# Constructible Assessment for Situation Awareness

## in a Distributed C2 Environment

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# Outline

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  - Objectives of study
- Constraints of experiments in field exercises
- Constructible Assessment for SA (CASA)
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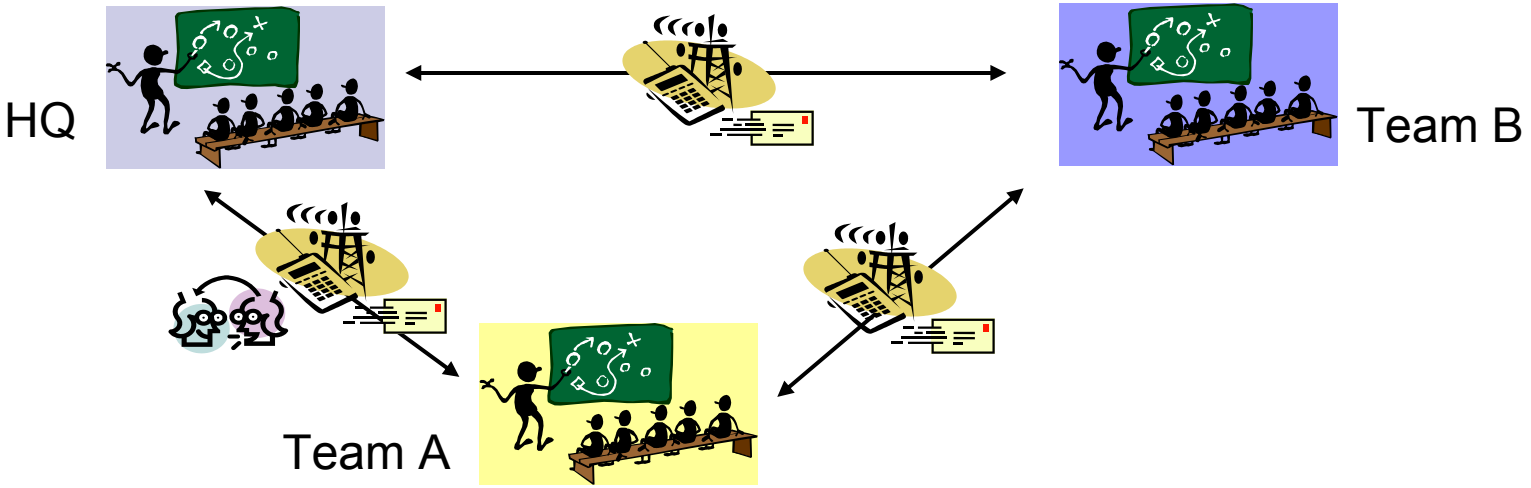
- Future Work

# Introduction

## Background

- In 2003, an exercise was conducted by the Singapore Armed Forces to experiment with distributed but collaborative command and control processes
- Division-Level exercise with human participants in Brigade and Division-level command post; computer generated forces for fighting units
- One of the experimental conditions: Two command teams differed in physical proximity to HQ but otherwise have identical communication links and information systems
- Cognitive performance was among the variables being investigated



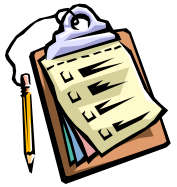
# Introduction

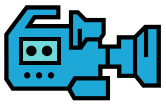
Objectives of study

- To assess cognitive performance of command teams in the exercise
  - To attempt and evaluate various methodologies for cognitive assessment in the field
- To collect data on baseline cognitive performance of command teams

Cognitive performance assessment methods used

- Situation Awareness (SA)
  - Constructible Assessment For Situation Awareness (CASA)
  - Situation Awareness Rating Technique (SART)
- Workload
  - NASA-TLX
- Communication activity
  - Video/Audio recordings

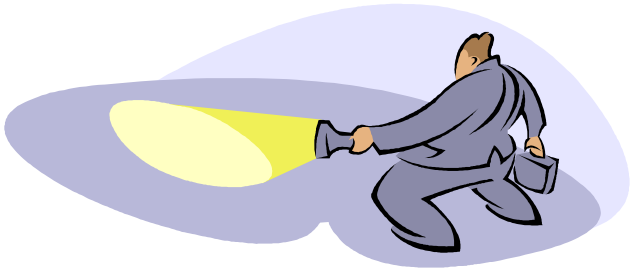




# Constraints of experiments in field exercises

- Intrusiveness of data collection to be minimized
- Exercise events take precedence over data collection
- Low degree of experimental control - possibility of unexpected event injects from Director of Exercise
- Logistics challenge
  - Large number of participants (56)
  - Long duration (24hrs)
  - Physical mobility of participants

# Categories of SA Measurement

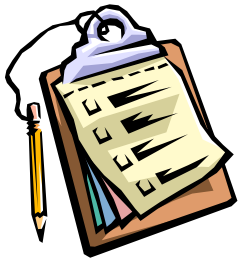


**Direct experimental techniques**

- Retrospective measures (e.g. recollection)
- Concurrent measures (e.g. verbal protocols)
- Psycho-physiological measures
- Direct questioning / freeze technique

**Performance measures**

- Global performance measures
- Subtask performance
- Performance in response to introduced anomalies or events



**Subjective measures**

- Direct self rating
- Comparative self rating
- Observer rating

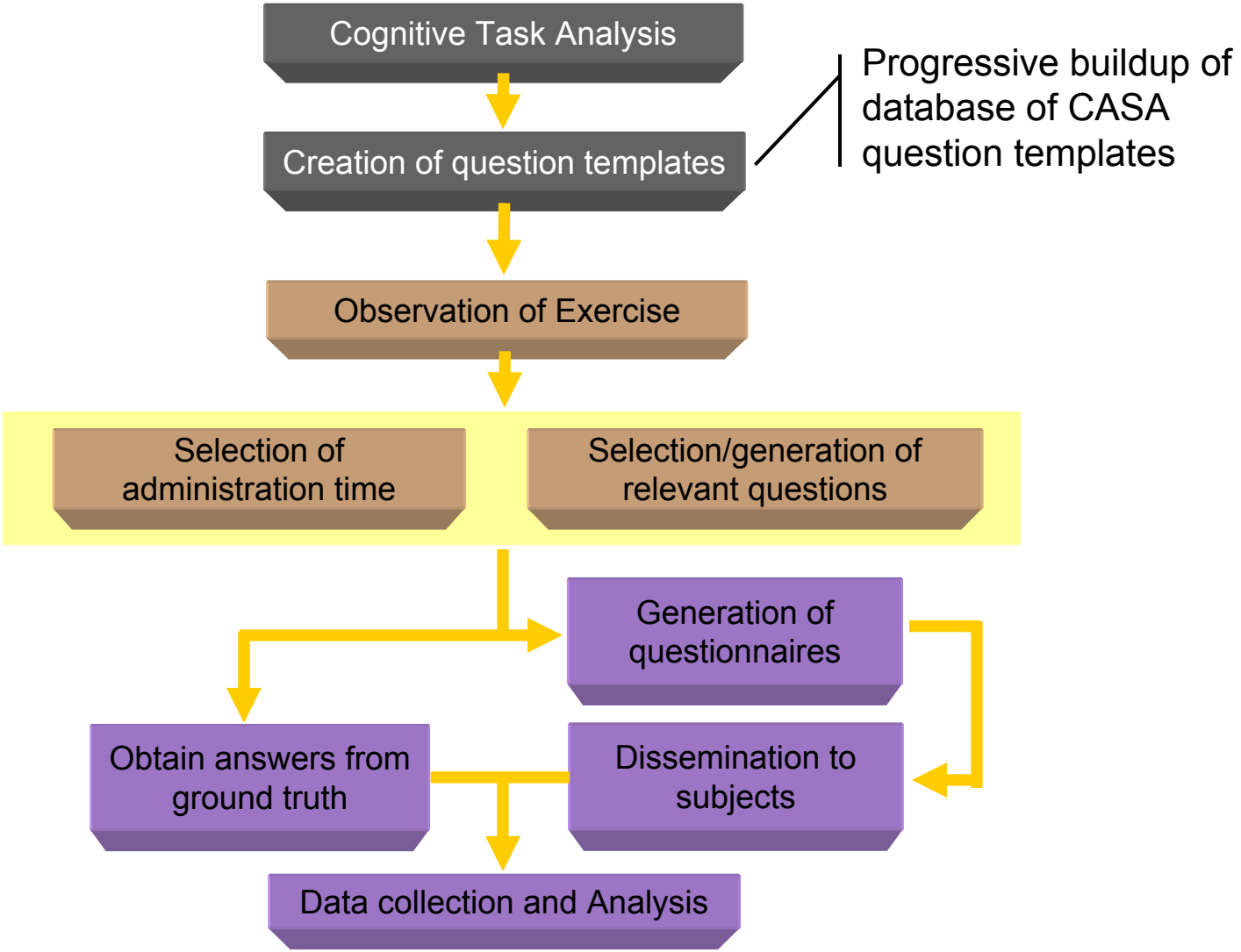
# Endsley's SAGAT

- Direct (explicit) measure of SA that is well-validated and widely applied
- Based on three levels of SA (Endsley, 1991)
  - Level 1 : Perception of elements in the environment
  - Level 2 : Comprehension of the situation
  - Level 3 : Projection of future status
- Randomised administration
  - exercise or simulation will be frozen
  - randomly-selected pre-determined questions based on SA requirements
  - probes into knowledge of environment and events
  - SA is captured in real-time rather than post-hoc to reduce memory errors

# Constraints of experiments in field exercises

- Intrusiveness of data collection to be minimized
  - Exercise freezes were not tolerated, administration times to be short (5 minutes)
  - Irrelevant questions from randomisation are a concern due to limited number of administrations over duration of exercise
- Exercise events take precedence over data collection
- Low degree of experimental control - possibility of unexpected event injects from Director of Exercise
- Logistics challenge
  - Large number of participants (56)
  - Nine key participants identified for objective SA assessment
  - Long duration (24hrs)
  - Physical mobility of participants
  - Paper-based administration

# Workflow of CASA



# Examples of CASA questions

## Question Formats

**Level 1 SA**

1. Mark the location of [red/blue] unit on map.
2. What is the current size force of [red/blue] unit? (e.g. “Coy+”)

**Level 2 SA**

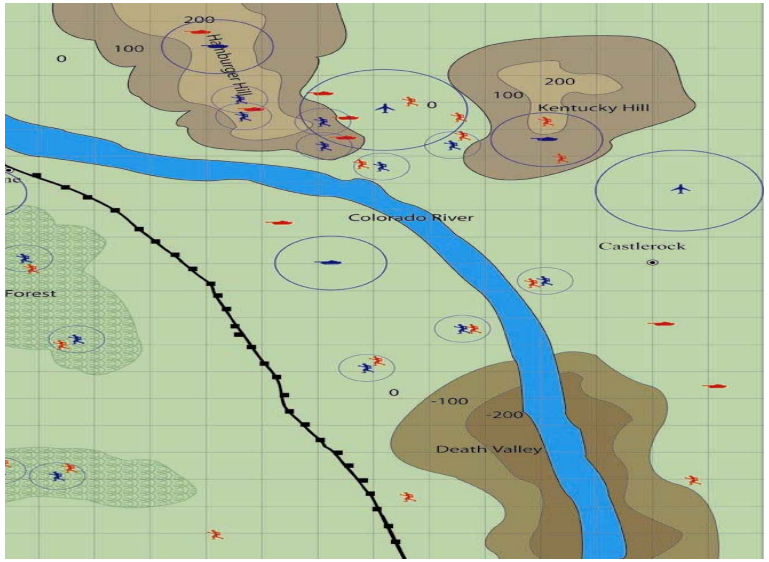
1. What is the most critical additional asset that [blue] unit requires to carry out its mission?
2. Which hostile unit currently poses highest threat priority to this [blue] unit?

**Level 3 SA**

1. When is the earliest projected time for the securing of [location]?
2. Is [red] unit likely to be in contact with [blue] unit by [time] ?

## Answer Formats

- **Only 1 correct answer per question**
- **Multiple choice questions**
- **Map-based**
- **Open-ended (constrained by context)**

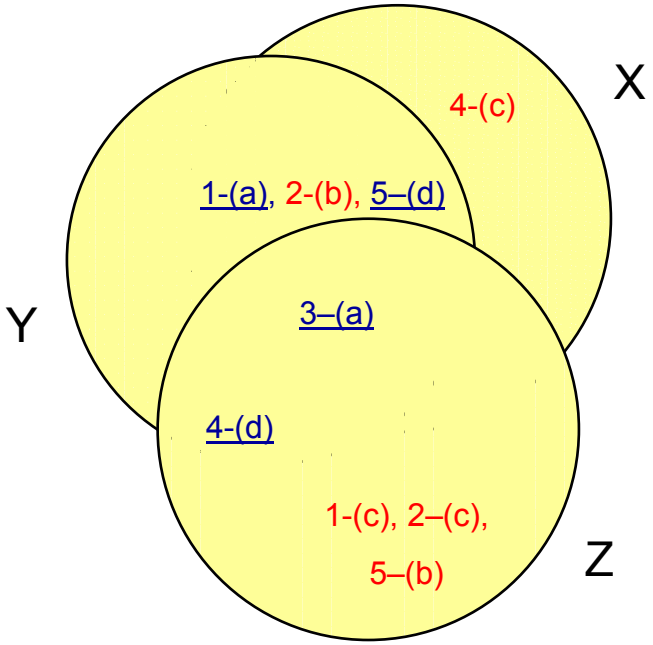


# CASA Analysis

| Question | X's answer | Y's answer | Z's answer |
|---|---|---|---|
| 1 | (a) ✓ | (a) ✓ | (c) × |
| 2 | (b) × | (b) × | (c) × |
| 3 | (a) ✓ | (a) ✓ | (a) ✓ |
| 4 | (c) × | (d) ✓ | (d) ✓ |
| 5 | (d) ✓ | (d) ✓ | (b) × |

Individual X SA = 3 ÷ 5 = 60%
Group XY SA = 7 ÷ 10 = 70%
Group XYZ SA = 9 ÷ 15 = 60%
Shared* XY SA = 4 ÷ 5 = 80%
Shared* YZ SA = 2 ÷ 5 = 40%
Shared* XYZ SA = 1 ÷ 5 = 20%
Complementary SA of XYZ = 4 ÷ 5 = 80%

* In this illustration, wrong answers contribute to Shared SA if respondents answered similarly




Shared SA = Intersection

Complementary SA = Union

## Legend

1-(a) represents Question 1 being answered correctly with option (a)

2-(b) represents Question 2 being answered incorrectly with option (b)

# Applying CASA

Pre-exercise preparation

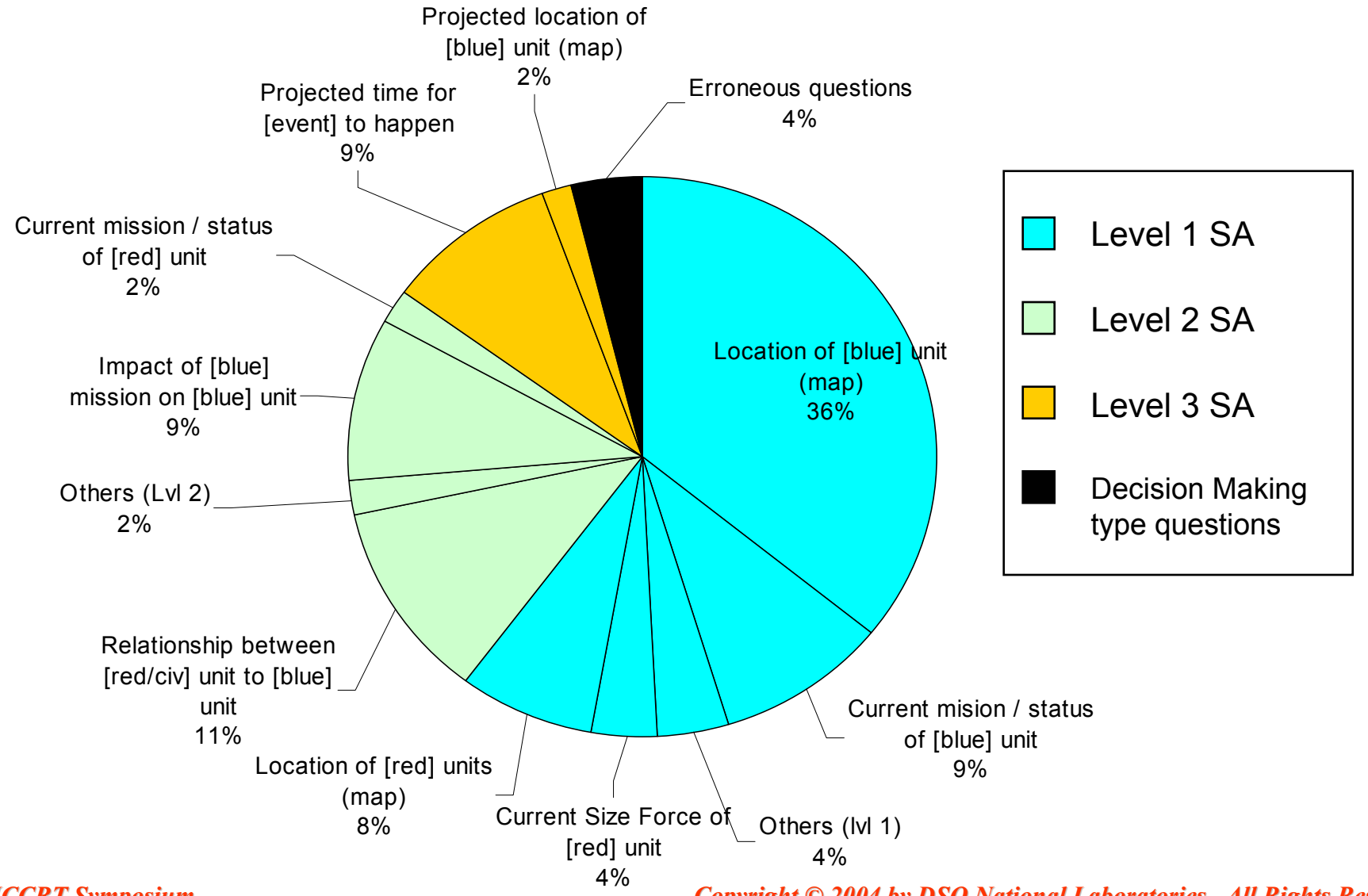
- Nine subjects identified
  - (Commander, Operations, Intelligence) x 3 teams
- Generation of CASA question templates
  - Interviews with 2 military Subject Matter Experts (SMEs)
  - Identified information requirements of Commanders, Operations and Intelligence officers to complete their tasks
  - Categorised requirements into three levels of SA
  - Translated information requirements into questions

# Applying CASA

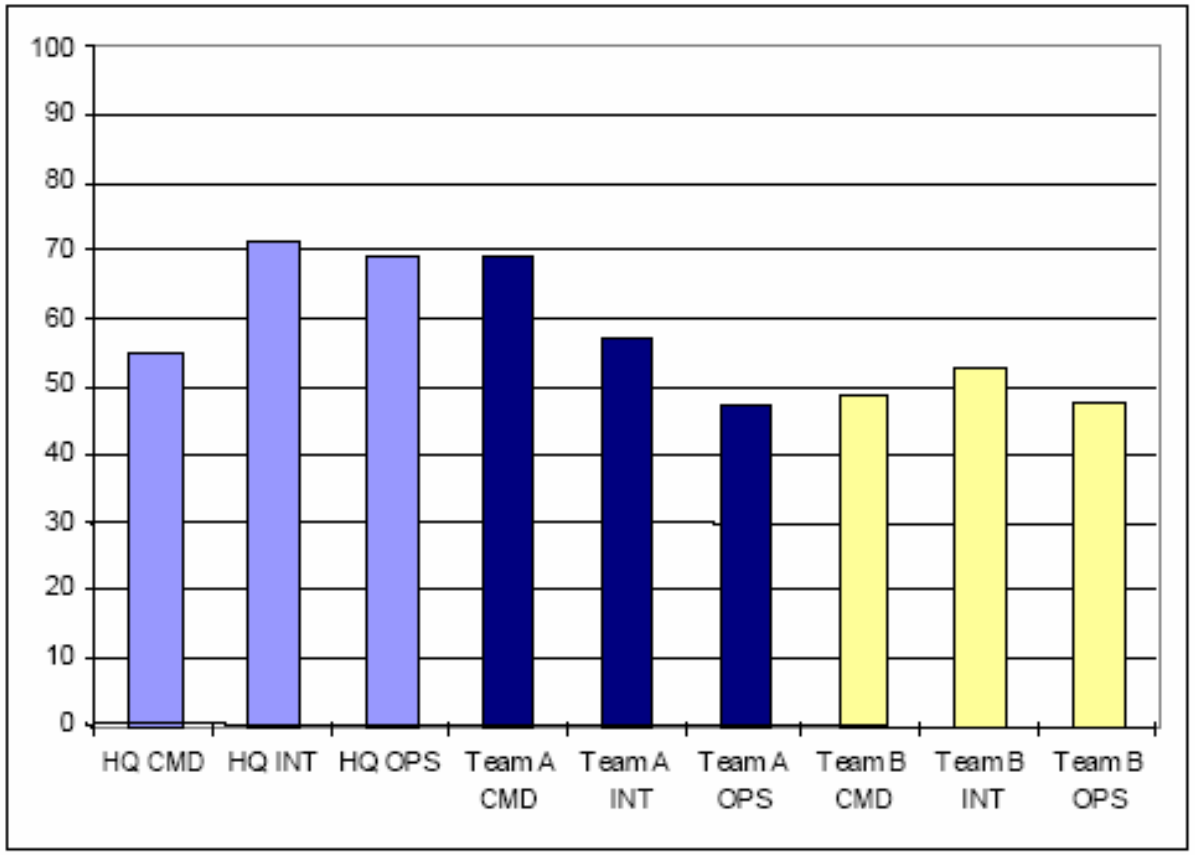
During the exercise

- Questionnaires were constructed 1-2 hours from the time it was decided to have an administration; jointly by DSO researchers and SMEs
- Disseminated to subjects within 5 minutes of time of administration
- Subjects completed questionnaires (10 or less questions) within 5 minutes
- Answers to queries (ground truth) were recorded at the appropriate times
- Questionnaires were graded against the answers

# Breakdown of CASA questions administered

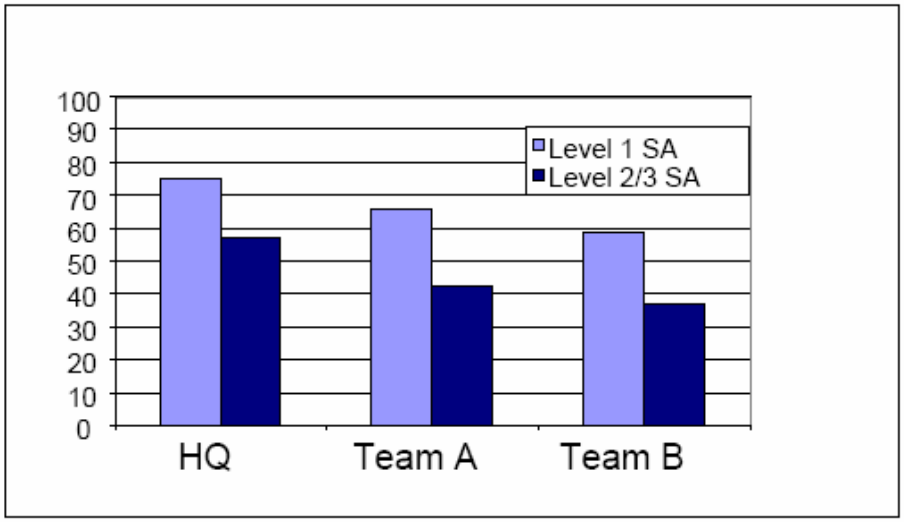


# Results




SA level of each individual, averaged across 5 assessments

# Results

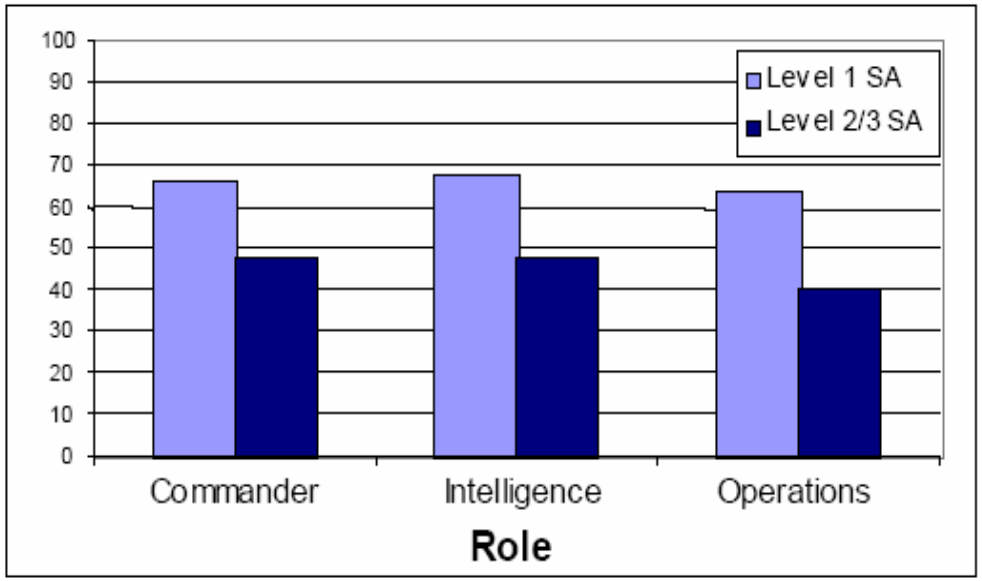



Group SA by Team

Level 1 SA > Level 2/3 SA

- Possible explanation: Level 1 SA information elements are currently better represented or conveyed compared to Levels 2/3 SA information elements.
- Need to enhance Level 2/3 SA representation and conveyance (e.g visualization, symbology, decision support, etc)

# Results

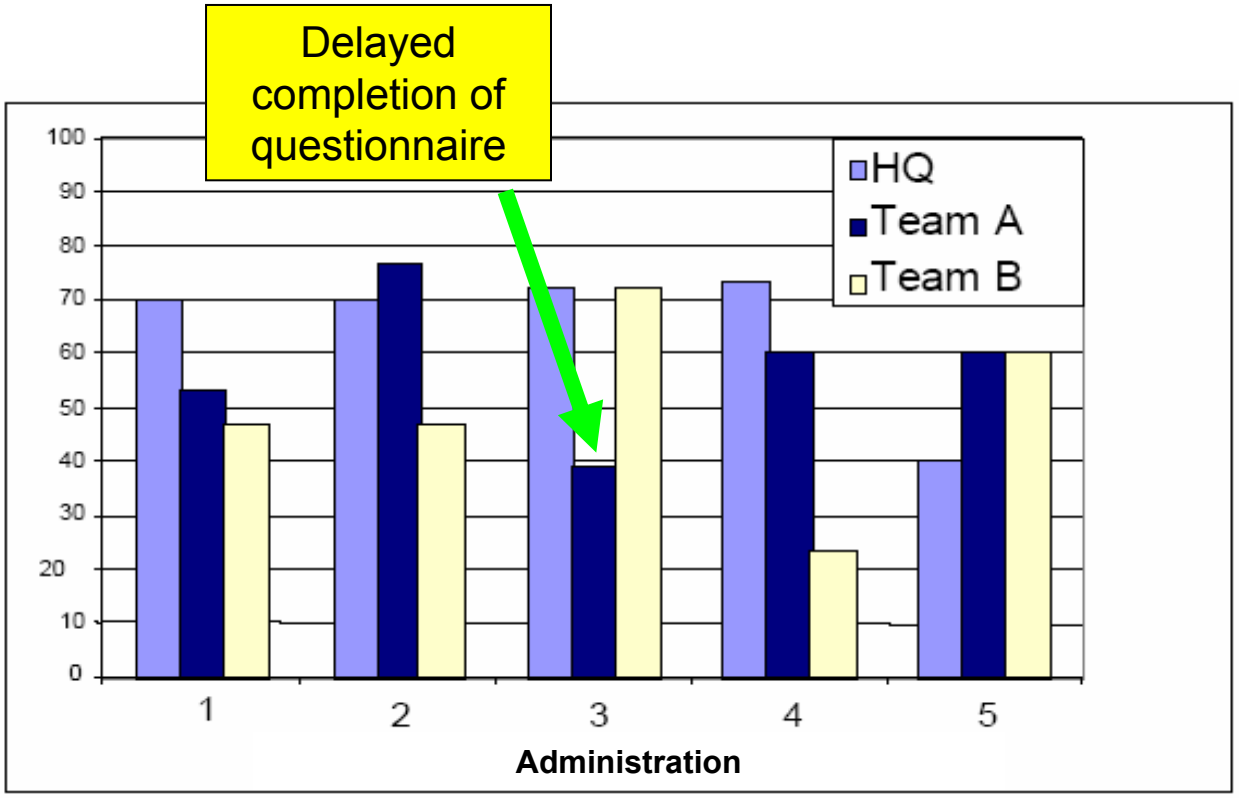



Group SA by Role

1. Intelligence SA > Operations SA
2. Level 1 SA > Level 2/3 SA

- Result consistent with the roles of intelligence and operations officers
- It has been suggested that Commanders' Level 2/3 SA > Level 1 SA as they focus on the big picture. However this is not supported by the results

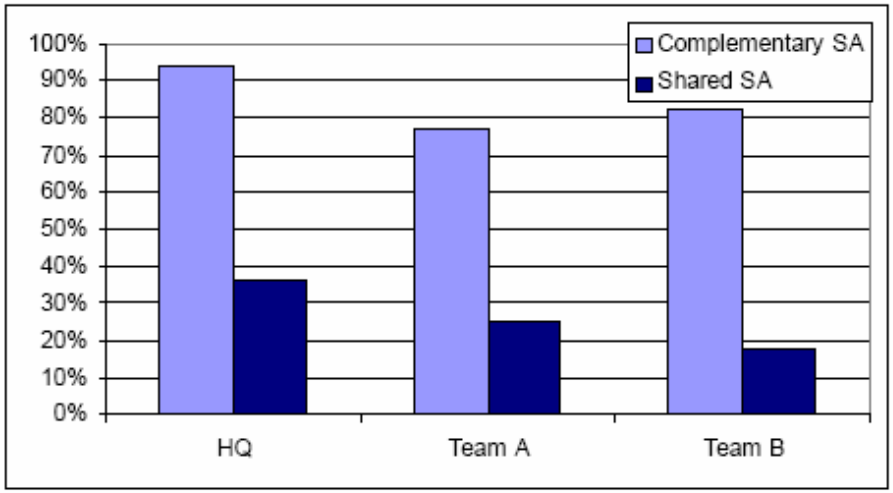
# Results




**Group SA by team**

SA level of Team A > Team B, except for Administration 3.

# Results




**Shared SA** measures how much information each member has in common with others

**Complementary SA** is a measure of team SA assuming all members readily share information – may be a more appropriate measure in the military C2 context with assigned roles

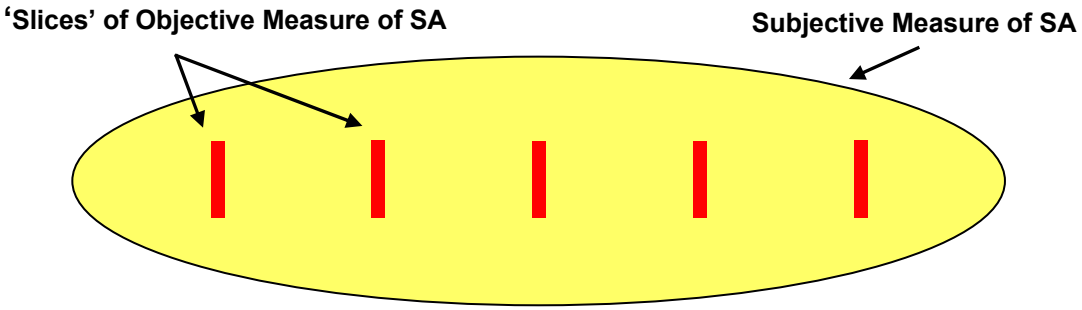
- Suggests that information was not shared as freely as may be desirable
- Need to enhance both (co-located) physical communication and (distributed) electronic tools to support communication

# Issues

- Possible introduction of bias on the part of SMEs
  - With regards to:
    (i) Selection of questions
    (ii) Selection of administration times
  - ➢ Mitigated with multiple SMEs or third-party researchers
- Labour-intensive method
  - Constant monitoring of events
  - Generating and administering questionnaires in a short time frame
  - ➢ Electronic means (e.g. wireless devices) to replace paper administration
- Diagnostic capability – allows experimenters to select or generate SA questions to probe participants on specific issues

# Reliability and Validity of CASA

- Reliability of CASA
  - Careful phrasing of question templates
  - Generation of actual questions from the question templates
- Validity of CASA
  - CASA results (objective measure) were compared with SART results (subjective measure) but they did not correspond
  - Possible Reason – Overestimation of own-self's performance




  - Possible Reason – Objective measures of SA measures a slice of an individual's SA over time, whereas subjective measures of SA may be more inclusive base on an individual's overall experience.

# Future Work

- Develop new measures of SA comprising both objective and subjective components
- Correlate SA with measures of effectiveness (MOE) e.g. time taken to formulate plans or quality of decisions made
- Correlate SA with workload in command teams
- Further validation of CASA in other experiments and settings

# Questions?