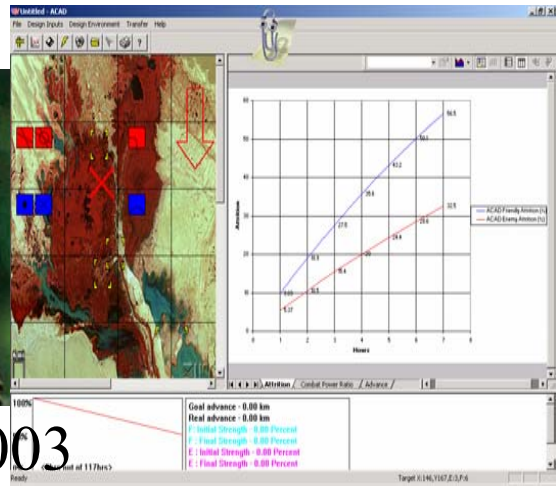
SUPPORTING COURSES OF ACTION PLANNING WITH INTELLIGENT MANAGEMENT OF BATTLE ASSETS



8th ICCRT/003

Contact Information:

CELESTINE A. NTUEN & EUI H. PARK

The Institute for Human-Machine Studies

North Carolina A&T State University

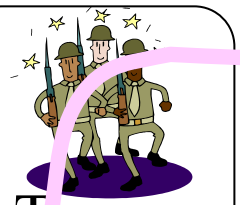
Greensboro, NC 27411

Phone: (336) 334-7780

Fax: (336) 334-7729

PRESENTATION OUTLINE

- INTRODUCTION
- RATIONALE
- EXISTING DECISION AIDS
- ACAD DESIGN & SIMULATION OUTPUT
- ACAD EVALUATION EXPERIMENT
- RESULTS
- CONCLUSION & FURTHER STUDIES

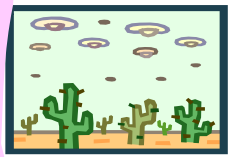

Troops


Time


Equipment

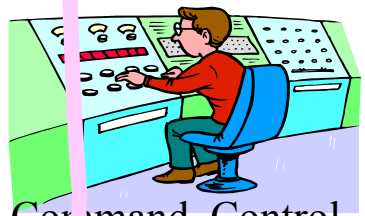

Logistics


Weather


Terrain


Decision & Judgment???

Cognitive Information Processor


Command, Control, Communication & Information

Terrain?
Min. Attrition?

Military Decision Making Process

Mission Analysis	COAD	COAA	RFR Estimated

RFR actual

Mobility

~~Attrition:~~
•Troops
•Equipment

Overwhelming Commander's Environment

RATIONALE

- TOO MUCH INFORMATION, BUT FIXED COGNITIVE ASSET OF THE COMMANDER

- INFORMATION PROCESSING REQUIREMENT
  - PERCEIVING & RECEIVING
  - FILTERING & COMPRESSING
  - FUSING
  - MAKING SENSE OUT OUT OF PROCESSED DATA (JUDGMENT)
  - DECIDING

RATIONALE

- DYNAMIC ENVIRONMENT:
  - CHANGES IN INFORMATION
  - INFORMATION VOLUME & DENSITY
  - HETEROGENEITY OF INFORMATION
  - INFORMATION SPEED

- UNCERTAINTY:
  - INCOMPLETE INFORMATION
  - UNAVAILABLE INFORMATION
  - UNRELIABLE SOURCE OF INFORMATION
  - FUZZINESS IN INFORMATION DESCRIPTION

RATIONALE

- BURDEN OF PROOF:
  - OPPORTUNITY FOR HUMAN ERROR
  - COGNITIVE WORKLOAD
  - TIME & DECISION ACCURACY

- SOLUTIONS:
  - COMPUTERIZED DECISION AIDS
    - Simulation & Modeling Tool
    - Predict, Forecast, Estimate Average Policies
      - Used for Anticipation & Envisioning

SOME EXISTING DECISION AIDS

- FOX-GA: COA MODEL USING GENETIC ALGORITHM
- CORAVEN: INTELLIGENT COLLECTION MANAGEMENT USING BAYESIAN BELIEF NET
- OWL: A DECISION-ANALYTIC WARGAMING USING REAL-TIME STATISTICAL DATA MINING
- SCAT: SENIOR COMMANDER AUTHORING TOOL USED FOR PLAN FRAMING
- MODSAF: 3D SIMULATION WARGAME WITH METT-T
- BVP: BATTLE PLANNING & VISUALIZATION TOOL
  - There are many other tools available*
  - Tools are task dependent, assumption-driven

ALTERNATIVE COURSES OF ACTION DISPLAY (ACAD)

- COA SIMULATION
- DRIVERS :
  - ANALYTICAL MODELS
    - COL DUPUY'S COMBAT MODEL (Refined)
    - BEHAVIORAL MODELS

ALTERNATIVE COURSES OF ACTION DISPLAY (ACAD)

- DRIVERS :
  - TABLES OF ORGANIZATION & EQUIPMENT
  - INTUITIVE GUI
  - MEET-T (MISSION, ENEMY, TROOPS, TERRAIN, & TIME)
    - Drilled-down, granular information level
    - C2 Intangibles (often ignored in other models)

ALTERNATIVE COURSES OF ACTION DISPLAY (ACAD)

- OUTPUTS :
  - Relative force ratio
  - Composite attrition factors
  - Troop advance rate
  - Time base performance data
  - Graphical displays
  - Battle state postures (Attack, defend, etc.)

SUPPORTING COURSES OF ACTION PLANNING WITH INTELLIGENT MANAGEMENT OF BATTLE ASSETS

Mission
Terrain
Weather
Time
Surprise
Mobility factors:
Road quality
Road density
Minefield

(Fixed input)

Force & Equipment Composition
Intangible C2 factors:
Morale,
Training
Leadership
(variable)

INPUT

TOE

VIE: A model for Visualizing Enfolding battle events

Heuristic refinement of Dupuy's Combat models

ACAD SYSTEM
C++, Visual Basic
EXCEL

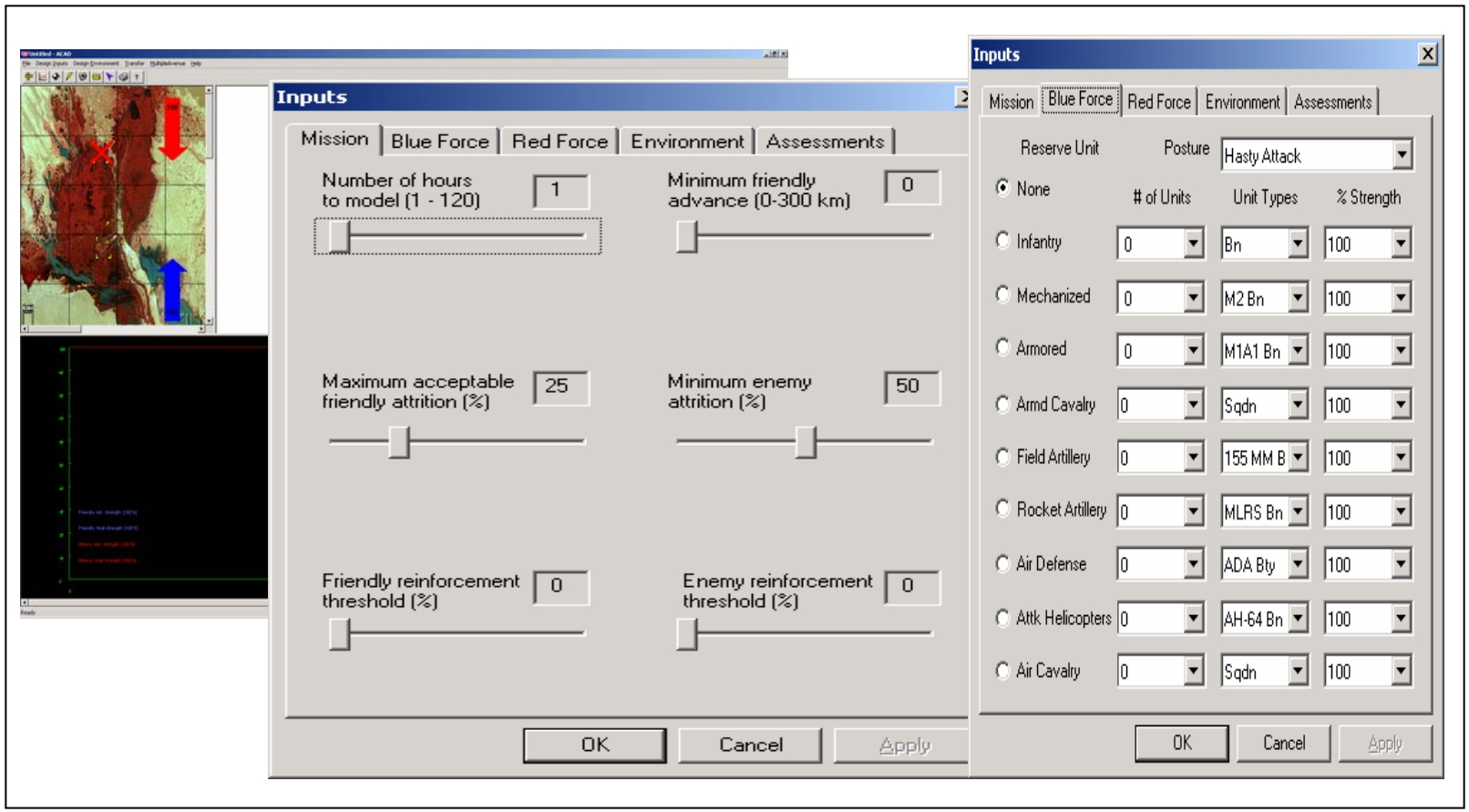
CADIV: Collection Asset Display & Intent Visualization

Resource Decision Model

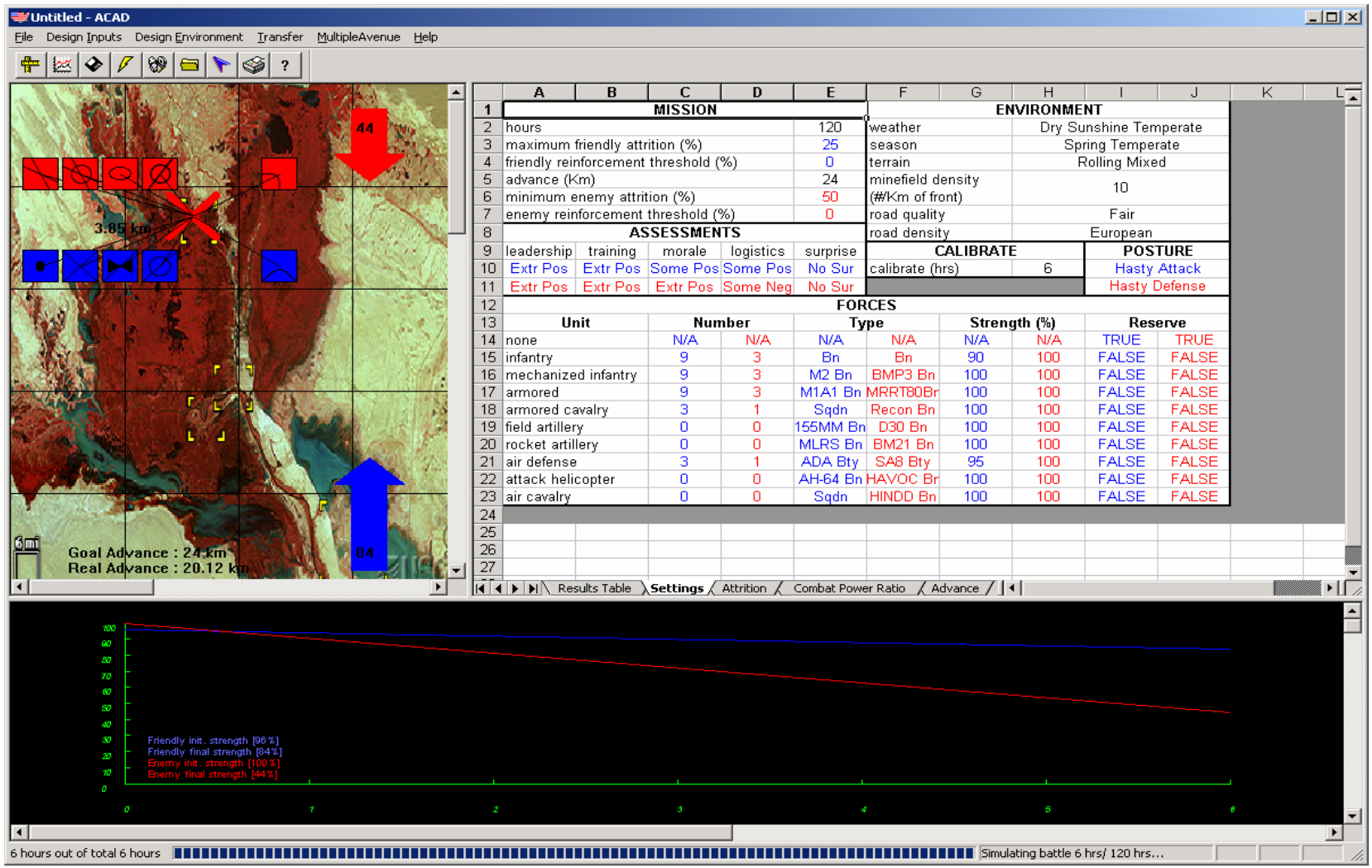
OUTPUT

Attrition
Mobility factor
Relative force ratio
Advance rate
Posture
Graphics

SAMPLE APPLICATION



SAMPLE APPLICATION



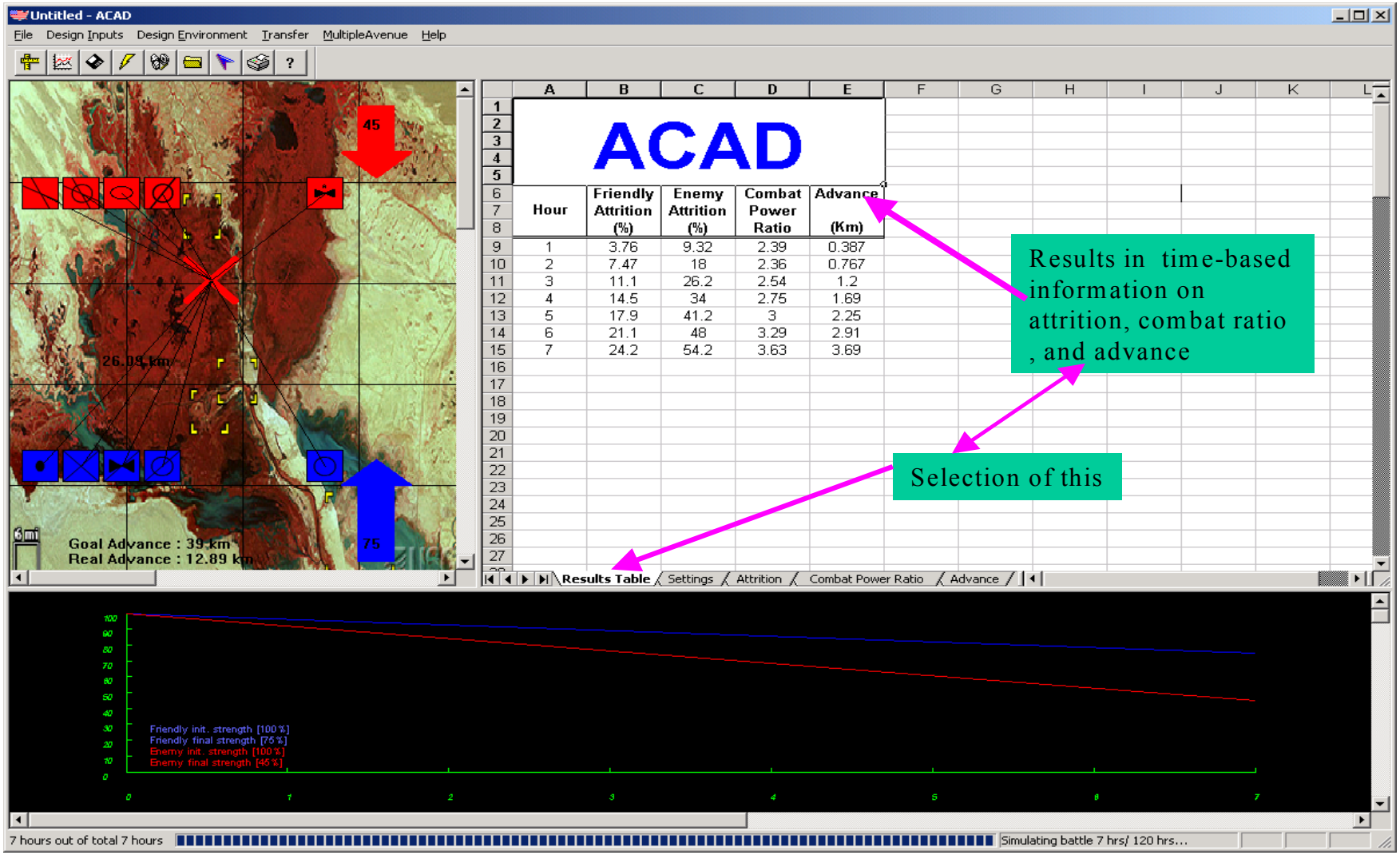
MISSION		ENVIRONMENT	
hours	120	weather	Dry Sunshine Temperate
maximum friendly attrition (%)	25	season	Spring Temperate
friendly reinforcement threshold (%)	0	terrain	Rolling Mixed
advance (Km)	24	minefield density (#/Km of front)	10
minimum enemy attrition (%)	50	road quality	Fair
enemy reinforcement threshold (%)	0	road density	European

ASSESSMENTS					CALIBRATE		POSTURE
leadership	training	morale	logistics	surprise	calibrate (hrs)	6	Hasty Attack
Extr Pos	Extr Pos	Some Pos	Some Pos	No Sur			Hasty Defense
Extr Pos	Extr Pos	Extr Pos	Some Neg	No Sur			

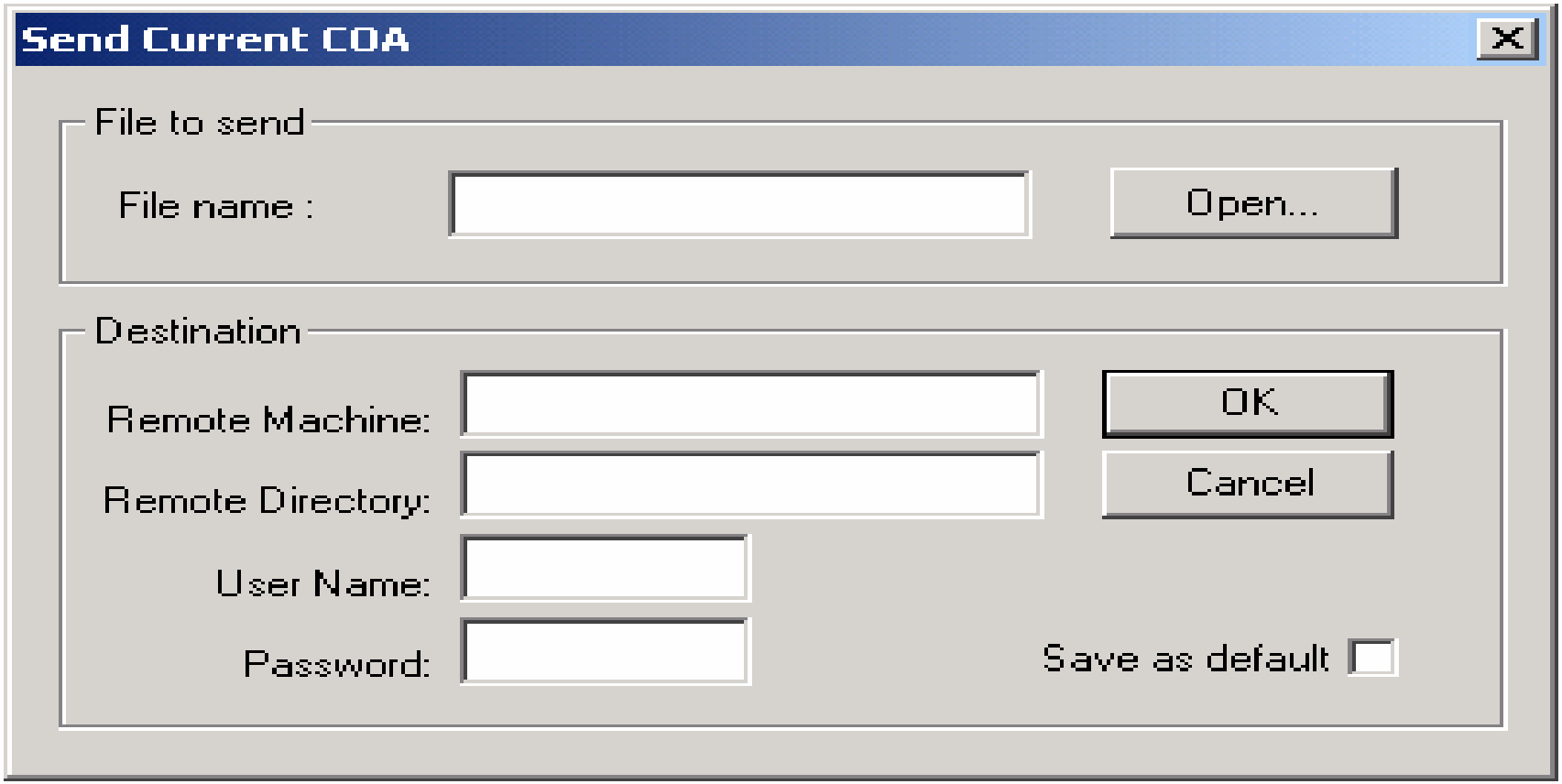
FORCES

Unit	Number		Type		Strength (%)		Reserve	
none	N/A	N/A	N/A	N/A	N/A	N/A	TRUE	TRUE
infantry	9	3	Bn	Bn	90	100	FALSE	FALSE
mechanized infantry	9	3	M2 Bn	BMP3 Bn	100	100	FALSE	FALSE
armored	9	3	M1A1 Bn	MRRT80Br	100	100	FALSE	FALSE
armored cavalry	3	1	Sqdn	Recon Bn	100	100	FALSE	FALSE
field artillery	0	0	155MM Bn	D30 Bn	100	100	FALSE	FALSE
rocket artillery	0	0	MLRS Bn	BM21 Bn	100	100	FALSE	FALSE
air defense	3	1	ADA Bty	SA8 Bty	95	100	FALSE	FALSE
attack helicopter	0	0	AH-64 Bn	HAVOC Br	100	100	FALSE	FALSE
air cavalry	0	0	Sqdn	HINDD Bn	100	100	FALSE	FALSE

SAMPLE APPLICATION



SAMPLE APPLICATION



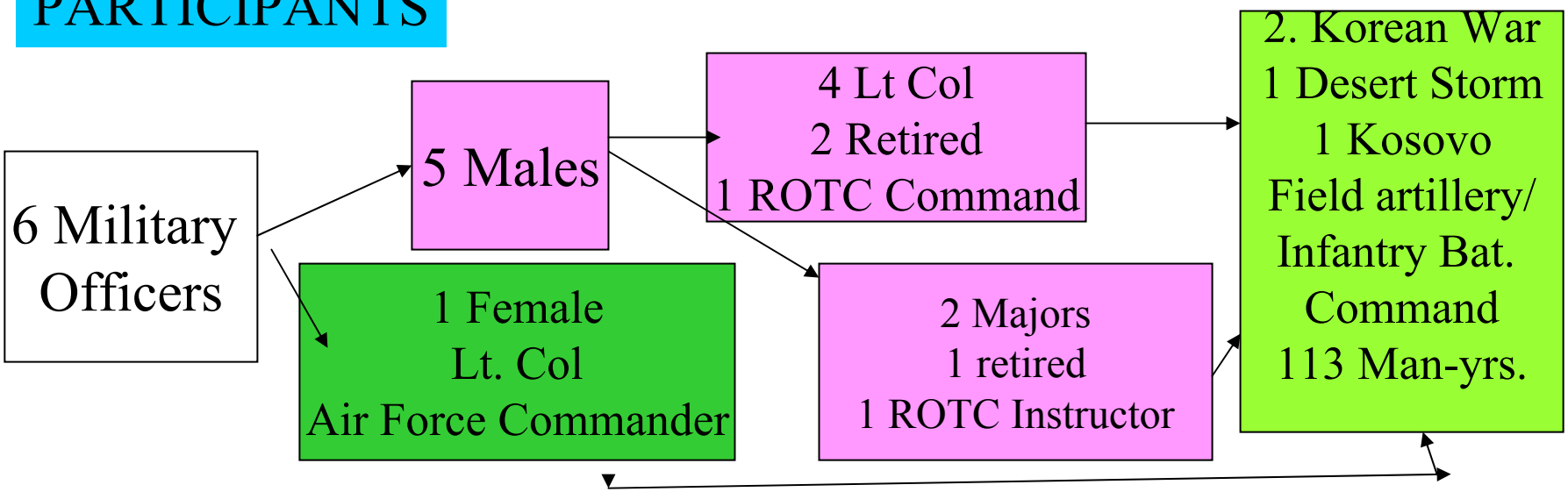
Writing ACAD Output to remote Machines

ACAD EVALUATION

MAIN HYPOTHESIS:

•TASK FAMILIARITY & COMMAND EXPERIENCE HAVE EFFECT ON USER'S TRUST ON ACAD

PARTICIPANTS



STUDY PERIOD: June –September 2000

DESIGN: Within-Subject study

TRAINING: MIN (40 min.) – 55 Min.

PRIOR INFORMATION: Decision Aid Expectation Form Questionnaire.

TASK COMPLEXITY: Based on information on enemy surprise

* Completely Known (LOW COMPLEXITY)
* 50% Known (MEDIUM COMPLEXITY)
* No Information (HIGH COMPLXITY)

EXPERIMENT 1: Paper & pen (Manual) (Option of 5 trials)

EXPERIMENT 2: Decision Aid (Using ACAD) (Must perform 5 trials).

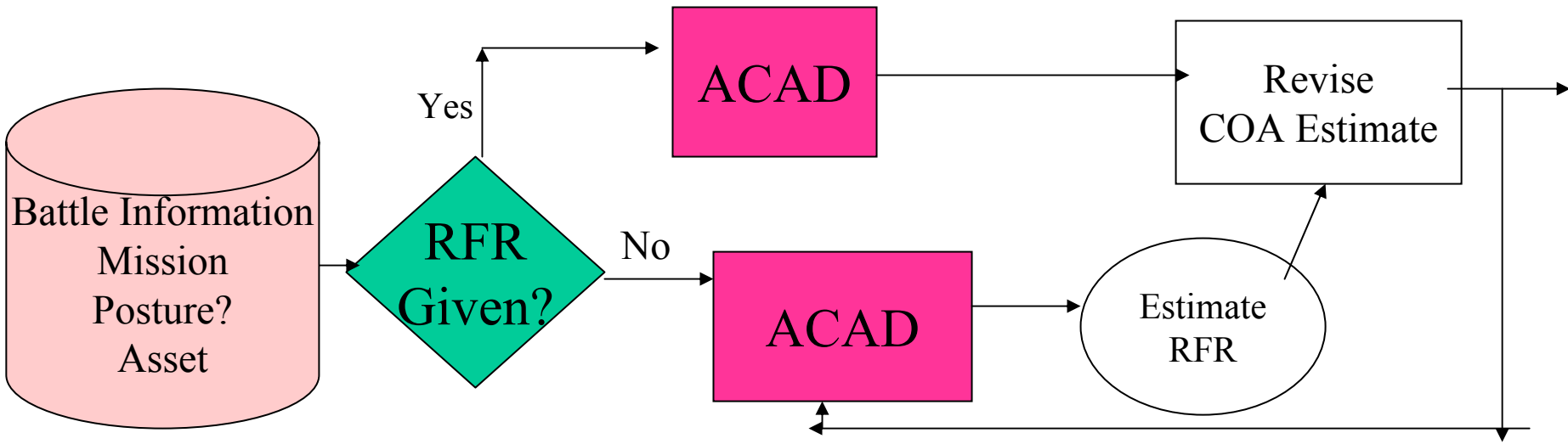
TIME LIMIT: Sufficient, open-ended time allowed.

POST TEST: Rate ACAD on given trust metric

SCENARIO PRESENTATION: Random on different days and trials.

GIVEN: Mission description, Military asset for friends and enemy, and posture.

DETERMINE: Favorable COA/ Asset combination to minimize composite attrition/



RESULTS

COA COMPLETION TIMES

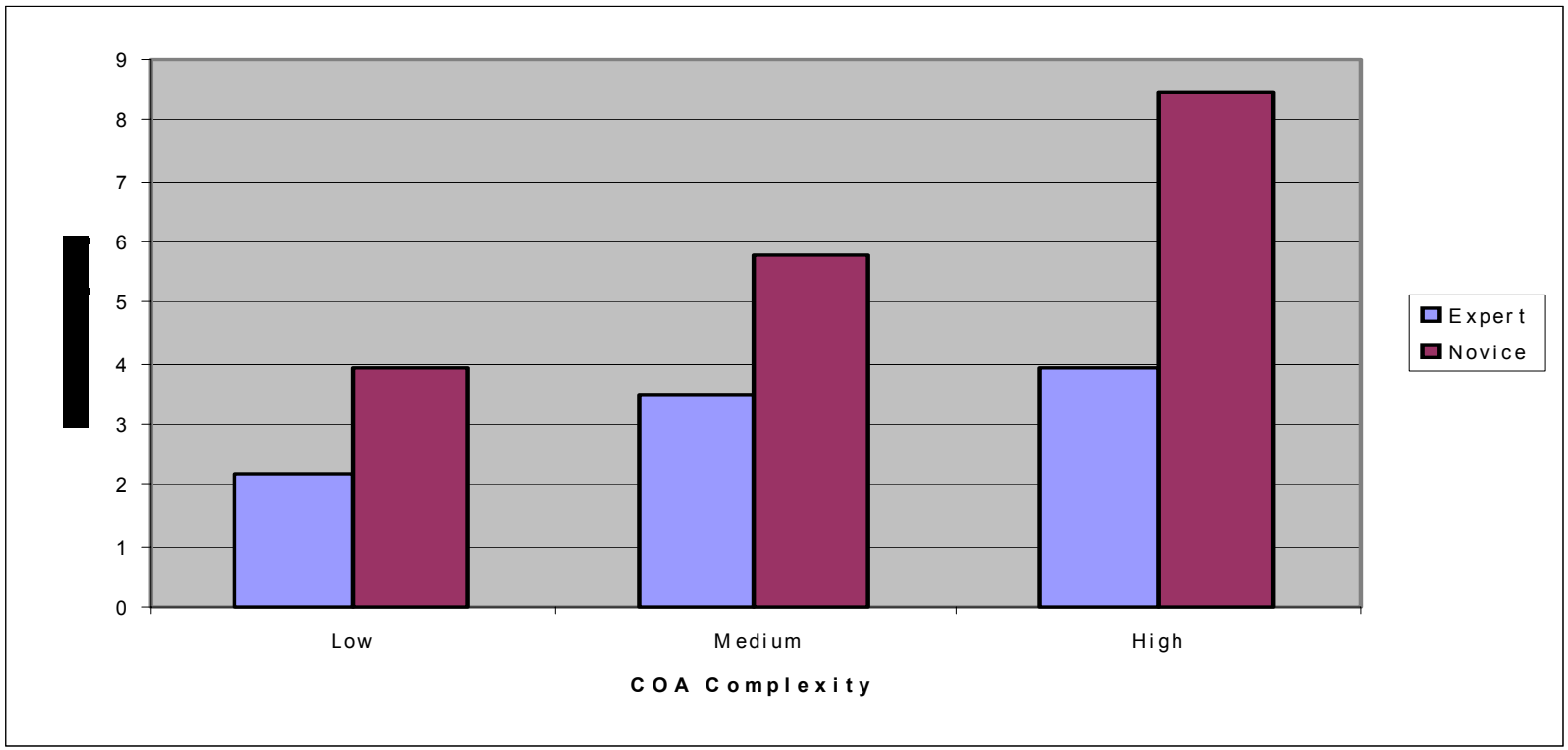
DATA ON ACAD ONLY

Experience level	Low uncertainty COA	Medium uncertainty COA	High uncertainty COA
Experts (Lt.Col.)	2.18 (std=0.26)	3.51 (std=0.62)	3.937 (std = 0.51)
Novices (Majors)	3.94 (std =1.03)	5.76 (std = 0.93)	8.43 (std = 1.27)

RESULTS

COA COMPLETION TIMES

DATA ON ACAD ONLY



RESULTS

COA COMPLETION TIMES

DATA ON ACAD ONLY

- 2 (Expertise) X 3 (COA Complexity) Within-subject ANOVA:
- Significant differences between Cols. & Majors ($F = 249$; $p = 0.018$)
- Information Complexity has effect on task times: $F = 19.45$, $p = 0.003$)

RESULTS

COA COMPLETION TIMES

DATA ON MANUAL VS ACAD

- 2 (Expertise) X 3 (COA Complexity) X 2 (Tool:Manual vs ACAD):

- ACAD VS. MANUAL Task: $F = 252$, $p = 0.0003$)
- ACAD Times were between 40-62% less

- ACAD vs MANUAL & Level of Complexity: No significant
  - Task complexity affected COA development equally
  - May be due to preprocessing time required
  - Need further analysis

RESULTS

ACAD PERCEPTION AS A COA ASSISTANT: LOW COMPLEXITY

($t = 3.98$, $p = 0.0009$: Differences between Cols. & Majors)

Attribute	Expert Score	Novice Score
Information content/ management	0.72	0.93
Reliability of decision	0.56	0.87
Personal dependency of decision aids	0.40	0.58
Robustness of decision aid	0.675	0.90
Confidence on decision aids	0.82	0.85
Trust score	0.913	0.966

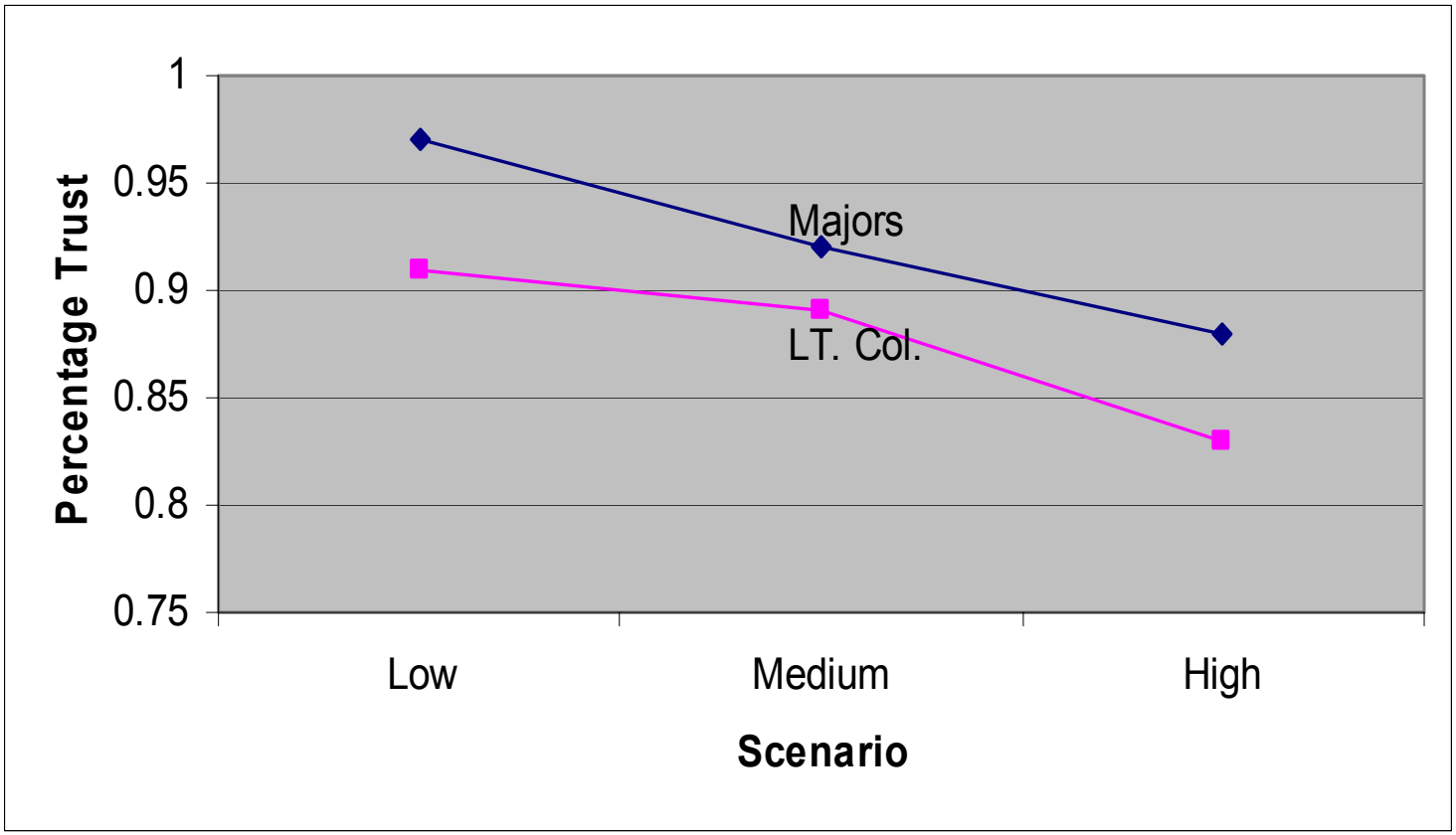
RESULTS

ACAD PERCEPTION AS A COA ASSISTANT: HIGH COMPLEXITY

Attribute	Expert Score	Novice Score
Information content/ management	0.64	0.83
Reliability of decision	0.56	0.87
Personal dependency of decision aids	0.35	0.65
Robustness of decision aid	0.62	0.81
Confidence on decision aids	0.72	0.89
Trust score	0.82	0.93

RESULTS

Expertise and Task Complexity affect trust on Decision Aid



CONCLUSIONS

- STUDY SEEKED TO ANSWER:
  - Does Decision Aid Help Commanders in COA Planning?
  - Do Expertise & Task Experience Affect Commander's Perception of Decision Aid Trust?
- FINDINGS:
  - 1. Decision Aids Support COA:
    - Time reduction (observed)
    - Judgment errors (observed, to be analyzed)
    - Real-time asset combination
    - Robust—"What if" & "What next"
    - Can generate multiple COAs

CONCLUSIONS

- STUDY SEEKED TO ANSWER:
  - Does Decision Aid Help Commanders in COA Planning?
  - Do Expertise & Task Experience Affect Commander's Perception of Decision Aid Trust?
- FINDINGS:
  - 2. Commanders with COA expertise and command experience consistently performed better than those with less expertise & experience:
    - Dependency on mental model
    - Comparative judgment (subject ACAD performance to rigorous field-value judgment)
    - Seek for information not known, or, if known, need

CONCLUSIONS

- STUDY SEEKED TO ANSWER:
  - Does Decision Aid Help Commanders in COA Planning?
  - Do Expertise & Task Experience Affect Commander's Perception of Decision Aid Trust?
- FINDINGS:
  - 3. Commanders with more experience tend to show conservative trust on ACAD while those with less command experience tend to show over reliance (more trust):
    - Look for estimates that "make sense"
    - Attrition factor watched with "passion"; need every asset and logistics to minimize attrition.

CONCLUSIONS

FURTHER STUDY:

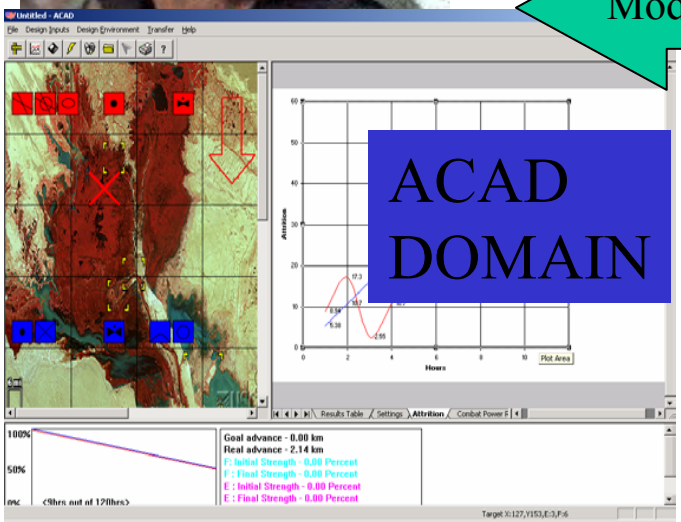
- Meta cognition study on what commanders really look for in in computer decision aids. It is not sufficient to simulate. How the result of simulation is used is important. May help to reduce the magnitude and scalability of simulation models

- More "Intelligent Interface" for the novice user. Avoid raising hopes. Allow the user to use "INQUIRY" methods within the interface to "EXPLORE" strategies.

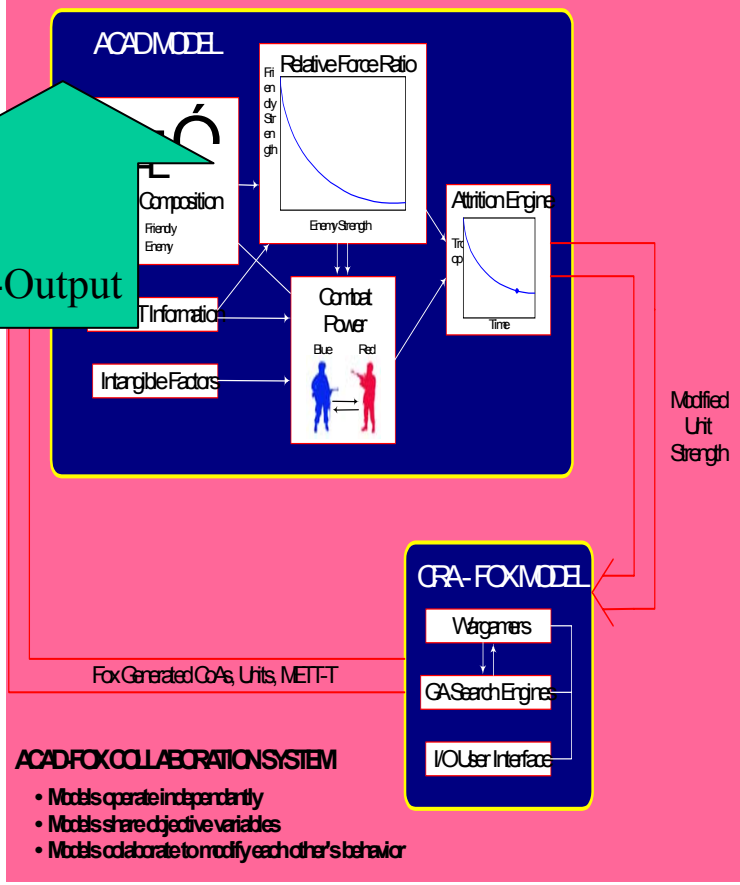
- Enhance Fuzzy data fusion in ACAD.

- Extend war game board to multiple objectives or area of interest. Current capability is one objective at a time.

ACAD-FOX COLLABORATION SYSTEM



Model Input-Output



ACAD-FOX COLLABORATION SYSTEM

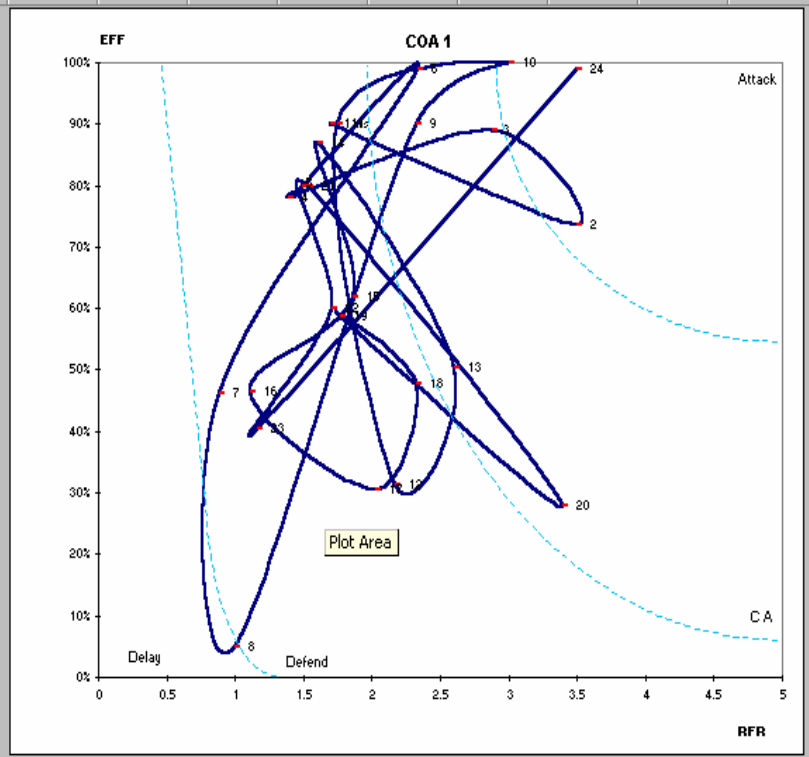
- Models operate independantly
- Models share objective variables
- Models collaborate to modify each other's behavior

Microsoft Excel - COAdata91.xls

File Edit View Insert Format Tools Data Window Help

	A	B	C
1	Time	COA 1	
2	hrs	RFR	Eff
3	1	1.70189	90%
4	2	3.5	74%
5	3	2.88	89%
6	4	1.39211	78%
7	5	1.4885	80%
8	6	2.33086	99%
9	7	0.88	46%
10	8	1	5%
11	9	2.33	90%
12	10	3	100%
13	11	1.75343	90%
14	12	2.17537	31%
15	13	2.6	50%
16	14	1.60811	87%
17	15	1.85993	62%
18	16	1.10969	46%
19	17	2.02986	30%
20	18	2.32871	48%
21	19	1.7698	59%
22	20	3.4	28%
23	21	1.52932	80%
24	22	1.71041	60%
25	23	1.1601	40%
26	24	3.5	99%

Update Random Number



View/Change data

Back to main

rerun