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Estimating Situational Awareness Parameters for Net Centric Warfare from Experiments

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What are the Determinants of Situational Awareness?

- Situational Awareness(SA)= the proportion of the mission critical set of warfighting platforms correctly identified by a warfighter (COG cf GT).(Hiniker & Entin,'90;Perry et al. RAND'04)

- H1: Use of a Common Operational Picture(COP) by a warfighting team causes improved SA.

- H2: Increased time spent by a warfighting team collaborating with the COP causes improved SA.

Scenario

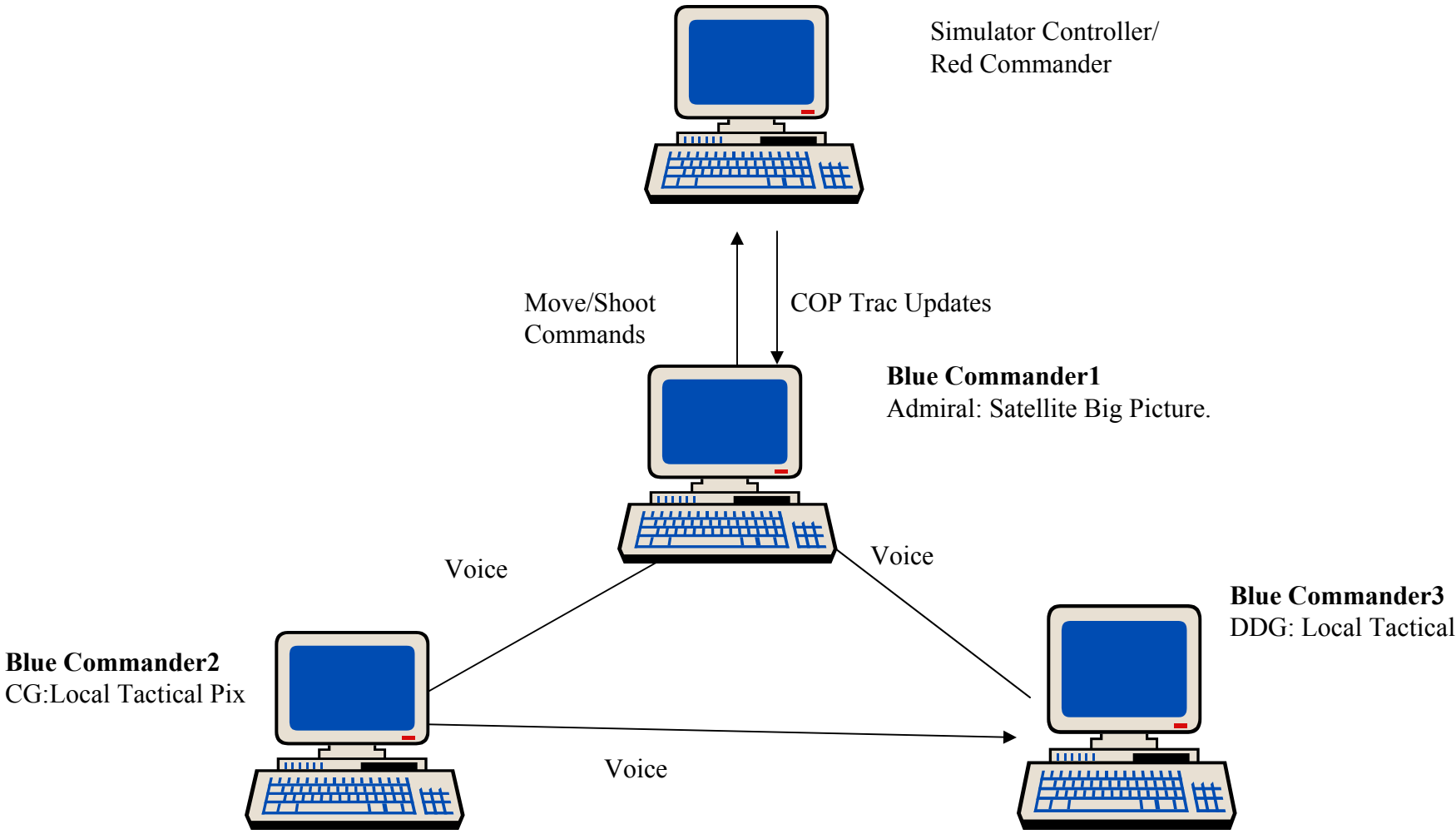
Persian Gulf setting where:

- Two Blue Ships, CG, and DDG, and air protecting several oil platforms are under attack by
- Twelve Red fast attack craft, Zhuks and Svetlyzks
- Analogous to Operation Praying Mantis in 1988 and to the Basrah terrorist incident of Spring 2004

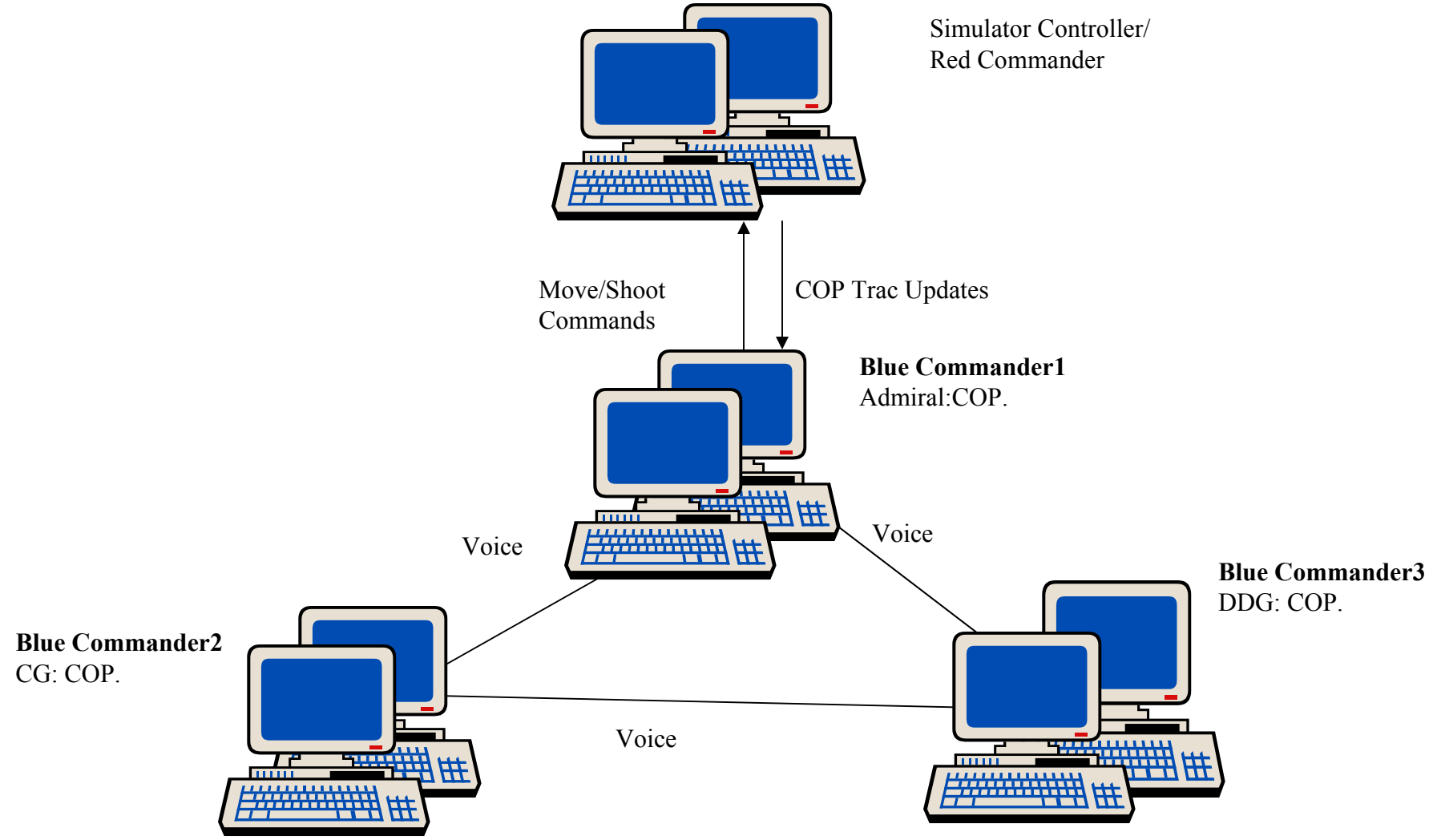
Baseline vs. COP Technology

- In the baseline condition, each of the two ship captains has only his local tactical picture fed by organic ship sensors and the admiral has only the big picture fed by satellites; they communicate by voice.
- In the experimental condition, all three military players share a COP view of the Gulf (big picture and little pictures) and communicate via voice.

Set Up for Exp: Baseline Condition



Set Up for Exp: COP Condition



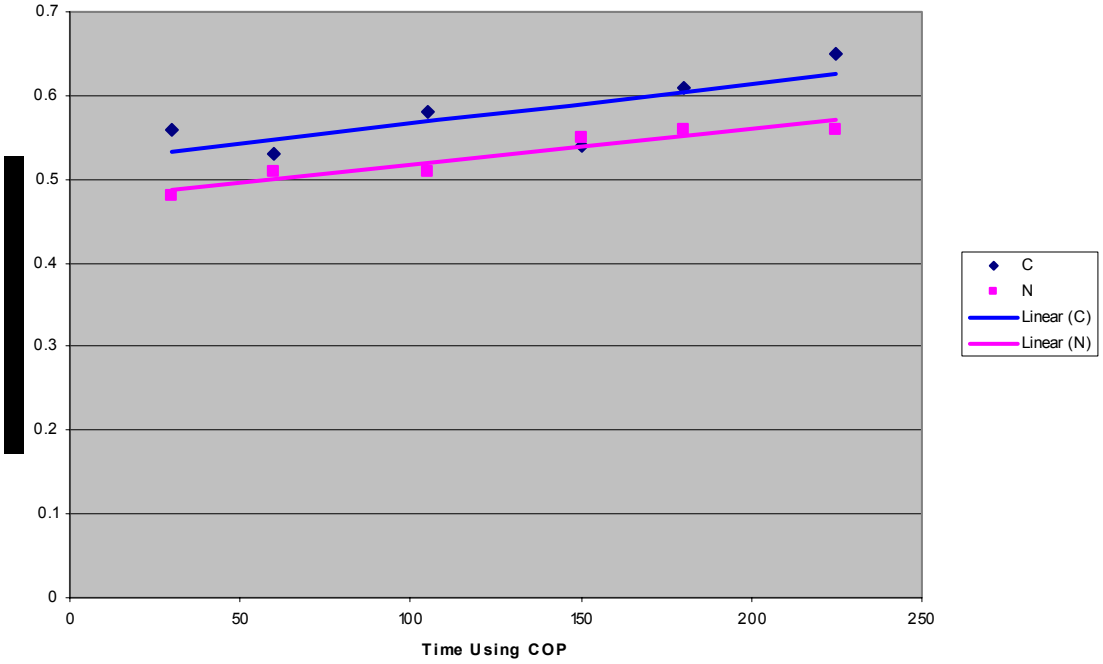
Creating Team Hardness in Lab

- **Team Hardness = the completeness of the team system for recording and retrieving info, TM(T), depends on how frequently team has recently collaborated, T.**
- **$T = t + \tau$, where t = time elapsed since start of the operation and τ = length of time the team has been training or operating together.(Perry, Signori, & Boone,2004)**

Results for H1:COP causes improved SA.

- Experiment at NOSC with 3, 3-man teams proving COP causes increased Situational Awareness:
  Δx = .05, .55 cf .50, n = 12 trials, confidence = 98%*
- ***Hiniker,P.& Entin,E. The Effects of Shared Battle Graphics on Team Performance in Crisis Situations: HEAT Experimental Results. *Proceedings of the JDL BRG C2 Research Symposium*, July 1990.**
- Experiment at MITRE with 4, 3-man teams proving COP causes more favorable Loss/Exchange Ratio:
  Δx = .14, .68 cf .54, n = 16 trials, confidence = 96%**
- ****Hiniker,P. & Entin,E. Cognitive Processing in Command Crises:New HEAT Experiments on Shared Battle Graphics & Time Tagging. *Proceedings of the JDL BRG C2 Research Symposium,* July 1992.**

Results for H2: Increased time spent by a team collaborating with COP causes increased SA

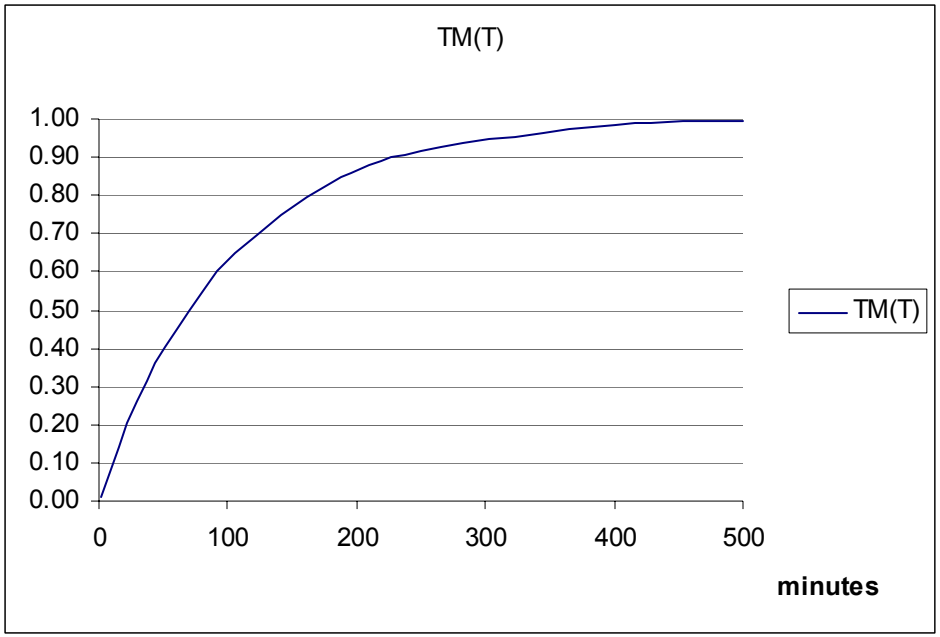


For COP Condition, r = .76, p = .07;
for Non-COP, r = .95, p = .004;
for Combined, r = .95, p = .003.

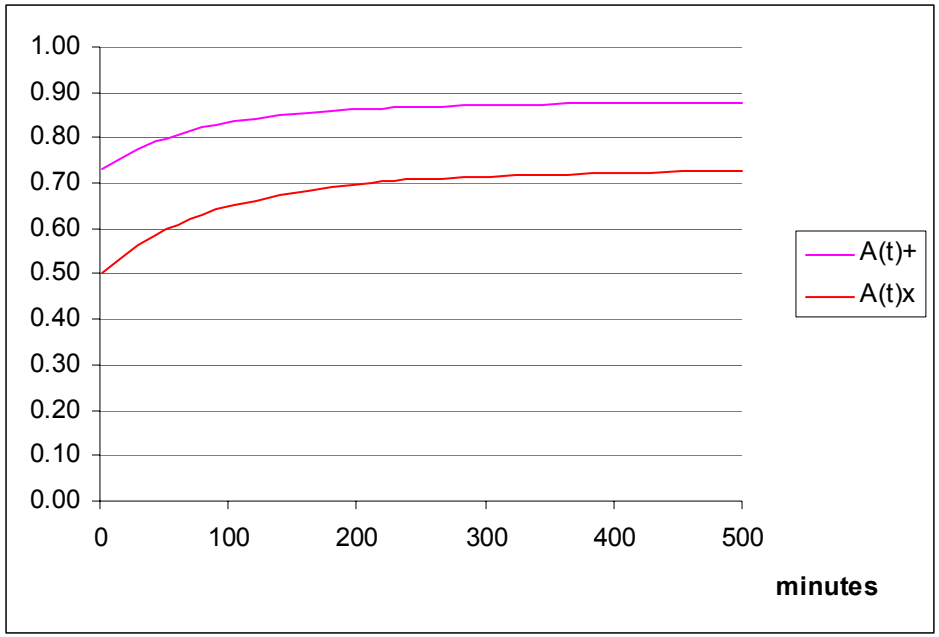
Discussion

- Strong experimental support was found for (H1) use of COP and (H2) Time spent by team collaborating as causes of improved Situational Awareness
- The form of the T⟶ SA relationship is linear, within the time range observed.
- Models of NCW involving SA should develop hand in hand with experimental investigations

Model Relationship between TM(T) and T, (where a = .01)



Dynamic Model Relationship between Situational Awareness (A(t)) and T, (where K = .98)



Back-Up Slides

- Examples of NCW Parameter Estimates
- Definition of NCW Measures
- Data Set

Confidence Intervals for Differences Due to Advanced Tech Usage on Situational Awareness Parameters

- For original COP cf Partial COP Exp at NOSC where sample size (n=12/2 pairs), sample deviation (s=.04), μ = true population difference: Obtained Situational
- Awareness $\Delta x = +.05$
- $.010 < \mu < .090$ @ 98% confidence;
- $.025 < \mu < .075$ @ 90% confidence;
- $.038 < \mu < .062$ @ 75% confidence.

- For augmented Exp with sample size (n=16/2 pairs), sample deviation (assumed s=.04), Situational Awareness…

- $\Delta x = .03$, yields 98% confidence in a true population difference;
- $\Delta x = .02$, yields 90% confidence in a true population difference;
- $\Delta x = .01$, yields 75%confidence in a true population difference.
- For Time spent by team collaborating with COP,
  $\Delta x = 2.5\%$ per hour, where $0 < T < 240$ minutes

Measurement Definitions for Operational Assessment of COP in NCW

- **Confidence Intervals for ΔSA** (Δx) from exp, for t-distribution
  $\Delta x - t_{\alpha} (s/\sqrt{n}) < \boldsymbol{\mu} < \Delta x + t_{\alpha} (s/\sqrt{n})$, where $s = \sqrt{(\Sigma x_i /n-1)}$

- Confidence intervals for ΔSA (Δx) from exp, for F-distribution
  $(x_{.1} - x_{.2}) - \sqrt{F_{\alpha}}\, s_w \sqrt{(2(k-1)/n)} < \boldsymbol{\mu} < (x_{.1} - x_{.2}) + \sqrt{F_{\alpha}}\, s_w \sqrt{(2(k-1)/n)}$,
  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)

Grouped Data from Exp. Trials

Sequence of Observations	COP	no-COP	Delta
I 1	.56	.48	.08
I 2	.53	.51	.02
I 3	.58	.51	.07
II 1	.54	.55	-.01
II 2	.61	.56	.05
II 3	.65	.56	.09
Average	.58	.53	.05