Joint Force Command & Control: Synchronization, Adaptation, and Coordination (SAC) Capability for Effects-Based Operations

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Abstract

In December 2000, the US Joint Forces Command (USJFCOM) Joint Futures Lab (JFL) in concert with the US Naval Warfare Development Center (NWDC) and the Naval Postgraduate School (NPS) conducted a limited objective experiment (LOE) in a simulated operational environment to gain insights and further develop the requirements for Joint forces to plan and execute effects-based operations.

This experiment confirmed that future Joint command and control requires a dynamic ability to synchronize, adapt, and coordinate efforts across the Joint force and cooperating elements. Furthermore, insights gleaned from the experiment indicate a fundamental need for **synchronization, adaptation, coordination** (SAC) procedures and tools that include at least four interwoven elements: a coherent timeline, consistent graphics, an integrated SAC matrix – providing rationale and details for all actions – and a visualization tool to track process status and workflows.

1. Problem

Future operational concepts require Joint forces capable of executing effects-based operations (EBO) against complex adaptive adversaries.[1] Competitive success of complex adaptive systems (CAS) in dynamic environments[2] favors those capable of quickly adapting operational activities, organization structure, and/or physical characteristics.[3] The challenge to adapt while concurrently directing Joint operations falls into the domain of the future Joint command and control capability (JC2C). This JC2C thus requires the dynamic ability to synchronize, adapt, and coordinate efforts across Joint forces and co-operating elements.

2. Relevance to Joint Command and Control

The future Joint command and control capability leverages the Collaborative Information Environment (CIE) as its fulcrum. The evolving concept for the CIE previously identified and incorporated four main requirements:

- Common situational awareness of all forces and elements in the Joint battlespace – driving requirements for the Common Relevant Operational Picture (CROP);
- Operational awareness of the potential impact of actions on results – driving requirements for the Operational Net Assessment (ONA) and effects assessment (EA);
- Integrated and focused information development – driving requirements for Joint Intelligence, Surveillance, and Reconnaissance (JISR); and
- A dynamic collaborative environment enabling concurrent, multi-echelon planning, coordination, and information dissemination – driving requirements for Joint Interactive Planning (JIP).

Future Joint command and control elements will employ Joint Interactive Planning to conduct effects-based planning (EBP) and control EBO. EBP and EBO posit proportional allocation of

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[1] USJFCOM, J9. *RDO White Paper*, October 2001 and *EBO White Paper*, October 2001.

[2] Hoffmeyer. "*The Global Semiosphere*", 1997.

[3] For example, see Pascale, Surfing the Edge of Chaos and Arquilla &Ronfeldt, Networks and Netwars.

forces, actions, and/or resources to achieve desired effects while operating against critical components and capabilities of an adversary's system. To secure these results without relying on traditional mass, Joint forces will incorporate and employ a range of capabilities available within the coalition force. These coalition force capabilities only reach their potential when employed in synchronized, adaptive, and coordinated actions centered on nodes critical to desired effects. Previous experiments and wargames have identified the need for an effects-based tasking order (ETO) that differs significantly from the traditional operations order (OPORD) and fragmentary order (FRAGO) and focuses Joint actions on desired effects.

3. Approach

In December 2000, the US Joint Forces Command (USJFCOM) Joint Futures Lab (JFL) in concert with the US Naval Warfare Development Center (NWDC) and the Naval Postgraduate School (NPS) conducted a limited objective experiment (LOE) in a simulated operational environment to gain insights and further develop the requirements to plan and execute EBO.

One of the objectives of this experiment was to review and refine the methodology for synchronizing actions to execute effects-based operations. Analysis conducted before the experiment projected potential discontinuities if this integration relied on disjoint tools: the war gaming synchronization matrix[4], the ISR synchronization matrix[5], the operational synchronization matrix[6], and the prototype effects-to-task matrix – extracted from the Operational Net Assessment (ONA) database[7]. The experiment confirmed the projected shortfall and added additional insights.

4. Observations

The Naval Postgraduate School report details observations and results of the ETO-to-Actions limited objective experiment.[8] The following synthesized comments – extracted from those observations – capture the essence of those relating to synchronization, adaptation, collaboration, situational awareness, and/or coordination and add insights from other observers and analysts within the USJFCOM Joint Futures Laboratory.

On Collaboration:

- Collaboration is the future … speeds decision cycle with the potential for multiple concurrent processes.
- Collaboration is key for maintaining situational awareness, however time constraints limit needed contacts … success hindered by concurrent meetings effectively inhibiting connections to the right person … you can't be everywhere, even virtually!
- Collaboration was a big plus, but not used enough.
- Participation in asynchronous collaboration sessions while engaging in other tasks was an effective way to conduct planning. Asynchronous collaboration was ***not*** part of the daily routine, however it *should* be used whenever possible … synchronous

[4] US DoD. CJCSM 3500.50A JTF HQ MTG. Mar 00. See MTG Task 206, Figure 206-2.

[5] Ibid, see MTG Task 403.

[6] Ibid, see MTG Task 401D and/or 211, Figure 211-1.

[7] USJFCOM, J9. *ONA: TTP for MC02*. November 2001.

[8] Hutchins. *"Knowledge Management and Collaboration in ETO-Actions LOE"*. June 2002.

collaboration is more resource intensive and time limited even when it is more effective for some tasks.

- Open discussions are good, but unstructured information flows are hard to capture. Discussions provided rationale for actions … why a node is important … aided in the development of the ETO … provided unity of purpose.
- Collaboration between the headquarters and components was superficial … there was little detail … more prompting than collaboration. Much of the time spent was not rewarding when sessions were limited to PowerPoint briefings.
- The components needed more interactive collaboration [in a well-defined, structured environment.] Course of action (COA) development was accomplished quickly when collaborative … divide the workload and delegate parts to make tasks reasonable and functional. ONA would support better component level planning if there were better linkage and collaboration across the components. Distributed workflow depends on reliable and visible status of precursor and internal processes.
- Adding subordinate commands to the collaboration equation will intensify the requirements for collaborative sessions and synchronized battle rhythm.

On Situational Awareness:

- Finding information was a problem.
- The information did not reach the components in a timely manner.
- Assessment process must support and update EBO/EPB processes and the CROP.

On Synchronization & Coordination:

- Collaboration among components and between the components and JTF headquarters is essential to synchronization and coordination of EBO. Collaboration helps synchronize desired effects. Synchronization meshes the planning process across echelons and across phases of the operation.
- Expected components to have independent but integrated and synchronized tasks. Lack of synchronization [tools and procedures] limited ability to de-confilct, synchronize, and synergize component actions. The EBO/EPB/EA process that was used was not sufficiently robust and lacked a supporting synchronization matrix. Critical information was not available or not displayed in a way that facilitated its use. Moreover, the collaborative information environment data were not linked to tool suites, tied to the Joint interactive planning (JIP) process, and supported by both synchronous and asynchronous collaboration. Hence, it was difficult to place activities in the time/space continuum and to understand all the inter-connections among nodes and effects. As a result, components continued to work stovepipe tasks and most planning was done sequentially so the undermanned components and cells would be able to participate.

- **Synchronization requires:**
  - Enough information and structure to pull critical information together quickly … to align actions with intent (desired effects), in time, in sequence, in space, and in geography … to facilitate subordinate plans driven by the ETO.

- ♦ A real-time display of significant activities for all components to input and share information with coherent distribution of [critical information] … with data tags to ascertain currency.

- ❑ ***A synchronization matrix … with:***
  - A single-source, integrated knowledge base …**pushed** to users.
  - Knowledge of actions of other components and their impact on all others, weaknesses in friendly courses of action, results of on-going or prior operations … with a visual cross reference of planned actions and intended nodes linked to desired effects … with clear links to component orders and execution matrices, target folders, target data bases, and the ONA.
  - Authoritative information on force availability, force allocation, force capability, logistics resource allocation, and intelligence resource distribution and use, and command relationships.
  - Clear visibility of mission objectives, tasks, and priorities.
  - Clear and timely feedback on on-going and prior operations.
  - Dynamic capability to integrate previous effects assessments, to reflect expected first and second order effects, to display potential and probable actions, and to highlight potential internal conflicts and constraint boundaries.

- ❑ ***An operations timeline … with:***
  - Links to the data represented in the synchronization matrix and operational graphic.
  - Timing and sequencing of actions, reactions, counteractions, and supporting actions (e.g., logistics, JISR, fires … CMO).
  - Dependencies and inter-relationships between actions.
  - Trigger events and/or decision points (flexible decision points and decision options versus fixed cyclical decisions).
  - Defined cycles for subordinate plan development … synchronized with the JTF ETO.

- ❑ ***An operations graphic … with:***
  - Links to the data represented in the synchronization matrix and operations timeline.
  - Links to projective battle data to aid in visualization of what may happen in the battlespace.
  - Visualization of integrated maneuver, fires, support … and **effects**.
  - Clear battlespace control measures.

- ❑ ***A workflow visualization tool … with:***
  - Status of precursor processes and internal processes in the development and execution of the EBO.

- An established battle rhythm with synchronization points for both synchronous and asynchronous command and control activities.

5. Assessments & Insights

On Adaptation

Observations made during the limited objective experiment (LOE) did not address the need for adaptability. That omission was to be expected since the scenario was not developed to stress the organizational capabilities, forces, resources, or structure of the Joint Task Force or its components. However, the future Joint Operational Warfighting (JOW) concept explicitly calls for Joint forces to be adaptable.[9]

On Understanding

The summary of comments by the experimental audience in the LOE demonstrates drift in the meaning assigned to three critical terms: *collaborate*, *coordinate*, and *synchronize*. Standard meanings for these terms will be critical to developing and understanding Joint warfighting concepts. Current documentation for emerging Joint concepts fails to explicitly define these three critical terms or the critical term: *adaptable*. Moreover, Joint Pub 1-02, the DoD Dictionary, only defines one of these terms, **synchronization,** as: *(noun) 1. The arrangement of military actions in time, space, and purpose to produce maximum relative combat power at a decisive place and time. 2. In the intelligence context, application of intelligence sources and methods in concert with the operation plan.*[10] However, the use of that term in the context of the LOE, in the context of emerging concept papers, and in the context of the doctrinal JTF Master Training Guide tend to invalidate the DoD definition.[11] Lacking standard terms, common understanding will be elusive.

In the subsequent sections, this paper adopts these terms as defined in common usage unless otherwise noted. Webster's[12] provides a general definition of these four terms as:

- **Collaborate:** (verb) *to work together*, especially *in a joint* intellectual *effort*.
- **Coordinate:** (verb) *to harmonize* in *a common effort*.
- **Synchronize:** (verb) *to take place at the same time; to move or operate in unison*; to cause to operate with exact coincidence in time or rate; *to cause to coincide* with an action (sound effects or dialogue).
- **Adapt:** (verb) to adjust to a specified use or situation; *change to fit a new or special situation in relation to the external environment*.

On Effects-Based Planning, Effects-Based Operations, and Joint Warfighting

Applying these common definitions, the Joint Force control elements would seek to *coordinate effects* and general *efforts* – establishing coherent intent for superior-subordinate-peer operations.

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[9] USJFCOM, J9. Joint Operational Warfighting Concept Brief [unpublished]. 5 March 2002.

[10] DoD, DoD Dictionary of Military and Associated Terms. 12 April 2001. Page 415.

[11] For example, in the US DoD, CJCSM 3500.50A JTF HQ MTG, Mar 00, the term "synchronization" appears 105 times; "synch [matrix]" appears four times; and "synchronize" appears 81 times. Most of the references are outside the scope of the limited DoD definition of the term "synchronization".

[12] Severynse (Editor). Webster's II New College Dictionary. 1995.

Distributed but integrated planning processes would permit and drive the command and components *to collaborate* to *select*, *synchronize* (in time and in space), *sequence*, and *support actions* aligned to the coherent intent. Subsequently, elements across the force would *execute actions* to meet desired effects within operational [diplomatic, informational, military, and economic] constraints. Concurrently, all elements of the force would *assess actions and effects* and *collaborate to build a cooperative knowledge base*. Finally, all elements would strive to *integrate knowledge to gain insights* and leverage those insights to *competitively adapt* in a complex, near-chaotic environment.

On Collaboration

Collaboration holds a central position in the development of effects-based tasking orders (ETO) and execution of effects-based operations. Collaboration must allow distributed forces and processes to produce integrated plans and execute coherent actions. In addition, collaboration must foster the development of a cooperative knowledge base that is critical to developing insights that can be exploited to competitively adapt to gain transient advantage in the Joint battlespace.

To be practical, collaboration must be able to exploit common data effectively and efficiently. Within today's technology, this implies that the data are orderly, easy to find, and pushed to users as needed. To be effective, collaboration must be supported and based on a well-defined planning and assessment process that retains sufficient flexibility to support operational adaptation. To be efficient, collaboration must incorporate and maximize the use of asynchronous collaboration tools and techniques.

6. Analysis

From Development of an Idealized Future Joint Operational Architecture

Much of the projective analysis of the effects-based planning process as executed during the ETO-to-Actions LOE was based on formative work within the USJFCOM J9 Joint Futures Laboratory on an objective Operational Architecture (OA) for a Joint Task Force conducting effects-based operations.[13] Lack of requisite tools, divergent outlooks on the degree of detail needed for EBP processes, and the exploratory nature of the experiment constrained implementation of the idealized objective architecture. Nevertheless, the precursor development and refinement of the OA produced insights that were validated by experimental observations and post-analysis.

- The effects-based operations decision cycle morphs the traditional Observe-Orient-Decide-Act (OODA) loop to incorporate distributed collaboration and organizational learning. [Figure 1]

[13] USJFCOM, J9, JFL. *MC02 FJOA.*

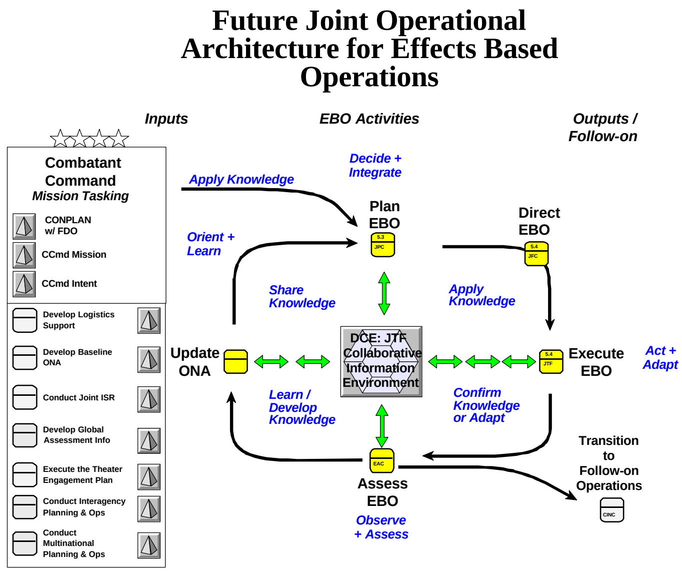

Figure 1: Future Joint Operational Architecture for Effects Based Operations[14]

- Coherent effects-based operations integrate actions outside the domain of the Joint Force before, during, and after the execution of the campaign. [Figure 2]

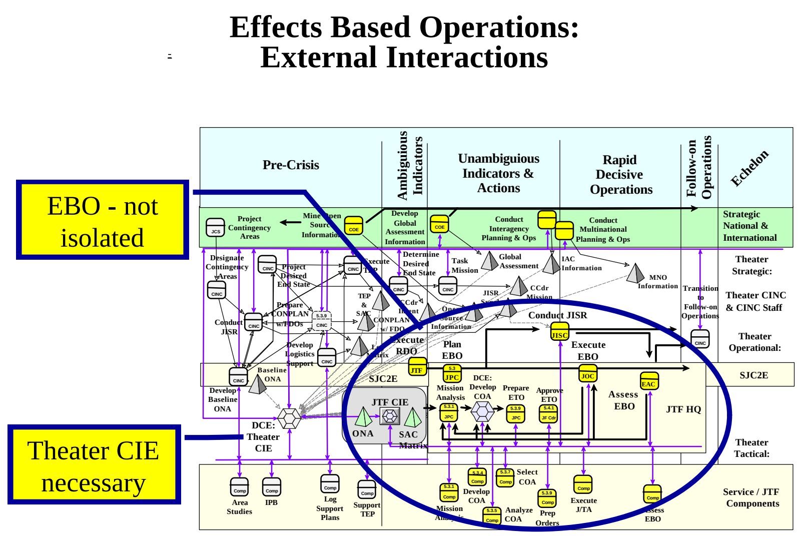

Figure 2: Effects Based Operations: JTF External Interactions

- EBP builds upon traditional Joint planning tasks and processes, but involves a wider set of participants in the collaborative planning process and incorporates iterative planning within the scope of the process. [Figure 3]

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[14] In this and subsequent diagrams, the small boxes represent task objects or collaboration participants; the pyramids represent product objects; the hexagons represent collaborative sessions; and the links between these objects represent process or information flows. The heavy (purple) links between nodes represent the distributed collaborative environment.

Effects Based Operations:
Effects Based Planning

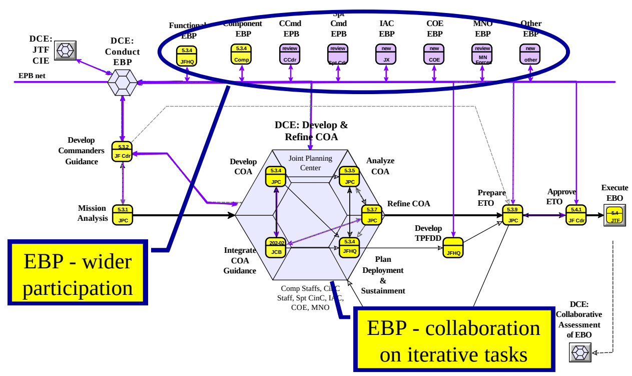

Figure 3: Effects Based Operations: Collaborative Effects Based Planning Process[15]

- Collaborative planning tasks can be allocated to specific collaboration sessions with an established agenda, expected participants, and well-defined products. These sessions may run in parallel or in series. Synchronous sessions should have a fixed timeframe aligned to a battle rhythm. [Figure 4]

Effects Based Planning: Mission Analysis

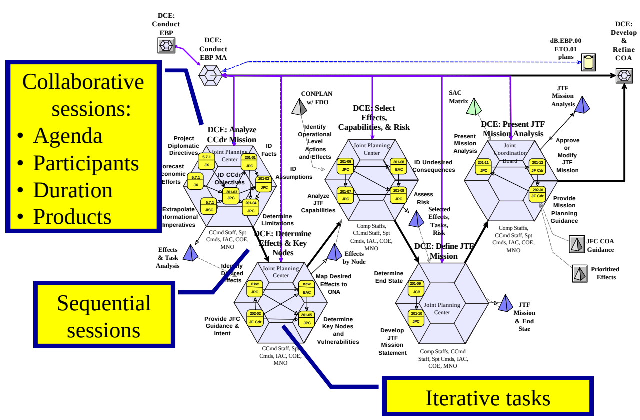

Figure 4: Effects Based Planning: Collaborative Mission Analysis[16]

- Collaborative planning must leverage parallel execution and asynchronous sessions that collect and distribute information to a wide array of participants in a standard location, format, and timeframe. Successful asynchronous planning must be

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[15] In this and subsequent diagrams, the iterative information flows within a collaborative session are shown by multiple data flow links (arrows) that may overlay and appear to have dual arrowheads … these data flows may or may not be conducted in a full-duplex mode.

[16] In this diagram, the collaborative sessions occur in series. The sequencing of sessions is indicated by flow arrows. Products produced across all sessions within the parent session are shown in dark blue. Products produced by external processes are shown in gray (static) or green (dynamic).

supported by a SAC matrix, a SAC graphic, and a SAC timeline. [Figure 5] In the face of the LOE experience, distributed planning would also benefit from workflow visualization tools that were not previously identified in the OA development process.

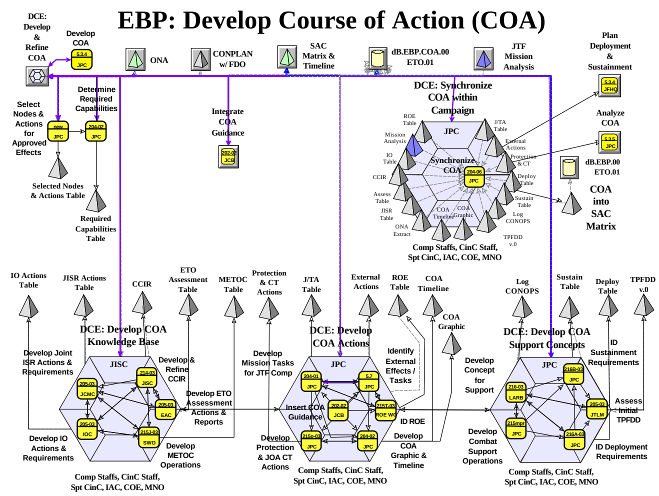

Figure 5: Effects Based Planning: Collaborative Development of Course of Action[17]

- Process development for collaborative sessions should extend down to a level of detail that defines the agenda tasks (the reason for the collaborative session), requisite data input from external sources or prior tasks in the process, expected participants and their anticipated contributions, and the product needed from the session.

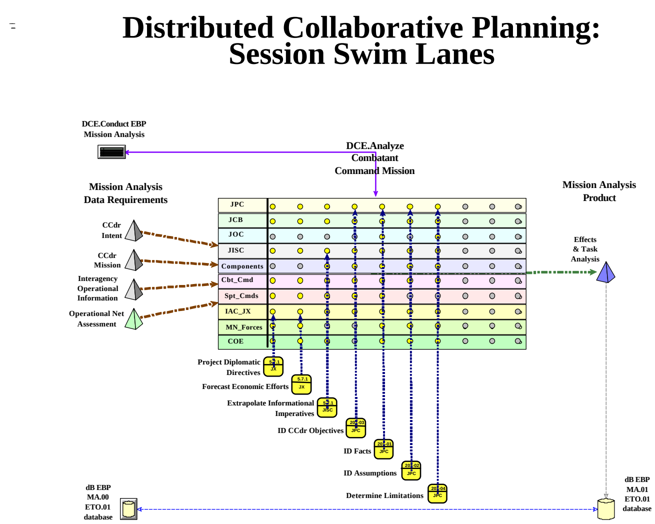

Figure 6: Distributed Collaborative Planning: Swim Lanes for Collaborative Planning Session for Effects Based Operations in Mission Analysis Process – Analyze Mission Task

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[17] Collaborative sessions shown in this diagram are concurrent (parallel) and at least one, the Synchronize COA session, is inherently asynchronous.

From Development of a Mathematical Model for Collaboration

Following the ETO-to-Actions LOE, reflections have catalyzed a basic mathematical model for collaboration that appears to be both operationally valid and potentially insightful. This development is a work in progress. As such, this paper only outlines the approach while reserving amplification for a future paper. Nevertheless, this formative model identifies interesting collaborative relationships.

This model defines a field in n-space of "*knowledge-base*" vectors. Each dimension in the n-space represents a knowledge domain. The set of all knowledge domains that spans the problem or issue topic for collaboration thus dimensions the minimum n-space field. Each knowledge-base (kb) vector in this n-space represents the base of knowledge for an entity with collaborative potential. Thus, kb-vector interactions over this n-space model potential collaborative interactions.

The approach does not rely on absolute coordinates for each kb-vector. While such codification would be powerful, it may not be practicable in most knowledge domains. Without these established kb-vector coordinates, the intent of the model forfeits any attempt to predict detailed results of interactions; rather, it serves to illuminate the nature of collaborative interactions. The proposed knowledge-base vector-space model appears to meet this more-limited, yet still useful, objective. Thus, static collaborative potentials are modeled as kb-vector interactions in n-space. By adding time dimensions, dynamic knowledge [learning] and dynamic interactions [collaboration] unfold.

Additional work will focus on developing and modifying the model and on subsequently validating or rejecting its use in this domain. Preliminary insights from the model appear promising:

- Collaboration – Closely aligned kb-vectors produce strong [potential] fields in the knowledge base. In contrast, a diverse array of kb-vectors provides broad reach across the domain space to reach new information and insights. Implications for EBO include the need to stimulate wide discussions in collaborative planning to ensure a minimal spanning set over critical domain spaces. Thus, in general, one-way information briefings will not suffice. To the extent that vector inner products represent common knowledge between the kb-vectors, synchronous collaboration sessions might best structure exchanges to amplify kb-vector segments extending beyond the bounds of the inner products (common knowledge). In contrast, asynchronous sessions may suffice in regions where the inner products are identical. Special attention should focus on the situation where kb-vectors have a zero inner product within a given knowledge domain since these cases reveal the potential for critical information exchanges that could enable collaborative entities to incorporate unusual knowledge and identify hidden relationships.
- Coordination – For coordination to occur, the kb-vectors for collaboration participants must span a common sub-space defined by the commander's intent. Moreover, coordinate orientation (positive or negative) must align with the direction defined by this intent.
- Synchronization – To synchronize kb-vectors over time, mappings between knowledge bases must include time shifts or synchronization points. In real terms, all

shared data must include metadata that validates and timestamps the data and tools must incorporate data-item appropriate aging and projection.

- Adaptation – EBO processes and tools must permit and encourage dynamic expansion and modification of entity kb-vectors [learning]. They must design cross-product interactions between kb-vectors to develop new associations. Furthermore, over time, they must accommodate the extension of the entire knowledge space [adding additional m-dimensions to the n-space].

7. Conclusions

The US Joint Forces Command (USJFCOM) Joint Futures Lab (JFL) conducted a viable limited objective experiment (LOE) in a simulated operational environment and gained insights to further develop the requirements to plan and execute effects-based operations. Specific insights and implications include the need to:

- Develop standard definitions for critical terms.
- Develop critical processes and detailed procedures to integrate interactions.
- Establish essential tools for EBP to select, synchronize, sequence, support, adapt, and coordinate (S^4AC) actions to execute effect EBO. At a minimum, tool components must include:
    - ♦ A S^4AC matrix;
    - ♦ A S^4AC operations timeline;
    - ♦ A S^4AC operations graphic; and
    - ♦ An EBO workflow visualization tool.
- Train users, test procedures, and employ support tools for critical processes:
    - ♦ To concurrently plan EBO across the Joint force, its components, and cooperating coalition elements.
    - ♦ To coordinate the execution of EBO.
    - ♦ To assess the effects of Joint actions and dynamically re-plan to meet operational objectives.
    - ♦ To adapt to changes wrought by an adaptive threat and a complex environment.
- Foster the development of knowledge base field theory and explore the implications for Joint collaborative planning processes.

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