

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

As much as 88% of human error is due to problems with situation awareness





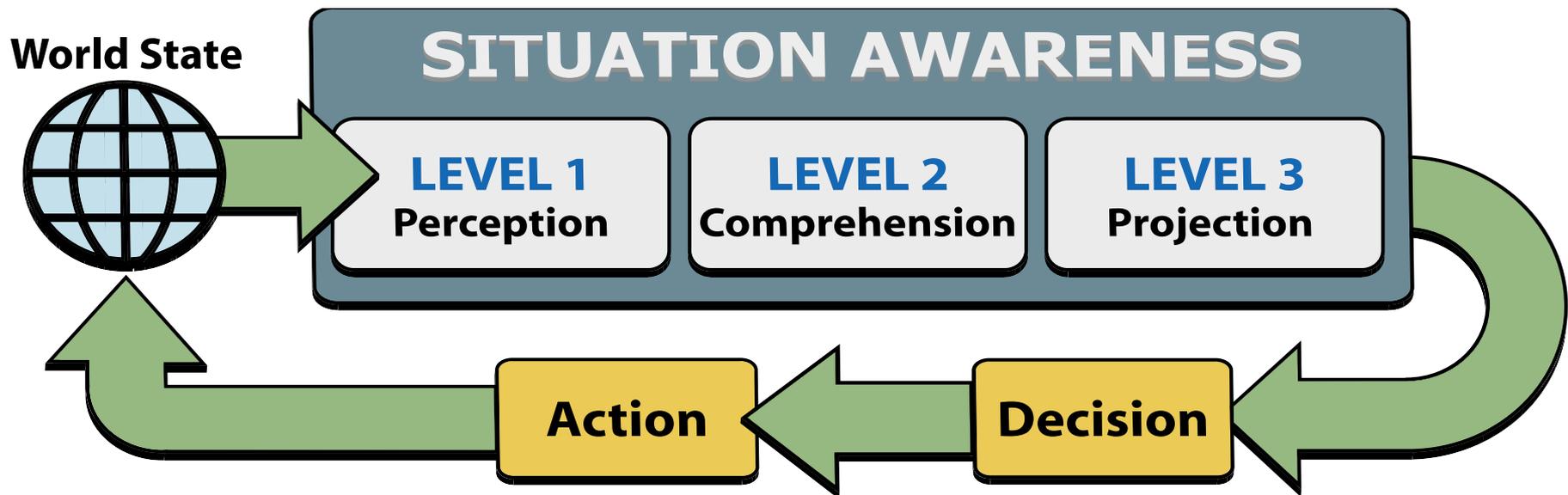
- **Macondo Well Blowout, April 2010**
 - BP did not inform Halliburton of the number of centralizers it eventually used, let alone request new modeling to predict the impact of using only six centralizers
 - What nobody appears to have noticed during those six minutes (perhaps as a result of all of 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.

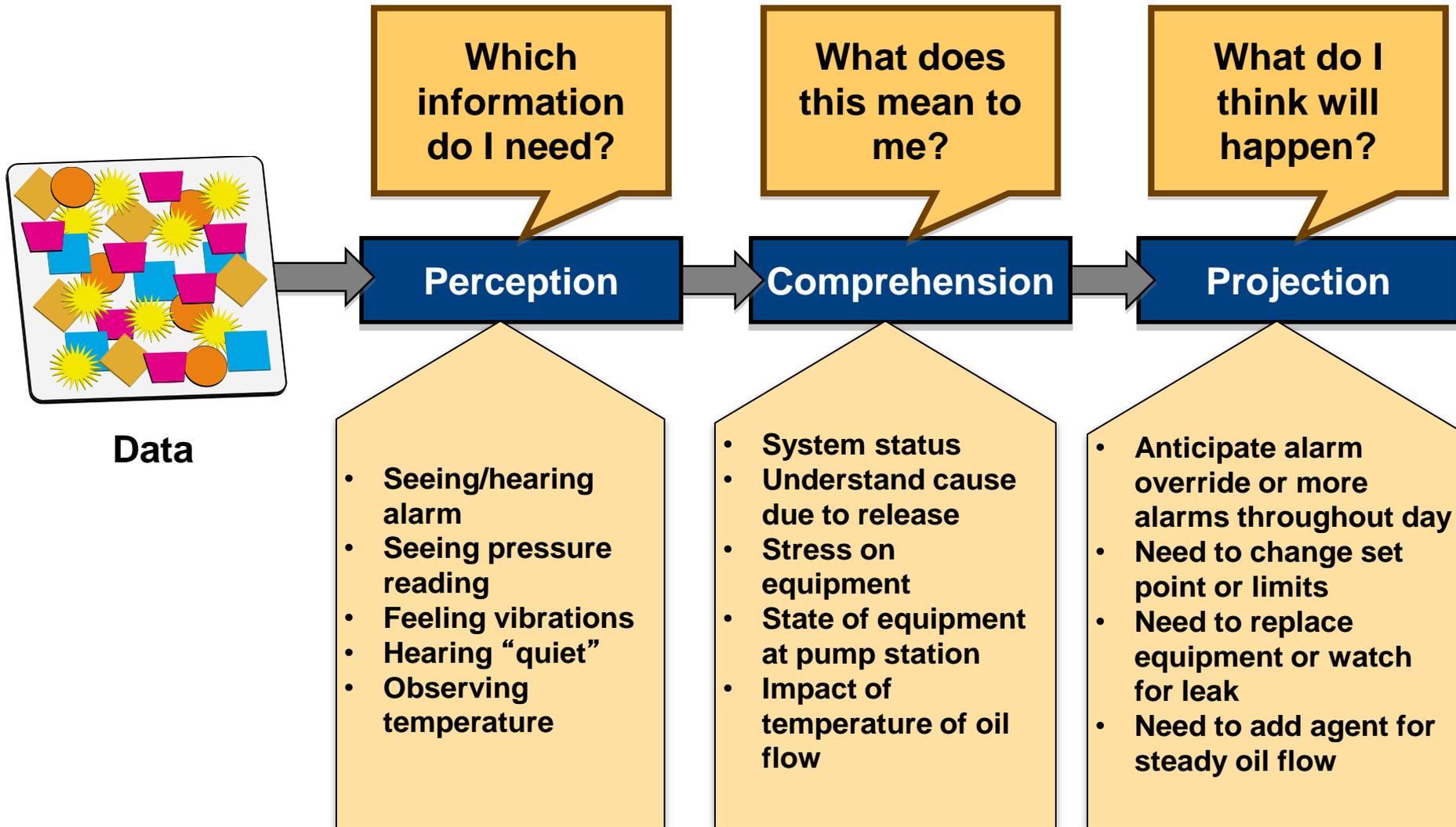
- **SA failures can also negatively effect pipeline operations**
 - **Needed information can be hard to detect**
 - Noise, distractions, failure to observe key features, leaks, automation status
 - **Operator can fail to comprehend the significance of information**
 - Tank venting, impact of heater placement, 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

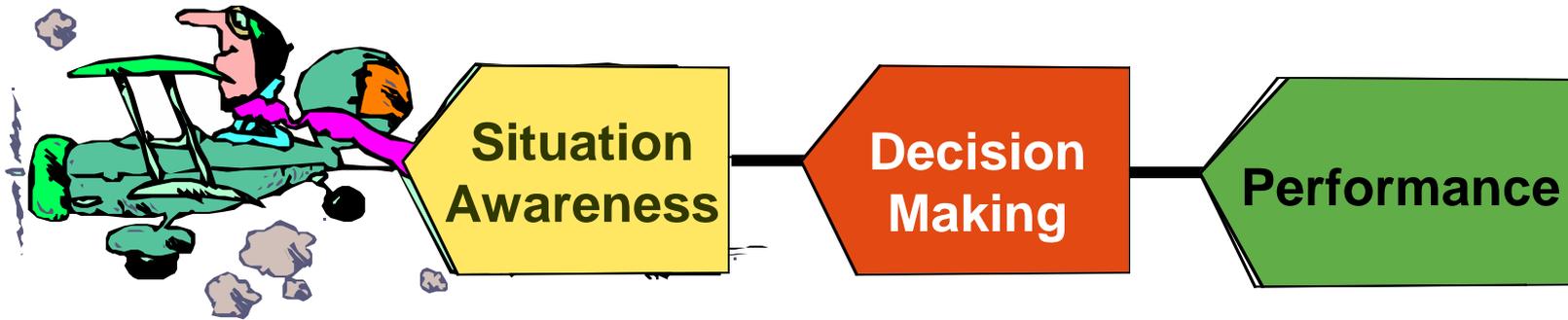


What is Situation Awareness?



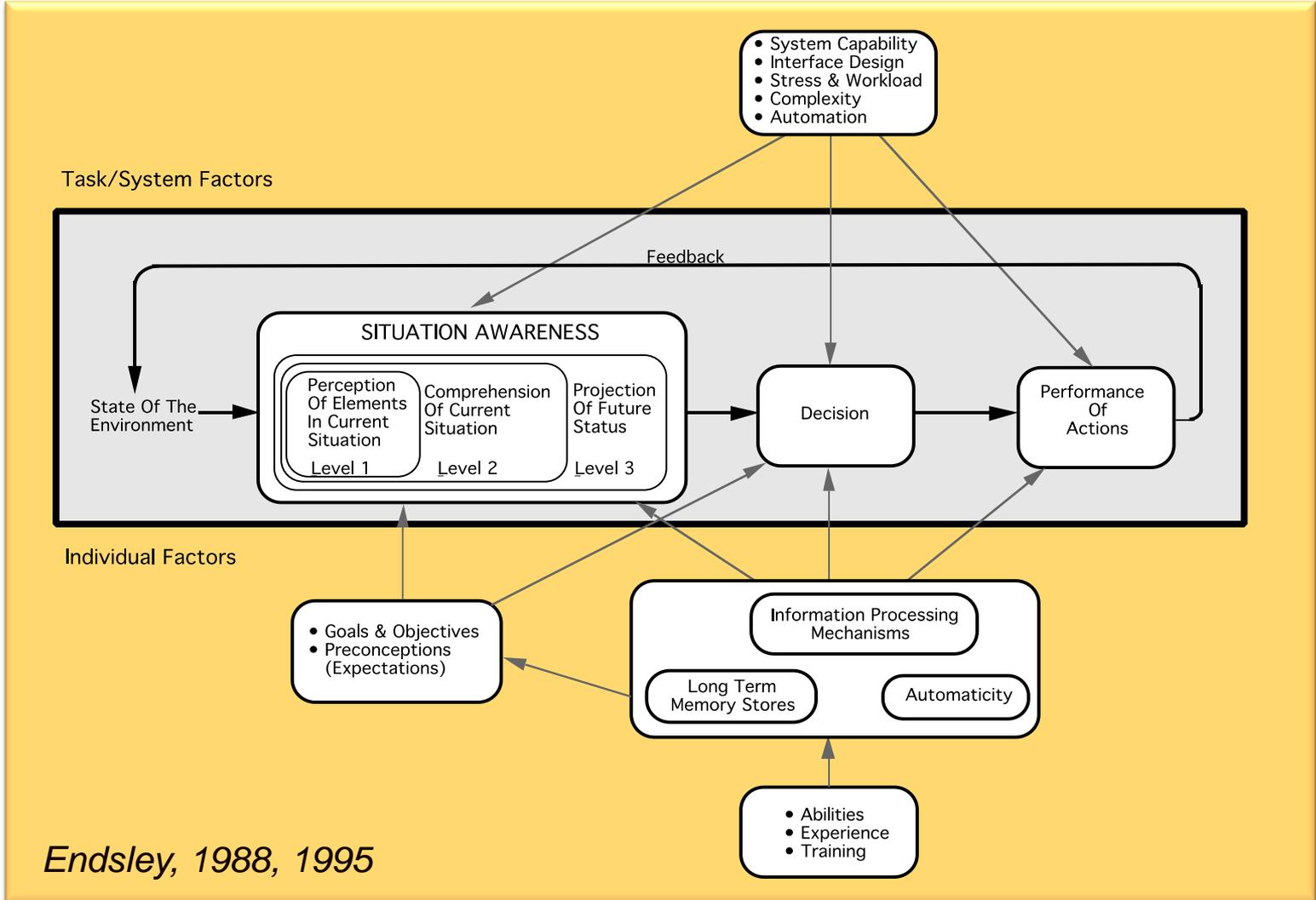
Situation Awareness is the *Perception* of elements in the environment within a volume of time and space, the *Comprehension* of their meaning, and the *Projection* of their status in the near future.*





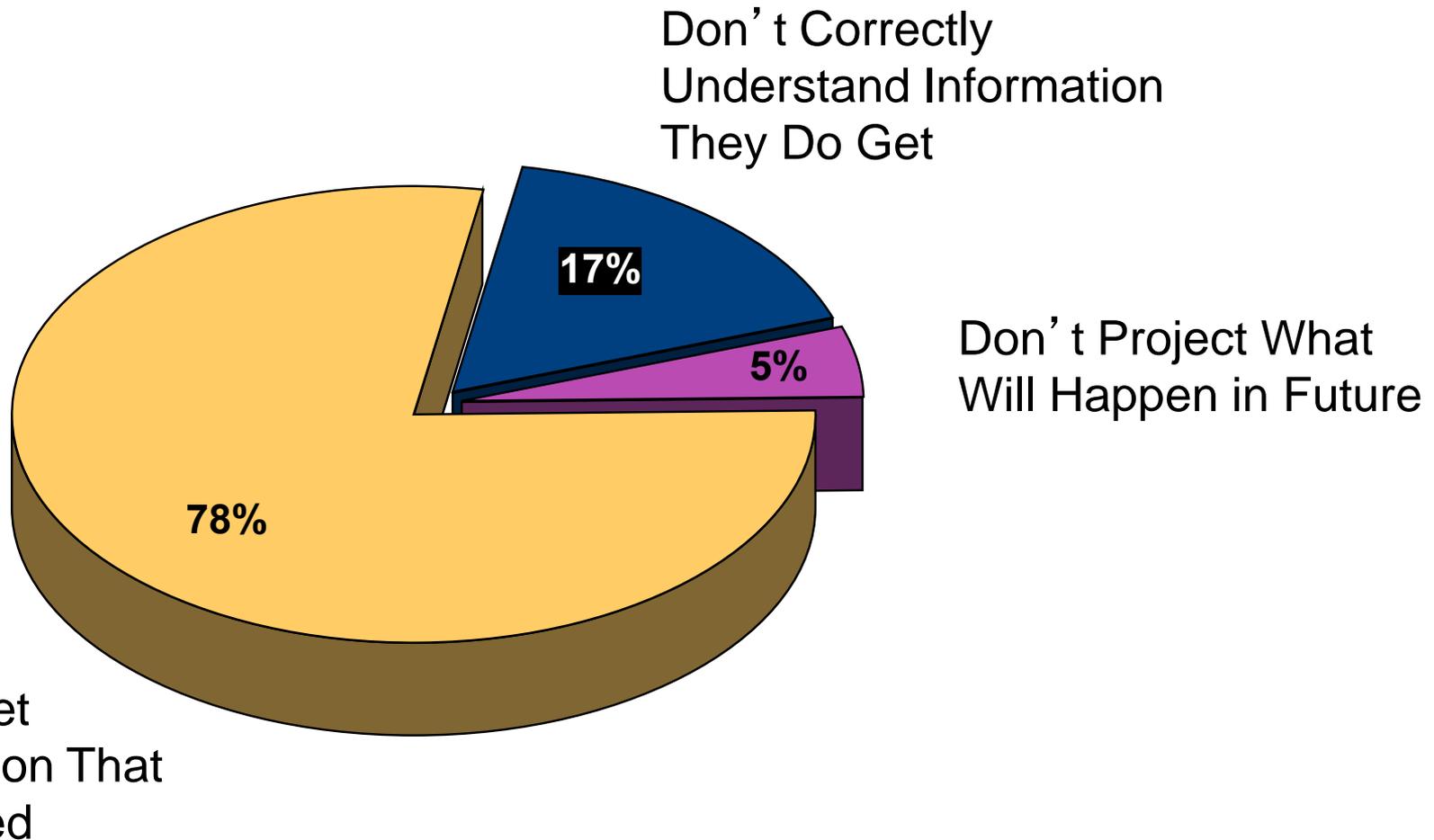
***Situation awareness is key to
good decision making and
good performance***

Model of SA

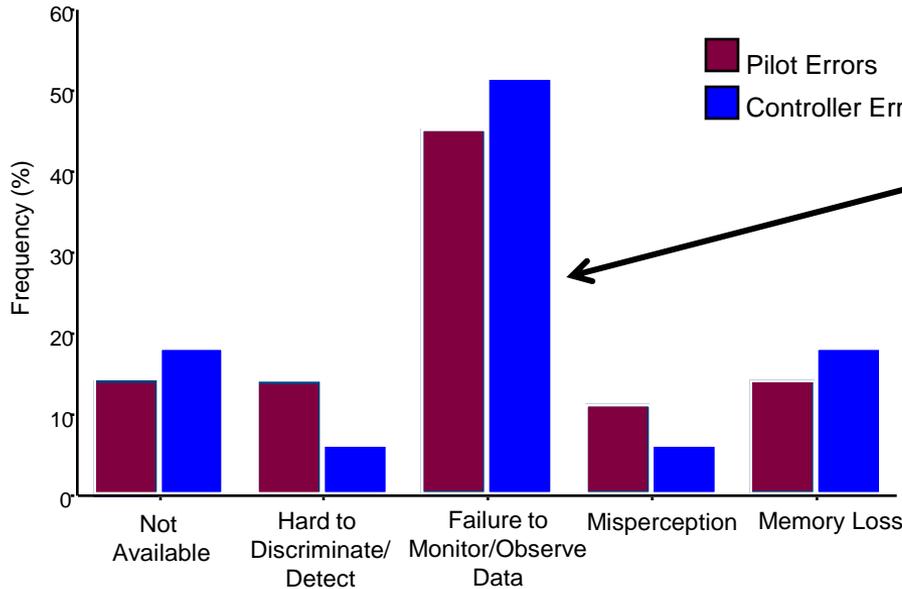


Endsley, 1988, 1995

What Kinds of SA Problems Do People Have?

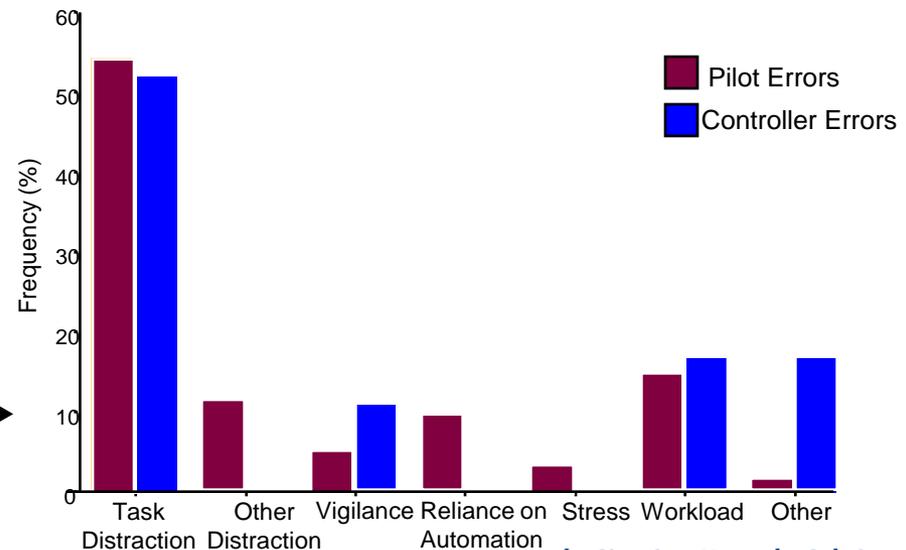


SA Errors

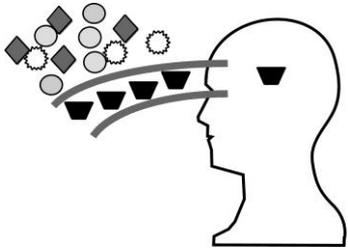


Majority of Level 1 Errors Due to failure to Monitor or Observe Data That is Present (50%)
Highest single cause of all SA error (30%)

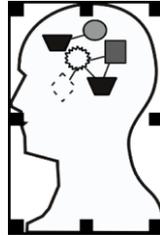
Biggest Single Cause is “Task Distraction”



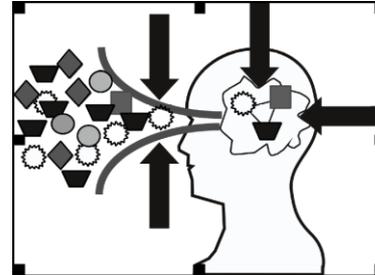
Know the Situation. Know the Solution.



Attentional Tunneling



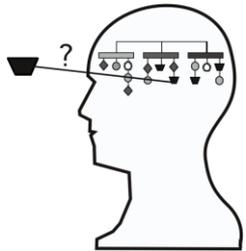
Requisite Memory Trap



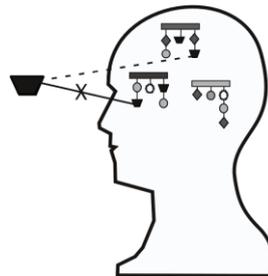
WAFOS: Workload, Fatigue & Other Stressors



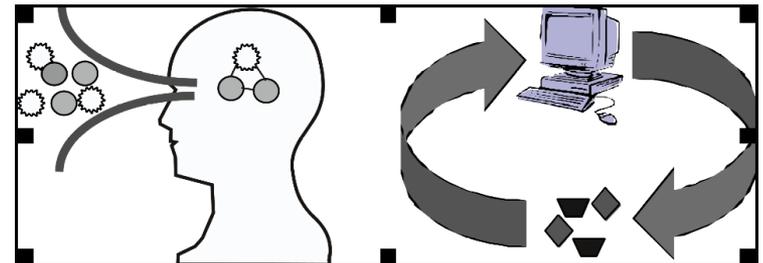
Misplaced Salience



Complexity Creep



Errant Mental Models

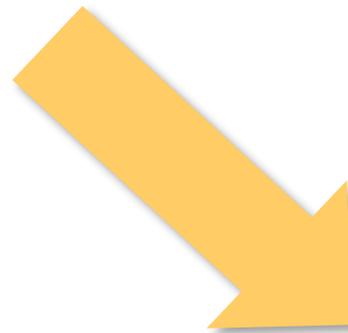


Out-of-the-loop Syndrome

Data Overload



Technology has
taken us from here

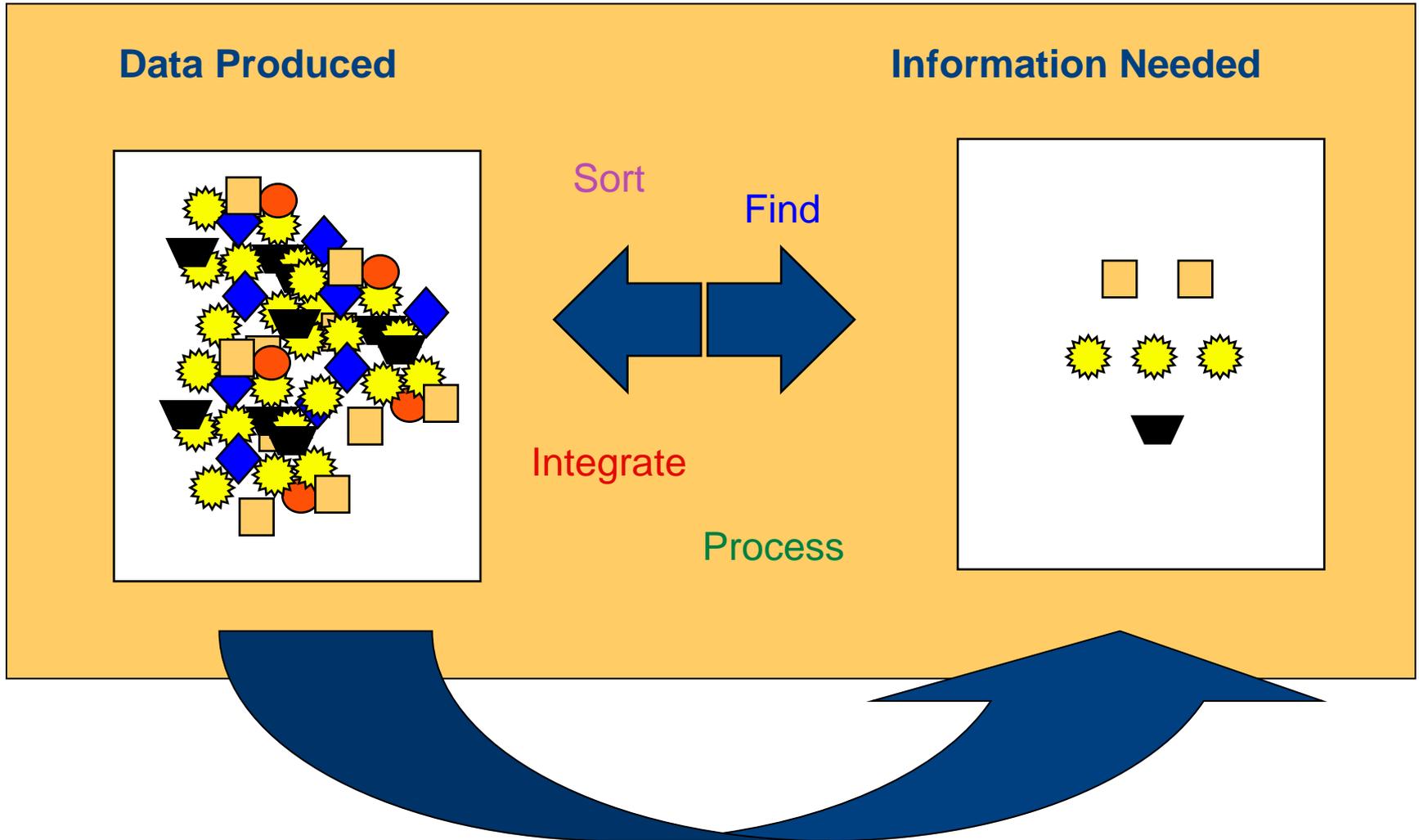


to here.

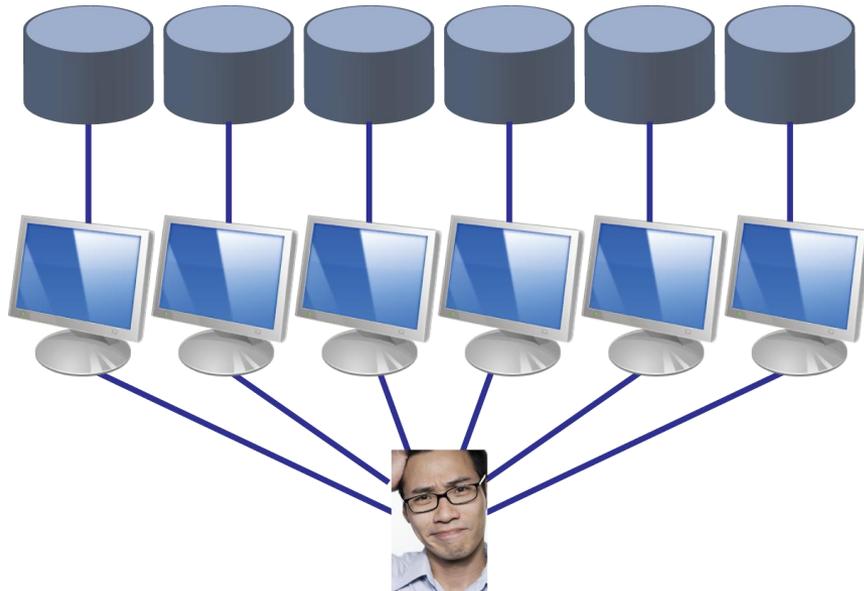
But we still can't
find what we really
want to know.....



Information Gap



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

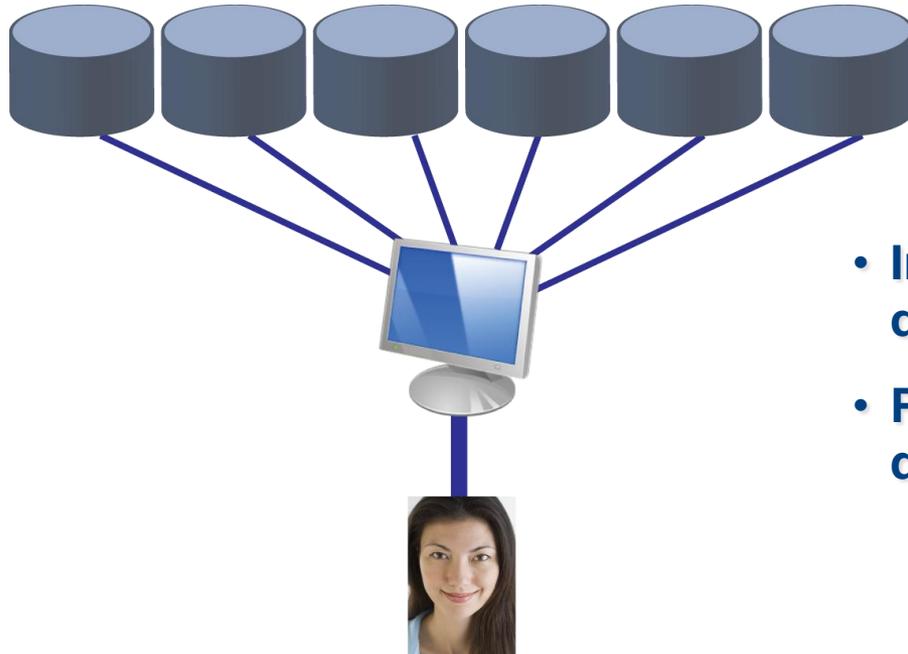
Technology Centered Design

Design Technologies

Let Human Adapt

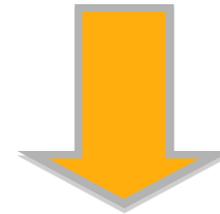
Fatal Flaw

- Human can only adapt so far
- “Human Error”
- Resultant System is Sub-Optimized



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

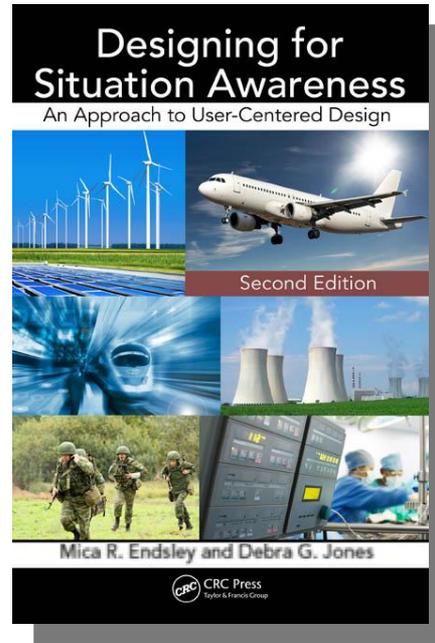


Result

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



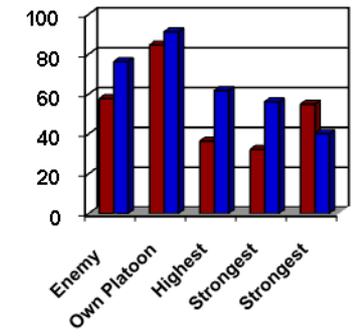
50 Design Principles



Goals

Decisions

- Projection Requirements
- Comprehension Requirements
- Data Requirements



SA Requirements
Analysis

SA-Oriented
Design

SA Measurement



SA Technologies

Goal Directed Task Analysis (GDTA)

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

Drives Design
Drives Training
Drives Evaluation



Goals

Sub-goals

- Projections
- Comprehensions
 - Data

GDTA specifies the detailed SA needs at all three levels for each role in the operation so that information presentation can be tailored

Monitor Tanks

Where can I put oil?
What flexibility do I have for oil storage?

- Projected availability of tanks
 - Capacity to receive oil
 - Volume of oil
 - Volume of water
 - Alarm state
 - Type of alarm
 - Severity of alarm
 - Maintenance
 - Work in progress
 - Workers in area
 - Planned work
 - What is planned
 - Time it is planned
 - Tank parameters
 - Total Volume
 - Pressure
 - Temperature
 - Flow rate into tank
 - Line flowing into tank (A or B)
 - Valves
 - Operational (yes/no)
 - Position (open / closed)
 - Mixers
 - Operational (yes/no)
 - Functioning (on/off)

SA Requirements
Analysis

SA-Oriented
Design

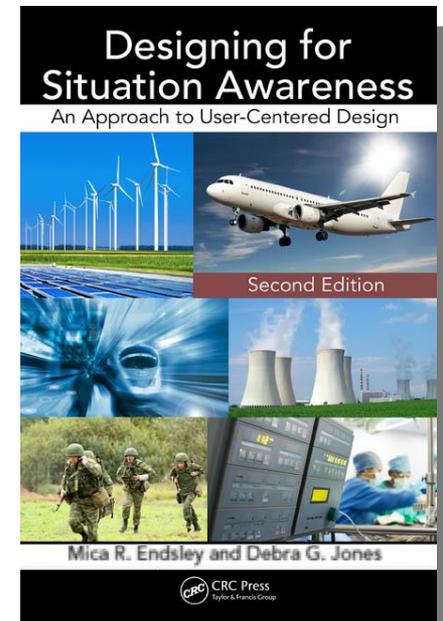
SA Measurement



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**

50 Design Principles



Power Transmission & Distribution Control Rooms

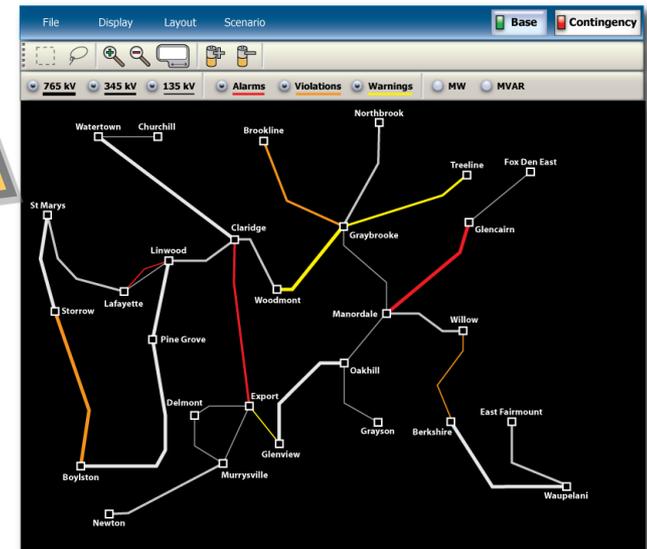
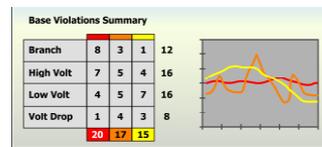
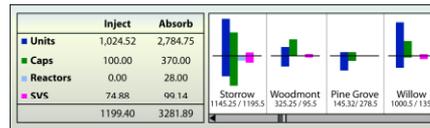


Poor SA: Leading Cause of Blackouts

- 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



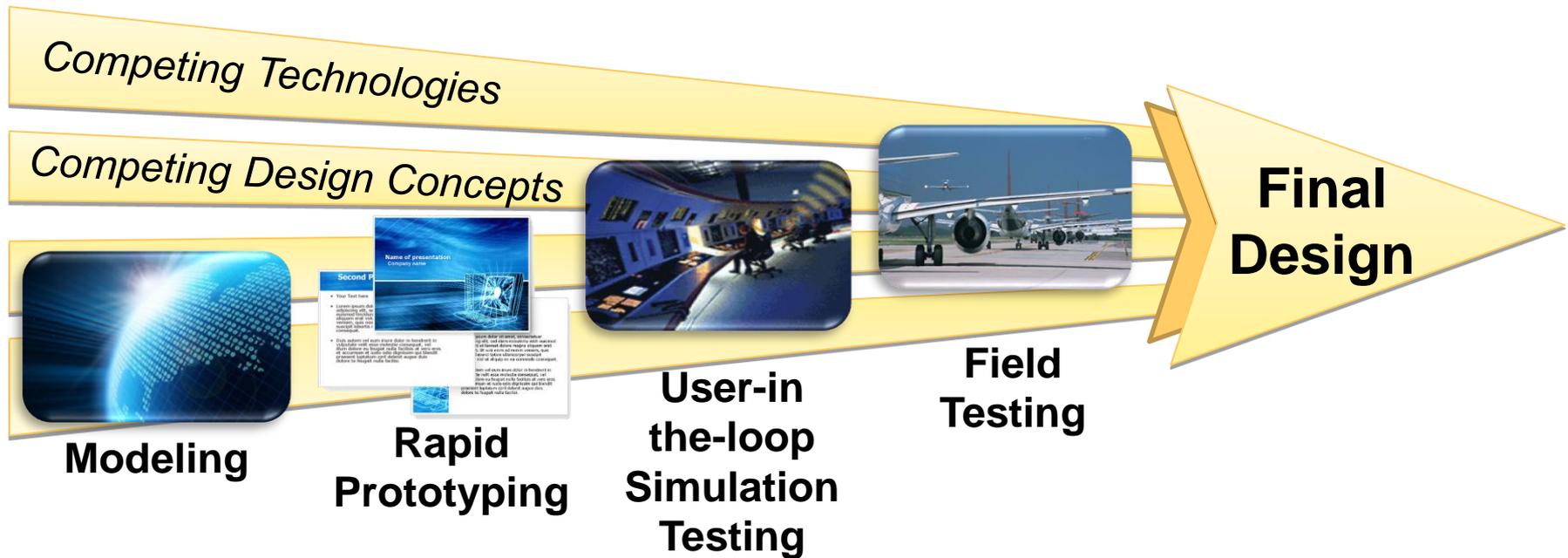
SA Requirements
Analysis

SA-Oriented
Design

SA Measurement



Test & Evaluation in the Design Process

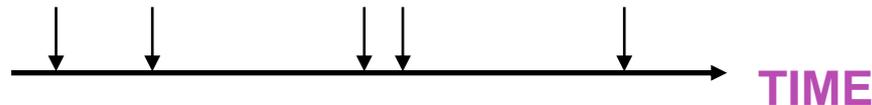


- ✓ Human Performance
- ✓ Decision Making
- ✓ Workload
- ✓ Situation Awareness

Situation Awareness Global Assessment Technique (SAGAT)

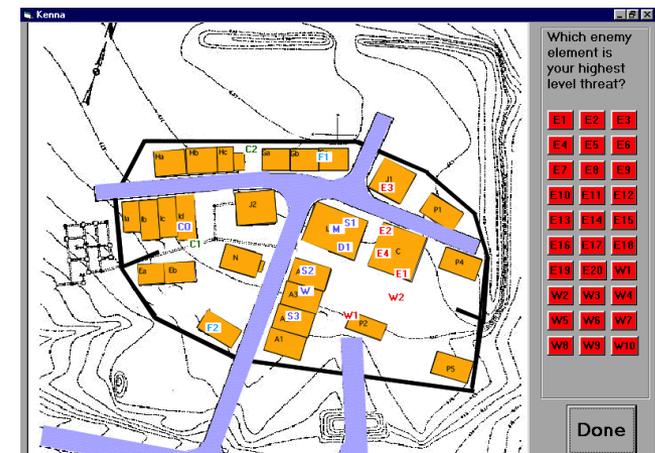
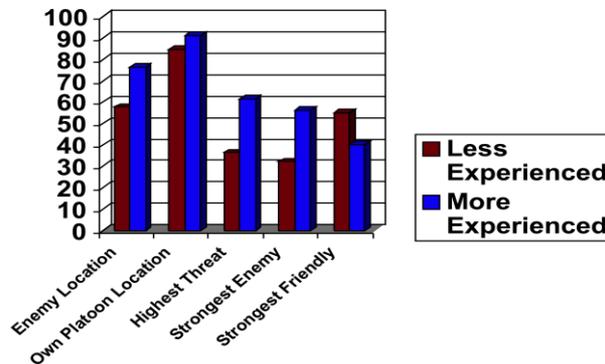
Objective measure of SA

- 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

*Only Validated
Objective Direct
Measure of SA*



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

10 Fold Difference in SA among Experienced Personnel

SA is demanding,
frequently incomplete
and erroneous

SA is fast, can be effortless,
more complete, greater
comprehension & projection



- Limited attention
- Limited working memory

- 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

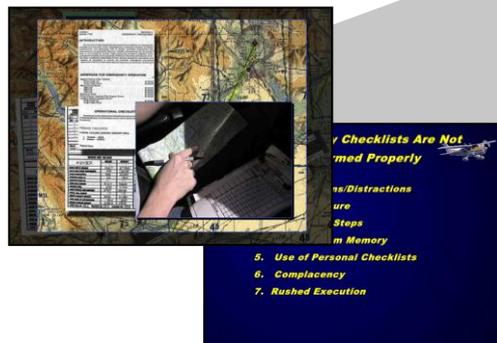
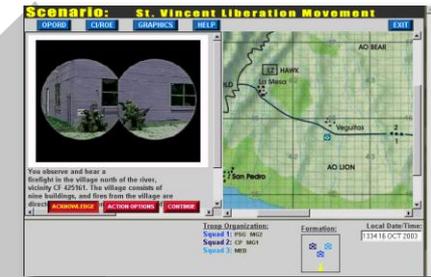
Training Situation Awareness Knowledge, Skills, & Behaviors



Virtual Environment Situation Awareness Rating System (VESARS)



Interactive Situation Awareness Trainer (ISAT)



SA Trainer



Situation Awareness Virtual Instructor (SAVI)

- **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**

