Assessments of IT’s Support of C2

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Outline

1. Introduction, motivation and core issues
2. Traditional Human-in-the-Loop (HITL) Assessment Methods of IT's support to C2 and their disadvantages
3. Use of M&S in IT assessments
4. Fundamental concepts of modeling for credible IT assessments
5. Objective measurement of modeled C2 processes
6. Conclusions
Introduction

• DoD’s Transformation roadmap is focused on Information Superiority, Agility via Focus and Convergence
• Consequently recent Future Force acquisitions emphasize IT developments; large portion of budget devoted to IT spending e.g. BFT, JTRS, UAS and UGS, etc.
• IT advances historically suggest C2 advances
  – WWI: telegraph
  – WWII: radios in Tanks
  – Current: NCW, agility and
• Whereas the METT-TC problem-solving factors remain largely unchanged
Motivation

• Goal of Information Superiority and focus on IT acquisitions presents an analytic challenge: how to assess IT’s support to C2 (IT’s raison d’être)

• The root problem is to identify those universal and relevant features of the consumers’ cognitive domains that lend themselves
  – to quantification, and
  – to objective assessments of IT’s support of C2
Core IT Assessment Issues

- It is a tremendous challenge to generalize the vast IT and C2 Domains to allow for interpretation into a variety of uncertain problem contexts
- Difficulty with cognitive domain that IT supports:
  - Cognitive domain much less transparent than physical science/engineering domains
  - Many micro-theories; no unified theory (Newell)
Traditional HITL Assessment Methods

- Observer/Controller (O/C) Team paradigm used during HITL experiments at CTCs
  - BCT assessments start with training objectives (identification of study plan), then analysis plan formed
  - O/C teams are staffed to track every key leader in a BCT
  - O/C teams collect data of many types: SA, performance MOPs; use tracking technologies
• Despite importance of O/C teams to CTC assessments, there are limitations, esp. re: objectivity
  – O/Cs are human, with typical cognitive limitations: collect, process, store, interpret, recall
  – don't have access to ground truth, and cannot see through the players they are assessing
  – In addition to the subjects’ inability to fully reconstruct a previously held belief, the public nature of AAR and subjects’ pride can limit the disclosure of (internally) confused states in *ex post facto* accounts of operations

• Cost issues: only a few experiments can be produced, very expensive, never identical
An Effective Alternative
IT Assessment Method

• Idea: employ M&S technologies to assess IT’s support of C2

• Advantages gained:
  – Produce **objective** assessments
  – Simple variability and Repeatability
  – Cost saving: time and money
  – Broad and persistent transparency and accessibility

• **But**…huge ontology for M&S representation; *fidelity (i.e. V&V and A) always in question*
Fundamental M&S Concepts

- **Existence**: identification of the referent(s)
- **Intention**: reason for the representation
- **Representation**: determining what model stands in for the real thing
- **Causality & determination**: how state changes to the representation are handled
- **Logical inference**: the creation of new knowledge from the representation (analysis)

Fundamental Requirements

• We must solve the problems of:
  1. identifying the *ideal phenomena* to measure,
  2. in the *most appropriate context*,
  3. and how to *objectively measure* that phenomena

• To evaluate IT’s support of C2, our solution is:
  1. To quantify *universal* C2 products that represent the consumer’s integration of the METT-TC factors
  2. in an *operational* context (represented via M&S),
  3. using a *self-referential comparison* method that avoids subjective judgments
Fundamental Requirements

• Two universal C2 products that represent the consumer’s integration of the METT-TC factors are SA and SU
  – Situation Awareness (SA) – pre-integration
  – Situation Understanding (SU) – post-integration

METT-TC Universal:
“Know the enemy and know yourself; in a hundred battles you will never be in peril. ….” -- Sun Tzu,

SA and SU products:
“Sweeny worked to paint a picture of Al Qaida’s network of safe houses, transportation nodes and escape routes out…” (Naylor, 2005, p. 25)
All data in the environment

Data detected by sensor systems

Data available on local C2 system

Lenses consist of individual states & traits, social and cultural factors, local context, plans, guidelines, experience

Data perceived by decision maker

Comprehension of decision maker

Projection of decision maker

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Ideal Context For Measurement

A dynamic competitive *operational scenario* employing naturalistic decision makers is an ideal context:

- It provides naturally occurring situational variation essential for measuring the C2 products of the subject agents (esp. robustness)
- It provides a cost effective and realistic way of generating the interchange of information across a network that constitutes the primary function of IT

[Contrast these features with behaviors and interactions produced by scripting or fixed rule bases]
Conceptualization of Objective Measurement

- Objectively measure SA and SU, the cognitive products arising before and after a consumer’s integration of METT-TC factors
- By comparing the decision maker’s products with those he would have produced with an alternative (improved) data stream
- Thereby avoiding the natural tendency to judge tactics based on the analysts’/SME's own experience
Quantification of the Concept

• The method is called the Objective Information System Assessment Method (OISA)

• The comparison central to OISA is produced by a software clone (of the subject simulation agent) that uses the exact same decision algorithms but operates with an alternative data stream, e.g.
  – Ground Truth Agent, vs. simulation agent, or
  – Perfect Communications Agent, vs. simulation agent

• With this method, we have 100% certainty that the clone agent knows EXACTLY what the subject agent would have done (contrast with HITL)
Implementation of the Concept

• Implementation is not onerous and does not depend upon particular simulation details

• The analyst need only establish comparisons between the SA and SU products produced by the subject simulation agents and corresponding clones

• OISA has been implemented in S4: Bernstein, et al., 2006; Davidson, Pogel, Smith, 2008; Hudak, Mullen, Pogel, 2008
Conclusions

- Key is objective assessments of IT support to C2
- M&S an effective alternative to HITL
- Significant obstacles to representing a massive domain
- Overcome obstacles through fundamental modeling concepts and use of OISA
- Future Work: move from concept development and initial implementation to full implementation in M&S