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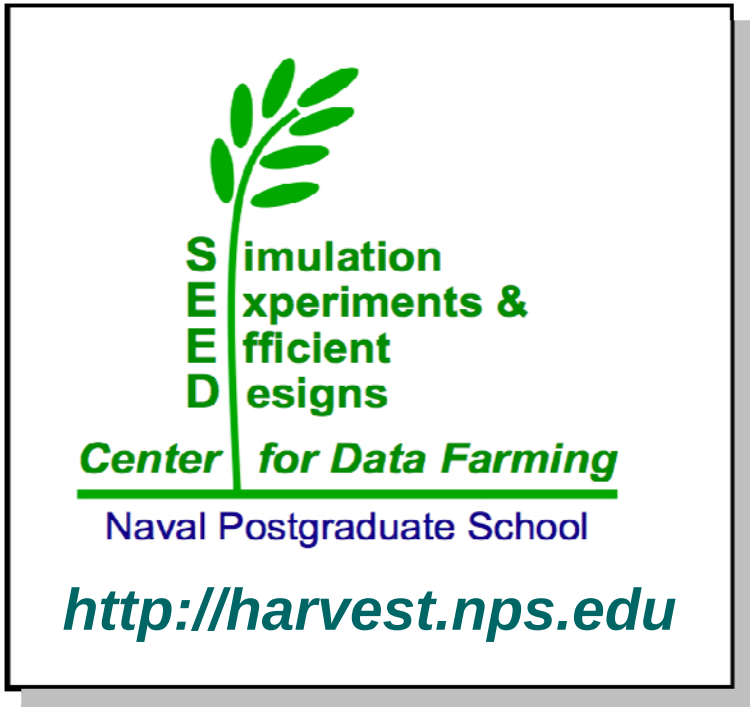

76th MORSS
June 2008

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

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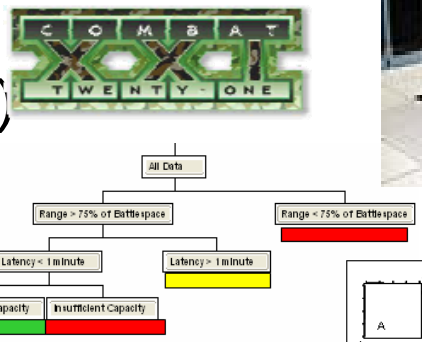
Agenda

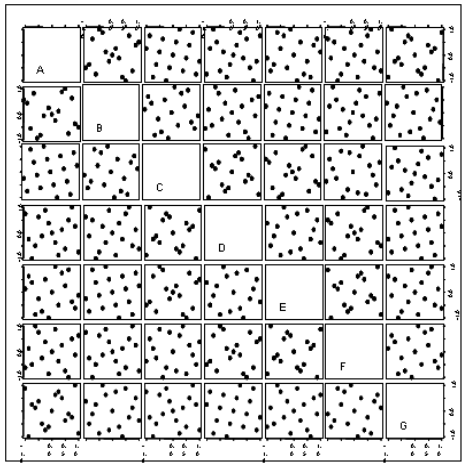
- SEED Center and Philosophy
- Data Farming
- Support to Joint Test and Evaluation Methodology (JTEM)
- Agent Based Modeling
- “TheTester” ABM

SEED Center in a nutshell…

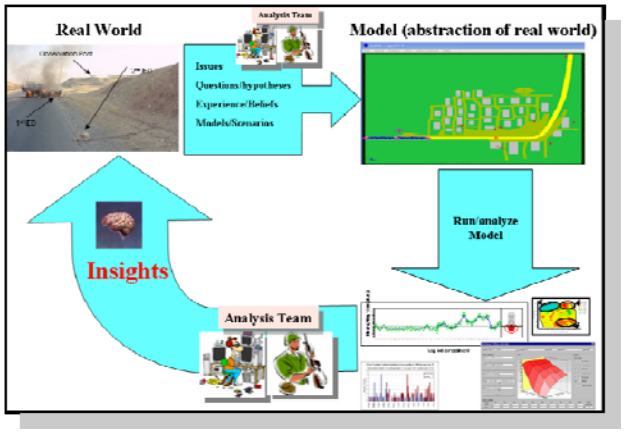
Enable rapid and efficient computational experimentation and analysis to be readily available to those informing decision makers

- **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



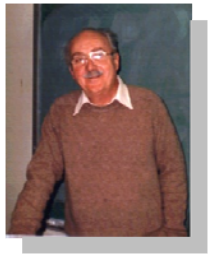
Resources: SEED Center for Data Farming

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



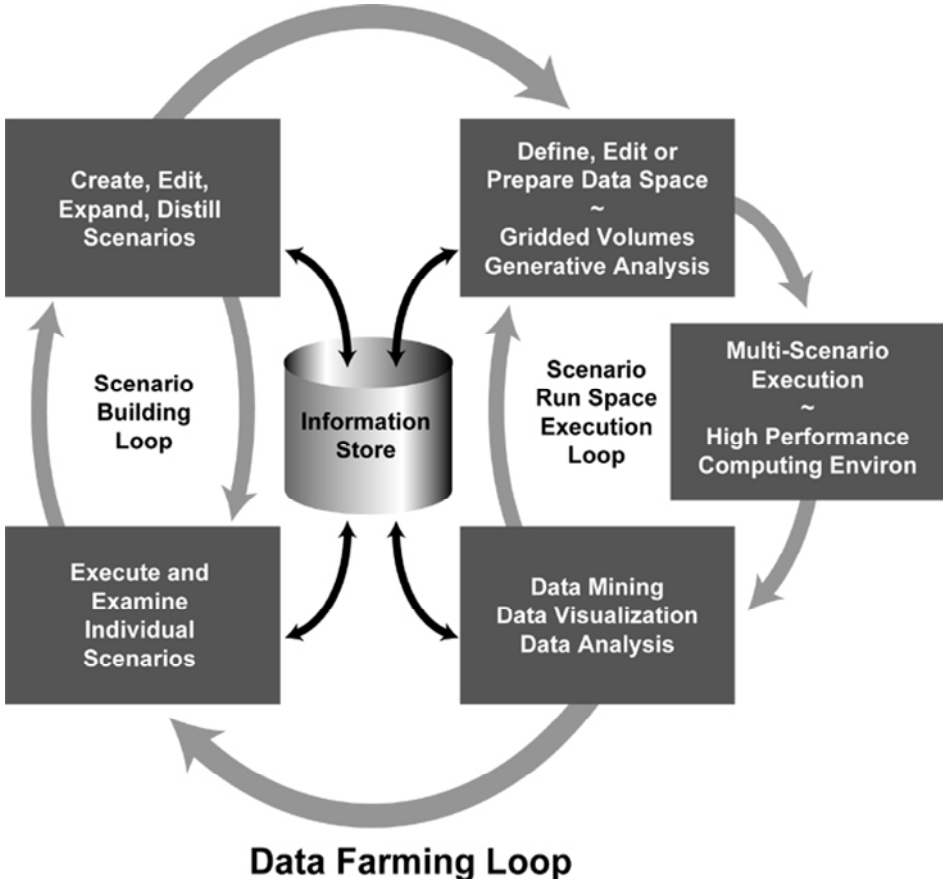
Simulation Experiments & Efficient Designs
Center for Data Farming
Naval Postgraduate School

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***

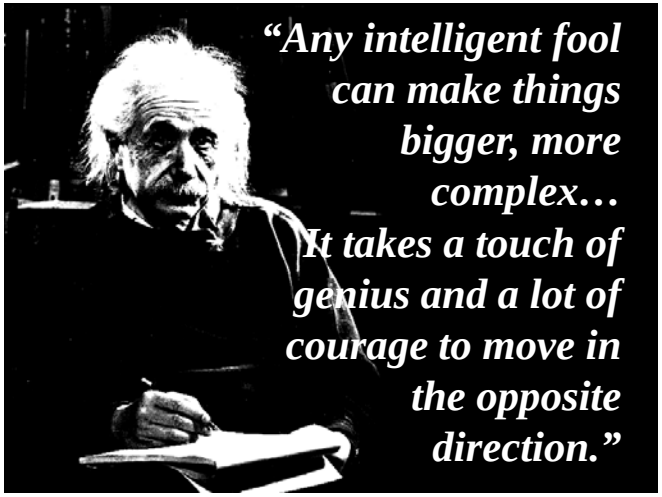


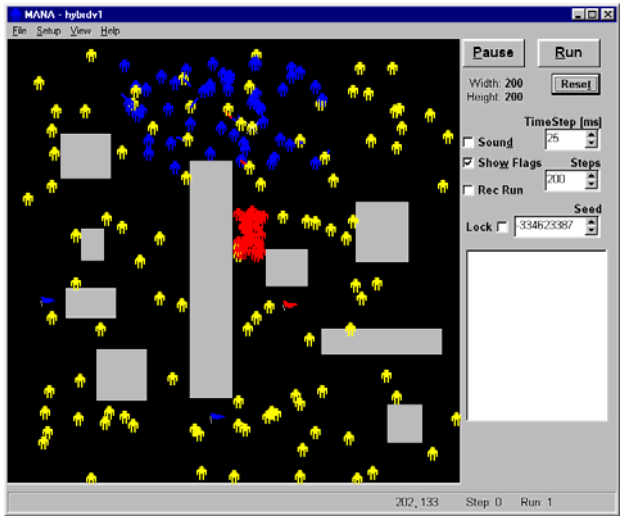
Support to Joint Test & Evaluation Methodology

- **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**





“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

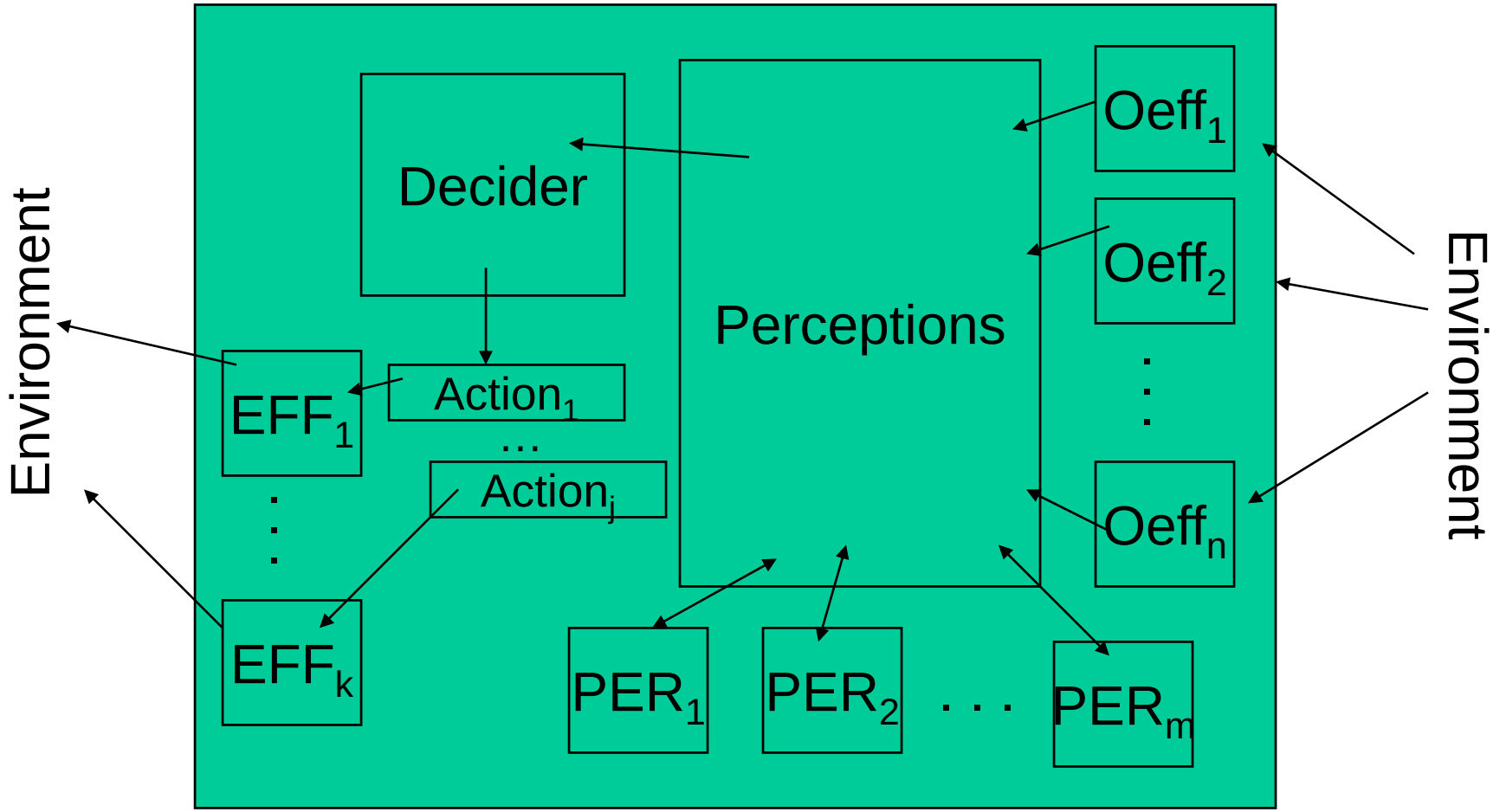
- Fast-running

  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	NEW
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?