Defense Information Systems Agency
Department of Defense

11th ICCRTS
Coalition Command and Control in the Networked Era

Assessing the Operational Impact of Network Centric Technology, Collaborative User Defined Operational Picture: A Controlled Experiment with Warfighters (Presentation I-095)

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September 26-28, 2006
DeVere Univ. Arms, Cambridge, UK

Delta Experiment Purpose

- **To demonstrate and prove the differences in operational effectiveness, on NCW metrics, between current warfare practices using present Command and Control technologies, and Network Centric Warfare practices using the combined DISA technologies of the User Defined Operational Picture (UDOP), and collaboration technologies instantiated by the Light Weight Collaborative White Board (LCW).**

Scenario Overview

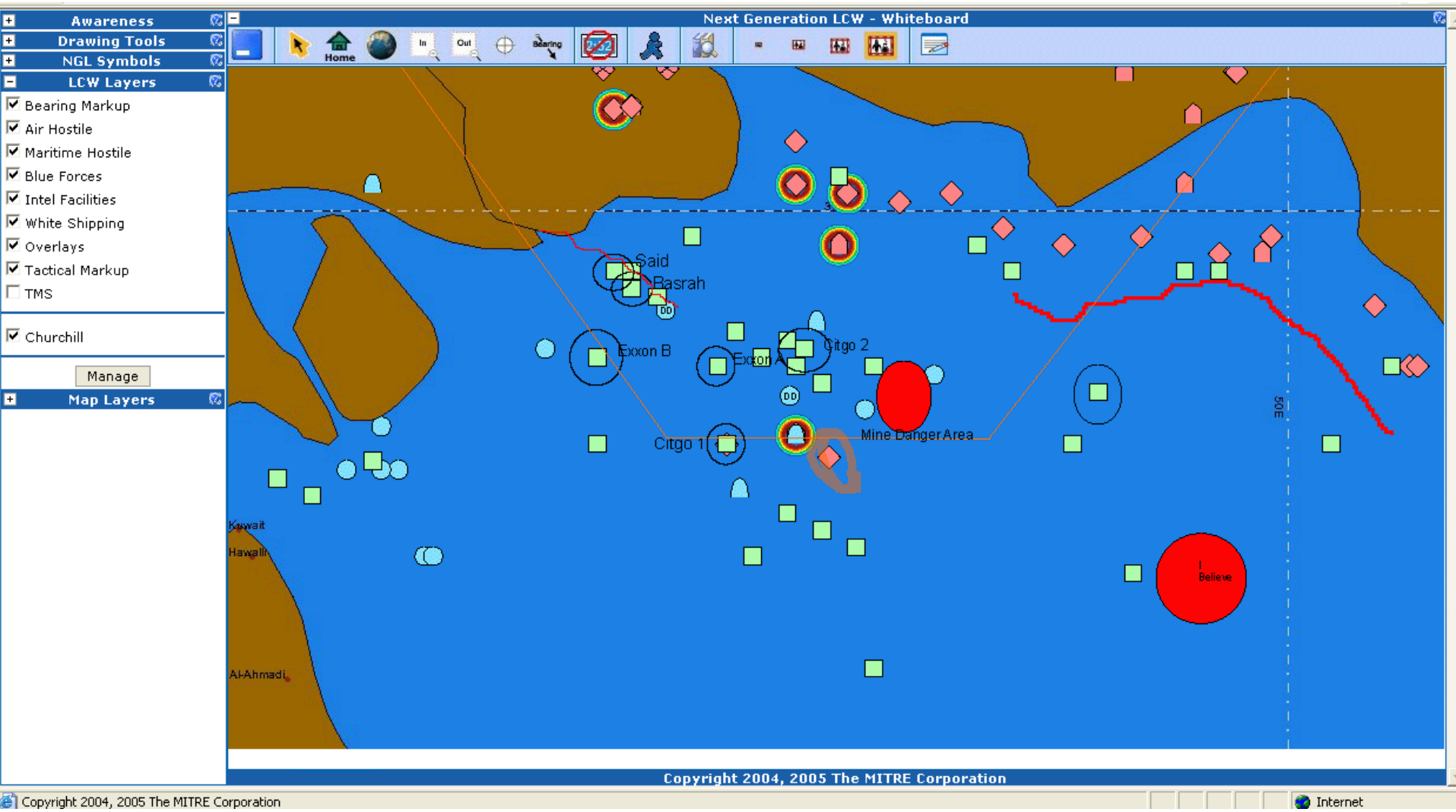
- Persian Gulf setting where: Operation Storm Petrel involves
  - Two Blue Ships (DDGs) and JFACC air protecting several oil platforms under attack by:
    - Twelve Red fast attack crafts, Zhuks and Boghammers
      - Analogous to the Basrah terrorist incident of Spring 2004
    - Pirated Aircraft

C2 Baseline vs. NCW Technology

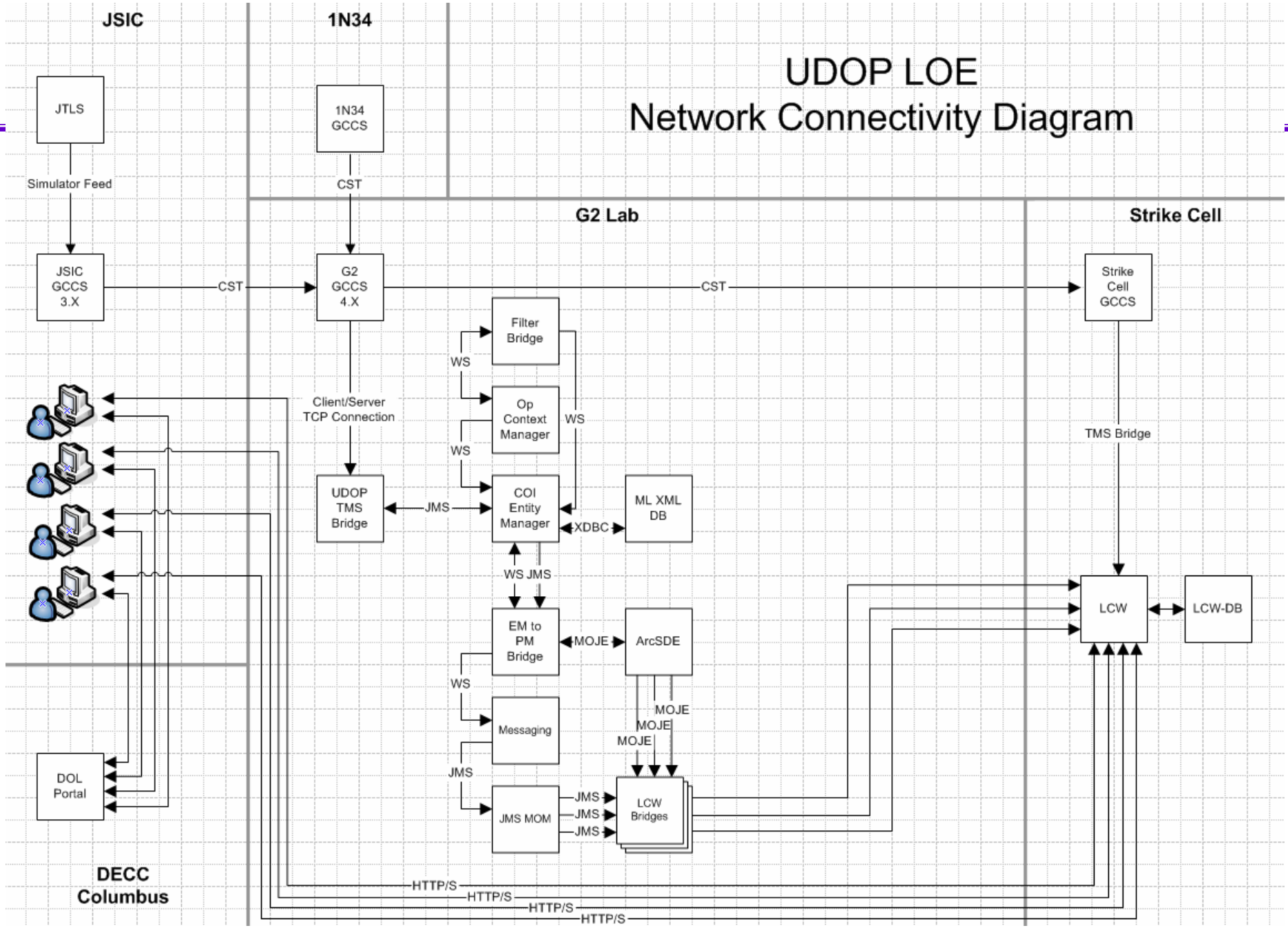
- **In C2 baseline condition, all three military players share a COP view of the Gulf and communicate via internet relay chat. Intelligence products are obtained under current time lines (e.g. via hard-copy message, I&W briefings).**

- **In NCW condition, JFACC/AOC subscribe to air track and intel OpContext for air Community of Practice, and two Navy destroyers subscribe to maritime track and intel OpContext for maritime Community of Practice, and all jointly collaborate over wide area network using common LCW with stated Commander's Intent forming a common Community of Action.**

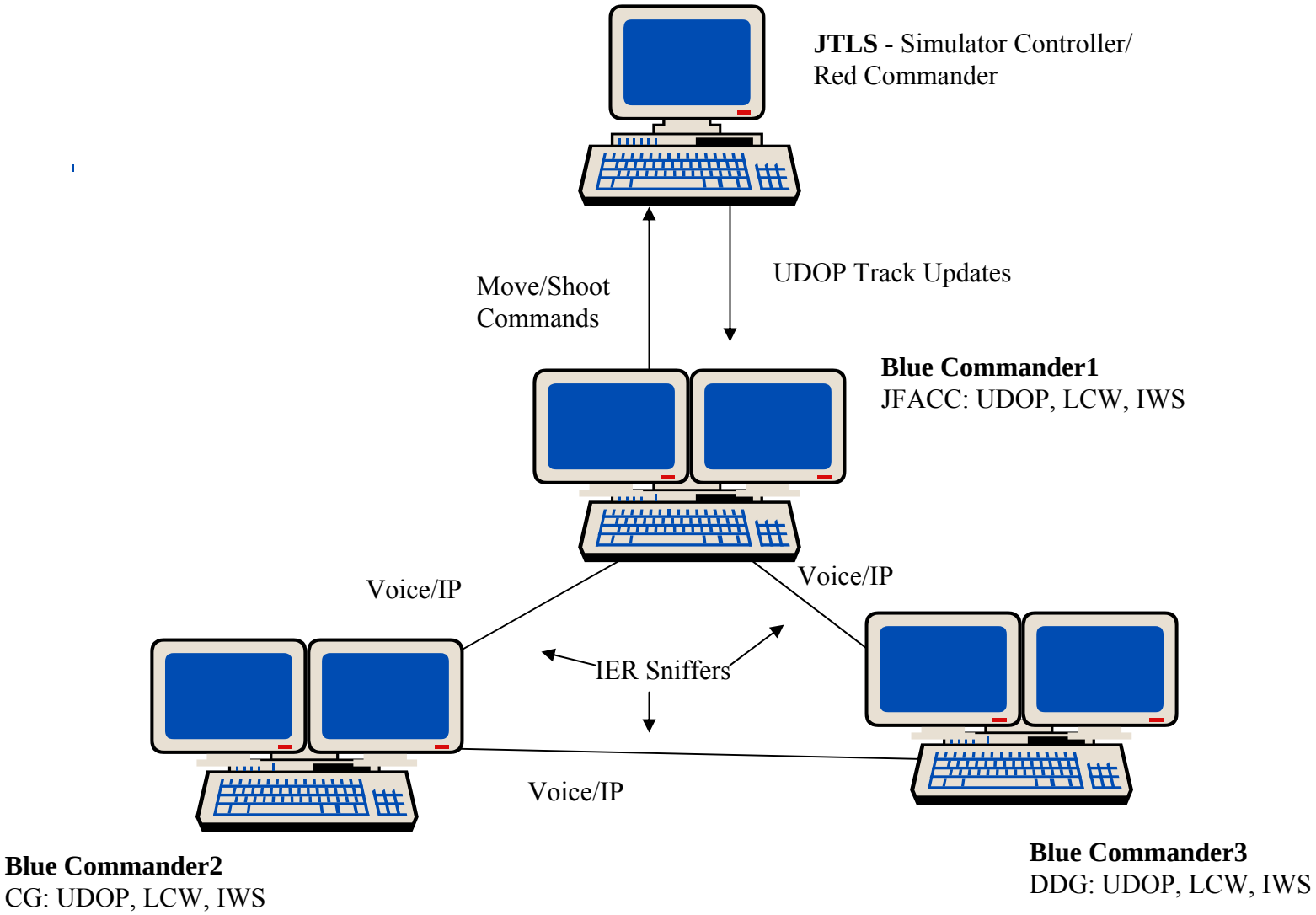
UDOP Screen Shot of Operation Storm Petrel Scenario



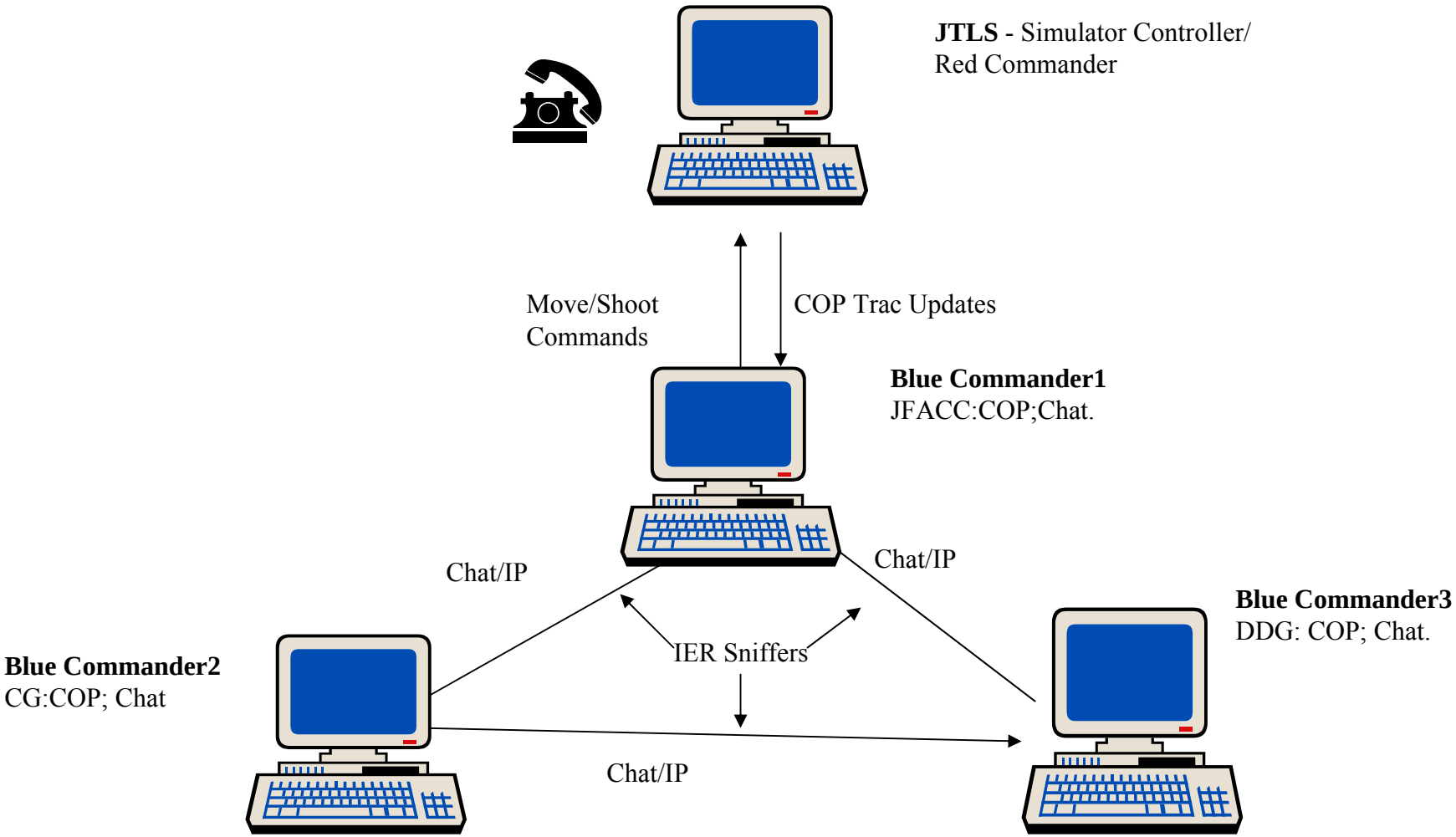
UDOP LOE
Network Connectivity Diagram



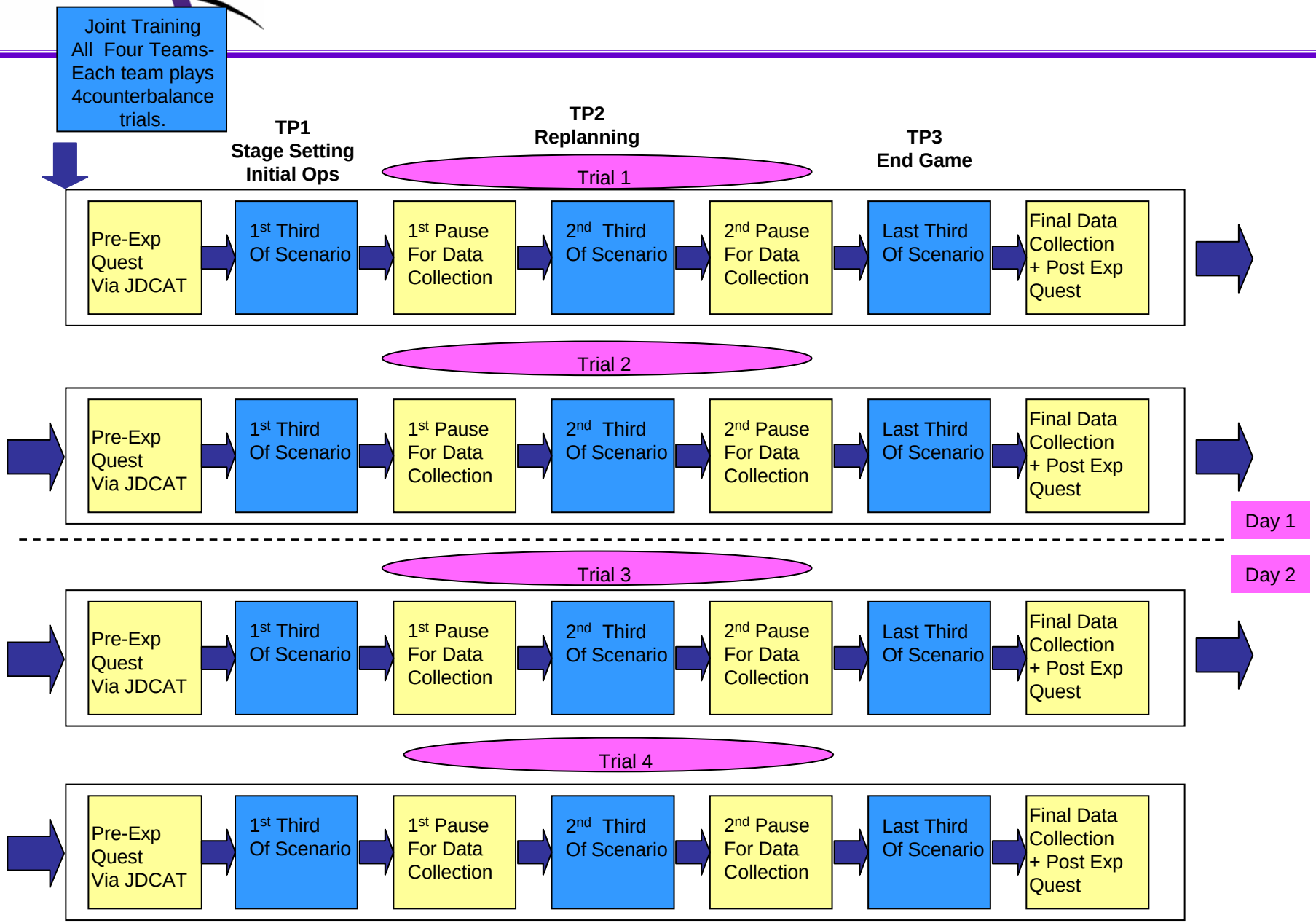
Set Up: UDOP/CollabTech Condition



Set Up: C2 Baseline Condition



UDOP-LOE Experimental Design



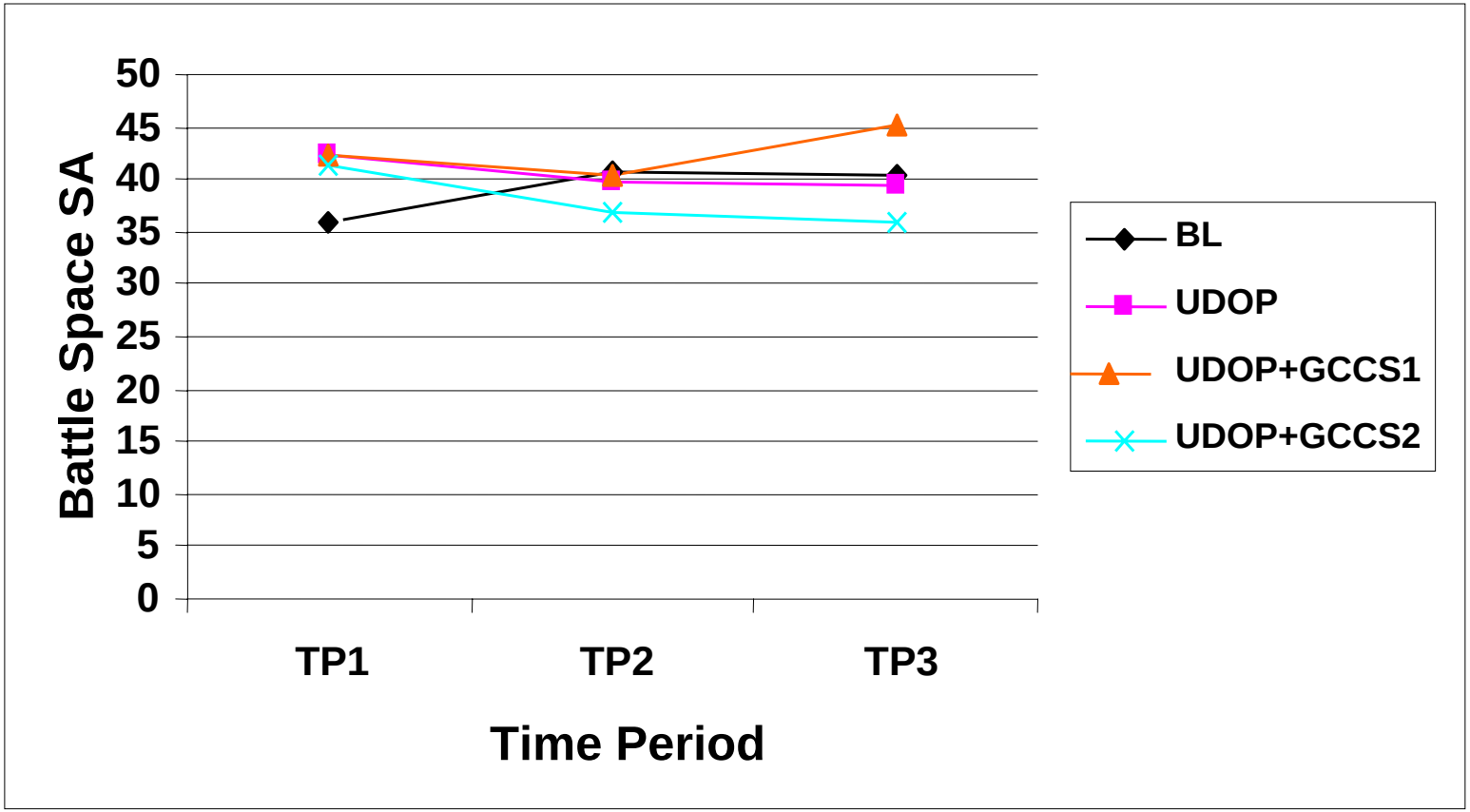
Hypotheses

By facillitating the development of more accurate shared mental models among members of the warfighting CAS, use of shared UDOP/CollabTech schema causes:

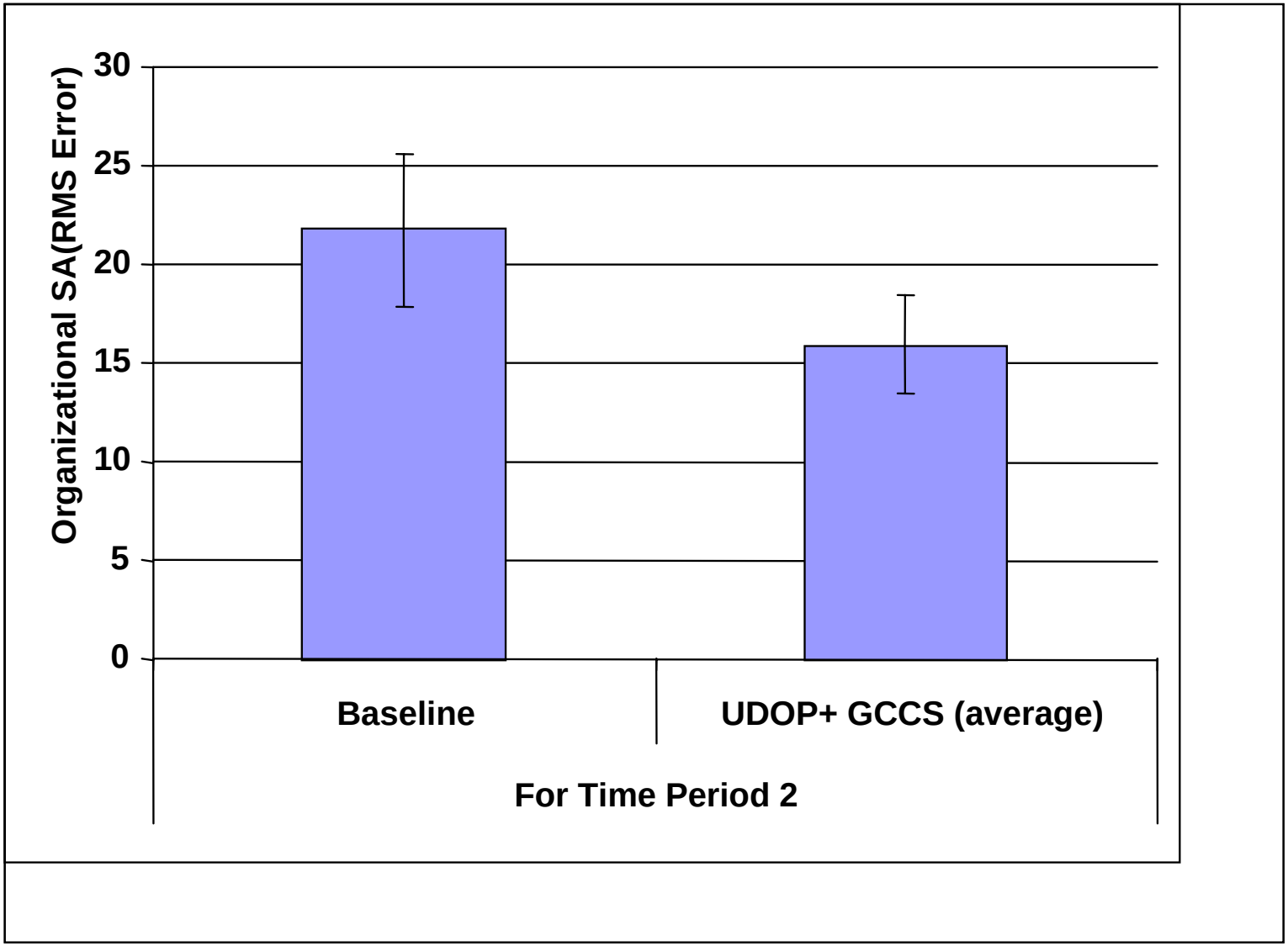
(H1) increased Situational Awareness(SA);

(H1A) increased Shared Situational Awareness(SSA);

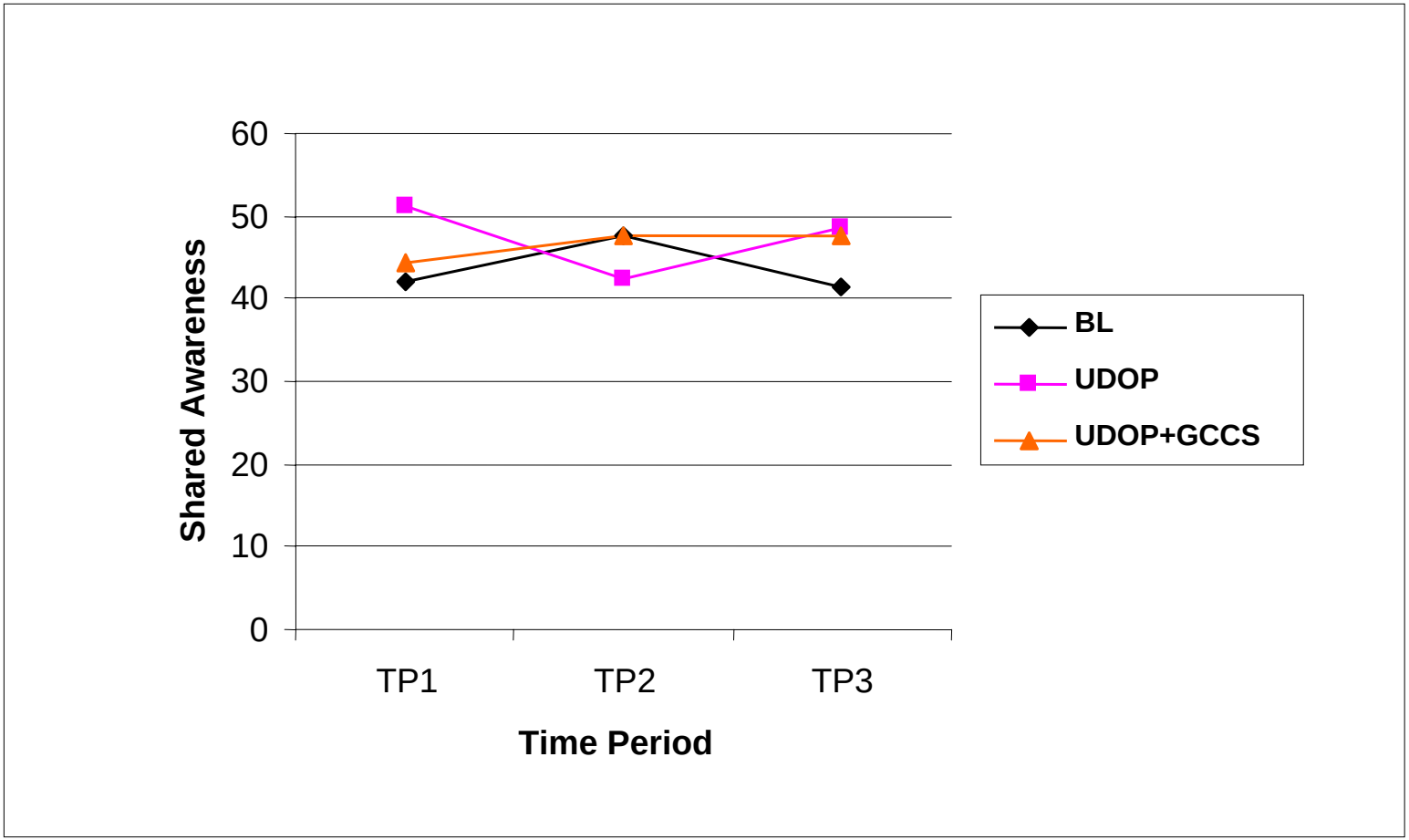
H1: UDOP Causes Increased SA



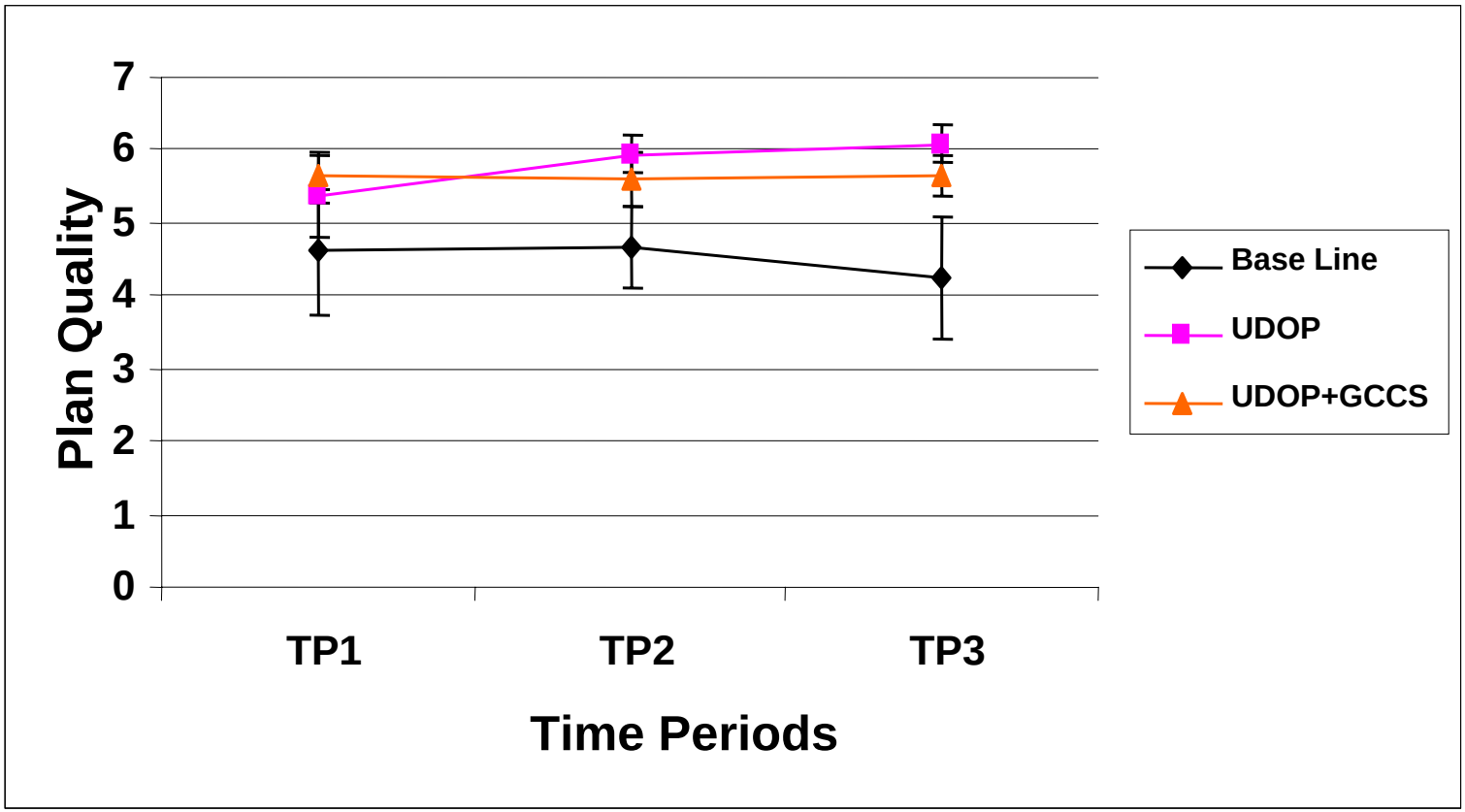
H1: UDOP Causes Increased SA



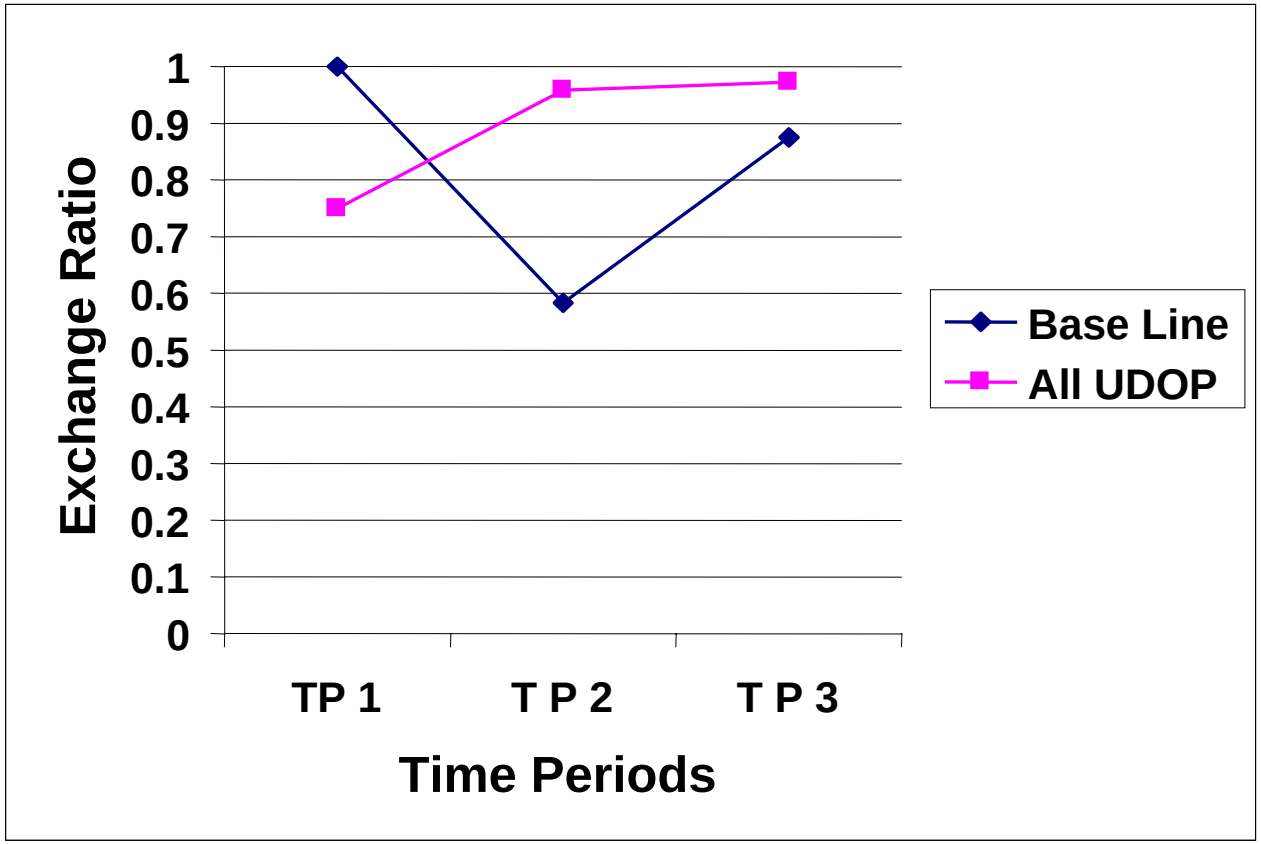
H1A: UDOP Causes Increased Shared SA



H2: UDOP Causes Increased Planning Quality



H3: UDOP Causes Increased Combat Effectiveness



Summary of Significant Findings

- (H1) Significantly increased Situational Awareness for TP 1 & 3 using UDOP+GCCS;
- (H1A)Significantly increased Shared Situational Awareness for TP 1 & 3 using UDOP;
- (H2)Significantly increased Planning Quality for TP 1, 2 &3 using UDOP;
- (H3)Significantly increased Combat Effectiveness for TP2(Replanning)&3(EndGame)usingUDOP;

Warfighters' Hotwash Inputs

- Sizable majority of the participants enjoyed their experience in the lab
- Plurality of participants felt their team did better with UDOP/CollabTech, especially for planning
- Many of the participants offered useful engineering suggestions

Conclusions

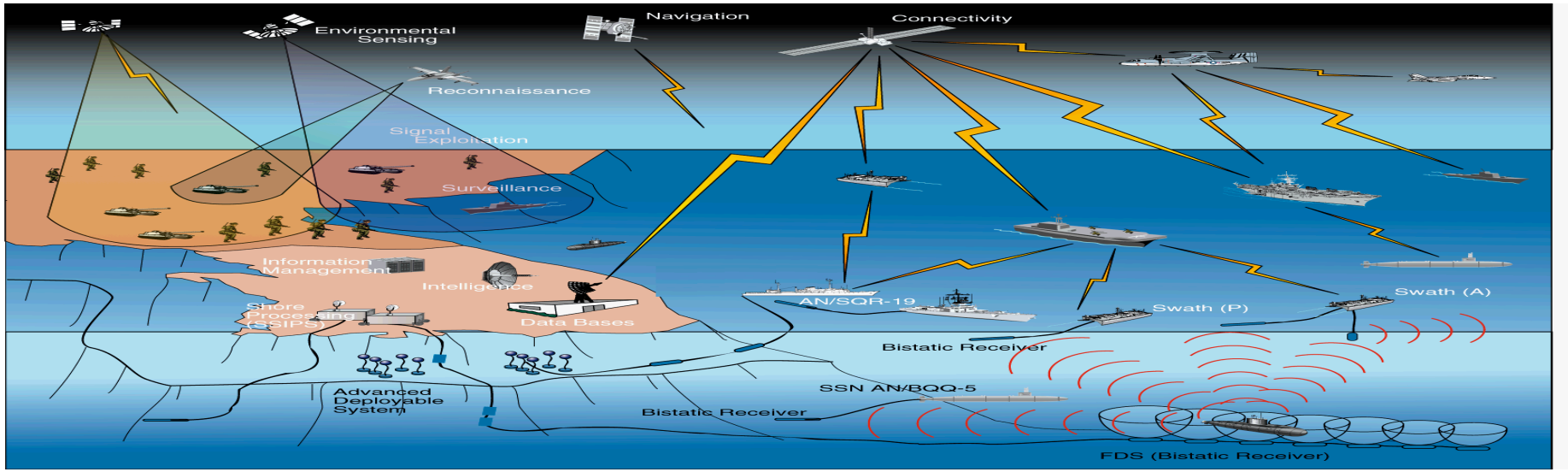
- Our findings imply that the collaborative UDOP environment can significantly augment warfighting team performance above that of the legacy GCCS environment.
-

  We believe that UDOP, with its tailorable map and collaborative capabilities, affords team members the opportunity to construct and maintain more informative shared mental models, both of the surrounding battlespace and of their teammate's activities

  - The UDOP technology produced superior teamwork, situational awareness, replanning quality and combat effectiveness over that of the legacy GCCS environment

Backups

Network Centric Warfare



- **A promise of Network Centricity: Unprecedented operational tempo and situational awareness through networked connectivity**
  - **Ability to support collaborative environments**

Dependent Measures

Three classes of dependent measures: observer based, self report, simulation based

Observer Based

- Team performance
- Plan quality
- Teamwork

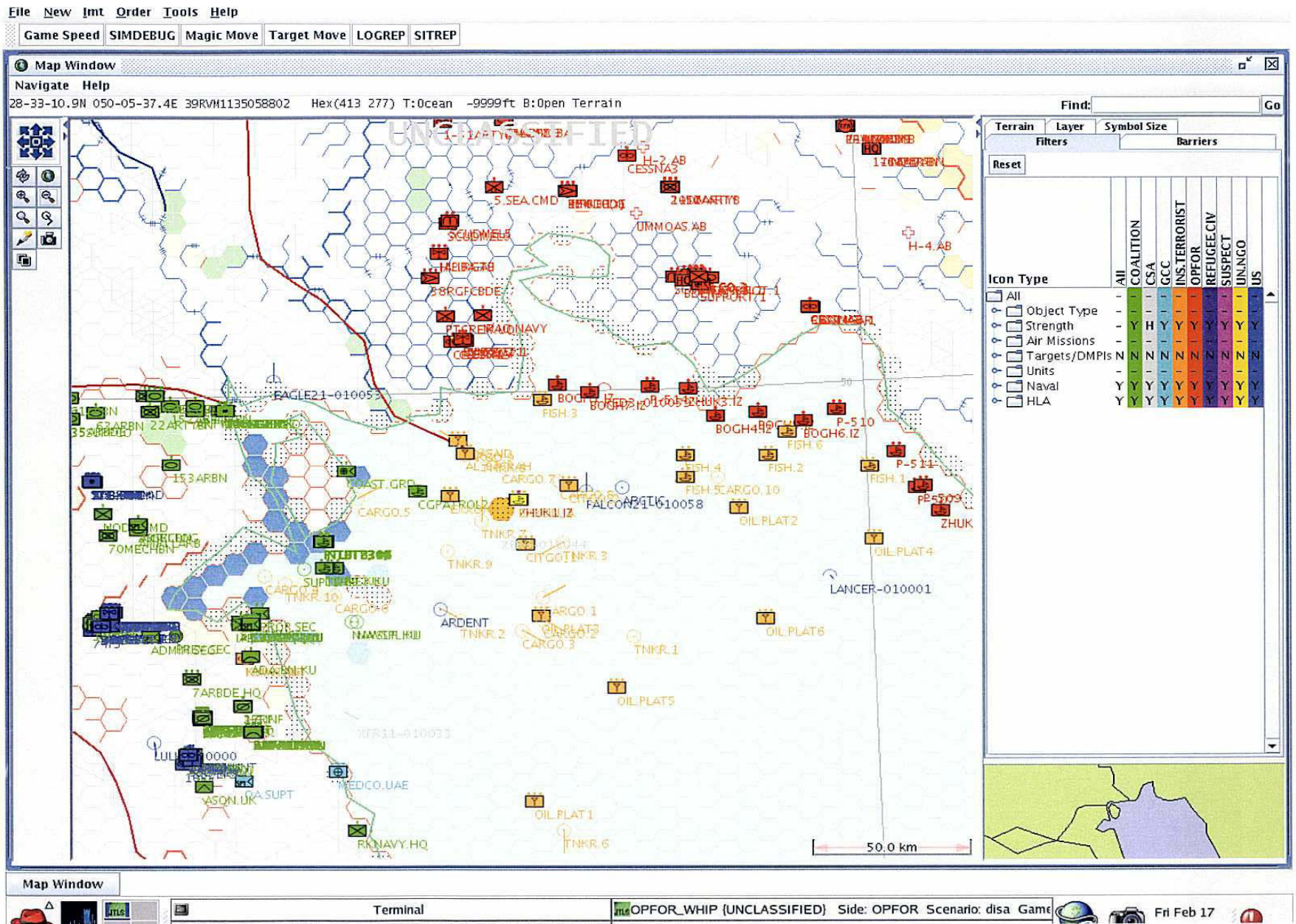
Self report

- Workload
- Situational Awareness (SA) based on RMS error

Simulation Based

- Exchange ratio
- Situational Awareness (SA)
- Shared SA

JTLS Screenshot of Scenario



Measurement Definitions for Operational Assessment of UDOP/Collab Tech

Confidence Intervals for ΔSA (Δx) from exp, for t-distribution

$$\Delta x - t_\alpha (s/\sqrt{n}) < \mu < \Delta x + t_\alpha (s/\sqrt{n}), \text{ where } s = \sqrt{(\Sigma x_i / n-1)}$$

Confidence intervals for ΔSA (Δx) from exp, for F-distribution

$$(x_{.1} - x_{.2}) - \sqrt{F_\alpha}\, s_w \sqrt{(2(k-1)/n)} < \mu < (x_{.1} - x_{.2}) + \sqrt{F_\alpha}\, s_w \sqrt{(2(k-1)/n)},$$

where $s_w = \sqrt{(wss/k(n-1))}$ and wss = within groups sum of squares

Situational Awareness (SA) = Proportion of mission critical set of warfighting platforms correctly identified by a warfighter (Ground Truth cf. COG @ t_i)

Shared Situational Awareness = Proportion of overlap between pairs of COGs for complete warfighting team.

Speed of Command ($t_d = t_c + t_r + t_a + t_b$), where total speed of command is the sum of time to size up situation + time to plan + time to act + time to complete decision cycle with battle damage assessment

Combat Effectiveness = Loss/Exchange Ratio= red platform losses / (red + blue + neutral losses)

Dependent Measures

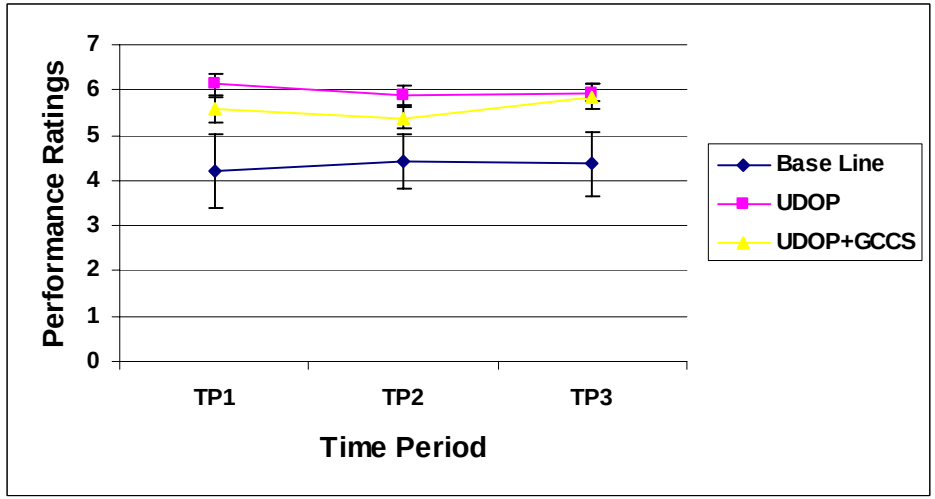
- **Situational Awareness**
  - Estimate of critical entities and their positions compared to ground truth
  - Shared awareness among the three team members
- **Plan Quality**
  - Observer's rating of over all plan quality & rating of each phase of OODA loop cycle
- **Team performance**
  - Combat Exchange ratio
  - Observer based instrument assessing quality of various task execution & overall
- **Teamwork**
  - How well team members worked together and coordinated
- **Extended workload (modified TLX)**
  - Individual workload, team workload, & estimate of other's workload (latter measure of organizational awareness – a type of situational awareness)
- **Pre & Post-experiment questionnaire**
  - Assessment of beliefs, attitudes, and opinions toward technologies, process, and experiment including validation of JDCAT measures
- **After-action review and extensive observer notes**

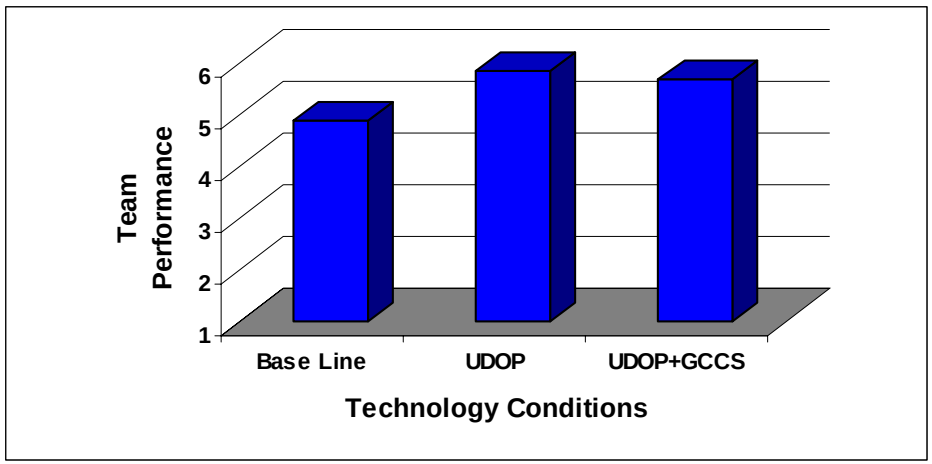
Control Treatment 1-Way ANOVA
Within-Subjects Design to Test Causal Hypotheses

- Conditions
  - Baseline (GCCS)
  - UDOP
  - UDOP + GCCS
- A Priori Contrasts (using Dunnett's test)
  - Baseline vs. UDOP + GCCS
  - UDOP vs. UDOP + GCCS
- Each of the four 60 minute trials divided into three 20 time periods
  - Two mid-scenario pauses and end of scenario data taking
  - Can be the basis of other within-subjects analyses
- Within-subjects means each team serves as their own control

Results: Team Performance

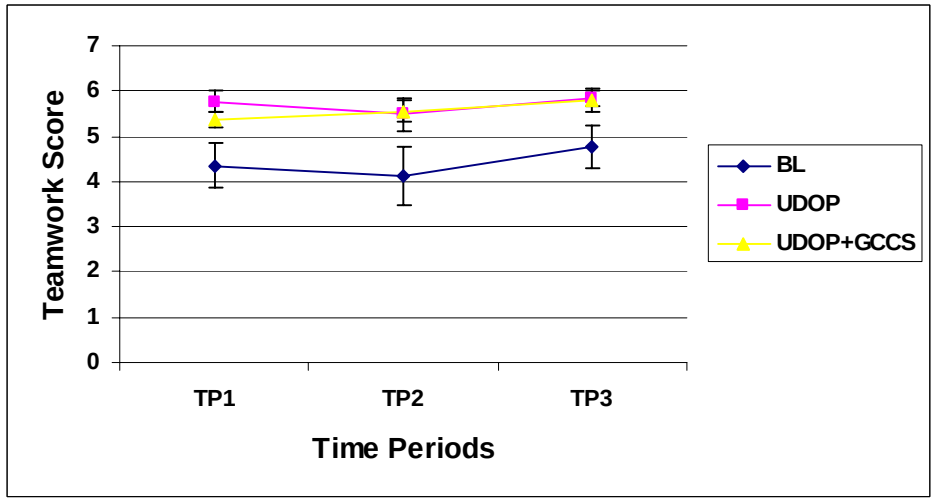
- **Observer based team performance was significantly higher in the UDOP technologies than in the baseline GCCS technology conditions**
  - **A measure of quality of performance**

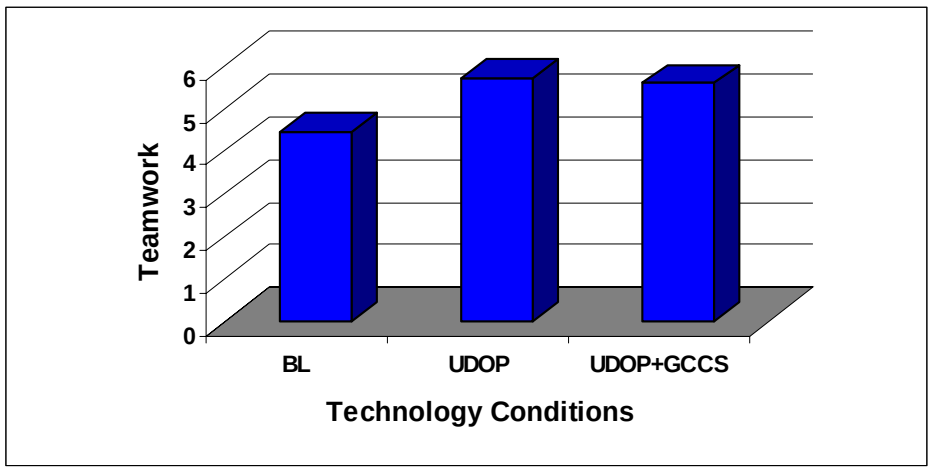




Results: Teamwork

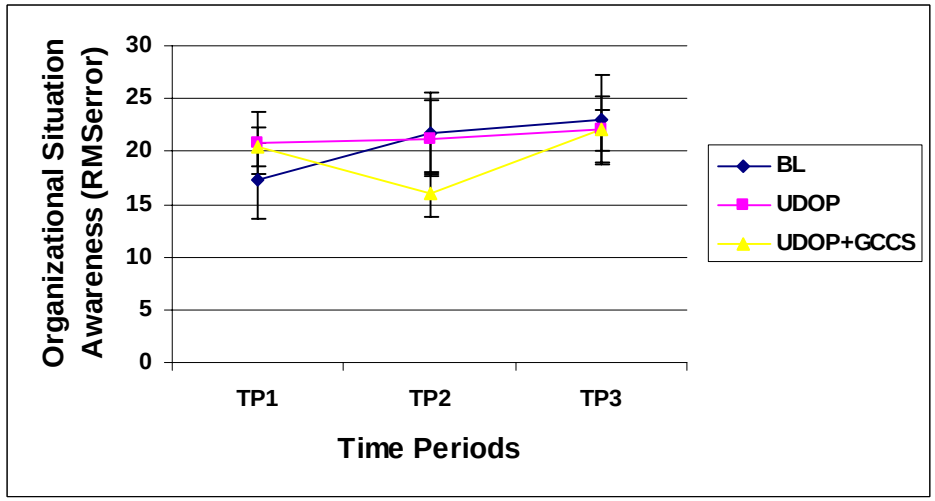
- The observer based **teamwork** score was **superior** in the UDOP technology conditions than the baseline GCCS condition

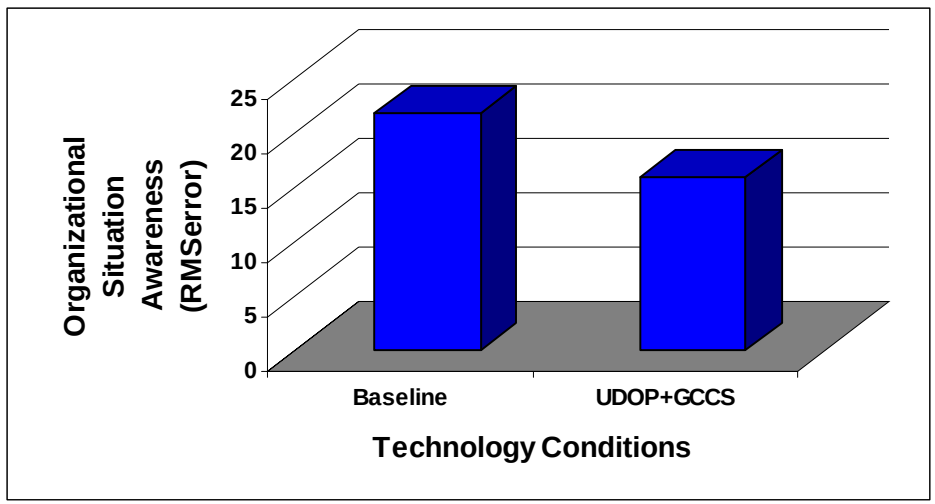




Results: Organizational Situational Awareness

- No significant differences between the UDOP and baseline technology conditions in either time periods one or three
- Organizational SA is higher for the UDOP+GCCS condition than the baseline GCCS condition, but only for time period two (replanning)





Participants

- Defense Information Systems Agency (DISA)
- Joint Interoperability Testing Center (JITC)
- Joint Forces Command (JFCOM)/Joint Systems Integration Command (JSIC)
- JFCOM J7
- HQ USAF
- Commander, Fleet Forces Command (CFFC)
- Commander, Naval Forces Atlantic (CNSL)
- SPAWAR Systems Center, San Diego (SSC-SD)

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