Realizing Operational Planning and Assessment in the Twenty-First-Century Air Operations Center

How a Refined Planning Construct and Semantic Technologies Can Enable Delivery of the AOC's Last Unsupported Functions (Part 1)*

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Operational planning and subsequent operational assessment are critical components of executing a modern military campaign and the supporting air operations.[1] Without future advancements, particularly in assessment, commanders will remain severely limited in their evaluations of whether their planned and executed actions have produced the desired effects. The variability of

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planning and assessment constructs and terminology, data sources, analysts' confidence, and the ability to readily understand and visualize operational schemes, plans, and evidence from the operational environment creates obstacles in campaign development and integration. The same is true of problems related to the access, collation, and analysis of related planning and assessment data. To address significant elements of these issues, this article proposes utilization of an evolutionary planning construct and abstract semantic data models of both operational plans and environments to relate and realign disparate data elements, thus enabling automated reasoning and inferencing across those models.

By way of recent example, for Operation Iraqi Freedom, US Air Forces Central planners had developed over many months a very detailed supporting joint air operations plan designed to attain air and space objectives. However, the assessment chain still had "weaknesses that might have resulted in significant fog and friction."[2] Determining and identifying intended operational effects are critical to executing component strategies; during Iraqi Freedom the joint force air component commander (JFACC) needed to know the actual effects of his operations on Iraq's regime as well as on its ground and air forces. However, a lack of timely operational assessment limited his review and adjustment of the air strategy. Moreover, the inability to assess airpower effects also impinged upon the land component commander's maneuver decisions. The same dearth of assessment constrained the land commander's determination of strength and movement of Iraqi ground forces in front of his forces, an uncertainty that forced him to change his strategy to a much less efficient form of offensive maneuver: "maneuver to contact."[3]

Although the above has focused explicitly on assessment, successful operations—like the proverbial three-legged stool—depend almost equally on three facets of the "control" aspects of command and control (C2) (i.e., planning, execution, and assessment). By necessity, each of these supports and enables in some way the other two—evidenced in many C2 research and development projects sponsored by the US Department of Defense (DOD). These projects have included problem statements regarding the necessity of "provid[ing] critical and actionable insight into planning and execution while supporting both co-located and distributed teams" through the application of "agile data integration."[4] Furthermore, these air-related C2 problems and capability shortfalls are symptomatic of capability gaps endemic across all US government operational domains. In addressing any problem areas in operational planning and operational assessment, therefore, one should extend the solution approach to or integrate it with all interagency, joint, coalition, and nongovernmental organizations' domains.

Part 1 of this article establishes and analyzes the shortcomings of current operational planning and assessment methods. The remainder answers how many of those issues can be addressed through both the employment of the Comprehensive Adaptive Planning and Execution (CAPE) methodology and the utilization of semantic models of operational plans and their operational environments.

Problem Description: Command and Control—the Failing Domain

Poor Cross-Domain Operational Planning, Execution, and Assessment

The US Air Force has sought to address the fact that its air and space operations centers (AOC) are significantly deficient in their accession, visualization, or understanding of underlying data, systems, and impacts from ongoing operational planning, execution, and assessment. The AOCs' processes and support tools do not adequately capture, convey, and display national strategic intent and objectives through both the joint force commander's and JFACC's operational-level plans to the latter's detailed, day-to-day direction in his or her air operations directive.[5] Finally, the multiple mission-specifics of the daily air tasking order (ATO) must be executed through the "fog and friction" of combat operations while undergoing a continuous assessment and recommendation cycle. Not only do these deficiencies exist within a single component acting at a single level of war but also no current capabilities exist to capture and visualize operational plans and data—either horizontally across the various service, functional, and interagency domains or vertically through the various levels of war (i.e., national strategic, theater strategic, operational, and tactical).

As a contribution to the Project on National Security Reform's study of the US government's interagency process, a paper entitled *Choosing War: The Decision to Invade Iraq and Its Aftermath* noted that "the future is likely to present complex contingencies that will require significant capabilities in which the power of the entire government will be needed to make plans to solve multifaceted problems overseas."[6] In a related study on crisis planning, Dr. Williamson Murray, a Senior Fellow at the Institute of Defense Analysis and a member of the National Strategic Studies Group, points out that "no matter how impressive the conduct of . . . operations might be at the tactical level, there is no guarantee that linkages will exist to the strategic and operational levels without a considerable intellectual effort to think through the potential effects of policy decisions and strategy, or the possible contributions that tactical actions might make to the achieving of operational or strategic effects."[7]

Against the backdrop of changes required across the entire US government and joint military community, the Air Force's operational AOCs face the following issues:

- Providing a leading or contributory role in the operational design, campaign planning, and development of detailed supporting plans for operations to deter or defeat dynamic threats in multiple domains.
- Synchronizing air; space; cyber; and intelligence, surveillance, and reconnaissance (ISR) actions by time, space, and resource across

multicapable component elements and with other functional and service components and agencies.

- Dynamic assessment and replanning of ongoing operations to better inform decision makers and offer appropriate recommendations.

Problematic Integration, Coordination, and Visualization of Operational Plans and Knowledge of the Operational Environment

A particularly problematic area in the C2 domain involves the integration, coordination, and consequent visualization of information from strategic guidance, operational plans, ongoing combat operations, intelligence sources, and an ever-morphing operational environment. Many efforts over the past several years have made strides in creating user-defined operational pictures or common operational pictures.[8] However, none have fully met requirements to supply a holistic view of the operational environment that is customizable and navigable by users at various levels of command who perform various functions.

A number of these problems were identified as factors that caused difficulties in assessing air operations during the initial phases of Iraqi Freedom. These included the format of mission report messages, which prevented rapid processing; incompatible joint and AOC information technology systems that hindered the effective sharing of assessment information; and a speed of campaign that served only to compound these and other problems. To address these issues, recommendations have included instituting systems that streamline the processing of mission reports and the enabling and promotion of the cross-domain use of common databases for information about targeting and battle damage assessment.[9]

Dislocated and Distributed Command and Control

As the Air Force continues to implement the organizational structure of the component numbered air force and distributed operations concepts, it will forward-deploy fewer AOC functions. Therefore, both co-located and geographically separated teams will need workspaces that provide critical and actionable insight into an AOC's operations, generate both situational awareness and shared understanding, and synchronize collective air, space, cyber, C2, and ISR activities.

Further, the problems of dislocated and distributed C2 are not solely those of component numbered air forces and their AOCs; rather, they remain inherently ubiquitous across all operational DOD domains. The DOD has also determined that current C2 and planning paradigms are too slow and cumbersome, often resulting in plans that address conditions that no longer exist and that cannot adapt to the demands of today's dynamically changing security environment. Moreover, these paradigms offer no mechanisms to facilitate early and frequent consultation between military and civilian leadership regarding plan development and refinement.[10]

The multifaceted nature of current and future crises will demand that all of the US government's national instruments of power fight as a team, the logical extension of which is the need to plan, fight, and assess as a team. Commanders will adjust operations based on their assessment to ensure the realization of planned military objectives. Their assessment process must be continuous and directly tied to decisions throughout the planning, preparation, and execution of operations.[11] Consequently, C2 support tools should at least enable the effective integration of planning and assessment processes and data across all domains and levels of war, even if the innumerable idiosyncratic vagaries of discrete tactical elements prohibit cross-domain integration of tactical execution processes.

Lack of Visualization That Supports C2 Planning, Situational Awareness, and Decision Making

Currently, C2 tools range from a few custom applications to the familiar Microsoft Office and Post-it sticky notes. For the most part, the available information technology tools support very specific and discrete C2 tasks. To the author's knowledge, no fielded C2 support tools explicitly relate tasked tactical missions with all of the following related data: (1) their associated operational and/or tactical objective(s), (2) entities in the operational environment with which the missions must directly interact (e.g., targets), and (3) entities on which one intends to produce any consequential effects. Additionally, because these basic data relationships aren't maintained, the shared understanding and visualization of those relationships have proved somewhat difficult to date.

One of the greatest limitations in today's conduct of the planning, execution, and assessment cycle is that teams performing one element of the cycle have limited insight into the decisions and products of prior elements. Information and decisions generated in prior cycle elements are not brought forward and presented in ways that effectively frame and support good decisions which maximize the attainment of larger strategy goals. For example, within the AOC, current systems do not maintain the linkage between the strategy or plan elements (e.g., operational and tactical objectives and tactical tasks), targets, and missions to aid in execution decisions and assessment. This significant deficiency in system/tool functionality is reflected by the necessary introduction into the AOC in recent years of additional personnel in the role of ATO coordinators (a.k.a. "football carriers"). These individuals ensure continuity and consistency from commander's intent through planning to action to assessment of each of the discrete—but multiple and overlapping—ATO cycles.[12]

As AOCs manage ever-increasing cross-domain operations, they will need support tools and visualizations that help planners apply separate and combined air, space, and cyberspace resources to meet a JFACC's operational objectives and understand their parts in the overall joint campaign. Knowledge of the progress towards those objectives and the shared understanding of their relevance and interactions within the campaign depend upon integrated and holistic AOC planning and assessment processes that can readily generate timely output that is easily and rapidly assimilated.

Solution Approach: Unifying and Visualizing Operational Plans and Environment through Dynamic Modeling

Unifying Cross-Domain Planning, Execution, and Assessment

To contend with the deficiencies in cross-domain operational planning, execution, and assessment, as discussed above, the DOD now recognizes the desirability of close integration and execution of any cross-government strategy that seeks to resolve any major crisis or conflict.[13] This realization prompted a widely held belief in the need for a fully inclusive, comprehensive approach to the conduct of future national and coalition operations.[14]

The foremost and driving imperative of such an approach entails the determination and delivery of end-state conditions and their necessary intermediate, enabling, and/or contributory conditions within an operational environment. Two key elements of such a conditions-based approach to crisis and contingency planning, applicable in any operational domain, include a holistic understanding of the operational environment and emphasis on the required outputs of change in that environment.

Therefore, as a vital precursor to supplying commanders and staffs with tailored support tools and visualizations based on common operational understanding, one must first identify a construct or methodology capable of capturing the "unifying logic" of conditions-based operational plans. Moreover, the construct or methodology should also have comprehensive utility and meaning across all joint, interagency, coalition, and nongovernmental organization domains. CAPE is such a methodology.[15] Only with the benefit of such a unifying, logical construct established and employed will it be possible to enable the effective coordination, adaptive planning, execution, and assessment of complex, cross-domain, horizontally and vertically coordinated, full-spectrum operations—and visualization of the same.

CAPE: The Unifying Construct

Since clear strategic guidance is universally considered essential to the planning of operations, CAPE's construct utilizes, at its highest level, strategic end-state conditions that would collectively comprise the strategic end state. Although a defined military end-state represents the military's overall goal, other strategic end-state conditions will likely be associated with other national instruments of power. The military commander, having established the military end state, will identify the various constituent end-state conditions that will define the realization of all military objectives.

The author defines the concept of a line of effort (LOE), a key construct element within CAPE, as a logical line (representing a causal chain) that defines the orientation of actions, causal links, effects, objectives, and/or end-state conditions in sequence and purpose within an operational design.[16] Further, the LOE is utilized as the main construct for logic-based visualizations. Figure 1 depicts a national strategic-level campaign visualization, displaying a number of notional strategic LOEs (diplomatic, military, economic, and information) delivering specific, individual strategic end-state conditions, along with a military end state comprising multiple, constituent military end-state conditions.

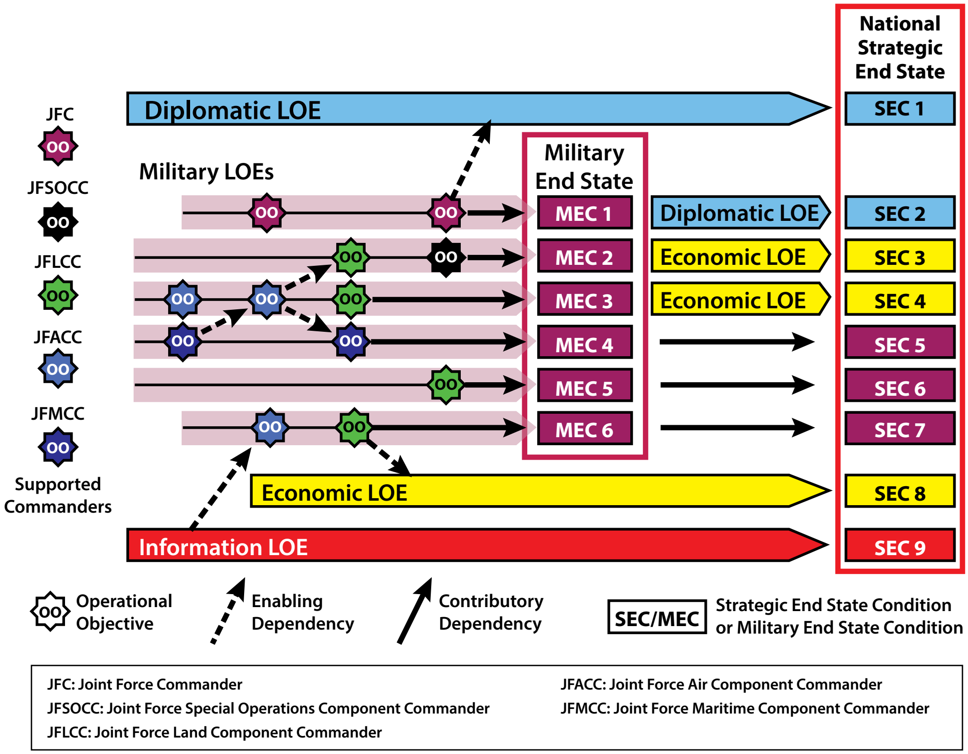

Figure 1. CAPE construct: Integrating military objectives with strategic lines of effort and operational objectives

A joint military campaign takes place primarily at the operational level of war; the production of sequenced and/or aggregated operational-level effects delivers the military end-state conditions. Within the CAPE construct, therefore, these intended operational-level effects become the operational objectives normally tasked to component/subordinate commanders. In essence, an operational objective is either an "enabling" milestone effect or final "contributory" effect required to reach a military end-state condition. One can develop and depict a military LOE, comprising sequenced operational objectives, for each mandatory military end-state condition. It is also possible to represent both established relationships or dependencies between a military LOE and other strategic LOEs and the assignment of responsibility for an operational objective to a subordinate commander (in joint doctrine terms, the "supported commander" for that objective).

CAPE can depict all of this (see the center of figure 1, where stars represent operational objectives [OO] within each of the military LOEs and color coding represents their assignment to a joint force component). The figure introduces and illustrates only the strategic- and operational-level planning elements, but the CAPE construct has been developed down to the lowest level of tactical missions, actions, and targets (see the example discussed in the next section and illustrated in fig. 3).

The development of CAPE as an underpinning, logical planning methodology included the identification, classification, and definition of every planning element within its construct. Many of the planning elements (or terms) come from existing US military doctrine (e.g., Joint Publication [JP] 3-0, *Joint Operations*, and JP 5-0, *Joint Operation Planning*) and the author's operational experience. Nevertheless, a continuing and extant problem within the C2 domain is that the vast majority of even the most widely used planning elements or terms, such as OO, tactical objective (TO), and tactical task (TT), have no formal definition or common schema for writing or applying them. Indeed, the author challenges this journal's readership to find any authoritative (or otherwise) definitions of these three most commonly used planning terms. CAPE has rectified these specific definitional deficiencies by development of the following:

- Lexicon of CAPE planning terms and elements, including a formal definition of each term and element, based mainly on extant and evolving joint and service doctrine.[17] It also includes many derived by the author.[18]
- CAPE planning element / syntax schema, which defines the structured syntax to be employed for the description and data capture of each category of CAPE planning elements.[19] This formalized structure enables automated system extraction of the contextual and semantic detail contained within all of the individual ele-

ments of an operational plan; furthermore, it supports subsequent modeling of their relationships with other plan elements and the operational environment.

- Logical abstraction of CAPE planning terms and elements, which details the logical and semantic relationships among all the planning elements as they would exist within an operational plan.[20]

Integration of Operational Knowledge through Dynamic Modeling

A unique methodology and technical solution makes possible the automated creation of dynamic, user-defined operational environment models (OEM). The latter offer multiple views of the operational environment through the integration of multiple sources of intelligence and operations data as well as ontological definitions of systems of interest. Just as a full, logical abstraction embraces all of CAPE's planning elements, so do multiple, similar abstractions include an exemplar range of entities that will exist in most operational environments (e.g., electricity power plants, power substations, airfields, air defense missile sites, hospitals, refugee camps, and petroleum distribution nodes).[21]

Upon these logical abstractions one can produce semantic OEMs and create visualizations. Figure 2 shows five entities (circles color-coded by political, military, economic, social, infrastructure, and information [PMESII] category) related by arrows that are color-coded by type of relationship link (logical, functional, physical, or behavioral).[22] Four of those entities, identified as "targets," are linked to their respective constituent facilities or aiming points (the red triangles). These OEMs provide not simply a "snapshot in time" of friendly, neutral, and enemy systems. They offer an understanding of the relationships among systems and an indication of how friendly actions against specific targets affect these interrelated systems, enabling richer comprehension of current and evolving operational environments and threat domains.

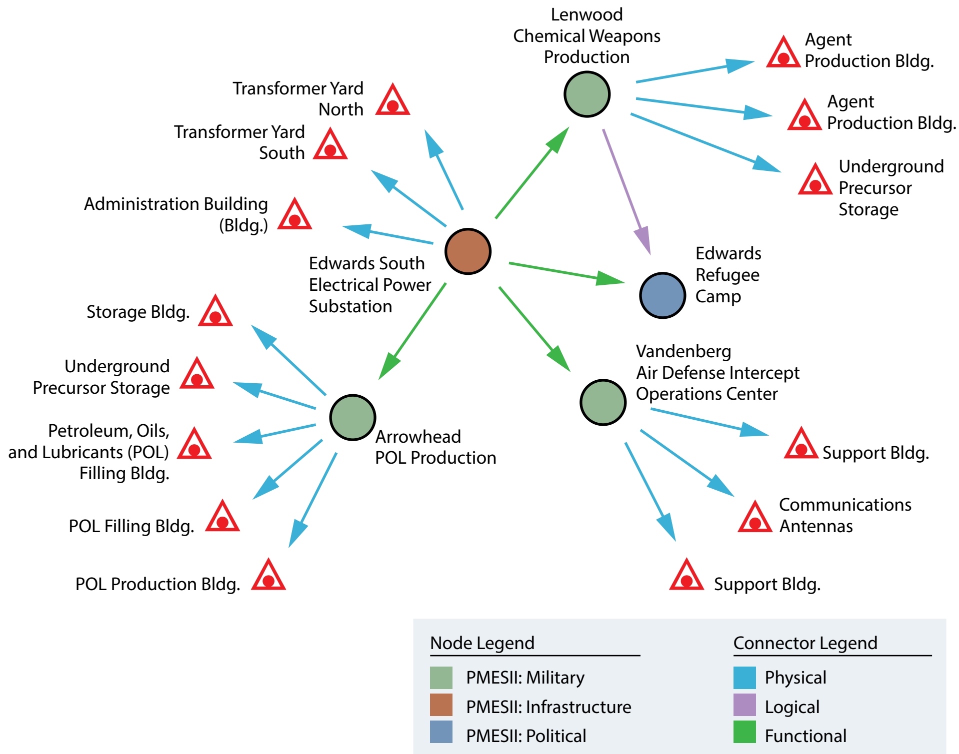

Figure 2. Logical representations of entities in an operational environment

In terms of the war fighter's and commander's understanding, such semantic data models, as exemplified by an OEM of an operational environment and its constituent enemy systems, can clearly (and to a significant degree) enable the much-sought ability to transform raw operational environment data into useful information, sound insights, and knowledge. Finally, they enable better decision making—a goal towards which the US government is currently making significant investments (more than $200 million) under its Big Data Research and Development Initiative.[23] Beyond this broad operational utility of better decision support, these OEMs offer for the first time the potential to deliver the modeling of systems and systems of systems. The latter, in turn, can allow the automated support of nodal analysis and system-of-systems analysis—core concepts of effects-based targeting as articulated and advocated widely within the Air Force and by Lt Gen David Deptula, USAF, retired, in particular.[24] They also allow the broader effects-based approach to military operations, as discussed and advocated in Air Force operational doctrine.[25]

An extension of developing these dynamic, user-defined OEMs entails using the logical abstractions of the CAPE construct to develop a complete operational planning, execution, and assessment ontology that, with tool or system support, allows construction and maintenance of an operational plan model (OPM) "on the fly" as commanders and staffs plan, execute, and assess an operation. Key to the practical employment of these OPMs is that the logical construct establishes (for the first time) a standard method for capturing and visualizing plans. It also defines and captures all the semantic relationships among an operational environment's constituent system elements and the various parts of a comprehensive, conditions-based plan.

Another key innovation—the identification within the CAPE construct of both *objects of action* and *objects of effect* as plan elements—plays a pivotal role in enabling this interconnection between an OPM and related OEM. An object of action denotes an operational environment element against which an action is planned or actually directed, whereas an object of effect is an operational environment element on which an effect is intended or actually produced. These key elements jointly act as one of two logical bridges or "touch points" between the two model types. That is, the plan model's objects of action and objects of effect will also be discretely represented as operational environment system entities with the OEM, therefore enabling modeling interaction between the OPM and OEM.

The recognition, capture, and visualization of causal links—another key innovation of the CAPE approach—act as the second of the two logical bridges or touch points between OPMs and OEMs. These causal links constitute an identified mechanism that causes a given effect to be produced that is of a different nature to that of the contributory effect or action. The author considers it wise at this point to quickly address the use of causal links within the CAPE construct, particularly the use of the phrase *identified mechanism*. To do so is appropriate, given the widely voiced criticisms of the effects-based approach to operations among elements of the US joint community, typified by statements such as "the ideas reflected in [effects-based operations] . . . have not delivered on their advertised benefits and . . . a clear understanding of these concepts has proven problematic and elusive for US and multinational personnel."[26] The pertinent element concerns the meaning of *identified*. Its use here is not intended in the context of a "preknown" mechanism but in the context of either a recognized or acknowledged mechanism. That is, whether the mechanism is a preknown fact or law of nature, something recently deduced from empirical observation or just a planner's or commander's best intuitive guess, it is the mechanism that has been identified (i.e., articulated and captured) as the assumed means of causing an intended effect. Perhaps one could ask the rhetorical question, What is the implication of an operational planning process that doesn't identify the logical linkages between intended actions and required outcomes? To the author, the adage regarding hope as a poor foundation for a plan seems germane to any attempted answer.

Figure 3 offers a visualization of some of CAPE's tactical-level planning elements, including the use of causal links. The figure depicts a tactical scheme for the delivery of the tactical objective "enemy Mechanized Infantry Brigade X unable to affect friendly ground assault." The planners identified that Brigade X had to cross a local river to affect the friendly assault and that four key bridges spanned the river. Therefore, they devised a tactical scheme (LOE) that involved a single tactical task with a single ATO mission (Mission XYZ) tasked to drop (deliver functional kills on) the bridges with the direct effect that all of them would be unusable by mechanized infantry. Obviously, the planners assumed that this action would deliver an intermediate indirect effect of "Mechanized Infantry Brigade X unable to cross river"—the actual purpose of the TT (its objective). Then, as the third-order consequence, the planners believed that the intended TO would be delivered.

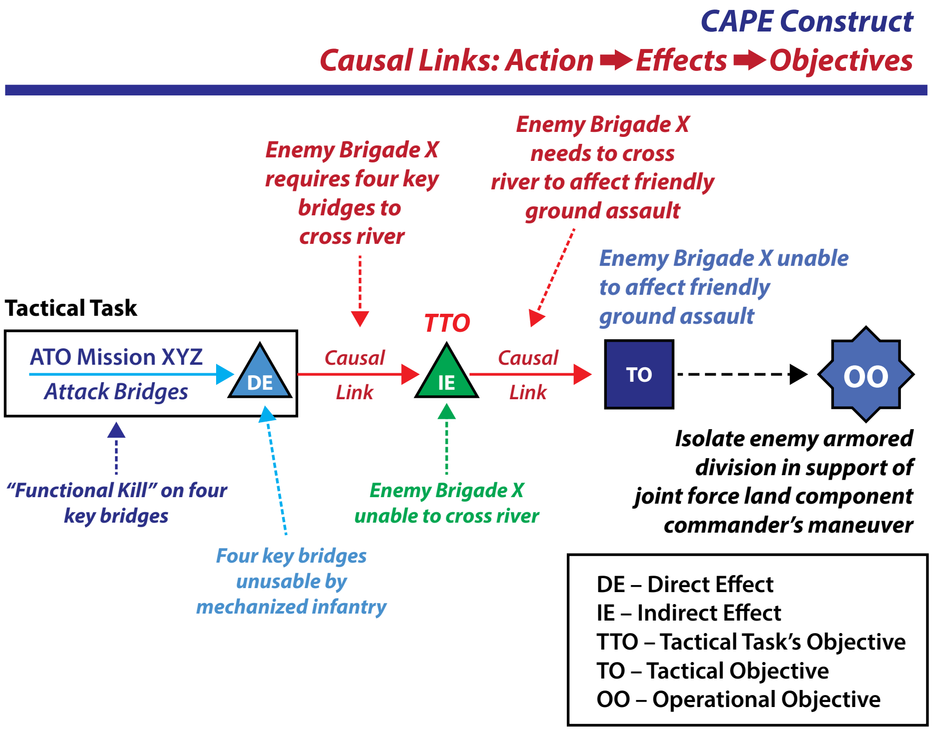

Figure 3. CAPE construct: Causal links within an operational plan

Therefore, in this example, the object of action was collectively the four key bridges, and the common object of effect (common to both second- and third-order effects) was the enemy's Mechanized Infantry Brigade X. However, one must note that the scheme sought to affect two different, specific capabilities of Brigade X: its ability to cross the river and its ability to affect the friendly assault. This is evidenced by the two discrete causal links that the planners assumed were in play: (1) enemy Brigade X requires four key bridges to cross the river and (2) to affect the friendly ground assault, enemy Brigade X must cross the river. Hopefully, the relevance of identifying and considering causal links is self-evident. As in the above example, if an assumed causal link proves false or not in play, the intended outcome or effect probably will not occur unless produced by some other unidentified causal mechanism or fortuitous happenstance—but certainly not by the intended cause-and-effect scheme planned for.

The author again challenges this journal's readership to consider the implications of the above tactical scheme in terms of assumed causal links if any one or more of the following circumstances were actually in situ within the operational environment:

- The action followed a long period of drought and the river had been dry for many months.
- Brigade X was equipped with and well trained in the use of bridging equipment.
- Brigade X's order of battle had just been enhanced with a supporting long-range artillery unit.
- The actual maneuver of the friendly ground assault had to swing up against the friendly side of the river.

In most cases, the causal links employed within a plan are deduced during the various operational design, estimate, and planning processes, as illustrated in the above vignette. One can therefore see that within the CAPE approach, a causal link so identified and employed within an operational plan can be instantiated within the OPM. It should relate to some form of link (physical, functional, behavioral, or logical) that actually exists (planning fact) or that one assumes to exist (an identified planning assumption) between the relevant system entities in the operational environment (e.g., between the object of action and related object of effect). Therefore it can and should be captured and represented within the respective OEM. In other words, and as depicted in figure 4, one can directly relate a plan's/OPM's causal links to discrete (actual or assumed) system links in an OEM, as one can similarly relate objects of action and objects of effect to system entities in the OEM.

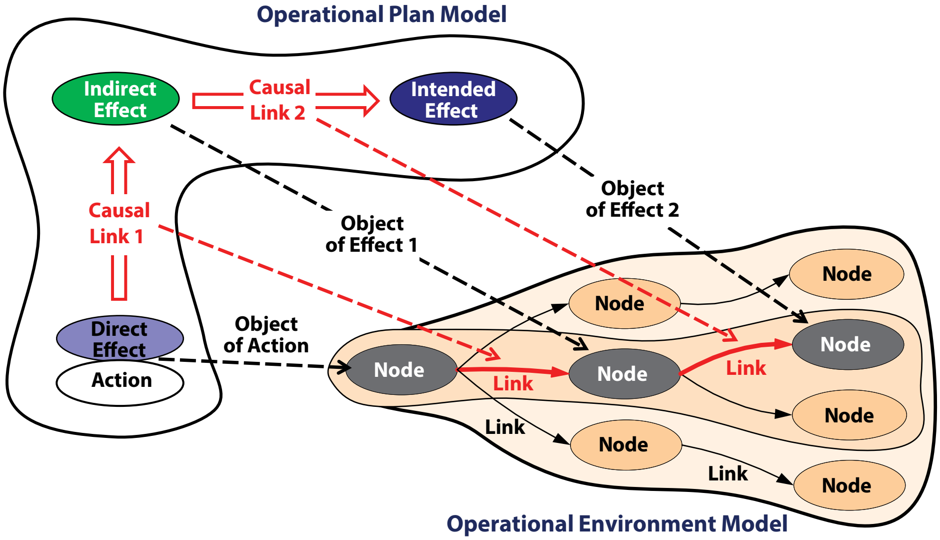

Figure 4. CAPE construct: Interconnections between OPMs and OEMs

As with the expansion above on the identification of causal links, it is worthwhile here also to expand on the introduction and use of the tactical task objective (TTO), a new planning element to those familiar with the Air Force's most common OO-TO-TT planning hierarchy. This evolution in terminology addresses both what is in fact the common (mis)usage of the term *tactical task* and the explicit identification and separation of tasked action from that of the action's desired effects. Specifically, CAPE defines a TT as a *discrete scheme of tactical action undertaken to produce an intended tactical-level direct effect* and a TTO as the *intended, discrete tactical-level effect that directly contributes to or enables the achievement of a tactical objective*.

In the author's AOC experience to date, TTs invariably have been written as intended tactical-level effects (equivalent to a CAPE-defined TTO); therefore, in CAPE terms, the current common usage already is OO-TO-TTO. CAPE is redefining the planning term *tactical task* to capture the tasks actually assigned to tactical units, as will eventually be represented in an ATO (or similar tasking order).[27] The tactical vignette offered above provides a clear example of this usage: the TT was the aircraft mission to deliver functional kills on four bridges, and the TTO called for preventing Brigade X from crossing the river.[28] Indeed, one can recognize this construct simply as realizing within the Air Force's strategy-to-task construct the mission-type order, already ubiquitously employed within Army and joint communities (i.e., tactical unit X is tasked in an ATO to undertake TT Y in order to deliver TTO Z). In the author's operational experience both as a member of a strike/attack aircrew during Operation Desert Storm and as an operational planner/tasker during Operations Southern Watch, Allied Force, Enduring Freedom, and Iraqi Freedom, the ATO conveyed to a tasked unit only the required tactical mission (the required direct effect of the weapons). Very rarely, if ever, did it offer any insight regarding the "in order to" element—that is, the action's actual, immediate objective (the TTO), never mind the associated higher-order objectives (TO and OO).

The CAPE methodology also enables the ready incorporation of mission-type orders within the JFACC's normal tasking vehicle (the ATO) through the simple expedient of facilitating the referencing of the related TTO (and, arguably, the parent TO) within each ATO mission's tasking data/narrative. To emphasize the potential benefits of enabling the mission-type-order concept within the ATO, the author for the final time challenges this journal's readership to consider the following situations:

- In the above fictitious bridge-related vignette, during execution the tasked mission approaches the target area and sees mechanized infantry equipment streaming across the dry river bed south of the target bridges in what appears to be a more direct route to interdicting the ongoing friendly ground assault. In one case, the mission lead is aware only of his ATO mission task of dropping four bridges; in a second case, the mission lead also knows about the mission's TTO of preventing a mechanized infantry brigade from crossing the river, which in turn is an order to prevent a mechanized infantry brigade from affecting the current friendly ground assault—the TO.

- In a second real-world vignette, which the author himself witnessed during Southern Watch, friendly forces tried desperately to locate a drone aircraft capable of delivering weapons of mass destruction (WMD) with which the Iraqis were playing a shell game among numerous hardened aircraft shelters (HAS). Out of the blue, ISR assets located the HAS housing the drone, so a strike mission launched with an ATO mission task of destroying HAS X. The mission returned, rightly boasting direct hits on the target HAS, and the crew added to the intelligence picture by reporting the sighting of a drone-like aircraft of interest sitting on the hard-standing across from the target HAS! Thus, as an alternate case to what actually occurred, the mission lead could have been made aware that the crew was tasked to destroy the HAS in order to destroy a WMD-capable drone aircraft believed to be housed in HAS X.

So both of the above situations raise the question, What would the likely variances in outcomes have been between the two cases (knowing or not knowing the "in order to"), and which would likely represent the more beneficial outcomes?

Conclusion to Part 1

Part 1 of this article has discussed the extant problems and failings of C2's operational planning and assessment capabilities across all of the US government's C2 domains and at all levels, which included ad hoc processes; a paucity of information-technology support tools; and limitations of data acquisition, correlation, analysis, and visualizations. It then examined how many of these shortfalls one could address through the employment of an evolutionary planning construct and methodology known as Comprehensive Adaptive Planning and Execution. The article went on to explain how the CAPE approach enables the utilization of abstract semantic models of both operational plans and operational environments to relate and realign data and to enable automated reasoning and inferencing across those models.

The second part of this article will describe how modern semantic technologies can efficiently implement—as services within a service-oriented architecture—the CAPE methodology, OPMs, and OEMs as a highly practical and effective planning and assessment paradigm for the twenty-first-century AOC. These services provide hitherto unavailable C2 resources and capabilities to commanders, planners, assessors, and analysts for timely decision making and achievement of campaign objectives. The second part will introduce the solution technology involved in the generation and integration of semantic planning and environment models and will discuss a proof-of-concept implementation. It will then show how the solution approach could benefit a comprehensive approach to planning, execution, and assessment, highlighting the solution benefits of this semantic, modeling-powered, CAPE-based approach to enabling unified and dynamic C2. ✪

Notes

1. This article is an abridged, amended, and updated version of the following: Redvers Thompson, Anton DeFrancesco, and Phil Warlick, "Enhancing Command and Control (C2) Assessment through Semantic Systems" (paper presented at the 16th International Command and Control Research and Technology Symposium, Québec City, Canada, 21–23 June 2011), http://www.dodccrp.org/events/16th_iccrts_2011/papers/135.pdf.
2. Lt Col David C. Hathaway, USAF, "Operational Assessment during Operation Iraqi Freedom: Assessment or Assumption?," Air War College research paper (Maxwell AFB, AL: Air War College, 25 May 2005), 18.
3. Ibid., 15.
4. Air Force Electronic Systems Command, Small Business Innovation Research Topic AF093-025: "Visualization of Cross-Domain C2ISR Operations," topic prerelease intent statement, July 2009.
5. Ibid., see "Description," http://www.afsbirsttr.com/TopicPreRelease/Profile.aspx?pk=20201; and author's personal operational experiences from Operation Allied Force (Vicenza AOC, Strategy Division, April–June 1999), Operation Enduring Freedom (Headquarters US Central Command, J5, September–December 2001), and Operation Iraqi Freedom (Headquarters US Air Forces Central [CENTAF], Strategy Division, July–December 2002, and Prince Sultan Air Base–CENTAF AOC, Strategy Division, January–April 2003).
6. Joseph J. Collins, *Choosing War: The Decision to Invade Iraq and Its Aftermath*, Occasional Paper 5 (Washington, DC: National Defense University Press, April 2008), 28, http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA479692.

7. Williamson Murray with LTC Kevin Woods, USA, *Thoughts on Effects-Based Operations, Strategy, and the Conduct of War* (Alexandria, VA: Institute for Defense Analyses, January 2004), 2, http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ada428069.

8. Sandeep Mulgund and Seth Landsman, "User Defined Operational Pictures for Tailored Situation Awareness" (Bedford, MA: MITRE Corporation, 19 June 2007), http://www.dodccrp.org/events/12th_ICCRTS/CD/html/presentations/090.pdf.

9. Hathaway, "Operational Assessment," 19.

10. Deputy Under Secretary of Defense for Advanced Systems and Concepts (DUSD [AS&C]) PowerPoint Presentation, "Adaptive Planning Pilot (APP)–Joint Capability Technology Demonstration (JCTD)–FY08 Rolling Start," 21 December 2007; and DUSD (AS&C), "Adaptive Planning Roadmap II–2008," March 2008.

11. Joint Publication 3-0, *Joint Operations*, 11 August 2011, II-9, http://www.dtic.mil/doctrine/new_pubs/jp3_0.pdf.

12. Normally, each ATO is assigned a team of ATO coordinators. This two-person team acts as the primary focal point for its assigned ATO, ensuring continuity and consistency, preventing corruption of JFACC strategy and guidance, and resolving issues, as required, to produce that period's effects.

13. DUSD (AS&C), "Adaptive Planning Roadmap II–2008."

14. "A 'Comprehensive Approach' to Crisis Management," North Atlantic Treaty Organization, 21 March 2012, http://www.nato.int/cps/en/natolive/topics_51633.htm; and Marine Corps Combat Development Command, *Countering Irregular Threats: A Comprehensive Approach* (Quantico, VA: Marine Corps Combat Development Command, 14 June 2006), http://www.fas.org/irp/doddir/usmc/irreg.pdf.

15. The author developed the CAPE construct and employment methodology during the course of the planning and execution of Operation Iraqi Freedom, subsequently enhancing and detailing them during his remaining time as the Strategy Division chief, UK Joint Force Air Component Headquarters. He made further refinements during his exchange tour at the US Air Force's 505th Command and Control Wing, during which he was invited to introduce and instruct on the CAPE methodology as part of the Air Force's Command and Control Warrior Advanced Course.

16. This development and advocacy of LOEs predates the concept's recent parallel adoption within US Army planning doctrine: "A *line of effort* links multiple tasks and missions using the logic of purpose—cause and effect—to focus efforts toward establishing operational and strategic conditions" (emphasis in original). Field Manual 3-0, *Operations*, February 2008, 6-13, http://downloads.army.mil/fm3-0/FM3-0.pdf.

17. The lexicon draws from work undertaken by Headquarters Air Force Doctrine Center; the Effects-Based Operations Integrated Process Team; the Air Force Assessment Task Force; the 505th Command and Control Wing at Hurlburt Field, Florida; the Dynamic Air and Space Effects-Based Assessment Subject-Matter Expert Users Group; and Air University's College of Aerospace Doctrine, Research and Education, as well as some of the efforts conducted by US Joint Forces Command.

18. Thompson, DeFrancesco, and Warlick, "Enhancing Command and Control," Appendix B.

19. Ibid., Appendix C.

20. Ibid., Appendix D.

21. Ibid., Appendix E: Exemplar Logical Abstraction of Operational Environment Entities; Military Production and Distribution.

22. "Welcome to the PMESII Tool Index," US Joint Forces Command, 8 August 2008, http://pmesii.dm2research.com/wiki/index.php/Main_Page.

23. "Obama Administration Unveils 'Big Data' Initiative: Announces $200 Million in New R&D Investments," news release (Washington, DC: Office of Science and Technology Policy, Executive Office of the President, 29 March 2012), http://www.whitehouse.gov/sites/default/files/microsites/ostp/big_data_press_release.pdf.

24. Brig Gen David A. Deptula, *Effects-Based Operations: Change in the Nature of Warfare* (Arlington, VA: Aerospace Education Foundation, 2001).

25. Air Force Doctrine Document 2, *Operations and Organization*, 3 April 2007, 13, http://www.e-publishing.af.mil/shared/media/epubs/AFDD2.pdf.

26. [Gen] James N. Mattis, "USJFCOM Commander's Guidance for Effects-Based Operations," *Parameters*, Autumn 2008, 19–20, http://www.carlisle.army.mil/usawc/Parameters/Articles/08autumn/mattis.pdf.

27. Although the author prefers to confine the main discussion here to the TT level and above, he wishes to preempt a question that may occur to some readers by noting that the term *tactical task* (TT) does relate to a discrete *scheme* of tactical action, which may be realized during tactical execution through one or more assigned ATO *mission tasks* (MT) (as determined during the targeting effects team [TET] and master air attack plan [MAAP] processes of the ATO cycle).

28. As discussed, normally the AOC's TET and MAAP processes determine whether in fact the TT is undertaken as a single mission (mission task), perhaps by a single bomber, or multiple missions (mission tasks), perhaps using multiple fighter missions and/or indirect fires from the land component commander's supporting assets (Army Tactical Missile System).

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