# Elements of Future COP Patterns

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## Abstract

*The concept of a common operational picture (COP) has been pervasive in the C4I domain for more than 30 years. However, an overly literal interpretation of the word "picture", an overemphasis on "common" and a focus on integrating and fusing data from sensors has limited the utility and scope of applicability of "COPs" built to date. This paper explores conceptual elements of future COP patterns that will address these limitations and thereby broaden the applicability and utility of COP implementations. In addition, the paper provides the beginnings of an open, net-centric pattern approach that will enable heterogeneous COPs interoperate with one another and with the many diverse data sources that contribute to the common operational picture. Key elements of the future COP net-centric pattern model are:*

- *The COP as an incomplete model of reality*
- *The COP as a consistent, vice common, model*
- *The COP as collaborative and human-based*
- *The COP as a dynamic order of battle*
- *The COP as a representation of operational context*
- *The COP as having defined operational scope*


## 1. Introduction

A key tenet of net-centric operations is that of shared awareness promoting "self-synchronization" among force elements trying to achieve some common objective. For example, the DoD Command and Control Research Program (CCRP)[1] published a number of noteworthy books on net-centric operations, including the seminal works **Network Centric Warfare** and **Power to the Edge**. However, even the more traditional top-down command and control paradigm benefits from shared awareness, both to allow the commander to better direct the force elements available and to have the engaged force elements convey a more accurate picture to the commander. While the tension between top-down command and control and the more bottom-up concepts of self-synchronization and net-centric operations is real, the difference is one of degree, and is motivated primarily by organizational culture and the operational context that a group might be addressing. At either extreme and at all gradations in between, a common operational picture is a desirable means to achieve some level of shared awareness among participants in an operation.

The intent of this paper is not to review or summarize the history of the concept of a common operational picture or to critique existing implementations. Rather, it is to abstract key elements from that experience which any future COP should consider incorporating. The intent is to provide the basis for developing a net-centric capability pattern for future COPs that will facilitate their interoperation with each other, with the people that use them, and with the sources of information that help to create and update/inform the COPs for any given operational scope and perspective. The paper draws on experience with a multiplicity of military command and control systems, DARPA collaborative technology programs, transportation and force deployment systems, intelligence systems, and commercial tracking systems. It also builds on the explicit scope and frame of reference discussion regarding representation of the C4I environment in an earlier C4I Symposium paper[2]

[1] DoD Command and Control Research Program published books on net-centricity are available at DoD CCRP web site (www.dodccrp.org).

[2] Polzer, Hans W., The Essence of Net-Centricity and Implications for C4I Services Interoperability, GMU C4I Symposium, May, 2008.

## 2. Limitations of Existing COP Approaches

Existing approaches to designing common operational pictures put too much emphasis on the word “picture” and don’t give enough consideration to what is meant by the word “common”. These lead to unnecessary limitations regarding what aspects of the operational situation can be represented (and for what purposes) and to assumptions about the operational situation that don’t make use of all the information available. The word “operational” also deserves further exploration as to its meaning and implications for COP utility.

Most COP implementations to date have focused on the COP as an operational “picture” in an almost literal sense. Many such systems implement the COP in the form of a map or similar geospatial background display with other data elements depicting the operational situation as icons or symbols superimposed on the geo-spatial display. This is certainly a powerful paradigm which leverages the pattern recognition mechanisms in the human brain, as well as general terrain awareness important to the operation at hand. However, there are many operational situation attributes that are not readily represented using a geospatial display. That is why we have organization charts and spreadsheets, audio recordings and PowerPoint graphics. Aggregates and operational relationships among aggregates are difficult to depict on a geospatial backdrop, as are relationships among humans - not that these don’t have some geospatial components. Recent focus on “human terrain” in the context of operational objectives illustrate this point by drawing on the “terrain” paradigm as a pattern recognition enabler, yet emphasizing the non-physical aspects of this “terrain”. One could just as readily talk of the “logistics terrain”, or the “industrial base” terrain (as in “Silicon Valley” or the “military-industrial complex”). The bottom line is that the “picture” in a COP needs to support a multiplicity of visualization modalities, not just geospatial modes, however important they might be in a given context.

A related aspect of the “picture” paradigm is that there is a lot of emphasis on real-time/current sensor data to populate the geospatial background with operationally relevant entities. But just because sensors can’t “see” (for whatever reasons) a particular object/entity, or its important attributes, doesn’t mean that it doesn’t exist. Much of the world operates on “encyclopedic” knowledge that is only occasionally (if at all) updated by actual sensor input data. And some of the sensors in question are other people reporting in relatively subjective, unstructured, and sporadic form. Lastly, the picture paradigm implies a current time frame “snapshot” that makes it difficult to run things forward and backward in time to detect temporal patterns, or to hypothesize possible alternate future states and compare alternative courses of action.

The word “common” is another problem with many COP implementations because it is used in the sense of lowest common denominator, i.e. depict only attributes of the operational situation that are important and understood the same way be everyone accessing the COP, no matter what their role/interest might be. This creates a lot of squabbling among COP stakeholders regarding what information should be included or not, and how it should be depicted on the map display (naturally) as an encoded symbol or icon or text string. There is pressure to not include anything that might be confusing to some COP users, and to limit the information content in the COP lest it be too complex or cluttered for users to extract the information important to their particular role/purpose. This leads to perfectly reasonable decisions not to include information that might in fact be important in some situations to some COP users. Current COP implementations are beginning to recognize the flaw in the word “common” by modifying it with adjectives such as “relevant” and “adaptive”. This implicitly admits that such a “CROP” contains information that is not common to all COP users (unless they explicitly ask for it), and that any two users are likely to be sharing a “picture” that is somewhat different as seen by each of them – but hopefully consistent.

The middle word in COP, “operational”, is also a term that leads to limitations in COP utility and interoperability. It carries a number of connotations with it that limit the scope of a COP, often implicitly so. For example, the operations that a given COP depicts are usually confined to a specific geospatial or geo-political area. Few COP implementations actually allow the users to discover what the operational area scope of such a COP actually is – they are just supposed to know that based on which COP instance they are accessing. And the operational area covered by a COP may include only operations and operational entities of specific types – not including commercial operations, or local government operations, for example – again, without specifying so explicitly.

Operations also have a temporal aspect that intersects with “routine” or “garrison” activities. Many COPs don’t distinguish between two or more operations happening in the same geo-spatial/geo-political area, or between routine activities and activities focused on the operation at hand. And as discussed under the concept of “picture”, most COPs don’t have a ready means to review past operations or future/planned operations. Yet such reviews can be very helpful for detecting past patterns of behavior (shared situation awareness and sense-making), and for planning future operations or comparing alternate courses of action to each other or to past operations. It also makes “continuous replanning” difficult to accomplish because COP information is not readily importable of viewable in planning systems.

The last aspect of “operational” that merits discussion is that it implies execution of actual activities in the real world. Yet many organizations benefit from training activities and “exercises” that prepare the participants for real-world operations. And some exercises actually move entities in the real world (not just in “Second Life”), but for practice purposes. One could view such activities as operations of a specific type or “modality”, but as indicated earlier, most COP implementations assume they are “pointed at” actual operations in a specific area of operations, and have difficulty distinguishing between/among operations, whether of different type or the same type.

Both the “common” word and the “operational” word in COP also creates a more subtle limitation, which is that of interoperability among COP implementations. Almost by definition, there will not be a single COP that everyone uses for all purposes. Each COP has constrained operational/temporal scope, that may overlap the operational scope of some other COP used by force elements with whom one might want to share objectives, such as in disaster relief, coalition operations, or in a commercial supply chain (or similar “virtual enterprise”). Such COPs are by definition not common with each other, but are likely to represent some common operational entities – probably using different representational conventions, frames of reference, or standards. Because the “common” paradigm tends to suppress differences and explicit representation of operational scope and perspectives, such COP implementations are ill-equipped to deal with other COPs that have made different representational decisions (for very good reasons).

In summary, COP implementations suffer from significant limitations that hinder their operational utility to their current user set and make it difficult for them to operate with other COPs in joint, multinational, civil, or commercial “virtual enterprise” contexts. They have been built with implicit assumptions regarding the scope and type of operations they are intended to support and typically do not explicitly represent their operational scope in a manner discoverable over a network connection. This makes it difficult for them to interoperate correctly with each other and with their users and data sources in a net-centric and dynamic, global environment.

The Network Centric Operations Industry Consortium (NCOIC) Systems Capabilities Operations Programs and Enterprises (SCOPE) model was developed in part to address the general issue of net-centric interoperability by providing a framework for systems/capabilities to explicitly define and represent their operational scope and frame of reference in net-centric discoverable fashion. The SCOPE model is available on the NCOIC public web site at www.ncoic.org . However, it takes more than simply explicitly representing operational scope to make COP implementations more generally useful and interoperable.

## 3. Net-Centric Patterns

The NCOIC has recognized the need for an architectural meta-model to help guide disparate system developments under heterogeneous sponsorship. It has adopted the concept of net-centric design patterns based on earlier work by Dr. Robert Cloutier at Stevens Institute of Technology[3] on applying the concept of patterns to systems architecture. The primary adaptation is to focus on patterns that reflect/embody the property of systems and system elements interacting with each other over a network connection, where the network transcends the boundaries of the individual systems. In the NCOIC pattern model, there are three types of net-centric patterns:

- Operational Patterns
- Capability Patterns
- Technical Patterns

Operational patterns represent behaviors among force elements enabled by and constrained by network connections among them without binding to any specific system or service design. An example might be an asset allocation pattern or information sharing pattern.

A capability pattern is a fragment of one or more operational patterns coupled to specific net-centric services and related information models and standards.

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[3] Cloutier, Robert and Dinesh Verma, Applying the Concept of Patterns to Systems Architecture, Systems Engineering Journal, Vol. 10, No. 2: 138-154,)

An example might be a friendly force tracking information exchange capability pattern.

A technical pattern is a pattern for supporting information and service exchange over a network connection that is insensitive to the specific capability or operational purpose for which it is being used. An example might be an instant messaging exchange (or "chat") pattern.

The general pattern compositional hierarchy is that technical patterns are used to implement a multiplicity of capability patterns, which in turn support multiple operational patterns. The challenge in developing patterns is to be sufficiently abstract so that the pattern is usable in multiple and diverse operational contexts, yet specific enough to provide significant design guidance and constrain actual system/service design to enable, or at least facilitate, interoperability with other implementations following the same pattern guidance. The SCOPE model cited previously helps to think about the possible operational scope variability of net-centric patterns under consideration and to specify in reasonably measurable terms any pattern scoping issues that are made. More information on the NCOIC pattern initiative and approach, as well as a pattern template description is also available on the NCOIC web site.

## 4. Net-Centric Principles

The net-centric principles[4] below are a set of high level principles still under development that provide guidance for net centric patterns in a domain independent way. This also helps to think about COP patterns from a new perspective since the principles as stated below abstract away defense community specificity and get to what might be view as the core conceptual model of net-centricity. We will draw on these principles later in the paper to show how the suggested elements for future COP patterns exhibit net-centric behavior. These principles are not mutually exclusive and are interdependent. Moreover, depending on the context or situation or other overriding constraints, there may be tensions among different groups of the principles. The net-centric principles identified to date are:

- **Explicitness**
  **A networked entity should make all information about itself explicit:** Any assumptions must be made explicit in a fashion that is usable by all network entities. This enables the Dynamism principle described later and allows key net-centric behavior (e.g. discovery).
- **Symmetry/Reciprocal Behaviors**
  **Relations among entities should exhibit symmetric characteristics and behaviors:** Design patterns should exhibit characteristics that are symmetric among involved entities (e.g. a symmetric binary relation). The behaviors and applicable attributes for the consumer/producer pattern/paradigm should be symmetric and mutually authenticated between producer and consumer. Network interactions should not assume any specific organizational, social, or other superior/subordinate relations. If they exist, they should be dynamically discoverable and negotiable by network entities. See Relationship Management below.
- **Dynamism**
  **Entities should support dynamic behaviors:** pattern attributes support dynamic behavior (as manifested by minimal a priori assumptions in the explicitness principle). To be useful dynamism is accompanied with a metric: any real system will have several levels of dynamic capabilities. The net-centric environment has multiple time scales of dynamic behaviors for negotiation, discovery, binding and resource allocation, from concept development time to service invocation time.
- **Globalism**
  **There should be no bounds on the scope of applicability:** Attributes do not require a priori operational nor institutional domain limitations (de facto limitations imposed by cost/risk/utility considerations). This impacts temporal, spatial, cultural domains, etc. It affects or impacts almost all other aspects or attributes of net-centricity. For example, the context of many security markings assumes a particular domain (e.g., a particular company or country) that precludes globalism of use or interoperability.
- **Omnipresent/Ubiquitous Accessibility**
  **Entities should have omnipresent or ubiquitous access to resources:** 'Resources' refers to the network, networked services, information, or other capabilities. The net-centric environment requires negotiation and

[4] Currently in development by NCOIC: see current mapping in Annex B of the NCSF v2.1 on the NCOIC website cited earlier.

discovery to meet allocation needs: the ability to discover resources and their constraints or costs. Discovery should be used to identify accessibility based on communication resources, policy/business model, and security.

- **Relationship Management**
  **Relations among entities should provide for negotiation and be explicitly managed (including dynamic formation and termination):** The internal and external relationships in a net-centric environment should allow or support a dynamic capability to negotiate a context/situation optimization. (e.g. authentication, authorization, certification, SLA, collaboration, enforcement, sanctions, consequence management, session management, self-management, aggregate management and monitoring).
- **Scaling**
  **The scale of the enterprise or system should not have an impact on net-centric behavior:** It is desirable for a net-centric pattern or behavior to be applicable across all environmental scales in all dimensions. There are no a priori bounds on which users and systems or how many might want to access a service at any given time over the network (other than network capacity). However in certain instances such scaling is physically or economically unrealizable, per the pragmatism principle below. The application of the relationship management principle suggests that any such pragmatic scaling constraints be exposed and factored into any relationship management activities.
- **Entity Primacy**
  **Entities have existence distinct from the contexts in which they participate.** Closely related to the symmetry/reciprocal behavior principle is the principle that entities have existence and identity distinct from their operational or enterprise domain context. Patterns should not assume that interacting entities only have an identity specific to an institutional or system context. They usually have a multiplicity of identities in a variety of system or operational contexts. Conversely, patterns should support hiding external or "native" entity identities from others only if that is acceptable or required for some relationships, per the Relationship Management principle (for example, not revealing Social Security Numbers for certain contexts).
- **Pragmatism**
  **The ability to improve operational effectiveness is paramount:** The intent of the principles is to improve operational effectiveness and capabilities among diverse participants via the network. There are tensions among some of the principles. For example, explicit relationship management hampers dynamism and scalability, but also supports dynamism in keeping track of dynamic binding decisions once made. In those cases pragmatism can be applied to clarify which of the principles has precedence and their applicability and for what reasons. (e.g. strategic intent, operational intent, costs/risks, objective alignment, and technological limitations).

## 5. Elements of Future COP Net-Centric Patterns

So what would a net-centric future COP pattern look like? First, it would probably support a multiplicity of operational patterns in a variety of operational contexts, but focused on establishing some level of shared situational awareness among the operation participants. From this description it is likely to be a capability pattern, or more likely, a set of mutually supportive capability patterns, like friendly force structure/situation awareness, operational environment awareness, sensor resource awareness, etc. The remainder of this paper will focus on elements that are pervasive across all such capability "sub-patterns", and which drive the technical pattern attributes that might be used to implement said future COP capabilities.

### 5.1 Explicit Scope Representation

It's important to recognize up front that every situational awareness service or system is an incomplete model of reality, kept up to date or informed from a variety of data sources that are themselves incomplete and with some potential/average latency and error rate in reflecting that reality. And there may be multiple realities that a given COP instance may be called upon to support. These might include any exercise, training, or built-in self-test modes that the COP might support, as well as specification of any named instances of operational contexts that any given situational data is associated with (e.g., Exercise Golden Slipper, Training Scenario 2A, Course of Action 3B of Plan XYZ).

Every COP has a focus area that reflects the perspective on the operational situation by the stakeholders that drove the creation of the COP instance. That focus area has operational scope limits, some of which may be fuzzy or shared with "adjacent" COP instances. Any net-centric COP pattern should include a service whereby a user or network entity can discover the operational scope of the specific COP instance being accessed, and any coupling to different realities that the COP instance supports at any given point in time. Coupling here means making current data sources and latency metadata explicitly visible/available to prospective COP users. These attributes support the explicitness and dynamism principles. The pattern should also provide a service to identify any other COP instances with which it overlaps and shares information so that service requestor can smoothly transition between areas of operational scope supported by two or more COP instances. The latter supports the globalism principle and the relationship management principle, and secondarily the scaling principle.

In addition, entities represented in a COP instance may be identified/named with identities formed from a frame of reference local to the COP instance (like track number or supply point identifier). If there are other possible external identifiers for the entity known to the COP service instance, it should make those discoverable or else provide a reference to an externally provided (i.e., third party/enterprise) service that provides the mapping service between the local identifier and the external/global identifier. This will support the entity primacy principle and the globalism and explicitness principles. The third party approach also supports the scaling and pragmatism principles – not every COP needs to fully support a global perspective.

## 5.2 A Consistent (vice Common) COP

As recognized by the growing acceptance of qualifiers such as "relevant", "adaptive", and "user definable" when describing the COP, the important attribute of a COP from a utility and human interoperability perspective is that the information obtained by two different users from the same COP instance an any given point in time is consistent and not contradictory, modulo any access/sensitivity restriction differences between the two users. The latter restriction is actually a manifestation of the fact that the operational contexts for the two users may not be identical from an information content, as opposed to a role perspective.

Differing sensitivity levels aside, two users who look at a situation depicted in a COP from two different role perspectives should see situation/entity attribute values that are the same or equivalent (if the attribute frame of reference used by the two roles is different, but mappable – for example different units of measure or different coordinate systems or naming conventions for describing/characterizing entities or activities/tasks).

The key to achieving this pattern attribute is to leverage the entity primacy principle in labeling/naming entities irrespective to their collective contexts, in addition to any local frame of reference identifiers that might be used to describe/capture the entity. Any entities depicted in a COP instance can then be dynamically mapped into the frame of reference of a particular COP user and presented in terms appropriate to the role the user plays and the access levels and operational contexts in which the user is operating. This is in marked contrast to the typical case today where the users have to map themselves into the context/scope of the COP in question. Note that COP instances can avail themselves of enterprise/third party services to reduce the implementation impact of this pattern element, as discussed in the explicit scope representation element above. This also suggests that some domain-specific or "value-added" COP services may evolve to support specific communities of interest and their general perspectives and frames of reference when viewing the operational area and the entities depicted therein.

This already appears to be happening in different operational domains, such as transportation and logistics (e.g: total asset visibility and in-transit visibility), and in used car sales where third part services exist to find appropriate car types desired by a customer and to provide automotive history on any specific used car offered up for sale. Note that such latter services are enabled by the use of a "universal" and "native to the vehicle" identifier for cars (VIN) that transcends manufacturer, title issuer/owner, license plate holder, or country of origin. Of course, VINs don't yet apply to golf carts or tanks, but there's hope that the entity primacy principle will take root in other domains of interest to C4I even if there are many barriers to its adoption..

An example that might be viewed as more COP-like, would be services related to automatic toll collection information. Such services are starting to appear in the commercial realm to support vehicle tracking and automated state vehicle tax payment services. Of course, these raise privacy concerns when tracking personal vehicles, but the conceptual model of specialty COPs providing services to each other and to "composite" COPs appears to be valid and useful. In the commercial world, such business models are tried and sustained if they work out. In the military and government domains, the budgeting and program sponsorship process generally lengthens the evolutionary trajectory and constrains the kind of experimentation that takes place, possibly more than commercial ROI calculus does.

## 5.3 Collaborative/Human Attributes

Another key element of any net-centric pattern for a future COP is the recognition that increasingly much of the information depicted on a COP will come from people, and will include social domain information about both other people/organizations (e.g., Ally X's law enforcement skills are very good) and about inanimate objects (e.g., landing at air base Delta is very stressful on the pilots this week because…). This puts a premium on human attribution for social domain information managed by a COP service/pattern. Such attribution should be symmetric – anyone can add information about anyone else and everyone is held accountable for the information provided. The explicitness principle is supported by attribution as well, and it is a form of relationship management. i.e, where did this information come from and is it possible to engage that source to see if their opinion about some entity might have changed since they posted the information (or to establish a new relationship to get more in depth and continuous inputs from the source)

Another aspect of this COP element is that collaborative groups of people may be formed dynamically to help definitize certain COP attribute values (like the intent of a specific opposing force element, or to help develop or assess alternative courses of action, given the current situation). This dynamically formed collaborative session is an example of the relationship management principle in action, and requires support for setting COP attribute values visible only to the collaborative group until they take some explicit action to post the results of their collaboration in a more widely accessible form.

A third aspect of this element is that a collaborative COP pattern facilitates or mediates interaction among humans who would otherwise have limited or no opportunity to interact with each other. The COP is central to C4I activities in any organizational force structure. Often the participants in an operation are geospatially and politically dispersed, and the COP can serve as the "virtual world" that allows them to interact with each other about the operation at hand. This suggests that the COP should include mechanisms that promote human interaction and decision making in addition to providing human data inputs on COP depicted entities and establishing formal collaborative teams with their own "private" subset of COP data values. General mechanisms for interacting among COP participants using social domain attributes can range from such simple things as instant messaging/chat – tied to cop entities formally represented in the COP data model when appropriate – and emoticons, to more sophisticated techniques that convey participant emotional state in a client device independent way or do automatic language or terminology translation on the fly. Voice and video conferencing fall into this category, but are usually not explicitly linked to elements in the COP representation. Future COP patterns will include more extensive and explicit linking of such social domain information to more structured representation of operational entities in the COP services (e.g., linking a video of the commander delivering a statement of his intent to the representation of alternative courses of action or the current operational plan objectives.

## 5.4 Dynamic Force Structure/Location

Probably the most radical element of the future COP pattern will be the shift from a primarily sensor-based representation and creation of the "COP", to a COP driven primarily by a pre-existing operational model which is only informed or updated by sensor data or human inputs. The key issue here is that sensors never provide a complete picture on a continuous basis. If a vehicle is powered down and doesn't report its position, that doesn't necessarily mean that the vehicle has disappeared or is inoperative. In many cases, entities in an operational area may not want to be detected by sensors, or insufficient sensors or sensor capacity is available to obtain all the situational information that might be desired. More importantly, most operational area sensors don't provide any information on the operational role or position of entities that might be detected. Such information is represented in the conceptual model that people have about the operational area. It can't generally be derived strictly from sensor data. A general shortcoming of COPs today is that this sense-making from sensor data is inadequate without human intervention and much of the information in COPs never transitions into the conceptual model space of operational entities that humans find important in order to achieve many types of operational objectives.

Yet many organizations spend a lot of resources to develop comprehensive models of their operational environment, including competitors, customers, partners, resources, transportation and lines of communication, terrain information, equipment and product information, and similar "encyclopedic" descriptions of the operational environment. In most cases, sensor data is used primarily to validate this information and confirm or update current attribute values, not to derive the entire encyclopedic model from scratch. Order of battle, installation data bases, line of communication files, equipment capability descriptions are all examples of information that is not well leveraged and integrated into current COP implementations. Since these types of data sources are heavily used in planning systems, there is usually a big disconnect between plan information and the COP. Few COP implementations support plan versus actual position information. Few COP implementations support operational element representations above the individual vehicle/platform level or support representation of ad hoc "task force" dynamic composite force structures.

The future COP patterns should leverage this existing operational model information to provide a more comprehensive picture of the operational area than sensor sources alone can produce. And they should manage this information over time, including both past (history) and future time (plans, potential force element commitments). Future COP patterns should implement the principle of relationship management to depict and manage the relationship among operational entities and sensor data sources/values over time. Application of the entity primacy principle will support representation of force elements in the COP over past, current, and future timeframes/contexts from a variety of operational and institutional perspectives (e.g., force element owner, force element allocator/sourcer, force element planner, force element employer, force element supplier or provisioner, force element transporter, trainer, or force element community co-resident). It should also explicitly couple the more limited scope of a particular COP to the global situation. This facilitates moving from one operational area to another and to help new users establish their own operational context model as they move into a new operational area. It promotes more global resource awareness and potential sharing across COP boundaries. It also supports scalability by allowing smooth "zooming out" to incorporate a larger scope picture than that provided by any one COP instance.

The upshot of this future COP element is breaking down the traditional somewhat artificial distinction between current and local operations situational display, and that of other operational area and other phases of operation. For example, deployment planning, deployment execution, employment planning, employment execution, replanning, and post operation reconstitution and re-training are all operational phases that a future COP should support – not just current force employment operational situation. These other operational "phases" should flow smoothly into one another with each leveraging the information created during the previous phase and augmented with new information important to the current phase of operations. This is especially important during extended operations where these phases blend into and overlap each other on an almost continuous basis, depending on the actual operational "rhythm" established for such an operation. It can be implemented by managing the history of every force element, its relationships to other force elements, operational locations (including garrison/training locations) and operational objectives over time. This may sound difficult or expensive, but it is already being done in disparate databases scattered throughout the force structure and over different operational phases and responsible command structures. Bringing this information together in net-centric fashion and applying the entity primacy principle, dynamism principle, and relationship management principle will provide much more comprehensive, useful, and interoperable COP patterns.

## 5.5 Operational Context Representation

The last element of the future COP pattern included in this paper (there are likely other important elements) is that of explicit operational context representation. Current COPs for the most part do not represent operational context explicitly. They only present the primitive operational entities to the COP users and let the users infer the operational context from that information and from externally provided context cues they might have access to. Few COP implementations explicitly associate an operational entity with a specific operation by name, or depict attributes or attribute values about that operational entity that are specifically associated with a named operation. Generally there is no explicit representation in the COP of background operational context information that is not inherently manifested in the representation of the operational entities in the COP itself. This harks back to the earlier discussion of geospatial displays having limited capability to depict aggregates and human institutional objectives not directly relatable to occupying geospatial terrain.

Operational contexts have scope that should be explicitly represented to enable users accessing a specific COP to understand which contexts and how much of those contexts the COP supports/represents. COPs have one or more perspectives on the operational context that they support. These perspectives should also be explicitly represented to allow COP users to understand what information they can get from a specific COP and the frames of reference that might be used by that COP to represent the situational information. The overall purpose of an operation and the purposes/objectives of constituent force elements are important elements of the operational context as well. These, too, are not well represented in current COP implementations, as are representation of assessments of capabilities and intent.

## 6.0 Summary

This paper has identified some key limitations of current COP implementations and conceptual models. It has provided an overview of the conceptual basis for the net-centric pattern approach to interoperable systems adopted by NCOIC and summarized key net-centric principles that such patterns should adhere to and apply/implement. Five key elements that future COP net-centric patterns should embody were described at a high level, with supporting motivation and relationship to the draft net-centric principles identified by NCOIC. These pattern elements also have implications for other C4I system functionality beyond COP services. Readers are invited to contribute additional significant elements that future COP net-centric patterns should incorporate. More importantly, readers are invited to participate with NCOIC in developing and evolving actual COP patterns that embody these elements.

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