Innovative Methods for Evaluating Human Performance in a Military Command and Control System

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Agenda

- Introduction
  - Common view of situation awareness (SA)
  - Process model of situated cognition
  - A few current measures of workload and SA
- Workload study
  - Method
  - Results
- SA study
  - Description of prototype
  - Progress to date
- Discussion

Descriptions of Situation Awareness

"The ***perception of elements*** in the environment within a volume of time and space, the ***comprehension of their meaning***, and ***their status*** in the near future." (Endsley, 1988)

"***A common, relevant picture*** of the battlefield scaled to specific levels of interests and special needs."
(TRADOC Pamphlet 525-5)

"The ***product*** of applying analysis and judgment to the common operational picture..." (FM 3-0 (Operations))

Ideal SA; Achievable SA; Actual SA
(Pew, 2000)

"Where am I? Where's my buddy? Where's the enemy?" (An Army Officer)

"That's my SA (pointing to his FBCB2 screen)." (An Enlisted Soldier)

State

Thing

Product

Information

An Alternative to Situation Awareness

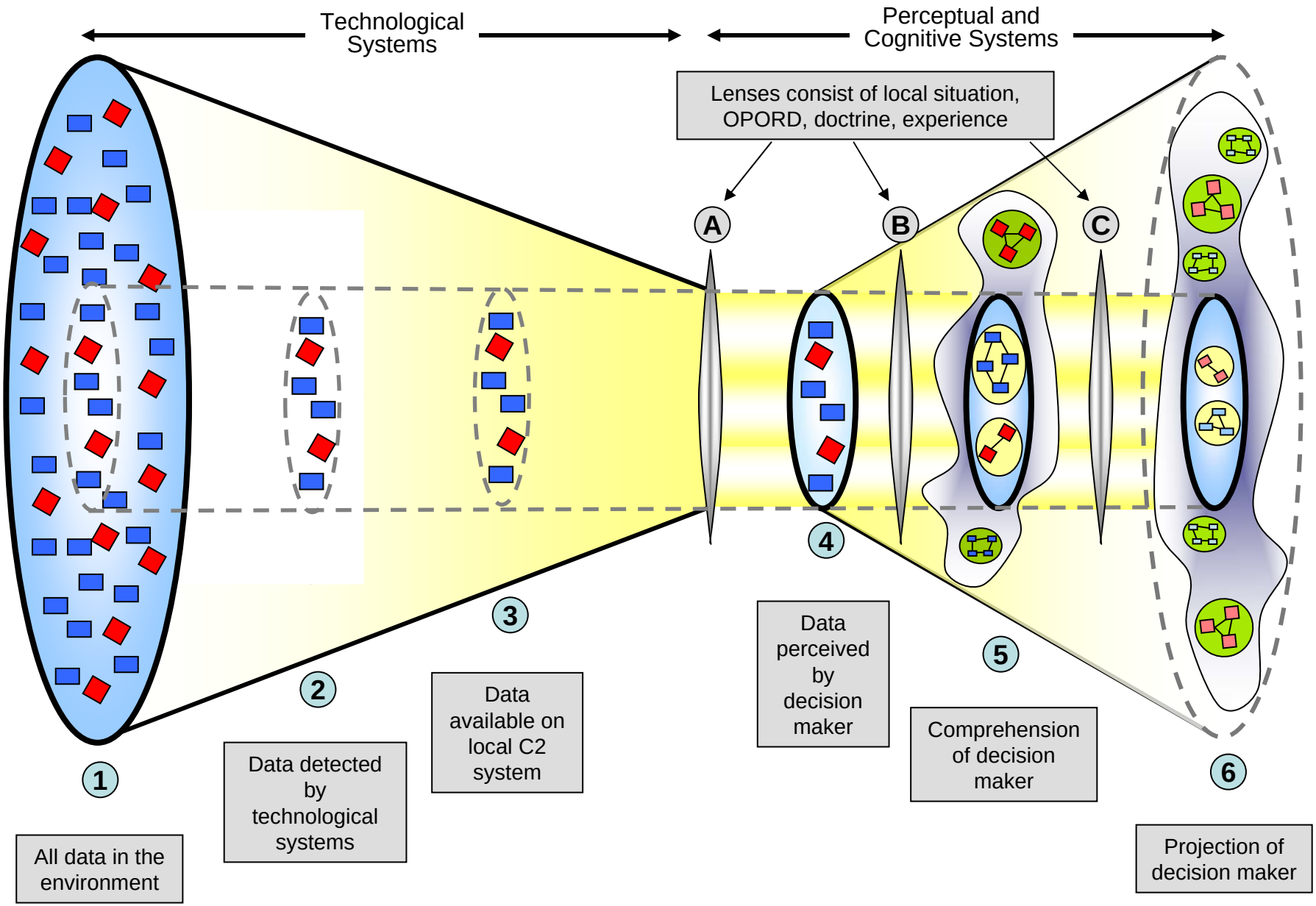
What is needed is a model and a methodology that:

- ❑ focuses on ***processes*** rather than states
- ❑ includes both ***human and machine*** ‘components’ of a system
- ❑ is oriented on assessing ***human-system performance***
- ❑ tracks the ***evolution*** of activities and cognition

Situated Cognition

- Borrowed from the learning and linguistics literature
- Includes mental activities ***embedded in an evolving context***
- Includes ***human and machine agents***
- Involves ***collaborative activities***
- ***Goal-directed***

A Dynamic Model of Situated Cognition



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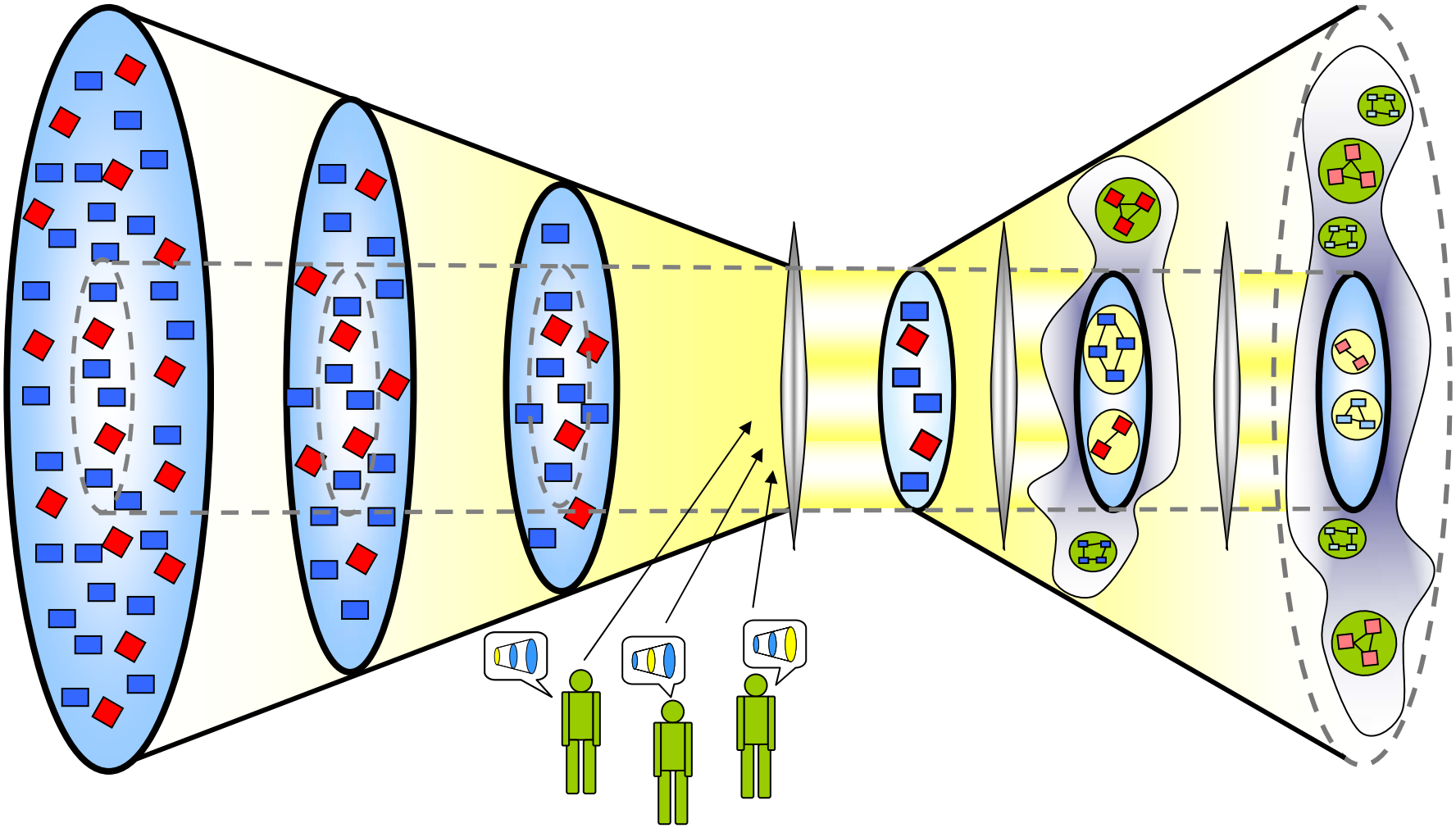

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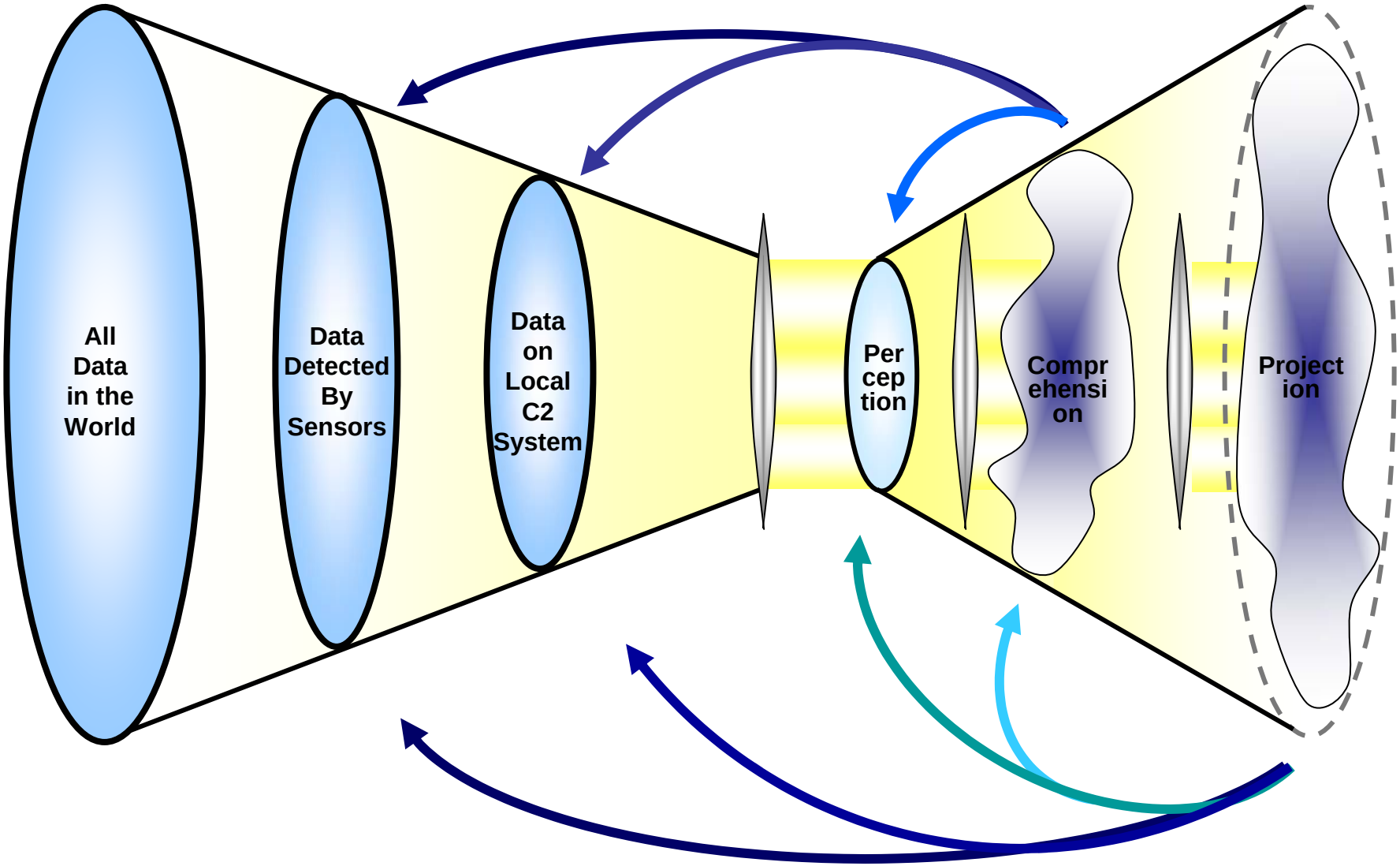
Feedback Loops in the Model



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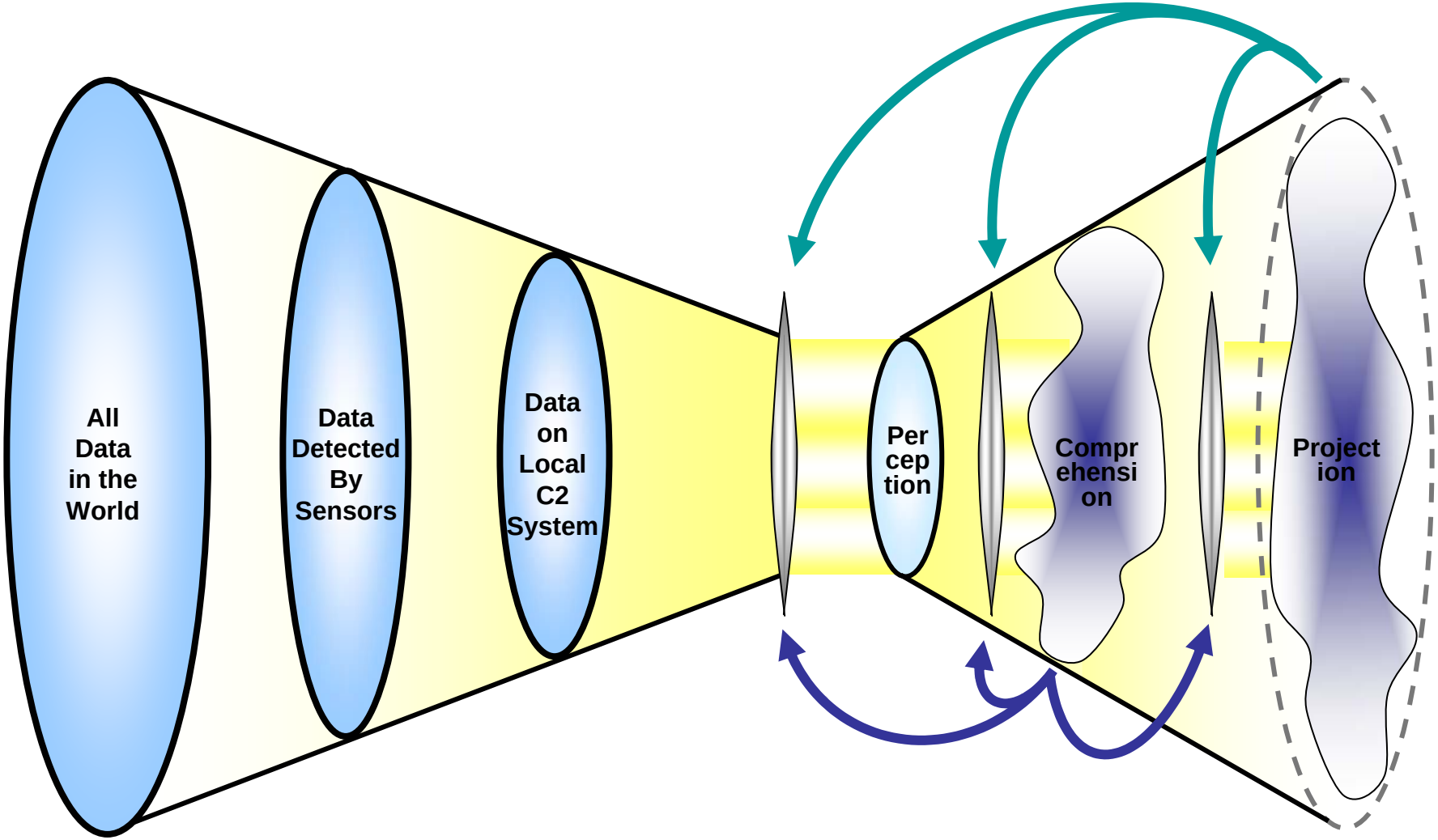
Feedback Loops in the Model



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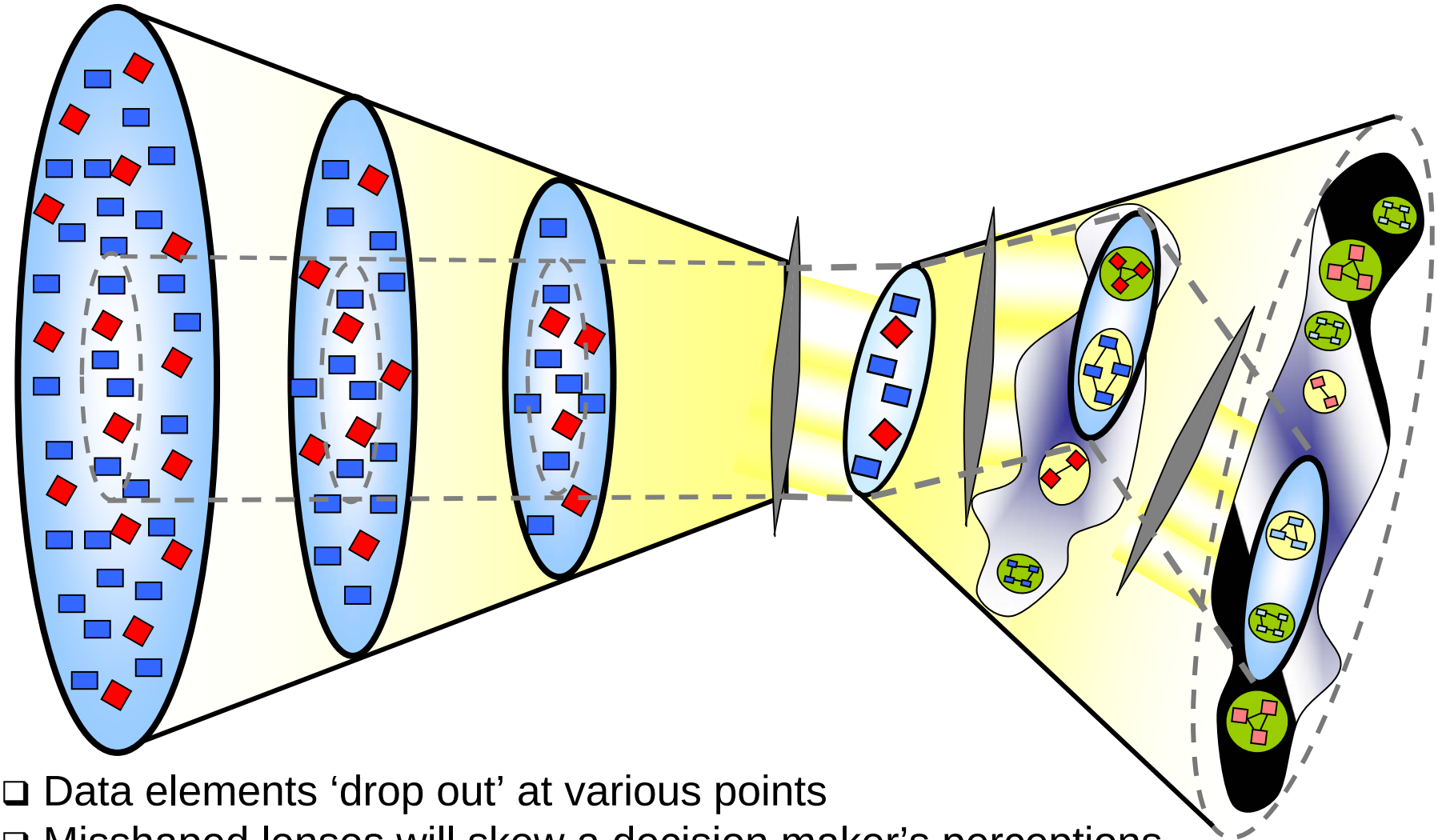
A Dynamic Model of Situated Cognition: A Few Reasons Why Things Go Wrong



- Data elements ‘drop out’ at various points
- Misshaped lenses will skew a decision maker’s perceptions, comprehensions, and projections
- Erroneous or lack of feedback loops

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Process Tracing

- Maps out how the incident unfolded
- Focuses on how a given outcome came about
- Externalizes internal processes
- Uses data from multiple sources
- Describes the sequence of information flow and knowledge activation

(After Woods, 1993)

Recent Methodological Studies on the Model of Situated Cognition

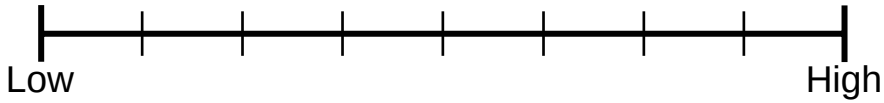
- Workload Assessment
- **Comparison of Subjective Measures of Mental Workload**
- Lenses and Loops
- Comparison of Subjective Measures of Situation Awareness
- **Geographical Recall and Analysis of Data in the Environment (GRADE) Scoring Metrics**
- The Effect of Context on Data Detection
- Analysis of Communication Flow in a C2 Environment

Workload Study:

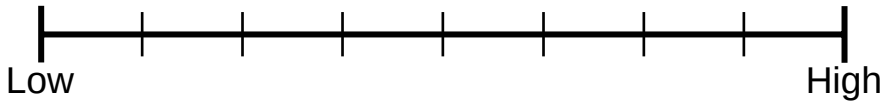
Comparison of Subjective Measures of Mental Workload

NASA Task Load Index (TLX)

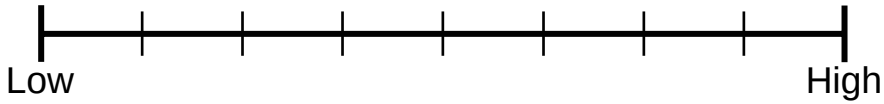
MENTAL DEMAND



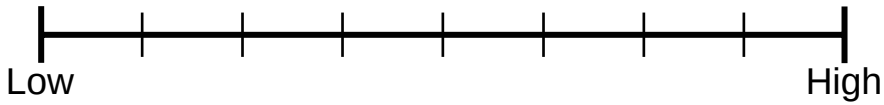
PHYSICAL DEMAND



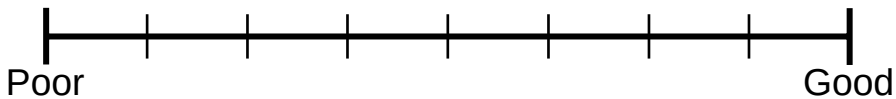
TEMPORAL DEMAND



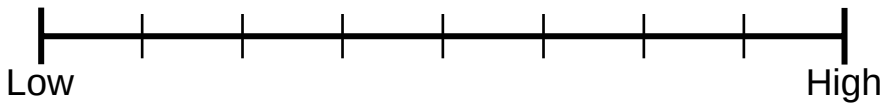
EFFORT



PERFORMANCE



FRUSTRATION LEVEL



Cumulative and Retrospective

Subjective Workload Assessment Technique (SWAT)

Time Load	*Mental Effort Load*	*Stress Load*
1. Often have spare time. Interruptions or overlap among activities occur infrequently or not at all.	1. Very little conscious mental effort or concentration required. Activity is almost automatic, requiring little or no attention.	1. Little confusion, risk, frustration, or anxiety exists and can be easily accomodated.
2. Occasionally have spare time. Interruptions or overlap among activities occur frequently.	2. Moderate conscious mental effort or concentration required. Complexity of activity is moderately high due to uncertainty, unpredictability, or unfamiliarty. Considerable attention required.	2. Moderate stress due to confusion, frustration, or anxiety noticeably adds to the workload. Significant compensation is required to maintain adequate performance.
3. Almost never have spare time. Interruptions or overlap among activities are very frequent, or occur all the time.	3. Extensive mental effort and concentration neccessary. Very complex activity requiring total attention.	3. High to very intense stress due to confusion, frustration or anxiety. High to extreme determination and self-control required.

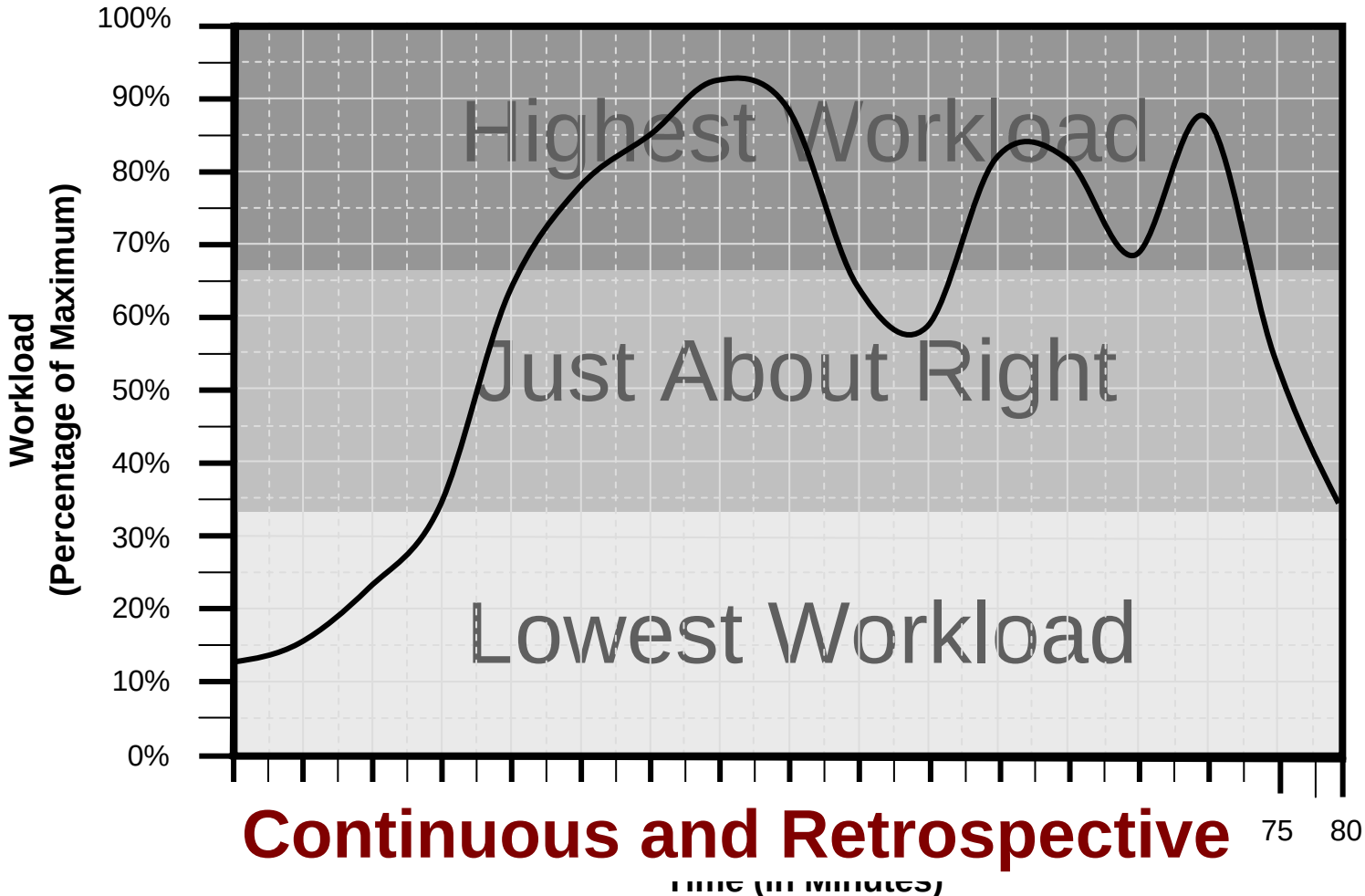
Discrete and Intrusive

Continuous Subjective Workload Assessment Graph (C-SWAG)

Instructions: Reflect back on the tactical activity just completed. As time progressed your workload probably increased or decreased in response to the activity in which you were engaged.

1. On the graph below, plot your workload **over time**. The curve you draw should describe the percentage of cognitive workload the activity required. For example, at the outset of the study, your workload was probably very low, increasing and decreasing over time.

2. Label the **high** points and **low** points on your graph by listing the activity that led to your workload assessment of those points.



Continuous and Retrospective

Workload Study Method

Participants

- 23 soldiers stationed at the Presidio of Monterey
- Students at the Defense Language Institute

Apparatus

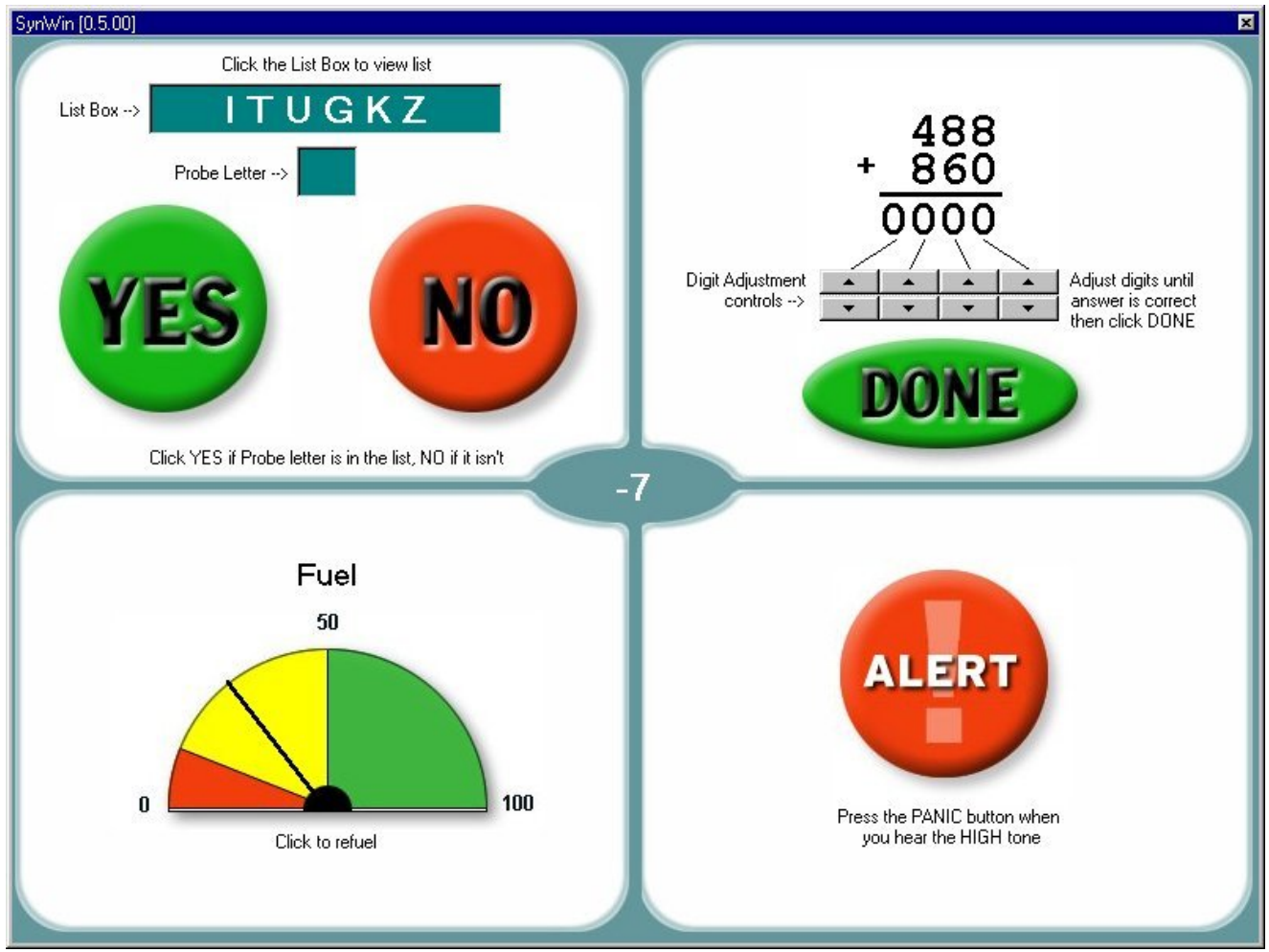
- SynWin (synthetic work program for Windows)
- Desktop/laptop PC
- Workload assessment instruments (NASA-TLX, SWAT, C-SWAG)

Procedure

- SynWin practice session
- Data collection session (6 levels of difficulty, 3 minutes at each level)
- SWAT administered during each 3-minute interval; NASA-TLX and C-SWAG administered after the session

Workload Study Method

SynWin Display



Workload Study Results

Correlations

NASA-TLX and C-SWAG	***0.617***
SWAT and C-SWAG	***0.620***

SA Study:

Geographical Recall and Analysis of Data in the Environment (GRADE) Scoring Metrics

Methods for Measuring SA

- SART: Situational Awareness Rating Technique
- SA-SWORD: Situation Awareness-Subjective Workload Dominance
- SARS: Situation Awareness Rating Scale
- MARS: Mission Awareness Rating
- SAGAT: Situational Awareness Global Assessment Technique
- SALIENT: SA Linked Instances Adapted to Novel Tasks
- SABARS: Situation Awareness Behaviorally Anchored Rating Scale

Many SA measures:

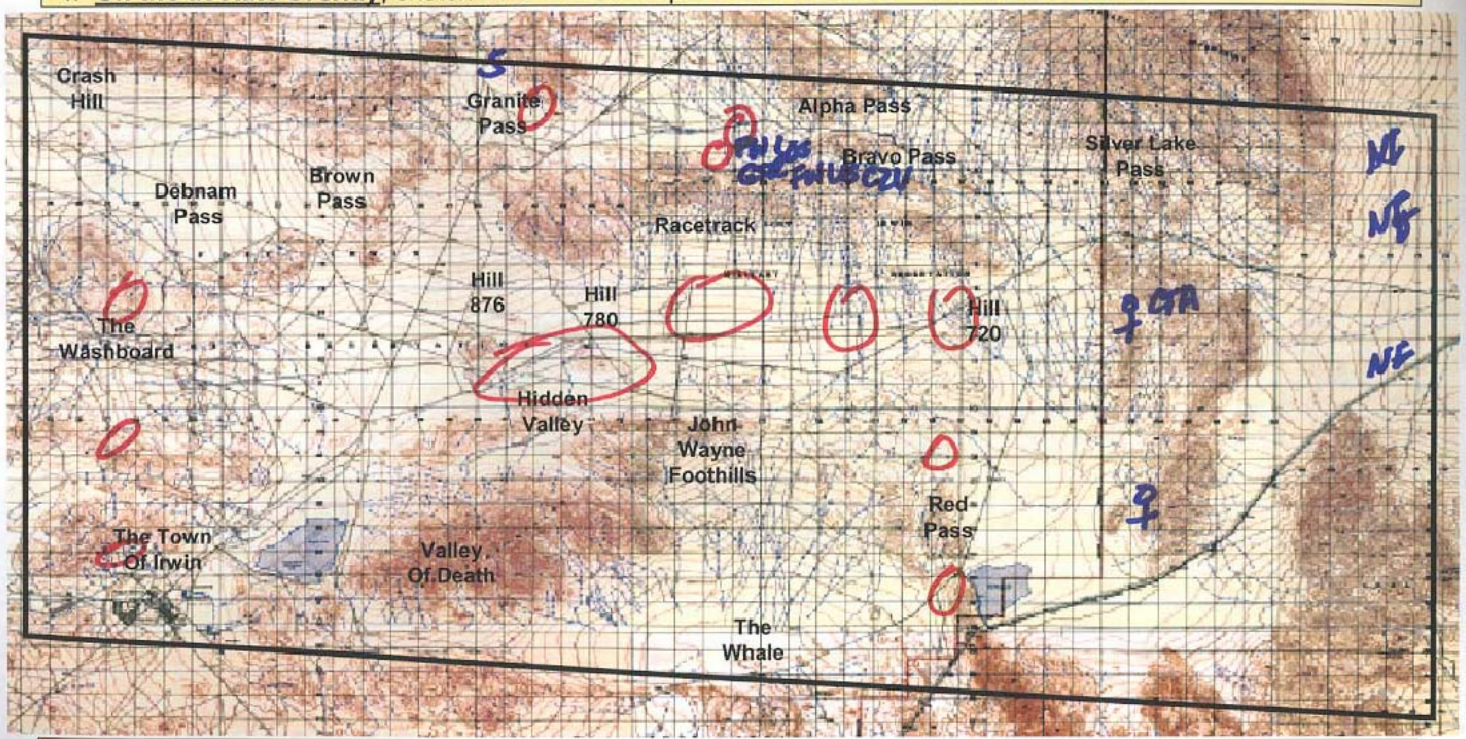
- **Use Likert scales**
- **Result in a single numerical value**
- **Do not provide insight into how and why a respondent's SA differs from ground truth.**

GRADE Prototype (Manual Version)

Seat ___ Date: _____ Time: _____

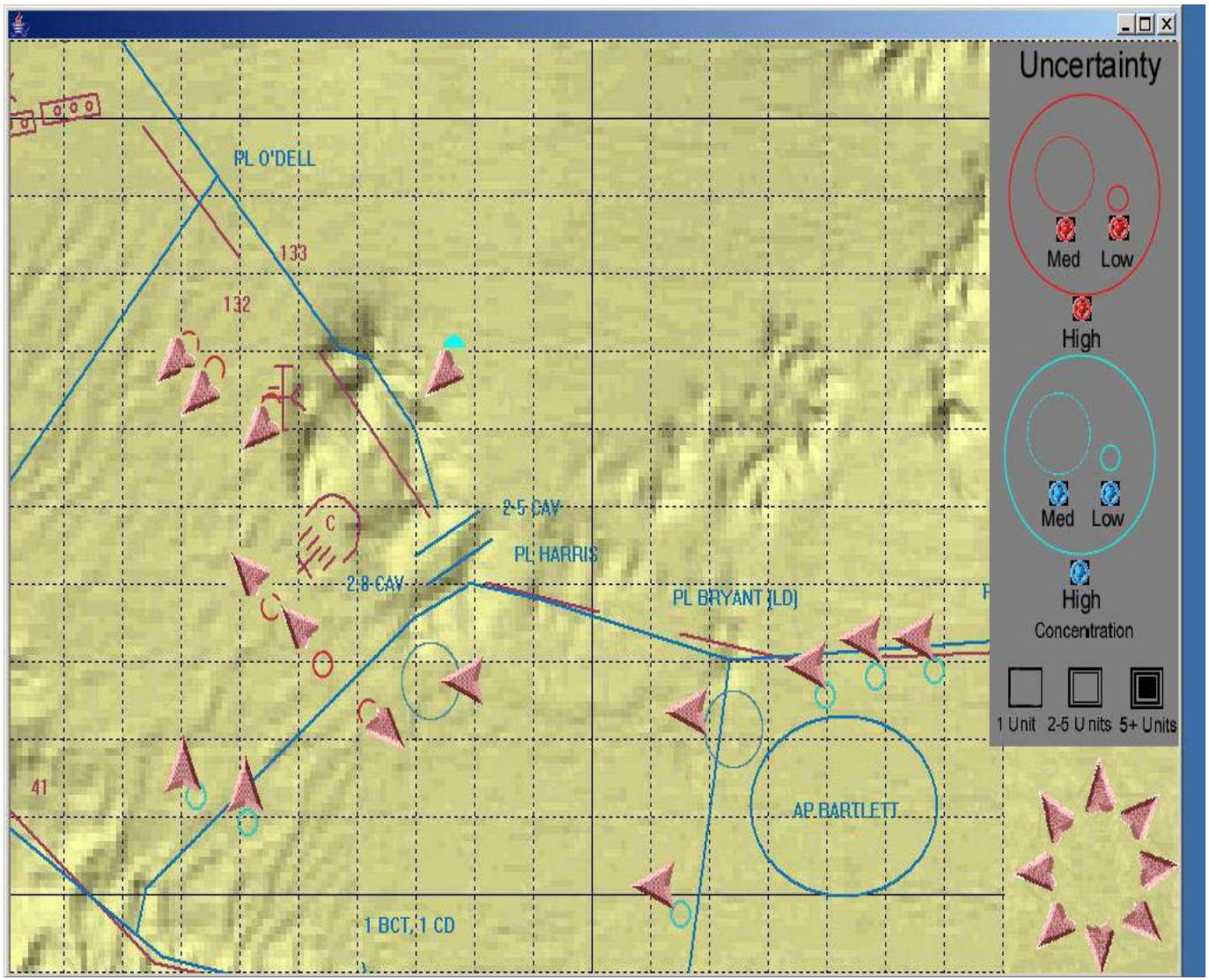
INSTRUCTIONS

1. Fill in your SART ratings below. (Refer to descriptions on the inside cover of this binder if necessary.)
2. ***On the paper map***, as quickly as possible, sketch the portion of the battlefield on which you are currently focused in sufficient detail to communicate it to a fellow staff officer.
3. Flip the acetate overlay.
4. ***On the acetate overlay***, sketch what the battlespace will look like 30 minutes from now.



Demand (1 to 7) 5 Supply (1 to 7) 6 Understanding (1 to 7) 5

GRADE Prototype (Computer Version)



Progress To Date

- Essential attributes identified (i.e., size, location, degree of uncertainty, etc.)
- Computer prototype software developed
- Scoring mechanism developed
- Pilot study conducted at NPA
- GRADE study underway at USMA

Discussion

- ↑ Preliminary results indicate strong correlation between C-SWAG and frequently used measures of workload.
- ↑ C-SWAG is continuous and retrospective (not intrusive).
- ↓ C-SWAG does not discriminate among workload categories.

- ↑ Initial results of GRADE study are promising.
- ↑ GRADE appears to provide better insight into respondent's SA than other types of measures.
- ↑ GRADE facilitates comparison with ground truth.
- ↑ GRADE facilitates analysis of respondent's attention

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