



2013 Honeywell Users Group Americas

Mike Miller, Shell Global Solutions

Peter Bullemer, Human Centered Solutions

Incident Analysis Failures in Operations Team Situation  
Awareness and ASM-based Mitigation Strategies

## Presentation Outline

- What is Team Situation Awareness (SA)
- ASM Consortium Effective Operations Practices & Process Safety Management
- ASM Root Cause Analysis SA Results
- ASM Solutions for SA Root Causes
- Conclusions & Discussion

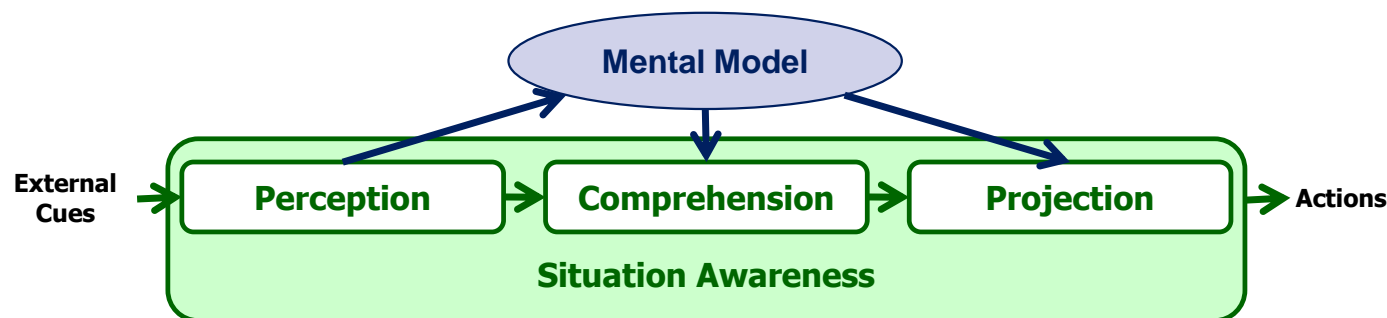
## Presentation Outline

- What is Team Situation Awareness (SA)
- ASM Consortium Effective Operations Practices & Process Safety Management
- ASM Root Cause Analysis SA Results
- ASM Solutions for SA Root Causes
- Conclusions & Discussion

## Team Situation Awareness

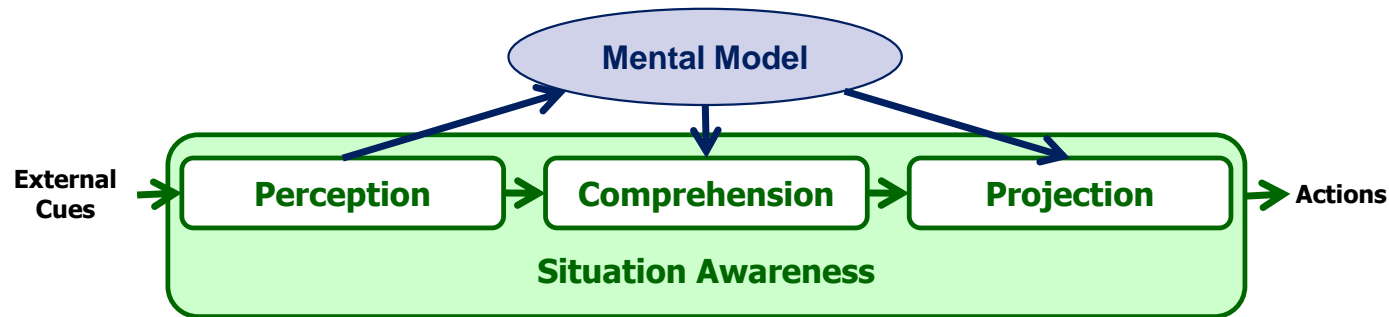
- To understand what Team Situation Awareness (Team SA) is...
  - We need to understand what *Situation Awareness for an Individual* is **first**

## What is Situation Awareness (for an individual)



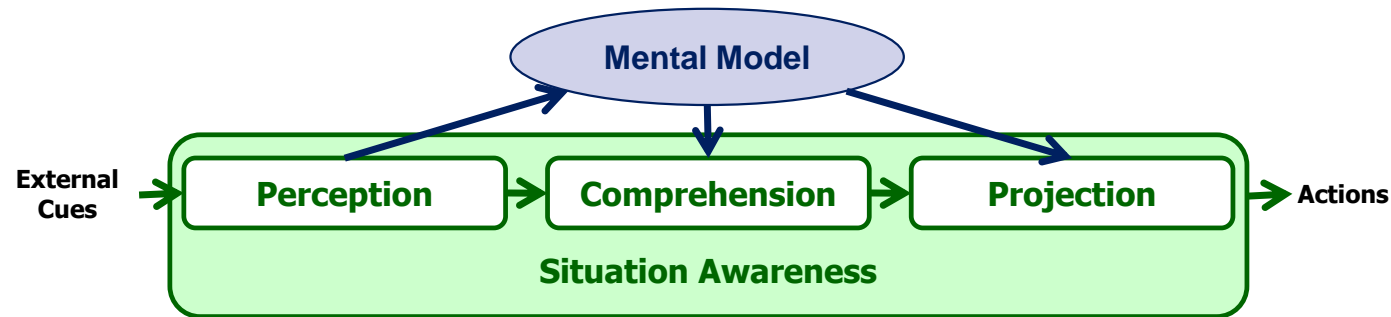
- Put simply, Situation Awareness is **“knowing what is going on round you so you can figure out what to do”** (Adam, 1993)
- Research in military and civil aviation has identified that problems with situation awareness were the leading factor contributing to:
  - Military aviation mishaps (Hartel, Smith & Prince, 1991)
  - Accidents among major airlines (Endsley, 1995)
- This has resulted in considerable study into pilot decision-making and training methods to improve situation awareness in aircraft pilots
  - However only recently has knowledge about SA been applied to process industries

## What is Situation Awareness (for a Process Operator)



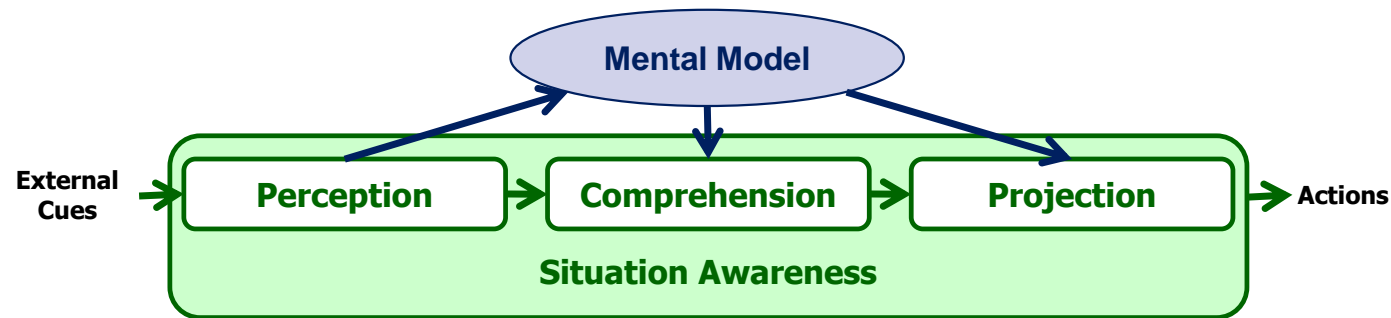
- **Level 1 SA** = involves perceiving important information
  - Failure to perceive important information leads to the formation of an **incorrect picture of what is going on**
- **Level 2 SA** = involves comprehending the perceived information with regard to specific job tasks and goals
  - Failure to accurately comprehend what is happening can lead to **reasoning with an incomplete or inaccurate picture** of what is actually happening
- **Level 3 SA** = involves projecting where the situation is going
  - Failure to accurately predict what will happen can lead to initiating **the wrong corrective actions**

## What is Situation Awareness (for a Process Operator)



- **Level 1 SA: Perception** of important information can be accomplished by —
  - Noticing patterns, deviations, or changes in key operating parameters
  - Listening to radio transmissions
  - Hearing audible alarms and reading the subsequent alarm descriptions
  - Listening for unexpected sounds in the physical plant during rounds

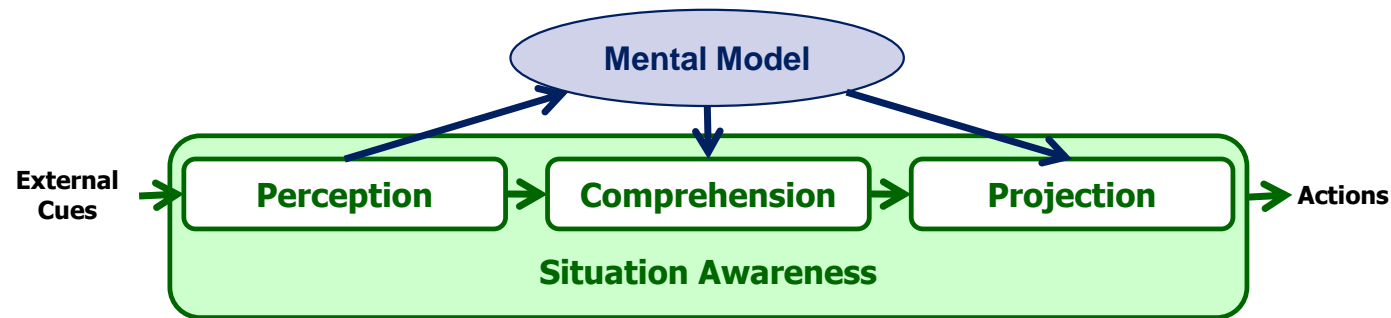
## What is Situation Awareness (for a Process Operator)



- **Level 1 SA:** Perception of important information
- **Level 2 SA:** Comprehension involves having an accurate mental model that can be applied to —
  - How the process operates
  - How close to critical operating limits the process might be running
  - How optimally the process is running
  - Whether the process is stable or not

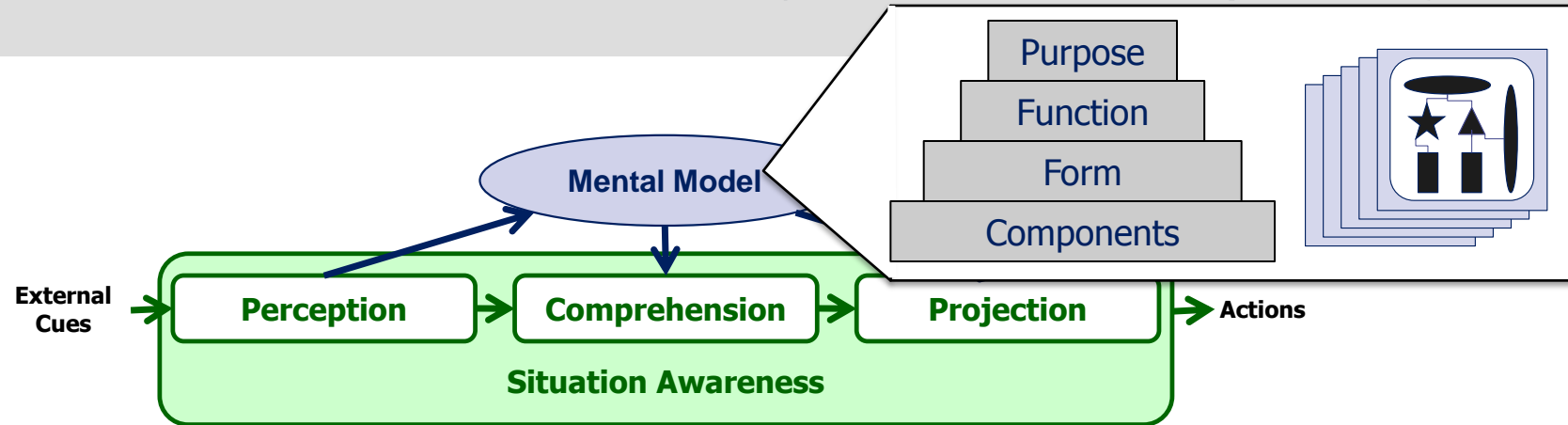


## What is Situation Awareness (for a Process Operator)



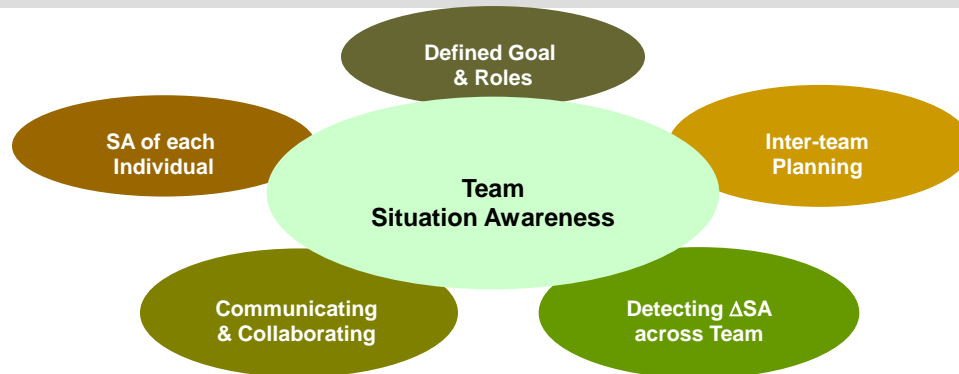
- **Level 1 SA:** Perception of important information
- **Level 2 SA:** Comprehension involves having an accurate mental model
- **Level 3 SA:** Projection involves —
  - Anticipating how quickly the process might exceed a limit
  - Knowing whether a control action will have the desired result (remain stable / become steady or how will it stabilize)

## What is Situation Awareness (for a Process Operator)



- Mental Models consist of several kinds of information:
  - Hierarchy of knowledge / understanding – an abstraction hierarchy
  - Facts, episodes, detailed knowledge (the what)
  - Schemas & scripts (e.g., procedural knowledge) (the how)
- This allows us to
  - Recognize patterns that we have seen / heard / experienced before
  - Reason about the same problem in different ways
  - Apply our expertise to a new, novel situation we've not encountered

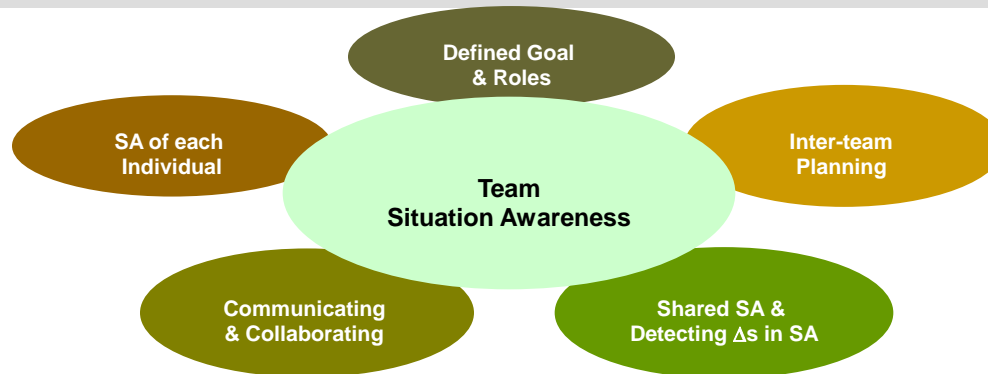
## Team Situation Awareness



- A **Team** has (Endsley et al, 2003)
  - A common goal for the team members
  - Specific roles defined for each team member
  - Roles of different team members are interdependent
- But a Team does not have a 'suprabrain' (Endsley et al, 2003)
  - Only the individual team members can have Situation Awareness (Endsley et al, 2003)

**Team SA must be embodied by the SA of the individual team members**

## Team Situation Awareness



- **Team SA** defined
  - “the degree to which every team member possesses the SA required for his or her responsibilities” (Endsley et al, 2003)
- **Shared SA** defined
  - “the degree to which team members have the same SA on shared SA requirements” (Endsley et al, 2003)

To accomplish high Team SA, individuals’ SA must be high and Shared SA between members must also be high

## Presentation Outline

- What is Team Situation Awareness (SA)
- **ASM Consortium Effective Operations Practices & Process Safety Management**
- ASM Root Cause Analysis SA Results
- ASM Solutions for SA Root Causes
- Conclusions & Discussion

## Abnormal Situation Management A Joint Research & Development Consortium

Founded in 1994

- Creating a new paradigm for the operation of complex industrial plants
- Developing solutions that improve Operations' ability to prevent and respond to abnormal situations

[www.asmconsortium.org](http://www.asmconsortium.org)



**ExxonMobil**



**UOP**

A Honeywell Company

**Honeywell**

**Human Centered Solutions**

Helping People Perform



**UCLA**

## What is an Abnormal Situation?

- An industrial process is being **disturbed** and the automated **control system** **can not cope**
- Consequently, the operations team **must intervene** to supplement the control system



*An Abnormal Situation Impacts Process Safety*

## Establishing Effective Operations Practices Not By Technology Alone

**Human performance that can lead to plant upsets and incidents is not changed by the mere exposure to data and technology**

- Many companies in the process industries seek to **improve operations reliability through operator performance improvements**.
- A key aspect of improving operation reliability is to **reduce the costs associated with abnormal situation management**.
- Effective solutions go **beyond** the delivery of more **data** and advanced **technology** to the operator.
- Establish effective operations practices that enable the operations to effectively **prevent and respond to abnormal situations**.

Cochran, E. and Bullemer, P. (1996). *Abnormal Situation Management: Not by New Technology Alone....* Paper presented at the AIChE Conference on Plant Safety, Houston, TX.



## ASM & Process Safety Management

### Safety Pyramid Illustration

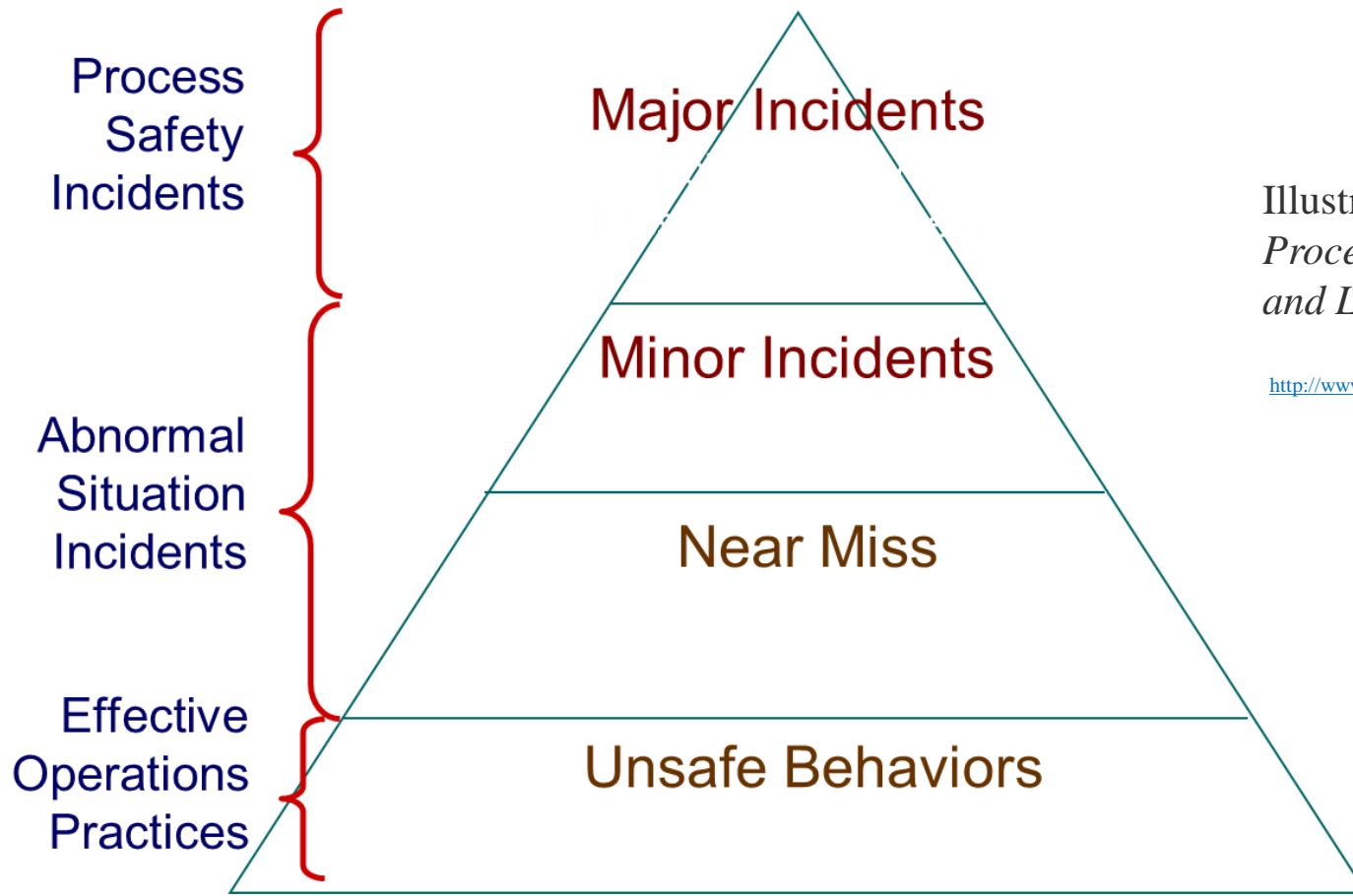


Illustration from: CCPS  
*Process Safety Leading and Lagging Metrics.*

<http://www.aiche.org/ccps/metrics/index.aspx>

## Presentation Outline

- What is Team Situation Awareness (SA)
- ASM Consortium Effective Operations Practices & Process Safety Management
- **ASM Root Cause Analysis SA Results**
- ASM Solutions for SA Root Causes
- Conclusions & Discussion

## Understanding Operations Practice Failures Analysis of 32 Major Incidents

- Identified 123 candidate incidents (99 public, 24 site)
- Priority given to **recent refining/chemical incidents** with severe consequences and detailed reports
- 32 incidents selected for analysis of operations failures

	Public	Site	<i>Total</i>
USA	14	7	21
Non USA	6	5	11
<b><i>Total</i></b>	<b>20</b>	<b>12</b>	<b>32</b>

A 2007-8 research study was sponsored by the Abnormal Situation Management® (ASM®) Consortium

Bullemer, P.T. and Laberge, J.C. (2010). Common operations failure modes in the process industries. *Journal of Loss Prevention in the Process Industries*. Elsevier.

## Operations Failures

- **Failure** is a practice flaw that, if corrected, could have prevented the incident or mitigated its impact
  - What went wrong in the words of the investigators
  - Example: Supervisor not accessible
- **Common failure modes** are shared operational practice failures across incidents
  - Failures map to *ASM Effective Operations Practices* Guidelines
  - Example: Ineffective first-line supervision



### **ASM® Consortium Guidelines** **Effective Operations Practices**

Last Revision Date: 3 March 2009

Version: 6.00

Filename: ASMOpsPractice\_v6.doc

Prepared by: Peter Bullemer, Ric Barreth, Jason Laberge and Ian Nimmo  
ASM® Joint R&D Consortium

Contact Information:

Consortium Director

HL-ASM-Director@honeywell.com

## Understanding SA Failures

### Re-analysis of 32 Major Incidents

Basic Causes	% of Causes
Work Direction	13%
Communications	11%
Management Systems	8%
Human Machine Interface	5%
Procedures	4%
Training	4%
Quality Control	1%
Non-SA Related	54%

- **50% of operations practice failures were SA failures**
- **46% of causes were SA related root causes**

## Understanding SA Failures

### Top Ten Root Causes

Root Causes	% of SA Root Causes
No Communication	12%
Crew Team NI	11%
Displays NI	9%
No Supervision	9%
Communications NI	5%
SPAC Not Followed	5%
Situation Not Covered	4%
Pre-job Briefing NI	4%
Learning Objectives NI	3%
No SPAC	3%
Total	65%

- **Top Ten represent 65% of the SA related root causes**

NI = Needs Improvement

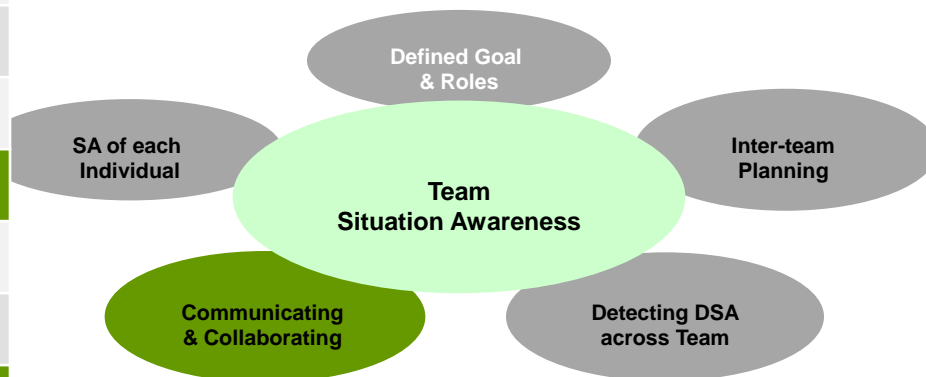
SPAC = Standards, Policies and Administrative Controls

## Presentation Outline

- What is Team Situation Awareness (SA)
- ASM Consortium Effective Operations Practices & Process Safety Management
- ASM Root Cause Analysis SA Results
- **ASM Solutions for SA Root Causes**
- Conclusions & Discussion

## Communications and Collaboration

Root Causes	% of SA Root Causes
No Communication	12%
Crew Team NI	11%
Displays NI	9%
No Supervision	9%
Communications NI	5%
SPAC Not Followed	5%
Situation Not Covered	4%
Pre-job Briefing NI	4%
Learning Objectives NI	3%
No SPAC	3%
Total	65%





## Communications and Collaboration

- Successful communication enables situation awareness **under normal, abnormal and emergency situations**
  - Communications practices allow operational and functional team members to efficiently **perceive, orient, evaluate and act on information** in context to the current team goals and constraints
  - Team members **coordinate with respect to goals and activities**, through the use of effective information media to ensure continuity in work conditions
- ✦ ***Solution Elements:***
- Structured daily communications
  - Operations & maintenance interactions
  - Task-based communications protocol



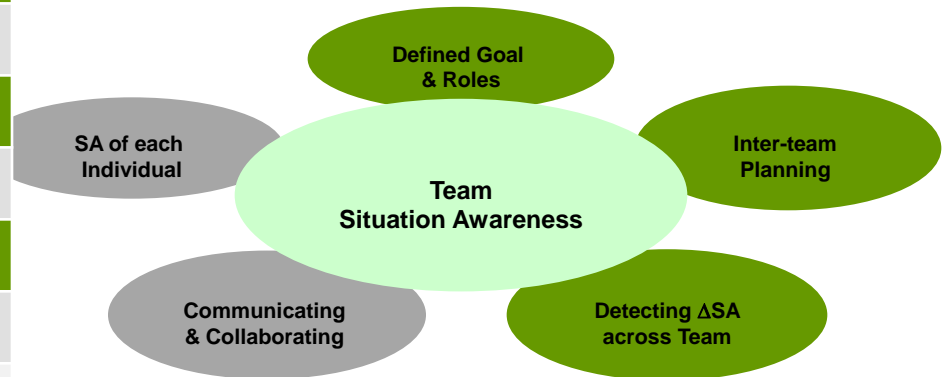
## Communications and Collaboration

### Checklist for Structured Shift Handovers

- Experiment at an ASM member refinery compared the quality of shift handovers using a structured checklist-integrated logbook to a traditional, less structured e-logging approach (~ 1-2 min. extra time in handover)
- Checklist-integrated shift log provided sub-categories of information, which prompted operators to acknowledge each detail even if there was nothing relevant to report
- Results
  - Higher-quality log entries compared to model entries generated by operations experts (+18.6%)
  - Second shift operators provided more accurate and comprehensive account of the unit situation (+9%)
  - Operators accuracy in answering questions without need to consult other team members (+8%)

## First-Line Leadership

Root Causes	% of SA Root Causes
No Communication	12%
Crew Team NI	11%
Displays NI	9%
No Supervision	9%
Communications NI	5%
SPAC Not Followed	5%
Situation Not Covered	4%
Pre-job Briefing NI	4%
Learning Objectives NI	3%
No SPAC	3%
Total	65%



## First-Line Leadership

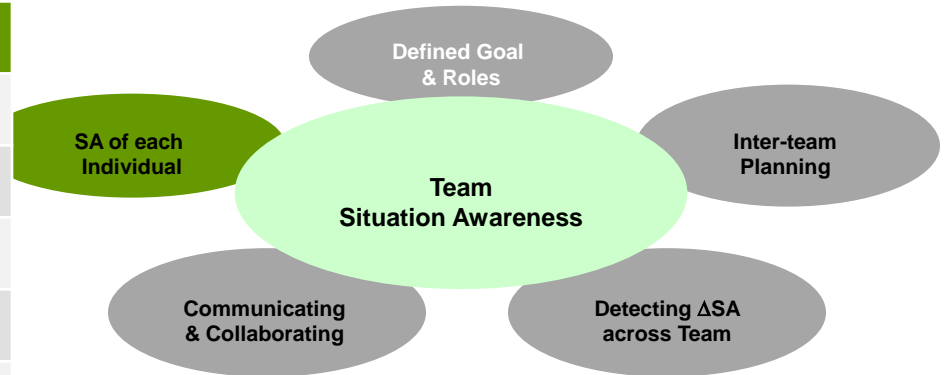
- The supervisor role is a **rostered – and back-filled – position** on the shift team
- The supervisor is **recognized by the operations team** as the leader and director of work activities, particularly during abnormal situations
- The supervisor is **available** for consultation and **maintains a presence** around the operations team work areas
- The supervisor ensures that individuals' behaviors **are compliant with site policy and work practices**
- ★ ***Solution Elements:***
  - First-line Leadership competency model
  - Leadership training
  - First-line Leadership Audit Checklist

## First-Line Leadership Audit Checklist Items Examples

- The supervisor maintains a presence in the control room and field areas
  - With face-to-face contact periodically throughout a shift to ensure good situation awareness of Operations and Maintenance activities
- The supervisor is easily accessible via radio contact by any team member to answer questions and respond to problems
- The supervisor assigns a stand-in responsibility when leaving the job site
- The supervisor enforces clear guidelines on when and how to conduct pre-job briefings
- The supervisor ensures that individuals' behaviors are compliant with site policy and work practices, and does not allow individuals to operate in the presence of known hazards without taking adequate precautions

## Operator Interface Design

Root Causes	% of SA Root Causes
No Communication	12%
Crew Team NI	11%
Displays NI	9%
No Supervision	9%
Communications NI	5%
SPAC Not Followed	5%
Situation Not Covered	4%
Pre-job Briefing NI	4%
Learning Objectives NI	3%
No SPAC	3%
Total	65%

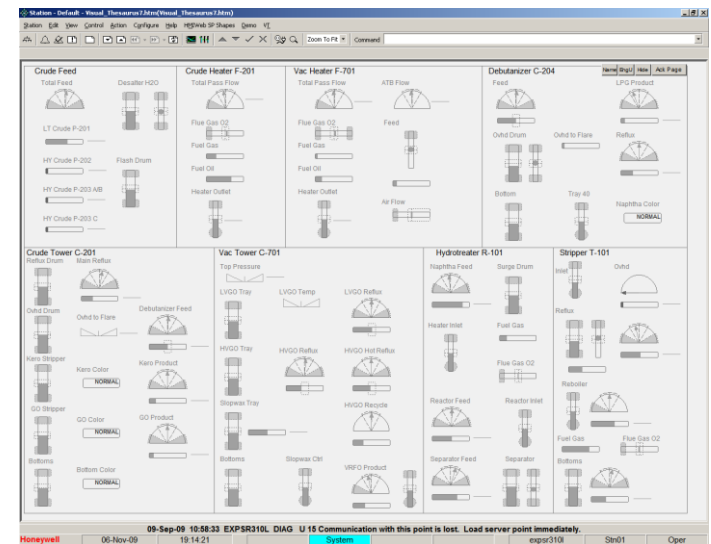
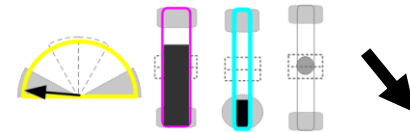


## Operator Interface Design

- A comprehensive and user-centered set of applications and tools that enables
  - A single point of access to the information needed for
    - Operations Team Situation Awareness
    - Effective prevention and response to Abnormal Situations

### ★ ***Solution Elements***

- Integrated information access
- Perceptual display objects
- Console-wide overviews
- Rationalized alarms
- Alarm Trend Summary displays
- Console view of field activities

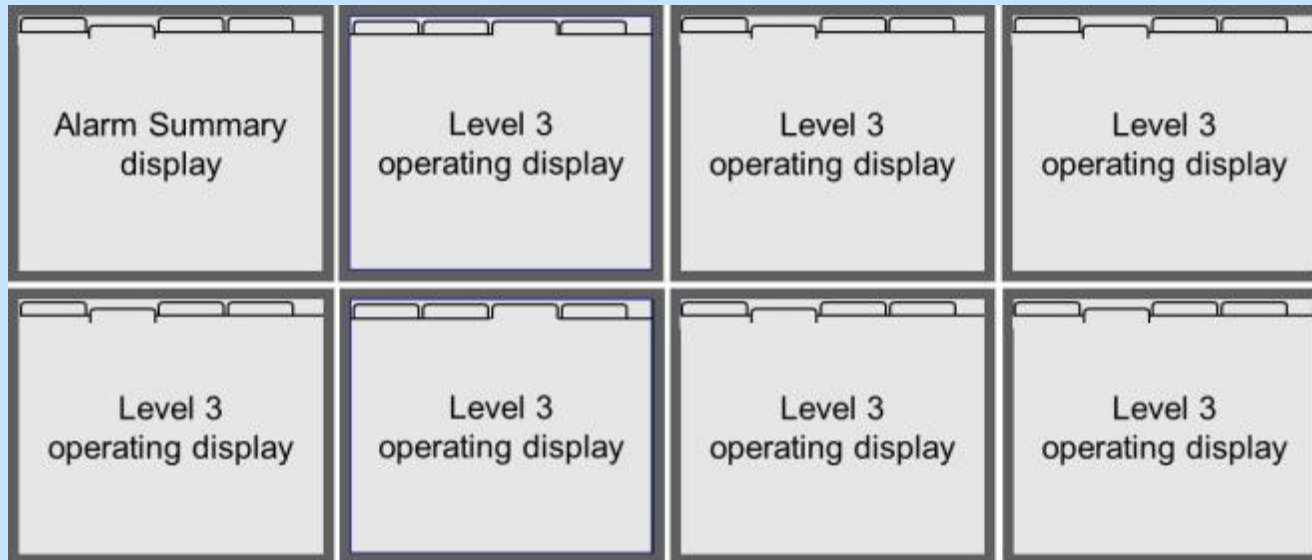


## Operator Interface Design

### Scope of Work vs. Screen Use

- Typical 'thinking' when talking about graphics... single screen-single display thinking

#### Typical Console screen use



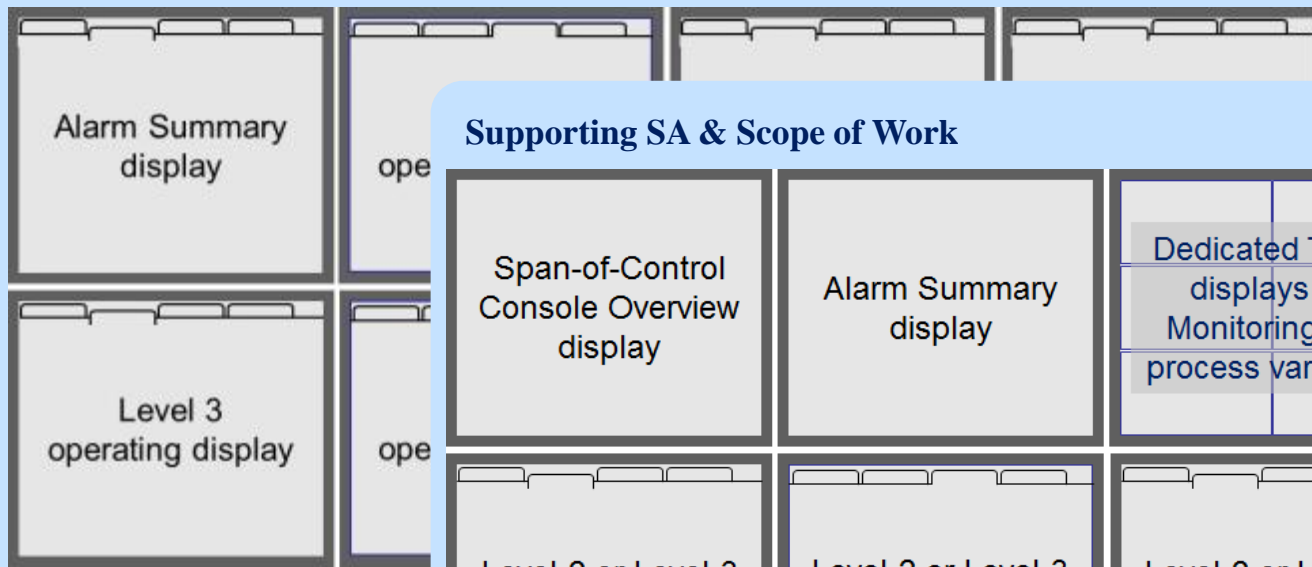


## Operator Interface Design

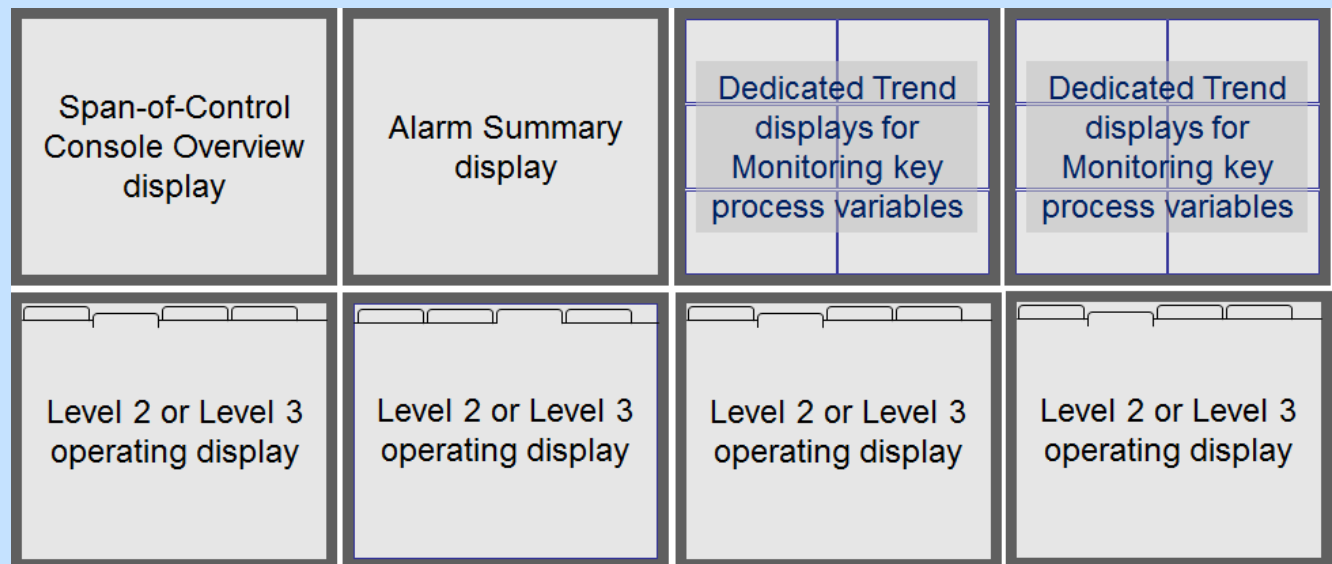
### Scope of Work vs. Screen Use

- Typical 'thinking' when talking about graphics... single screen-single display thinking

#### Typical Console screen use



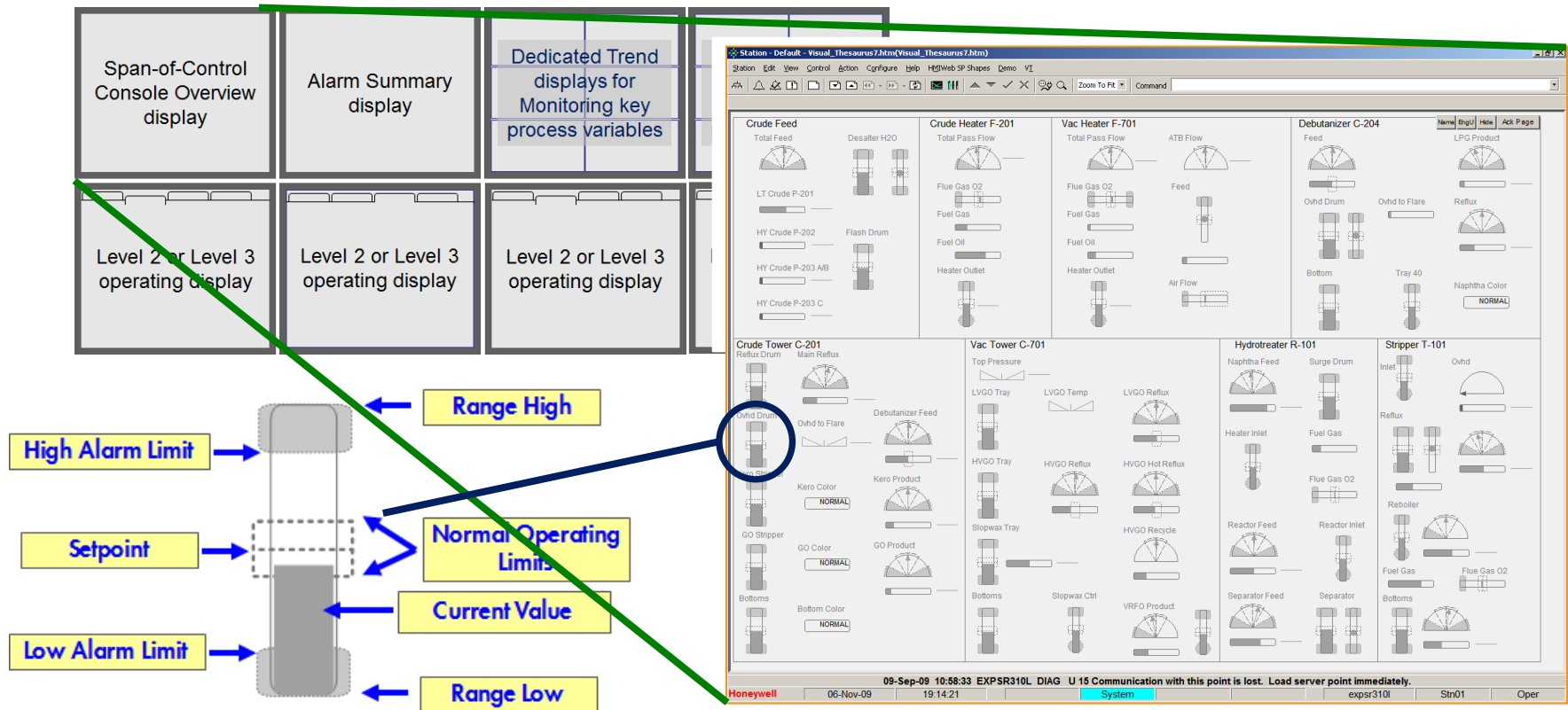
#### Supporting SA & Scope of Work



## Operator Interface Design

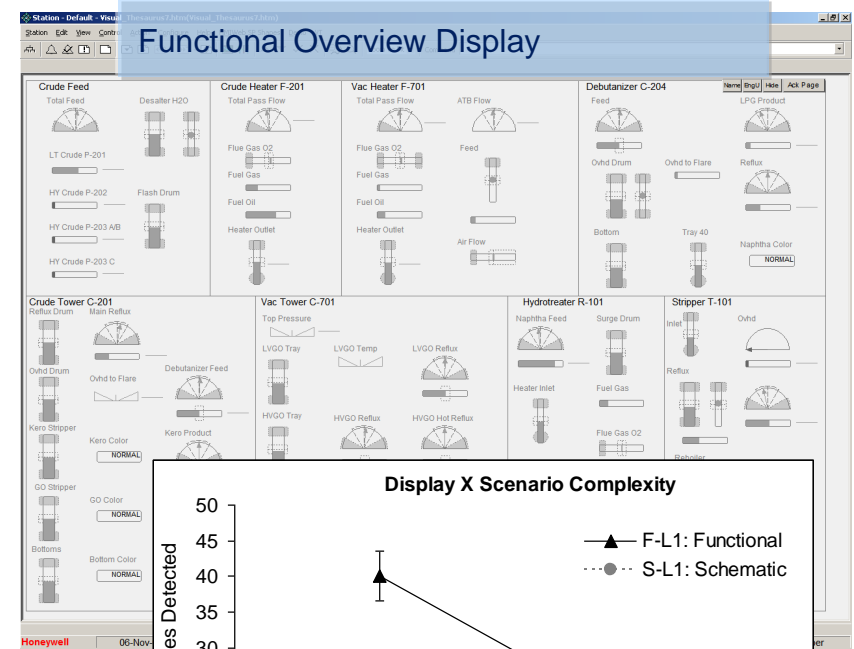
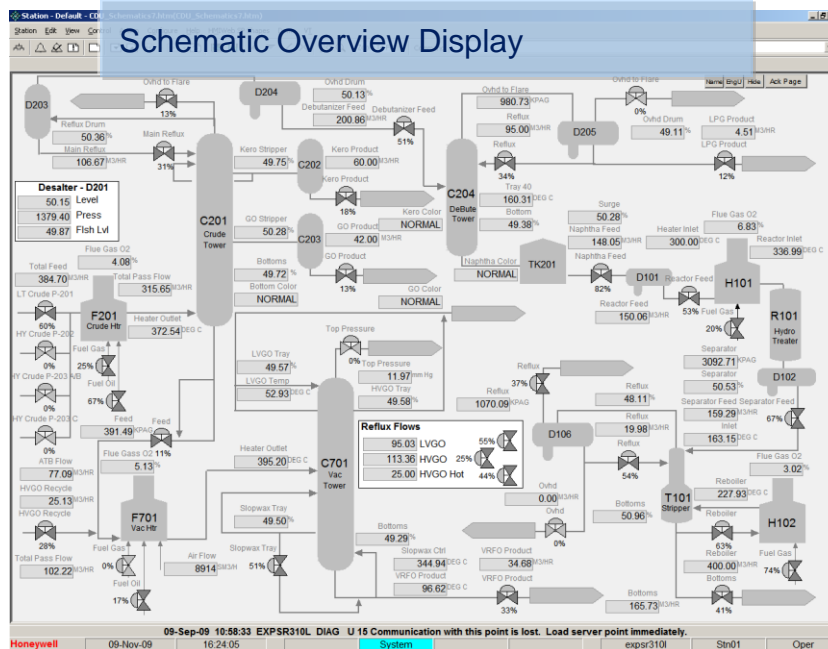
### Effective Span-of-Control Overview Display Design

- Supporting At-a-Glance Situation Awareness in SOC Overview displays

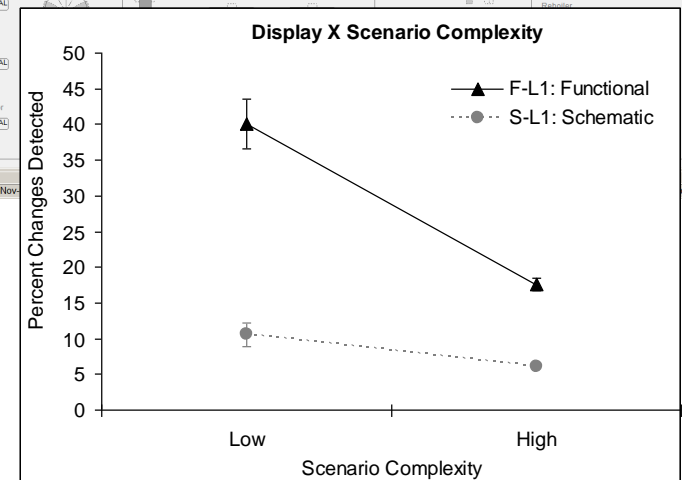


## Operator Interface Design

### Effective Span-of-Control Overview Display Design

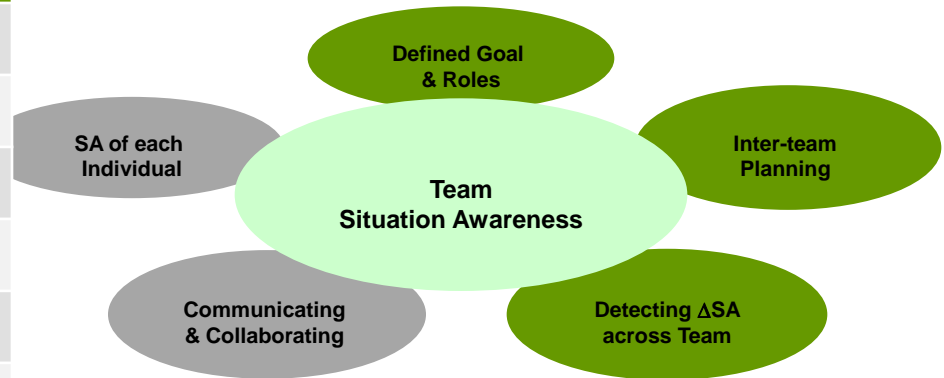


- Operator Performance Study with a simulator platform
  - Main equipment areas & Variables were the same
  - Significant Finding—more changes detected using Functional Display



## Operator Development & Training

Root Causes	% of SA Root Causes
No Communication	12%
Crew Team NI	11%
Displays NI	9%
No Supervision	9%
Communications NI	5%
SPAC Not Followed	5%
Situation Not Covered	4%
Pre-job Briefing NI	4%
Learning Objectives NI	3%
No SPAC	3%
Total	65%



## Operator Development & Training

- Knowledge and skill development
  - Establishes and maintains the competencies needed for effective abnormal situation response.
  - Is a continuous process that is supported by a performance evaluation framework that
    - Identifies training opportunities and
    - Enables sustainable operator performance over time
- ✦ ***Solution Elements:***
  - Common mental model development
  - Problem-solving & troubleshooting
  - Team-based abnormal/alarm response strategies

## Strategy for Improving Teamwork

### Upset Response Training

- **Define clear roles and responsibilities** that emphasize value of team work
- Assign someone responsibility for **maintaining the big picture**
  - i.e., what has been, what is now going on, the risks of specific actions or inactions, etc.
- Train to **common functional models** of plant/process operations
- Train to common cause/effect **troubleshooting strategies**
- Conduct team-based training exercises
  - Periodic review of procedures
  - Periodic red-tag drills

## Presentation Outline

- What is Team Situation Awareness (SA)
- ASM Consortium Effective Operations Practices & Process Safety Management
- ASM Root Cause Analysis SA Results
- ASM Solutions for SA Root Causes
- **Conclusions & Discussion**

## Conclusions & Discussion

- To accomplish high Team SA, individuals' SA must be high and Shared SA between members must also be high
- 32 incidents selected for analysis of operations failures
  - **50% of operations practice failures were SA failures**
  - **46% of root causes were SA related** root causes
- ASM Solutions that address the Top Ten root causes
  - **Communications protocols (e.g., structured handover checklist)**
  - **First Line Leadership audit checklist**
  - **Span of Control Overview display design**
  - **Upset Response Training**

