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Topic: C2 Experimentation

Title: Integrated Battle Command Experimentation: Evaluating Transformational Concepts and Cutting Edge Technology In An Operational Environment

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Abstract

The Defense Advanced Research Project Agency (DARPA) in association with the U.S. Joint Forces Command (JFCOM) is developing transformational concepts and technologies to enhance the capability of commanders and staffs to plan and execute effects-based campaigns. An integrated team effort, with an innovated experimentation approach, is required to fully evaluate DARPA's Integrated Battle Command development.

The simultaneous refinement of emerging warfighting concepts, development of new technologies and integration of diverse components of the government requires an innovative approach to experimentation and evaluation. The integrated experiment development team developed experiments that would utilize the developing concepts and fully stimulated and evaluated tools being developed by competing contractors. Real world missions and supporting information are used to stimulate the models and provide outcomes that can be evaluated by experts in their fields as well as the operational staff.

A series of limited objective experiments will evaluate and provide guidance for the technical development of the Visualization, Option Exploration and Tool Importation and Modification capabilities. The Phase 1 Capstone Experiment will utilize three planning staffs, involved in multiple missions, to determine the relative capability of each contractor's IBC tools and provide recommendations on which should continue into Phase 2.

Emerging results will be shown and discussed as well as plans for the transition and continual refinement of successful components of the Integrated Battle Command software to operational staffs to use in current conflicts.
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1. Introduction

The Defense Advanced Research Project Agency (DARPA) in association with the U.S. Joint Forces Command (JFCOM) is developing transformational concepts and technologies to enhance the capability of commanders and staffs to plan and execute effects-based campaigns[1]. Leaders and staffs at all levels must understand and effectively operate in the complex Political, Military, Economic, Social, Information, Infrastructure (PMESII) environments. They require tools to visualize the environment, explore possible actions to determine the range of possible effects, and plan long range campaigns, encompassing various political, military, economic, social, infrastructure lines of operation to achieve national objectives.[2]

DARPA and Joint Forces Command have a joint effort to develop, evaluate and transition technologies that provide these capabilities. The objective is to develop technology to support commanders in conducting future, complex, multi-dimensional, coalition-oriented, effects-based campaigns. This includes a comprehensive suite of decision support tools that can automate and greatly facilitate the human actions in command and control. The DARPA technology provides prototype software that is hosted on current or future command and control systems. JFCOM is refining transformational command and control concepts, such as effects based operations, as DARPA develops the decision support tools to support command and control in future operational environments.[3]

The Integrated Battle Command effort has multiple coordinated efforts. Senior leaders and JFCOM Staff continue to refine emerging JFCOM warfighting concepts and help guide the technical development. Two separate contractor teams developed separate tools sets to demonstrate a basal capability. The experimentation team designed experiments that utilized emerging concepts, stimulated the tools being developed and provided a thorough evaluation.

The simultaneous refinement of emerging warfighting concepts, development of new technologies and integration of diverse components of the government requires an innovative approach to experimentation and evaluation. A series of limited objective experiments (LOE) evaluated and provided guidance for the technical development of the Visualization, Option Exploration and Tool Importation and Modification capabilities. Real world missions and supporting information was used to stimulate the models and provide outcomes that can be evaluated by experts in their fields as well as the operational staff. The LOEs also exposed the contractor teams to a wide variety of operational expertise as they refined their developments. The Phase 1 Capstone Experiment utilized three planning staffs, involved in multiple missions, to determine the relative capability of each contractor's IBC tools and provide recommendations on which should continue into Phase 2.[4]

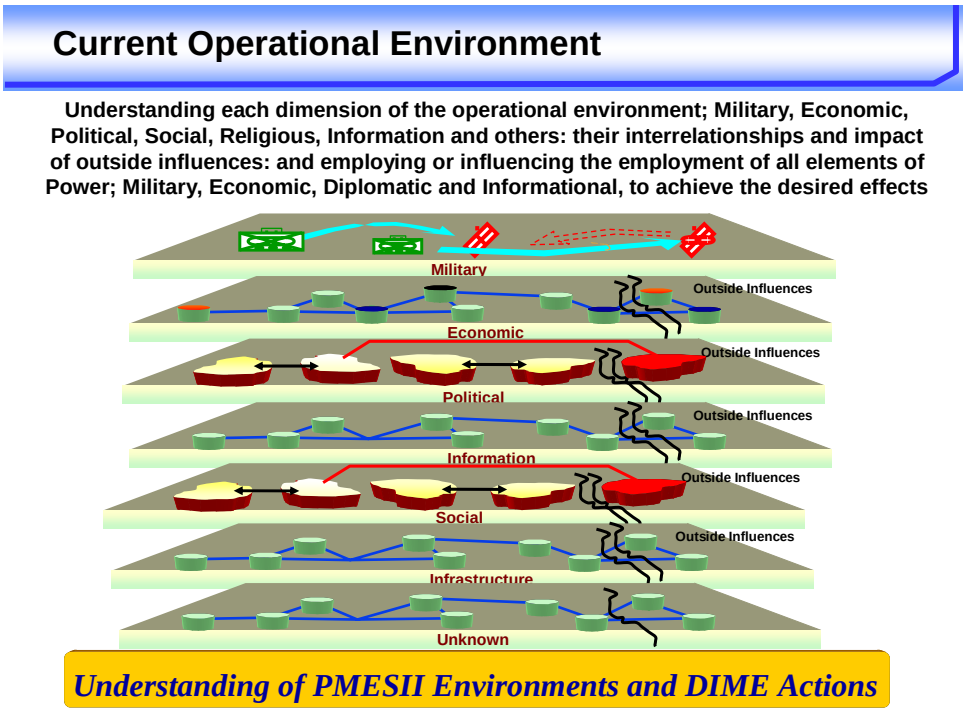
2. Evolving Concepts

2.1 Current Operational Environment and Evolving Concepts

U.S. Joint Forces Command (JFCOM) is developing, testing and delivering transformational concepts for conducting future campaigns to the Regional Combatant Commanders (RCCs). These include Operational Net Assessment, Effects Based Operations/Planning, the Joint Interagency Coordination Group, and the Joint Fires Initiative. The Integrated Battle Command program utilized senior leaders and JFCOM staff expertise to refine concepts and provide more detailed guidance for the technical development.[5]

Leaders and staff operate in an incredibly complex environment where a variety of systems: *Political, Military, Economic, Social, Infrastructure, Information* – PMESII are interconnected and various National actions: *Diplomatic, Information, Military, Economic* – DIME can be taken to resolve issues. The PMESII construct provides a means to categorize and understand information. It is meant to assist leaders in understanding the environment and stimulate creative thought in solving complex problems. Critical elements include providing an understanding of the various PMESII environments; key nodes, their relationships, influences and sources of power; identification of critical nodes and paths; available information, and the full range of possible outcomes. Visualization should always be viewed holistically as a system of interconnected PMESII and other environments.[6] Components include:

- Elements of National Power: What elements of national power, Diplomatic, Information, Military, Economic are available
- Political: The political structures, formal and informal organizations overlaid on each other
- Military: Essential aspects of the security environment such as armed forces, security forces, insurgent groups, paramilitary and criminal groups.
- Economic: Organization of the economy. Formal economy; production, distribution, consumption and labor force. Impact of trade outside the control of the government in goods and services, as well as illegal trade
- Social: How do members of this society construct their identities. Identity and affinity groups overlaid on each other
- Infrastructure: The Infrastructure system is more than just a collection of physical assets. The importance of the individual or collective assets is drawn from the situation and their relationship to the PMESII components.
- Information; The ability to influence groups or populations, through either direct or indirect action. Understanding who influences various audiences and what resources do they require; Knowledge; Expertise; Tools; Money

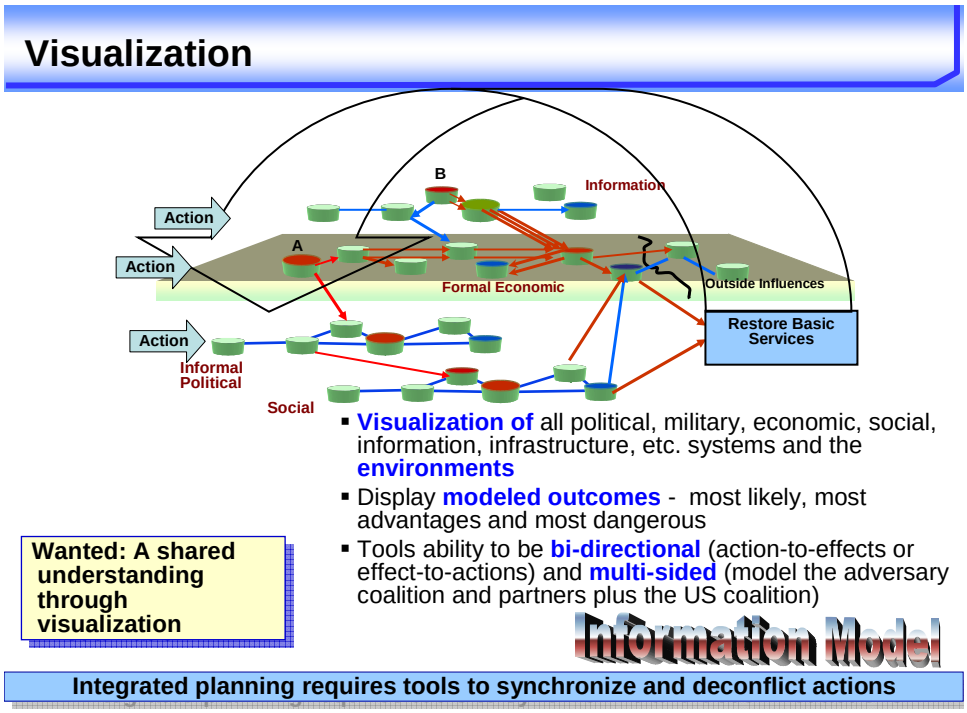


2.2 Visualization

The visualization capability enables leaders to easily understand and operate in the complex Political, Military, Economic, Social, Information, Infrastructure (PMESII) and other environments. Key elements of visualization include providing an understanding of the various PMESII environments; key nodes, their relationships, influences and sources of power; identification of critical nodes and paths; available information, it's quality or absence; the full range of possible outcomes by taking specific actions against nodes within the PMESII environments, their likelihood and possible impact on achieving operational objectives.[7]

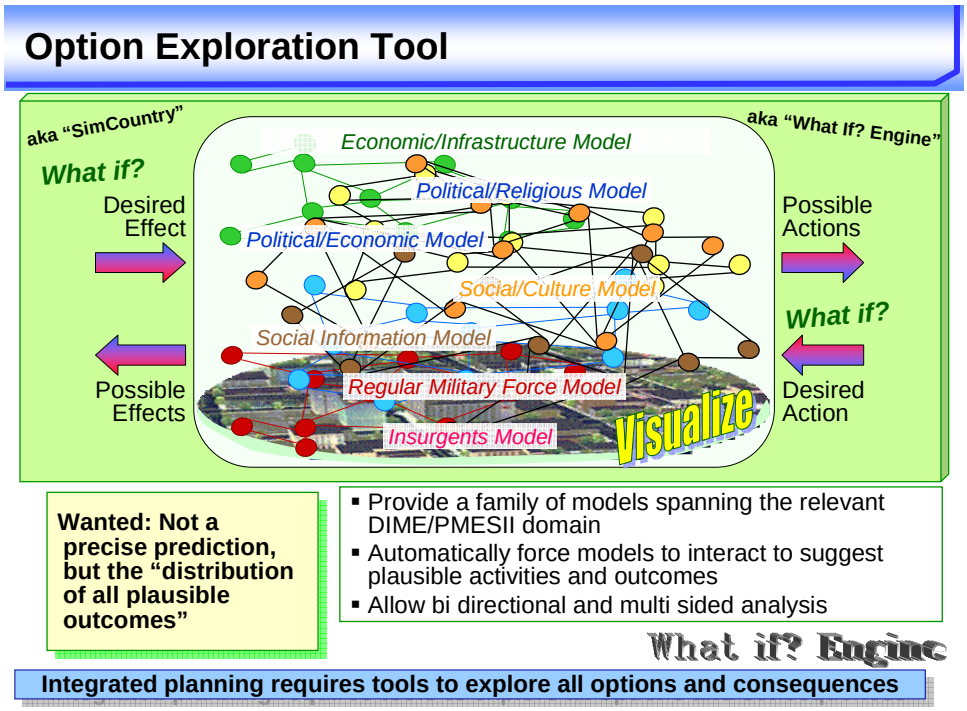
The PMESII construct provides a means to categorize and understand information. It is meant to assist leaders in understanding the environment and stimulate creative thought in solving complex problems. It does not give an exact representation of the battlespace or of modern operations. Visualization should always be viewed holistically as a system of interconnected PMESII and other environments. This holistic perspective enables leaders to sense changes in macro-patterns of behavior, see possible outcomes of actions, and decide on the appropriate courses of action to achieve their objectives.

Leaders, civilian and military, and the staffs that support them have very different visualization needs. Leaders tend to focus on a broader view of the conflict while the staff works on specific actions in individual environments. All of the groups needed to see all of the possible actions, or series of actions, and the probable causal linkages that will produce the most likely, advantages and most dangerous outcomes



2.3 Option Exploration

Option Exploration Tools enable leaders and staff to generate and evaluate the effects that might result from an action or the actions that could be employed to achieve a desired effect. These tools do not predict exactly what will happen, but only what might happen; generating the distribution or range of all plausible outcomes. The tools are essentially a “What If Engine.” and employ a large family of models. They allow command center personnel (not computer scientists or specialized domain experts) to find and integrate models into the family and to modify, customize, and tailor models to a particular military campaign -- on-the-fly -- as the campaign unfolds.[8]



3. Concept for Experimentation

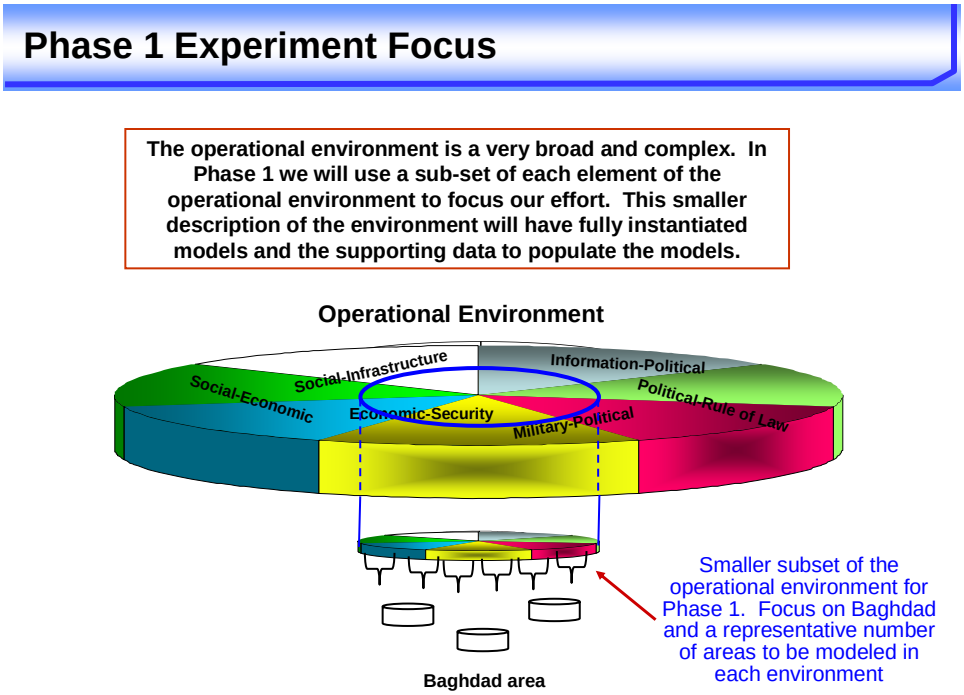
Phase 1 experimentation consisted of a series of JFCOM sponsored limited objectives experiments (LOE) to evaluate progress and guide technical development. The experimentation required close coordination with the contractors, experimentation design and technology teams to ensure the tools are exercised and had supporting information and data that enabled a thorough evaluation. The LOEs utilized an Iraq scenario and actual supporting information gathered from government and other sources to demonstrate the IBC tool capability. Each LOE was built upon the previous experiment and provided feedback on improvements to each component of the IBC system. The final experiment utilized three planning staffs, involved in multiple missions, to determine the relative capability of each contractor's IBC tools and provided recommendations to the program manager on which contractor should continue into phase two.

3.1 Experiment and Evaluation Development

The experimentation required close coordination with the contractors, experimentation design and technology teams from DARPA and JFCOM, as well as Senior Mentors and Subject Matter Experts, to ensure the tools were fully exercised and supported for evaluation. The Experiment and Evaluation (IPT) developed and executed the limited objective experiments, provided guidance to the development teams and evaluated the developers initial IBC capability. The IPT utilized experts from JFCOM J9 Experimentation, Joint Systems Integration Command and the Standing Joint Force Headquarters, retired senior military officers, and representatives from the Department of State and USAID.

The Experiment and Evaluation (IPT) needed to understand the decision tools being developed, how they functioned and the supporting information that would populate the models in order to design an effective experiment.

Current operations in Iraq served as the setting for the experiment scenario and the source for much of the knowledge, Operational Net Assessment (ONA) data and supporting orders and operations. Information to instantiate the models came from experts in their fields and those with experience in Iraq. Data to stimulate the models was drawn from classified and unclassified sources. This enabled a realistic evaluation of the tools capability as well as a smooth transition of successful software development to operational staffs. The entire operation in Iraq was too large for the initial experimentation. Baghdad and the surround areas provided a fairly complete subset of the entire problem and provided an excellent experimentation scenario.



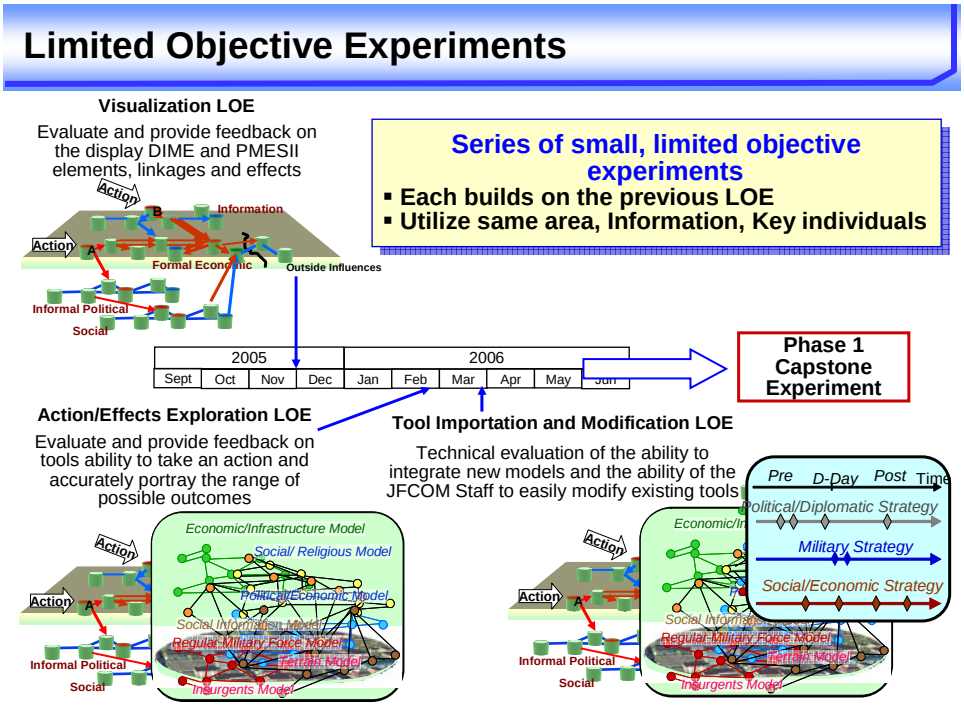
A wide range of expertise was required to validate the tools and measure the improved capabilities of operational staffs. Subject matter experts and staffs used the objectives and specific questions developed for the Limited Objective Experiments to evaluate progress and helped guide development. During the Capstone Experiment the same experts evaluated the relative capability of each contractor's IBC tools and provide recommendations on which should continue into phase two. Evaluation Metrics included:

- Favorable and Unfavorable Outcomes identified. Looking at quantity, quality and time.
- Multi-Dimensional Capability. The tools are able to be used by one or more sides and can be b-directional

- Ease of Use by leaders and staff
- Model Modification and Insertion. The ability to insert new models into the family of models and easily modify existing models[9]

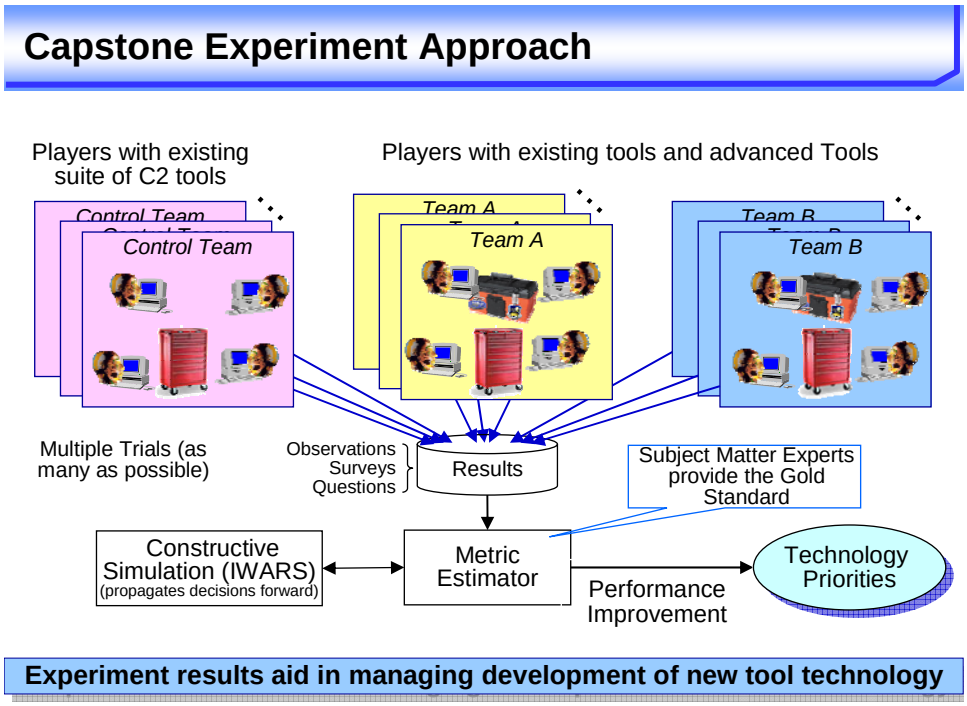
3.2 Limited Objective Experiments

A series of JFCOM sponsored limited objectives experiments (LOE) were used to evaluate progress and guide technical development. The LOEs utilized an Iraq scenario and actual supporting information gathered from government and other sources, to demonstrate the IBC tool capability. Each LOE was build upon the previous experiment and provide feedback on improvements for Visualization; Action/Effects Exploration; and Tool Importation and Modification.



3.3 Phase 1 Capstone Experiment

The Phase One Capstone experiment evaluated the ability of the IBC tools to provide significant improvement in the operational capability to a Joint Task Force planning staff. Two planning staffs used the two contractor's tools to plan several missions. A third staff used currently available JFCOM planning tools to establish a baseline capability. The experiment continued to utilize the Iraq scenario, ONA data base and other sources of information from the contractor and outside sources to stimulate the tools.



4. Experimentation

4.1 Limited Objective Experiment (LOE# 1) Visualization

4.1.1 Experiment Execution

The US Joint Forces Command and DARPA executed Limited Objective Experiment (LOE# 1) Visualization to evaluate and guide contractor development of visualization technology that assisted leaders and staff in understanding the planning and execution of unified campaigns in complex contingencies. This was the first of a ground breaking series of limited experiments where operational expertise was used to inform and guide technical development. The experiment was conducted at the JFCOM facilities in Norfolk Virginia. Experts involved included operational planning staff members from JFCOM J9 and the Standing Joint Force Headquarters, retired senior military officers, and representatives from the Department of State and USAID. The Iraq scenario and supporting ONA data bases and information was used to demonstrate the tools capability and the contractor teams operated the tools.[10]

The experts were divided into two teams with a mix of leaders and staff and a team was sent to each contractors. Two contractor teams led by BAE Systems and Lockheed Martin presented the capabilities and operations of their tool kit. Experts then split into four sub groups and asked more detailed individual questions. The Leader and Staff subject matter experts asked a series of questions to examine, in some depth, each of the visualization toolkits capabilities and ability to visualize conditions within the overall PMESII environment. After the initial session, the teams were interviewed on their

impressions and they switched contractors and repeated the exercise. Contractors recorded the expert's questions and asked follow on questions to understand the expert's views and recommendations for visualization. This enabled the contractor teams to received valuable experience and feedback from a wide variety of experts and gain insight into the needs of operational-level commanders, non-military leaders, and their staff.

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Limited Objective Experiment 1 Visualization

- **DARPA and JFCOM used subject matter experts (SME) in effects based approach to joint operations, command center operations, the different PMESII areas, and senior leadership decision-making**
- **SMEs were asked to examine, in depth, each visualization toolkit**
  - **Goal: Provide each contractor team with concrete feedback on:**
  - **What parts of the displays appear to aid in visualization of the overall PMESII environment … which do not [1]**
  - **What additional information and/or linkages would be useful to a staff in assessing the overall situation**
- **Event structured around planning scenarios based on current conditions in the Middle East**
  - **To support experimental events, each team was provided a copy of the current Multi-National Forces Iraq (MNFI) Operational Net Assessment (ONA) database**

- **[1] Note: Integrated Battle Command Visualization and IBC concept papers provide a detailed listing of key elements that must be visualized.**

4.1.2 Emerging Results

The diverse set of experts reinforced two substantively different end-user needs/expectations for the tool. The JFCOM Staff approached the tools from the current military planning process perspective using Effects Based Operations techniques and a mission analysis-like planning methodology. The Leaders took a longer view, desiring instead an accurate sense of the operational environment in order to illuminate potential diplomatic, informational, military and economic strategies and enable them to plan and execute campaigns.

The contractors were not nearly as far along as had been expected and were still struggling with what Leaders and Staff wanted to visualize. The contractors reverted back to showing the Operational Net Assessment (ONA) data base and other data bases used to populate the models as well as some of the working models. This was more of a computer science view of the problem and not what operational leaders and staff required to understand the environments and effectively operate. Leaders were looking for a means to use the information from the instantiated models and supporting data bases to show the operational environment, key nodes and interactions between

them. The staff was interested specific actions, relationship between nodes and expected effects.

The two contractor teams showed very different approaches to solving the visualization, modeling and human-computer interaction aspects of the project. Both approaches showed promise but needed significant refinement and additional development. The contractor teams received extensive and valuable experience and feedback and gained insights into the needs of operational-level commanders, non-military leaders, and their staff.

Limited Objective Experiment 1 Visualization Emerging Results

- **Competing contractors demonstrated different approaches for visualization and situational understanding. LOE #1 provided a vigorous and constructive exchange of views and feedback to the contractors on their individual approaches.**
- **Leaders and Staff have significantly different needs and operations to perform with the IBC tools.**
  - **Senior Leaders were interested in understanding the situation, links and influences between different groups and broad actions that could be taken to achieve objectives**
  - **Operational Staff focused on specific effects, nodes, actions; the current military planning process model utilizing EBO techniques and quickly pursued a mission analysis-like planning program.**
- **Overall**
  - **Require the flexibility to modify views to meet the Senior Leader, Operational Staff requirements**
  - **Need to focus the visualization on the user needs and not on the models and databases**
  - **Human Engineering is important**

Enabled Leaders and Operational Staff to provide direct feedback to contractors and influence the technical development

4.2 Limited Objective Experiment (LOE# 2) Action/Effect Exploration

4.2.1 Experiment Execution

The second LOE built on the first and provided an evaluation of the revised Visualization capability as well as an evaluation and guidance for contractor development of Action/Effects Exploration technology. The experiment was conducted at the JFCOM facilities in Norfolk Virginia with essentially the same group of operational and subject matter experts that participated in LOE # 1. The Iraq scenario and supporting ONA data bases and information were used with improved visualization and additional models built off LOE #1 developments. [11]

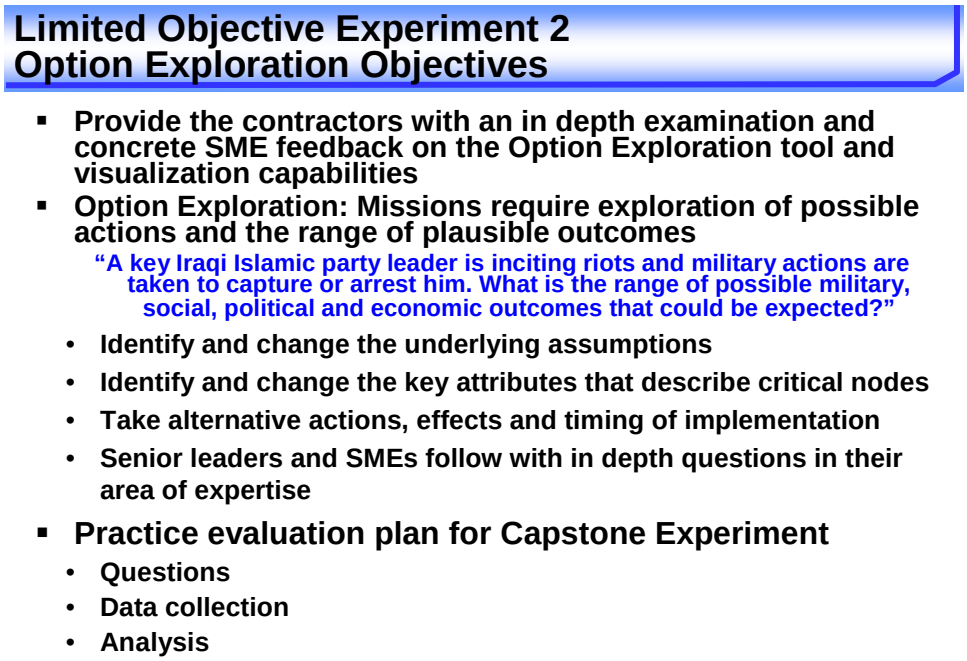
The experts were divided into two teams and further sub divided into smaller Leader and Staff only groups. Key environments and expected interactions were identified and incorporated into the questions provided the experts. This helped bound the scope of the LOE, focused discussion and showed the functioning models. The experts used the

questions as a start point and then asked more detailed questions in their area of expertise.

An example of the type of questions asked were:
The Sunni leader of the Iraqi Islamic party is inciting advocating the violent overthrow of the current Iraq government and inciting riots.

1. If military actions are taken to capture or arrest him, what is the range of possible military, social, political and economic outcomes that could be expected?
2. Who should lead the action?
    a. US Forces
    b. Iraqi Army
    c. Iraqi Police?
3. What are the underlying assumptions of the modeling for each action?
    a. Change them. What are the results?
4. What are the attributes that describe the key nodes?
    a. Change them. What are the results?

After the initial session, the teams were interviewed on their impressions and they switched contractor and repeated the exercise. Contractors recorded the expert's questions and asked follow on questions to understand the expert's views and recommendations.



4.2.2 Emerging Results

LOE #2 reexamined the required visualization capabilities and reviewed the Action/Effects Exploration model interactions and operations. The visualization capabilities were divided into those used by Leaders and those used by the supporting

staff. The Leaders continued to take a longer view, desiring a sense of the operational environment they were operating in. The contractors took different approaches to accomplish these tasks. Both made significant strides in presenting the information to the very different users. The Leaders saw progress in representing the environments and interactions but still thought the displays were too simplistic and focused more on the staff tasks.

The staffs were generally pleased with the progress of the visualization. The contractors tented to automate or assist in the current method of doing their job today. The problem with the displays and visualization is that they focused on today's method of operation, not on providing future capabilities. The LOE showed a need to have the ability to manipulate and change the views, attributes displays and modifications based on specific user desires.

The Action/Effects Exploration provided an initial capability to model the Political, Military, Economic, Social, Information, Infrastructure (PMESII) environments. Again the contractors were not nearly as far along as the government team would have liked. Both were able to show individual models working and the ability to change key assumptions and attributes. In certain areas, multiple models, linked together showed the possible outcomes in a variety of PMESII environments. They demonstrated the capability to link and provide inputs for various models, but it was a rudimentary capability. Most models needed to be instantiated and much more detailed. The linkage between models had to be expanded. The range of possible outcomes had to be increased, clearly identified and presented in an easily understandable fashion.

Limited Objective Experiment 2 Emerging Results

- **Contractors demonstrated significant progress on providing leaders and staff a more comprehensive visualization and situational understanding.**
- **LOE #2 provided a vigorous and constructive exchange of views and feedback to the contractors on their individual approaches.**
- **Option Exploration provided an initial capability to model the Political, Military, Economic, Social, Information, Infrastructure (PMESII) environments**
  - **Contractors were not nearly as far along as expected**
  - **Demonstrated individual models working and the ability to change key assumptions and attributes**
  - **Demonstrated that multiple models, linked together, showed the possible outcomes in a variety of PMESII environments**
- **Overall**
  - **Most models needed to be instantiated and much more detailed**
  - **The linkage between models had to be expanded**
  - **Range of possible outcomes had to be increased, clearly identified and presented in an easily understandable fashion**

Continual Leaders and Operational Staff feedback enabled the technical development to meet operational needs

4.3 Limited Objective Experiment (LOE# 3) Tool Importation and Modification

4.3.1 Experiment Execution

The Tool Importation and Modification LOE was a two part evaluation. The objective was to evaluate the ability of the contractor's Integrated Battle Command suite to accept and integrate other models. This was primarily a technical evaluation. A second evaluation looked at the ability of a trained planning staff to modify and use their IBC tool set. The planning staff used the tools on simple problems to manipulate views, models and operations.

LOE # 3 was run at the individual contractor facilities. The government team arrived on day 1 with a new model and documentation. The contractors had 24 hours to integrate the model into their family of models and then demonstrate that if functions correctly and impacts on the range of possible outcomes generated.

The second part of the LOE took place on the afternoon of the second day. Contractor took one half of a day to introduce the system to the staff and train them on the use of the tool. The staffs consisted of JFCOM operational staff members and subject matter experts with expertise in computer-based models, databases, human-computer interfaces, and senior leadership decision-making. [12]

Limited Objective Experiment 3
Tool Importation and Modification Objectives

- **Evaluate the ability of the contractor's Integrated Battle Command suite to accept and integrate other models**
  - **Provide new model with documentation**
  - **Contractor has 24 hours to fully integrate**
  - **Demonstrate that the new model has been integrated into the family of models, functions correctly and impacts on the range of possible outcomes generated**
- **Usability: Ability for a trained staff to operated the IBC suite of tools**
  - **JFCOM operational staff members and subject matter experts with expertise in computer-based models, databases, human-computer interfaces, and senior leadership decision-making**
  - **One half day training**
  - **Execute simple planning problems**

4.3.2 Emerging Results

LOE # 3 March 06

4.4 Lessons From the Limited Objective Experiments

The Limited Experiments (LOEs) were extremely valuable in providing the contractors feedback and guidance on the technical development. Somewhat unexpectedly they also exposed some deficiencies in the experimentation plan that had to be addressed for the Capstone Experiment. Key areas that had to be modified were the personnel and skills required for the Capstone experiment and the specific type and amount of data needed to determine a Go, No Go decision.

We found that not all of the participants were able to let go of current doctrine and today's procedures to see how the emerging technical could influence operations in the future. Those who were focused on the day to day real operational world tended to have a tough time implementing new concepts and developing new technologies. Generally they were somewhat closed minded and only saw the technology as a means to improve or automate the current process. Initially we had intended to use the senior leaders as part of the evaluation team. The technology enables a closer and continuous coordination between the leaders and staff. The need for much more open minded staff and ability to military and civilian leaders to be much more involved in the planning development allowed several changes in the experiment staffing. Senior leaders, both military and civilian, were made a part of the experiment planning staff, looking at possible contingency operations a Joint Task Force in Baghdad would face. The three staff elements now consisted of a senior military leader, senior civilian leader and three operational staff planners. These staff elements operated with either BAE tools, manned by BAE operators; Lockheed Martin tools manned by LM operators; or a non tools staff using existing SJFHQ tools and the inputs from six System of Systems Analyst. These three staff elements rotated between the different support structures with each vignette.

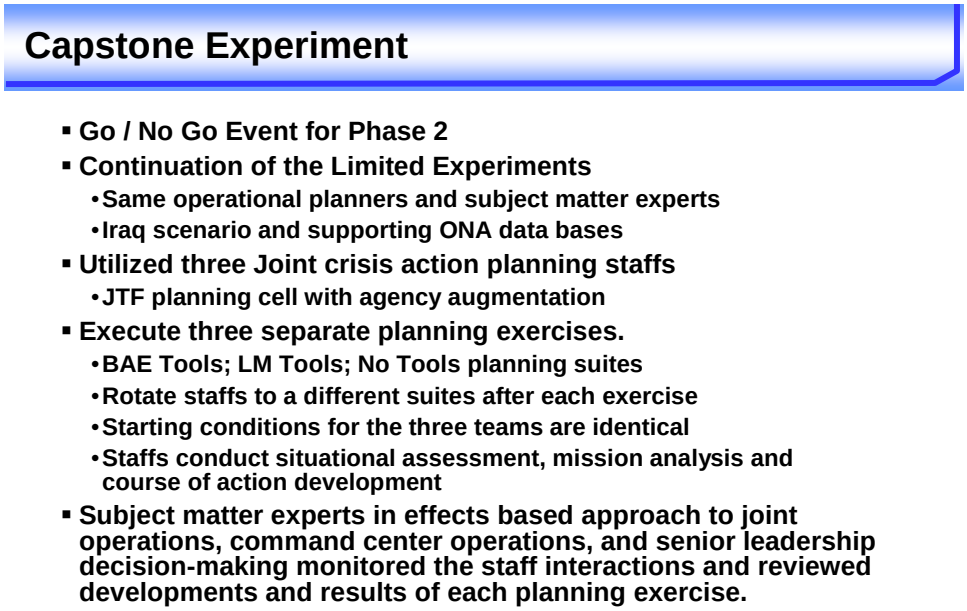
Baghdad and the current operations provided a rich, realistic, full body of information to stimulate the staff planning. However, the limited experiments showed that many people were too familiar with the current situation and tended to rely on their own knowledge and not the information provided in the experiments. The decision was made to utilize the underlying data bases and knowledge that had been developed but to add several critical new entities to the situation that would have a significant impact on operations. This leveled the playing field and forced all participants to carefully examine all of the experimentation information before developing courses of actions.

The design of the Capstone experiment was also changed based on lessons learned from the limited experiments. The initial evaluation plan called for the collection of a large amount of information without regard for the time or resources required to collect or analyze the data. Data collection of a representative sample of the information during the LOEs simply overwhelmed the evaluation team. The experiments identified the need to reduce the data collection effort by focusing on the metrics and critical information needed to make the Go No Go decision. The key decision metrics involved the number of positive and negative outcomes that could be identified using the tools verse no having the tools available.

4.5 Phase 1 Capstone Experiment

The Capstone Experiment utilized essentially the same group of operational and subject matter experts that participated in the LOEs, the Iraq scenario and supporting ONA data bases. The three week experiment was conducted at the JFCOM facilities in Norfolk Virginia.

This experiment utilized three Joint crisis action planning staffs, each of which performed a series of three separate planning exercises: one with the tools currently available to the planning staff, one using the BAE toolkit, and one using the LM toolkit. For each planning exercise, the starting conditions for the three teams were identical; only the tools available differed. After each exercise, the teams rotated to the next toolset, so that each team had an opportunity to use each of the three available toolsets. Subject matter experts in Effects Based Operations, command center operations, and senior leadership decision-making monitored the staff interactions and reviewed developments and results of each planning exercise. Key elements examined were the depth of analysis, accuracy and completeness, and the absence/presence of consideration for second- and third-order possible outcomes in the process. The evaluation team had to be aware of individual planner's actions as the tools allowed them the opportunity to execute their own independent what/if analysis. Quantitative pair-wise comparisons were made using the "Expert Choice" toolkit.



The staffs began the experiment after the situational assessment step in crisis action planning and went through crisis assessment and course of action development to determine possible recommended courses of action. The time period available to conduct the planning was constrained as time to develop sources of action, depth of

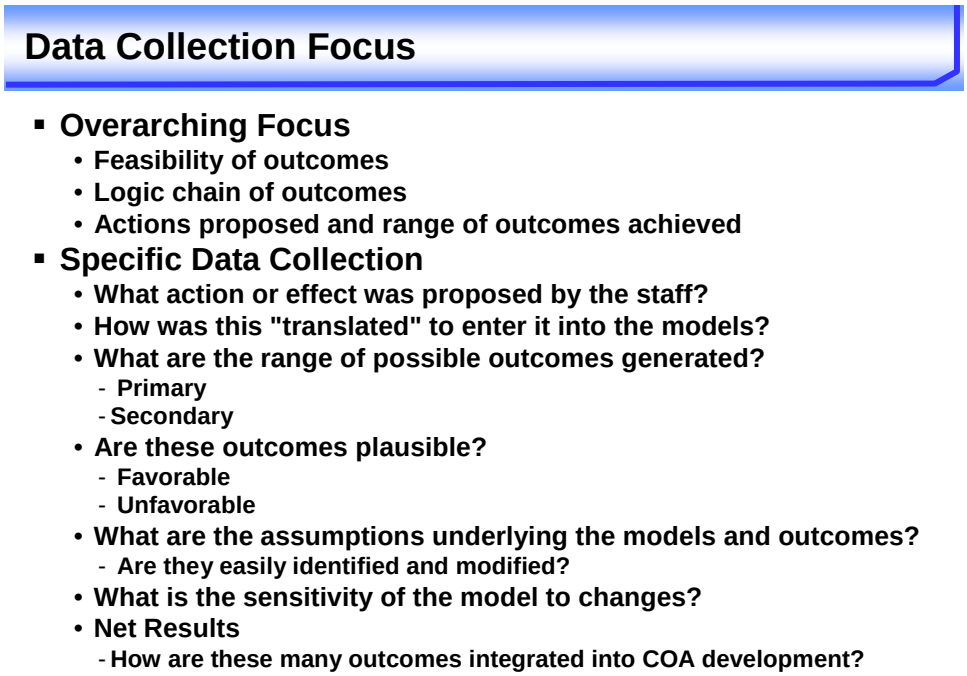
evaluation and number of actions evaluated was key evaluation criteria. The staffs provided the range of possible outcomes from individual and multiple actions to support the choice of a course of action. After the experiment at JFCOM, those recommended actions were inserted into a Plan Evaluator, based on the IWARS simulation, to see the possible effects of actions over time.

IBC Program Metrics

- **DARPA Metrics:**
  - ***DARPA M1*: Number of Predicted Unfavorable Outcomes**
    - **Measure the quality of the identified outcomes, amount of time to develop those outcomes and the number of outcomes**
    - **Unfavorable outcomes are defined as outcomes that have a negative impact on the decision-maker's objective**
    - **Threshold: 10:1 increase over the use of current tools**
  - ***DARPA M2*: Net Number of Favorable Outcomes Achieved**
    - **Measure the quality of the identified outcomes, amount of time to develop those outcomes and the number of outcomes**
    - **Favorable outcomes are defined as those that support the decision-maker's objective.**
    - **Threshold: 10:1 increase over the use of current tools.**
  - ***DARPA M3* : Ease of Use: Allow a trained planning staff to learn and operate the system with limited outside training. The tools should be intuitive, easy to use, and provide useable embedded training and help functions.**
  - ***DARPA M4*: Model Modification and Insertion: The tools should allow the user to insert new models into the family of models, and to easily modify the parameters and variables (assumptions) of existing models.**
  - ***DARPA M5*: Multi-Directional Capability: *legitimate yet plausible low-probability, high-consequence events, or high-probability, low-consequence***
    - **Bi-Directional: *A*ction-to-effects or effect-to-actions**
    - **Multi-sided: Model the adversary coalition and partners plus the US coalition)**

Provide Leaders feasible outcomes that surprise and astound them

The emerging technical capability fundamentally changed how an operational planning staff would plan and execute operations. A concept for operations for a staff using the Integrated Battle Command tools had to be developed and evaluated as the experiments progress. These operational changes had to be understood and different means developed to capture the data required to evaluate the impact on a SJFHQ planning staff executing crisis action planning.



4.5.2 Emerging Results

Capstone Experiment May 06

5. Conclusions

New technology developments that support operations in this new operational environment and involve emerging warfighting concepts can be developed simultaneously. It requires team effort and extremely close working relationship between concept developers, contractors and the operational staffs. The Defense Advanced Research Project Agency (DARPA) and U.S. Joint Forces Command (JFCOM) establish this partnership with an implementing Memorandum of Agreement and strengthened it with continuous open and frank dialogue.

Experimentation to evaluate the developing transformational concepts and technologies had to be an integrated team effort, with an innovated experimentation approach. The experimentation team needed to understand the emerging concepts; the tools being developed and how they functioned; and how leaders and their staffs would use this enhance capability to plan and execute effects-based campaigns. The models needed realistic information to instantiate the models as well as data to populate them and provide realistic and relevant results.

The Integrated Battle Command team was able to execute a series of limited objective experiments that evaluated capabilities and provided guidance for the technical development of the Visualization, Option Exploration and Tool Importation and

Modification capabilities. The Phase 1 Capstone Experiment, with three planning staffs, involved in multiple missions, provided an operational evaluation of the tools and enabled the selection of a contractor team to continue expanded development of Integrated Battle Command.

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