Analytic Rigor *User Requirements*

Modeling Complex Warfare (MCW) in Both Simulation & Wargaming

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Briefing Abstract

In 2010, as JFCOM was being disestablished, the J9 Division, Experimentation, Joint Exercises, and Analytical Wargaming was using the Joint Analysis System (JAS) model to create future environments that could be modeled in full scale simulation similar to Strategic Scenarios. JAS was the follow-on to the Congressionally mandated and funded JWARS program to build a joint global model that represented all the warfare domains including space, as well as explicit C4ISR, integrated logistics and global transportation functionality.

JAS operates on explicit information flows on networks among its agents. Those agent transmissions are also human-readable, and JAS generates sensor information that can be displayed as a Common Operational Picture (COP). Because of this, JFCOM (J9) was able to modify the simulation to pause the model and allow human participants to take the place of selected computer agents. The humans could then read the status messages, see the sensor-based, but typically less than complete and timely, COP, and then make their decisions under uncertainty before letting the JAS simulation proceed at high speed.

JAS simulated several Complex Warfare topics, not found in other campaign models. For example, it could simulate both pre- and post-war non-combat operations, conduct limited engagements without automatically starting whole-scale war, allow for truces between the sides, support the representation of more than two sides, represent human soft factors such as training and morale, and portray civilians in the battlespace who could be influenced by information warfare.

JAS was used by government organizations and government-sponsored industry, FFRDCs, and academia. OSD/CAPE used it to simulate Multi-Domain environments of three Strategic Scenarios in a single model and for some non-traditional scenarios. In 2011 CAPE withdrew from campaign modeling and, as the original developer of JAS, called in the model and archived it. However, it is still available from CAPE for approved users.

My Thoughts on Modeling Complex Warfare

- The U.S. has been involved in real world Complex Warfare for a long time,
- And it is far more than our current campaign models address, e.g.
  - Competition without engagement (Demonstrations, Blockades, Search & Seizures)
  - Engagement without kinetics, e.g. cyber, EW, Info Ops, coercion, etc.
  - Engagement without automatic escalation, e.g. controlled violence
  - Proxy wars with U.S. support (lethal weapons and/or non-lethal support, e.g. ISR)
  - Engagement with escalation to WMD with some level of use on a proxy or Ally
  - Temporary truces, surprise and panic, surrender of units, and side-switching by units
  - Decisions based on sensor-driven perceptions carried by possibly degraded/disrupted comms and requiring those decisions to be made under varying Degrees of Uncertainty.

Joint Pub 5.0 – The Operational Environment

- JCS Pub 5-0 has no definition of Multi-Domain or Complex Operations but does have an example of the Operational Environment (OE), comprised of: Land, Air, Maritime, Space, Cyberspace **and just about everything else.**
  - This implies that the Services are responsible for defining their roles in MDO and,
  - Using the Cycle of Research to test if its parts can support the entire spectrum of DOTMLPFS improvements to ensure our military prevails (in conjunction with Allies).

So what is this Cycle of Research?

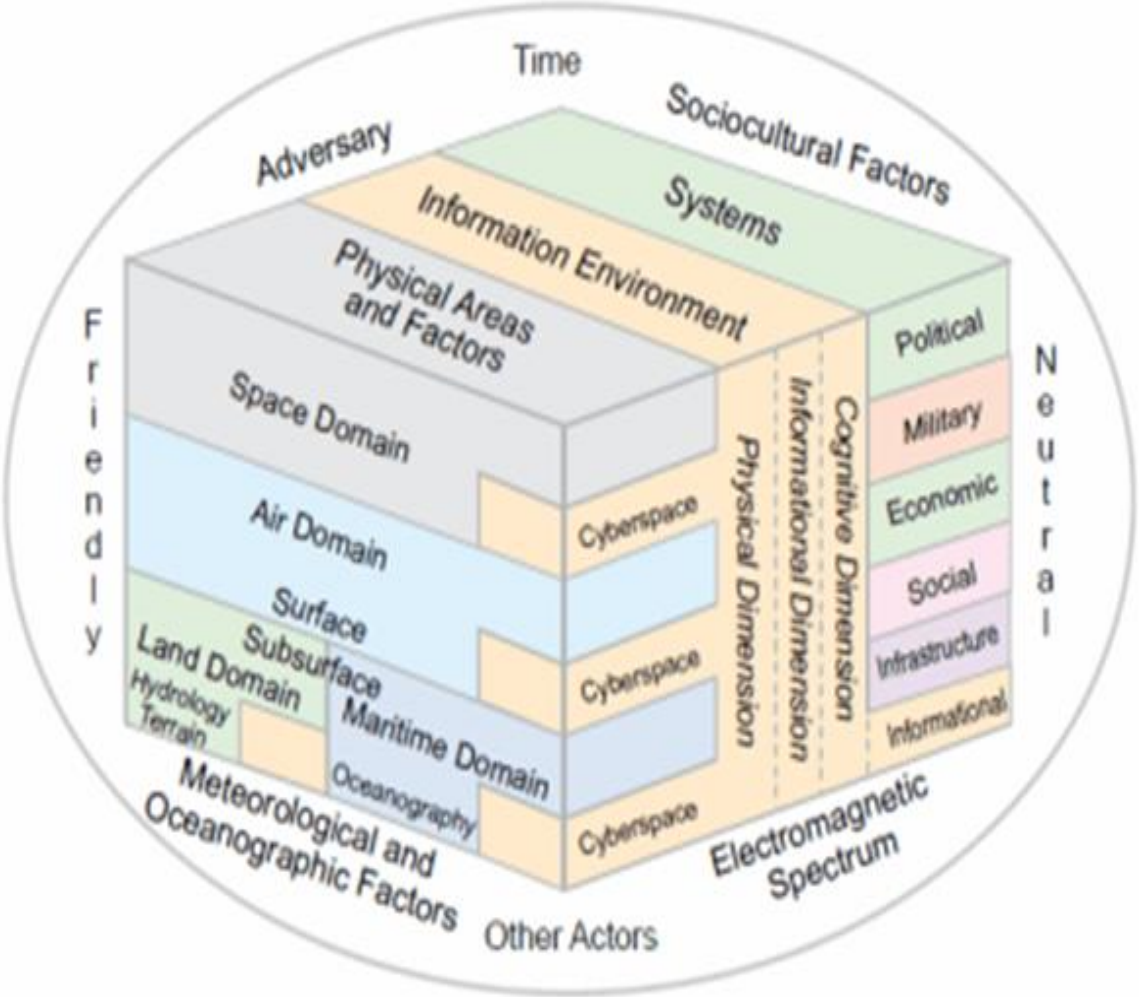
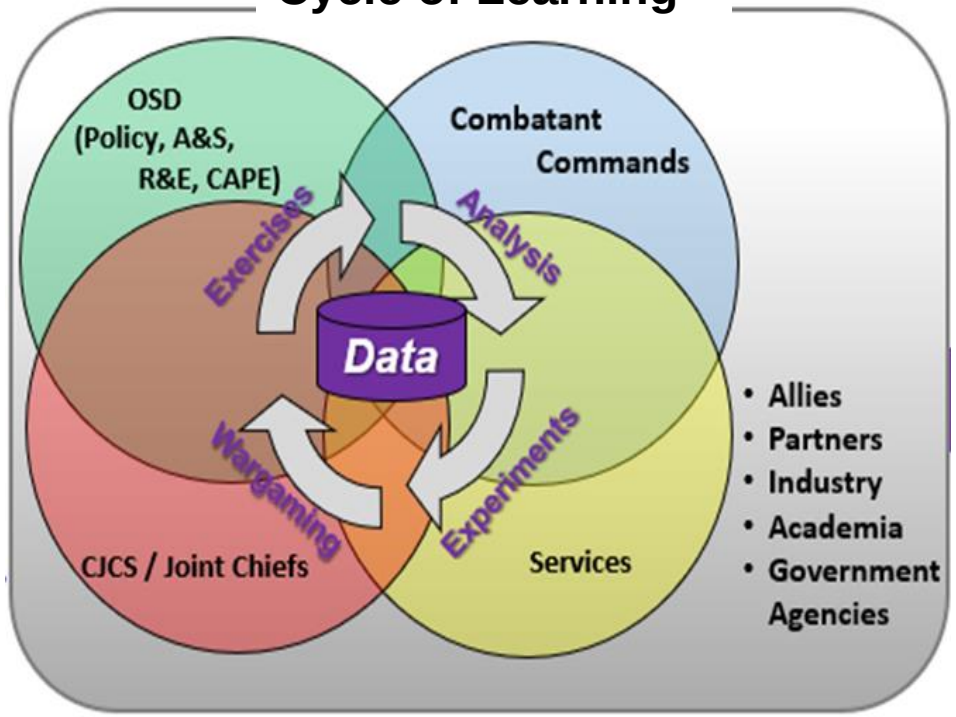


Figure IV-5 Holistic View of the Operational Environment

Cycle of Research/Learning

- "The Cycle of Research is an iterative application of the principal tools the military uses to explore, understand, and prepare for future conflict."
  - The elements of the cycle include systems and operations analysis, wargames, exercises, and assessment of real-world experience and history. **Used in concert, as shown in the Figure to the right**
- The results would effectively link new capabilities and concepts to [forces] ready to respond to threats and opportunities and prepared to adapt/exploit surprise.

Cycle of Learning



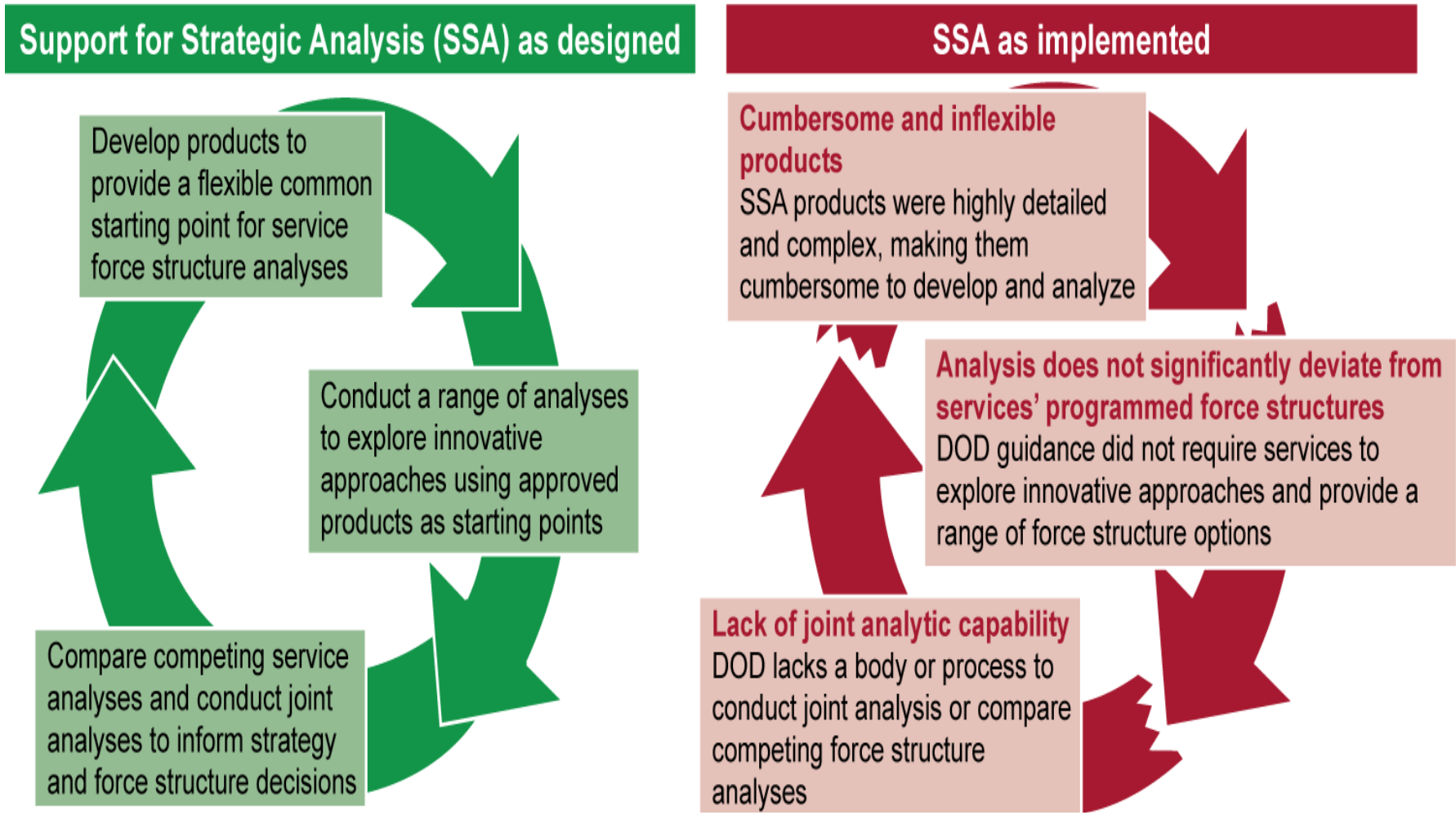
Charles W. "Bill" Robinson
Joint Integrated Learning Branch
Joint Wargaming and Experimentation Div.
Joint Force Development and Design Center
Joint Staff (Suffolk) J-7 - 2020 Slide for MORS Complex Warfare Workshop, WG6

***Phil Pournelle, "Preparing for War, Keeping the Peace" US Naval Institute 2014**

So, Let's Look at Simulation as Part of the Cycle

In its 2019 Report, GAO found that [models] have been hindered by three interrelated challenges:

- **[Campaign] Products are cumbersome and inflexible.**
- **Force Analysis does not significantly deviate from Services' programmed force structures or test key assumptions.**
- **DOD lacks joint analytic capabilities to assess [joint] force structure.**



Source: GAO analysis of the Department of Defense (DOD) documents and interviews with officials. | GAO 19-385)

Analytic Rigor *User Requirements*

Assessing Our Analytical Sims Representing Maneuver

In 2014 and 2015 Rand conducted a series of unclassified wargames that examined the probable outcome of a Russian invasion of the Baltic states.

Rand developed [a] map-based, tabletop exercise for the wargames **because existing models were ill-suited to represent the many unknowns and uncertainties surrounding a conventional military campaign in the Baltics.**

BTG and Armored Brigade Combat Team (ABCT) Comparison

	U.S. ABCT	Russian BTG	Advantage
Tank Company	4	1	United States
Mechanized Infantry Company	3	3	–
Anti-armor Company	0	1	Russia
Field Artillery Battery	0	2	Russia
Rocket Battery	0	1	Russia
Air Defense Battery	0	2	Russia

Fox and Rostow. The Land Warfare Papers No. 112, March 2017, The Institute of Land Warfare, AUSA

[In this conflict] maneuver between dispersed forces would likely be the dominant mode of combat — rather than pushing and shoving between opposing units arrayed along a linear front

But There Is Another Campaign Model

Legend	
Campaign	C
Mission	M
Engagement	E

The Joint Analysis System (JAS) (JWARS renamed) emphasizes C4ISR, maneuver, & the balanced representation of all military Services, allies, neutrals, and opponents.

JAS was part of the OSD Strategic Analysis M&S Tool Kit up until early 2011, when it was recalled from all users and archived at OSD/CAPE JDS.

Strategic Analysis M&S Toolkit Tool Classification

Tool	Planning			Traditional Force-on-Force			C4ISR			Mobility and Logistics			WMD		Non - Traditional		
	Adaptive Planning	Effects Based	Force Allocation	Air Power	Ground	Maritime	C2	COMM	ISR	Logistics	Inter-Theater	Intra-Theater	Missile Defense	CBRN	Special Operations	Behavior	Consequence Mgmt
Core Analysis Tools																	
AB Tools																	
AMP/ELIST										C		C					
AMP/MIDAS										C	C						
COSMOS							M	M	M								
EADSIM				M			M	M	M				M				
HPAC														E			
ITEM				C	C	C			C		C	C	C	C			
JAS		C		C	C	C	C	C	C	C	C	C	C	C	C	C	
JCATS	M				M										M		
JICM				C	C	C			C	C	C	C	C	C			
PYTHAGORAS			E												E		
STORM	C		C	C	C	C			C	C							

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And Despite What You May Have Heard about JWARS/JAS

Extract from message, "Closure of the JAS Support Office," January 2011

"Due to budgetary pressures, OSD/CAPE has decided to close the JAS Support Office and is currently in the process of moving JAS into archive status.

"Over the past five years, the Simulation and Analysis Center has used JAS as one of its Strategic campaign tools in numerous key Departmental studies and has been very satisfied with the results it provides, its functional robustness, and the agility and usability of the model."

/Signed/

John Borsi, Managing Director, OSD/CAPE SAC, January 2011

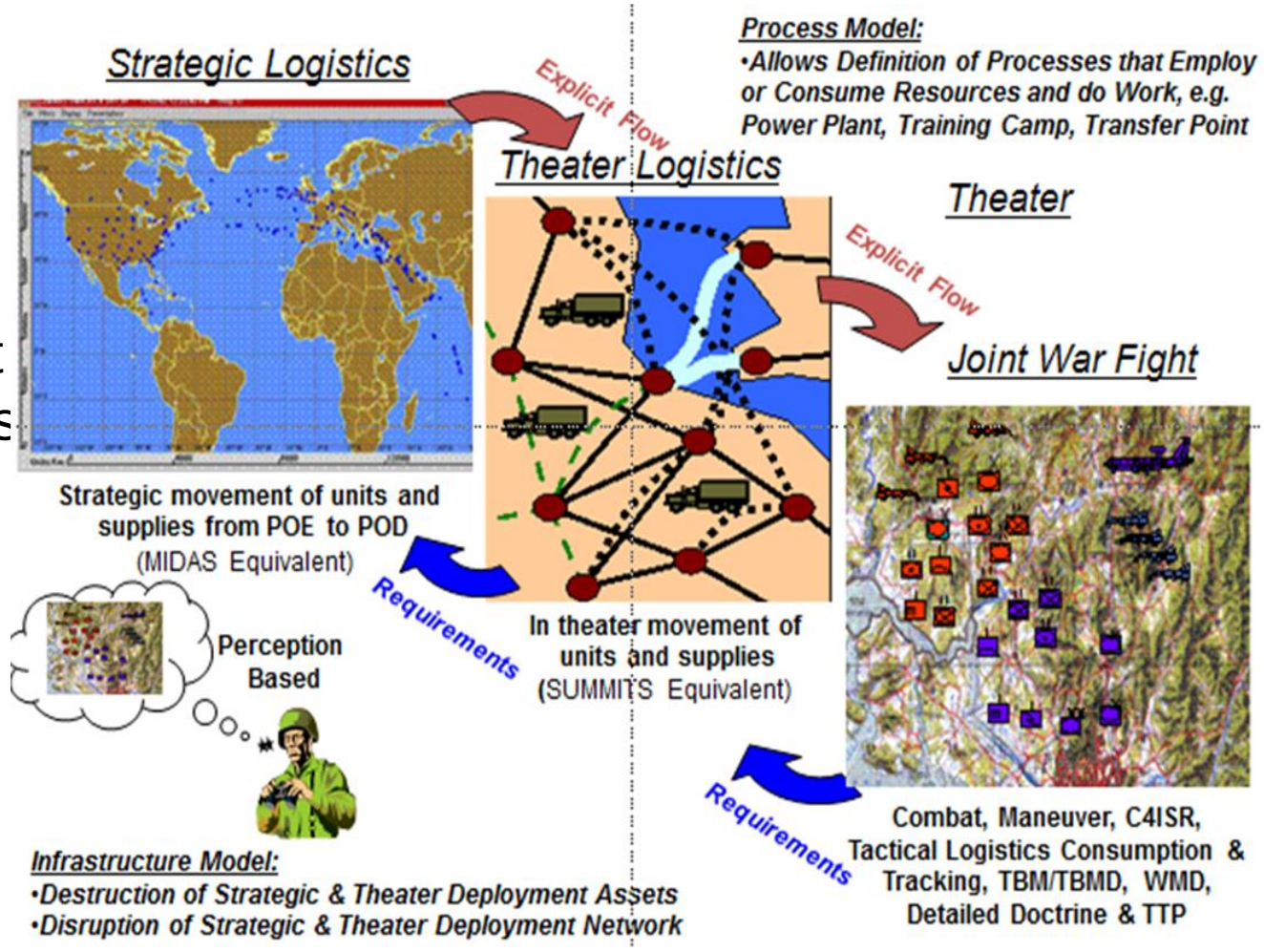
Agent-Based, Event-Stepped, Data-Driven

JAS is a global fully-integrated “single engine” simulation incorporating many internal sub-models from planning to adjudication.

It employs rule-based agents, steps from event to event (not time-stepped), allows easy access to its data, and is stochastic for most functions.

It simulates air, land, maritime, space, and C4ISR including EW & deception. Logistics & Transportation, human soft factors, civilians, TBM/TBMD, and WMD are all fully integrated.

JAS decisions are based on perceptions!



Advantages of the JAS Model

Full MDO and Considerable MCW Functionality in a Single Set of Software

- Complete multi-domain joint/coalition scope with flexible coupling of interactions
- Fire/Maneuver oriented with amphibious & airborne assaults. Can mix large & small units
- C4ISR and communications based. Decisions based on ISR-driven perceptions
- Integrated theater transportation & logistics. Executes an "at risk" supplied TPFDD
- Plays TBMs, TBMD, and WMD (in the context of current weather/operations)
- ***Simulated three different Strategic Scenarios with a single model***

Significantly Reduces Support Requirements

- Reduced Support Staff vs using multiple models.
- All users have direct access to JAS data, and JAS tracks and records each change
- Once developed, JAS scenarios can be saved, reloaded, and modified. The scenarios were distributed on-line or on CDs allowing all users to load new scenarios in minutes
- JAS software updates distributed with "Transform" for automatic scenario updates

Modeling Complex Warfare in JAS

JAS has demonstrated simulating:

- Intel Collection prior to war (I&W) & Proxy warfare with only U.S. Intel support
- Training proxy fighters with SME estimates of unit improvements based on length of training and impacts from providing them better ISR/comm equipment
- Commanders/Leaders with personality traits, e.g. lack of concern for losses
- Civilians in the battlespace
- Humanitarian Assistance/Disaster Response (HA/DR) and protecting civilian infrastructure, e.g. Power Plants, Water Treatment, Fuel Distribution, etc.
- Noncombatant Evacuation Operations (NEO) within a Strategic Scenario
- Defense against EMP, Chemical, and Biological attacks (DTRA sponsored)

JAS as a Simulation-Supported Wargame

JFCOM J9 Acceptance Requirement: Support a major simulation-supported wargame with emphasis on Seabasing and Shore to Objective Maneuver (STOM) 2006

In its wargame mode, JAS supports: "Pause, Modify, Resume," which allows players to:

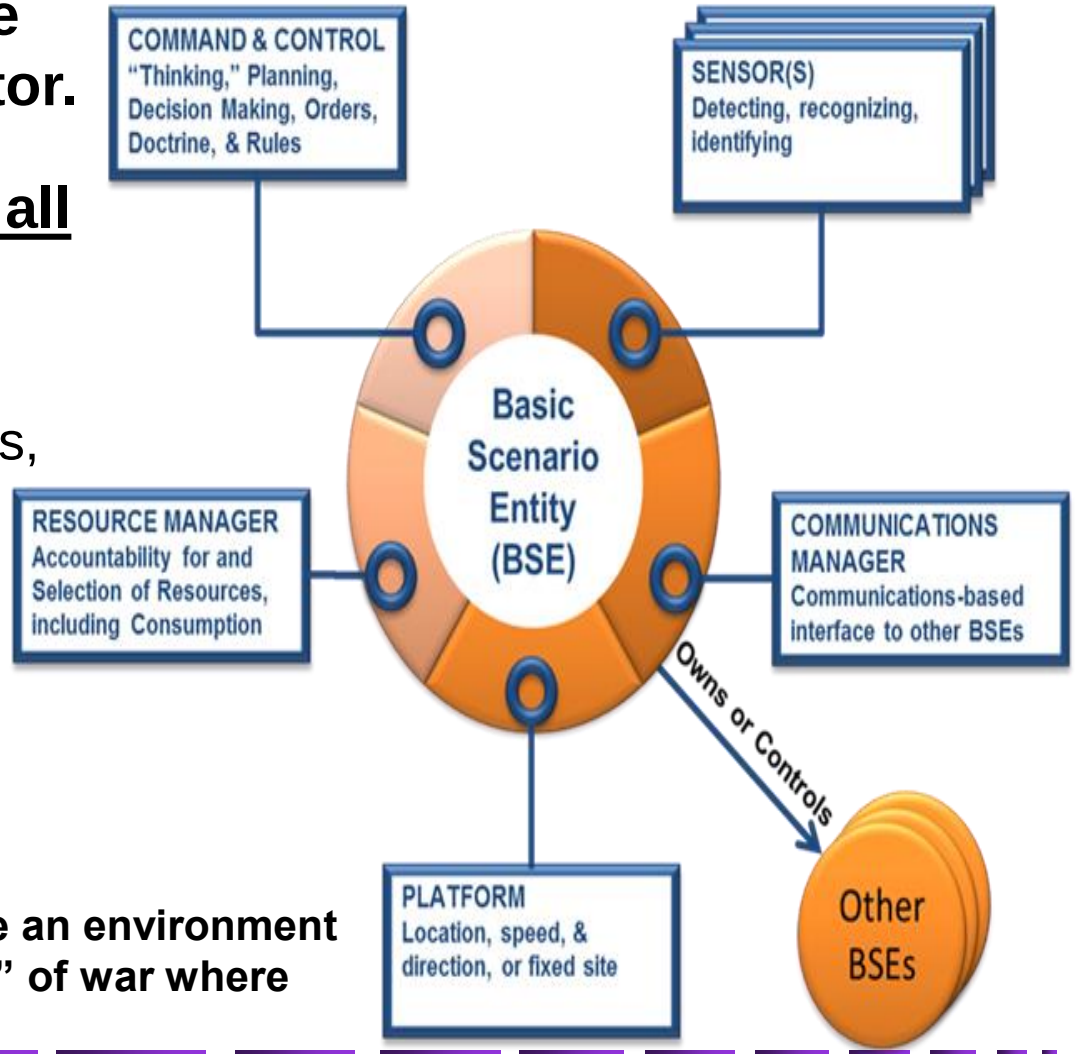
- **Review JAS-generated status reports** including Blue casualties and perceived Red casualties
- **Review a map of Blue/Red/Green/Gray locations** on a perception-based Common Operational Picture (COP)
- **Input new orders and change priorities, rules, etc.** either directly or through a White Force Controller

The same explicit messages and the COP used to inform the perceptions of the intelligent agents are also used for the humans (metadata is the same)

C4ISR with Explicit Information Transfers

JAS C2 Agents all have five basic capabilities. Some have specific knowledge, e.g. fire support coordinator.

- **<u>Explicit simulated communications networks link all "thinking" units/players</u> (agents and/or human)**
  - Easy to modify connections, e.g. between domains
  - Internal message flows (orders, requests, status reports, etc.) and are disruptable by both kinetic and nonkinetic means
- Subordinate agents respond automatically to orders for movement, combat, calls for fires, logistics requests, etc.
- Agents can be assigned Specialized Knowledge Bases



Former DepSecDef Work stated that "The best wargames seek to create an environment for applying critical reasoning techniques under the "fog" and "friction" of war where incomplete and imperfect knowledge prevails."

Advantages of Using the JAS Wargame Mode

- Attrition is computed for specific weapons/munitions, day/night, moving/stationary, protection measures, **AND** "human soft factors" (training, leadership, morale, etc.)
  - *Poor Soft Factors have impacts: shoot worse, lower breakpoints, slower operations, etc.*
  - All weapon-victim outcomes are recorded and reported in detail in a Killer-Victim spreadsheet
- Humans input orders, target priorities, etc. and then subordinate agents maneuver units, task sensors, and direct fire. Agents conduct combat, delays, ambushes…
  - An order to move a Brigade will move all subordinate units in a user-designated or unit self-selected formation
- Enemy action both kinetic and non-kinetic can cause loss, degradation, or delay of information, the loss of which can affect decision-making in both speed & accuracy
  - Cyber effects can be assessed in the context of all other C3 attacks/disruptions (EW, Deception, Kinetic Attack)
- Both Agent and Human Decisions are based on "perception" not ground truth.
  - But ground truth is also recorded for later comparison.

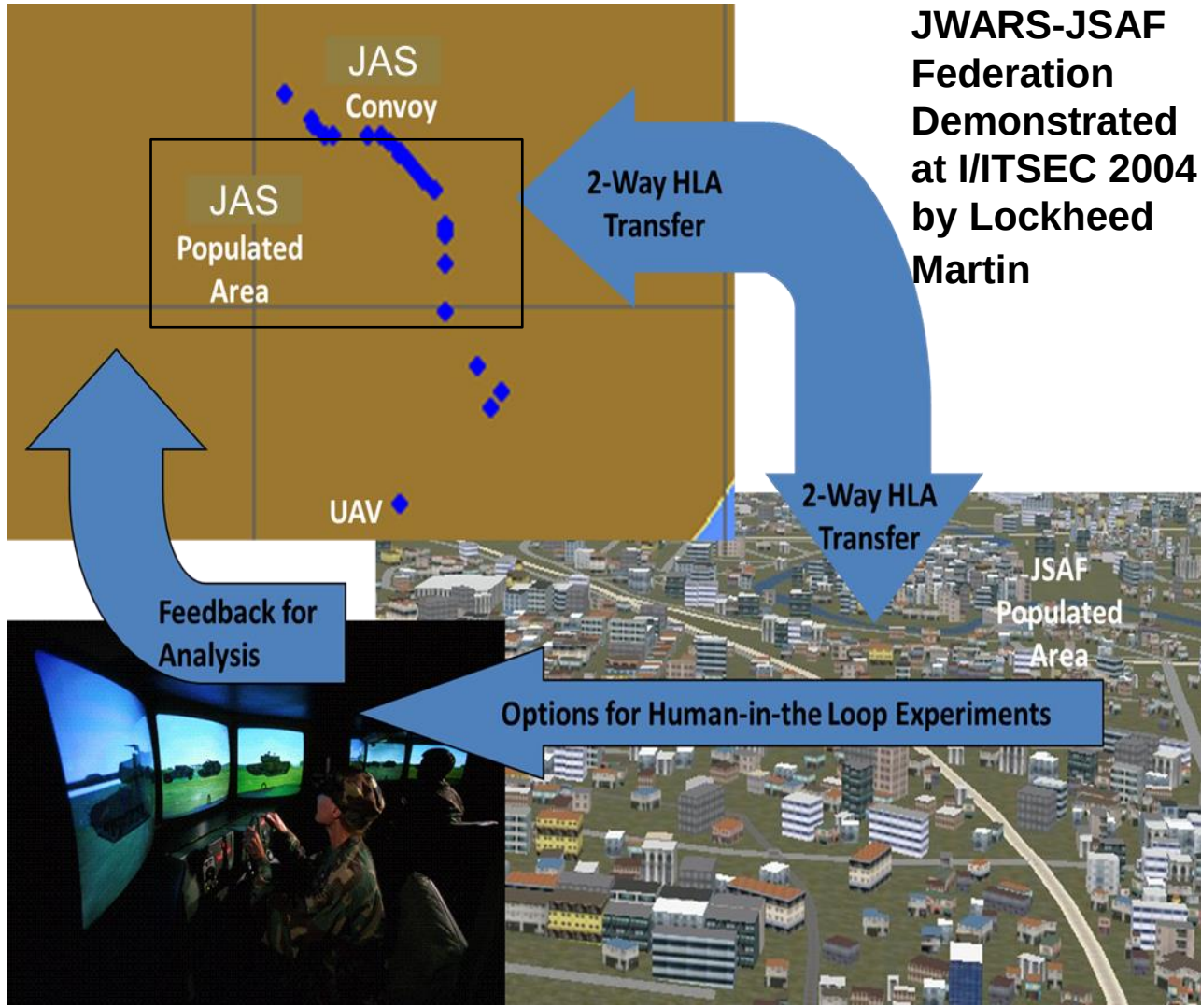
JAS Multi-Tool Analytic Options

- Because it collects all wargame data in the same format as its sim data, **JAS can rerun a wargame as a simulation and vice versa**. This provides the opportunity to conduct cycles of Wargame-Simulation-Wargame-Simulation. It also offers the opportunity to rapidly repeat wargames with new players, new decisions, new conditions, or even run multiple wargames at once.
- By using the same scenario in both analytical wargames and campaign simulations there is opportunity for generating more coordination between the two communities and the exchange of capabilities, e.g.
  - Automated Attrition and Movement from simulation to wargaming
  - Wargame provides doctrinal/TTP innovations and input to simulating human Soft Factors (training, morale, leadership, etc.) with SME validated effects on marksmanship, speed of movement suppression, breakpoints, etc.

JAS is Not All Encompassing

JAS contains wide functionality but also has an extensive capability to link vertically with a wide range of models:

- JAS has federated with mission level models using the DoD High Level Architecture (HLA) and engagement/ engineering models, e.g. Air Defense flyout models.
- Made direct connection to running models or their backplanes, e.g. DTRA HPAC
- Sneaker-net feeds with external data inputs during model pauses (wargame mode only), e.g. weapons ranges.



JWARS-JSAF Federation Demonstrated at I/ITSEC 2004 by Lockheed Martin

Summary: Modeling Complex Warfare

- Complex Warfare is not new in the real world, but from 2005 to 2011 JAS simulated a lot of it at the Campaign level with balanced levels of detail
  - All weapon/munition types individually represented – not aggregated together)
  - Unit sizes could mix down to individuals (units can evade or "break contact")
  - JAS HCI was designed to assist analysts, with "drag and drop" units onto maps, pull-down menus, cloning/modifying weapons - JAS complexity is inside the model
  - JAS demonstrated multiple sides (up to 7) and put civilians in the battlespace
  - **JAS simulated three very different Strategic Scenarios in a single model.**

JAS can run the same scenario either as a pure Simulation or as a Simulation-Supported Wargame, with studies gaining the benefits of each and offering the opportunity to conduct **Wargame-Simulation-Wargame-Simulation as Cycles of Research/Learning**.

JAS Functionality (Release 3.20 Dec 2010)

✓ – Implemented
P – Partially Implemented
– Not yet Implemented

C3	
✓	JTF Command and Control
✓	Land, Maritime, Air C2
✓	Communications
✓	Indications and Warning
P	Electronic Warfare
P	Restore Destroyed C2
P	Information Warfare
ISR	
✓	Intelligence Processing
✓	Sensing
✓	Reconnaissance
✓	Collection Plan
✓	Perceived Truth
	Combat ID Errors
Land	
✓	Maneuver
✓	Direct Fire
✓	Indirect Fire
✓	Forcible Entry (Airborne)
✓	Attack Helicopters
✓	Maneuver Planning
✓	Land Sustainment
✓	Rear Area Security
P	Mobility / Countermobility
Intertheater Logistics	
✓	Intertheater Lift Scheduling
✓	Intertheater Lift Movement
✓	Air POD and Sea POD Operations

Air	
✓	Dynamic ATO Planning
✓	Close Air Support
✓	Cruise Missiles
✓	JTCB Planning
✓	Air Defense (Surface-to-Air)
✓	Counter Air (Air-to-Air)
✓	Attack / Interdiction (Air-to-Ground)
✓	Fleet Air Defense
✓	Air-to-Surface
P	Suppression of Enemy Air Def
✓	Air Unit Sustainment
✓	Time Critical Targeting
✓	Integrated Air Defense
P	Air Delivered Mines
✓	Air Refueling
P	Multi-Mission Aircraft
Space	
✓	Force Enhancement
✓	Space Control
P	Counter Space
TBMD	
✓	Threat Missile
✓	Airborne Laser
✓	DSP Cueing
✓	Simplistic TBMD C2
✓	Theater Wide Joint Defense
✓	Terminal Defense
P	Integrated TBMD C2

Intratheater Logistics	
✓	Road and Air Transportation/Ports
✓	Rail and Pipeline Movement
✓	Host Nation Support/Infrastructure
✓	Sustainment and Production
P	Maintenance and Service Support
Maritime	
✓	Surface-to-Surface
✓	Submarine on Ship
✓	Naval Blockade
✓	ASW (Submarine on Submarine)
✓	ASW (Ship on Submarine)
✓	Mine Warfare (Ship Dep'd Mines)
✓	Naval Gun Fire Support
✓	Forcible Entry (Amphibious)
✓	Maritime Sustainment
✓	ASW (Air on Submarine)
✓	Countermine
Special Operations	
✓	Special Reconnaissance
✓	Direct Action (DA) - Forcible Entry
✓	DA - Control Long Range Fires
WMD	
✓	Chem/Bio Offense
✓	Chem/Bio Defense (MOPP)
✓	Unit Effects
P	Nuclear and EMP
Agent Operations	
✓	Individual & Collective Rules
✓	Crisp and Fuzzy Rules
Weather	
✓	Air, Land & Oceanographic

Simulation Supported Wargaming in JAS (1)

"No one form of wargame can meet all our needs. [And each is] not without limitations:"

1. **It is difficult to play such games in other than real time, actual decision making cannot take place in anything other than real time … for the simple reason that humans can live and act only in real time.***

   – **JAS is compliant with HLA Time Management and can be slowed to match wall clock speed (or any other time that is slower than the fastest speeds it can attain). Time can be paused during decision-making or allowed to progress at wall clock time with updates continuously provided to the players.**
   – **Between pauses, JAS can run faster than 500 to 1.**

***Perla, Peter P. and McGrady, ED (2011) "Why Wargaming Works," *NWC Review*: Vol. 64 : No. 3 , Article 8.**

Simulation-Supported Wargaming in JAS (2)

2. It is difficult to record what happens and why with enough fidelity and completeness to make it profitable and instructive to review and reflect upon events and decisions.*

- **JAS human inputs are interpreted by the model in exactly the same manner as those from the agents (the meta-data is identical).**
- **Consequently, given the same initial random seed is used, JAS wargames can be replayed without any humans in the loop, but the decisions humans made and orders they gave will be executed in exactly the same manner by their agents**

***Perla, Peter P. and McGrady, ED (2011) "Why Wargaming Works," *NWC Review*: Vol. 64 : No. 3 , Article 8.**

Simulation-Supported Wargaming in JAS (3)

3. It is difficult to repeat an in-person, multiplayer game like a high engagement game and impossible to "replicate" it in the sense of a Monte Carlo simulation experiment.*

- **In JAS, separate random number streams are provided to every entity and process. Draws in any stream are independent of each other and will only affect other BSEs due to specific interactions (cause and effect), not due to randomness.**
- **However, a change in the initial master seed resets all streams. JAS wargames can thus be replayed as Monte Carlo simulation experiments with different initial master seeds to test the robustness of both human and agent decisions under a range of changed conditions, e.g. weather, sensor deployments, enemy dispositions, etc.**

*Perla, Peter P. and McGrady, ED (2011) "Why Wargaming Works," *NWC Review*: Vol. 64 : No. 3 , Article 8.

Simulation-Supported Wargaming in JAS (4)

4. It is difficult to explore variations in the decisions made and what the outcomes of those decisions might have been, especially to explore all the mistakes that we make.*

- **Any JAS game with the same initial master seed can be repeated identically up to a given point and paused. This allows:**
  - **rehashing the specific decisions of interest by exploring what was the cause of the "mistake", e.g. bad intel, lack of timely planning, misperceptions on the part of the decision-maker**
  - **making a change in the orders to see if other decisions provide a better outcome. No JAS decisions are currently made by the "flip of a coin" although nothing prevents a user from setting such a rule.**

*Perla, Peter P. and McGrady, ED (2011) "Why Wargaming Works," *NWC Review*: Vol. 64 : No. 3 , Article 8.

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