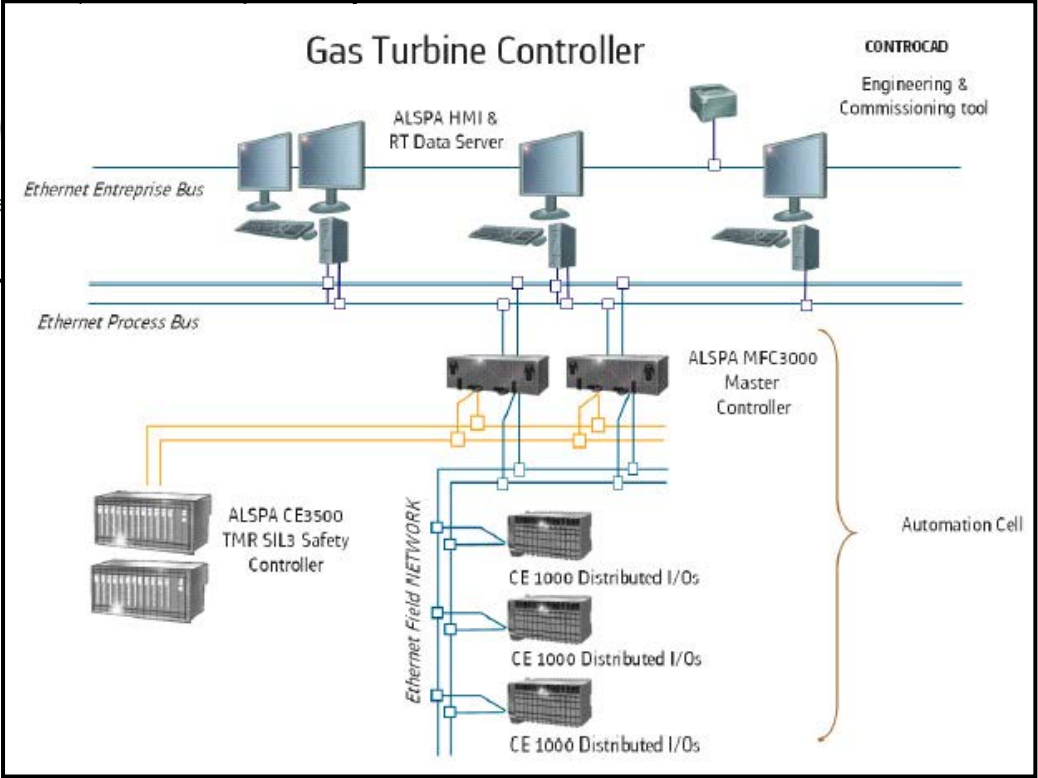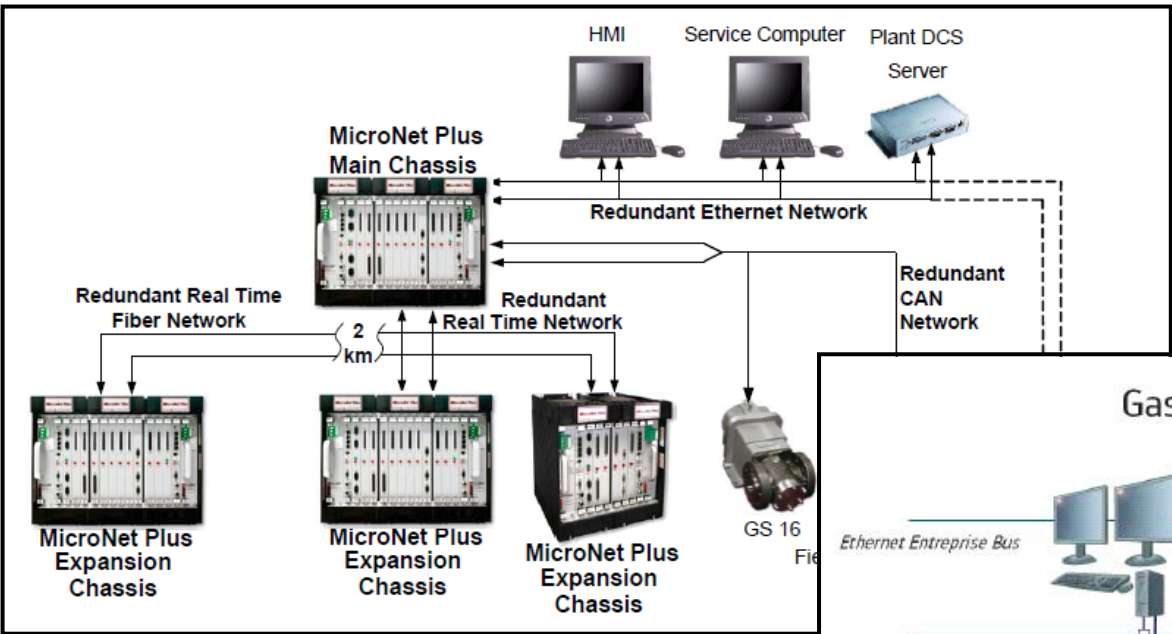
Supervisory Network

- Non-time critical
- Used for engineering functions
  - Changing settings
  - Interrogating fault logs
  - Performance monitoring and plant historian
- Interface with corporate systems

Control Interfaces

- Daily running of the turbine and generator.
- Alarm listing
- Maintenance screens

Engineering Interfaces

- Change the controllers' logic.
- Probe & force IO points.
- Set up trend recording.
- Access to the plant controllers is via gateway devices.
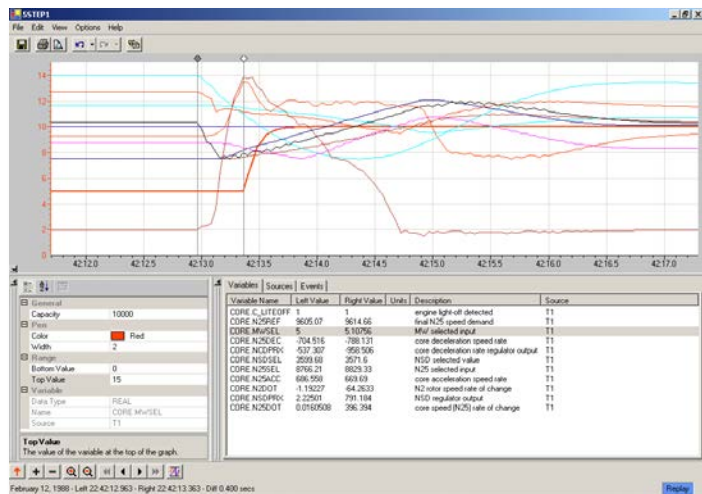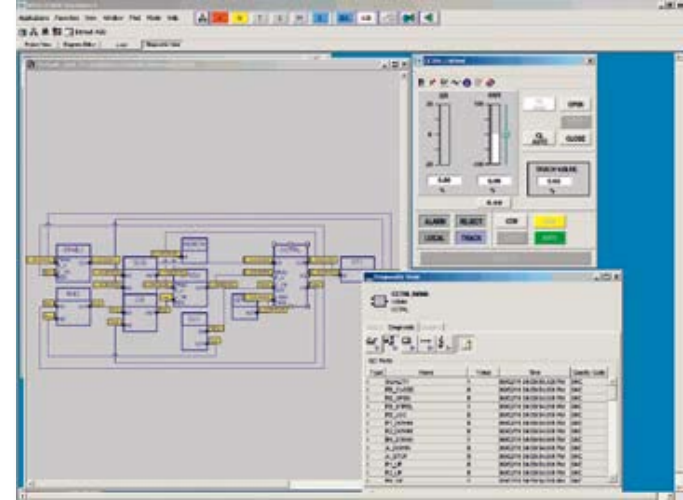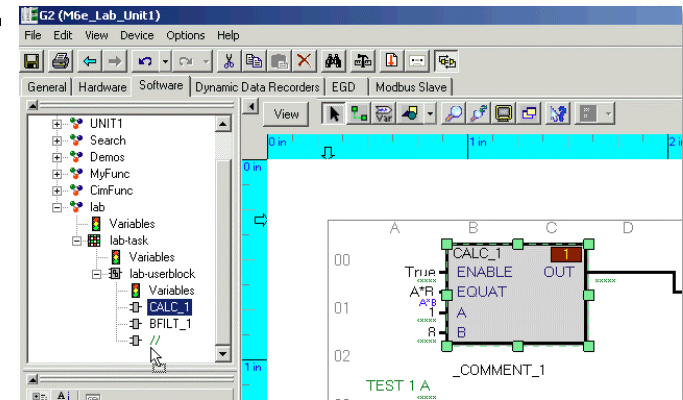
Safety Systems

- Digital protection
  - Turbine over-speed
  - Combustion temperature
  - Fuel gas detection
  - Bearing temperature
- Needs to be reliable
  - Triplex or Duplex almost always required to achieve required reliability.

Eskom (Sth Africa) Duvha Unit 4, Feb. 2011 Overspeed test failure

Safety Requirements

- Safety Integrity Level (SIL)
  - AS 61508 *Functional safety of electrical-electronic-programmable electronic safety related systems*

- Detailed analysis required
  - Gas turbine control systems typically SIL3.

- Sometimes additional 'safety controllers' are installed.

AS 61508.0—2006
IEC/TR 61508-0.2005

AS 61508.0—2006

Australian Standard®

Functional safety of electrical/electronic/programmable electronic safety-related systems

Part 0: Functional safety and AS 61508

STANDARDS
Australia