Calhoun: The NPS Institutional Archive

DSpace Repository

Faculty and Researchers   Faculty and Researchers' Publications

2018-06

The Use of Agent-Based Modeling and Data Farming for Planning System of Systems Tests in Joint Environments

McDonald, Marry; Upton, Stephen; Horne, Gary

Monterey, California: Naval Postgraduate School

McDonald, Mary, Stephen Upton, and Gary Horne. The use of agent-based modeling and data farming for planning system of systems tests in joint environments. NAVAL POSTGRADUATE SCHOOL MONTEREY CA DEPT OF OPERATIONS RESEARCH, 2008.
http://hdl.handle.net/10945/61900

The Use of Agent-Based Modeling and Data Farming for Planning System of Systems Tests in Joint Environments

Mary McDonald

Stephen Upton

Gary Horne

Operations Research Department

Naval Postgraduate School

Monterey, CA

S imulation
E xperiments &
E fficient
D esigns

Center for Data Farming

Naval Postgraduate School

http://harvest.nps.edu

**76th MORSS
June 2008**

SEED Center Mission: Advance the collaborative development and use of simulation experiments and efficient designs to provide decision makers with timely insights on complex systems and operations

Report Documentation Page

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 JUN 2008	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The Use of Agent-Based Modeling and Data Farming for Planning System of Systems Tests in Joint Environments	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Operations Research Department Naval Postgraduate School Monterey, CA	

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM202527. Military Operations Research Society Symposium (76th) Held in New London, Connecticut on June 10-12, 2008, The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**19**	

MORS
GOVERNMENT DISCLOSURE FORM

712B

MORS P#: (if known)

DEADLINE: 2 MAY 08
Fax to: 703-933-9066

PART I Author Request: The following information is required to be included in the proceedings or disclosed in the hard copy documentation of the results of the MORS Symposia and/or publication in the MORS's Final Report for inclusion on the MORS/CD or for posting on the MORS Web site.

Principal Author:
Mary McDonald

Other Author(s):
Gary Horne, Stephen Upton

Principal Author's Organization:
Naval Postgraduate School

Complete mailing address:
1411 Cunningham Rd
Monterey, CA 93943

X ~Mary McDonald~
Principal Author's Signature: ↑ Date: 3/25/2008

Phone: (703) 655-8234

FAX: (703) 590-8802

Email: mlmcdona@nps.edu

Title of Presentation:

The Use of Agent-Based Modeling and Data Farming for Planning System of Systems Tests

This presentation is believed to be: ☐ **SECRET** ☐ **CONFIDENTIAL** ☑ **UNCLASSIFIED** and will be presented in:

☐ Special Session ☐ Tutorial ☐ Demo ☐ CG: A–B–C–D–E–F (Circle one) ☑ List all WG(s) #: 31

PART II Government Releasing Official Endorsement and DoD Directive 5230.24 Required Applicable Distribution Statement.

The Releasing Official, with the understanding that MORS Symposia are supervised by the OCNO N81, that all attendees have current security clearances of at least SECRET and that no foreign nationals will be present confirms that the overall classification of the presentation is:

☐ SECRET ☐ CONFIDENTIAL ☑ UNCLASSIFIED ☐ OTHER: _____ and authorizes disclosure at the meeting.

Classified by: N/A   Declassified by: N/A

Downgrade to: N/A   On:

The applicable distribution statement below must be checked and stated to complete this form.

☒ **Distribution statement A:**

This presentation/paper is unclassified, approved for public release, distribution unlimited, and is exempt from U.S. export licensing and other export approvals under the International Traffic in Arms Regulations (22 CFR 120 et seq.)

☐ **Other distribution statement:** (List here or attach separate sheet)

N/A

Releasing Official's title: ASSISTANT SECURITY MANAGER

X ~Guillermo Costello~
Releasing Official's Signature: ↑

Printed name: GUILLERMO COSTELLO

Organization: NAVAL POSTGRADUATE SCHOOL

Date: 05 MAY 2008

Complete mailing address:
Security Manager Code 261
Naval Postgraduate School
1411 Cunningham Rd, Rm B-13
Monterey, CA 93943-5015

Phone: 831-656-2450

FAX: 831-656-2350

Agenda

- SEED Center and Philosophy

- Data Farming

- Support to Joint Test and Evaluation Methodology (JTEM)

- Agent Based Modeling

- "TheTester" ABM

SEED Center in a nutshell…

Enable rapid and efficient computational experimentation and analysis to be readily available to those informing decision makers
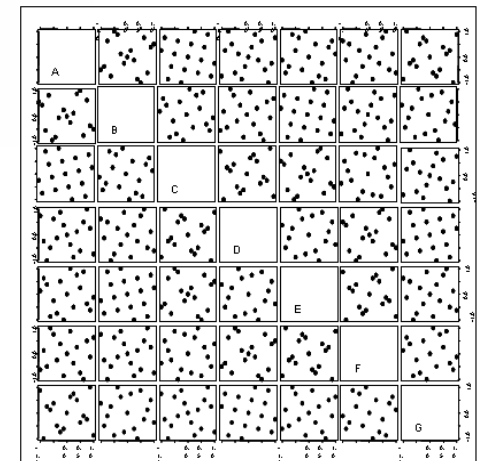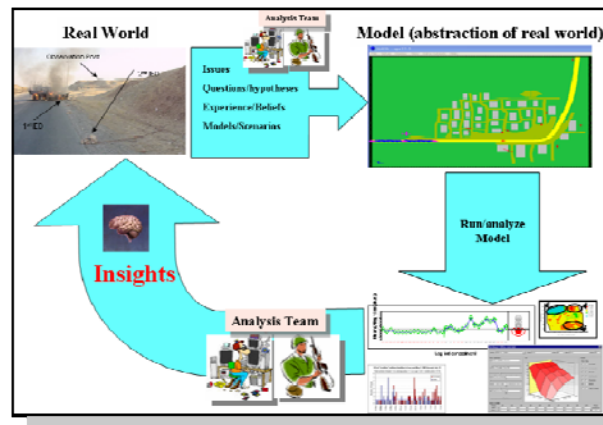

- **Harnessing Enabling Technologies**
  - High-performance computation
  - New Design of Experiments (DOE)
  - (Emerging) models
  - Data mining and visualization
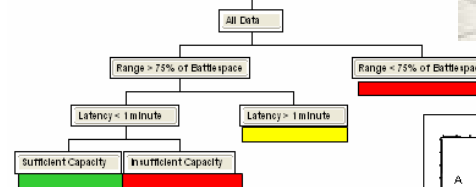
- **Revolution in analysis capabilities**
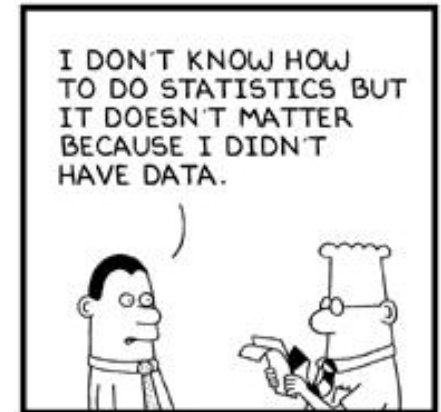 - Quick turnaround…
  - Address uncertainties
  - Robust solutions

Resources: SEED Center for Data Farming
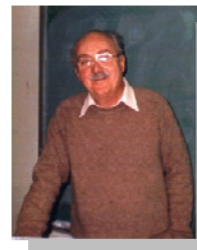
http://harvest.nps.edu

Check here for:

- lists of student theses (available online)

- spreadsheets & software

- pdf files for several of our publications, publication info for the rest

- links to other resources

- updates

All models are wrong, but some are useful—George Box

Data Farming: Iterative Loop of Loops

- **Data Farming Loop**

    - **Scenario/Model Building Loop**
        - Iterate model/simulation for experiment definition and analysis to support definition of hypothesis, and areas of interest

    - **Possibility Space Development Loop**
        - Iterate model/simulation using high-performance computing to refine analysis, study parameter sensitivity, drill-down into areas of interest, and confirmation or refutation of hypothesis
        - Data exploration, mining

and then

- **Adjust-Synthesize (another loop)**
    - **Adjust model/simulation with knowledge/ concepts/intuition from data farming… *Repeat***
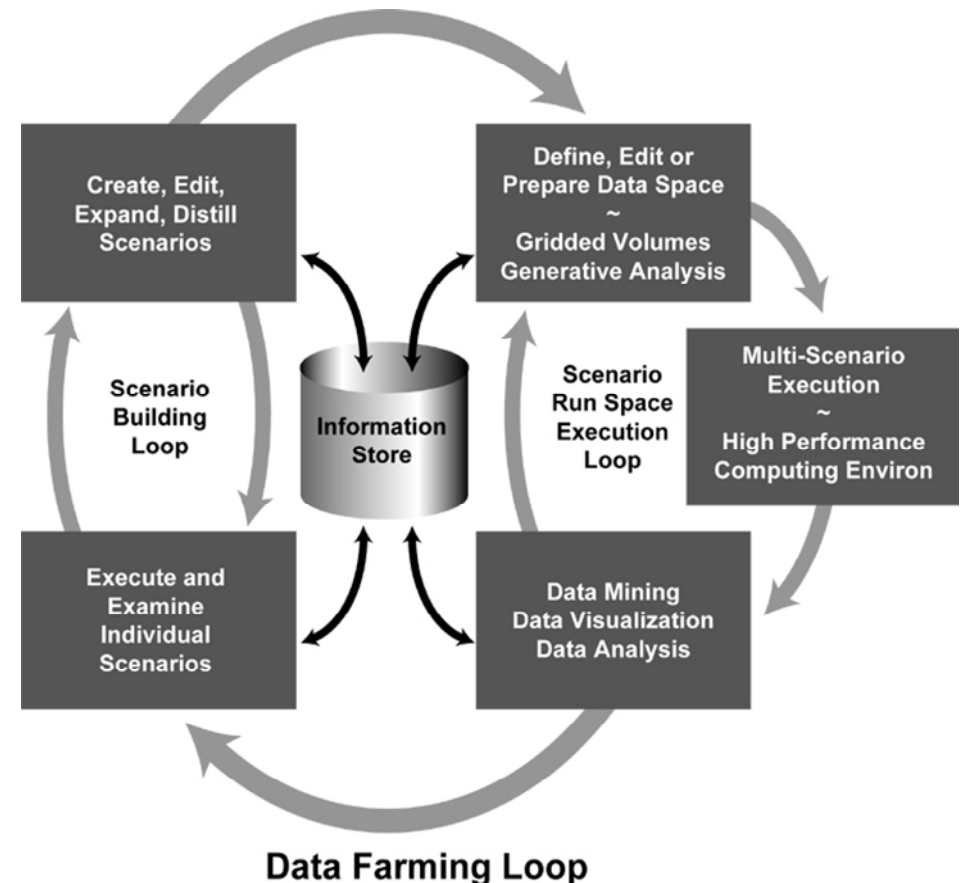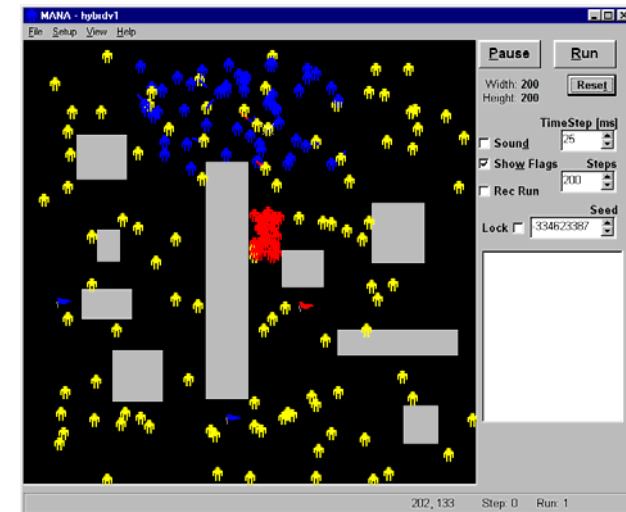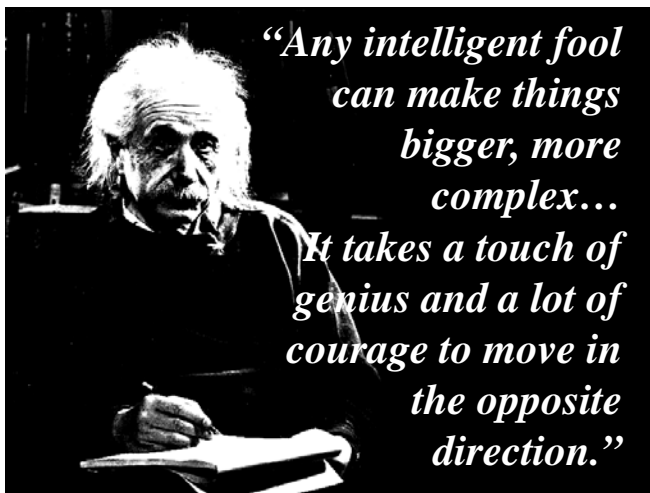
Support to Joint Test & Evaluation Methodology

- **Overall Objective:** Determine if analytical techniques employing agent-based models and data farming can be applied to the following areas
  - Helping to select a limited number of test vignettes for accomplishment in an actual L/V/C joint mission environment
  - Determining overall joint mission effectiveness
  - Establishing the relationship between system or system-of-system performance and joint mission effectiveness

- **Previous Effort:**
  - Tested other agent-based models for applicability
  - Ran computational experiments within the SEED Center's Data Farming environment
  - Developed custom-made agent-based modeling environment ("TheTester")

Agent Based Modeling (ABM)

- **What is an ABM?**
  - Composed of (usually) relatively simple discrete autonomous entities making decisions based on interactions with other agents and their local environment
  - Are characteristically intuitive, transparent, transportable, repeatable, and farmable
  - Have been useful in studying complex adaptive systems in a number of domains

- Several have been developed specifically for military domain (ISAAC, MANA, Pythagoras, SEAS)

- **Scenarios (usually) can be produced in a matter of hours/days vs weeks/months**

"Any intelligent fool can make things bigger, more complex… It takes a touch of genius and a lot of courage to move in the opposite direction."

"TheTester" ABM

- **Motivation:** To address some of the limitations encountered using more traditional agent-based models based on reactive agents, while retaining their strengths in farmability, ease of use, and fast run times

- **Primary Design Goal:** Focus on Systems of Systems testing, initially modeling one aspect (Joint Fires) of the C2 Joint Capability Area (JCA)

"TheTester": Model structure

- Is written in JAVA, and uses the MASON multi-agent simulation toolkit for its underlying simulation infrastructure www.cs.gmu.edu/~eclab/projects/mason/

- Time-stepped

- Continuous 3D space, flat terrain

- Uses XML for input - working on an Automated Scenario Generator

- Selectable MOEs (CSV output)

- 3D visualization with probes

"TheTester": Other Design Goals

- ## Composable

  allows users to build up or construct agents using software components specific to the domain

- ## Extensible

  allows users to develop their own software components to extend functionality provided by the basic framework

- ## Farmable

  ☐enhances computational experiments with the model by allowing users to easily vary input parameters associated with the agents

- ## Fast-running

  analyses could be completed within a reasonably short period of time, commensurate with our experience with other agent-based models used for similar purposes

Agent Decision Making

- Each Agent has OODA loop

- "Observe" - depends on whether Agent has Effector for sensing

- Orient
  - Process Comm messages
  - Update Perceptions from other Perceivers

- Decide
  - Agent Decision Making is based on Deciders: these are composable object structures that base decisions on Perceptions - SimpleRuleBaseDecider currently implemented. Different agents can have different Deciders. SimpleRuleBaseDecider has a set of Rules that are a conjunction of Clauses (Perception Condition Value), with Actions as consequents
  - E.g., If NewEnemyDeteteced then SendMessageASR

- Act
  - Each Agent has a set of Actions that it can accomplish (based on what Effectors can do)

"TheTester": Agent structure
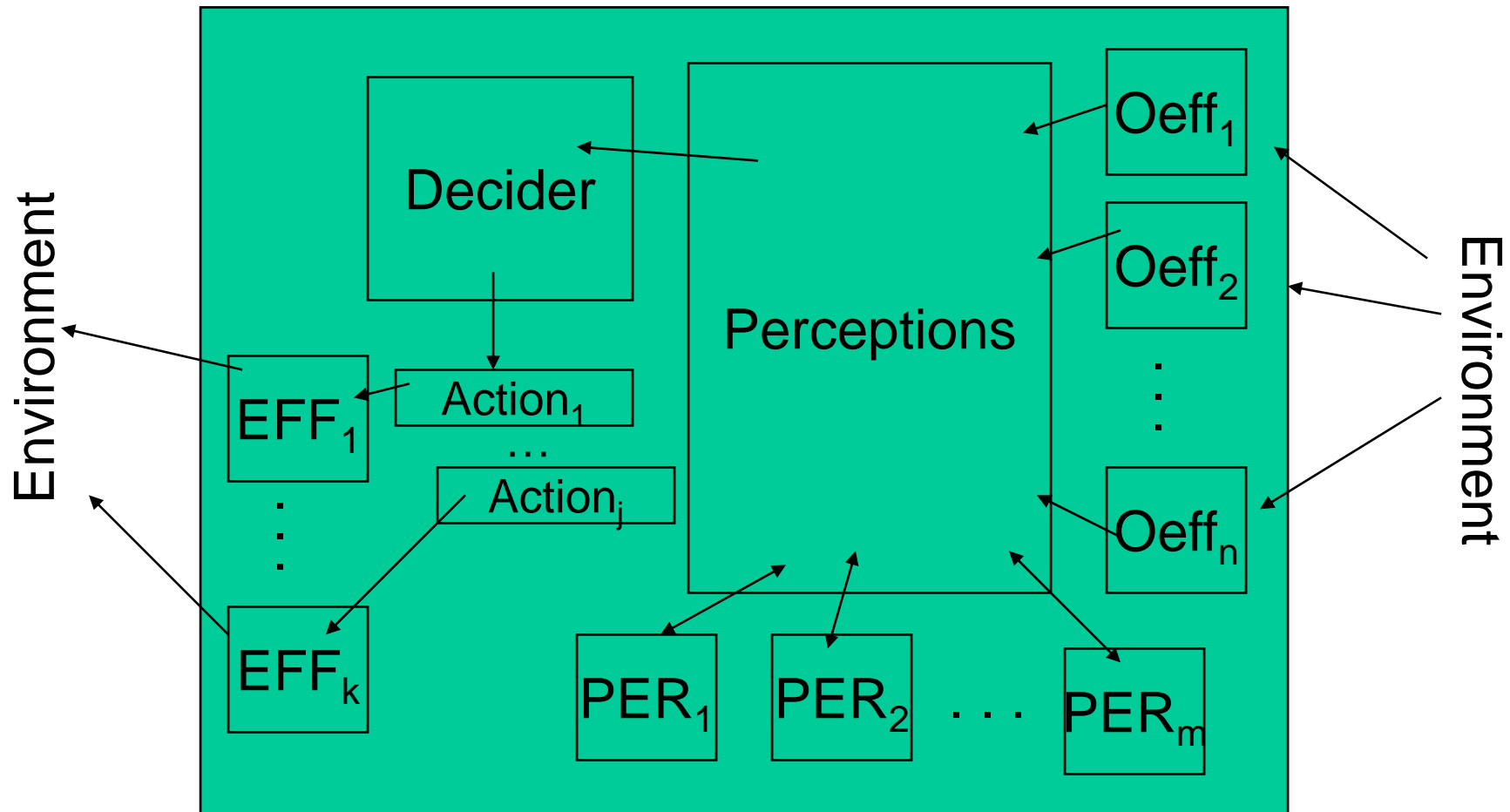
Examples (Implemented So Far)

- ## Observe-type Effectors
  - CookieCutterSensor

- ## Perceivers
  - SimpleThreatPerceiver
  - BasicMessageProcessor
  - MessageSentTracker
  - MemoryContactFilter

- ## Other Effector types
  - MoveAlongWaypoints
  - AgentCarrier / AgentCarried
  - BasicMessageSender
  - SingleMissionEffector
  - MultipleMissionEffector
  - FiresMissionTasker
  - BasicIndirectWeapon

Examples (cont.)

- Perceptions (concepts an agent "knows about")
  - AgentPercept
  - LocationPercept
  - MessagePercept
  - Observation
  - RestrictedOperatingZone
  - SimplePercept
  - TargetPercept

- Deciders (used to choose an action, based on the current state of perceptions)
  - SimpleMoveDecider
  - RuleBaseDecider

Comm modeling

- CommLinks
  - Explicit communication links specified in input file
  - Reliability for the link
  - Range for the link

- MessageData – for each message class
  - messageClass for each message
  - probUnderstood
  - inProcessTime, inProcessTimeOffset
  - outProcessTime, outProcessTimeOffset
  - probability distribution used for times

- MessageHandlers - for inserting and extracting content

- Implemented Message Handlers
  - CallForFireMessageHandler
  - FiresMissionMessageHandler
  - GoToRequestMessageHandler
  - ThreatLocationMessageHandler

FY07 Scenario Comm Matrix

	RSTA	BNFSE	BDEFSE	CAOC/JAOC	ASOC	AWACS	FIRE BN FSE	NLOS/FSPM	JSTARS	JTAC	CAS_AIRCRAFT	MEW
RSTA		CFF										
BNFSE			RELAY-CFF									
BDEFSE				ACMREQ1; RFZ	ACMREQ1-COPY ACMREQ2; RFZ		FIREMISSION					
CAOC/JAOC			RELAY-ACMR APPROVAL		ACMREQ1-APPR COPY; ACMREQ APPROVAL	ACMREQ1-COORD				ACMREQ2 APPROVA		
ASOC			ACMREQ2-COORD			ASR-APPROVAL TASKING				ASR-APPRO TASKING		
AWACS				ACMREQ1-APPROVAL							CASMISSION	
FIRE BN FSE								RELAY-FIREMISS				
NLOS/FSPM	SHOT-CONFIRM	SHOT-CONFIRM	SHOT-CONFIRM				SHOT-CONFIRM					
JSTARS										THREATLOC		
JTAC			ASR								9LINE-ORDER	RETARGET-ORDER
CAS_AIRCRAFT									ONSTATION WPN-COOR TRANSFER		THREATLOC LAUNCHORD HANDOFF ORDER

Short Term Future Work on "TheTester" Will Include …

- Expert System / Fuzzy Logic Decider (JESS, Fuzzy JESS)

- Move to a Discrete Event Framework

- GUI / Automated Scenario Generator

QUESTIONS?