Risk Mitigation through Enhancement of Team Situation Awareness

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Risk

Prior Speakers…

• “complex systems”
• “cost pressures”
• “demand will outstrip supply”
• “frontier” developments
• “Thatcher’s Law”

Situation Awareness
Introduction

LNG operations personnel can face challenges from a deficiency in both individual and team situation awareness, which can influence the risk associated with work activities.

This presentation will introduce a technique to help evaluate risk and identify mitigating opportunities where situation awareness can be enhanced through improving aspects of the work environment (e.g. instrumentation, process control, communication, and ergonomics).

The Situation Awareness Identification Technique (SAIT) utilizes hierarchical task analysis and a novel method to rate performance shaping factors (PSFs) for individuals within an operating team framework to evaluate and improve situation awareness.

The objective of SAIT is to identify the system variables that influence the probability of success in completing work tasks and identifies opportunities to improve an Operators’ mental model of current and future states of the system.
Human Factors Studies

- How can we achieve further improvement in Safety, Health and Environmental performance? – Progress will come by taking better and more explicit account of the way people interact with every aspect of their workplace; in other words, incorporation of human factors… we need to consider how individuals interact with each other, facilities, equipment and management systems – International Association of Oil and Gas Producers.


- Prediction of Human Error Probabilities for Muster Actions During LNG Tanker Emergencies, DiMattia, D., IGURC, S. Korea, 2011.
Human Factors

**Human factors:**

- Environmental, organizational and job factors, system design, task attributes and human characteristics that influence behaviour and decision making.

**Human error:**

- Any human action or lack thereof, based on an understanding of the current and future state of the system in question that exceeds or fails to achieve some limit of acceptability, where limits of human performance are defined by the system.

<table>
<thead>
<tr>
<th>PSFs</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity</td>
<td>Intricacy of the action or sub-action. Can promote short cuts while following procedures (e.g. violations).</td>
</tr>
<tr>
<td>Weather</td>
<td>Impact of weather conditions on the ability of team to effectively communicate and complete outside tasks. May impact an individuals ability to work in effectively and may cause delays or promote improvisation to compensate.</td>
</tr>
<tr>
<td>Experience</td>
<td>Experience as related to the task to be completed. Individuals with less experience may perform tasks at a slower pace and may work under greater level of stress. Individuals with greater level of experience may form biases and may not be as responsive to certain cues.</td>
</tr>
<tr>
<td>Training</td>
<td>Training as related to working in a manner that accomplishes tasks in a safe and responsible manner. Training in understanding equipment operation and process knowledge.</td>
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</tbody>
</table>
Situation Awareness

Process systems generate large amounts of data very rapidly. The challenge for the Operations Team is finding what information is needed, when it is needed. The data must be accurate and discernible to allow for proper processing by the receiver and communicated, as required, between team members.

Situation awareness is defined as follows:

• The continuous development of mental models based on an understanding of the work domain through the interpretation of data, information and communications, to describe and explain the current state of the domain and to predict future states.

The 3 levels of situation awareness are as follows:

1) Perception
   • Level 1 situation awareness addresses perception and is considered the basic level of situation awareness.

2) Comprehension
   • Level 2 situation awareness encompasses how people combine, interpret, retain, and store information.

3) Projection
   • Level 3 is the ability of an Operator to forecast a future state marks the highest level of situation awareness.
Sources of Situation Awareness

Situation awareness is derived from a variety of information sources within the work domain.

- DCS feedback
- Communication
- External factors such as sound and visual cues
- Local instrument feedback
- Equipment interface
Work Team Goals

- Individual tasks (subgoals), within a team framework, overlap to achieve an overall team goal.

- An improvement in an individual’s situation awareness improves the overall team situation awareness through more accurate shared mental models.
Situation Awareness Identification Technique

• The SAIT process allows for its application on a wide basis across operating procedures in whole or in part, focusing on specific goals.

• The SAIT technique is flexible and allows users to work in cross functional teams.

• SAIT allows for the inclusion of any PSFs deemed pertinent.

• The Success Likelihood Index (SLI) for a given action is determined based on the PSFs.
The Success Likelihood Index

Determining the Success Likelihood Index (SLI) for an action:

- **Performance Shaping Factor Weight (PSF)** provides the importance of the PSF.

- **Performance Shaping Factor Rating (PSF)** is a measure of the quality of the PSF.

- **SLI** is a relative measure of the probability of success in completing an action successfully.

\[
\theta_j = \sum_{i=1}^{n} \omega_{ijk} \quad \sigma_{ijk} = \frac{\omega_{ijk}}{\theta_j} \quad \sum_{i=1}^{n} \sigma_{ijk} = 1 \quad \beta_{ijk} = \sigma_{ijk} \times \delta_{ijk}
\]

- For each work action consider the associated PSFs (i) to be as severe as possible for the given task.
- A PSF is identified that if improved provides the greatest possibility of completing the task successfully. That PSF is given a value of 100 (PSF\(_{100}\)).
- In increments of 10, the remaining PSFs are weighted (\(\omega_{ijk}\)) against PSF\(_{100}\).
- The weighting of the remaining PSFs do not need to be unique.
- The weights are summed for each action (\(\theta_j\)). The PSF weights are then normalized for each action (\(\sigma_{ijk}\)).
- For the given action a rating (\(\delta_{ijk}\)) is determined for each PSF.
- A PSF Rating Table is utilized to establish the rating value, on a scale from 0 to 100, in increments of 10.
- A rating of 100 indicates that the PSF is optimal while a rating of 0 indicates the PSF has no effect. The rating for each PSF does not have to be unique.
- The Success Likelihood Index (\(\beta_{ijk}\)) is the product of normalized weight and rating for each PSF.
SAIT Output

The results from the SAIT process are compiled in a spreadsheet for review and analysis.

- Compiling the data in this manner allows for a review of the SLI for each PSF within each category for a given action component.
- Weaknesses within the system can be flagged and addressed accordingly to promote a higher level of situation awareness on an individual and team basis.

### Major Goal: 1.0

<table>
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<tr>
<th>Subgoal</th>
<th>1.1</th>
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<table>
<thead>
<tr>
<th>Task</th>
<th>Subgoal</th>
<th>PSF Cat. 1</th>
<th>PSF Cat. 2</th>
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<tr>
<td>SA Action</td>
<td>1.1A</td>
<td>PSF 1</td>
<td>PSF 2</td>
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<td>Component</td>
<td>1.1A.1</td>
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<tr>
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<td>1.1A.1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Component</td>
<td>1.1A.1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SA Action</td>
<td>1.1A.2</td>
<td></td>
<td></td>
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<tr>
<td>Component</td>
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<tr>
<td>Component</td>
<td>1.1A.2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SA Action</td>
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<td></td>
<td></td>
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<tr>
<td>Component</td>
<td>1.1A.3.1</td>
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<tr>
<td>Component</td>
<td>1.1A.3.2</td>
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<th>PSF Cat. 1</th>
<th>PSF Cat. 2</th>
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<td>SA Action</td>
<td>1.1B</td>
<td>PSF 1</td>
<td>PSF 2</td>
</tr>
<tr>
<td>Component</td>
<td>1.1B.1</td>
<td></td>
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<tr>
<td>Component</td>
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</tr>
<tr>
<td>Component</td>
<td>1.1B.1.2</td>
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<tr>
<td>SA Action</td>
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<tr>
<td>Component</td>
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<tr>
<td>Component</td>
<td>1.1B.3.2</td>
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SAIT Output:
- Adaptable
- Transparent
- Consistent
Scenario: The start-up of the second stage LNG send out pumps, after maintenance.

- Occurs in several steps that requires very good **coordination between the CCR and Outside Operators**.
- **Team based activity** that requires continuous assessment of the situation to avoid making errors in the field / CCR.
- **Human error** can lead to operational upsets at pump start-up or a loss of containment from an improper cool down.
- The valve preparation and cool down work **can take more than a 12 hour shift** to accomplish.

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### Operating Procedure

1. **Task Analysis**
2. **Determine PSFs**
3. **SLI Computation**
4. **Data Analysis and SA Ranking**
5. **Risk Mitigation Review and Reassess if Required**
6. **Compile Results**

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### SAIT Flow Diagram

- LNG Tanker
- LNG Vapour Return Line
- BOG Compressor
- LNG Unloading Line
- LNG Storage Tank
- 1st Stage Send Out Pump
- Recondenser
- Vaporizer
- Fuel Gas
- Pipeline
- 2nd Stage Sendout Pump(s)
Work Goals and Tasks

**Major Goal 1.0**
Return Send Out Pump to Service
Restablish send out rate to natural gas system

**Subgoal 1.1 - Pump Preparation**
Valve set-up and purging of air using nitrogen

**Subgoal 1.2 - Cooldown of Pump Suction and Caisson**
Preparing piping and pump for LNG

**Subgoal 1.3 - Cooldown of Pump Discharge**
Preparing piping for LNG

**Subgoal 1.4 - Valve and Controls Set-up**
Valves are start-up position and pump controls are set

**Subgoal 1.5 - Test Pump and Startup**
Jog pump and ensure systems are ready for start. If ready, pump is started.

**Subgoal 1.2 - Cooldown of Pump Suction and Caisson**
Valve set-up and purging of air using nitrogen

**Task 1.2A - Valve Set-up**
Valve set-up in preparation for cool down

**Task 1.2B - System Cool Down**
Cool down of suction system to send out pump

**Task 1.2C - Charge Pump**
Fill up pump caisson while achieving target temperature

**Task 1.2D - Valve Set-up**
Set-up valves in pump suction in readiness for next task

**Scenario:** Start-up of the second stage LNG send out pumps, after maintenance.

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**April 19, 2013**
Predicting the SLI

### Rating Scale

<table>
<thead>
<tr>
<th>SLI</th>
<th>Weather</th>
<th>Ergonomics</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>No effect</td>
<td>High quality</td>
</tr>
<tr>
<td>50</td>
<td>Some effect</td>
<td>Mid quality</td>
</tr>
<tr>
<td>0</td>
<td>Large Effect</td>
<td>Low quality</td>
</tr>
</tbody>
</table>

### SLI %

<table>
<thead>
<tr>
<th>SLI %</th>
<th>SA Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>26-50</td>
<td>Needs Improvement</td>
</tr>
<tr>
<td>51-75</td>
<td>Adequate</td>
</tr>
<tr>
<td>76-100</td>
<td>Enhanced</td>
</tr>
</tbody>
</table>

### Cooldown of Pump & Caisson

<table>
<thead>
<tr>
<th>Cooldown of Pump &amp; Caisson</th>
<th>1.2</th>
<th>External Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Cooldown</td>
<td>1.2B</td>
<td>Weather</td>
</tr>
<tr>
<td>Assess and Monitor</td>
<td>1.2B.1</td>
<td></td>
</tr>
<tr>
<td>Assess Task Activities</td>
<td>1.2B.1.1</td>
<td>28.6</td>
</tr>
</tbody>
</table>

### Risk mitigation:

- Car seal log survey and update.
- Construction of temporary scaffolding to access valves.
- Replacement of valve tags where needed.
Conclusions

• Situation awareness is operationally defined as **the information an individual needs to know and an understanding of those elements** to facilitate better decision making and performance.

• **Situation awareness and performance are connected in a probabilistic manner**, there is no defined limit to optimal situation awareness that can guarantee a given level of individual Operator or team based performance.

• Situation awareness should be thought of in relative terms, that is, **how can PSFs be optimized** to provide Operators the best chance of making good decisions and fewer errors.

• Decisions to modify designs and processes to raise the level of situation awareness in Operators can best be made through **proactive assessment techniques** with input from root cause failure analysis of prior incidents.

• SAIT provides a **systematic means** to break down procedures into tasks that can be readily analyzed through an evaluation of the relevant PSFs that influence situation awareness.

• Capturing **lessons learned** actively promotes a feedback loop into the SAIT protocol, allowing for the refinement of PSF weight and rating calculations, as well as the effectiveness of mitigating actions to improve Operators’ level of situation awareness.
Thank You!