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Opportunities for Improving Decision-Making in the Cockpit

Jared T. Freeman, Marvin S. Cohen, & Bryan Thompson
Cognitive Technologies, Inc.
4200 Lorcom Lane
Arlington, VA 22207
www.cog-tech.com

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Overview

- A framework for understanding how decision makers think critically under uncertainty
- Empirical validation of parts of the model
  - A study of decision making by pilots
  - A study of decision making in anti-air warfare
- Opportunities for improving decision making by leveraging critical thinking
  - Training
  - Decision support systems
  - Procedural support for critical thinking

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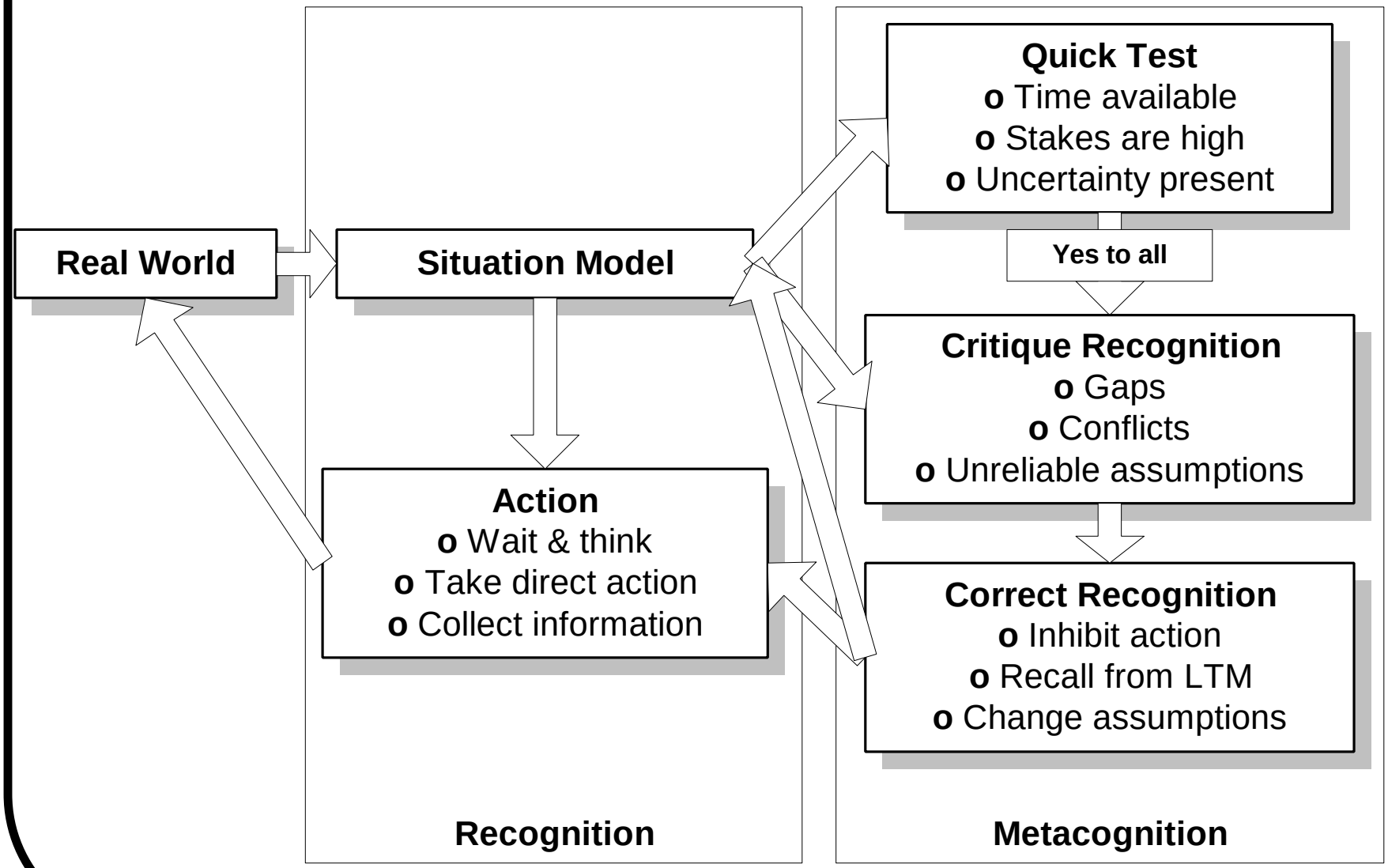
Recognition / Metacognition Model



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Validation of the R/M Model: Study of Pilots

- **Goal: Examine the correlation of experience with metacognitive skills among commercial airline pilots.**
- **Participants: Convenience sample of 41 pilots recruited in a pilots' lounge at Dulles (IAD).**
- **Experimental task: Act as Capt., non-flying pilot in low-fidelity flight scenario. Experimenter acts as ATIS, ATC, etc.**
- **Design:**
  - **Between subjects:**
    - **Scarce vs. plentiful fuel, or decision time**
    - **Years of total flight experience**

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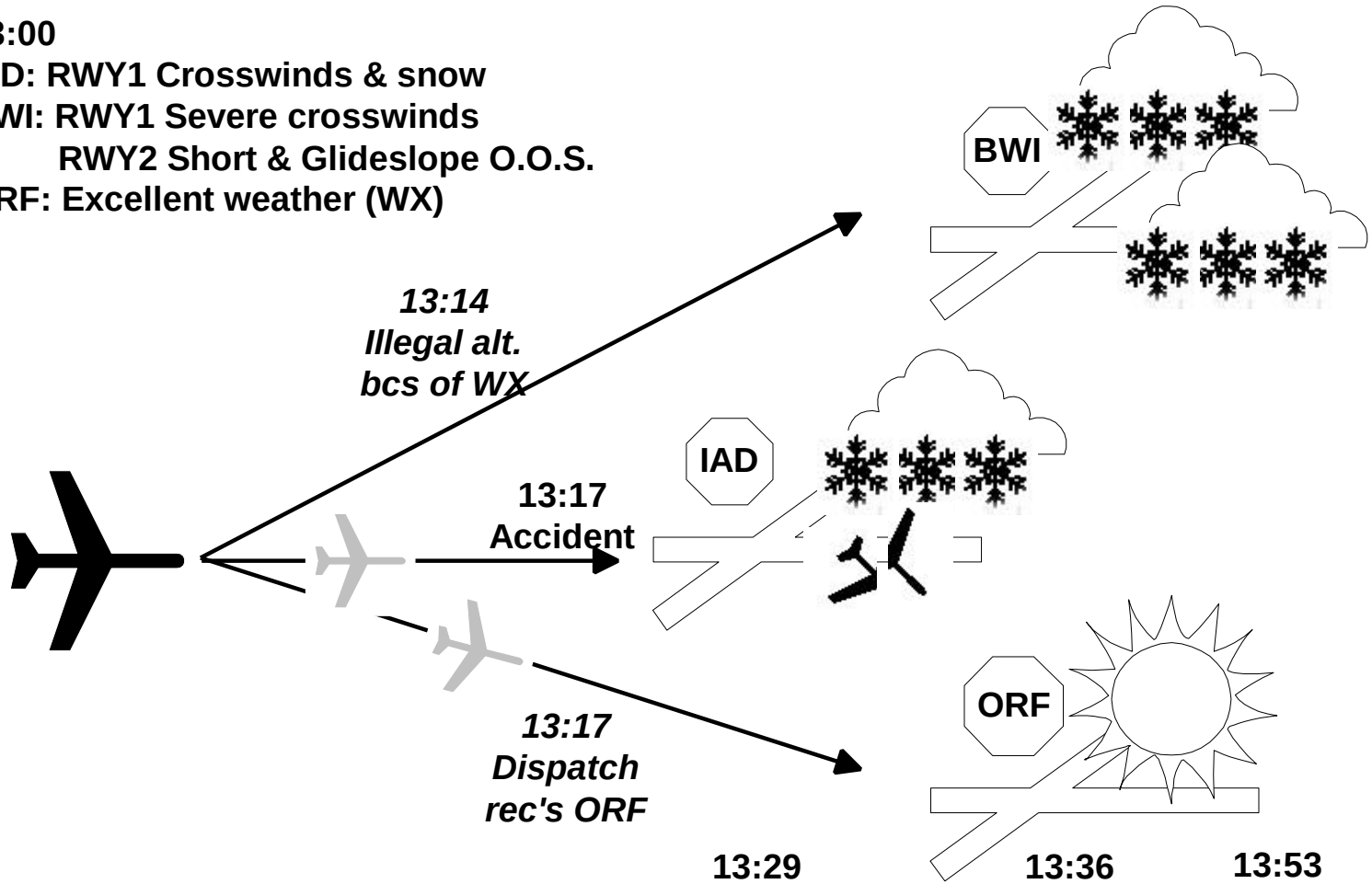
Scenario Events at IAD, BWI, ORF

13:00
IAD: RWY1 Crosswinds & snow
BWI: RWY1 Severe crosswinds
RWY2 Short & Glideslope O.O.S.
ORF: Excellent weather (WX)



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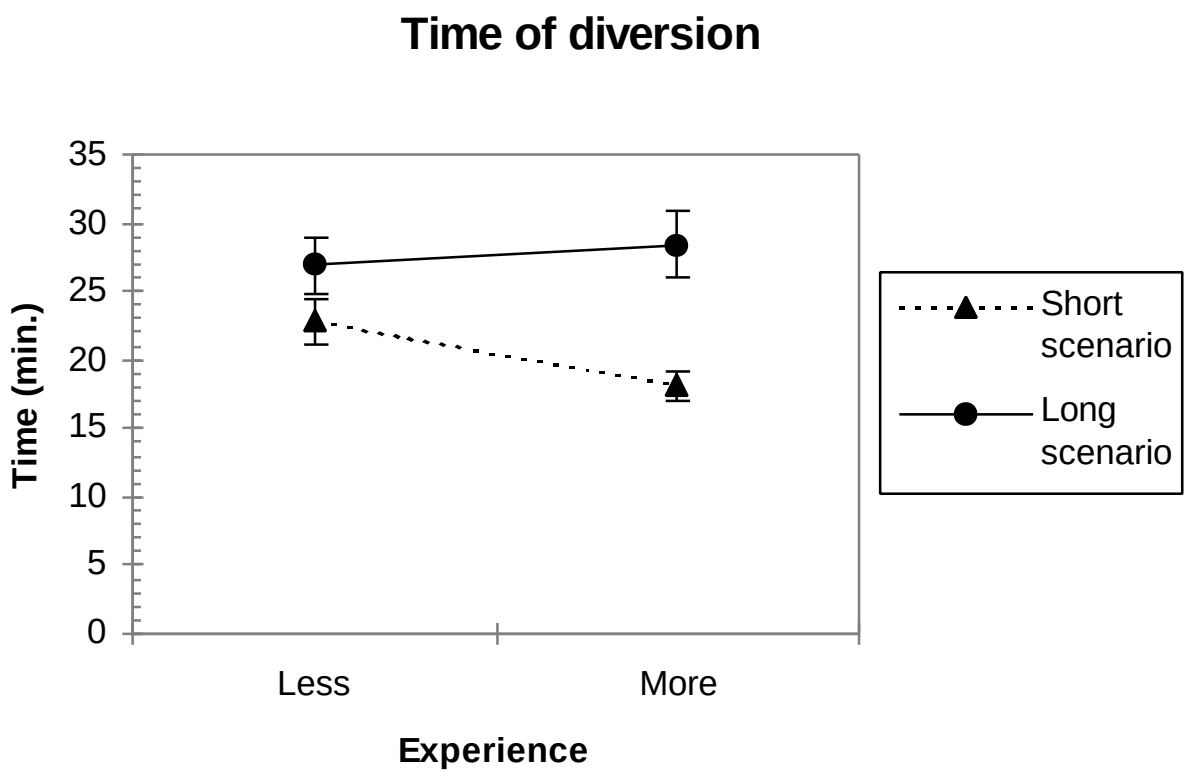
The Quick Test

- **The more decision time there was available, the more decision time experienced pilots used before diverting (*p* = 0.041).**
  - **Perhaps more experienced pilots made better estimates of available flight time from fuel load…But in fact they did not.**



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Critiquing & Correcting

- **Handling unreliable assumptions**
  - **Accident:**
    - **EFC might vary rapidly after the accident. Assumptions about EFC were unreliable.**
    - **Pilots with more experience requested EFC updates more promptly after the accident announcement than did other pilots (p = 0.005).**
  - **Wx:**
    - **Assumptions about weather were unreliable given the unexpected changes in the severity of the storm.**
    - **Pilots with more experience were more likely to request information about weather at IAD (trend: p = 0.075).**

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Critiquing & Correcting

- **Handling gaps in knowledge**
  - **Local air traffic congestion**
    - **No information was volunteered to pilots concerning local air traffic that might compete with them for clearance**
    - **More experienced pilots were more likely to request information concerning local air traffic ($t_{39} = 2.427$, $p = 0.020$).**
  - **Airport availability**
    - **Pilots initially received no information concerning airports other than the destination & two alternates.**
    - **There was a trend for pilots with more experience to request information about airports other than IAD, BWI, and ORF earlier when time was scarce, later when it was plentiful. Pilots with less experience exhibited the reverse pattern. (trend: $F_{1,10} = 2.892$, $p = 0.120$).**

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Validation of the R/M Model: Training Study in AAW

- **Goal: Do experimental manipulations that *should* influence critical thinking do so?**
- **Participants: Navy officers with ~10 years experience**
- **Experimental task**
  - **Execute high-fidelity AAW scenario.**
  - **Assess selected tracks and offer arguments concerning assessments.**
- **Design**
  - **Critical thinking training (CTT) vs. control**
  - **Individual vs. dyad**
  - **Decision support vs. no decision support**

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Main Effects: Process Measures

	CTT	Group	DSS
Evidence considered	+ 25% (n.s.)	+ 28%**	- 9% (n.s.)
- Evidence considered for favored assess	+ 7% (n.s.)	+19%*	- 20% (n.s.)
- Evidence considered for disfavored assess	+ 38%^{T}	+ 36%**	+ 5% (n.s.)
Alternative assessments	+ 21%*	+ 17%**	- 17%*
Conflict identified	+ 59%**	+ 67%**	+ 44% (n.s.)
Explanations of conflict per conflict	+ 32%*	+ 69%**	+ 26% (n.s.)

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Main Effects: Outcome Measures

	CTT	Group	DSS
Accuracy overall	+ 25%*	+ 15%^{T}	(n.a.)
Accuracy Charlie overall (1,2,3)	+ 30%^{T} (+,+,+)	-9% n.s. (+,-,=)	(n.a.)
Accuracy India overall (1,2,3)	+ 20% (=,+,+)	+36%** (+,+**,+^{T})	+ 49% (n.s.) (break 3 only)
Confidence	- 3% (n.s.)	-2% (n.s.)	+46%^{T}

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Opportunity #1: Enhancing Decision Making Through Training

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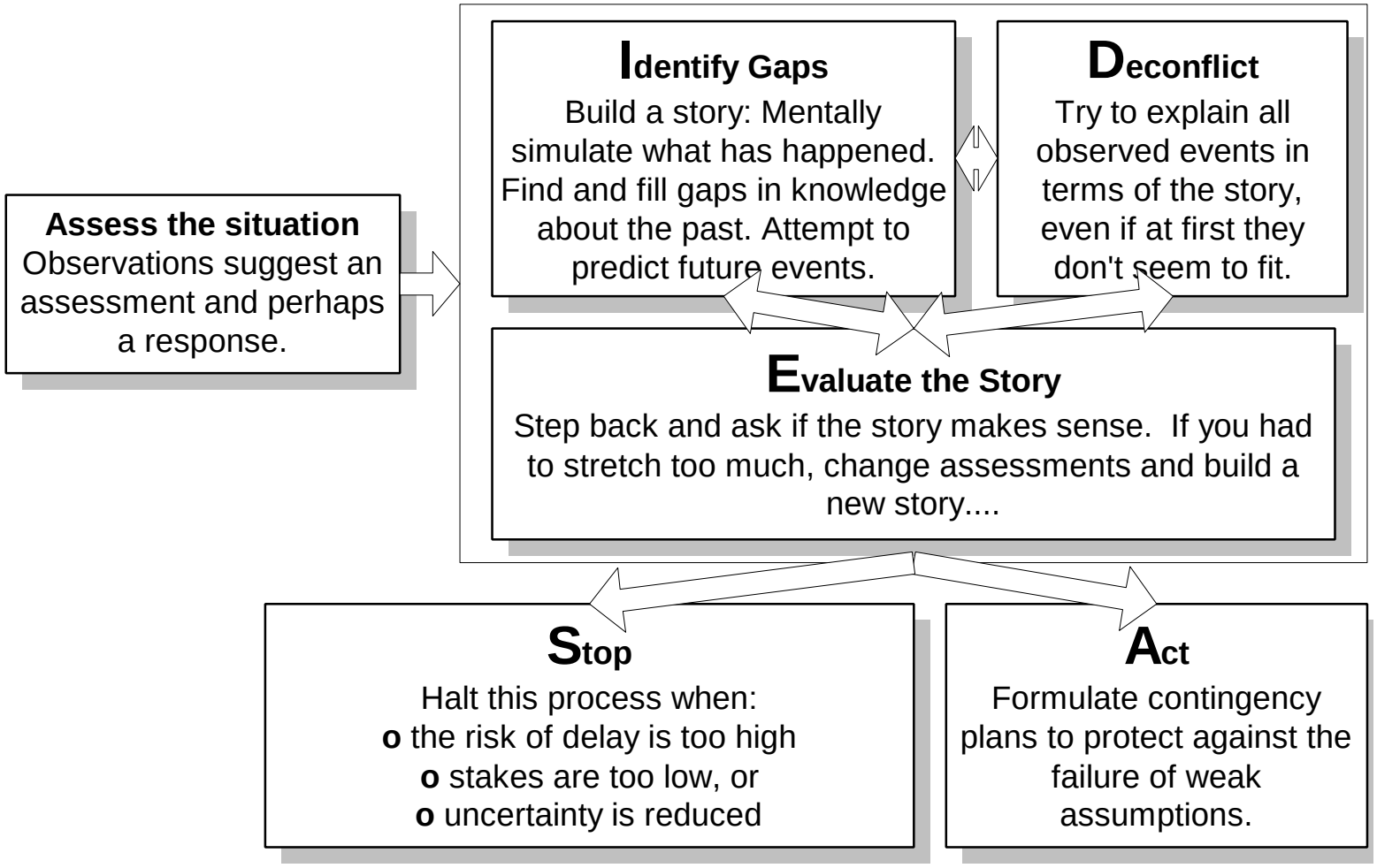
I.D.E.A.S. Representation of the R/M Model for Training



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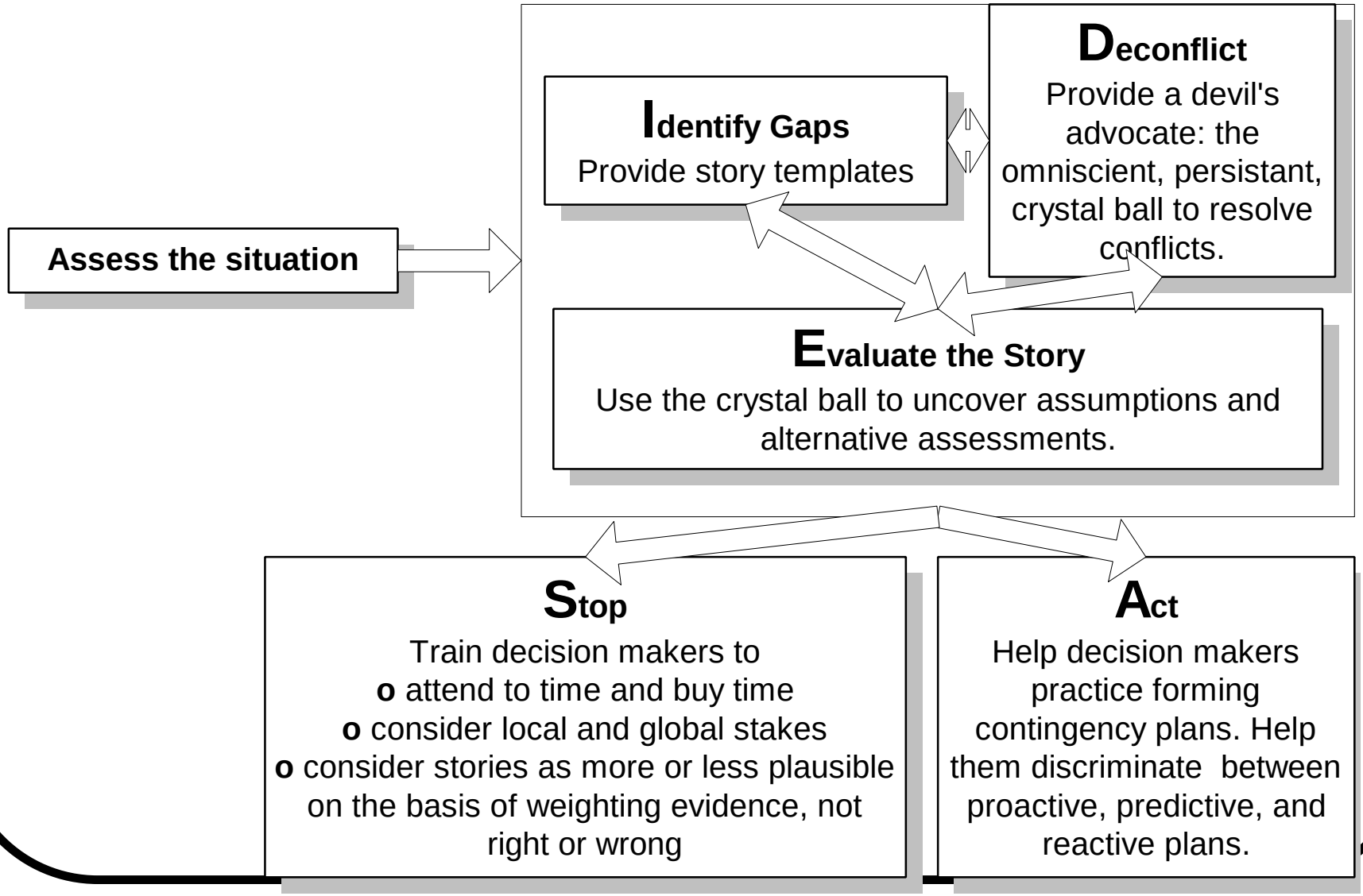
Training Strategies Using I.D.E.A.S.



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Training Enhances Critical Thinking Skills

- **Training in critical thinking improves decisions (assessments) and critical thinking processes**
  - **Thinking critically does not diminish confidence**
- **CTT for individuals approximates the effects of joining individuals into groups**
  - **However, groups generally gained more from CTT than individuals (analyses not shown).**

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Opportunity #2: Enhancing Decision Making Through System Design

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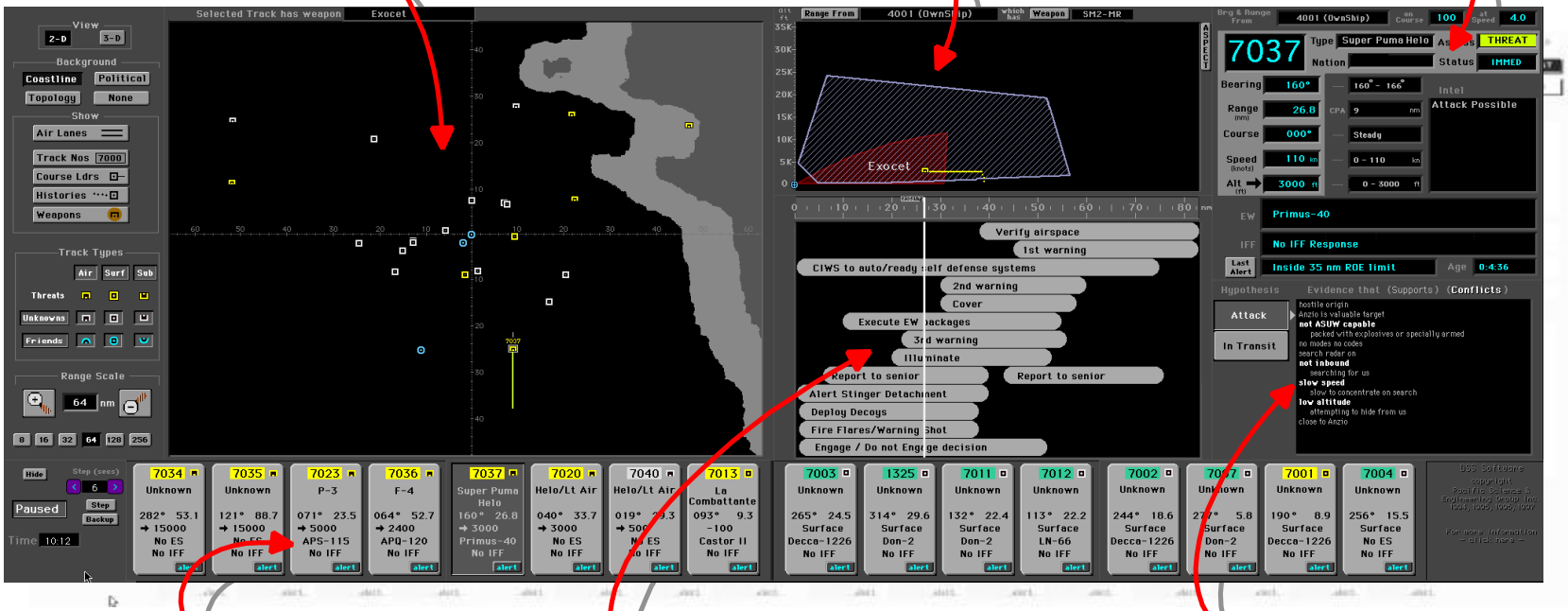
Design Example: SPAWAR's DSS

Geoplot

Single track in profile view

Track data (real time & trend)



Track characteristics by track, prioritized

Tactical responses

Assessments, evidence, conflicts, & assumptions

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Summary: Effects of DSS

- **Officers using the DSS (vs. officers without DSS; *see tables*)**
  - **Were more confident (46%, a trend)**
  - **Produced fewer alternative assessments**
    - **Perhaps due to their relatively high confidence in their favored (and generally correct) assessments**
  - **Exhibited no decisive changes in critical thinking skills:**
    - **non-significant improvements in accuracy, conflict identification, & conflict handling.**
    - **n.s. decrements on some other CT measures.**

- **Conclusion: Enhancing access to real time data and trend data may be sufficient in many circumstances but has disturbingly little effect on critical thinking.**
- **Recommendation: Aids to critical thinking may need to be highly salient, and tightly integrated with displays of data.**

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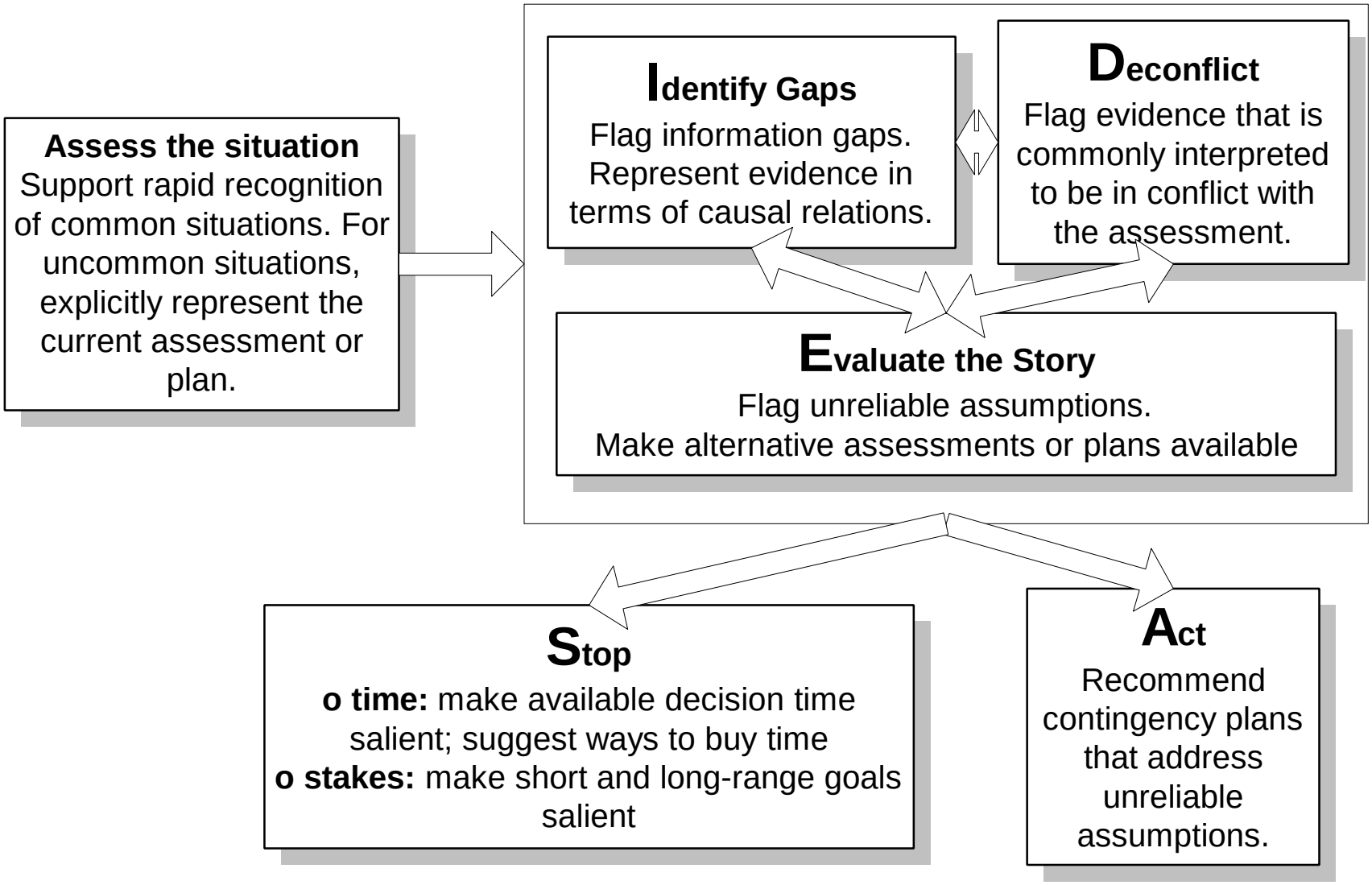
I.D.E.A.S. for Decision Support



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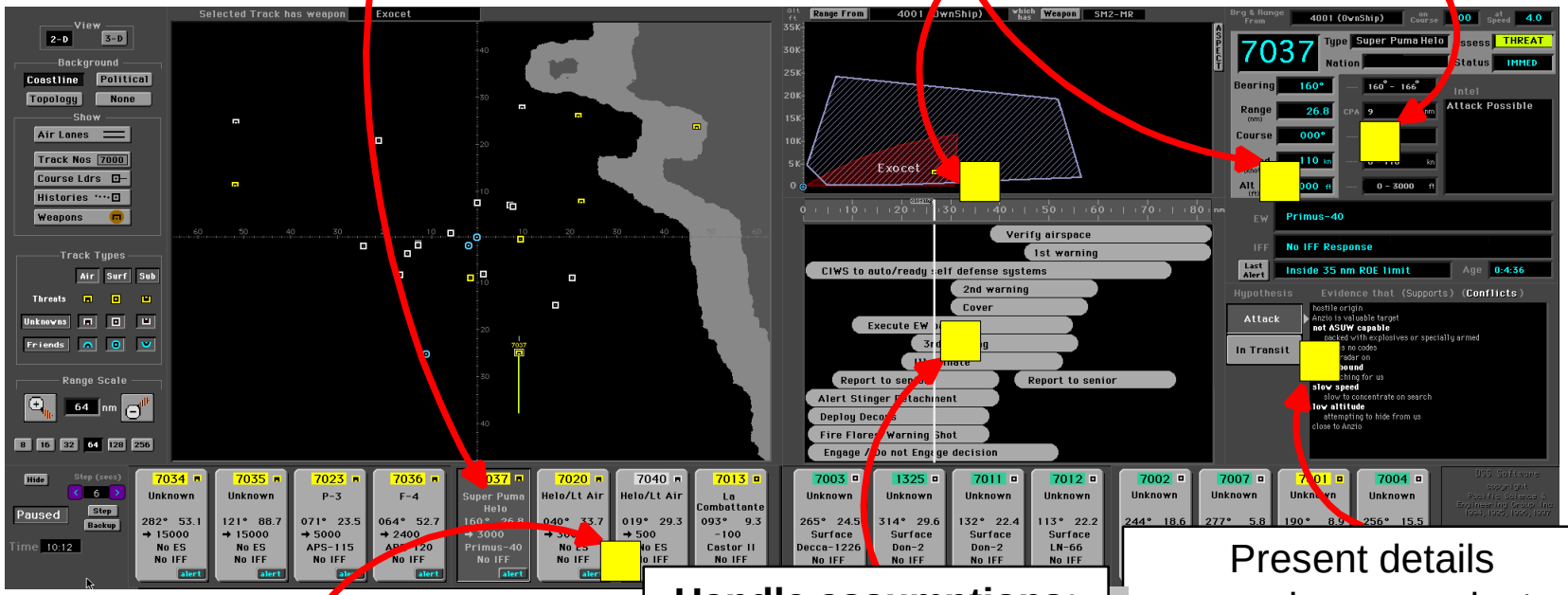
Concept for Integrating CT & DSS

Quick test: Highlight tracks appropriate for critical thinking

Critique: Label conflicting evidence

Critique: Indicate missing evidence



Critique: Indicate unreliable assumptions (e.g., mis-correlation of platforms)

Handle assumptions: List actions for a contingency plan that addresses uncertainties.

Present details concerning any selected flag with resepect to an explicitly represented assessment.

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Design Example: Support for Target Recognition

- **Goal: Evaluate concepts for supporting recognition & metacognition**
- **Participants: Experienced Army helicopter pilots**
- **Experimental task: Make engagement decisions regarding each of 12 vehicles in a field of vehicle images**
- **Design:**
  - **Within subjects:**
    - **Stakes: Varies % of friendly vehicles in field**
    - **Decision time: 30 vs. 60 secs. per 12 images**
  - **Between subjects**
    - **Color-coding to aid quick test**
    - **Labeling scheme**
  - **Within blocks of image sets:**
    - **Vehicle range and viewing angle**
    - **Accuracy of aiding**

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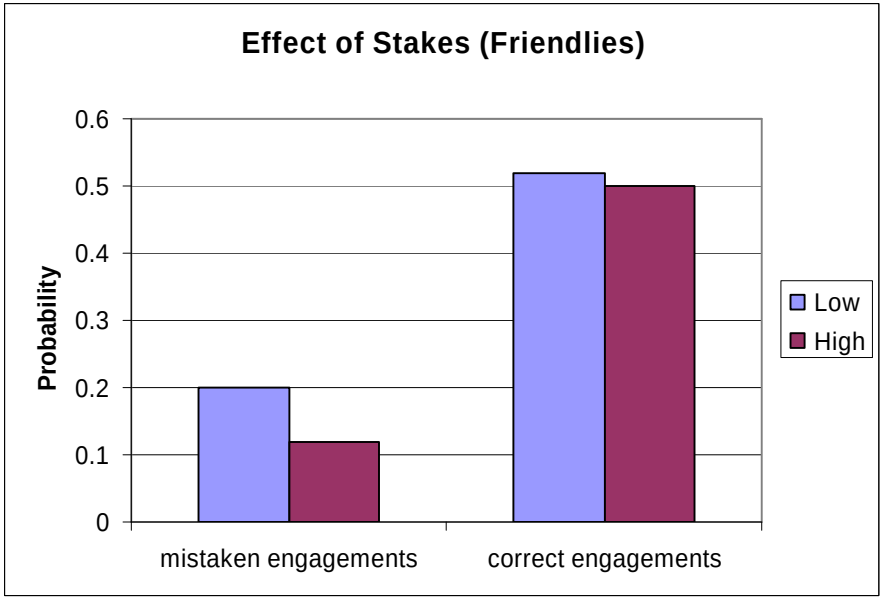
Validation: Unaided Quick Test

- **As stakes rise, pilots attend more carefully or critically**
  - **Pilots don't just shoot less as stakes rise (a mark of shifting bias). Incorrect engagements decline, while corrects engagements do not.**
- **As decision time increases, pilots spend more time on images (not shown).**



p = .008 **ns**

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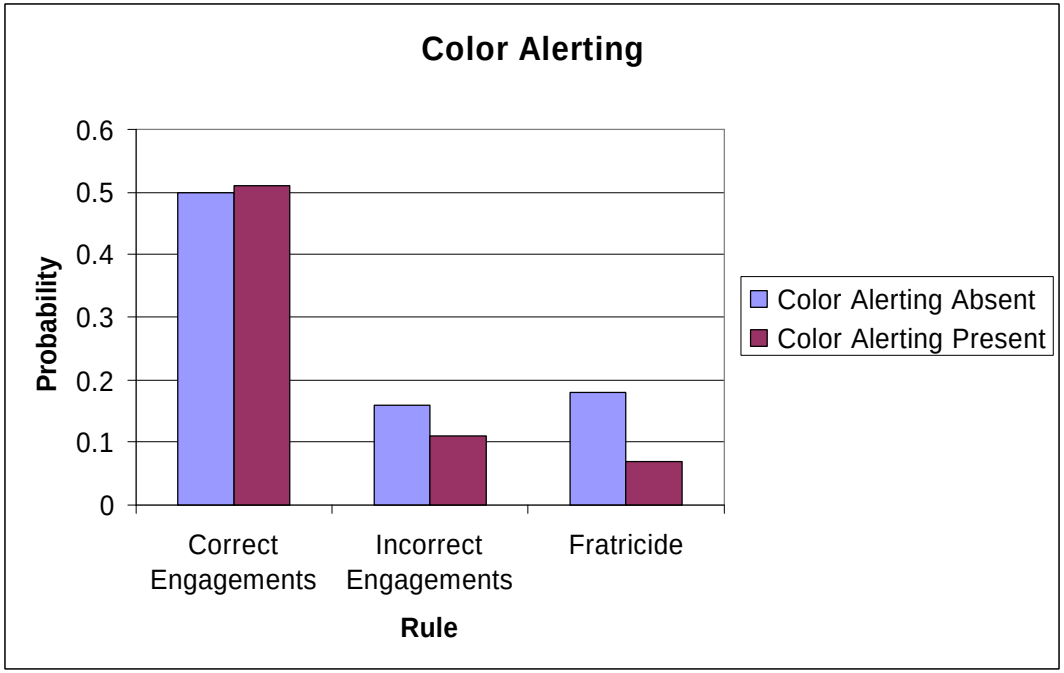
Aided Quick Test

- **Color coding images reduces fratricide by ~40% (p=.02)**
  - **Yellow alerts pilots to ambiguous**
  - **Other colors categorize unambiguous images (friend, enemy target, enemy non-target)**
- **Color coding is particularly effective when time is available to resolve ambiguities (when quick test is appropriate)**

- **Color coding non-significantly increases viewing time per image. I.e., it may encourage a second look where it counts.**



ns ns p = .02

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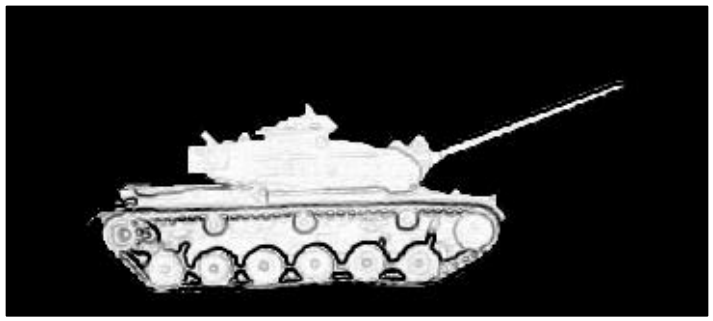
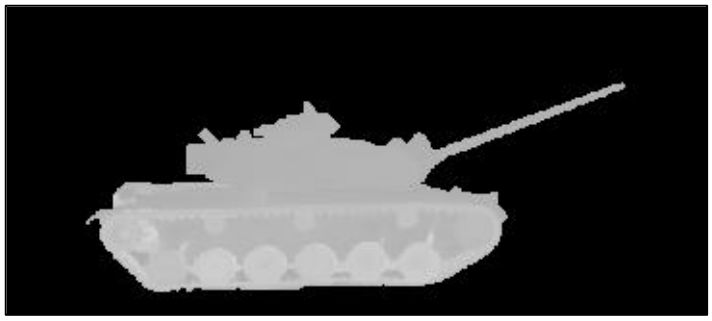
Aiding Visual Recognition: A Delicate Business

- **Enhancement of *silhouette* (darkening of figure to heighten contrast with surround) improved recognition most (76% vs. 63% unenhanced FLIR baseline)**
- **Selective enhancement of track/wheels or guns/turrets helped somewhat less (69%)**
- **Highlighting *everything* (entire vehicle) did not help at all (62%)**



Enhanced wheels/tracks



Enhanced silhouette

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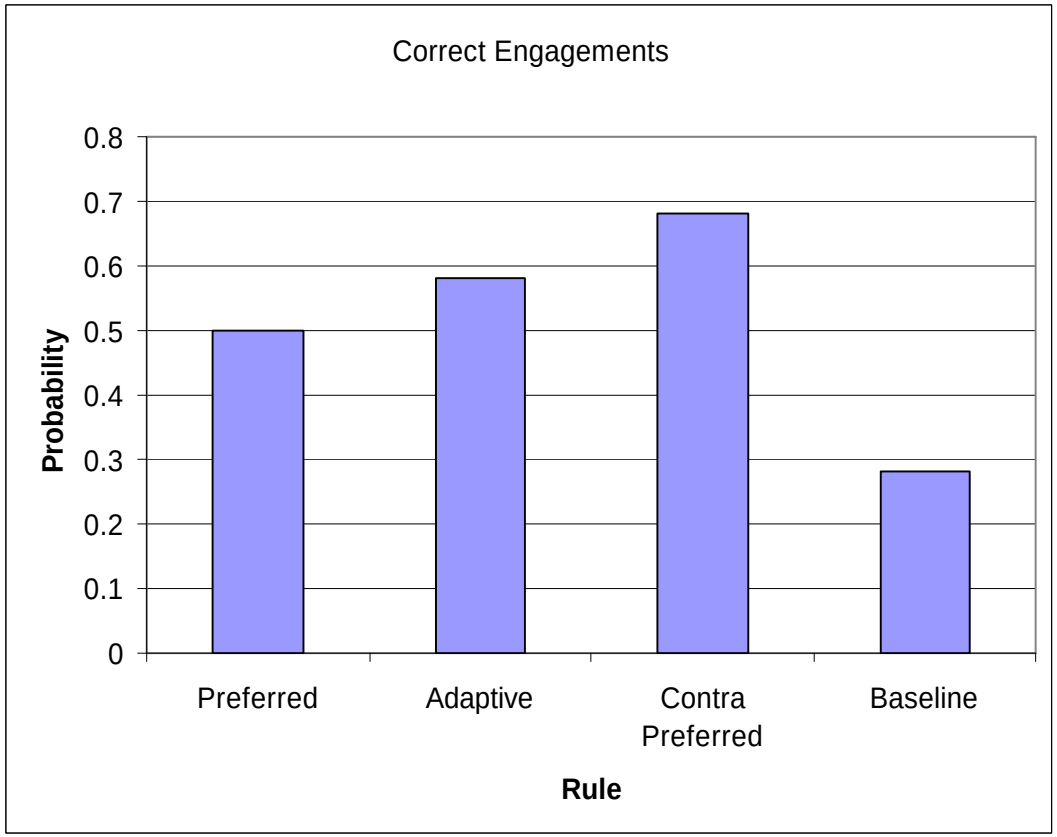
Aiding Linguistic Recognition

- **Labels may increase correct engagements (*p* = .134)**



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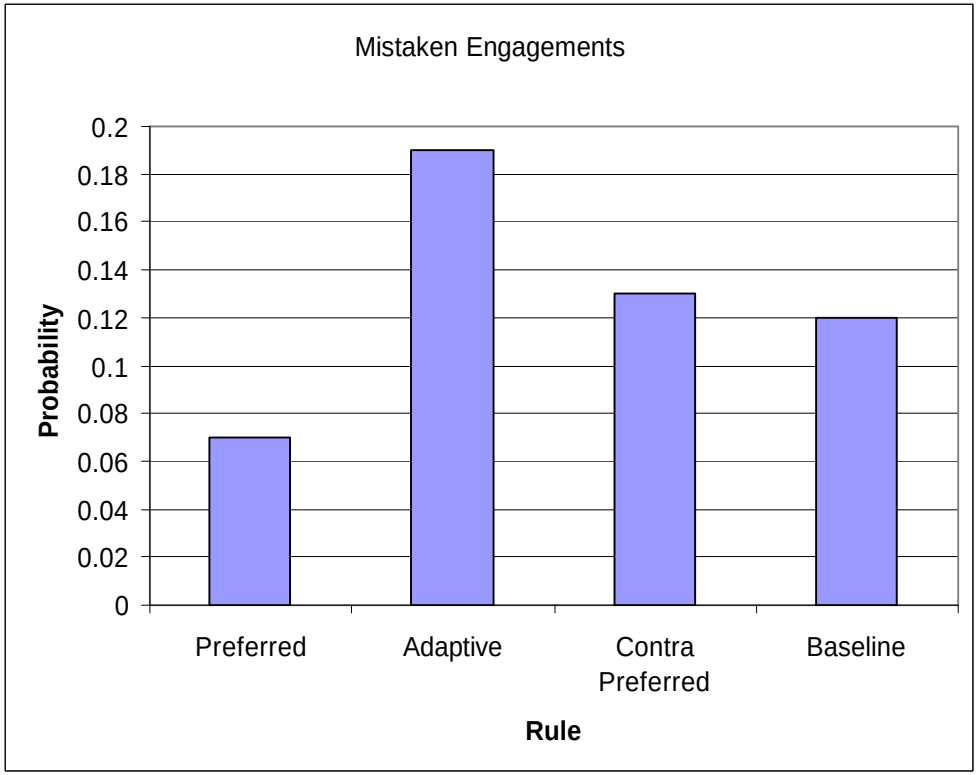
Aiding Linguistic Recognition: A Delicate Business

- **Labels may decrease mistaken engagements, but only if label specificity is appropriate to the class of object:**
  - **Jeep = "Jeep"**
  - **Tank = "Tank / T60" or "Friendly tank"**
  - **APC = "BMP", "BTR"**
- **Of all labeling schemes, this produces fastest responses (ns), though all labels increase viewing time.**



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Opportunity #3: Enhancing Decision Making Through Procedures

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Enhancing Decision Making Procedurally

- **Procedures: Develop decision making protocols that engage critical thinking skills <u>when appropriate</u>:**
  - **Institute the devil's advocate or crystal ball as a procedure or a role**
  - **Task appropriate problems to competing individuals or groups**
  - **Task appropriate problems to groups**
    - **<u>But</u>: Where problem solutions are not demonstrable, groups may be even more susceptible to error than individuals, at least in part because group members jointly accept and apply inappropriate decision-making heuristics (Tindale, 1993).**
    - **<u>Therefore</u>: Help groups build a shared model & critique options (Hirokawa, 1985)**
    - **<u>And/Or</u>: Require individuals to defend their conclusions (Sniezek & Paise, 1989)**
    - **<u>And/Or</u>: Require individuals to solve the problem independently before entering the group (Sniezek & Buckley, 1993)**

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For more information...

- **Cognitive Technologies, Inc.:**

  www.cog-tech.com

- **Critical thinking training:**

  www.cog-tech.com/MEMO/Prototype/index.html