

Modeling Complex Warfare (MCW) Text

Intro: I should also mention that I spent almost sixteen years (1996-2012) as a contractor supporting the Simulation and Analysis Center or SAC in the OSD Cost Assessment and Program Evaluation or CAPE office and its predecessor the Program Analysis and Evaluation (PA&E) office.

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1. A longer version of this presentation was originally developed for the MORS “Modeling Complex Warfare” Workshop that was to have been presented in March but was truncated to a small set of virtual Plenary presentations on a single day.

2. The abstract is here just for an overview of the presentation. Please go to slide 3

3. The U.S. has been involved in real world Complex Warfare for a long time, and it involves far more than our current campaign models address as shown in the partial list below. The rest of this briefing covers many of these items, but focuses mainly on the last item - Decision-making under uncertainty.

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4. JCS Pub 5-0 has no definition of Multi-Domain or Complex Operations, but it does have a view of the holistic Operational Environment (OE), comprised of: Land, Air, Maritime, Space, Cyberspace and just about everything else.

The complexity of that Operational Environment will however demand more than just simulation to properly fit all these pieces together and as was discussed extensively in Working Group 6 at last November’s MORS Workshop on Advancing Campaign Analytics, there is an approach called the Cycle of Research that can be a key contributor to a more complete understanding .

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5. So what is this Cycle of Research, sometimes called the Cycle of Learning. In 2014, Phil Pournelle, a noted wargaming enthusiast, in his article Preparing for War, Keeping the Peace called it “an iterative application of the principal tools the military uses to explore, understand, and prepare for future conflict” Its elements include systems and operations analysis, wargames, exercises, and assessment of real-world experience and history. And they are to be used in concert, as shown in the Figure to the right reinforcing each other and filling in the gaps in our knowledge and understanding.

‘Bill’ Robinson of J7 in Suffolk provided the diagram and since J7 is a training organization, they use the term Cycle of Learning. But his division is supporting Joint Force Development and Design via ongoing integration of experimentation, wargaming

and analysis of operating concepts and capabilities with the object of providing an evidentiary basis for investment decisions.

I like to add Training and Testing data to the cycle of Research, essentially anything that will give us better insight into how well our systems and people will actually work short of war. And you may question the word history in the list of sources, but as an example, we particularly need to understand and learn from what happened in Eastern Ukraine just a few years ago and to some extent continues today.

But why don't we see the word simulation on the chart?

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6. Maybe it's because the wargamers are suspicious of anything to do with simulation, but it might also be because in its 2019 Report, GAO found that the campaign models used by the OSD, JCS, and the Services have been hindered by three interrelated challenges

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

From the GAO's point of view, the Process of Support for Strategic Analysis is broken. Here's what they say it's supposed to be:

1. Develop products to provide a flexible common **starting point** for Service force structure analysis, what we call Strategic Scenarios
2. Conduct a range of analyses to explore innovative approaches using approved products as starting points, and
3. Compare competing Service analyses and conduct joint analyses to inform both strategy and force structure decisions

The response from OSD/CAPE, OSD/Policy, JCS, and the Services was that they understood the problem and were working on it.

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7. But is there is more going wrong with simulation? In 2014 and 2015 Rand conducted a series of unclassified wargames that examined the probable outcome of a Russian invasion of the Baltic states. Their wargame showed that a near-term Russian invasion could reach the Estonian and Latvian capitals in <60 hours.

To quote them, 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 especially since maneuver between dispersed forces would likely be the dominant mode of combat.”**

While STORM portrays individual aircraft and ships, both STORM and JICM represent land forces as aggregated brigades with scripted maneuver and large time steps. That

was sufficient for the 1980s Fulda Gap scenario against massed Soviet tank armies, but has little applicability to the highly mobile, mostly armored, and relatively self-supporting strike force represented by the high mobility and armored Russian BTG shown to the right. Even worse, the aggregation of our land forces focuses on their ability to generate lethality, but does not seriously consider the other side of the coin, for example the rapid loss of CPs detected and immediately brought under long range fires, towed artillery that cannot “shoot and scoot” in time to avoid counterfire some of which might be thermobaric, the communications vulnerable to electronic jamming, direction finding, and cyber attacks, and a host of other problems.

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8. But there is another Campaign model that was specifically designed to have the functionality and the detail to handle such conflicts. -- The government-owned Joint Analysis System (JAS) (JWARS renamed) emphasizes C4ISR, maneuver, & the balanced representation of all military Services, allies, neutrals, and opponents. For over 5 years from 2006 to 2010, JAS was controlled by JFCOM J9 Experiments in its simulation-supported wargaming and freely made copies available to government, and government-sponsored industry, FFRDCs, and academia. JAS was also part of the OSD/CAPE Strategic Analysis M&S Tool Kit, right up until early 2011. That’s when, after JFCOM had been disestablished, OSD/CAPE recalled JAS from all its users and archived it.

So, did JWARS/JAS collapse of its own weight as is so often claimed?

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9. This slide contains an Extract from the message, “Closure of the JAS Support Office,” dated January 2011 and makes two points. First, JAS was archived because CAPE was getting out of the campaign modeling business and archiving JAS as part of its mandated 10% headquarters cut. And more important, that the SAC used JAS “as one of its Strategic campaign tools in numerous key Departmental studies and was very satisfied with the results it provided, its functional robustness, and the agility and usability of the model.”

Between 2005 and 2011, JAS was used by other government organizations such as DTRA, industry such as Lockheed Martin and Northrop Grumman, FFRDCs such as Mitre, and academic organizations such as the Virginia Modeling, Analysis, and Simulation Center (VMASC), a state-sponsored branch of Old Dominion University in Suffolk, VA.

The closure letter also stated that all that was needed to get a copy of JAS was the approval of a submitted Standard Use and Distribution agreement. But despite a 2017 letter from the Director of CAPE stating that same policy, access to the model has been tightened so much as to permit only Federal government employees access and they were furthermore not allowed to let contractors have access any of the JAS materials.

Nevertheless, former JWARS/JAS developers estimate that JAS could be operational again on a stand-alone computer within a few weeks. And would be able to portray the three Strategic Scenarios used in 2010, which were projected to 2015-2020, given they are still in the archives.

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10. 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) and is stochastic for most functions

Fully integrated means that combat can impede all other functions. Likewise, failure in functions such as C4ISR and Logistics and Transportation can disrupt combat operations. JAS simulates critical infrastructure such as fuel pipelines, railroads, tunnels, canals, and their platforms and products. And while JAS is a complex tool, it was built with the analyst in mind and supports easy analyst access to both view its data and to modify it with a host of support tools such as drop and drag units on a map, duplication (cloning) weapons and units as needed, and many others. Also, a decision was made early to use a team of analysts at the CAPE Simulation and Analysis Center (SAC) to build the baseline scenarios and then distribute them with the unclassified JAS code to allow other analysts to simply load both and begin a run within a few minutes, with no need for software personnel. Alternatively, later in the program the model and the scenarios were made available on some of the DoD High Performance Computing Centers (HPCs – compare to secure cloud computing).

JAS is minimally aggregated with all weapon types explicitly represented and countable (not aggregated). They each have their own characteristics and consume munitions when they fire. When it was still active, JAS used much the same Air and Maritime data as the STORM and the ITEM models, but its C4ISR was developed specifically for the model and creates organizations with “thinking” agents at all units with HQs or supporting units making local decisions. Land operations employ mostly battalions with the locations of the subordinate companies arranged in user-modifiable formations appropriate for the operation being conducted. But battalions are not the only echelon of units in JAS, the model supports mixing various echelons of Land units down to High Value Individuals and employs ground attrition algorithms from approved Army training simulations for every engagement. These are NOT Lanchester algorithms, but Lanchestrian results occur if units are forced to stay in contact rather than withdraw from combat or receive fire support as they can in JAS.

And its biggest difference from other campaign models, is that it passes explicit information-bearing messages over simulated communications links to its units with agents. This allows representing the importance of C4ISR more accurately and the effects of the disruption of those flows.

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11. Most of the information at the top of this slide has already been mentioned, but I want to bring to your attention the line of red text because even as late as 2010, building Major Combat Operations (MCOs) now referred to as Strategic Scenarios in the Simulation and Analysis Center of CAPE was typically done using up to seven models, and repeating that process to conduct an excursion was virtually impossible due to the time constraints of bringing all the models up to speed. As a demonstration of its capabilities, the CAPE JAS analysts followed the completion of an MCO in JAS by conducting 9 major excursions in a two-week period ranging from swapping out F-22s for F-35s to estimating the impact of a major electromagnetic pulse (EMP) experienced by various elements of a US force conducting an operation.

There were seven JAS analysts in the CAPE SAC, more than any other model, but less than half the total number involved in employing all the other models. And when JAS MCOs were completed and reviewed, they were distributed to approved organizations who could immediately load them and run. There was no manual data entry required and no Federation necessary – much like a commercial on-line game.

Considerable “Help” information was embedded in the model data, and one of my favorite tools, the TRANSFORM function, accompanied all releases of a new set of JAS configured software and would automatically update the required data of any JAS scenarios whenever they were loaded into a newer version of JAS. All the analyst had to do was execute the function when notified, and when completed press Save.

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12. Once the first iteration of each of the JAS-based MCO scenarios was built, the next versions could be rapidly generated because every JAS scenario was saved and could be reloaded and rerun at any time. And generally, over 90% of a saved MCO scenario could be reused and simply updated with data that had changed. JAS tools also supported automatically duplicating units and facilities in one scenario and pasting them into another. For example, the entire 101st Airborne division could be replicated with one click and deployed to another COCOM with another click.

JAS was often assigned other studies that ranged from examining how long a carrier task force crossing the Pacific could expect to remain undetected to determining how long an allied government could hold out against an invasion without US combat assistance (where only US ISR was provided). In that scenario, because JAS can represent civilians as their own side, we also simulated a Noncombatant Evacuation Operation or NEO which generated a lot of questions for which we did not have definitive answers. A similar situation occurred when we examined a “loose nuke” scenario. Situations occurred that the team did not feel comfortable simulating without external agency participation and that led, to the first time, that JAS was used in CAPE to generate the situational data for what these days would be called a focused seminar wargame. The feedback on the expected outcomes developed by wargamers from DTRA, SOCOM, and other organizations was surprising, and was used in later JAS simulation runs of that scenario.

Chemical WMD representation in JAS includes not only the lethality of the chemical agents, but the defense of personnel and units both in terms of PPE/MOPP and downwind warning. For bio-warfare, JAS can represent transmission rates and recovery/lethality rates and times.

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13. That brings us to a discussion of the use of JAS as a Simulation-Supported **Analytical** Wargame.

As used by JFCOM J9, for their experiments, JAS could be paused at any point in a scenario and individual wargamers could assume the role of any agent in a JAS scenario (usually a commander) and receive the same status messages and see the same Common Operational Picture in human readable format. The wargamers would then form their own perceptions of the situation, make their own decisions in place of those of the agent and, issue orders to implement those perceptions either through the Graphical User Interface or using the White Team.

Swapping roles in JAS is straight-forward as the inputs of both the agents and the players use the same meta-data. And when some agents are replaced by human players, all other agents continue to operate as before, not making any distinction between agent or human inputs.

And maybe most important, all wargame inputs are automatically recorded by the JAS software, and the whole scenario with the human decisions can be replayed either as a closed simulation or as another iteration of the same simulation-supported Human-In-The-Loop wargame. The objective was to critique and improve the decisions being made by the simulation agents, validate the overall scenario from two different points of view, and improve the combat, logistics and C4ISR fidelity of the wargames without additional cost to them.

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14. Every JAS agent has a minimum of five functions

Command and Control, including planning, doctrine, orders, and maneuver,

Resource Management, of the unit including allocation of critical items and reordering

Sensor Understanding and Appropriate Reaction,

Platform Control (speed over specific terrain, selecting paths, etcetera), and

Management of its Communication with, superiors, subordinates, supporting elements, and any other organization an analyst connects it with.

There are also roles (sets of rules and knowledge bases on how to do their job for dozens of other supporting agents such as Fire Support Coordinators, Transportation Managers, Forward Air Controllers, etc. Users can modify these and create new ones.

JAS scenarios go beyond the static “kill chain,” and its units can call for fire support from any asset appearing as currently available in their fire support data base with which they are in communication either directly or through intermediaries. Analysts are not restricted on their choice of weapons and a submarine employing cruise missiles is not a problem.

- There are also ways to create “series of maneuvers” that lead to positions of tactical advantage or disrupt enemy rear area operations
- There are deceptions that hide an opponent’s strengths or are designed to create an incorrect perception
- And a host of other “chains” that can be linked together through plans and decisions of when to implement, when and how to modify, and when to abandon them, e.g. chains of orders to coordinate units, chains of preplanned fire dependent on events, and branches and sequels driven by the perceived situation.

At the bottom of the slide, I quote Former DepSecDef Bob Work who stated in 2015 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.”

Let me say that even with perfect communications and sensors that detect 100% of everything they can see, you may still never get the complete picture in time.

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15. In both the JAS simulation and the JAS simulation-supported wargame, each **indirect fire** event is adjudicated separately based on the type of the munition employed and the condition of the target. **Land direct fire** attrition is computed for specific weapons and munitions, range to the target, and the conditions of day versus night, moving versus stationary, terrain roughness, defilade and target protective measures such as body armor. And these results can be further adjusted for “human soft factors” such as training, if the user desires.

- *Poor Soft Factors have user designated impacts based on a relative scale. For example, poorly trained units shoot worse and thus cause less attrition than a better trained one with the same weapons, they suppress more easily, and are slower in their operations.*

- And all weapon-victim outcomes are recorded and reported in a detailed Killer-Victim spreadsheet in chronological order and can be filtered to display information on specific weapons.
- While humans input orders, target priorities, and similar information, subordinate agents use this information to select targets, maneuver units, task sensors, and conduct combat, including delays and ambushes.
 - For example, a human order to move a Brigade will be passed by the Brigades to all its subordinate units and form in user-designated formations or unit self-selected formations from a user-expandable library of formations and move out. and units will execute changes in formation as circumstances dictated.
- As in the simulation mode, enemy actions during the wargames, both kinetic and non-kinetic can cause loss, degradation, or delay of information, the loss of which can degrade decision-making in both speed & accuracy
 - In JAS, Cyber effects could be assessed in the context of all other C3 attacks and disruptions including EW, Deception, and Kinetic attack
- And once again, both Agent and Human Decisions are based on “perception” not ground truth.
 - But remember ground truth is also recorded for later comparison of the degree of difference and the effects that caused.

And all these doctrinal and TTP factors are in data and accessible to the JAS users, who can not only modify them, but also add to them.

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16. Again, I emphasize that JAS can rerun an **analytical wargame** both as a simulation and as an analytical simulation-supported wargame. This provides the opportunity to rapidly repeat wargames with new players, allow for new decisions, and insert new conditions. This conflicts with Peter Perla’s 2011 article with Ed McGrady on, "Why Wargaming Works," in the Naval War College Review where he gave four reasons that wargames couldn’t be automated. But JAS addresses all four of them. However, a demonstration of this will have to wait until JAS is again available.

JAS also offers the opportunity to conduct cycles of **Wargame-Simulation-Wargame-Simulation** as part of a Cycle of Research for a specific scenario or topic of interest. By using the same scenario in both analytical wargames and campaign simulations, there is the potential for generating more coordination between the two communities and exchanges of both data and capabilities, for example

- Automated Attrition and Movement sometimes referred to as “In Stride Adjudication” becomes available to wargaming and offers an alternative to dice rolls, aggregated attrition tables, and hex-covered maps.
- Meanwhile wargamers can provide the Simulation Community with doctrinal and TTP innovations specific to their common scenarios, generate data applicable to simulating human Soft Factors, and potentially provide the tactics of an aggressive Red Force unconstrained by the part it may have been directed to play in a simulation scenario.

Simulation enthusiasts often fault wargames for being non-repeatable, but if we require multiple models to create a Strategic Scenario, there is no guarantee that that simulation can be repeated. And wargamers often throw the BS flag at simulation scenarios which they would play differently if they conducted them in their wargames. Hopefully, we can address both complaints.

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17. While JAS contains a wide range of functionality and in some areas has more detail than some other existing Campaign models, it is not all encompassing and has never tried to do all things for all people as it has often been accused of. When a user needed more detail, JAS provided the ability to vertically federate and link to more detailed models through DoD High Level Architecture (HLA) protocol, direct access, or by sneaker-net during wargame pause mode.

- As early as 2004 when JAS was still called JWARS, Lockheed Martin federated it with the Joint Semi-Automated Forces or JSAF mission level model (interim OneSAF) using HLA, and they demonstrated that interaction at the I/ITSEC Convention in Orlando. The following year, CACI linked JWARS with engagement and engineering-detail Air Defense flyout models.
- JAS has also made direct connections to complex models or their backplanes, for example, the DTRA Hazard Prediction and Assessment Capability model or HPAC model
- And finally, JAS supports Sneaker-net feeds with external data inputs by the White Team during model pauses (wargame mode only), to provide new data or change a situation.

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18. In Summary: 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 fully balanced levels of detail.

- All weapons and munition types and, in fact all resources are individually represented, countable, and tracked – not aggregated into a single kill rate.
- Unit sizes can be mixed all the way down to high-value individuals. And outnumbered or outgunned units can call for fire support, choose to evade, or attempt to “break contact”.
- JAS **is** a complex model, but most of the complexity is inside the model and the JAS Human-Computer Interface was designed specifically to assist analysts with tools and help and to minimize manual entry, and **automatically** Transform older scenarios to run the latest software release --
- JAS also provides several functionalities associated with complex warfare, though users are not required to employ them. Samples include, simultaneously simulating multiple competing sides (up to 7 have been demonstrated each with their own doctrine and alliances), civilians in the battlespace, and the opportunity to reflect the impact of human soft factors in a scenario’s results.
- **And as my “foot stomper” JAS has demonstrated simulating three very different Strategic Scenarios using only a single model. Those same scenarios can be saved, distributed to other JAS users, reloaded, modified, and rerun with a minimum of effort. JAS can also use these same scenarios to support analytical wargames, and together with other sources greatly improve our Cycle of Research.**

Thank you for your attention.