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"C2 for Complex Endeavors"

Title: Network-Centric Analysis and Representation Requirements for Successful Effects Based Operations

Topic 1: C2 Concepts, Theory & Policy; Topic 4: Cognitive & Social Issues; Topic 6: C2 Assessment Tools & Metrics; Topic 7: Network-Centric Experimentations & Analysis

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Achieving Effects Based Operations (EBO) desired impact requires a revolution in how EBO is conceptualized and represented to C2 decision-makers. An "effect" is the functional outcome, event or consequence that results from specific physical actions (Joint Publication 1-02). The relationships between the physical components of the adversary's system-of-systems are complex and must be represented as a set of many-to-many functional linkages, in order to make effective EBO targeting decisions. Current EBO conceptualizations tend to be based on physical metaphors (e.g., maps with icons), which mask the relationships between adversary systems, as well as mask the multi-functional capabilities of a single physical asset. Further, most current EBO assessments degrade into physical damage on target. The many-to-many functional-to-physical relationships form a network that can be characterized by its large number of disparate entities and which must be understood, in order to predict cascades of effects and other network behavior. Failing to identify network interactions and functional alternatives to C2 decision-makers may falsely lead them to the conclusion that the application of combat power to a single target will lead to the removal of that capability. The defining element necessary for achieving effects includes emphasis on developing support tools and a knowledge model capable of accurately representing the adversary's system-of-systems. This paper will outline an approach for conceptualizing and representing the many-to-many functional relationships inherent in EBO and offer visualization tools that enable C2 decision-makers to effectively execute EBO.

Network-Centric Analysis and Representation Requirements for Successful Effects Based Operations

The U.S. military has moved toward a new concept of military planning and operations that is agile and adaptable to the conflict at hand (Joint Warfighting Center, 2004). This Effects Based Operations (EBO) concept encompasses processes, tools, and organizations that focus on planning, executing, and assessing military activities for the effects produced rather than merely tallying the number of physical targets destroyed. EBO requires a deep knowledge of the enemy capabilities and structures. In addition, there is the need to understand how physical actions will cause effects that will propagate through the innate dependencies and relationships within the enemy's physical networks. Because EBO emphasizes outcomes and seeks to minimize the costs of conflict, EBO is much more information-intensive than physical attrition-based military operations.

The ability to achieve the desired set of effects demands that information about the functional relationships of the enemy's physical system of systems is available to decision makers in order for them to understand the environment. This is more than a matter of collecting information on the military operations, the technical characteristics of weapon systems, and the geographic distribution of friendly and enemy forces. To date, the movement toward EBO has rested upon the building of military doctrine, organization, and operational experimentation (Air Combat Command, 2004). However, *the lynchpin of EBO ultimately will be the development of conceptual tools that link physical military actions with their resulting cascade of functional effects.*

The establishment of this relationship between the physical world and functional world is critical for EBO to be successful. "Function" is defined as the property of a physical object, and from an engineering perspective, it is the objective, goal, or purpose for which it is used (IEEE, 1998). When conducting an EBO analysis it is critical to realize the same function can be accomplished using different physical processes. For example several different physical objects can accomplish the main function of a clock. Mechanical, electronic, or atomic mechanisms can be used to drive the representation of time. Similarly, a single physical object can be used to achieve of multiple functions. A brick (a very simple physical object) could be used for a multiple functions including: building a wall, anchoring a boat, sanding a surface, cracking a nut, or as a projectile weapon. Thus there is a many-to-many mapping between the physical

world and functional world. Further complicating this, the EBO operator actions are physical actions on the physical assets of the adversary. However, these actions are intended to achieve functional (effects based) results.

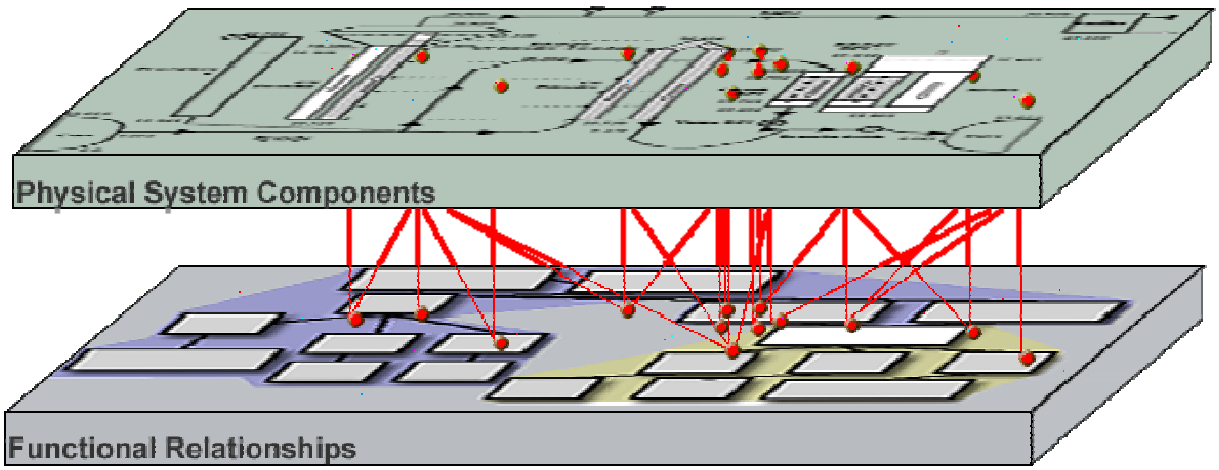

Figure 1. Many to Many Physical to Functional Mapping

The current suite of analytic tools employed is insufficient to support this approach to military operations (Lee & Kupersmith, 2002). These tools were not initially designed to determine how the use of force affects adversary functions or to represent unintended consequences (i.e., the "other" functions associated with the physical component attacked). The reason for this is that the requirements used to develop these tools did not accurately reflect the many-to-many physical to functional relationships inherent within the systems of interest to military operations. This paper will outline an approach for conceptualizing and representing the many-to-many physical to functional relationships inherent in EBO and offer requirements for visualizations that enable decision-makers to effectively execute EBO.

Defining EBO

Effects-Based Operations (EBO) are actions taken against enemy systems designed to achieve specific effects that contribute directly to desired military and political outcomes (Air Combat Command, 2004). Identifying desired and undesired effects (conditions related to achieving objectives) within the operational environment connects military strategic and operational objectives (prescribed friendly goals) to tactical tasks (direct friendly action). Effects-based doctrine utilizes a "Systems View" to help clarify the

relationship between tasks and objectives by describing the conditions that need to be established to achieve the military objectives and attain the desired end state.

A systems view strives to provide an understanding of interrelated systems (e.g., political, military, economic, social, information, infrastructure, and others). Within an EBO context, a "System" is defined as a network of nodes and links within a battlespace that represents any combination of people, material, facilities, and information and their relationships to one another (Joint Warfighting Center, 2004). The EBO methodology suggests that every system can be analyzed by using node-link analysis. A system is also understood as any organized assembly of resources and procedures united and regulated by interaction or interdependence to accomplish a set of specific functions. A system of systems is defined as grouping assemblies of resources, methods, and procedures regulated by interaction or interdependence to accomplish a set of specific functions. Developing an accurate systems view can promote a commonly shared understanding of the operational environment. Understanding systems, their interaction with each other and how system relationships will change over time is critical for commanders and their staff in order for them to create the desired effects.

EBO doctrine defines an "Effect" as the physical or behavioral state of a system that results from an action, a set of actions, or another effect (Joint Warfighting Center, 2006). A set of desired effects contributes to the conditions necessary to achieve an associated military objective. At the lowest effect level, weapons employment (physical actions) typically creates discrete physical results (i.e., destruction) and functional effects on specific systems. The process of linking the desired effects of fires to actions and tasks at the component level to objectives is critical for effective military operations. Strategic and operational effects relate to changing the larger functional aspects of various systems' behaviors. At the strategic and operational levels, it is necessary to understand the functional relationships (links) between the physical system nodes when considering how best to produce a desired effect. The full set of desired effects would represent the conditions for achieving the national strategic objectives – an EBO Effects Network. However, prediction is difficult because it is hard to determine what physical actions must be accomplished against which physical targets in order to generate the desired effects over a period of time. This is especially complicated at the operational and strategic levels of war where the desired results are less concerned with physical damage and more concerned with achieving the functional effect. *EBO needs a framework for explicitly linking physical actions to functional effects*.

Problems with current Approach to EBO

Currently concepts within EBO tend to be based on physical metaphors (e.g. maps with icons), which are ill-suited to representing the functional issues at the heart of EBO. In order to integrate decision support into an EBO framework, better support tools are need to conduct a functional analysis of the enemy's systems and processes as the basis for understanding what functional impacts can be imposed on the enemy by selected friendly actions. Most current Air Force systems use hierarchies to represent the relationships between plan elements as well as the desired effects on the enemy. A hierarchy is an organizational simplification that makes it easier to represent and implement in software tools. In addition to inadequately representing an adversary's system of systems, hierarchies do not accurately portray the relationships between a single physical (friendly) action, its physical effects on the adversary's assets, and their multiple functional impacts on the adversary's operations. The use of hierarchies masks the functional relationships between systems as well as the multiple functional capabilities of a single physical entity. Unfortunately, a hierarchy's simplicity also makes it inadequate to represent the many-to-many couplings between physical entities and their functions, as well as dependencies between functions. Current solutions to EBO do not achieve the desired effectiveness due to the large scale, complex interrelationships, and dependencies of the distributed adversary systems that cannot be understood through the physical data alone.

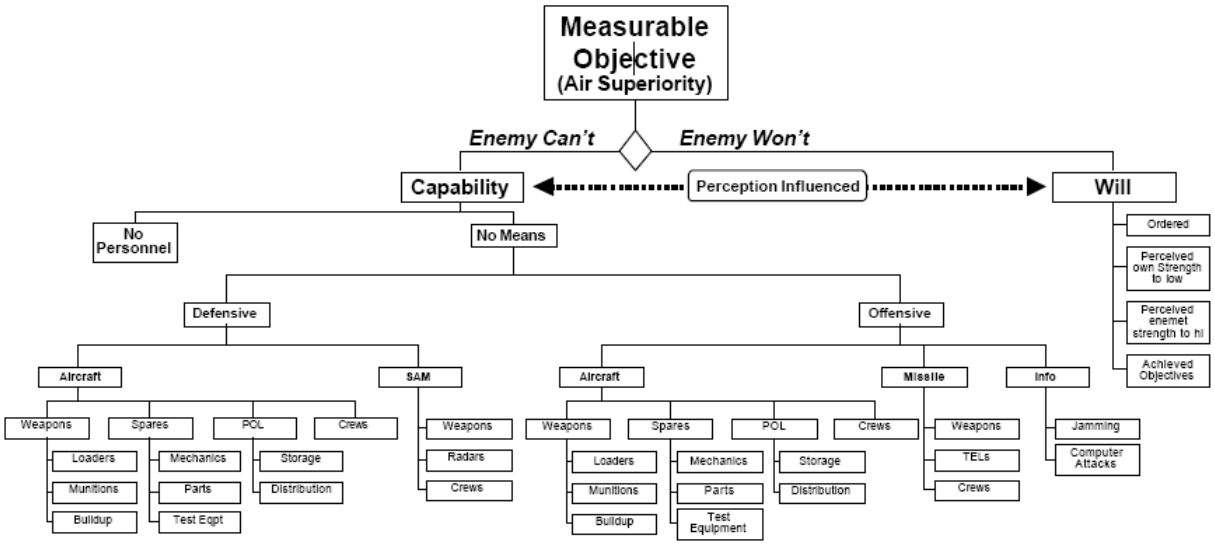

Figure 2. Traditional EBO Representations Do Not Accurately Portray the Relationship Between Physical Components and Functional Effects

From an EBO perspective, the adversary is made up of many different systems (social, information, infrastructure, etc…); within each adversary system there are huge numbers of entities (from the thousands to hundreds of thousands) that must be considered when developing an EBO plan. Additionally, there are complex relationships between the various physical entities that must be understood and planned for in order to achieve the desired effects. Without that understanding, identifying desired effects within the operational environment connects and linking them to tactical tasks is nearly impossible. In addition, planning must consider the unintended effects that an action might create. The inability of the warfighter to see the potential functional linkages between physical entities is problematic. Even more problematic is the net potential of unintended effects based on the combination of a set of physical actions. These cascading effect can be addressed, if the physical entities are being considered in isolation without consideration of how the entities are functionally related.

While the relationships look simple from the perspective of any one physical entity in the system, the multitude of interconnections within the relationships between entities makes understanding the of the adversary's system extremely difficult. The ability understand the functional impact of attacking one physical entity while being overwhelmed by ripple of functional results at the effects network perspective can be compared to being lost in an unfamiliar town. While one can navigate forward and backward along the streets of the town moving from one block to the next, it is nearly impossible to determine how to get a particular location without a frame of reference. Currently EBO lacks a method for building that frame of reference.

The large scale and complexity of the physical operational environment for military operations causes several complications for the management of EBO. Due to the complex relationships between the many physical entities, the impact of a single event anywhere within the operational environment can have an untold number of effects elsewhere in effect space. This produces a kind of butterfly effect, in which the smallest disruption anywhere in the operation (and small disruptions happen all the time) can cascade into catastrophic consequences for the plan. EBO is made more difficult because decision-makers are unable to see and understand the operation-wide implications of each small disruption (and any large disruption) in the EBO plan, and made even more difficult as many disruptions occur simultaneously in large military operations.

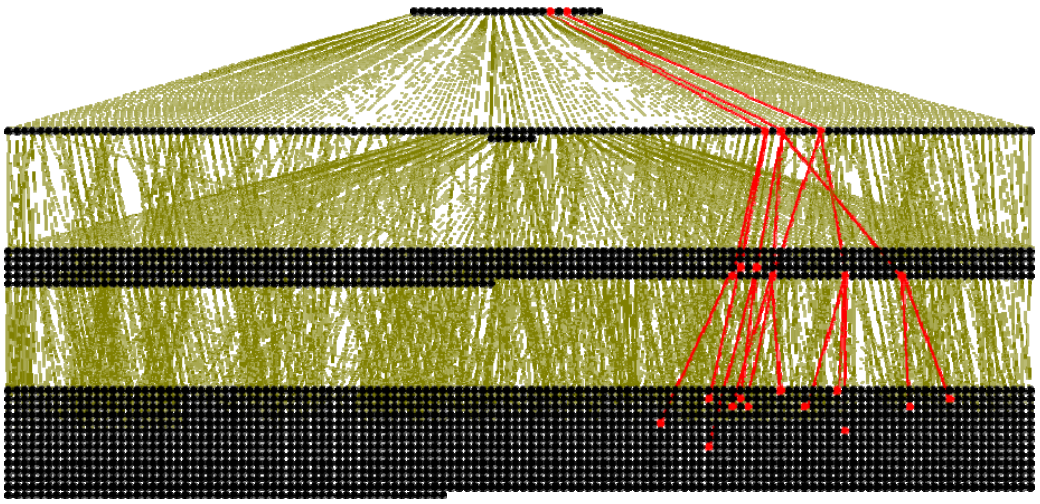

Figure 3. The Butterfly Effect: An Attack on a Single Physical Entity may Impact multiple components Due to the Many-to-Many Physical-to-Functional Linkages

Additionally, as most military operations are resource-constrained, in that there isn't enough resources to do all the work that is requested (either in effect implementation or assessment), it is very difficult to manage the set of physical entities when new, high-importance effect requests are introduced, when currently tasked resources go down, or when currently tasked resources get behind schedule. Today, EBO decision-makers have a tough time with the delicate balancing act of constantly retuning the plan's myriad of moving parts to achieve the individual mission effects as well as the overall operational objectives.

One of the goals of EBO is to create a coordinated and synergistic operation that will produce the desired effects. Continuous assessment must measure and evaluate the impact of actions taken in the physical world. Assessment includes: determining if the actions achieved the desired effects, produced unintended effects, and if the executed actions contributed to achievement of the desired objectives. The proposed many-to-many representational framework will provide decision-makers with the perspective that they need to effectively execute EBO.

Finally, it is difficult generating a shared knowledge of the status of the overall EBO effects network. While individual members of the decision-making team may have good situational awareness (SA) of their own portion of the EBO effects network, the collective SA required to manage the effects network as a whole has been insufficient. This has exacerbated the problem of retuning the plan as individual decision-makers are only able to tune their own subsystems, often in contradiction to what is optimal for the overall

operation. EBO decision-makers do not have the required collective situational awareness needed to alleviate these problems.

What is needed for successful EBO

EBO depends on a different perspective on the target set, one that focuses on the inter-relations of the physical entities that comprise the target set within a larger system. The associated functional inter-relationships within the adversary's overall operation need to be understood. Particular attention needs to be devoted to those properties and mechanisms that account for coherent behavior in the system and the functional relationships between physical entities of that comprise that system. While EBO may provide a longer list of targets than contemporary targeting methods, it does not necessarily mandate more effort. In fact, the goal of EBO is to provide more information about the behavior of the entire target system so effects can be more reliably predicted and more logically derived (Effects-Based Operations Panel, 2003). In addition, EBO supports lethal, non-lethal, and information warfare attack unification and synchronization across the target set, providing greater economy of force than current "stove-piped" application of these means.

Achieving the desired impact and agility for EBO requires a revolution in how EBO is conceptualized. EBO's functional nature must be the focus of support – the desired effects that the warfighter is attempting to achieve are the result of influencing functional processes and there fore must be observable to the warfighter. However, in order to make effective EBO targeting decisions, the functional relationships of adversary's systems must be correctly mapped to the physical components of that system. Because all actions executed, even those in an EBO framework, are manifested as physical behaviors against physical entities, the physical-to-functional mapping must be understood by the decision-makers. *This ability to understand and represent the relationship between physical entities on the battlefield and their functional affordances is one area that needs further development in order for EBO C2 to be effective and successful.*

The function of an object may change dramatically without changing any of its own physical properties. For EBO to successful, it is necessary that a domain analysis of the adversary be conducted to understand and document the goals to be achieved in the domain and the functional means available for achieving them. The objective of this functional analysis is a structured representation of the functional concepts and their relationships to serve as the context for "effects targeting". It depicts the functional abstractions and relationships of the domain (rather than part-whole representations, temporal work task representations,

etc.) as the best representation to achieve the needed richness. The challenging aspect of this is the systematic discovery of the most abstract of the functional concepts (Rasmussen, 1986). The physical aspects of the domain can be viewed and touched and inspected, the abstract functional concepts require understanding. An effective analysis properly discovers these essential, elusive abstract concepts and how they relate to each other.

An abstract model of the functional nature of the adversary's system of systems, including the desired military objectives and effects, provides the necessary exploration of highly abstract concepts of the battlespace. This functional framework is sufficiently robust (independent of the physical particulars of the situation) that an effects based plan can be mapped on to it, while avoiding the brittleness inherent in plans that only address physical components. Thus, the system's functional view defines the fundamental skeleton of the plan and ultimately the form of the effects network communicated to the decision-makers controlling operations.

A second area that needs further development for successful EBO is the ability for decision-makers to coordinate their actions. What is needed is a new kind of collaborative environment, in which participants share data, information, knowledge, and concepts, in real time regardless of physical location. This environment must be more than just a "virtual conference room" or "common operating picture". It must be functionally organized and enable planners to build a plan in discrete parts or sub-plans concurrently and continuously rather than sequentially, and enable the integration into the overall plan. The collaboration environment must provide planners with a "view of the whole" while working on various sections of a plan, which helps them to identify and resolve planning conflicts early. Given the challenge in understanding the interdependencies of EBO by an individual decision-maker, it is even more challenging when dispersed across operational environment. With a truly collaborative environment, the plan itself becomes the brief and removes the need for the traditional sequential briefing process. A process that takes away assets (warfighters) offline of the fight to build briefings and conduct them

Effective EBO demands that commanders and staffs collaborate in planning (e.g., determining the mission, operational objectives, desired effects, and tasks), executing, and assessing operations. The central issue is the way collaborating decision-makers manage to coordinate and adjust their actions to the processes of knowledge construction and problem solving that occur between them. Coordination is realized by a complex interaction between task related strategies, cooperative intentions and communication processes

during collaboration learning. Although face-to-face interaction is desirable, modern warfare frequently requires collaboration among dispersed forces. Collaboration requires that the decision-makers acquire a common frame of reference (grounding) in order to be able to negotiate and communicate their individual viewpoints and inferences. The effects network derived from a functional analysis provides a common frame of reference that will serve as the cornerstone for all EBO planning, execution, and assessment. Commanders and their staffs require capabilities that not only provide a common understanding during routine interactions, but also can enhance combat effectiveness during time-compressed operations.

By focusing decision-makers on the effects network as the common frame of reference, they will maintain a shared discourse and will try to repair their common frame of reference when divergence is noticed. Furthermore, by checking new information with regard to the existing effects network, the commanders and their staffs guard the coherence and consistency of their collective knowledge base.

Commander's and their staffs need knowledge management tools and systems to advance the effectiveness of EBO. These tools must be accessible, accurate, and timely to support planning, execution, and assessment requirements. Effective integration of large amounts of EBO relevant information will require a visualization that enables the relationships within the effects network to be apparent as well as the status of each effect in the network. Real-time update of the visualization is necessary to incorporate the results of attacks on enemy assets into dynamic EBO planning tools and decision aids. In addition, these tools must support dynamic tasking and assessment, provide a seamless collaborative information environment through integration of tools, processes, data, and information, and asynchronous information flow. The primary challenge to meeting these needs is providing an effects network visualization. Effects network visualization should simultaneously provide an overview of current operations while also providing sufficient detail to support real time plan evaluation and dynamic re-tasking of assets.

Functional Analysis – the key to unlocking EBO Success

Traditional analytic efforts to understand and represent EBO concepts have provided little insight into what information is actually required by the decision maker. By contrast, the Applied Cognitive Systems Engineering (ACSE) methodology is based on understanding functional concepts within a domain and their relationship to one another. These same functional concepts and relationships are inherent in EBO. In addition, ACSE is designed specifically to support the representation of the abstract concepts and

commodities. These concepts and commodities provide the substrate on which EBO effects are situated. The use of ACSE can provide a systematic approach to analyzing the functions of an adversary's systems.

The ACSE methodology addresses the analysis, design, and evaluation of a decision support system. ACSE begins with the concept development process as a cognitive analysis "support[s] the development of revolutionary systems unconstrained by previous solutions" (Sanderson, Naikar, Lintern, & Goss, 1999). Cognitive analyses are powerful because they abstract away the organizational partitioning of the work domain to model the underlying goals, functional relationships, and cognitive work. The cognitive work analysis phase of ACSE uses a focused approach to generate the understanding of the work domain, in order to develop support requirements. While many of the standard knowledge elicitation (KE) approaches are used to create the baseline domain knowledge, the information gathered from these techniques is then combined with situated observation in the work domain to generate specific focus areas. These focus areas are based on why a user is performing a particular task, because understanding the why drives at the decision-making the user is trying to accomplish, helping to define the functional goals fundamental to the work domain. These functional goals, and the relationships between them, are captured within a Functional Abstraction Network (FAN). This lays the foundation from which the system design should be based.

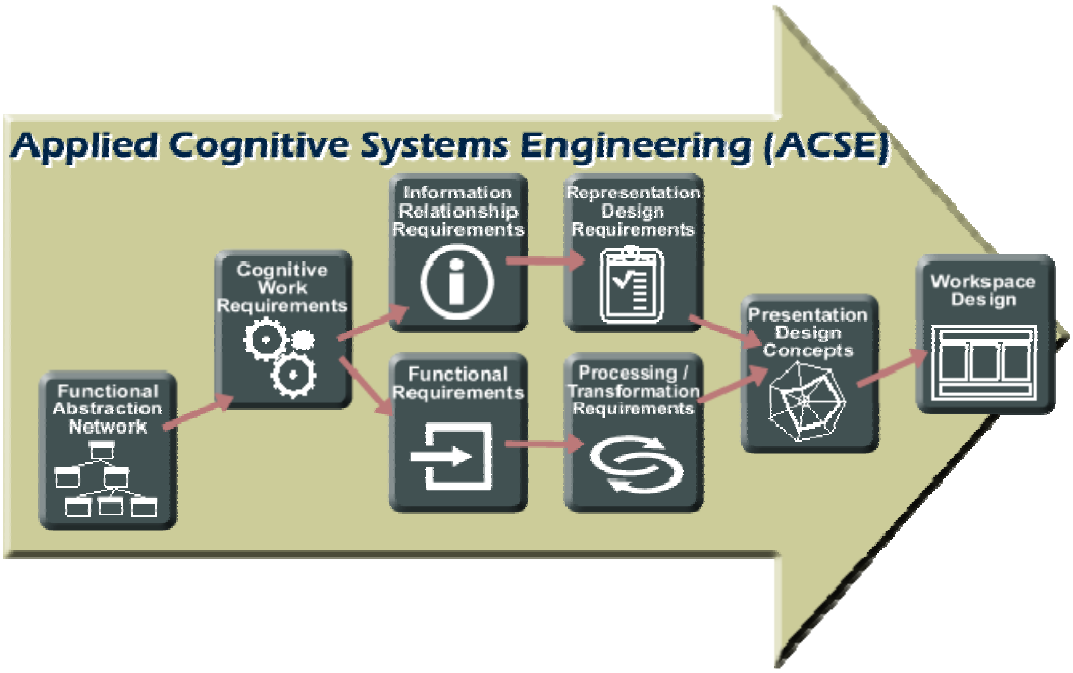

Figure 4. Applied Cognitive Systems Engineering Process

Once the functional goals of the domain are represented in the FAN, the next step in the ACSE methodology involves overlaying Cognitive Work Requirements (CWR) on the functional model as a way of identifying the cognitive demands, tasks, and decisions that arise in the domain and require support. The system requirements that follow from these CWRs must allow users to accomplish this cognitive work with the decision support tools. Identifying the functional relationships in the work domain and their associated cognitive work leads to sufficiently detailed requirements specification to support the relevant decision-making within the resulting system design.

The ACSE approach has demonstrated itself to be extremely robust and able to accommodate a wide variety of command and control systems – these include WitchDuck, a mission effectiveness tool for monitoring network traffic, eSyncMatrix, a component of the Information Warfare Planning Capability (IWPC) tool; and the Advanced Threat Assessment Capability program for Defense Research and Development Canada-Valcartier's (DRDC-V) Advanced Threat Assessment Capabilities (ATAC) program (naval air defense).

ACSE provides a methodology for capturing the fundamental relationships within the EBO domain and transforms them into support tools that result in intuitive and effective decision-making. Just as a software application depends on its underlying design models, effective decision support designs need to have a solid, research-proven analytical model from which potential technologies can be generated and evaluated. Specifically, prior experience in developing visualizations for domains similar to EBO suggests that:

- Functional, abstract visualizations dramatically improve difficult decision-making under stress
- Visualizing effects at multiple levels within the strategy-to-task decomposition is similar to an expert's mental model and will lead to greater understanding
- Network-based visualizations, which reveal the many-to-many physical to functional relationships also provide the basis for data fusion, which have been shown to represent the intrinsic relationships in the domain
- Representing the linkage between simple direct effects through their resulting culminating effects as a functional abstraction network has been shown to provide higher fidelity visualizations

An ACSE based approach provides the functional framework for mapping the EBO plan's desired effects and shows how the effects of friendly actions impact the enemy as a system. For example, consider a

planning shop with specialists in multiple domain areas each developing their own list of effects they want to achieve. One member of the EBO planning team wants to destroy a particular bridge in order to have the effect of reducing the transportation between one side of the river and the other. However imagine that this bridge also carries a gas pipeline, a telephone cable, and a power line across the same river valley. If one decision-maker nominates the bridge as a target to delay troop transport, how will the other warfighters know what impact that attack had on their areas of interest and desired effects? Current approaches to EBO representation do not enable warfighters to "see" the full functional impact of their actions. Similarly, if the planner desires to interrupt that power flow to a critical enemy C2 node, failing to identify the functional alternatives to providing the power may falsely lead to the conclusion that attacking that bridge will disable the C2 node. Utilizing the ACSE approach for EBO represents a prime example of a complex information environment resulting from the functional understanding of the domain advancing much faster than the systems designed to make that information usable to a decision maker.

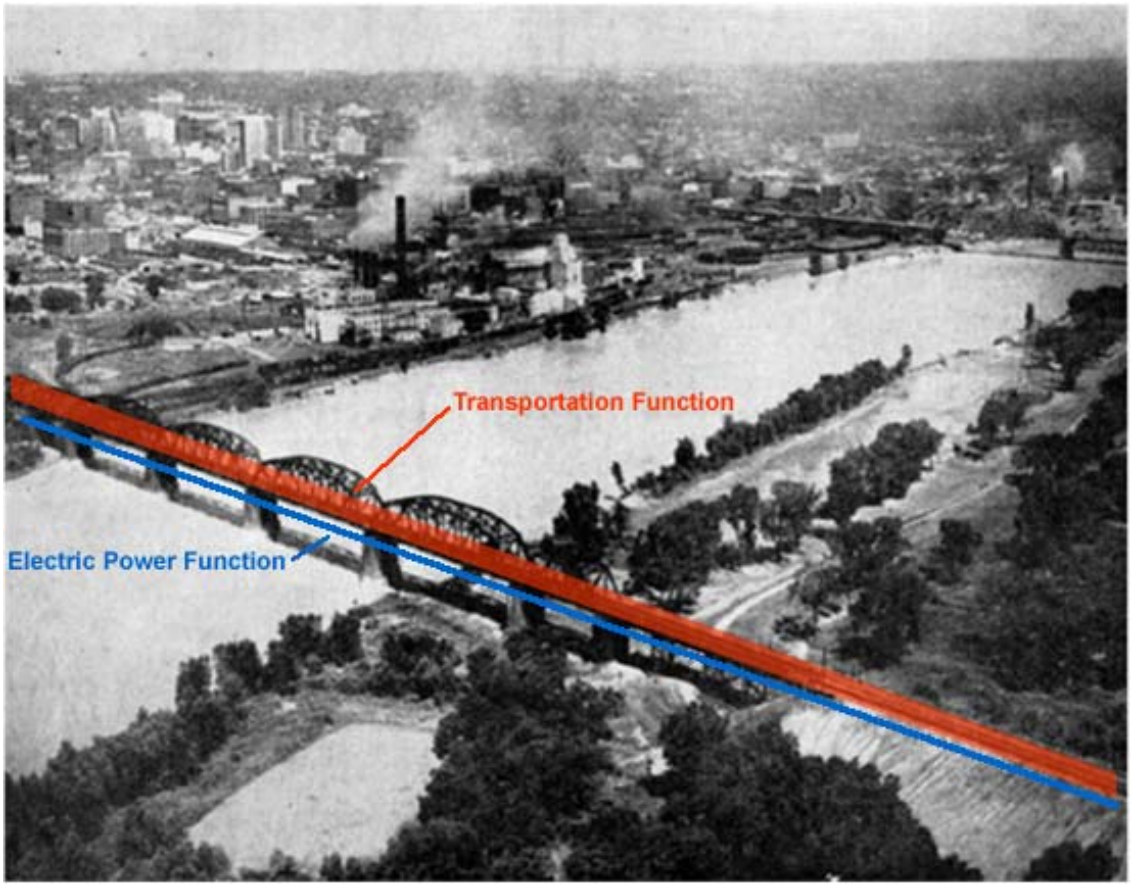

Figure 5. Multiple Functional Purposes of a Bridge

The functional understanding provided by ACSE will make available insights into the adversary system's vulnerabilities and exploitable weaknesses. This will enable decision-makers to determine what effects likely can be achieved against target systems and their associated activities from both kinetic and non-kinetic weapons. Examining EBO from an entirely new perspective, the ACSE methodology will lead to the development of tools that will revolutionize the way the warfighters see the EBO battlespace. This will provide the warfighter with information dominance that will enable them to be more effective than with current decision support.

A New Approach to Representing EBO

Technology in general, has been viewed as a principal enabler of the EBO methodology. Early attempts to apply the EBO methodology were severely limited by available technology. For example, the strategic air operations of World War II were limited by the ability to determine valid targets, achieve desired effects against them, and measure the results. Technological improvements made such an approach more feasible by the time of Operation Desert Storm. Improved command and control systems, fused information, and other technologies can solve many of the past inhibitors. Full application of the EBO methodology is possible with the right decision-support system representations for the warfighter.

The defining elements necessary for achieving effects include emphasis on developing knowledge of the adversary, viewing the adversary as a complex adaptive system, and an understanding of the environment. Knowledge of the enemy will enable decision-makers to determine the effects that need to be achieved. In order to provide decision support for EBO representations, the business layer must be built to transform collected data into the information required for understanding the desired effects network. An ACSE-based analysis provides the requirements necessary to transform physical events in the world into the functional knowledge that is necessary to successfully execute EBO. The conversions made in the business layer are then able to be portrayed to decision-makers through information representations in the presentation layer. This enables the presentation of the state of the EBO effects network in a logical, intuitive manner.

The ACSE informed business layer will serves as the Rosetta Stone for EBO decision-makers and allow for coordinated decisions about the state of the functional effects network in response to the application of force in the physical world. The ACSE-based business layer will enable the representation of events anywhere in the physical world, and, through visualizations, make the impact of these events on the effects network available to all EBO decision-makers.

Developing an EBO visualization using the ACSE design process supports warfighter decision-making by

explicitly representing the many-to-many physical-to-functional relationships. A notional representation would include a coordinated display linking a physical representation of the adversary system with an effects network displaying the functional impact of each physical component. This will enable the representing side effects, as well as representing competing goals.

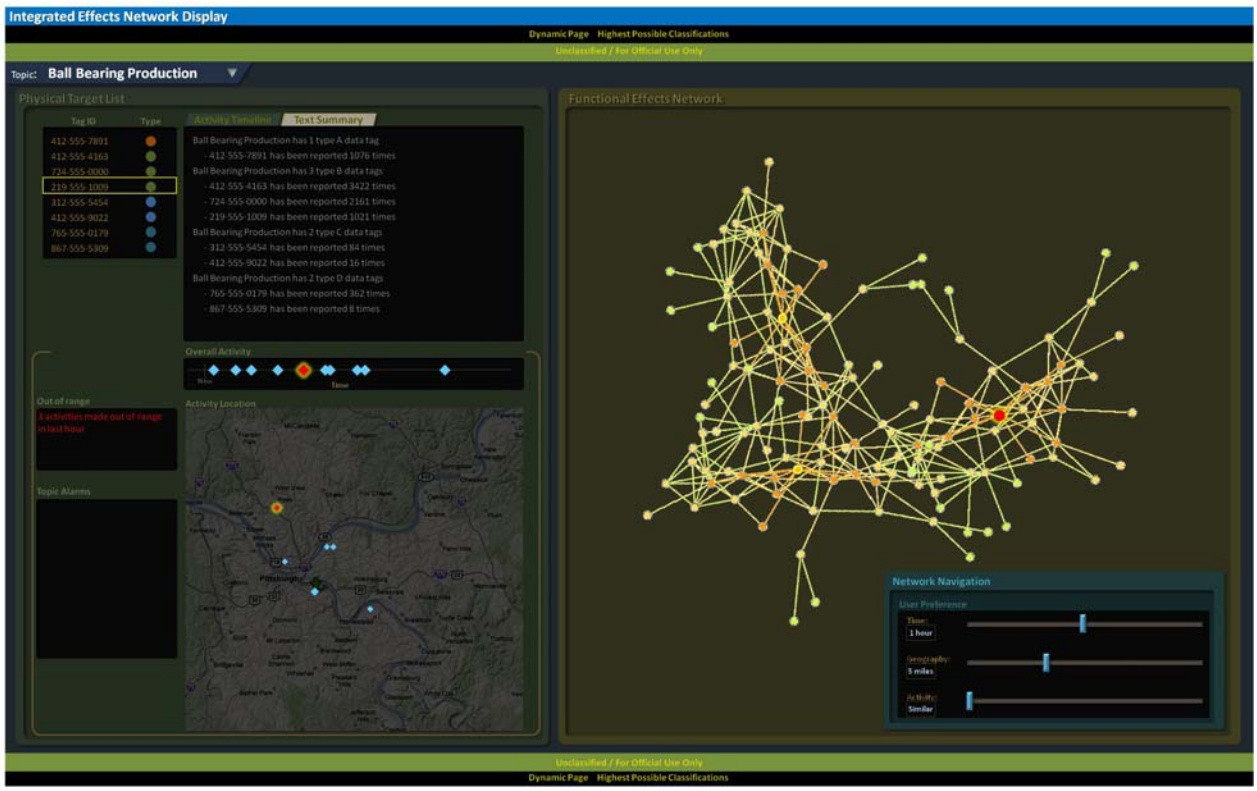

Figure 6. Notional ACSE-based Visualization Illustrating the Many-to-Many Functional-to-Physical Coordination Necessary for Effective Decision-Making

ACSE-based EBO visualization tools will provide presentation concepts, which will better support the ability of warfighters to see causal linkages between actions and effects. The resulting EBO decisions are then based on functional relationships rather than physical proximity, and, enable greater collaboration and communication among the warfighters for better planning and effects network assessment. The ACSE-based approach provides the basis for the development of a totally different class of network visualizations that can capture and present functional side effects that are currently invisible to the warfighter.

Effective EBO visualizations require mechanisms for representing complex effect networks, as well as the military operations that are being executed to impact that network. Such a representation improves the warfighter's observability into the battlespace (i.e., the ability to form insights into processes and events in

the battlespace or the automated systems supporting EBO). This provide the warfighter with the capability to dynamically synchronizing operations by collaborative execution monitoring and re-tasking of shared assets across echelons, missions, components, and forces. The ability to see a representation of the effects network creates a capacity for building intuition that is unsurpassed by summary statistics. To build effects network visualizations, it is necessary to examine carefully questions about the meaning and implication of relationships between effects and time in the status of the effects network. The goal is to present effects network status information in such a way that the warfighter has all of information that he needs on demand through a distributive, collaborative, scalable EBO capability.

Conclusions

Fully implementing the EBO methodology requires a corresponding revolution in the design of C2 systems intended to support EBO decision-making. The tools that are currently available to support EBO are insufficient for it to reach its potential. What are needed are new tools that provide a better way for conceptualizing the desired set of effects. While nothing can ever completely remove the "fog and friction" that surrounds warfare, visualizations based on a functional understanding of the adversary's physical system of systems will improve the effectiveness of decisions that the warfighter makes. Adherence to legacy representations (i.e., maps, spreadsheets) despite the adoption of EBO's of new ideas is needlessly conservative and could be dangerous due to the mismatch between operational concepts and decision-support tools.

With ACSE-based EBO decision-support, warfighters will be provided with the ability to rapidly fuse and assess data about the extent to which the planned effects are being prosecuted and achieved. CSE-based EBO visualizations enable warfighters to understand and control the hundreds or thousands of individual effects and operations, while still providing insights into the bigger picture created by emergent patterns (cascade of primary, secondary, and tertiary effects) in the larger effect network created by physical actions on the battlefield. This ACSE-based representation will provide observability of the impact of local physical actions in the physical world on the functional relationships of the adversary's system of systems and thus the entire effects network plan.

Warfighters will more rapidly and accurately assess plan components; develop multiple high-quality response options based on the relationships between effects; be able to quickly diagnose problems in the plan; and be able to present options for their remediation. An ACSE based approach will be robust enough to handle atypical problems faced in EBO planning, execution, and assessment while still

supporting the ability to easily handle standard, known issues. This will enable the warfighter to see the set of intentional and potential unintended effects. This is something that would not be seen by the warfighter without the benefit of functionally derived decision support tool that illustrates the whole effects network.

In addition CSE-based visualizations will provide situational awareness of the entire EBO effects network at a glance. This will allow warfighters at all levels, distributed around the globe, to work cohesively from on a shared understanding of the status of the EBO effects network. Understanding the many-to-many functional impact of physical actions in the battlespace will by provide revolutionary improvements in the decision effectiveness of EBO warfighters.

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