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Operator / OEM Collaboration on Trip & Alarm Rationalization

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Author bios

Niran Singh Khaira BEng in Mechatronics & Robotics (Monash University), joined ExxonMobil in 2007. Worked multiple Machinery engineering related positions in ExxonMobil Malaysia where he first developed the Machinery trip philosophy. Followed by assignments in USA and UK. He is currently leading the Machinery Group in ExxonMobil Malaysia.

Michael Matheidas BSc - over 20 years of experience working in Upstream machinery system design, start-up, operations and research. Current role is a Regional Facilities Advisor responsible for technical and business development support to upstream production units, projects and business partners in the Asia Pacific, Middle East and Caspian regions for ExxonMobil.

Azeem Meruani - MSc – Senior Technical Advisor for Machinery Controls for ExxonMobil Upstream Production based in Houston, USA. Responsibilities include providing engineering support for ExxonMobil upstream projects and producing assets globally - key focus machinery controls. Joined ExxonMobil in 2007 as a machinery engineer.

Author bios

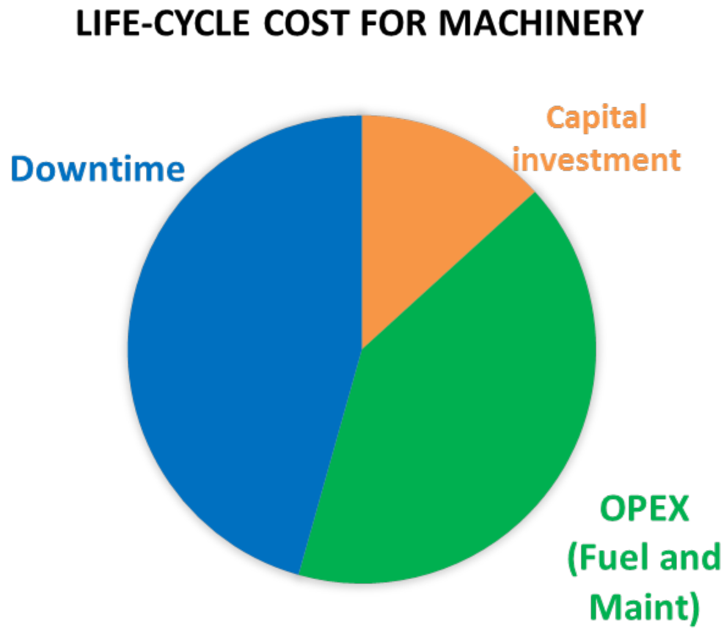
Mohamad-Ali Mortada, PhD – GT Controls Team Lead within the Aero-derivative Gas Turbines Department of the Distributed Power Generation Division at Siemens in Montreal, Canada. Responsibilities include delivering design improvements to the control system for the purpose of enhancing Reliability and Mean Time between Forced Outage. Joined Siemens (previously Rolls-Royce Energy) in 2011 as a Field Support Engineer working on Root Cause Investigations to resolve failures impacting product safety and reliability. Holds a PhD in Industrial Engineering from École Polytechnique de Montreal.

David Wilson is the Senior Engineering Sales Support Manager for the Siemens SGT-A35, SGT-A45, and SGT-A65 gas turbines for use in Mechanical Drive and Power Generation applications within the energy sector. He has responsibility for customer facing aspects of the Siemens Aeroderivative product lines and technical aspects in customer qualifications and customer project management. He has worked for Rolls-Royce for 27 years in various roles including helicopter, marine and energy gas turbines. He is based in Montréal, Canada.

Abstract

Turbomachinery has increased in complexity and monitoring capabilities over the last several decades. This has resulted in an increased number of trips to protect various machinery systems. The prevailing OEM philosophy has been to protect the machine assuming that an immediate trip is safer and results in the lowest financial consequences. ExxonMobil and Siemens collaborated to redesign machinery protection and control systems with an "Operator's mindset" – considering the integrated, full plant risk. The goal was to maximize safety and minimize integrated risk resulting in an increase in mean time between forced outage (MTBFO).

Business Case

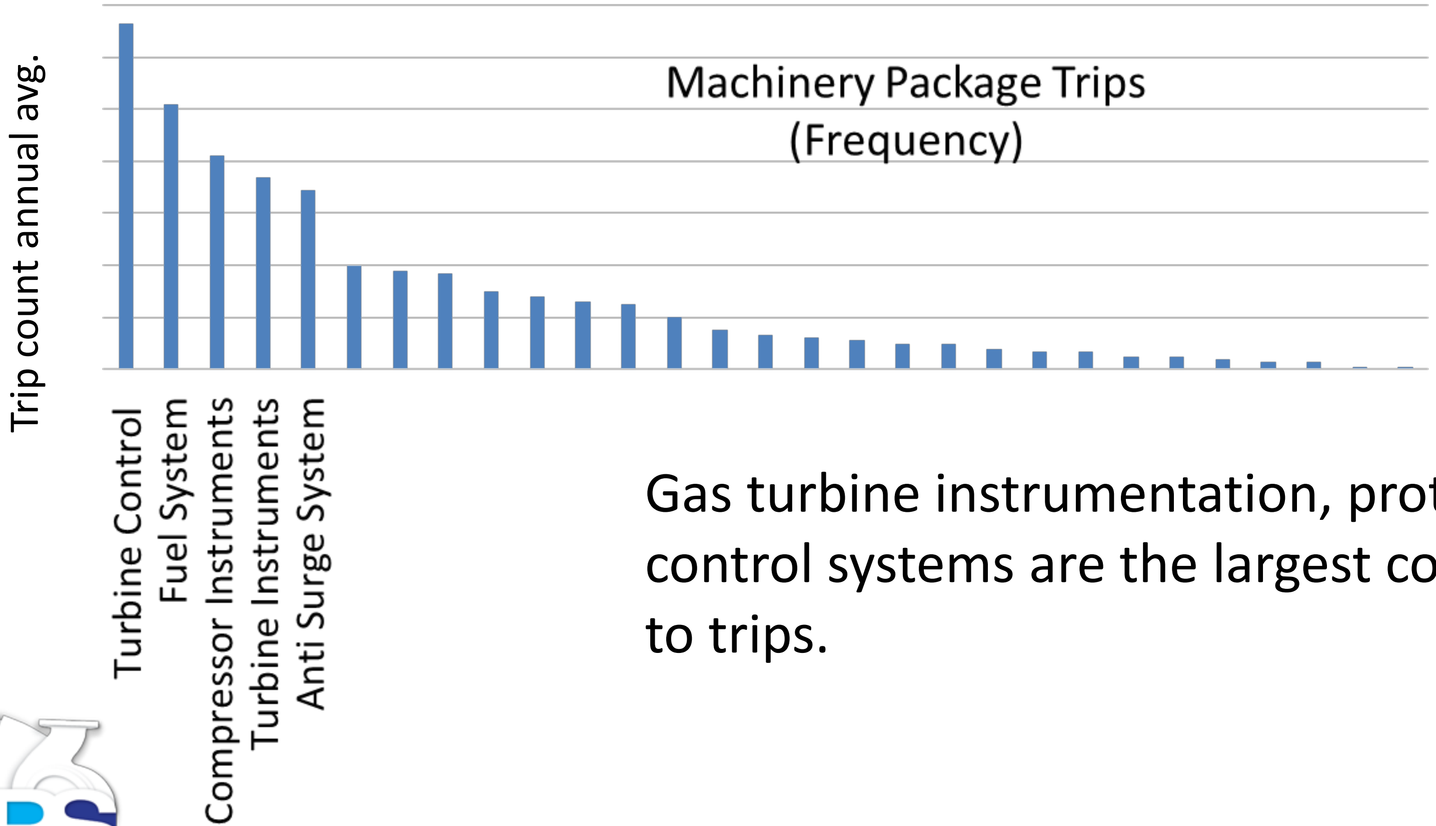


*Data based on LNG service, 2015 average LNG price and internal cost / downtime estimates.

Trips can increase safety exposure by putting demands on safety systems and personnel exposure during restarts

Downtime is often a key contributor to life cycle cost

ExxonMobil Fleet Analysis



Gas turbine instrumentation, protective & control systems are the largest contributors to trips.

Shift in Mindset

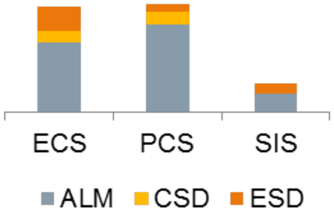
Solution: Changed strategy to collaborate with OEMs to update OEM standard design - Sustainable solution rather than a one off design

- More trips do not necessarily improve safety.
- More trips do not necessarily lower financial risk.
- Design one build many.
- Control systems are getting more complex, yet it is harder to determine health of machine.
  - According to the U.S. Chemical Safety Board, incidents during plant start-up are 10 times more likely than during normal operations.*

*http://www.controleng.com/channels/process-control/process-control-news/single-article/the-role-of-simulator-technology-in-operator-training-programs/cb88591ddf.html

Drive to Collaborate

BEFORE

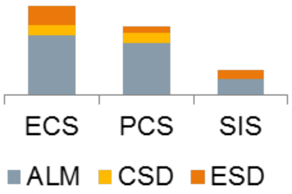


"Machine only Mindset"

Alarms & Trips geared primarily towards machine Protection.

New Risk Based Alarm & Trip Rationalization Methodology factoring in Operator Down Time

AFTER



"Operator Mindset"

Alarms & Trips to protect the facility – maximizing safety & minimizing integrated risk.

LEGEND:

ECS	Engine Control System
PCS	Package Control System
SIS	Safety Instrumented System
ALM	Alarm
CSD	Controlled Shut Down
ESD	Emergency Shutdown

Methodology

1. Develop Methodology

- Risk Based Approach Focused on Understanding Protection Rationale
- Compares Risks with and Without Automatic Action to Tolerable Level

2. System Based Implementation

- Maximizing Uptime using System's Physical/Synthesized Redundancy
- Empower Operator to Manage Risks of running in Degraded State

Operator

3. Periodic Operator Reviews

- Calibrate Risk Assessment Against Operator's assessment
- Alarm Management Tools (Response Procedure, Priorities, etc..)

4. Coding & Roll-Out

- Coding & Validation of New Protections using Simulation Tools
- Roll-Out to Select Sites, Collection of Operational Data, and Feedback

OEM Process – Internal Q&A

<u>Trip Rationale</u>

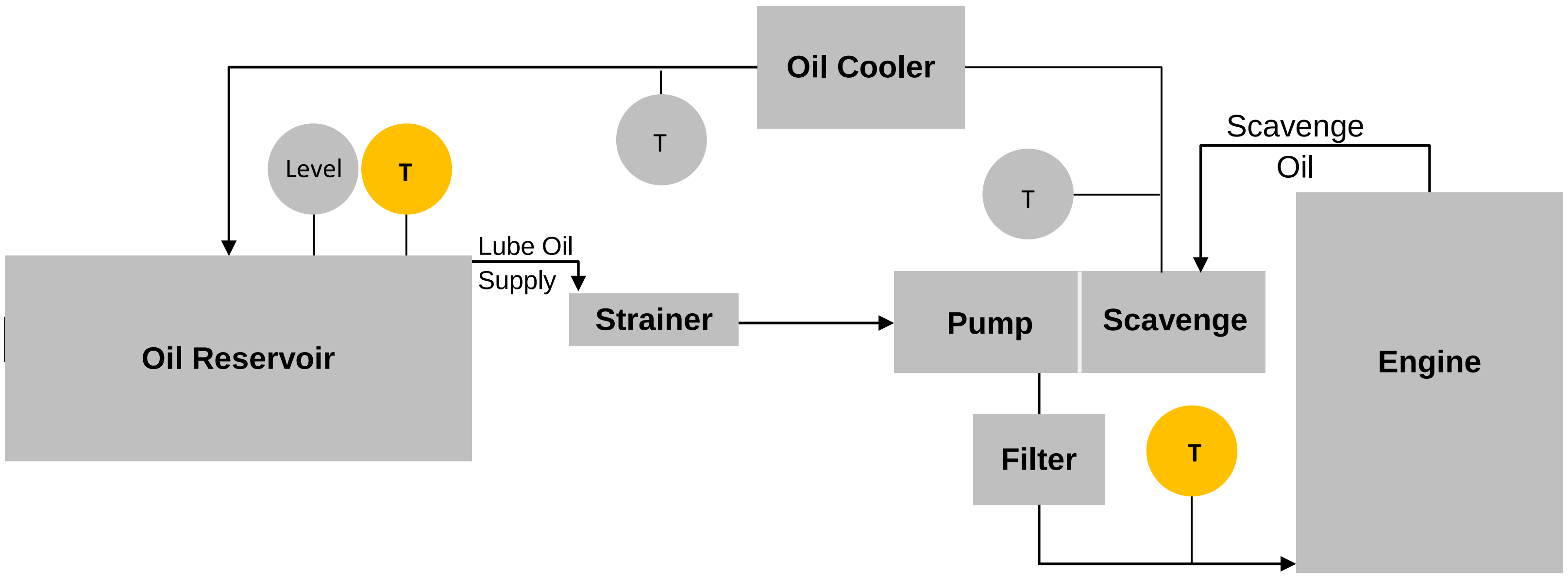
- Do we need to trip? What is the failure we are trying to prevent trip?
- When do we arm/disarm trip?
- Is there an automatic action that can be done to prevent tripping? - Run back or trip to idle
- Is there another trip that prevents the same failure mode? Is it redundant?
- Cross reference signals to eliminate/minimize spurious instrument failure trips?
- Eliminate/minimize Single Point of Failure (SPOF) trip devices

<u>Trip Timers</u>

- How long is it acceptable to continue operation before tripping?
- Are there time delays/filters to eliminate/minimize instrument/processor "spikes" – example 3

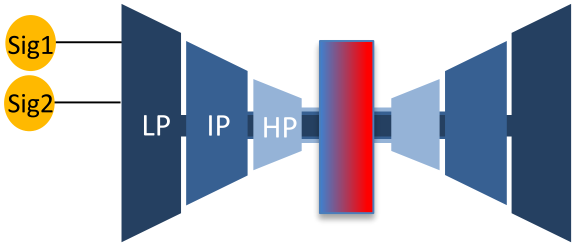
Example 1

Abnormal Condition	Failure Risk	Trip Risk	Mitigation	New Trip Risk
GT Lube Oil Supply Temperature Signal Fault	High	High	Use Tank Temperature for Redundancy if Sensor Fails	Low



Example 2

Abnormal Condition	Failure Risk	Trip Risk	Mitigation	New Trip Risk
LP Compressor Inlet Pressure Cross-Check Error	Low	Low	Remove Shutdown and Use Synthesized Value	Low



Fault	LP Inlet P (Before) =	LP Inlet P (After) =
No Signal Faults	AVG(Sig1,Sig2)	AVG(Sig1,Sig2)
Single Signal Fault	Remaining Healthy Sig	Remaining Healthy Sig
Cross-Check Error	Shutdown	Use Synthesized Site Ambient P to Arbitrate
2oo2 Signal Faults	Shutdown	Synthesized from Site Ambient P

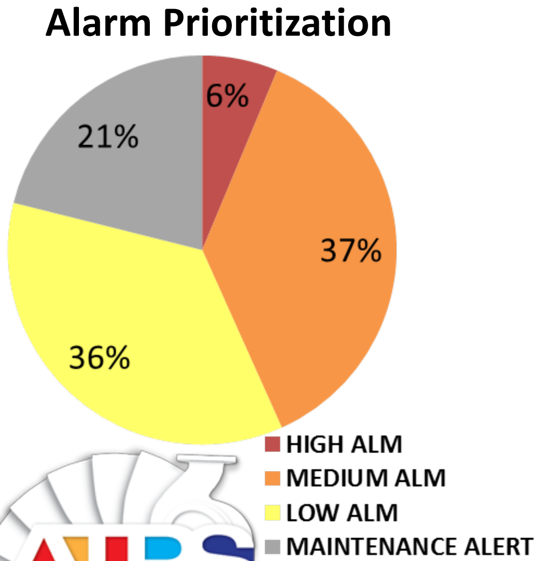
Example 3

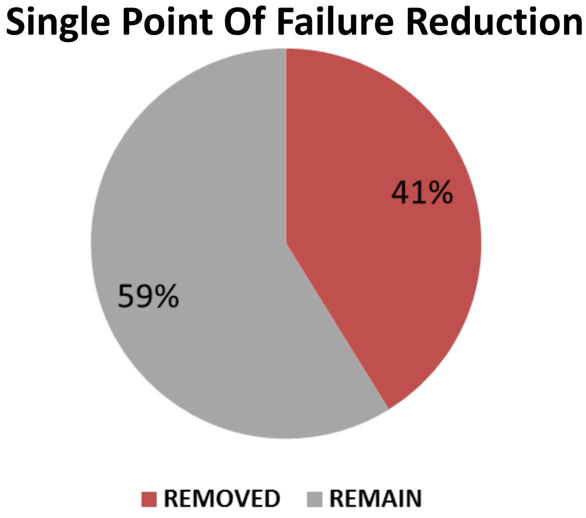
Improved Signal Validation on All Instrumentation (e.g. IP Compressor Inlet Pressure)

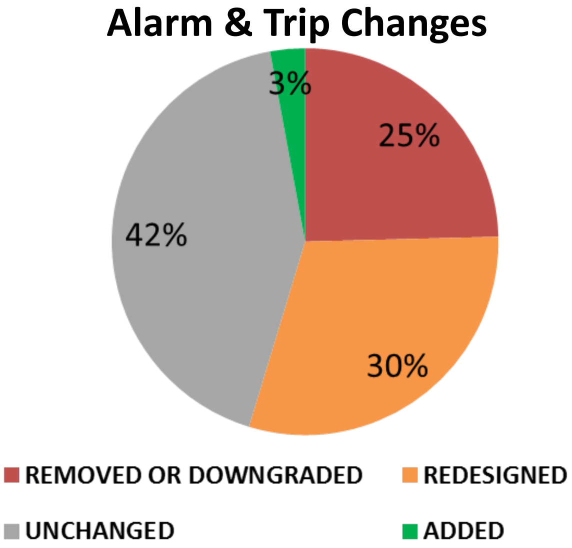
Condition	Before	After
Signal Fault Trigger	Instantaneous Signal Kick Out	Confirmation Delay of X secs Freeze Last Good Value in Mean Time
Signal Reinstate	Can Only Reinstate After Engine Shutdown	Automatic Signal Reinstate if: 1- Signal Returns to Normal X sec/mins within Fault 2- Signal Experiences “Y” mins of Good Behavior during the reinstate window

Results

- Exercise Conducted on SGT-A65 Gas Turbine Control System
- New Software Tested & Implemented at Several Sites
- Solution is Now the New Standard for Siemens







Conclusions

- Operators and OEM collaboration resulted in a new standard solution for the OEM.
    - 20-25% expected increase in run time between forced outages
    - Prioritized alarm list following industry standard – ISA 18.2
    - Benefits customers for new units
    - Scope expanding from SGT-A65 TR to other unit types
    - Software changes can be incorporated into existing equipment
    - Sustainable solution - OEMs continue to learn and improve with fleet data by addressing repetitive trips
- Benefits the industry if more operators collaborate with OEMs to improve OEM standard design.