Text for Simulation Supported Wargaming at the Campaign Level

1. **Simulation-Supported Wargaming at the Campaign Level:** Title

2. **Analytical Wargame Technical Challenges:** While I am a proponent of human-in-the-loop wargaming, I am frustrated by the many technical restrictions it faces that I believe can be solved while simultaneously enhancing the role of the participating human decision-makers. Most of us are aware of the shortfalls in Wargaming: the long preparation times, the limited reuse of components, the heavy investment in manual support functions, and the inability to exactly replicate a game.

   And while "in stride" or fully automated Adjudication in support of wargaming has been a goal that has been reached in some limited scope wargames, We need to reach it at the campaign level across all domains. And this is my topic today. That we actually have a government-owned Campaign level model to both simulate Strategic Scenarios in a single model and use that same scenario to conduct simulation supported wargaming. And do so:

   a. With fewer Resources and less Preparation Time
   b. And Provide Verified Automated Record Keeping ensuring **Repeatability and Options For Analyses Of a Range Of Options**

3. **Joint Analysis System – Global Campaign Model**: Specifically, that government-owned, Agent-based, Multi-Domain, C4ISR enabled, and perception-driven model is the currently archived Joint Analysis System or JAS used by OSD/CAPE for five years to build Strategic Scenarios and conduct studies. More to the point of this presentation, the JAS model was also used for Campaign-level Simulation-Supported Wargaming by JFCOM J9 until its disestablishment in 2010.

   In additions to standard multi-domain, JAS already simulates space platforms for both sensors and communications including warnings as well as C4ISR that includes Command and Control, Sensors of all types, and Communications networks carrying the status and sensor messages that EW, deception, & cyber. Plus, fully integrated Logistics & Transportation, human soft factors, Ballistic Missiles and Ballistic Missiles, and Weapons of Mass Destruction. **New Name?**

4. **OSD Strategic Analysis M&S Toolkit: T**he Joint Analysis Simulation or JAS was part of the OSD Strategic Analysis M&S Tool Kit up until early 2011 when OSD/CAPE both abandoned participation in building and simulating Strategic Scenarios and archived the JAS model calling in all copies of it.

   It was archived in operational status with several scenarios and could be brought back
   It is agent-based, event-stepped, data-driven, and stochastic for most functions
   It is a complete multi-domain model with balanced air, land, sea, space, & C4ISR including C^2, EW, deception, & cyber. Plus, it has fully integrated Logistics & Transportation, human soft factors, TBM/TBMD, and WMD. And to

provide realism, JAS decisions are based on perceptions, not ground truth, but ground truth is saved for later comparison.

5. **Despite Whatever You May Have Heard about JWARS/JAS**: And despite whatever you may have heard about JWARS/JAS it did not fail because it tried to do too much. These complaints were most often from the other Campaign models that for the past ten years have been building in many new functions on a base that is still time-stepped (meaning an algorithm computed what happened during that period) rather than event-based and has minimal agent support.
However, the Managing Director of the CAPE Simulation and Analysis Center or SAC stated in the message archiving JAS that, "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."

OPTIONAL PRESENTATION INFO: In 2005, well before 2011 when it was archived, a vote by the DoD Modeling and Simulation Executive Council redirected $50 million of new Congressional funding for 5 more years of JWARS support to the Presidential Directive ordering all DoD components to contribute to the Iraq War. When the list was published, the Airforce was at the top of the contributors with a Billion from the B2 bomber budget of $10 Billion and at the bottom was $50 Million from the Joint Warfare System (JWARS) budget of $50M.

As the JWARS Program Office was subsequently closing, JFCOM J9, impressed with the JWARS ability to simulate a fully operational Strategic Scenario, asked if the model could also support wargames with its agent generated messages and map-based Common Operational Picture (COP). And when it was demonstrated that it could, J9 took responsibility for sponsorship of the program and renamed it JAS and used it to conduct extensive wargames and major exercises. However, the JWARS Development Office still closed for lack of funds.

I will not go into the politics of the following years, but with the disestablishment of JFCOM in 2010, OSD/CAPE reclaimed ownership of JAS and decided to call in all copies and archive them due to "budgetary pressures" and its decision to no longer participate in building and then simulating Strategic Scenarios.   Despite requests for release, CAPE has continued to increase the requirements for release of the unclassified model to the point where only federal government will be considered and they cannot use contractors to support them. This compared to six years when it was available to government and government-sponsored industry, FFRDCs, and academia.

6. **JAS as a Simulation-Supported Wargame** So how do you support a large wargame with a Campaign simulation? In its wargaming mode, JAS supports: "Pause, Modify, Resume," which allows players to:

    a.   Review simulation-generated status reports including Blue casualties and perceived Red casualties, Blue logistics status, and infrastructure condition, such as airbases and ports.

    b.   Review Blue/Red/Green/Gray units on a perception-based and digitally displayed Common Operational Picture (COP)

    c.   Input new orders, priorities, rules, etc. either directly through the graphical User Interface or through White Force Controllers and then have them implemented by JAS computer agents and highspeed with complete record keeping.

    Explicit messages and COPs carry the same information used to inform the perceptions of the JAS agents, which continue to fill all unmanned command and support roles. Swapping roles between humans and JAS agents is straight-forward, and Joint Forces Command used JWARS to support its Unified Vision Experimentation Wargames

7. **Simulation-Supported Wargaming in JAS (1)**: I agree with Peter Perla, the DoD Wargaming Guru when he says that "No one form of wargame can meet all our needs. [And each is] not without limitations:" But in the article **Perla, Peter P. and McGrady, Ed (2011) "Why Wargaming Works," he makes a series of pronouncements on analytical wargaming that I do not agree with since they are successfully addressed by JAS. The first is that actual decision making cannot take place in anything other than real time. Now I do agree with that part, but JAS complies with the DoD High Level Architecture commonly referred to as HLA and using Time Management can be paused or slowed to wall clock time.

    But agent based and potentially later AI-based decision-makers are not as constrained although even some simulated decisions take longer than others such as producing the Air Tasking Orde or creating the COP. But, when the agents execute their orders, JAS runs at speed of 500 to 1 on a single desktop computer, hence the time for the next decision cycle is not limited to the real time wargame task of determining attrition, moving units to new positions, etc. Rather, it's Run fast - Pause/Evaluate/Decide/Input – Run fast and Repeat.

8. **Simulation-Supported Wargaming in JAS (2)**: JAS is an "Event Driven" model and every event is recorded with a precise time and place. And given that JAS Human Decisions are recorded and interpreted by JAS in exactly the same manner as Decisions from its computer agents (the meta-data are identical) human orders are automatically added to the event tree and executed.

    And given the same initial random seed is used to start the simulation and the JAS-supported wargame, then it can be replayed in pure simulation exactly as it was in the wargame without any humans in the loop. But the data the humans changed and the orders they gave will be executed accurately by the agents

they temporarily replaced, giving wargamers the means to later review all data, reports, and video associated with the original wargame.

9. **JAS is Run by Agents Who Communicate**: So, let's talk about these computer agents and the communications they use to exchange information among themselves. Every adaptive agent shown here as a Basic Scenario Entity or BSE has five basic capabilities, only some of which may be used in any given position, but all of which are available. As shown in the slide, these are Command and Control, Resource Management, Platform Control, which is primarily for BSEs that can move, Communications Manager, and Sensors, a basic understanding of its own sensors and those it controls including eyeballs, which can be enhanced with resources such as binoculars for range and Night Vision Devices for detection and range at night.

   Messages and data sent between the BSEs move over simulated communications networks that link agents and transfer that information. They can range from space to terrestrial to maritime subsurface assets. And when those communications are disrupted: orders do not flow, sensor reports are late or never delivered, calls for fire go unanswered, resupply is late or nonexistent, and so on.

10. **Plug-ins and Knowledge Bases**: And how do these Agents know how to do all the tasks that need to be done, Well, JAS has over 50 categories of basic Command and Control plug-ins for different Services, at different echelons, and with widely different tasks. most of which are for planning. JAS also has dynamic C2 plug-ins that allow BSEs to adapt to different situations that an agent of that type may encounter. These can be added to any BSE that must reason about information on itself and its subordinates, their mission and resources, the enemy, and/or the environment. Examples range from Ballistic Missile Defense Coordinator to Waterway Dock Operations.

    OPTIONAL PRESENTATION INFO: JAS exposes agent decision logic and knowledge Bases or KBs to the user and allows users to make changes in the hope of exploring options for continued improvement in the model's Knowledge and other parameters without major software upgrades. The <<Rules>> pane allows the user to add a new rule, clone, modify & rename existing rules and reset the rule priority (based on sequence of top-to-bottom).   Facts can take on a variety of values, e.g.
       Boolean (e.g., Underfire = True or False)
       Numeric (e.g., NumberOfDivisionsAbsentGarrison = 5)
       String (e.g., State = Unambiguous)

11. **Simulation-Supported Wargaming in JAS (3)**: As stated earlier, any JAS simulation can be repeated identically up to a given point and paused. This allows:

a. Rehashing the specific decisions to explore the cause of the "mistake", e.g., bad intel, disrupted comms lack of timely planning, misperceptions on the part of the decision-maker, or other causes. And
b. Making changes in the orders to determine if other decisions provide better outcomes.
c. Examining if changes in doctrine or tactics might work better and estimating how the enemy might respond

12. **Quoting Former DepSecDef Bob Work in 2015:** And what is the effect of doing wargaming this way? In 2015, then DEPSECDEF Bob Work *stated that "The best wargames seek to create an environment for applying critical reasoning techniques and diagnosing the characteristics of <u>competition under the "fog" and "friction" of war where incomplete and imperfect knowledge prevails</u>."*

JAS automatically produces delayable/disruptable English-readable status messages and probabilistic sensor reports that create a viewable, map-based Common Operational Picture. This supports Indications & Warning (I&W) and Maneuver Planning as well as Targeting.
JAS Communications Networks and the flow of information on them generate a realistic environment for EW/cyber-attacks and for an understanding of the response times needed to restore C4ISR without suffering a major operational impact.
And JAS does this for every side engaging in the battlespace.

13. **The Role of a Campaign Model:** JAS as a Campaign model is a system of systems model that plays out over months to years and fulfills the gray area to the left of the relatively new Mission-level model being promoted by the Air Force Systems Command, the Advanced Framework for Simulation, Integration, and Modeling or AFSIM. In addition to its other capabilities, JAS has the potential for interfacing with Mission-level models through the DoD High Level Architecture or HLA protocol. JAS HLA capability was demonstrated by JWARS as early as 2004 with the Joint Semi-Automated Forces (JSAF) mission-level model.

    OPTIONAL PRESENTATION INFO: As shown in the slide, the Mission Level model or AFSIM provides a comparative measure of performance in an operational environment that:
    a. Supports a spectrum of uses across the development cycle
    b. Defines its "Home Turf" as Mission Effectiveness Analysis across the constructive, virtual, and/or live methods of portraying those missions at a platform level of detail in an operational environment.
    c. The Air Force has developed new tools for improving its effectiveness and made them widely available to government, industry, FFRDCs, and academia. Much like JAS was before it was archived.

14. **So, Let's Look at current Campaign Simulations for a minute**. If you wonder why I am pursuing the release of JAS when the Services

already have two Campaign models, I'll quote from a GAO March 2019 Report, entitled, "Revised Analytic Approach Needed to Support Force Structure Decision-Making." In it, GAO found that [current Campaign models] have been hindered by three interrelated challenges:

a.   [Campaign] Products are cumbersome and inflexible.

b.   Force Analysis {using those models] does not significantly deviate from Services' programmed force structures or test key assumptions. and,

c.   The DOD lacks <u>joint</u> analytic capabilities to assess [joint] <u>force</u> structures.

OSD/CAPE, OSD/Policy, and JCS J8 agreed and said they are working to solve the problem. But did not mention the existence of the archived JAS model.

But I'm not picking on simulations or wargames, some of which have come to wildly different conclusions other than that we should spend a lot of money on each services' preferred solution as the following 2021 headlines point out.

- US 'Gets Its Ass Handed To It' In Wargames: Here's A $24 Billion Fix - David Ochmanek, based on 2019 Rand Corp Wargaming report

- "A US Air Force war game shows what the service needs to hold off — or win against — China in 2030" Defense News Apr 2021

- The U.S. Military 'Failed Miserably' in a Fake Battle Over Taiwan - Popular Mechanics, Aug 2021

15.   **Simulation-Supported Wargaming in JAS (4):** So how do we bring Simulation and Wargaming into a more coordinated and cooperative relationship to help solve both their shortfalls? Perla and McGrady said "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."

– But JAS simulates equivalent detail for every domain plus logistics and transportation, What the JAMIP called a "balanced representation." And it addressed one of the major shortfalls in simulation, the use of a single random stream to provide the answer to a probabilistic draw and thus a change in any factor such as a new sensor needing a probability of detection changed consumed the next random number and every subsequent draw of a number was changed without cause. JAS uses a <u>separate random number stream for every entity.</u> Thus, the new sensor drawing a rando number does not change all subsequent draws bur instead leaves them as they were, thus maintaining strict cause and effect. In more graphic terms, the addition of a new sensor in the scenario would not cause a ship on the other side of the world that originally survived an attack to suddenly sink due only to the new sensor changing its random number.

– And every event in the scenario whether in a simulation or a simulation-supported wargame is recorded and can be replayed as a pure simulation or as the same wargame up to the point of new human interactions.

– And with different initial master seeds generating unique random number streams, JAS wargames can be replayed and act as Monte Carlo simulations to

test the robustness of both human and agent decisions under the same conditions.

The JAS simulation can also rapidly evaluate the effects of changes in a range of conditions, e.g., weather, friendly force structure, enemy dispositions, weapons, tactics and so on, where the effects of each can be observed in detail, analyzed, and evaluated by small teams of analysts.

16. **Quoting Former DepSecDef Work Again:** Quoting former DepSecDef Work again, he also wrote that *"…players should be able to observe and live with the consequences of their actions in the face of a thinking and reacting competitor, and so come to understand dynamic military competition from the perspective of opposing sides. Actions taken by the players on both sides must have tangible consequences that are determined by the actual performance of weapons and sensors in the real world, backed by a rigorous adjudication process…."*

• JAS sensors do not move directly from detection to identification, but rather must recognize and classify potential targets before identification can occur and a determination to engage is made. JAS has the option to populate the battlespace with civilians, who could become collateral damage if an incorrect ID is made. JAS sensors are also subject to deception.

• All JAS weapon systems and clusters of unit systems, for example gun batteries, produce coherent Attrition in line with available credible data, for example the JCS Casualty Rate tables and historical battle data. And as newer and better data becomes available, users can modify the attrition tables including range, lethal areas, kill rates and so on and observe their effect. All engagements whether successful or not are recorded in a Killer-Victim Scoreboards (KVS) to assess the success or failure of each use of each type of lethal force. There are over twenty of these scoreboards.

• User's plans direct general Movement and Maneuver, but agents can plan routes and make modifications to address obstacles, enemy forces, supply shortages, changes in orders and so on.

17. **Land Forces Patterns of Operations:** Because there is far more in JWARS/JAS than can be addressed in the time available, I am going to show you a few slides and screen captures, some from almost 20 years ago. More recent data is not available because CAPE archived all current documentation and JAS materials and has not approved any request for release.

I'll start with the Land forces. While most of the functionality of existing Air and Naval campaign models could be replicated in JWARS the Land Forces model was limited to scripted frontal assaults by aggregated Brigades in piston-like movement with minimal variations. To address that problem, JWARS allowed users to build units at any level of detail and worked closely with George Kuhn, then of LMI, to replace the still-used "piston" model of land unit engagements with the concepts of Operational Forms and Peaks & Pauses. Generally, the

Attacker recognizes when an attack has failed and a breakpoint is reached, the commanding agent pauses to regroup, assess, and then continue the assault, hunker down and wait for reinforcements or more fire support, or withdraw. The Defender holds until the attack fails or unit breakpoints are reached and then usually attempts to withdraw, but the defender may have a "fight to the death" doctrine. During disruptions and disintegrations as we've seen recently in the Russian forces in Ukraine, assaults into the Russian rear can then create opportunities for rapid advances.

18. **User Oriented**: Continuing with the Land Forces, here we see in the top middle of the slide the pull-down says, "Campaign Planning View." That is the User Oriented Ops or analyst view for each domain and operational task. There is also a Data View for those who are most concerned with data entry. Shown here is a small portion of the Land Order human computer interface addressing such issues as the Mission, Objective, and the Participants.

JAS provides a wide range of tools to assist the analyst or wargamer including Pull Down menus, Drag & Drop icons, Point & Click input, Automated route selection and viewing, and many more. The JAS GUI also has error detection and as seen in the lower right of the slide an English language summary of the order just input which is saved for reference. It does take some time to learn the GUI and JFCOM used their JAS trained staff to input the orders resulting from the senior officers' decisions in higher level wargames.

19. **Detailed Direct Fire Engagements**: The two current Campaign models use aggregated kill factors for different types of units throughout the whole scenario simply reducing the percent effectiveness of the specific unit regardless of the local conditions for the battles. JAS has modifiable baseline kill rates for every direct fire weapon over given ranges against specific targets, humans, and weapons platforms.

These are modified for every engagement to reflect the current conditions for each of the agent-led units, For example attrition is reduced due to poor terrain and Line of Sight, night engagements without night vision devices, moving versus stationary shooters and targets, and poor visibility due to weather. Meanwhile survivability of the target is enhanced by defilade such as foxholes, body armor, and camouflage. In JAS human factors such as leadership and training can both improve and degrade unit effectiveness, in unit marksmanship, unit movement and maneuver, time to clear minefields, donning protective gear, increasing firing rates, reducing suppression, and so on.

And for indirect fire munitions and bombs, JAS attrition is determined at given ranges from the center of the blast using an algorithm provided by the former Army Material Systems Analysis Agency, now part of the Army Combat Capabilities Development Command Data and Analysis Center.

20. **Maritime Ops & Video Replay:** JAS has a full set of maritime operations with logistics support in port and resupply at sea. Data sets for various theaters include an actual 18 months of Sea States and Atmospheric weather including a Pacific typhoon.

Elements of a Carrier Strike Force are located west of Thailand and elements of the force are shown in lower left screen and each can be interrogated for further information. In the lower right-hand corner, I have inserted a screenshot of multiple cruise missiles being launched from a cruiser. Only a few events like launch, climb, level off, and detonate (due to intercept or target impact) generate a smooth video display.

21. **And not to Forget the Marine Corps** a snapshot from old Video Replay shows Amphibious assault craft being spawned from their mother ship and carrying elements of the assault force and their supplies. Once a user-set percentage of a unit is successfully ashore, these individual elements assemble into that unit and await the arrival of the rest of the units. Note at the center top Aircraft flying missions in support of the island assault.

22. **JAS Air Operations – Auto ATO Generation** JAS Air operations planned and executed all types of air missions: multiple types of Air Defense, Combat Support, Joint Targeting, Maritime Air and Airlift. Mission packages were assembled automatically and included Strike aircraft, Airborne Electronic Warfare, and Tanker Support. The Collection Plan is shown here as User Specified but was later generated daily from the standing and Phase-based Priority Intelligence Requirements.

23. **Air & Space Operations:** Air Operations in JAS are global both in basing and strike capability. Air missions, especially remotely piloted ones are not dependent of a 24-hour cycle. Standard Configured Loads of weaponry, self-protection, and extra fuel are generated based on distance to the targets, target type and hardness, and projected air defenses.

Space missions include 24/7 communications and sensor allocation. Space sensor assets can be redirected in real time.

24. **JAS TBM/TBMD Layered Defense:** JCS J8 was responsible for current operations and OSD/CAPE for future, hence some capabilities were included that were based on commercial capabilities. Satellites providing warning, multiple types of radars, and even an airborne laser waiting for the day when it would have enough power, accuracy, dwell time, and survivability to successfully engage TBMs.
It should also be noted that this briefing shows only unclassified systems, but the JAS model could include not only US and Allied systems and those of

our opponents and their Allies, but also neutral countries who would cooperate with one or more sides.

25. **Chemical Defense:** Chemical warfare and chemical defense is included in the model along with contaminated areas, detailed clouds that increase in size and move with the wind, and dissipating lethality. Unit survivability and subsequent effectiveness are determined by a unit's speed in assuming a given level of Mission Oriented Protective Posture (MOPP) Gear status, MOPP level effectiveness against the agent used, and the amount of time spent in MOPP, which degrades unit effectiveness, based air temperature and workload. The JWARS team worked closely with the Defense Threat Reduction Agency (DTRA) to properly represent not only chemical defense and enemy effectiveness in chemical attacks but expanded this support to include biological attacks and Electromagnetic Pulse generated by high nuclear detonations.

Note: Since OSD/CAPE archived not only the JAS model and its associated materials (all of it unclassified except some data within the Strategic Scenarios), it left little to access for subsequent briefings. This explains why I have no slide on Bio warfare and EMP, but they are in the model.

26. **Simulation and Wargame Cooperation:** So, let's review what JAS can do for Wargaming before, during, and after the wargame.
a. First it can assist in examining alternative scenarios and building a road to war that does not start on Day 1 of the conflict.
b. And during Wargame execution, JAS can generate a rich scenario environment with detailed attrition without dice rolls and look-up tables. It provides fused sensor results showing digital map-based locations and suspected locations without any tabletop maps and markers being pushed across them. And it can record the complete scenario with a minimum of staff.
c. And finally, for post-wargame After Action Reviews, JAS can provide reports on a wide range of topics and video of every part of the theater during the entire scenario. The saved wargame scenario can also be used for further analysis to improve both the simulation scenario and future wargames.

And equally important, is what wargaming can do for Campaign modeling in JAS. In particular, wargame SMEs' review of agent Decision-Making can validate and improve that area and also provide credible effects of Soft Factors (training, leadership, experience, etc.) on unit breakpoints, marksmanship, suppression, speed of movement and so on.

However, for this to be of most use, we need more efforts to engage both simulation-supported wargames and simulation-based studies developing and using common scenarios, which can be used to conduct Wargame-Simulation-Wargame-Simulation Cycles.

27. **Other Potential JAS Wargame Options**

a. **"Take-Home" Package:** Since saved simulation-supported wargame scenario can be replayed as either a simulation or wargame, human <u>players could request a "take home" to allow them to replay the wargame and revisit their decisions at their home station</u> without requiring a full wargaming staff to support them. A software license is not needed as the game is saved in a "packaged" mode but may require government sponsor approval.

b. **Distributed Wargame:** <u>Since only the players' inputs need to be communicated</u> from the remote sites, a single White Team Site. There the players' inputs (generally in the kilobytes) are combined and sent out as a consolidated set of changes to each site, where if no further changes are made, everyone can be confident that the JAS results over the next wargame period results will be the same at each site.

Since the saved wargame scenario in either of the cases above can be replayed as either a simulation or wargame, Take home Simulation-Supported Wargames can continue to support evaluations and exchange ideas long after the original game. They could also be placed in the DoD Wargame Repository where DoD Agencies and JAS government sponsored FFRDCs and industry which did not participate could, with approval, have access and replay the wargame as either a wargame or a simulation to gain insights on results and propose a wide range of potential improvements.

28. **Advantages of Using the JAS Wargame Mode (1)** Former DEPSECDEF Bob Work asked for two primary improvements in Wargaming – Decision making under Uncertainty and better, more detailed information on Attritions. JAS provides both and adds the ability to both conduct wargames more efficiently and save the wargames as simulations. In JAS,

Both Agent and Human Decisions are based on "perception" not ground truth. But ground truth is also recorded for later comparison.

a. There are over 150 modifiable plugins and Knowledge Bases providing the necessary software to support Agent assigned tasks, e.g., Fire Support Coordinator, Transportation Manager, etc. and these knowledge bases can be reviewed by users and changed.

Enemy action both kinetic and non-kinetic can also cause loss, degradation, or delay of Communications messages and Sensor data, affecting decision-making in both speed & accuracy

Cyber effects (denial of networks, destruction or corruption of data, destruction of physical equipment, etc. can be applied to simulated networks, their data flows, and supporting equipment.

These effects can be assessed in the context of all other C3/Sensor attacks/disruptions (EW, Deception, Kinetic Attacks not only on equipment but on Command Posts and Centers)

29. **Advantages of Using the JAS Wargame Mode (2):** Attrition is calculated for specific weapons/munitions, day/night, moving/stationary, protection measures, **AND** "human soft factors" (training, leadership, morale, etc.)

a. *Poor Soft Factors have impacts: shooting accuracy is worse, units have lower breakpoints, unit operations are slower, and so on*

b. All weapon-use outcomes are recorded in detail in Killer-Victim spreadsheets, (A2A, S2A, etc.)

Humans input orders, various priorities, and then subordinate agents maneuver units, task sensors, and direct fire. Agents deal with routes, delays, engagements, and such. For example, An order to move a Brigade will move all subordinate units in a user-designated or unit self-selected formation

Analytical Wargames can be replayed in JAS simulation mode with all human inputs to review decisions and outcomes and, if desired, paused to observe specific actions in more detail to improve the realism of the operation.

30. **JAS Functionality:** I'm wrapping up with the JAS Functionality Achieved at the time when the JAS model was archived for your review. I'll leave that up with my name and email address on it, while I answer any questions.