15th ICCRTS
"**The Evolution of C2**"

Maritime Operations Center (MOC)
Collaborative Information Environment (CIE):
A Concept Demonstration for Visualizing Requirements

Modeling and Simulation
Experimentation and Analysis
C2 Assessment Tools and Metrics

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Maritime Operations Center (MOC) Collaborative Information Environment (CIE): A Concept Demonstration for Visualizing Requirements

Abstract

The Maritime Operations Center (MOC) in concert with the Maritime Headquarters provides a framework from which Navy commanders at the operational level exercise command and control (C2). C2 entails both the processes and systems as they relate to the exercise of authority and direction over assigned or attached forces and organizations (Reference 2). The Navy has identified shortfalls in the form of significant variations within and among operational-level C2 processes across the range of military operations, which negatively affect the Navy's ability to deploy distributed operations capabilities across its core missions. Our paper presents an approach to improve standardization of MOC processes and the use of those processes to facilitate increased situational awareness and understanding of the mission as it evolves during planning. Process standardization and improvement is achieved via modeling and simulating MOC planning processes, which in turn, are translated into actionable workflow in the form of a prototype Maritime Collaborative Information Environment (CIE). The CIE will be used to visualize planning requirements, i.e. determine what works and what doesn't work, as they evolve and to demonstrate how planning products and their status can be shared collaboratively during the mission planning.

1. BACKGROUND

The Maritime Operations Center (MOC) is a Navy priority for improving planning and execution at the Operational Level of War (OLW). The MOC in concert with the Maritime Headquarters provides a framework from which Navy commanders at the operational level exercise command and control (C2). C2 entails both the processes and systems as they relate to the exercise of authority and direction over assigned or attached forces and organizations (Reference 2). The Navy has identified shortfalls in the form of significant variations within and among operational-level C2 processes across the range of military operations, which negatively affect the Navy's ability to deploy distributed operations capabilities across its core missions.

Navy Warfare Publication (NWP) 3-32 (Reference 1), Maritime Operations at the Operational Level of War, provides organizational guidance to the Fleet Commander for integrating into the Joint Force and for directing subordinate commands. Further, through the release of the Navy Tactics, Techniques & Procedures (NTTP) 3-32.1 (Reference 2) (Maritime Operations Center) manual in October 2008, Chief of Naval Operations Admiral Gary Roughead directed all numbered fleets and Navy Component Command (NCC) Headquarters to adopt the MOC systems approach, allowing

commanders to more easily and effectively control assigned and attached forces by monitoring, assessing, planning and directing missions. One question regarding that guidance is how to standardize MOC C2 processes and utilize those standardized processes within and among MOCs in a distributed, collaborative environment.

As a step towards addressing that question, U.S. Fleet Forces Command (USFF), in concert with the Johns Hopkins University Applied Physics Laboratory (JHU/APL), is developing/augmenting a structured decomposition of its mission-level C2 planning, directing, monitoring, and assessing (PDMA) processes with the goal of representing those processes via formalized modeling and simulation (M&S). M&S will be used to support "what-if" analysis for process standardization and improvement as well as the translation of those processes into actionable workflow in the form of a Maritime Collaborative Information Environment (CIE). The CIE will be developed in prototypic form to allow war fighters to visualize planning requirements, i.e. determine what works and what doesn't work, as they evolve. It will leverage characteristics and attributes of the existing Integrated Strategic Planning and Analysis Network (ISPAN) CIE, a USSTRATCOM initiative, but will be enhanced with adaptations addressing maritime workflow. The CIE will contain content and status pages that provide MOC operators functional and organizational views of their mission tasks. The CIE will also be used to demonstrate how planning processes can be standardized and how planning products resulting from those processes and their developmental status can be shared collaboratively to increase situational awareness and understanding during mission planning.

2. SCOPE

The scope of this paper includes a brief description of the Multi-resolution Modeling Evaluation Framework (MRMEF) modeling approach used for the project, which is more fully described in the References (3, 4). It discusses workflow modeling regarding one portion of MOC mission planning, i.e. the Conduct Operational Mission Planning process that we addressed so far in this year's research. Finally, the paper presents an overview of the structure utilized within the concept demonstration form of the MOC CIE that will allow war fighters to visualize planning requirements as they evolve.

3. NET-CENTRIC C2 EVALUATION DESCRIPTION

Several key elements, listed below, are considered to be significant enablers for the successful evaluation of net-centric C2. Those elements are described in detail in the following paragraphs.

- Multi-resolution Modeling Evaluation Framework (MRMEF)
- Workflow Modeling

3.1.1 Multi-resolution Modeling Evaluation Framework (MRMEF)

The MRMEF was developed to serve as our foundational basis for evaluating net-centric C2. It utilizes constructive, virtual, and live simulations and hardware-, software-, and humans-in-the-loop, where appropriate, to support that evaluation. Multi-resolution Modeling (MRM) has many advantages over more traditional approaches for analyzing C2. It has been successful because it has the characteristics needed to solve difficult analysis problems by integrating information achieved with high-fidelity models and generalizing the results and implications via a low-resolution model (Reference 5). An overview of the MRMEF is shown in Figure 1. A brief summary of the MRMEF is provided in Appendix A.
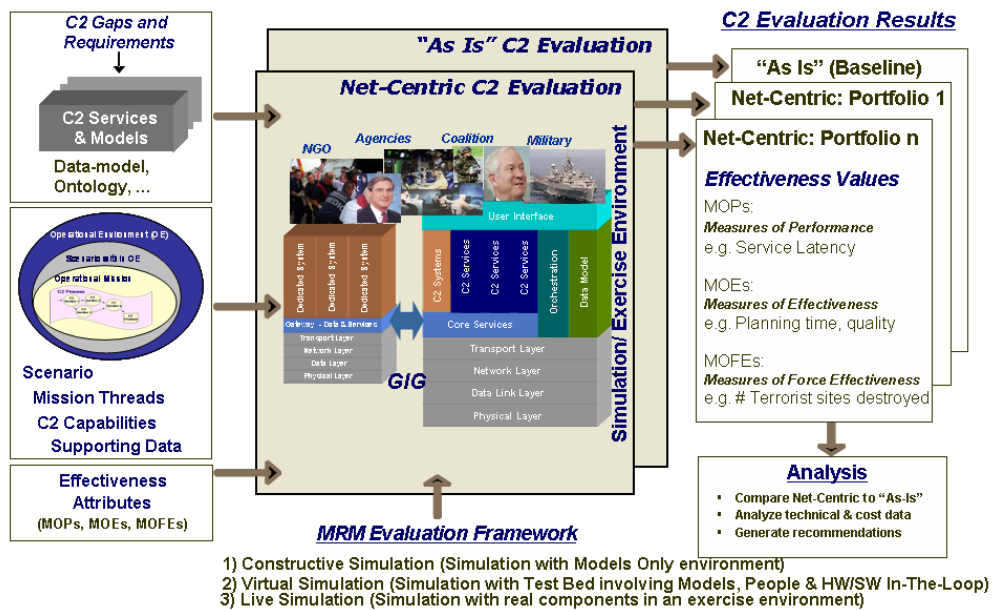

Figure 1. Multi-resolution Modeling (MRM) Evaluation Framework (MRMEF)

3.1.2 Workflow Modeling

One of the requisite enablers for the successful analysis and evaluation of C2 and a key element of the MRMEF is the ability to decompose C2 processes in the context of a mission domain. Our research this year has focused on C2 as it applies to operational level of war planning processes in a maritime domain. Based on the MOC architectural products developed by U.S. Fleet Forces Command, we developed a model and simulation of the Conduct Operational Planning process (Figure 2). The model is divided into a series of functional swim lanes. The Future Operations (FOPS), Future Plans (FP), and Naval Component Commander (NCC CDR) swim lanes represent the tasks and workflow associated with each of those respective organizational elements. The MOC

CIE swim lane represents the various products that are produced and consumed by those functional tasks. The Battle Rhythm (BR) swim lane represents the key events that occur during the conduct of the mission. Those events depend on the work being performed by the FOPS, FP, and NCC CDR organizational elements and the products that each produce and consume, which are stored in the MOC CIE. The simulation, an executable form of the Conduct Operational Planning model, allows us to analyze temporal aspects of the various products being produced by the functional swim lanes. This is particularly important when the battle rhythm needs to be compressed and products produced at a faster rate. In the future, the simulation will support analysis of resources associated with each swim lane and help us determine when resource loading with respect to product generation is reaching a problematic state. We used the Telelogic ProcessModel ™ tool to develop the model and simulation.
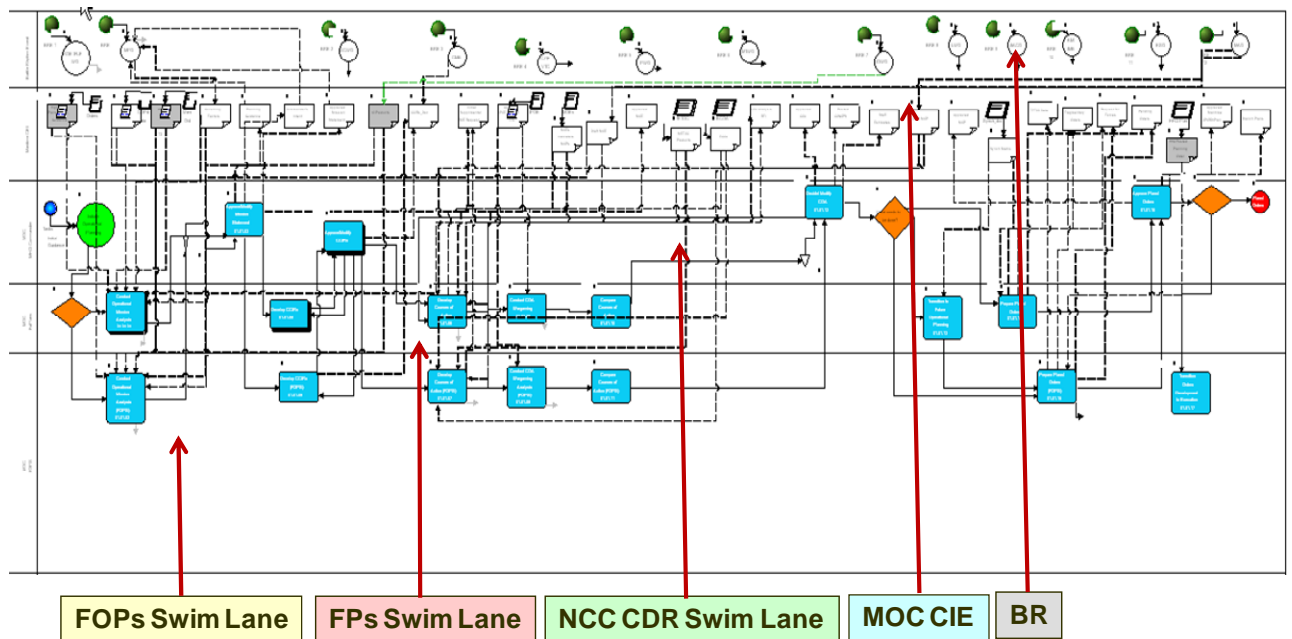

Figure 2. Model of the MOC Conduct Operational Planning process

4. CONCEPT DEMONSTRATION FORM OF THE MOC CIE

Based on the process model, we began developing a set of requirements for converting the model workflow into an actionable work flow, in the form of a prototypic version of a MOC CIE that would facilitate situational awareness and understanding during the mission planning process. A conceptual representation of the MOC CIE is shown in Figure 3.
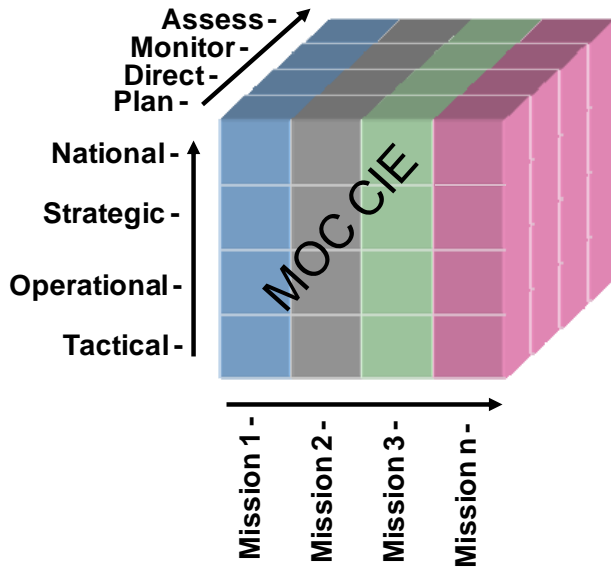
Figure 3. Conceptual representation of MOC CIE

In the representation, each "mission slice" through the cube represents a set of pages in the CIE supporting a given mission. Each cube within a "mission slice" represents one or more content and status pages based on a PDMA/National, Strategic, Operational, and Tactical (NSOT) pairing, e.g. a set of Planning (P) pages at the National (N) level. It is envisioned that mission page sets and their external links are instantiated dynamically at mission creation time. Based on that conceptual framework, we developed a set of CIE page layout structures, the top level of which is shown in Figures 4 and 5. Figure 4 represents the selection of an existing Irregular Warfare (IW) mission from an organizational view perspective. All of the organizational elements that have mission related roles are depicted on the right side of the diagram. These include the MOC Command Element (MCE), Naval Component Commander (NCC CDR), Communications Information Systems (CIS), Military Intelligence Operations Center (MIOC), Logistics Readiness Center (LRC), Current Operations Cell (COPS), Future Operations Cell (FOPS), Fires Elements (FE), Information Management (IM), Maritime Assessment Group (MAG), Future Plans cell (FP), Training Division (Train), Administrative and Personnel Division (Admin), and METOC cell.

The completion status of the work products being produced by each of the organizational elements is represented by the colored circular objects next to each element name. Figure 5 represents a similar page layout approach but from a functional view perspective. Seven top level mission functions exist; each of which are further decomposed into multiple sub-functional levels. The Plan function, for example, is decomposed into twelve sub-functions. A similar decomposition was applied to the organizational view described previously but not elaborated upon here.
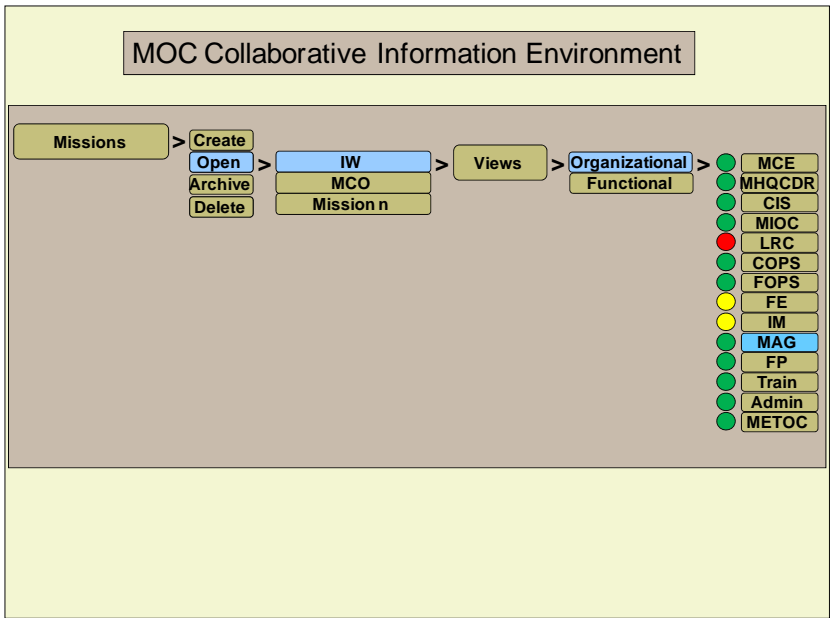
Figure 4. Top level MOC CIE page structure from an organizational view perspective
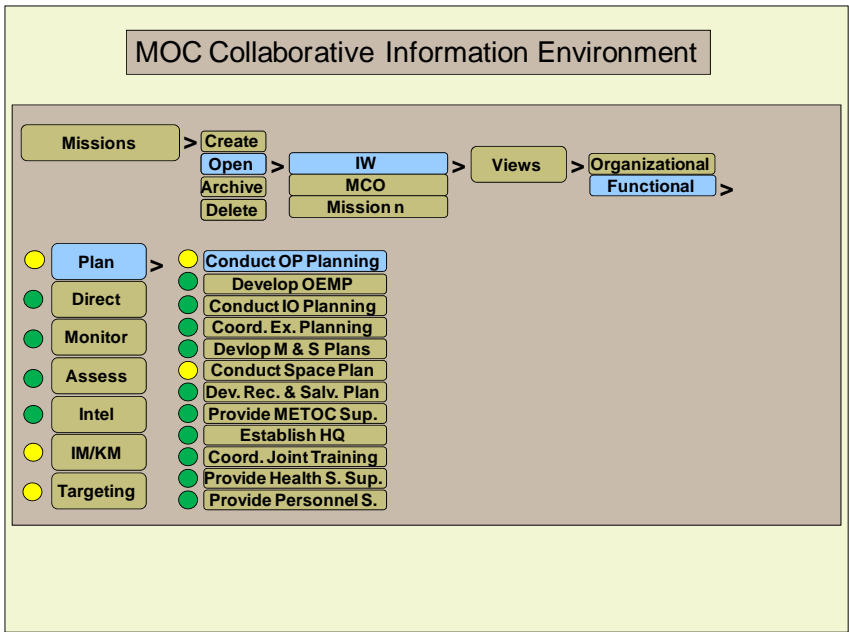
Figure 5. Top level MOC CIE page structure from a functional view perspective

This year's effort has focused on the Conduct Operational Planning sub-function, which is highlighted in blue in Figure 5. As in Figure 4, the completion of work products associated with each functional area is depicted by the colored circular status objects. Figure 6 shows the decomposition of the Conduct Operational Planning process into seven sub-functions that are the responsibility of the Future Plans element. Each of those sub-functions is further decomposed into a more detailed set of sub-functions. Figure 7 shows the decomposition as it applies to the Conduct Operational Mission Analysis process.
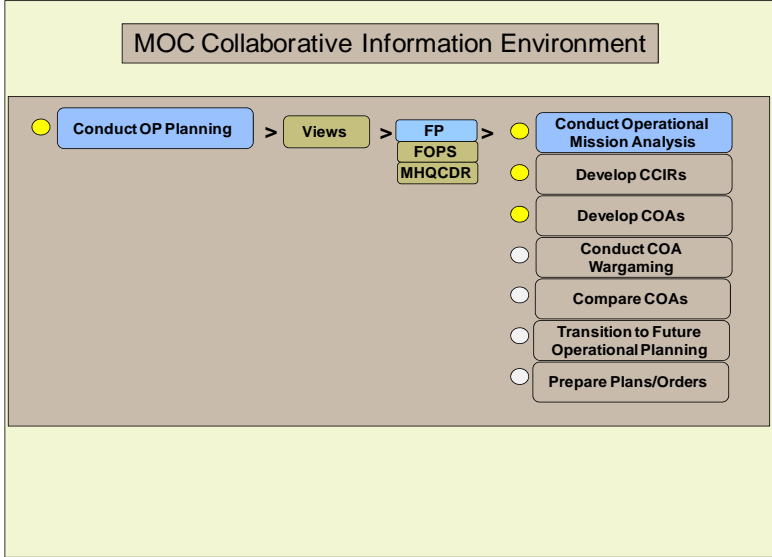

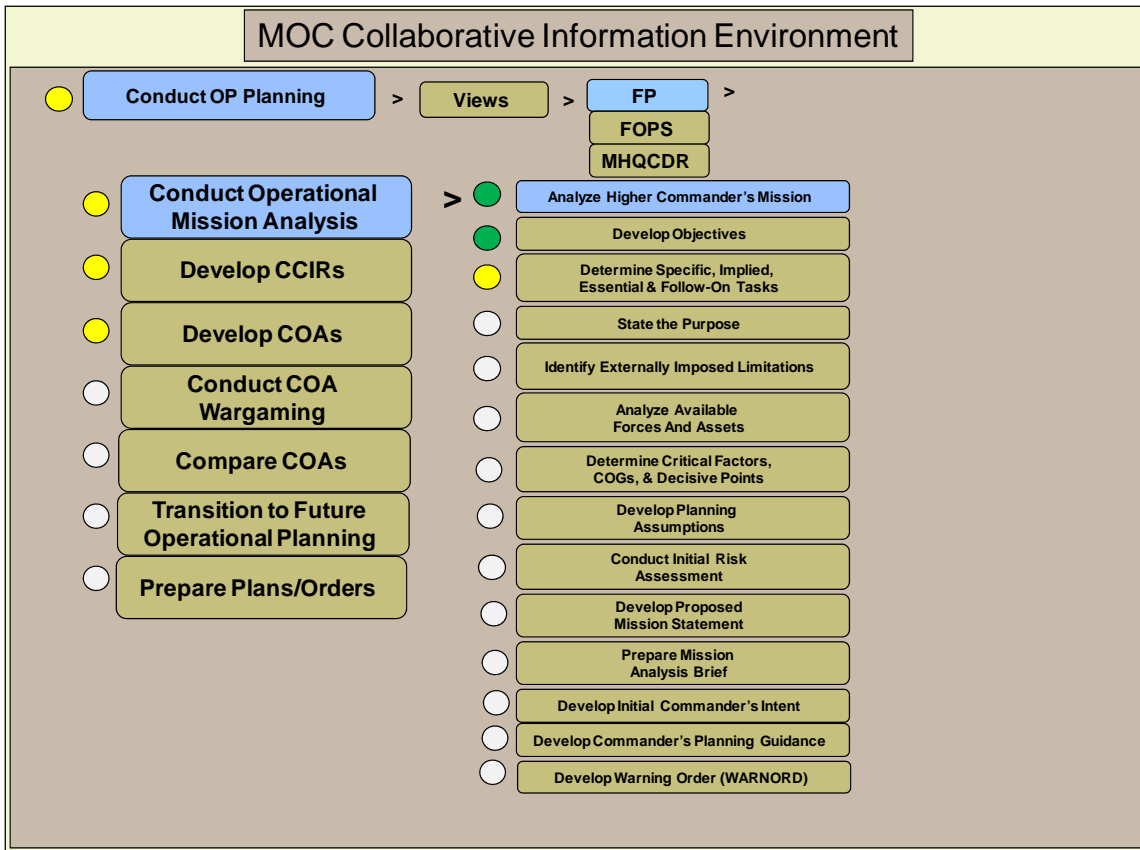Figure 6. Decomposition of Conduct Operational Planning, Future Plans View

Figure 7. Decomposition of Conduct Operational Mission Analysis

Finally, Figure 8 represents a "leaf", or end node, of the cascading menu chain in which work associated with any given function, in this case Analyze Higher Commander's Mission, is depicted as a set of inputs needed to complete the work associated with that function and the set of outputs that represent the work completed. The inputs and outputs can be linked to documents or other pages within the CIE, or web parts/portlets representing actual work content. In some cases that content is developed by operators interacting with the page directly and in other cases that content is provided by systems external to the MOC CIE through web service interfaces.

In addition to providing collaborative access to mission products and their respective development status, we also plan to include a requirement for a method by which dependencies across key mission events/products associated with multiple lines of operation can be visualized in a graphical environment. An example of such a visualization is provided in Figure 9.
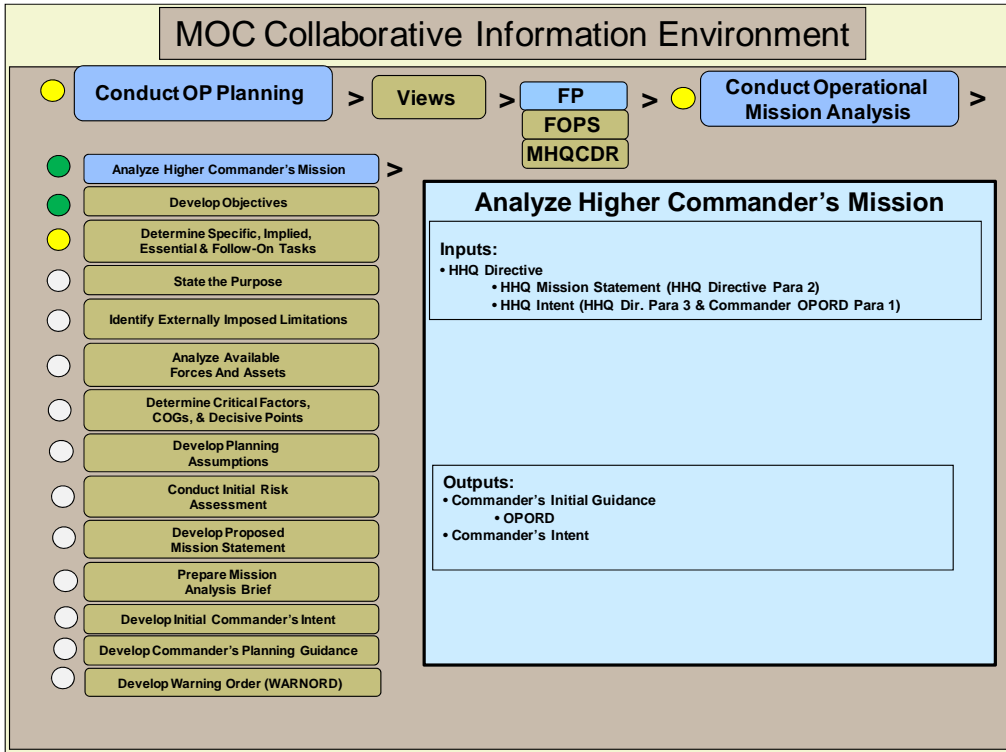
Figure 8. Inputs/Outputs Associated with the Analyze Higher Commander's Mission
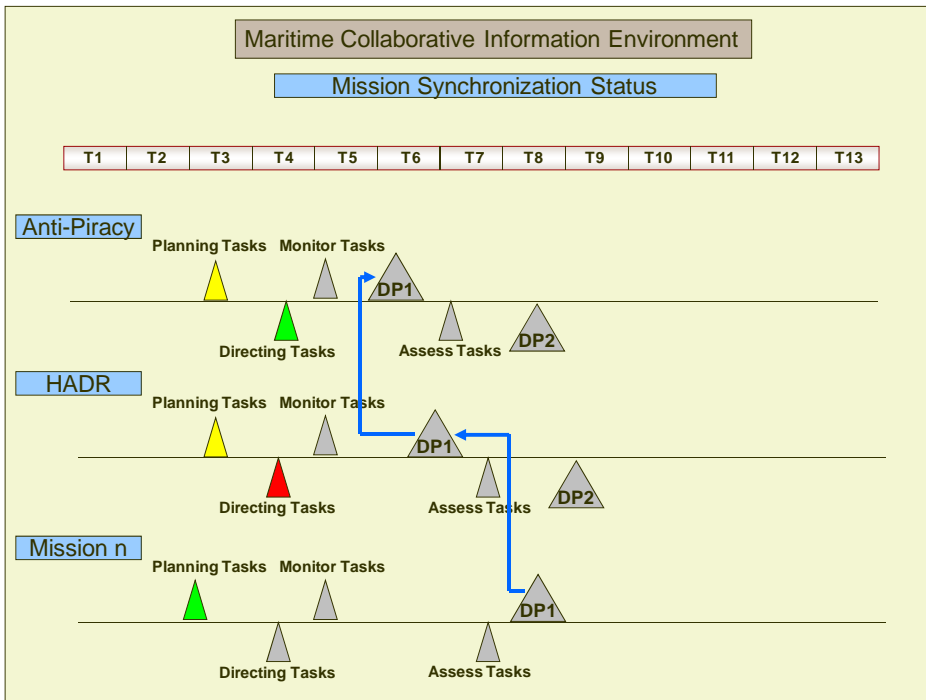

Figure 9. Example of a Mission Synchronization Matrix

5. CONCLUSIONS

The purpose of building a concept demonstration of a MOC CIE is to allow war fighters and operators to visualize the requirements associated with that environment. An example of such a requirement is the ability to show product developmental status at the top mission level all the way down to the lowest functional level. The status will reflect whether a particular product had been created and whether or not that product was produced in a timely manner to support an associated key event in the mission battle rhythm.

Our plan is to develop a demonstration of this capability based on an irregular warfare scenario. During the demonstration, a simulation will be used to populate the MOC CIE with products based on the scenario, e.g. WARNORD, OPORD, Rules of Engagement, Course of Action options, etc. as if they were being produced by actual mission war fighters in a live environment. Status of those products will be generated dynamically and reflected on the MOC CIE web pages as shown above. Finally, we plan to include a depiction of battle rhythm status as it applies to key events and the status of required products needed to support those events.

We feel the ability to visualize MOC CIE requirements/capabilities using this type of approach will add significant value to the process of developing an operational MOC CIE because the associated requirements will be well understood and as such can be discussed, vetted, and modified in a rapid, agile fashion.

6. REFERENCES

1. NWP 3-32, Maritime Operations At The Operational Level Of War, October 2008

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7. ACKNOWLEDGEMENTS

Appendix A. Multi-resolution Modeling Evaluation Framework

A significant challenge to evaluating net-centric C2 is to develop an approach that facilitates evaluation of C2 capabilities in a complex hybrid architecture environment. Our approach, referred to as the Multi-resolution Modeling Evaluation Framework (MRMEF), uses constructive, virtual, and live simulations and hardware-, software-, and humans-in-the-loop where appropriate. Multi-resolution Modeling (MRM) has many advantages that are needed to analyze C2. MRM has been successful because it has the characteristics needed to solve difficult analysis problems by integrating information achieved with high-fidelity models and generalizing the results and implications via a low-resolution model (Reference 5). An overview of the MRMEF is shown in Figure A-1.
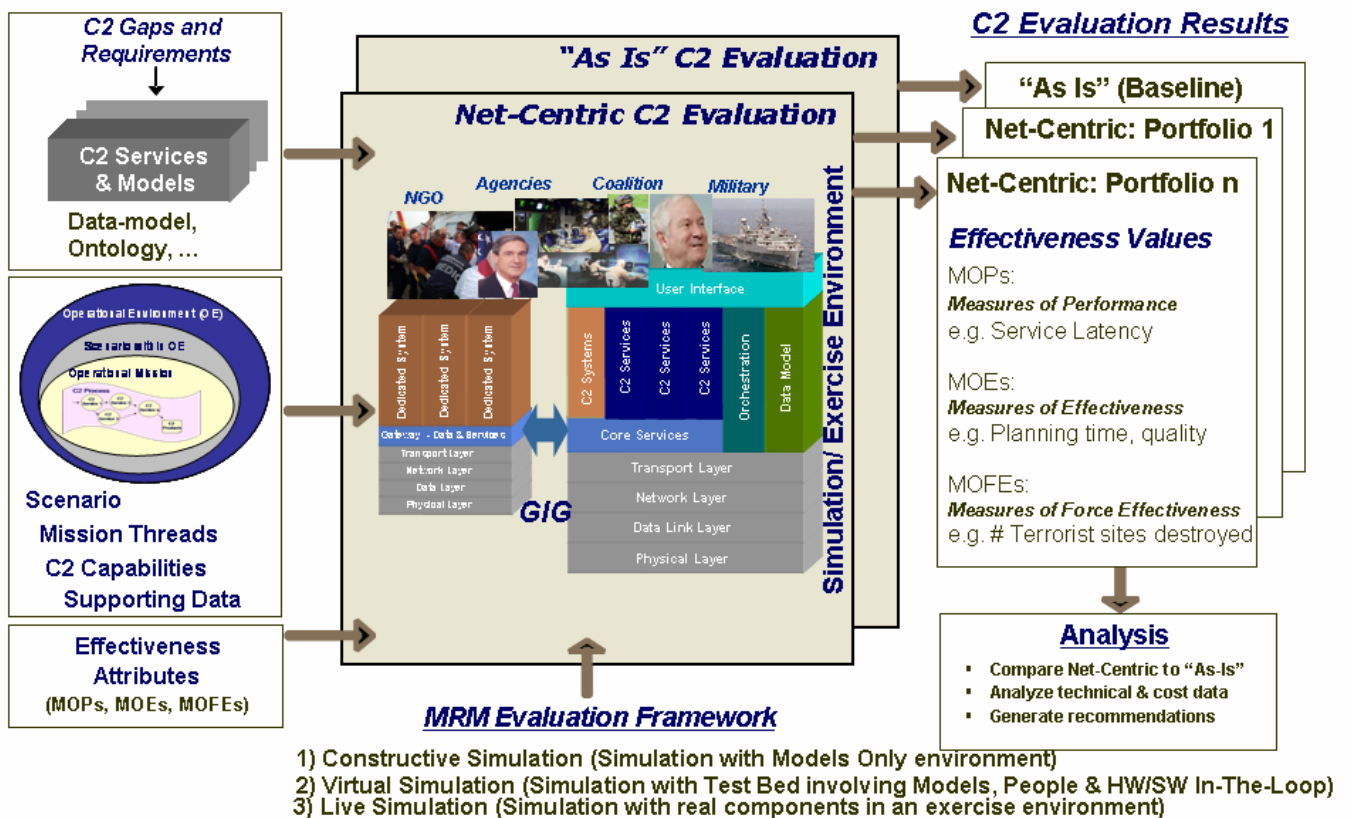

Figure A-1. Multi-resolution Modeling Evaluation Framework

The simulation/exercise environment of the MRMEF contains the entire hardware and software infrastructure needed to support the constructive, virtual, and live simulations of the framework.

The "cube" portion of the diagram represents real or modeled C2 or C2-related components. Inputs to the framework consist of a set of C2 services to be evaluated; the

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services were derived from C2 gap analysis, C2 requirements definition, data modeling, and so forth. A scenario defines the operational mission, i.e., the problem to be solved, and serves as the contextual basis for the evaluation. Measures to assess performance and effectiveness are defined based on the context of the scenario. Evaluation of C2 capabilities is accomplished by executing the "cube" components, (real, simulated, or a combination of real and simulated) in the context of the appropriate MRMEF simulation/exercise environment. C2 evaluation results are generated as a result of executing the scenario.

An "as-is" evaluation is accomplished by developing a scenario-based model of the "as-is" process to be evaluated and executing that model as a constructive simulation within the framework. A second model is developed representing the net-centric equivalent of that process. The net-centric process, which may involve a hybrid of legacy and net-centric components, both real and simulated, is executed within the framework as a virtual simulation. When real components are used, they are interfaced with the simulation via a separate test bed, which allows the real components to interact as necessary with modeled components. The resulting simulation executes at a higher level of fidelity or resolution overall. The framework also encompasses a very high-fidelity live simulation executed outside the laboratory environment with real players and components.

Analysis consists of comparing the "net-centric" with the "as-is" results and analyzing the differences to determine, both qualitatively and quantitatively, whether the application of net-centric principles and components to an existing process has enhanced or degraded engineering, command and control, or mission-level performance as measured via MoPs, MoEs, and MoFEs, respectively. If cost information about deploying and maintaining net-centric C2 capabilities is available or estimated, those data can be combined with the technical evaluation results to help guide future architecture, acquisition, and deployment decisions.