T78 - Improve Safety and Compliance Using The Connected Enterprise
The Connected Enterprise delivers transformational value in productivity and global competitiveness.

- Faster Time to Market
- Lower Total Cost of Ownership
- Improved Asset Utilization
- Enterprise Risk Management

Productivity

Risk
Business Goal: *Attain productions goals at an acceptable level of risk*

“What is your company’s appetite for risk”?  
Cal Beyer – Vice President, Zurich NA
49% of companies claim safety as a core value…

Yet only 19% have executive commitment to make necessary investments.

SAFETY AND RISK MANAGEMENT IN THE AGE OF IIoT AND DIGITAL TRANSFORMATION
LNS Research 2017
Workers’ Risk Management…
safety or productivity?

- Safety First!
  …really?

- Workers’ continuous dilemma
  - Safety vs Productivity
  - Influenced by corporate culture and commitment
Functional Safety Definition

- Random hardware faults, systematic design errors or human mistakes shall not result in a malfunction of a safety related system with the potential consequence of:
  - Injury or death of humans or
  - Hazards to the environment or
  - Loss of equipment or production
Machine Safety

Functional Safety Life Cycle
ISO 13849

1. Risk Assessment

2. Functional Requirements Specification

3. Design & Verification

4. Installation & Validation

5. Maintain & Improve
Smarter, Safer
Machines & Equipment

Real-time Data
Running Time, E-stops, Guard Status

Information
CONTEXTUALIZATION
Quality, OEE, Safety

Knowledge
ANALYTICS
Safety System use/abuse

Wisdom/Action
OPTIMIZE
More safe & efficient process workflows
Safety **Data** Availability at Machine Level

- Device Status
- Operational Status
- Error/Fault Codes
- Event Counters & Timers
- Event Sequences
- Stoppage Codes (Manually Entered)
- Motion Monitoring (Speed, Acceleration, Direction, etc.)
- Notifications of modifications to Safety Logic

Real-time Data → Information → Knowledge → Wisdom/Action
Smart Safety Devices In The Connected Enterprise

The Connected Enterprise/Industry 4.0

Benefits of Smart Safety

Visualization

Design Environment

Information Software

Logic Programmable Automation Controller

Input

Logic

Output

EtherNet/IP

EtherNet/IP

EtherNet/IP

Emergency stop

Non contact switches

Guard locking switches

Key Interlock Switches

Cable pull switches

MAB CIP Safety

Light Curtains CIP Safety

Safety Scanner CIP Safety

Future Design
Production AND Safety Information in The Connected Enterprise = Knowledge

- **Information**
  - How often are my safety systems tripped?
  - Are the safety systems being utilized properly?
  - How often and why is machinery power being removed?
  - How often is Lockout/Tagout being performed?

- **Knowledge**
  - Where are current safety solutions impeding productivity?
  - Are safeguards being defeated?
  - Are certain individuals, shifts, or areas of production “better” than others?
  - Are particular machine types causing more safety problems than others?
  - Are particular product runs causing more safety problems than others?

Real-time Data → Information → Knowledge → Wisdom/Action
Barriers to Safety and Environmental Performance Improvement

Top Challenges to Safety and Environmental Performance Improvement

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disparate systems and data sources</td>
<td>49%</td>
</tr>
<tr>
<td>Poor collaboration across departments</td>
<td>46%</td>
</tr>
<tr>
<td>Inadequate ROI Justifications for improvement</td>
<td>31%</td>
</tr>
<tr>
<td>Ineffective metrics program</td>
<td>31%</td>
</tr>
<tr>
<td>Lack of continuous improvement</td>
<td>28%</td>
</tr>
<tr>
<td>Lack of executive support</td>
<td>17%</td>
</tr>
<tr>
<td>Lack of talent</td>
<td>12%</td>
</tr>
</tbody>
</table>

SAFETY AND RISK MANAGEMENT IN THE AGE OF IIoT AND DIGITAL TRANSFORMATION
LNS Research 2017
Access to and use of safety-system information

- Monitor safeguard use, and misuse
- Better understand safety risks
- Enhance ROI of safety investments

5. Maintain & Improve
Example 1: Emergency Stop Data
Example 1: Emergency Stop Data Report

**Line 1**
- Safety & Productivity
- E-Stops: 73 Activations
- Average Downtime: 94 Seconds

**Line 2**
- Cycle Stops: 44 Activations
- Average Downtime: 6 Seconds

**Line 3**

**Why e-stop??**

**Weekly Report**
- Total Stops: 156 Stops
- Reason Code Ranking:
  - Jams: 54%
  - Product Misfeeds: 18%
  - Adjustments: 15%
  - No Material: 7%
  - Cleaning: 6%
Example 1: Emergency Stop Data Line/Shift Information Report

PLANT A

Line 1
Line 2
Line 3

DAILY REPORT

Emergency Stop Activations >5 Flagged RED

Line 1: 26 Emergency Stop Activations
Line 2: 4 Emergency Stop Activations
Line 3: 18 Emergency Stop Activation

Where & when?

DAILY REPORT

Emergency Stop Activations >5 Flagged RED

Shift 1: 0 Emergency Stop Activations
Shift 2: 0 Emergency Stop Activations
Shift 3: 48 Emergency Stop Activations
Example 1: Emergency Stop Data
Plant Information Report

DAILY REPORT

<table>
<thead>
<tr>
<th>Plant</th>
<th>Emergency Stop Activations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant A</td>
<td>0</td>
</tr>
<tr>
<td>Plant B</td>
<td>3</td>
</tr>
<tr>
<td>Plant C</td>
<td>48</td>
</tr>
<tr>
<td>Plant D</td>
<td>22</td>
</tr>
</tbody>
</table>

Emergency Stop Activations >5 Flagged RED
Example 2: Real Time Risk Calculator
Example 2: Real Time Risk Calculator

- Risk Reduction measures are designed to lower the risk to an acceptable level.
- All (good) machine builders, engineering firms, and service contractors conduct and document risk assessments in accordance to industry recognized standards
- Most documented risk assessments are rarely re-evaluated.
Example 2: Real Time Risk Calculator
Typical Machine Risk Assessment Document

<table>
<thead>
<tr>
<th>Item ID</th>
<th>Area</th>
<th>Existing Safeguarding</th>
<th>Severity of Hazard</th>
<th>Exposure to Hazard</th>
<th>Probability of Occurrence</th>
<th>Probability of Government</th>
<th>Estimated Risk Level Existing</th>
<th>Compliance Issue</th>
<th>Status (Suitable)</th>
<th>Existing</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA.2.2</td>
<td>Filler - rotation of timimg, screw, star wheels and head rotation.</td>
<td>Fixed and interlocked panels and doors. Single channel circuit.</td>
<td>S3</td>
<td>F2</td>
<td>A1</td>
<td>O2</td>
<td>4</td>
<td>Opening in guards allow access to hazards. Safeguarding circuit not suitable for severe hazards (F, V).</td>
<td>Mitigated</td>
<td>Not Mitigated</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item ID</th>
<th>Area</th>
<th>New Safeguarding</th>
<th>Severity of Hazard</th>
<th>Exposure to Hazard</th>
<th>Probability of Occurrence</th>
<th>Estimated Risk Level After</th>
<th>Validation Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA.1.3</td>
<td>Filler / Capper - rotation of timing, screw, star wheels, filler and copper head rotation.</td>
<td>Install additional guards to reduce opening size to not permit access to hazards. Upgrade safety circuit to dual channel with safety relay (F, V). Lockout machine.</td>
<td>S3</td>
<td>F1</td>
<td>A1</td>
<td>O1</td>
<td>Risk Mitigated</td>
</tr>
<tr>
<td>RA.2.3</td>
<td>Filler / Capper - rotation of timing, screw, star wheels, filler and copper head rotation.</td>
<td>Install additional guards to reduce opening size to not permit access to hazards. Upgrade safety circuit to dual channel with safety relay (F, V). Lockout machine.</td>
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<td>F1</td>
<td>A1</td>
<td>O1</td>
<td>Risk Mitigated</td>
</tr>
</tbody>
</table>
Example 2: Real Time Risk Calculator
Typical Machine Risk Assessment Document

What does the information tell us?

<table>
<thead>
<tr>
<th>Access Point</th>
<th>Anticipated Exposure</th>
<th>Current Month Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Point 1</td>
<td>&lt; 1 per month</td>
<td>2</td>
</tr>
<tr>
<td>Access Point 2</td>
<td>&lt; 1 per month</td>
<td>0</td>
</tr>
<tr>
<td>Access Point 3</td>
<td>1 per month</td>
<td>44</td>
</tr>
<tr>
<td>Access Point 4</td>
<td>1 per month</td>
<td>12</td>
</tr>
<tr>
<td>Access Point 5</td>
<td>1 per week</td>
<td>5</td>
</tr>
<tr>
<td>Access Point 6</td>
<td>1 per week</td>
<td>14</td>
</tr>
<tr>
<td>Access Point 7</td>
<td>1 per shift</td>
<td>427</td>
</tr>
<tr>
<td>Access Point 8</td>
<td>1 per shift</td>
<td>77</td>
</tr>
<tr>
<td>Access Point 9</td>
<td>&gt; 1 per shift</td>
<td>1836</td>
</tr>
<tr>
<td>Access Point 10</td>
<td>&gt; 1 per shift</td>
<td>0</td>
</tr>
</tbody>
</table>

From Risk Assessment

[Color codes indicating risk levels: ±25%, ±100%, ±250%, ±500%]
### Example 2: Real Time Risk Calculator

Typical Machine Risk Assessment Document

What does the information tell us?

<table>
<thead>
<tr>
<th>Access Point</th>
<th>Anticipated Exposure</th>
<th>Current Month Exposure</th>
<th>6 Month Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Point 1</td>
<td>&lt; 1 per month</td>
<td>2</td>
<td>2.3</td>
</tr>
<tr>
<td>Access Point 2</td>
<td>&lt; 1 per month</td>
<td>0</td>
<td>1.1</td>
</tr>
<tr>
<td>Access Point 3</td>
<td>1 per month</td>
<td>44</td>
<td>38</td>
</tr>
<tr>
<td>Access Point 4</td>
<td>1 per month</td>
<td>12</td>
<td>0.9</td>
</tr>
<tr>
<td>Access Point 5</td>
<td>1 per week</td>
<td>5</td>
<td>4.3</td>
</tr>
<tr>
<td>Access Point 6</td>
<td>1 per week</td>
<td>14</td>
<td>2.7</td>
</tr>
<tr>
<td>Access Point 7</td>
<td>1 per shift</td>
<td>427</td>
<td>561.2</td>
</tr>
<tr>
<td>Access Point 8</td>
<td>1 per shift</td>
<td>77</td>
<td>91</td>
</tr>
<tr>
<td>Access Point 9</td>
<td>&gt; 1 per shift</td>
<td>1836</td>
<td>867</td>
</tr>
<tr>
<td>Access Point 10</td>
<td>&gt; 1 per shift</td>
<td>0</td>
<td>655</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exposure</th>
<th>±25%</th>
<th>±100%</th>
<th>±250%</th>
<th>±500%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access 1</td>
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<td></td>
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<td>Access 9</td>
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<td>Access 10</td>
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<td></td>
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<td></td>
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</tbody>
</table>
Example 3: Safety System Reliability
Example 3: Safety System Reliability

EN 954 Withdrewn 2011

Published 2005/6

PL = Performance Levels
SIL = Safety Integrity Levels

PL

SIL

EN ISO 13849

IEC/EN 62061

EN 954

CATEGORY

FAULT TOLERANCE

DIAGNOSTICS

RELIABILITY

SYSTEMATIC

SAFETY REQ. SPEC.

FUNCT. SAFETY MNGT.

Fault Tolerance

Diagnostics

Reliability
Example 3: Safety System Reliability

- Safety systems designed to meet ISO 13849-1 are required to have a Performance Level (PL) for each safety function.
- Performance Levels are a rating of reliability. One of the factors in determining a Performance Level is MTTFd.

<table>
<thead>
<tr>
<th>Performance Level (PL)</th>
<th>Average Probability of Dangerous Failures per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>≥10^-5 to &lt;10^-4</td>
</tr>
<tr>
<td>b</td>
<td>≥3 · 10^-6 to &lt;10^-5</td>
</tr>
<tr>
<td>c</td>
<td>≥10^-6 to &lt;3 · 10^-6</td>
</tr>
<tr>
<td>d</td>
<td>≥10^-7 to &lt;10^-6</td>
</tr>
<tr>
<td>e</td>
<td>≥10^-8 to &lt;10^-7</td>
</tr>
</tbody>
</table>

Contribution to Risk Reduction
Example 3: Safety System Reliability (MTTFd)
Designing Safety Functions

1-2 shift

1-2 hour

SISTEMA Verification Software

Required Performance Level

Achieved Performance Level
Example 3: Safety System Reliability
Real Time Performance Level Calculations

<table>
<thead>
<tr>
<th>Safety Function</th>
<th>Required PL</th>
<th>Actual PL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Function 1</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Safety Function 2</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Safety Function 3</td>
<td>D</td>
<td>B</td>
</tr>
<tr>
<td>Safety Function 4</td>
<td>D</td>
<td>B</td>
</tr>
<tr>
<td>Safety Function 5</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Safety Function 6</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Safety Function 7</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Safety Function 8</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Safety Function 9</td>
<td>E</td>
<td>B</td>
</tr>
<tr>
<td>Safety Function 10</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

This can be a trigger to re-evaluate the Safeguarding Solution.
Example 4: Change Management and Asset Compliance
Example 4: Change Management and Asset Compliance

- Audits of Programmed or Configurable Devices
  - Change Tracking of Safety Programs
- Reduction in MTTR – Recovery of Assets
DEVICE
• Information from smart assets
• Third party device integration
• Machine/fleet management for remote assets

SYSTEM
• Real-time optimization of machines, processes & plants
• Predictive maintenance
• Abnormal system awareness & action

ENTERPRISE
• Site to site benchmarking
• Operational analytics
• Integration to/from business systems
• Data visualization & discovery

DESCRIPTIVE
What happened?

DIAGNOSTIC
Why did it happen?

PREDICTIVE
What will happen?

PRESCRIPTIVE
What should I do?

Decision Support

Decision Automation

Continuous Improvement

DATA

DECISION

ACTION

FEEDBACK
Manufacturing Excellence - Maturity

- Two aspects of maturity
  1. Connected Enterprise
  2. Enterprise Risk (Safety)

- Fits into and driven by business strategy
- Risk management can be an impetus for a Connected Enterprise
Rockwell Automation’s Four-stage Connected Enterprise Execution Model

1. **Assess and Plan**: Evaluate existing infrastructure, including controls, networks, information solutions and security.

2. **Secure and Upgrade**: Create a backbone that delivers secure, adaptable connectivity from the plant floor to the enterprise.

3. **Data and Analytics**: Transform data into knowledge to drive business improvements.

4. **Optimize and Collaborate**: Create an environment that improves collaboration across sites and with the entire enterprise, including suppliers and customers.

The Connected Enterprise

- **Faster Time to Market**
- **Lower Total Cost of Ownership**
- **Improved Asset Utilization**
- **Enterprise Risk Management**
Personas Traditionally Involved in The Connected Enterprise Journey

### VP of Manufacturing
- Control and visibility to all aspects of production for all plants globally
- Use Common KPIs to benchmark plants to drive productivity

### Plant Management
- Control and visibility to all aspects of production
- Increased collaboration between departments
- Reduce and control costs (Mfg, labor, maintenance, inventory, etc.)

### Finance
- Utilize collected data to justify high ROI CAP X projects
- Results of CAP X Projects

### Maintenance
- Use MTTR and MTFB to improve operations
- Top 10 hitter report on demand
- Foundation for TPM Initiatives

### IT Team
- Increase user satisfaction
- Application consolidation and re-platforming
- Integrated production environment with enterprise
- Decrease shadow IT projects

### Production and Line Supervisors
- Production & quality reporting by line and by crew
- Production and process data

### Quality
- Reduce and track scrap through early warning
- Foundation for CI Projects
- Finished goods quarantine to multilevel genealogy

### EH&S
- Personas Traditionally Involved in The Connected Enterprise Journey
Some key steps to make the most of safety in The Connected Enterprise

- Active EHS representation
- Assess the current state
- Determine meaningful data and information
- Implement or upgrade safety systems
- Analyze and optimize
Key Takeaways

- Safety is fully integrated into automation and The Connected Enterprise
- Smart, Safety, Secure machines driven by demand for Enterprise Risk Management and Corporate Social Responsibility
- EHS is an integral part of the manufacturing enterprise and the business strategies
- The safer the company is, the higher its OEE
Harnessing the power of safety and operational data can substantially improve safety compliance and performance.

The Connected Enterprise enables this, empowering safety professionals with a real-time understanding of worker behaviors, machinery compliance, causes of safety shutdowns or stoppages, and safety anomalies and trends.

Thank You!