Live cycle upgrade Turbine Control Systems
Focus on Maximization Reliability

Luc Lauwers
BASF E&I-expert Turbo Machinery Controls
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BASF Antwerp: Ethylene - plant overview

- Built (commissioning ‘Steam cracker’) in 1993 – Linde (D)
  - 800 kt/y
- Expansion in 2007 – Linde (D)
  - 1080 kt/y
- In 2013 Live cycle replacement Turbine Governor main compressor drivers
  - Installation of 3 new Industrial Turbine Control Systems (ITC)
  - Turbine Governor is seen as an ‘critical application’
- Near future (2019): Replacement of aging Compressor Control Systems
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- Steam turbine manufacturer Siemens (D)
  - Industrial turbines: 26 MW – 53 MW
- Original Control systems: Siemens – Simadyn-D
  - Simplex system: CPU & I/O
  - Fully Open System (~PLC)
  - High reliable (8086 µP)
  - High level of functionality
  - User friendly
  - Obsolete since 2003

→ Search for new fully valued and suitable systems started in 2010
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- Start-up detailed benchmark in 2010
  - With focus on particular functional reproduction of current application
  - Future optional integration of the turbo compressor controls (anti-surge- & performance- controls)
  - Focus on:
    - OEM PLC-system integrators (customized retrofit solutions)
    - Standard system package solutions from Turbo-machinery OEM’s
    - Specialized providers of turnkey solutions on different open platforms
Control system concept first objective(s) ➔ high availability

- Basic strategy likewise for example standard DCS arrangements
  - **High availability** encompass all things related to productivity, including reliability and maintainability (on line)
  - Solution focuses on redundant design philosophies - mainly cpu’s (DCS)
  - Redundancy method’s to achieve and ensure high availability, practically besides the system I/O-limits, using dual sensors or actor configurations
- However:
  - Redundancy increases the number of components
  - Which increases the number of potential component failures
  - Comparison logics (in application) required to isolate a anomaly or integrated automatic testing features (channel line diagnostics)
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- **Control system basis ➔ minimum requirements**
  - Duplex or redundant configurations (fully fault tolerant)
    - Single failure on a system component will not interrupt the turbine operation
    - On line repairing of a single fault – system component – without any restriction
    - Embedded I/O-monitoring including automatic channel line testing with bumpless transfer and defining the fault system component
    - Long term support guaranteed (hardware) and fully open systems (software)
**Vendor list (bench marking)**

- Compressor Controls Corporation (CCC) : Vanguard Series 5 (Duplex)
- Continuous Control Solutions (CCS) : Siemens S7-400H/300 ET200 (Duplex)
- Elliott (Voith Turbo) : Turcon R32 (Duplex)
- General Electric : MARK VIIe (Duplex/TMR)
- Gebhardt Automation (GA) : DUPLEX-(7/Smart) / TMR-Smart (Duplex/TMR)
- Woodward (Turner Engine Controls) : Micronet Plus / Mirconet TMR (Duplex/TMR)
- TRIsen System Corporation (Tri-Sen) : TSx (RTP Corporation : 3000) (Duplex/TMR)

- **Rockwell Automation (RA) : TMR Trusted 8000 (ICS Triplex) (TMR)**
**Control system benchmarking results (general)**

- More complex structured systems ('Triplex' concept) could apparently meet our preferred redundancy specifications to ensure the required reliability.

- The quality and reliability of these redundancy concepts depends on the built-in diagnostics on the I/O-boards or even additional engineered software (customized) solutions if standard not present.

- Standard available ‘Duplex’ systems have a complex layout with varied redundancy concepts, limited by the on-board diagnostic techniques.

- The considered ‘Duplex’ systems are offering different - but mainly limited - strategies (for ex. periodic processed) for their integrated fault tolerance.

- Finally, the end user has limited access to the principal construction of these on-board I/O-channel healthy checks (if present) to validate the obtained redundancy or fault tolerance level of the final system.

- Conclusion: ‘Full’- ‘Triplex’ systems could offer the highly required system reliability (fault tolerance) to ensure bumpless response on system component faults.
Availability of triplex systems (factors)

- Triplex (TMR) or Triple Modular Redundant architecture
  - Achieves the highest level of availability
  - Triplication eliminates the influence of any single component failure
  - Supported by the uniform and embedded 2 out of 3 (hardware) principle as errors are detected through discrepancies

- System and component-level diagnostics for detecting and isolating common failures additional required

- Annunciation of faults including tools for troubleshooting

- Time to replace or repair including accessibility

- Ability to change out or add components (expansions) by trained technicians

- Finally: - easy to troubleshoot, reliable diagnostics and embedded voting
  - easy to modify and to repair on line without affecting the process
Impact of maintainability on availability

- Maintainability is the ability of a system to be changed and repaired
- Maintainability of a complex system significantly impact the end user perception of final achieved availability
- Increasingly complex designs are challenging diagnostics routines to detected the predict failures which must be ensured by the system
- Besides the increasing complexity of the application or end user control strategies
- Increasing micro processors (computing) capacity support this trend
- Keeping a complex system maintained (repairing) needs qualified and trained personnel.
Survey results industrial turbine control systems

- Overall evaluation made, based on technical detailed quotations, taking in account:
  - Hardware platform and system lay-out configuration and overall cabinet lay-out
  - Relevant system documentation including the suggested control strategies or vendor philosophies
  - Including the relevant vendor experience with turbo-machinery controls and installed base (references)
  - Vendor response (their efforts) concerning their interpretation and conformity with our request to achieve the highest level of availability
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- Survey results industrial turbine control systems
  - Technical evaluation results in a standard solution and platform

Rockwell Automation Oil and Gas Solutions
Fault Tolerant TMR Trusted 8000 PLC- Technology
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- 64 bit Motorola RISC microprocessor (600 series)
- Remplacement à chaud
- Temps de cycle et throughput rapide
- 2 x Ports Modbus
- IRIG-B synchronisation horloge
- Hardwired alarmes système
- Condamnation mémoire
- Stockage de l’application non volatile
Simplex Design Approach
3-2-0 or 3-3-2-0 Degradation Route
Hot Replaceable
Dual Modbus Communications
Low & High Density I/O Interface
Clock Synchronisation
IEC1131-3 Programming Software
Online Modifications