Building Situation Awareness
In Oil & Gas Operations

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Situation Awareness is critical in a Wide Variety of Domains.

- Aviation
- Air Traffic Control
- Maintenance
- Medicine
- Military Command & Control
- Intelligence
- Space Flight
- Power Systems
- Oil & Gas
- Transportation

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Consequences of Poor SA

As much as 88% of human error is due to problems with situation awareness
Oil & Gas Drilling

- **Macondo Well Blowout, April 2010**
  - BP did not inform Halliburton of the number of centralizers it eventually used, let alone request new modeling to predict the impact of using only six centralizers.
  - What nobody appears to have noticed during those six minutes (perhaps as a result of all of the activity) was that drill-pipe pressure was increasing again. With the pumps off, the drill-pipe pressure (red line in yellow box in Figure 4.8) should have stayed constant or gone down. Instead, it went up by approximately 250 psi.
  - BP’s team appears not to have seriously examined why it had to apply over four times the 750 psi design pressure to convert the float valves.

In the future, the instrumentation and displays used for well monitoring must be improved. There is no apparent reason why more sophisticated, automated alarms and algorithms cannot be built into the display system to alert the driller and mudlogger when anomalies arise. These individuals sit for 12 hours at a time in front of these displays. In light of the potential consequences, it is no longer acceptable to rely on a system that requires the right person to be looking at the right data at the right time, and then to understand its significance in spite of simultaneous activities and other monitoring responsibilities.
SA in Pipeline Operations

• SA failures can also negatively effect pipeline operations
  – **Needed information can be hard to detect**
    • Noise, distractions, failure to observe key features, leaks, automation status
  – **Operator can fail to comprehend the significance of information**
    • Tank venting, impact of heater placement, need for pressure equalization, effect of vibrations on valves, reason for alarm
  – **Failure to project future events**
    • Potential for fire
    • Overfill of tanks
    • Future repeats of existing problems
    • Behavior of automated systems
What is Situation Awareness?

Situation Awareness is the *Perception* of elements in the environment within a volume of time and space, the *Comprehension* of their meaning, and the *Projection* of their status in the near future.*

*Endsley, 1988*
Situation Awareness

Data

Perception
- Seeing/hearing alarm
- Seeing pressure reading
- Feeling vibrations
- Hearing “quiet”
- Observing temperature

Comprehension
- System status
- Understand cause due to release
- Stress on equipment
- State of equipment at pump station
- Impact of temperature of oil flow

Projection
- Anticipate alarm override or more alarms throughout day
- Need to change set point or limits
- Need to replace equipment or watch for leak
- Need to add agent for steady oil flow
Situation awareness is key to good decision making and good performance
Model of SA

Endsley, 1988, 1995
What Kinds of SA Problems Do People Have?

- Don’t Get Information That Is Needed: 78%
- Don’t Correctly Understand Information They Do Get: 17%
- Don’t Project What Will Happen in Future: 5%
SA Errors

Majority of Level 1 Errors Due to failure to Monitor or Observe Data That is Present (50%)
Highest single cause of all SA error (30%)

Biggest Single Cause is “Task Distraction”
SA Demons

Attentional Tunneling

Requisite Memory Trap

WAFOS: Workload, Fatigue & Other Stressors

Misplaced Salience

Complexity Creep

Errant Mental Models

Out-of-the-loop Syndrome
Data Overload

Technology has taken us from here to here.

But we still can’t find what we really want to know......
Information Gap

Data Produced

Sort

Find

Integrate

Information Needed

Process

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Know the Situation. Know the Solution.
Why the Information Gap?

- Data is gathered and presented from different systems & sources
- Each new system is just added on
- Data not integrated or transformed into real needs of user
- Decision maker left to figure it out

Technology Centered Design

Design Technologies
Let Human Adapt

Fatal Flaw
- Human can only adapt so far
- “Human Error”
- Resultant System is Sub-Optimized
User-Centered Design Philosophy

Design technology to fit capability of humans

- Integrate data around real needs of decision makers
- Present information in ways that are quickly understood and assimilated

Result

- Better Decision Making
- Improved Safety/Reduced Injury
- Improved User Acceptance & Satisfaction
- Improved Productivity
SA-Oriented Design

SA Requirements Analysis → SA-Oriented Design → SA Measurement

50 Design Principles

Goals
- Projection Requirements
- Comprehension Requirements
- Data Requirements

Designing for Situation Awareness
An Approach to User-Centered Design
Second Edition

Mica R. Endsley and Debra G. Jones

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Know the Situation. Know the Solution.
Goal Directed Task Analysis (GDTA)

- Goals
  - Subgoals
  - Decisions
    - Projection Requirements
    - Comprehension Requirements
    - Perception Requirements

Drives Design
Drives Training
Drives Evaluation
GDTA specifies the detailed SA needs at all three levels for each role in the operation so that information presentation can be tailored.
SA-Oriented Design Principles

• General Principles
• Confidence and Uncertainty
• Dealing with Complexity
• Alarms, Diagnosis and SA
• Automation and SA
• Supporting SA in Multi-Person Operations
• SA for Unmanned and Remotely Operated Vehicles
• SA Oriented Training
Command and Control

- Fast, easy operations on the move
- One-step access to any screen or task
- Situation understanding at a glance
- Tailored information organized and integrated around key role goals and decisions
- Easy monitoring across multiple task demands
- Integrated collaboration tools for shared situation awareness across the distributed force
- Warfighter controlled flexibility for changing needs and priorities
- Intelligent assistance to manage workload without being intrusive

Approved for Public Release, Distribution Unlimited, TACOM 22 NOV 2006, case 06-274.
Poor SA: Leading Cause of Blackouts

- Data is piece-meal
- “Las Vegas” presentation
- High false alarm rates
- Limited diagnostics
- No integration across control centers

SA-Oriented Design

- Integrated to provide information, not just data
- SA at a glance
- Support for alarms
- Built in diagnostics
- Approach for shared SA
Test & Evaluation in the Design Process

- Human Performance
- Decision Making
- Workload
- Situation Awareness

SA Requirements Analysis → SA-Oriented Design → SA Measurement

Competing Technologies

Modeling

Rapid Prototyping

User-in-the-loop Simulation Testing

Field Testing

Final Design

✓ Human Performance
✓ Decision Making
✓ Workload
✓ Situation Awareness
Objective measure of SA

- Real-time man-in-the-loop simulation of system (rapid prototyping)
- At random times, freeze the simulation, blanking all displays
- Administer a rapid battery of queries to ascertain the subject's SA at that point in time
- Score the subject's SA on the basis of objective data derived from the simulation
Key Features of Approach

- **User Centered Design**
  - Detailed analysis of operator work flow, situation awareness, and human error causal factors

- **Highly Functional Information Visualizations**
  - Based on state of the art in human factors and situation awareness research

- **Objective Evaluation of Design Solutions**
  - Early, iterative user testing reduces risk and ensures that final products will meet operational needs

- **Work Collaboratively in a Team Based Approach**
  - Support multi-disciplinary teams of architects and engineers to provide human factors and ergonomics inputs as part of a total solutions
  - Develop detailed design specifications and prototypes for implementation
The Development of Expertise at SA

10 Fold Difference in SA among Experienced Personnel

SA is demanding, frequently incomplete and erroneous
- Limited attention
- Limited working memory

SA is fast, can be effortless, more complete, greater comprehension & projection
- Schema of prototypical situations
- Mental models of domain
- Automaticity of processes
- Learned skills (e.g. scan patterns, communications)

Abilities
- Spatial
- Attention
- Memory
- Perceptual
- Cognitive

Knowledge
- Mental models
  - Schema
  - Critical cues
- Goals
- Preconceptions and objectives

Skills
- Information management
- Communication
- System operations
- Scan patterns
- Planning

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Training Situation Awareness
Knowledge, Skills, & Behaviors

Virtual Environment Situation Awareness Rating System (VESARS)

Interactive Situation Awareness Trainer (ISAT)

SA Trainer

SA Feedback
Mental Models & Schema Training
Basic Skills
Meta-Cognitive Skills
Conclusion

• Situation Awareness is critical for effective decision making
• Many challenges for SA exist in Oil & Gas operations
• Situation Awareness can be directly enhanced through improved systems design to enhance information sharing and integration
• Development of training programs focused on critical cognitive skills & knowledge are needed
• Tools for objectively measuring SA can be used to validate system designs and training programs