GSE Engineering™
Systems & Simulation

Developing Situational Awareness Skills Through Simulation

WHITE PAPER

The Madeerpour, Nazir, and Lu applied Endsley Error Taxonomy model is used by the process industry to identify common error causes at each level. GSE has identified how EnVision tutorials and simulation models can help build the skills to minimize those errors in operators and teams.

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Situational Awareness Error Taxonomy

Error Type	Error Description	Simulation capabilities
Level 1: Failure to correctly perceive information		
Data not available	Data are not available due to failure of the system design to present it or failure in the Distributed Control System (DCS) or other communication and control systems.	Inserting malfunctions such as transmitter drift or a valve failing open/closed can present faulty information to the operator. This forces the trainee to evaluate all information presented to notice and understand the true, current state of the process.
Data hard to discriminate or detect	Data are available; however, control room conditions such as inadequate lighting, noise, and obstructions blocking the view, or design limitations such as poorly presented process equipment data in human-system interfaces (HSIs), or because of the nature of data, prevent operators to detect or discriminate data.	The trainee station can be limited to 1 monitor to minimize the monitoring capability of the simulated DCS intentionally.
Failure to monitor or observe data	Data are available but are not scanned due to simple omission, attentional narrowing, distractions due to multi-tasking, or high workload.	The instructor can add distractions such as phone calls or requests to provide operating condition data away from the failed area of interest. A failure or field misoperation with minor/negligible impact could be introduced and nearing resolution before a more serious failure to encourage continued diligence and prioritization.

Misperception of data	Data are misperceived due to the influence of prior expectations or misunderstood due to task distraction.	Faulty information or actions (e.g., lining up the wrong pump or process line by instructors acting as outside/field operators) can test the console operator's ability to verify actual plant status. The ability to fail a piece of equipment in multiple ways, such as pump degradation vs failure vs seal failures, can test whether the operator is misperceiving data based on experience. Even with oft-practiced failures, different timing or severity can generate a response different from the expected. With the instructor involved, we can also introduce the necessity of closed-loop-communication between people, make intentional mistakes and see how. An interesting exercise is to have the Trainer (Field Operator) reply to the communication with (OK) and misinterpret the message. How does a control room operator notice the fault and how do they act? SA is also about sharing your mental model with others to see if you are still on the same page
Memory loss	Forgetting information due to disruptions in routine or startup operations or high workload.	Launching disruptive malfunctions during a startup procedure may distract the operator and cause missteps when returning to the procedure.
Level 2: Failure to correctly integrate or comprehend information		
Lack of or poor mental model	A poor mental model does not enable the combining of information needed to meet goals, primarily associated with automated systems.	Automation can act as a barrier to really understanding what is happening in the system. EnVision Tutorials provide the necessary background information to understand the process and a structured way of information gathering (monitoring) combined with evidence-conclusion relationship comprehension. Our critical thinking exercises ask the operator to anticipate the results of a change in state, perform the operation and document the results. Immediate feedback helps the student correct or confirm their mental model of plant performance.

Use of incorrect mental model	Interpreting cues through an expected but wrong mental model of the system behavior leads to the incorrect assessment of the situation.	The operator can often restore normal conditions if the correct mental model is used. SA skills are sharpened by confirming the effect of the response and then re-evaluating/adjusting their mental model to mitigate the problem entirely. Use severity and malfunction ramp features to develop a deeper understanding of the phenomena and timing of the event horizon.
Over-reliance on default values	Routine expectations of the system are assumed even though conflicting information is available but not accessed	The simulator can be set up to show similar performance but through different causal malfunctions for example, equipment fouling and a leak may present very similar data to the operator. Because setpoints are often still achieved, transmitter drift failures can give the impression that all is still well. Operators also learn to monitor controller outputs, which may change to hold normal conditions. If left unchecked, a controller may eventually saturate at 0 or 100 % and control will be lost.
Other	Information is improperly integrated or comprehended due to working memory lapses or other undetermined cognitive reasons.	Alarms and operator actions are monitored and recorded in an event log for later review. This can help determine the misunderstandings or circumstances that were difficult for the trainee.
Level 3: Failure to project future actions or state of the system		
Lack of or poor mental model	Information about the current state is correctly understood, but a projection of that state into the near future fails because of a poor understanding of how to do so.	Multiple step change exercises and startup practice allow the trainee to develop an understanding of cause/effect. Test the operator's understanding of the timing of events, and accident progression. Ramping and severity selection of malfunctions can develop an understanding of magnitude and timing.

Over-projection of current trends	The current state is projected into the future correctly. However, it is projected further into the future than for which the data is realistically valid. This, combined with not updating the projections at appropriate intervals, can lead to incorrect plans for the future	Utilizing both real-time and fast-time capabilities of the simulator can allow an operator to witness the effects of an event, view how it progresses over time and then practice decision-making in real time.
Other	Projection of a current state onto the future often fails because it is a demanding task, that in a multi-tasking environment, is not always performed. This is possibly due to the lower priority it is given or due to limits in cognitive resources.	Maximize confidence, understanding and capability by using every step of a startup as an opportunity to practice developing and dynamically refining a mental model
General		
Failure to maintain multiple goals	Failure to maintain multiple goals in memory degrades SA across all three levels	Plant alerts are particular messages beyond DCS alarms; they are used to remind trainees they are violating key goals such as avoiding releases, going off-spec on products, or some other environmental or safety issue.
Executing habitual schema	Performing tasks automatically can result in essential system cues being overlooked.	Introducing minor malfunctions during repetitive and routine procedures can test the operator's observation skills. Best practices of scanning trend graphs for anomalies can be promoted**.** Simulations are generally built and used without PLC logic or similar automated operations. Trainees, therefore, develop their diagnostic, critical thinking, and operating skills.