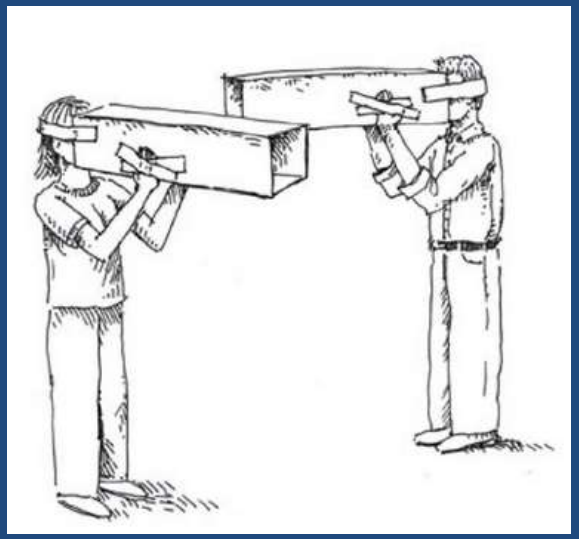
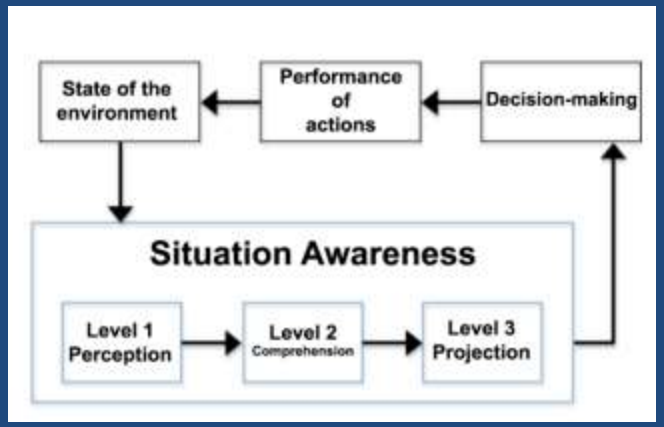
SITUATIONAL AWARENESS:
What the Science Says





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Virginia Department of Emergency Management

SITUATIONAL AWARENESS:
Agenda

1. National Strategy for Information Sharing
2. Definitions of Situational Awareness
3. How to Measure
4. Model of Situational Awareness
5. Cognitive Limitations
6. Time Limitations
7. Other Issues
8. Multitasking
9. Satisfaction, Certainty, and Accuracy
10. Information Processing
11. Role of Experience
12. Search versus Knowledge
13. Decision Support Tools
14. Simplifying and Summarizing
15. Puzzles and Mysteries
16. Plausible Solutions

SITUATIONAL AWARENESS:
National Strategy for Information Sharing and Safeguarding, December, 2012

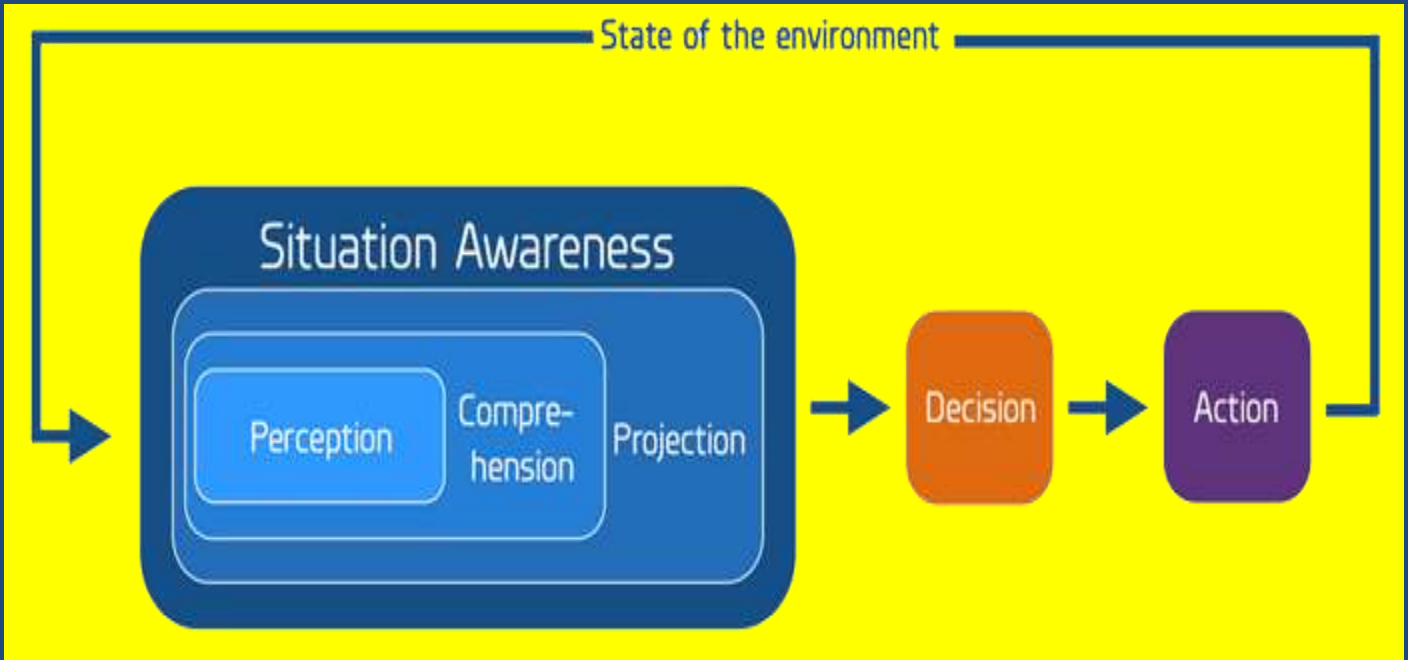
"The value of…information sharing is measured by its contribution to proactive decision making."

- ***Not*** by how much information flows
- ***Not*** by the technology used.

"The objective is to increase the usefulness of information in operations through the consistent application of policies, exchange standards, and common frameworks…"

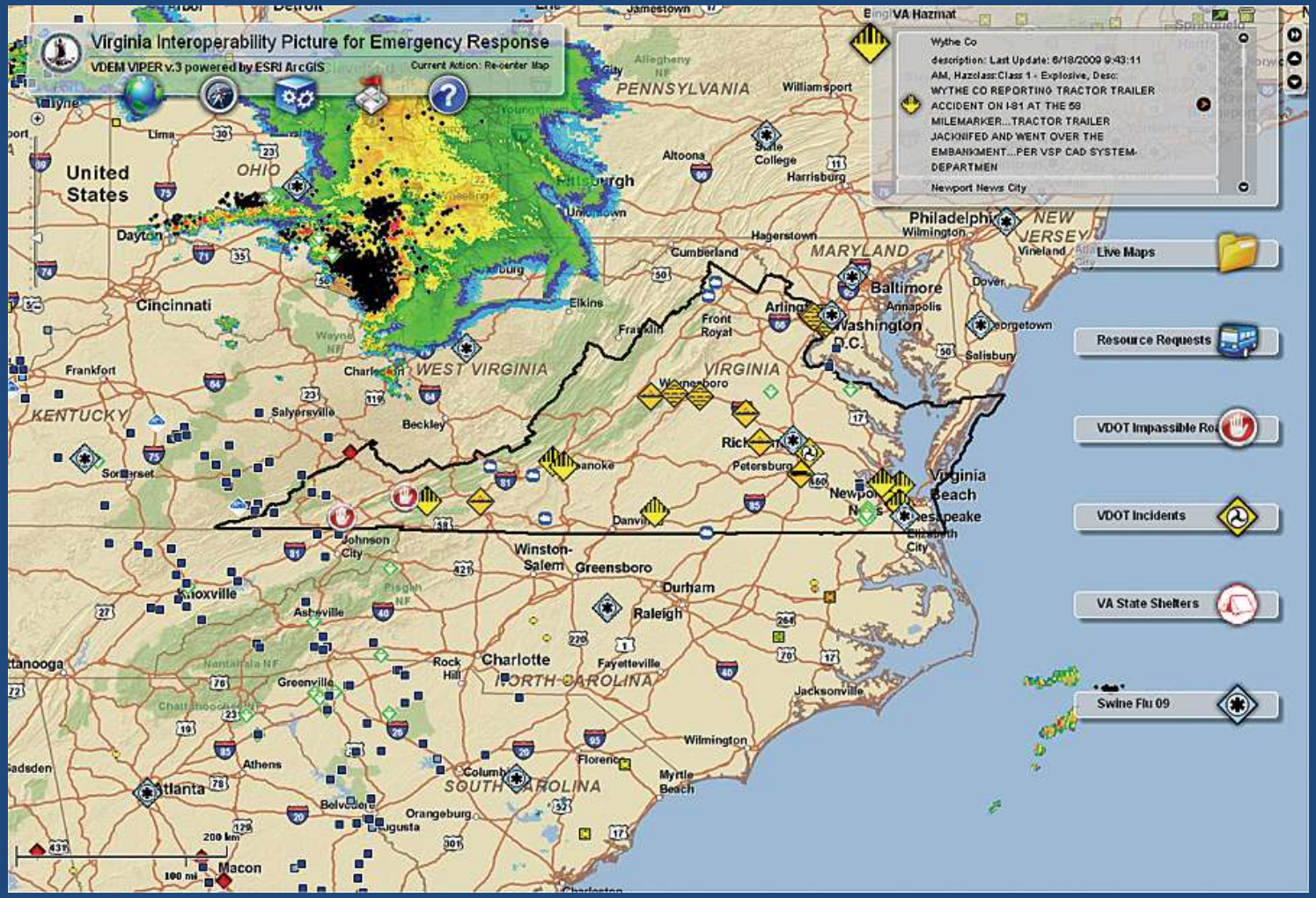
"Sharing the right information with the right people at the right time…"

SITUATIONAL AWARENESS:
Defining what it is…



What the Science Says…

Situational Awareness - Example



SITUATIONAL AWARENESS:
Defining what it is…

"Situational awareness is as squishy and ill-defined a term as you will ever find."

"There is no clearly understandable, generally accepted, objective way to measure situational awareness."

"It is merely an assumption that improved situational awareness will lead to improved performance."

"Excellent situational awareness cannot make up for poor judgment resulting in an inability to accurately predict the outcome."

[Source: Nofi, A.A., (2000)]

SITUATIONAL AWARENESS:
Definitions

"Situational awareness is an abstraction that exists within our minds, describing phenomena that we observe in humans performing work in a rich and usually dynamic environment."

[Source: Billings, C.E. (1995)]

"Situational awareness is the ability to identify, process, and comprehend the critical elements of information about what is happening to the team with regards to the mission. More simply it's *knowing what is going on around you.*

[Source: USCG (1998)

"Situational awareness is being aware of everything that is happening around oneself and the relative importance of everything observed - a constantly evolving picture of the state of the environment."

[Source: Harrald, J., and Jefferson, T. (2007)]

SITUATIONAL AWARENESS:
How to Measure it?

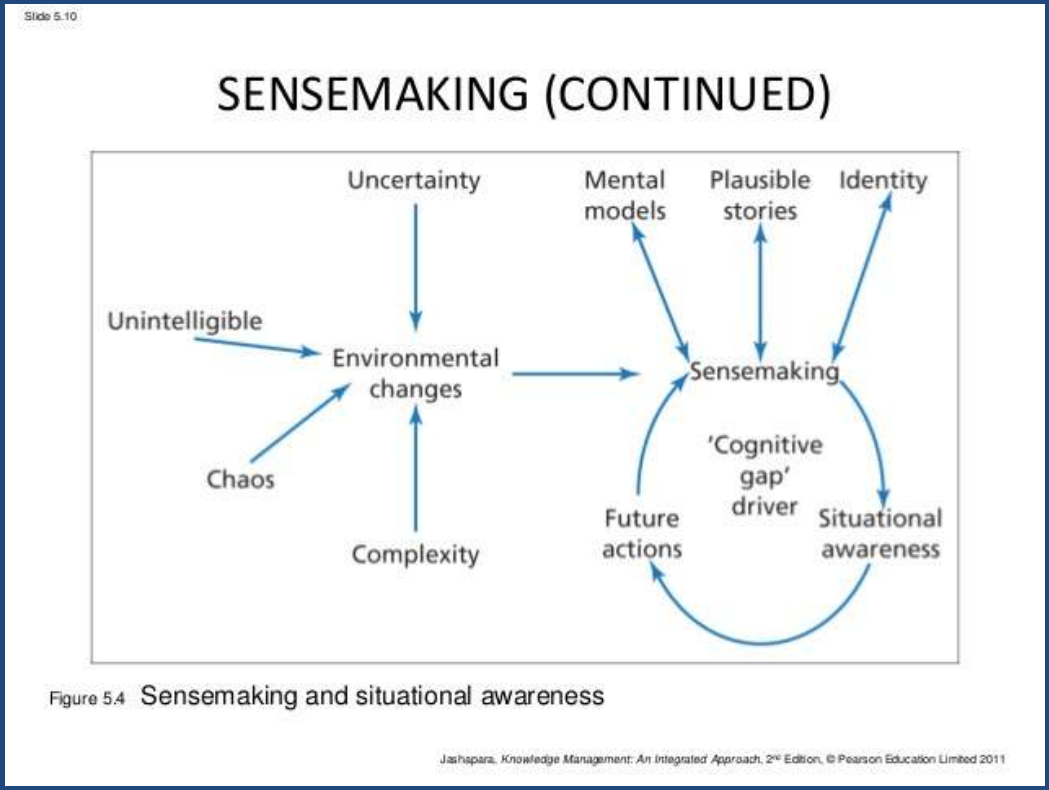
"Situational awareness refers to the degree of accuracy by which one's perception of his current environment mirrors reality."

[Source: Harrald, J., and Jefferson, T. (2007)]

Objective measures of situational awareness: "1) *Does the team understanding of the situation at any particular point conform to reality?,* and 2) *Is the mission being successfully executed?"*

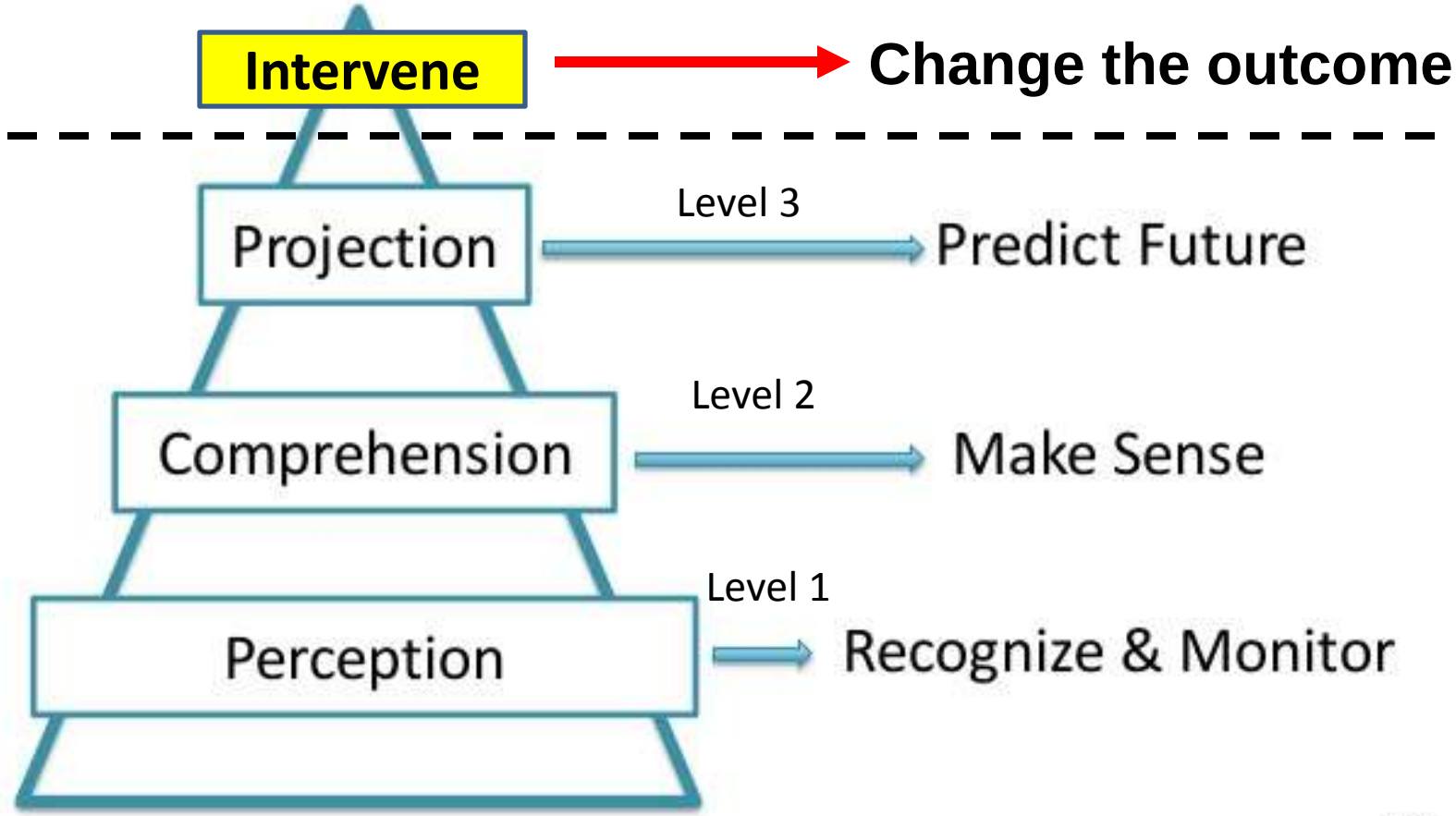
[Source: Nofi, A.A. (2002)]

SITUATIONAL AWARENESS:
Is there a Model of Situational Awareness?



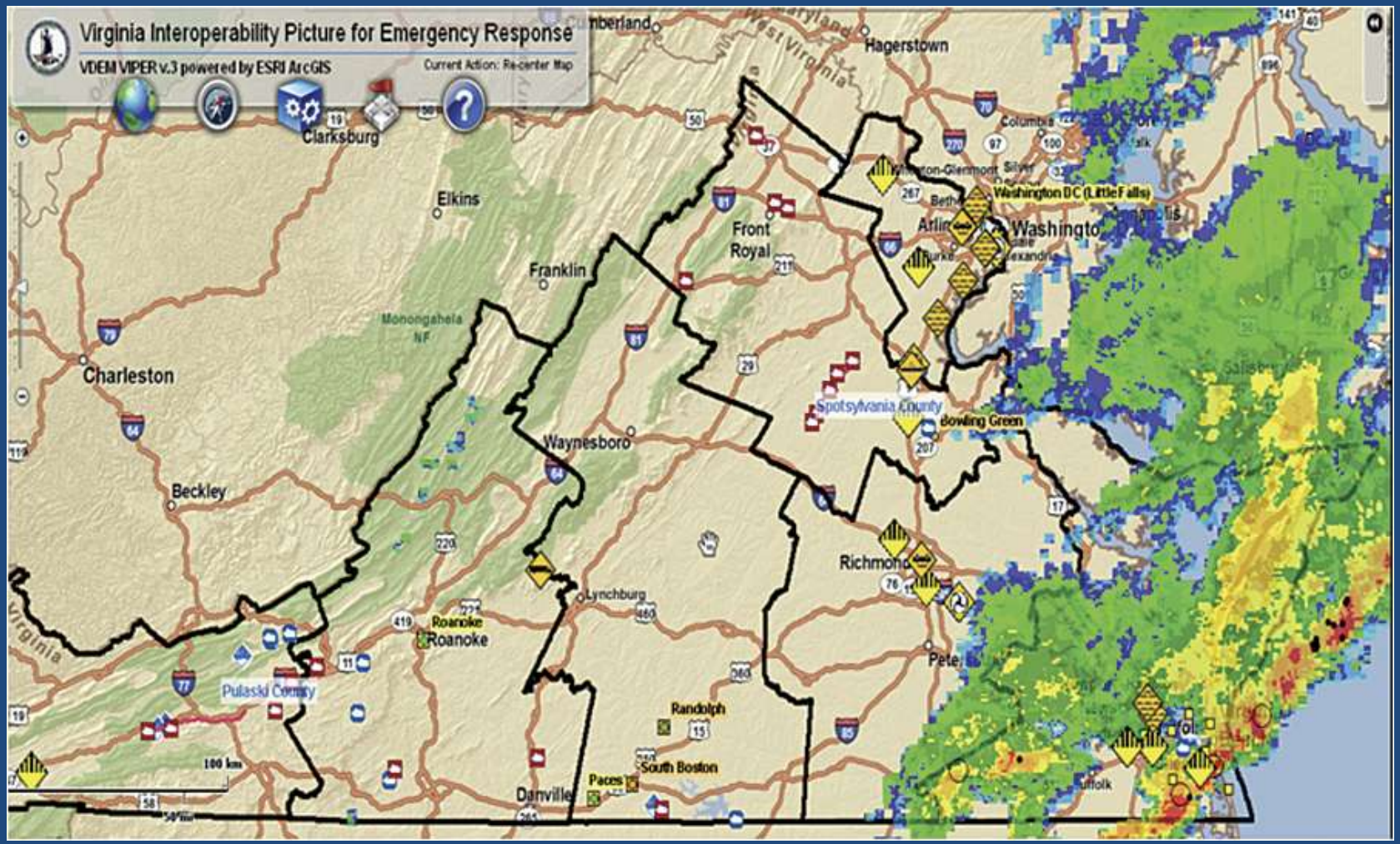
What the Science Says…

Situational Awareness



* Endsley, M.R. Toward a theory of situation awareness in dynamic systems. Human Factors, 1995, 37(1), 32–64

What Level of Situational Awareness this?...



SITUATIONAL AWARENESS:
What are the Cognitive Limitations?

What the Science Says…

SITUATIONAL AWARENESS:
Human Cognitive Limitations

Title: "The Magic Number seven, plus or minus two"

"We possess a finite and rather small capacity for making unidimensional judgments…"

"There is a span of attention that encompasses about six objects at a glance."

These attributes "…impose severe limitations on the amount of information we are able to receive, process, and remember."

[Source: Miller, G.A.(1956)]

SITUATIONAL AWARENESS:
Human Cognitive Limitations

"Respondents experienced information overload when provided with more than 10 choice alternatives."

[Source: Molhotra, N.K. (1982)]

"Choice accuracy decreases when the number of attributes increased from 5 to 15 or more and when the number of alternatives increased from 5 to 10 or more."

"Advocates for providing substantial amounts of information often act as if this maximum is a large number, ignoring the known fact that humans are cognitively limited."

[Source: Keller, K.L., and Staelin, R. (1987)]

"Information overload occurs when the decision maker has to deal with more than approximately 10 information cues."

[Source: Iselin, E. (1989)]

SITUATIONAL AWARENESS:
Human Cognitive Limitations

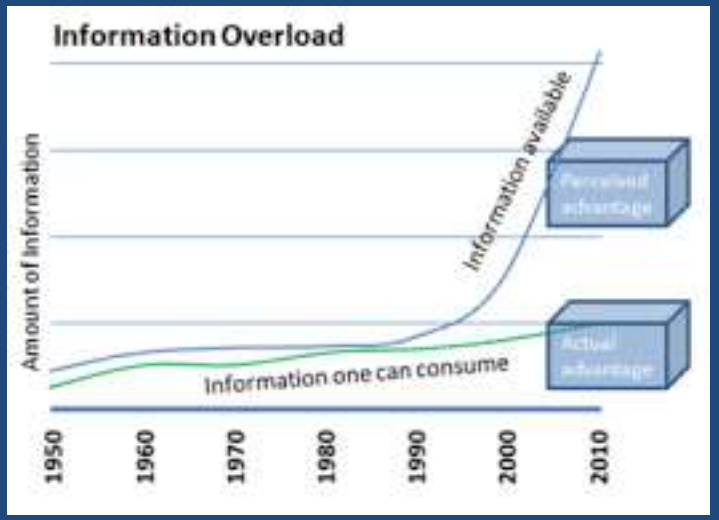
"Human beings are able to manage you to a range of 5 to 9 information cues to perform optimally."

[Source: Chan, S.Y. (2001)]

"Our total range of categorizing one-dimensional alternatives is between 3 and 15. Increasing this range leads to a loss of overall judgment accuracy"

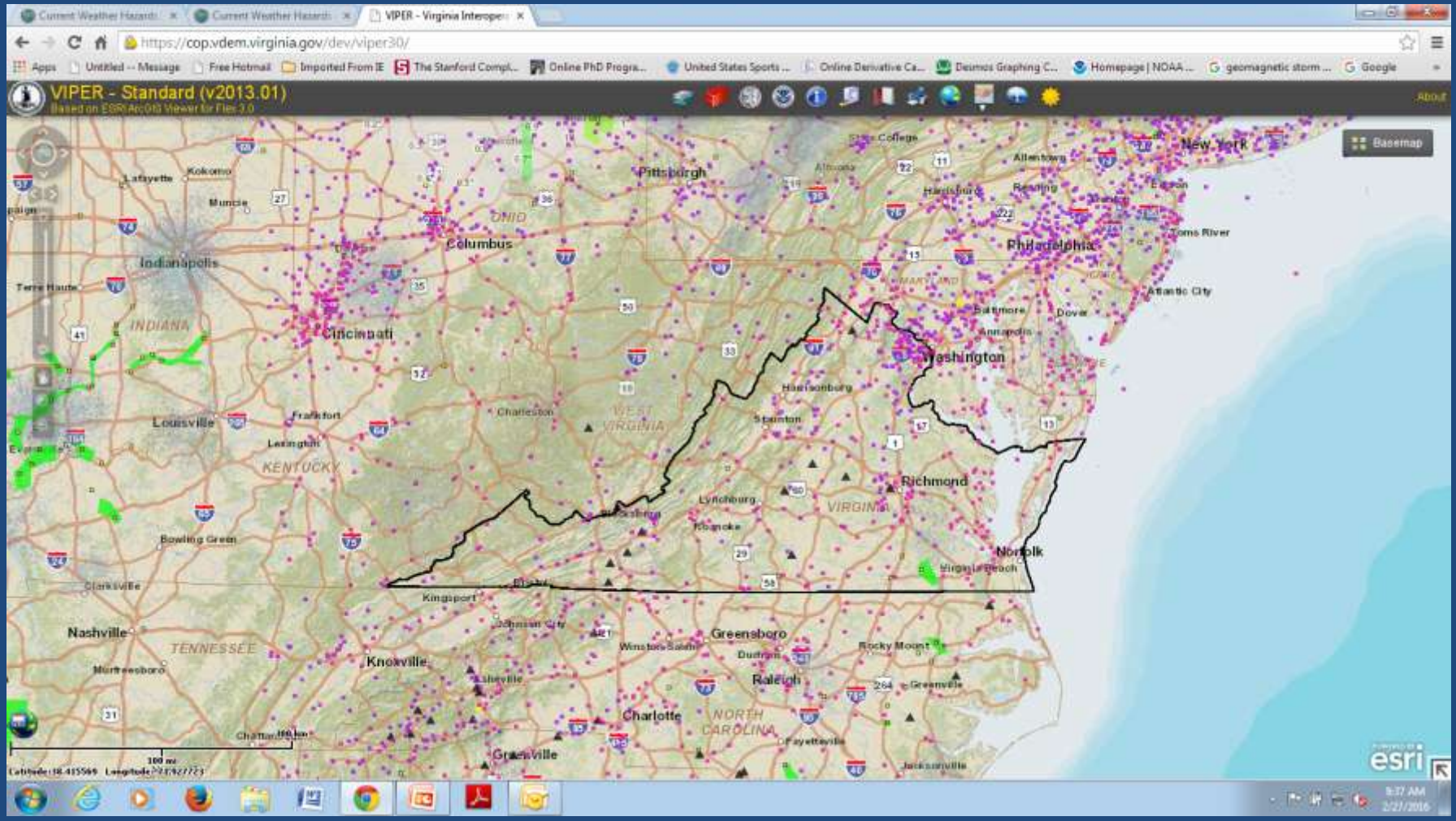
[Source: Karr-Wisniewski, P., and Lu, Y. (2010)]

So what?...



[Source: Davis, D. (2013)]

Information Overload, or a Clear Picture?



SITUATIONAL AWARENESS:
What are the Limitations Imposed by Time?

What the Science Says…

SITUATIONAL AWARENESS:
Information Processing - No Time Constraints

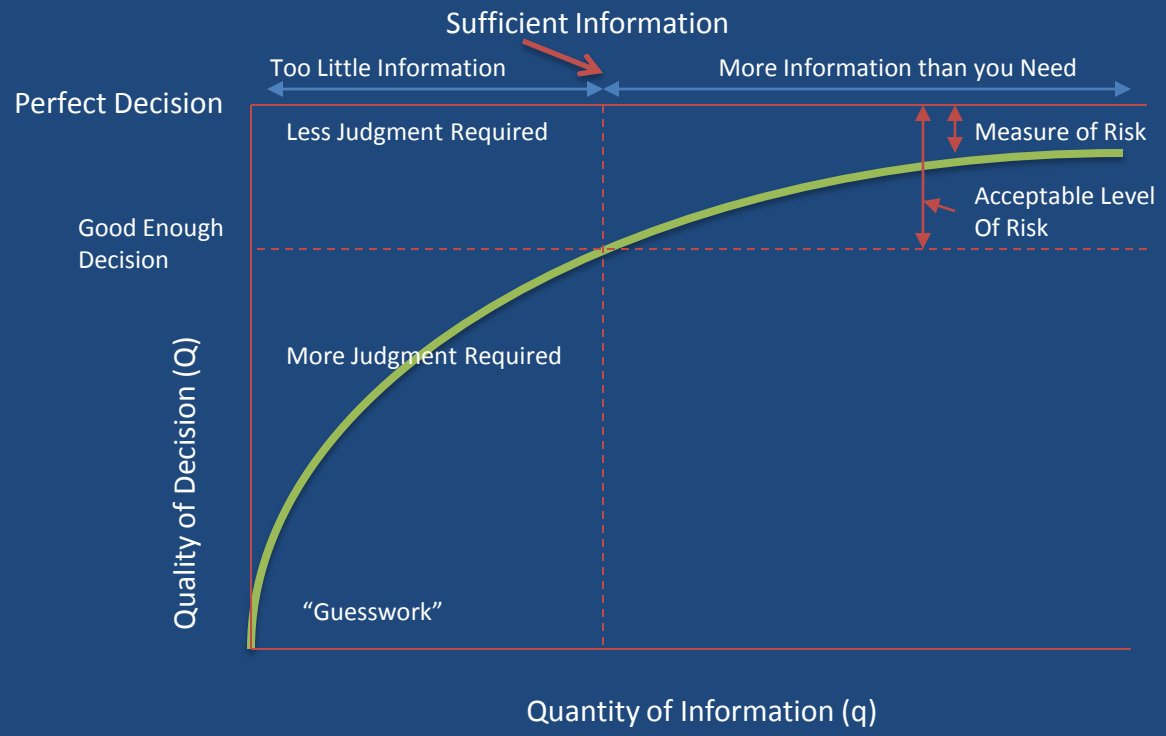
"If time is unlimited there is no effect of information overload."

[Source: Buchanan,J., and Kock, N. (1999)]

"With little or no information, individuals have little or nothing to process and consequently make poor decisions. As the amount of information increases, so too does information processing and the quality of decision making."

[Source: Ruff, J. (2002)]

Case 1 – No Time Constraints:



Assumptions:

1. Decision Quality (Q) improves with Information Quantity (q)
2. Slope is always positive – $dQ/dq > 0$.
3. Gains of Q are great when q is small; gains of Q are less as q increases.
4. There exists some "Perfect Decision" that is approached as q increases but is never quite reached.
5. More information always yields better decisions.

SITUATIONAL AWARENESS:
Information Processing – Time Constrained

"Judgment accuracy is an inverted-U function of the supply of information."

[Source: Shields, M.D. (1983)]

"Increases in information quantity…lead to decreases in decision effectiveness due to information overload."

[Source: Keller, K.L., and Staelin, R. (1987)]

"Decision quality is a U-shaped function against information load when time pressure is present, but not when time pressure was absent."

[Source: Hahn, M., Lawson, R., and Lee, Y.G. (1992)]

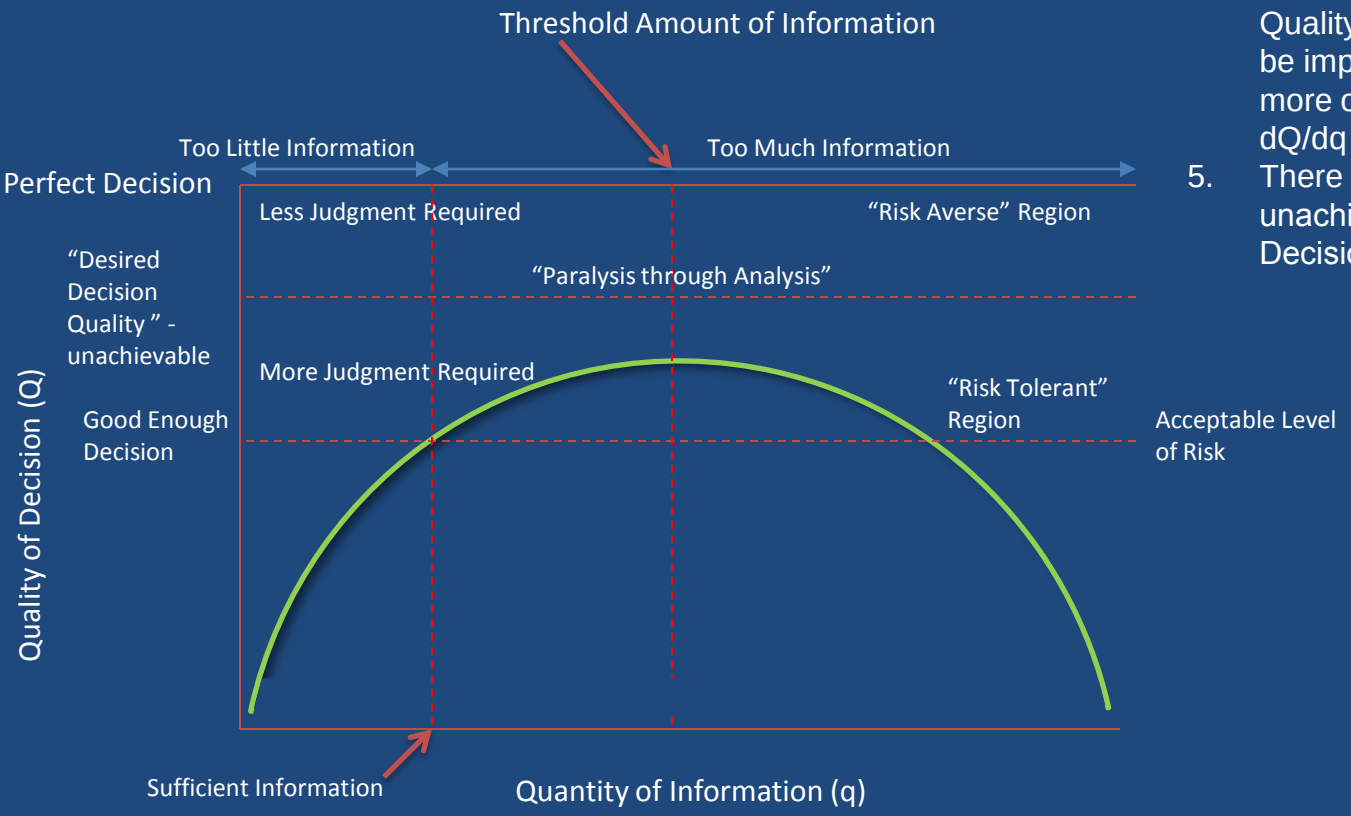
"Increases in information load are associated with decreases in accuracy and timeliness of decisions."

[Source: Chan, S.Y. (2001)]

"After a certain point is reached, *the decision-maker has obtained more information than he can process*, information overload has occurred, and decision-making ability decreases."

[Source: Ruff, J. (2002)]

Case 2 – Time Constrained:



Assumptions:

1. Decision Quality (Q) improves with Information Quantity (q) when q is sparse.
2. Q decreases with increasing q when q is abundant.
3. Slope is not always positive (i.e. – dQ/dq can be (+) or (-)).
4. There exists some Maximum Quality of Decision that cannot be improved upon by either more or less Information (i.e. – dQ/dq = 0).
5. There exists some unachievable "Perfect Decision"

SITUATIONAL AWARENESS:
Are there Other Issues?

What the Science Says…

SITUATIONAL AWARENESS:
Information Processing – Other Issues

"Individuals intolerant of ambiguity will tend to prefer more information that those tolerant of ambiguity"

[Source: Dermer, J. (1972)]

"Higher uncertainty produced longer decision times and poorer quality decisions."

[Source: Iselin, E. (1990)]

"Subjects under time pressure place greater weight on negative information about alternatives – if individuals are more sensitive to a negative outcome they…become more conservative."

[Source: Hahn, M., Lawson, R., and Lee, Y.G. (1992)]

SITUATIONAL AWARENESS:
Information Processing – Other Issues

"There is a danger of circular reasoning where situation awareness is presented as the object and the solution to information sharing:

> 'How does one know that situation awareness was lost? Because the human responded inappropriately. Why did the human respond inappropriately? Because situation awareness was lost.'

Is this keen insight or muddled thinking?"

[Source: Flach, J.M. (1995)]

"Presenting just the right amount of information may be a challenge to information suppliers."

[Source: Huang, M.I., and Lin, J.W. (1999)

SITUATIONAL AWARENESS:
Information Processing – Other Issues

"Subjects working under the heaviest information loads were found to take longer and did not predict better than those working under low information loads."

[Source: Chan, S.Y. (2001)]

"Increased information availability had a detrimental effect on information processing efficiency leading to reduced decision accuracy."

[Source: Handzic, M. (2001)]

"'Nearly rational' decision makers can be made worse off by receiving more information."

[Source: Van Zandt, T. (2001)]

"…when making complex decisions, we may feel the need to have, and therefore request, massive amounts of data—but having too much information is the same as not having enough."

[Source: Ruff, J. (2002)]

SITUATIONAL AWARENESS:
Information Processing – Other Issues

"Research has shown that time constraints have a negative effect on the ability of individuals to make decisions effectively. Because dynamic situations change over time, decision makers must process new situations continuously and be able to retain information while concurrently processing incoming variables."

[Source: Gonzalez, C. (2004)]

"Acting on less information (at times a single cue) can be highly beneficial."

There is a need to have stopping rules – when to stop receiving and analyzing additional information and to act."

[Source: Hanoch,Y., and Vitouch, O. (2004)]

SITUATIONAL AWARENESS:
Information Processing – Summary

"Decision makers tend to seek more information than is necessary and this information overload decreases decision making performance."

[Source: Karr-Wisniewski, P., and Lu, Y. (2010)]

SITUATIONAL AWARENESS:
Failure to cope with Information Overload – Multitasking

What the Science Says…

SITUATIONAL AWARENESS:
Failure to cope with Information Overload – Multitasking

"When humans attempt to perform two tasks at once, execution of the first task usually leads to postponement of the second one. This task delay is thought to result from a bottleneck…of information processing that precludes two response selections or decision making operations from being concurrently executed…"

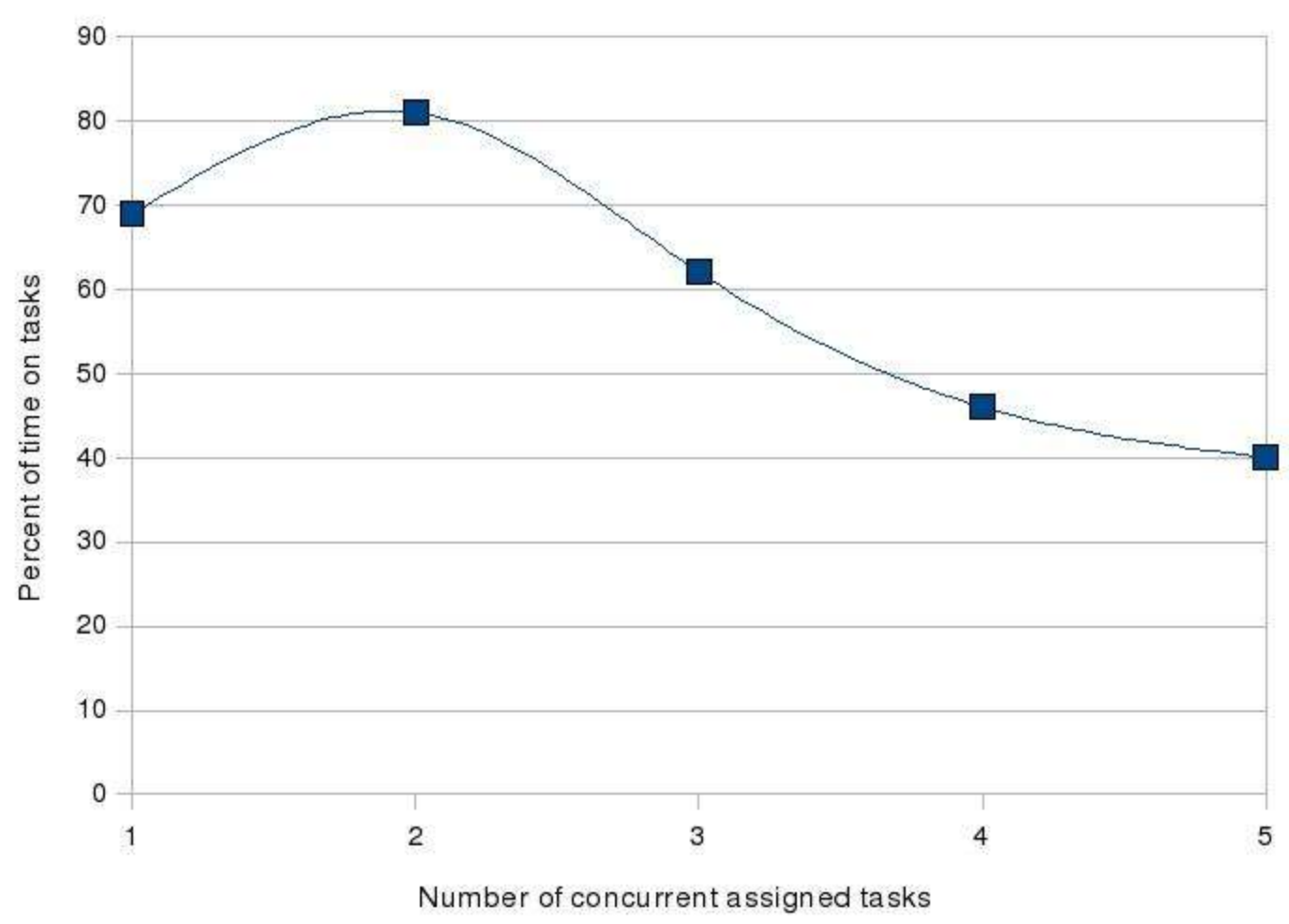
"Humans suck at multitasking. The problem isn't so much that we don't do well at multitasking. It's that we think we do."

[Source: Green, H. (2011). NOTE – not a scientific journal article]

"Laboratory research consistently confirms that multitasking impairs task performance."

[Source: Wang, Z., and Tchernev, J.M. (2012)]

Multitasking :Percent of Productive Time versus Number of Tasks.



[Source: Wheelright, S.C, and Clark, K.B. (1992)]

SITUATIONAL AWARENESS:
Failure to cope with Information Overload – Multitasking

It makes us less efficient. In one study participants who engaged in several tasks at once took nearly 1/3 longer to complete those tasks. They also made twice as many errors…"

[Source: Green, H. (2011). NOTE – not a scientific journal article]

"Most perceived benefits of multitasking are only myths."

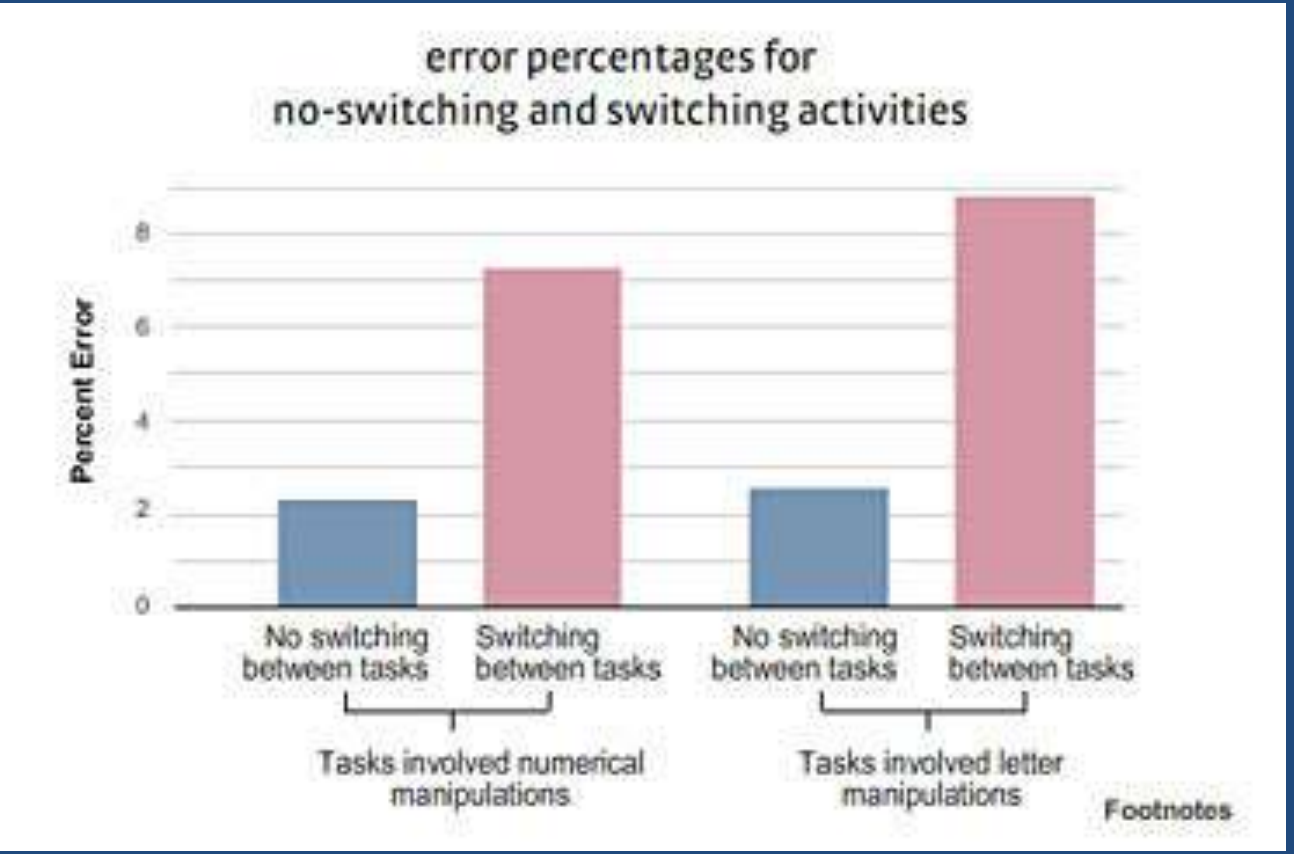
"The 'myth' of multitasking is partially caused by the 'misconception' of the efficiency of multitasking and by positive feelings associated with the behavior, which is emotionally satisfying but cognitively unproductive."

"Heavy…multitaskers are more distracted by irrelevant stimuli."

"Heavy multitaskers are less efficient at switching tasks."

[Source: Wang, Z., and Tchernov, J.M. (2012]

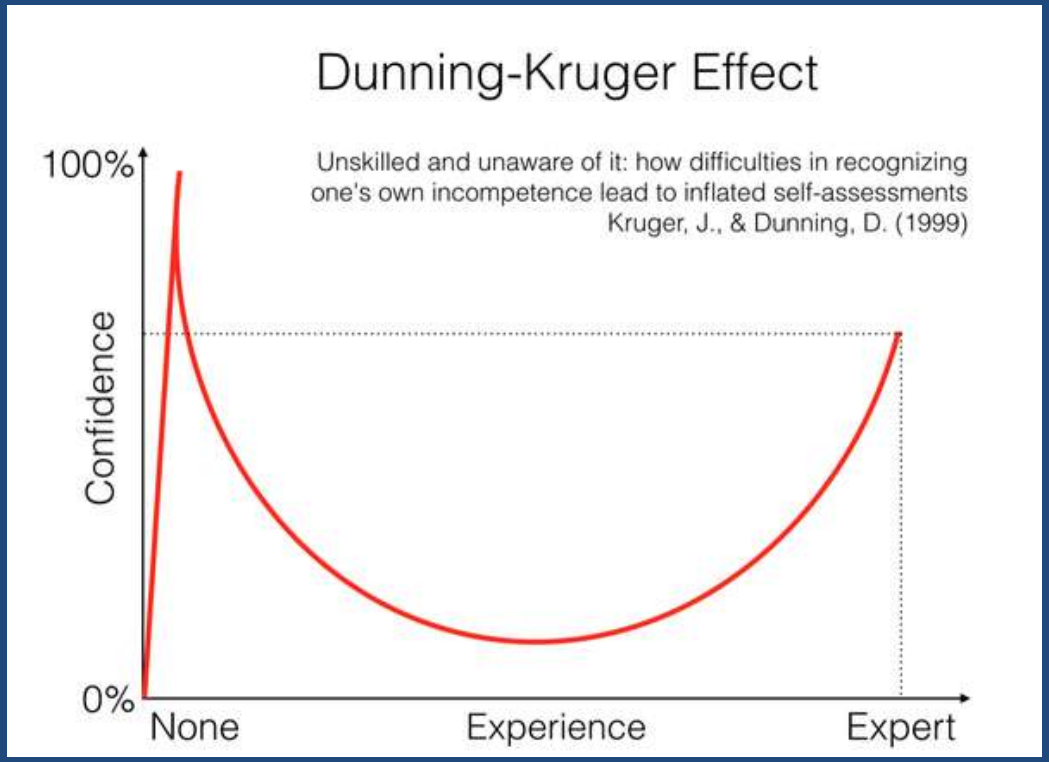
Multitasking: Increased Number of Errors



[Source: Rogers, R.D., and Monsell, S. (1995)]

SITUATIONAL AWARENESS:
How we Feel about Situational Awareness?

"They did not know very much, but they believed a great deal."
[Source: Ingersoll (1896)]



What the Science Says…

SITUATIONAL AWARENESS:
Decision Satisfaction, Certainty, and Accuracy

"Perceived information overload is associated with higher satisfaction and lower performance than perceived information under-load."

[Source: O'Reilly, C.A. (1980)]

"Participants were overconfident in answering questions about both impersonal and personally witnessed events."

"Mean confidence was positively correlated across domains, whereas mean accuracy was not."

It is difficult to determine the degree to which a given individual's confidence is indicative of his or her accuracy."

"…people believe they know more than they do…"

[Source: Bornstein, B.H., and Zickafoose, D.J. (1999)]

SITUATIONAL AWARENESS:
Decision Satisfaction, Certainty, and Accuracy

"There can be a real difference between what an operator KNOWS and what he THINKS HE KNOWS."

[Source: Nofi, A.A. (2000)]

"Increasing information availability had a detrimental effect of information processing efficiency leading to reduced decision accuracy. Results provide no support for the proposition that a broader supply of factual information will enhance individual working knowledge and improve performance in a decision making context."

"The findings emphasize the danger of dramatic increases in information supply enabled by new technology."

[Source: Handzic, M. (2001)]

SITUATIONAL AWARENESS:
Decision Satisfaction, Certainty, and Accuracy

"Additional information increases decision maker confidence and satisfaction in their decisions, even though the decisions are poorer—individuals believe that 'more information is better,' but this is not the case."

[Source: Karr-Wisniewski, P., and Lu, Y. (2010)]

"Even if they have all of the relevant information, some individuals might not identify and make the choice that best meets their objectives."

"Grade B decision makers show that, even in relatively simple and controlled settings, they cannot make rational decisions."

[Source: Kariv, S., and Silverman, D. (2012)]

SITUATIONAL AWARENESS:
Decision Satisfaction, Certainty, and Accuracy

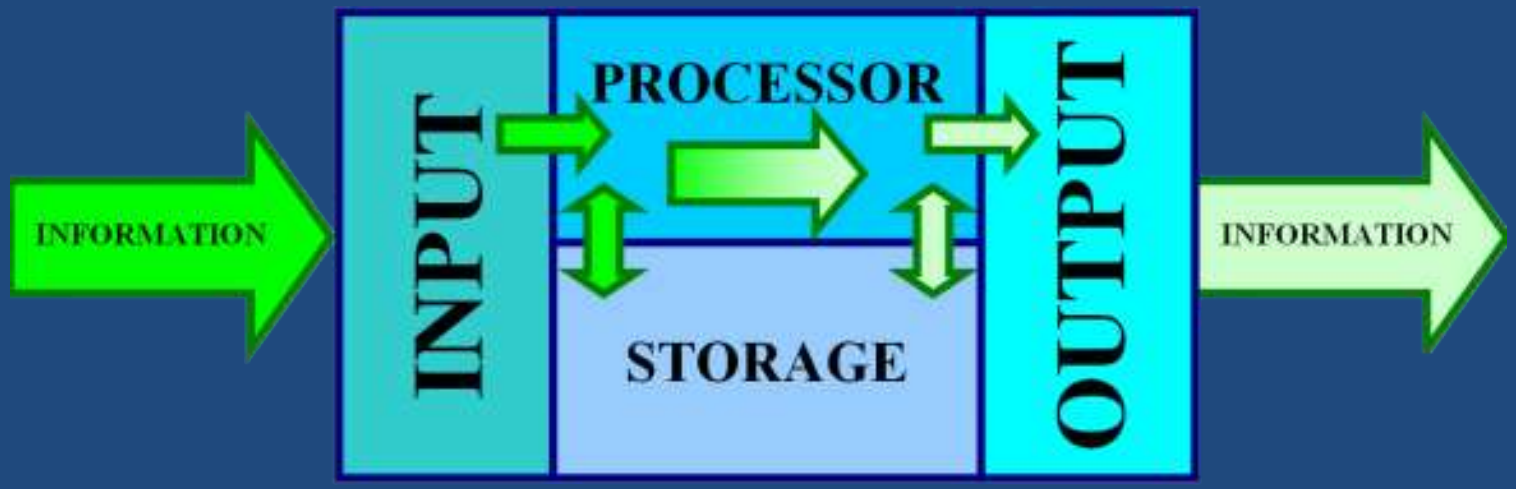
"The scientific literature on decision making is replete with studies showing the confidence and accuracy are often not highly correlated. Overconfidence is ubiquitous."

We must be mindful that if we are typically more confident than right, then the analyst, the briefer or other persuader is too."

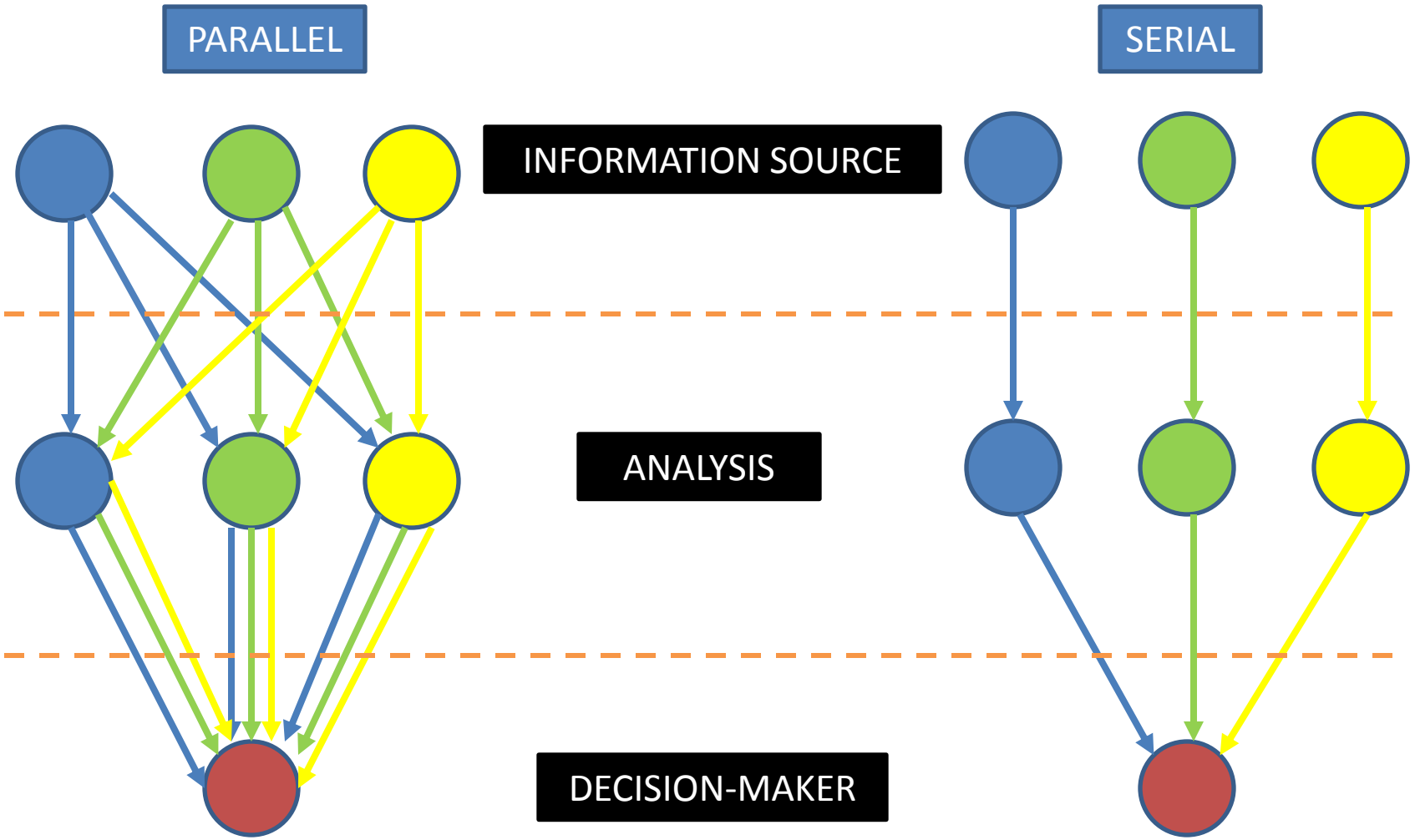
"Do not mistake certainty for accuracy."

[Source: Borum, R. (2014)]

SITUATIONAL AWARENESS:
Does Information Processing Matter?



What the Science Says…


PARALLEL
SERIAL
INFORMATION SOURCE
ANALYSIS
DECISION-MAKER

SITUATIONAL AWARENESS:
Parallel versus Serial Processing

"Those using the parallel approach had more difficulty in establishing situational awareness."

"Serial methods allowed subordinates to do their jobs."

[Source: Artman, H. (1999)]

"Parallel work organizations form fewer collective hypotheses on how things are developing…they waste time in analyzing information that could have been used for understanding the situation."

Serial work organization ensures that the participants attend to the same kinds of information…"

[Source: Artman, H. (2000)]

"It may be beneficial for direct-reports to provide summaries to managers rather than providing all of the data."

[Source: Karr-Wisniewski., P., and Lu, Y. (2010)]

SITUATIONAL AWARENESS:
What is the Role of Experience?

What the Science Says…

SITUATIONAL AWARENESS:
The Role of Experience

"High experience and high learning resulted in better decision performance."

[Source: Iselin, E., (1989)]

"As one's familiarity with a topic increases, one's searching efficacy increases and one's reading time decreases."

[Source: Kelly, D., and Cool, C. (2002)

"Domain experts search differently than people with little or no domain knowledge. They employ different search strategies and are more successful in finding what they are looking for than non-experts."

[Source: White, R.W., Dumais, S.T., and Teevan, J. (2009)]

"If decision-making quality is a trait, better decision-making in the experiment should predict better decision-making in the real world."

[Source: Kariv, S., and Silverman, D. (2012)]

SITUATIONAL AWARENESS:
The Role of Experience

"An expert generally won't need to delay a decision, but a novice generally should delay as long as possible."

"If you only have a few seconds to make a decision, you had better be an expert."

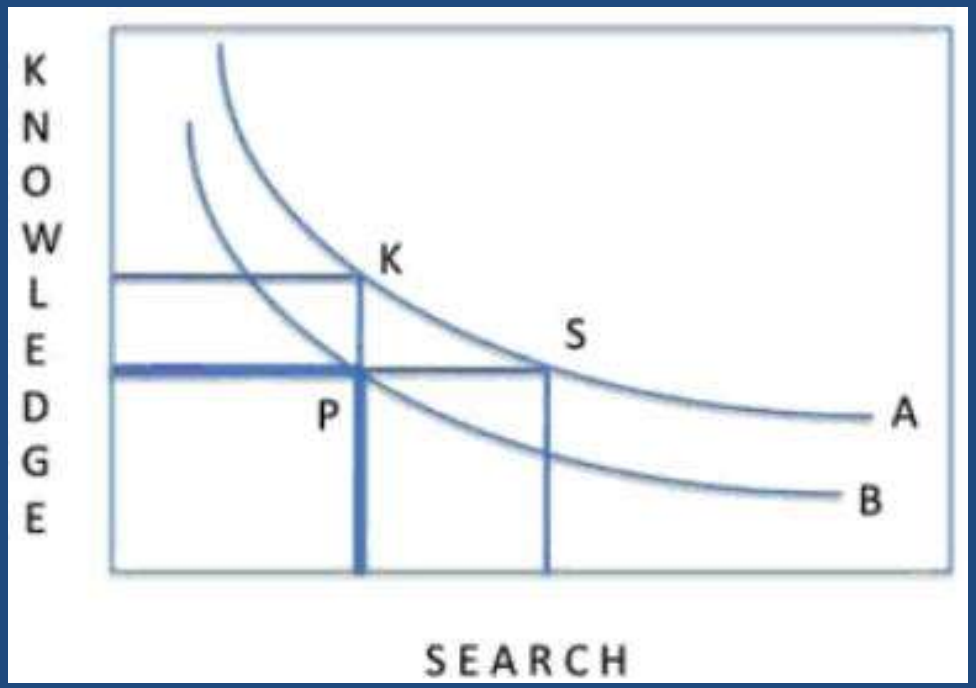
•"Novices who wrongly believe that they are experts are doomed."

"We are accepting a quick answer when we should be answering a slow question."

"Don't jump to firm conclusions about the unknown."

[Source: Partnoy, F. (2012)]

SITUATIONAL AWARENESS:
Role of Search versus Knowledge?



What the Science Says…

SITUATIONAL AWARENESS:
Search versus Knowledge

"Perfect knowledge about a domain renders a search unnecessary, and exhaustive search obviates heuristic knowledge."

"Various combinations of knowledge and search can result in equivalent performance."

"This implies that for shallow search…more knowledge is required to move to a higher isocurve than for deeper search depths."

"…for deeper searches, the benefits of additional knowledge are more significant than for additional search."

"Diminishing returns must exist…small improvements in knowledge, even at the expense of some search efforts, could greatly improve performance."

[Source: Junghanns, A., and Schaeffer, J. (1997)]

SITUATIONAL AWARENESS:
Search versus Knowledge

"The rapid capacity to learn may be more important than experience."

[Source: Kiel, L.D. (1995)]

"If diminishing returns exist, then there will come a time when the performance gains for the additional search effort are small…." people will have to invest more time on their knowledge if they want to improve in a significant way

[Source: Junghanns, A., Schaeffer, J., Brockington, M., Bjornsson, Y., and Marsland, T. (1997)]

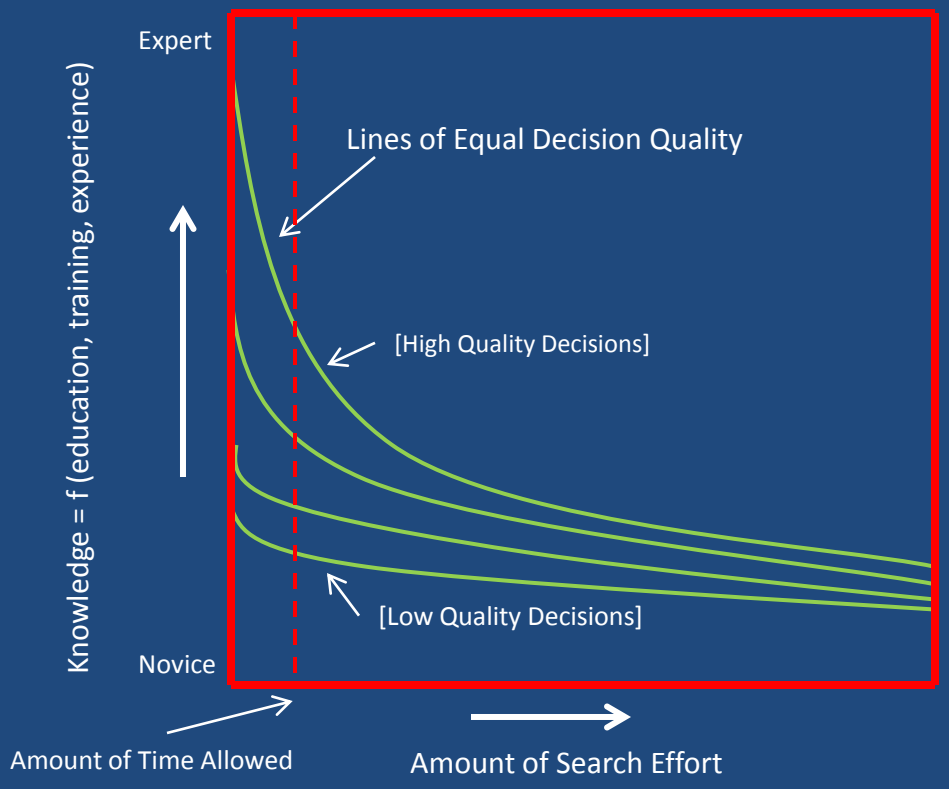
Decision Quality Based Upon Knowledge and Search Effort No Time Constraints:

Assumptions:

1. Decisions of equal quality are possible with a range of Knowledge provided enough Search Effort is taken.
2. A person with less Knowledge must expend more Search Effort to make the same quality decision as a person with greater Knowledge.
3. Persons with greater Knowledge are expected to make better decisions given no Search Effort than those with less Knowledge.
4. At some point, additional Search Effort reaches diminishing returns.
5. At some point, the only practical way to improve decision making is through improving your Knowledge.

[after: Junghanns and Shaeffer, 1997]

Decision Quality Based Upon Knowledge and Search Effort Time Constrained:



Assumptions:

1. Under time constraints, persons with low Knowledge are unlikely to make as high quality of decision as a person with greater Knowledge.
2. Improving decisions through increased Search Effort are only possible for those with greater Knowledge.
3. If you have little time and need a high quality decision, you had better be an Expert!

[after: Junghanns and Shaeffer, 1997]

SITUATIONAL AWARENESS:
Simplifying and Summarizing

What the Science Says…

SITUATIONAL AWARENESS:
Simplifying and Summarizing

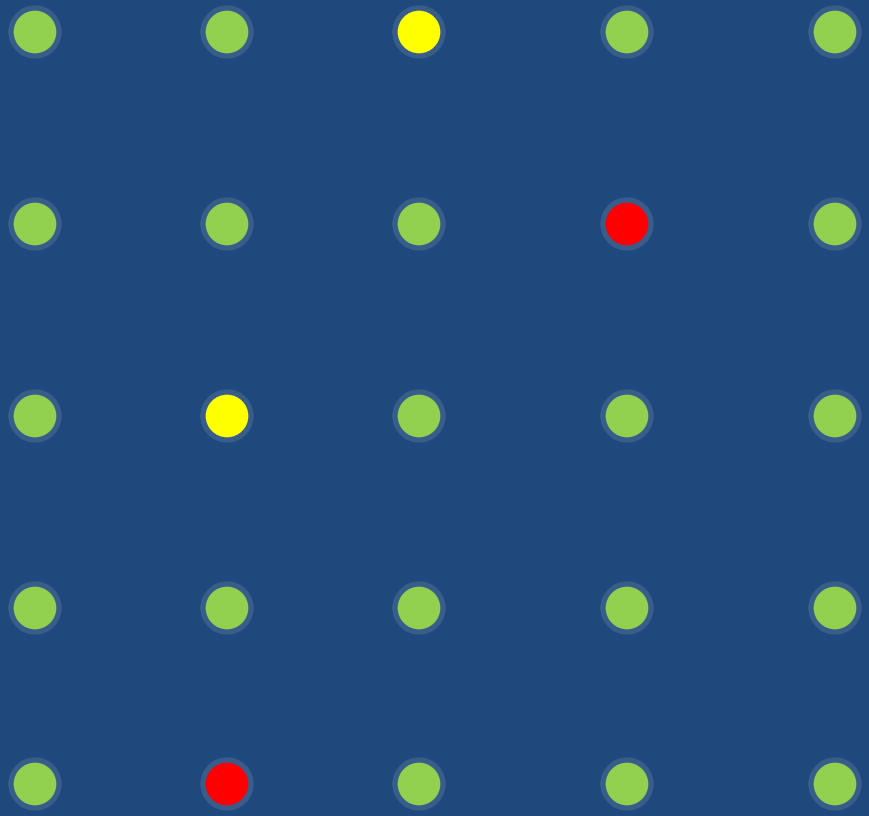
“Providing good and accurate information is as important as condensing the information to concise depictions.”

“The vulnerabilities are presented in a way that is clear to understand the severity levels, such as low, medium, high and critical.”

“This dashboard provides a concise and accurate view of the vulnerabilities in the environment along with detailed remediation information for analysts.”

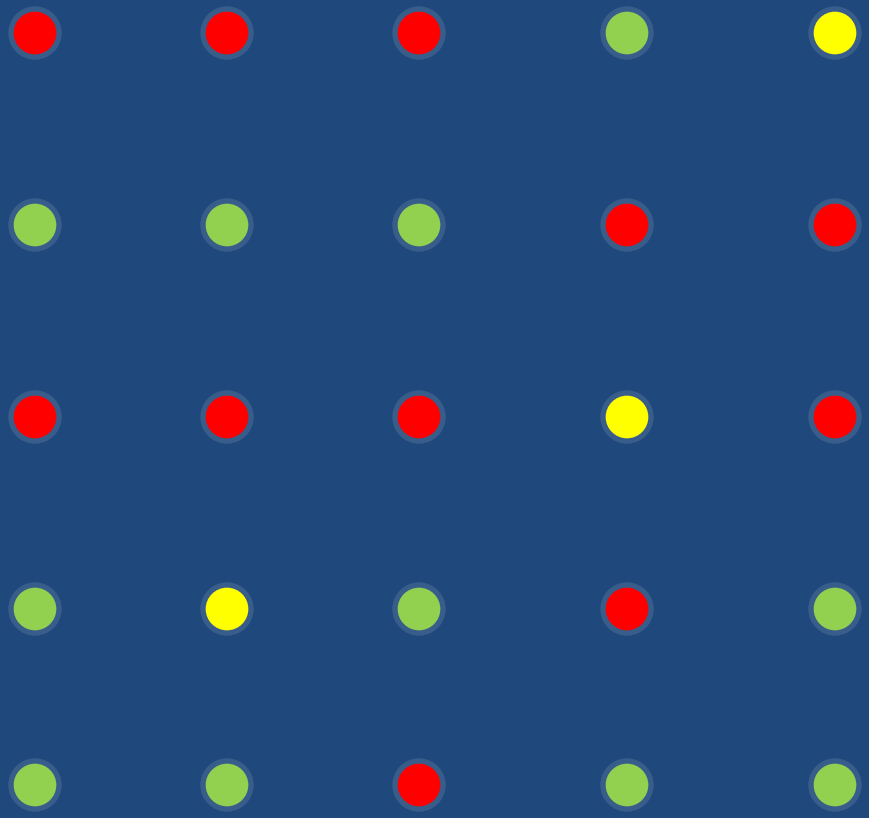
[Source: Freeborn, A. (2015)]

Easy to comprehend…



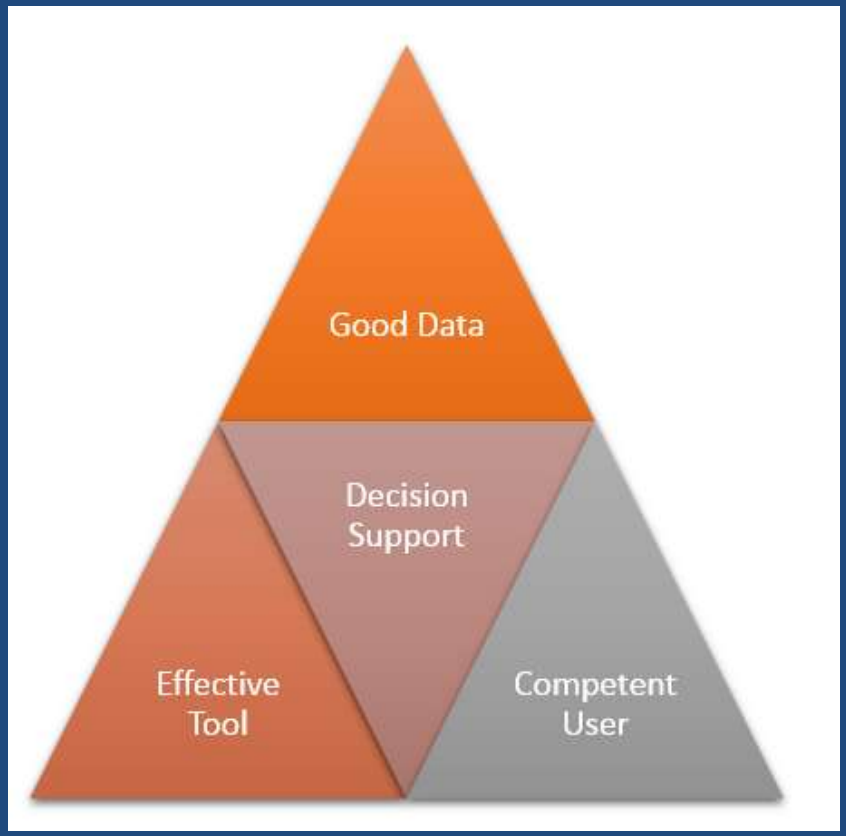
Easy to respond to…

What about now?...



Remember 7 ± 2…

SITUATIONAL AWARENESS:
What about Decision Support Tools?



What the Science Says…

SITUATIONAL AWARENESS:
Decision Support Tools

"By taking away the easy parts of his task, automation can make the difficult parts of the human operator's task more difficult."

"Aiding is best used at higher workloads."

"Humans must know which tasks the computers are dealing with – allocation of responsibilities."

"Humans are less effective problem solvers under time constraints."

[Source: Bainbridge, L. (1983)]

SITUATIONAL AWARENESS:
Decision Support Tools

"No single individual can acquire and process the diverse and often rapidly expanding information needed to create and execute plans effectively."

[Source: Sonnenwald, D.H., and Pierce, L.G. (2000)]

"Decisions are found to improve with stress up to an optimal threshold beyond which deterioration is observed."

"Decision support systems have the potential of mitigating or enhancing the perception of stress and, hence, impacting decision quality."

"Use of a decision support system mitigated the perceptions of dynamism and uncertainty for the high stress group. It did not mitigate the perceptions of information overload."

[Source: Phillips-Wren, G., and Ayda, M. (2009)]

SITUATIONAL AWARENESS:
How are Puzzles and Mysteries Different?

What the Science Says…

SITUATIONAL AWARENESS:
Puzzles versus Mysteries

"Puzzles can be solved. They have answers. Even when you cannot find the right answer, you know it exists."

"But a mystery offers no such comfort. It poses a question that has no definitive answer because the answer is contingent; it depends on a future interaction of many factors, known and unknown."

A mystery cannot be answered; it can only be framed by identifying the critical factors and applying some sense of how they have interacted in the past and might interact in the future. A mystery is an attempt to define ambiguities."

"Puzzles are more satisfying, but the world…offers us mysteries."

[Source: Treverton, G.F. (2007)]

SITUATIONAL AWARENESS:
Puzzles versus Mysteries

"Puzzle-solving is frustrated by a lack of information."

"Mysteries often grow out of too much information."

[Source: Treverton, G.F. (2007)]

"Mysteries require judgments and the assessment of uncertainty, and the hard part is that we do not have too little information but that we have too much."

"If things go wrong with a puzzle, identifying the culprit it easy: it's the person who withheld information. Mysteries, though, are a lot murkier: sometimes the information we have been given is inadequate, and sometimes we aren't very smart about making sense of what we've been given, and sometimes the question itself cannot be answered."

[Source: Pescovitz, D. (2009) Note—not a scientific journal article.]

SITUATIONAL AWARENESS:
What are some Plausible Solutions?

What the Science Says…

SITUATIONAL AWARENESS:
Some Plausible Solutions

Definitions of Situational Awareness:

- Be sure to define what you mean by Situational Awareness.
- Are you talking about a state of being; an abstraction; an ability?
- Are you concerned about the product or the process?

How to measure it?

- Conformance to reality? Is this possible?
- Ability to form mental models that are useful and lead you to a solution?

SITUATIONAL AWARENESS:
Some Plausible Solutions

Model of Situational Awareness:

- Adopt the Endsley (1995) model.
  - ❑ Level 1 – Identify and visualize what is happening.
  - ❑ Level 2 – Make sense of it.
  - ❑ Level 3 – Project and predict what will happen into the future.
  - ❑ Intervene and change the outcome.

SITUATIONAL AWARENESS:
Some Plausible Solutions

Human Cognitive Limitations:

- Can only deal with a small number of things at once.
- Remember 7 ± 2.
- Simplify and summarize – rely on SMEs.
- Rely on heuristics and “rules of thumb” where appropriate.
- Limit the amount of information you have to deal with – filter.
- Summarize information for your boss – don’t pass along all of the data.

SITUATIONAL AWARENESS:
Some Plausible Solutions

Time Constraints:

- Time constraints negatively effect decision-making effectiveness.
- Analytic methods work well where there are no time constraints.
- With time constraints, more information is not necessarily better.
- Find a point of acceptable risk and act.
- Improve the knowledge-base to reduce the time needed for search.
- Experts react instinctively to known situations.
- Experts identify novel situations more quickly and adapt.
- If you do not have much time you had better be an expert.

SITUATIONAL AWARENESS:
Some Plausible Solutions

"Other Issues":

- Learn to be more comfortable with ambiguity.
- Avoid circular reasoning the "explaining-away" of contradictory information.
- Finding just the right amount of information is difficult.
- Information load decreases decision-making speed and accuracy.
- Develop "stopping rules."

SITUATIONAL AWARENESS:
Some Plausible Solutions

Multitasking:

- Decisions are poorer and take longer.
- We are very satisfied with the results, even though they are poorer.
- Learn to focus on one thing at a time, because multitasking does not work!
- Delegate tasks to others – if you do not have others, that is the problem that needs to be solved.

SITUATIONAL AWARENESS:
Some Plausible Solutions

Satisfaction, certainty, and accuracy:

- Do not confuse certainty with accuracy.
- Do not confuse satisfaction with having the right answer.

Information processing:

- Everyone should not get everything.
- No one person has the ability to integrate all of the relevant information.
- Let SMEs see the data that are relevant to them.
- Trust in their judgments.
- Filter and summarize.

SITUATIONAL AWARENESS:
Some Plausible Solutions

Role of Experience:

- Generally, the greater the experience, the greater the knowledge, skills, and abilities.
- Experience is domain-specific.
- Ability to learn quickly may be more important.

Search versus Knowledge:

- Without time constraint, long search can provide equivalent quality decision and high knowledge.
- With time constraints, high knowledge is critical.

SITUATIONAL AWARENESS:
Some Plausible Solutions

Decision Support Tools:

- Valuable.
- Tend to decrease the perception of dynamism and uncertainty under high stress conditions.
- Have the potential to mitigate the perception of stress, but it can go either up or down.
- Do not mitigate the perception of information overload.

Puzzles and Mysteries:

- Emergency Management is more like a mystery than a puzzle.
- Accept the fact that there may be no “solution.”
- More information may be the problem with mysteries – sorting through the information may help solve them.

SITUATIONAL AWARENESS:

Questions?