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Title: The Formal Representation of Administrative and Operational Relationships within Defense Organizational Constructs

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C-133 – The Formal Representation of Administrative and Operational Relationships within Defense Organizational Constructs

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Abstract

The objective for Global Force Management (GFM) is to establish a transparent and universal process to manage, assess and display the worldwide disposition of US forces. This includes US force availability, readiness and capability to assess the risks associated with proposed allocation, assignment and apportionment options.[1] Fundamental to GFM and foundational to transformation is the GFM Data Initiative (GFM DI), which addresses organizing force structure data in a joint hierarchal way for integration across Service lines. A major task of this endeavor is the creation of Service, Joint, and Office of the Secretary of Defense (OSD) organization computer servers to provide the basic, default reference data to which other data may be related. This data must be formally documented using unambiguous semantics so that sophisticated computer programs can economically exploit it. The abstraction of tree graphs has been chosen to formally represent this information. The nodes of the tree represent "organizations" while the links represent the associations between organizations. Although natural language definitions exist for many associations, the terms are often heavily overloaded with numerous definitions so that their meaning becomes ambiguous. Two examples are the terms "assigned" and "assignment of forces." This paper describes the representations chosen for the GFM organization servers, the basic semantics of those associations, and how they are applied to common situations.

1. Introduction – The Global Force Management Data Initiative

The Global Force Management Data Initiative (GFM DI) has two major objectives. The first is to address the fundamental technological and policy issues that hinder the production of formally represented force structure data in a form conducive to machine manipulation. The second is to expose and eliminate obstructions that prevent this data from being readily available to a diverse set of users via a single authoritative data source called an organization server (OS). The GFM Team is developing a prototype using a set of force structure "slices," one from each Service, to

[1] Chamberlain, Boller, Sprung, and Badami; "Establishing a Community of Interest (COI) for Global Force Management," *Proceedings of the 10th International Command and Control Research and Technology Symposium*; Ritz-Carlton Hotel, McLean, VA; 13-16 June 2005.
See: http://www.dodccrp.org/events/2005/10th/CD/papers/151.pdf

demonstrate the viability and utility of this capability. As part of the development process, several terms had to be re-defined to correct imprecision.

To begin, several informal definitions are presented; some will be defined formally later.

Command: (DOD) The authority that a commander in the Armed Forces lawfully exercises over subordinates by virtue of rank or assignment. Command includes the authority and responsibility for effectively using available resources and for planning the employment of, organizing, directing, coordinating, and controlling military forces for the accomplishment of assigned missions. It also includes responsibility for health, welfare, morale, and discipline of assigned personnel.[2]

Command Structure: The organizational hierarchy through which command is exercised. The (default) command structure is represented by the administrative associations that exist between organizations.[3]

Chain of Command: (DOD) The succession of commanding officers from a superior to a subordinate through which command is exercised.[4]

There are two fundamental command structures, one administrative and one operational. For a Service, the administrative chain of command runs through the Secretary of Defense (SecDef) and Service Secretaries, while the operational chain of command runs through the SecDef and combatant commanders. The operational chain of command is directed through a process known as the *assignment of forces*. The President, through the Unified Command Plan (UCP),[5] instructs the Secretary of Defense to document his direction for assigning forces. Title 10 §162(a)[6], states:

> *"Assignment of Forces.--*
> *(1) Except as provided in paragraph (2), the Secretaries of the military departments shall assign all forces under their jurisdiction to unified and specified combatant commands…to perform missions assigned to those commands."*

Based upon direction provided by the SecDef on the number and type of forces to be assigned to each Combatant Commander, the Service Secretaries select the actual forces for assignment (i.e., they assign the forces).[7] The legal effect of this assignment process is two fold: first, it categorizes every uniform military person and military organization as either assigned or not assigned to a combatant command, and second, it establishes the "Combatant Command (Command Authority)," or COCOM, of the combatant commander over the assigned forces. This is called a COCOM relationship. Primary reasons for not being assigned are, one, special exception by the SecDef, and two, performing US Code (USC) title functions, such as Title 5, 10, 14, 32, and 50, the most common being Title 10.

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2 Joint Publication 1-02 (JP 1-02), *Department of Defense Dictionary of Military and Associated Terms,* 12 April 2001, as amended through 31 August 2005, pg 101. See also: http://www.dtic.mil/doctrine/jel/doddict/

3 Used in the GFM Organizational and Force Structure Construct; formally defined in Section 2 on page 4.

4 JP 1-02, *op. cit.*, pg 81.

5 UCP, for brief introduction, see: http://www.defenselink.mil/specials/unifiedcommand/

6 United States Code (USC) Online (USC Online) via GPO Access;
See: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse_usc&docid=Cite:+10USC162

7 Global Force Management Guidance, 4 May 2005, p. I-2.

Assigned Forces: Those forces and resources that have been placed under the Combatant Command (Command Authority) of a Unified Commander by the direction of the Secretary in his "Forces for Unified Commands Memorandum" IAW [Title] 10 USC [Section] 162. Forces and resources so assigned are available for normal peacetime operations of that command.[8]

Allocated Forces: Those forces and resources provided by the President or Secretary for execution planning or actual implementation.[9]

Assigned forces are uniformed military personnel under the legal authority of a combatant command, either in individual positions or in units. The assignment of these forces is relatively stable, and is only changed by written approval of the SecDef. When forces are *allocated* to another combatant command for actual employment, a different relationship is invoked and the COCOM relationship to the original unified command is not changed. To modify a COCOM relationship requires an explicit action by the SecDef.

COCOM is one of four command relationships defined by joint doctrine:

Command Relationships: The interrelated responsibilities between commanders, as well as the operational authority exercised by commanders in the chain of command; defined further as combatant command (command authority), operational control, tactical control, or support.[10]

This paper focuses on the formal specification of the COCOM relationship and its interaction with the administrative command structure. The other three command relationships will be described only to the extent necessary to explain their effects on this portion of the force structure.

An OS includes only the default operational organization and force structures of the Department of Defense (DoD). The term operational is used to indicate the inclusion of all organizations that are used routinely in the employment of the unit. Also included in the OS is the manpower and equipment authorizations associated with the default structure; these will be defined in detail in the next section.

The following sections describe alternative interpretations and the resolutions proposed to formalize several joint command relationships to produce an unequivocal definition of assigned forces required to characterize military capabilities. This was accomplished via the continuing process of identifying, clarifying, and unifying representations across the Services as part of the GFM-COI.[11] Finally, the implementation of these results is described. The GFM Information Exchange Data Model (GFMIEDM), that is an augmented subset of the NATO JC3IEDM[12], is the medium used to incorporate these results.

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[8] Ibid, pg. A-2-2
[9] Ibid, pg. A-2-1
[10] JP 1-02, *op. cit.*, pg 104.
[11] Chamberlain, Boller, Sprung, Badami, *op. cit*.
[12] JC3IEDM: Joint Consultation, Command and Control Information Exchange Data Model, the impending result of the Multilateral Interoperability Programme (MIP) combining efforts with the NATO Data Administration Group. See: http://www.mip-site.org/

2. The Organizational and Force Structure Construct[13]

The GFM Organizational and Force Structure Construct[14] (OFSC) provides the semantics for building force structure representations. The original name was simply the Force Structure Construct, but early debate as to what parts of the DoD were actually considered "force structure" led to this new name. This was the first of several key terms whose definitions had to be more rigorously scrutinized. Ultimately, it was decided that force structure is the uniformed military positions of the operational arm of the DoD that could be *assigned* to a unified or specified command (coined "assignable forces")[15], whereas an "organization" could be any node within the DoD tree, whether it was a military authorization, a government civilian employee, or a non-government civilian contractor. Additionally, the term "assigned" also caused considerable debate. For the purposes of the GFM organizational representation, the accepted meaning is based upon the concept of "combatant command (command authority)" from Joint Pub 1-02 as it refers to the authority granted to a Combatant Commander under the USC. Consequently, the word "Organizational" was prepended to the title to allow inclusion of all DoD organizations.

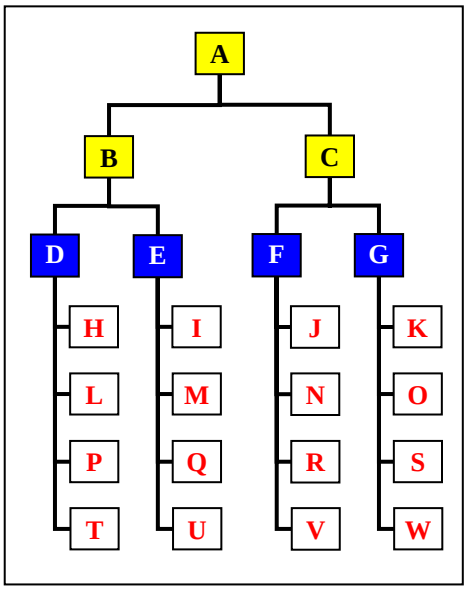

Figure 1: A Tree Graph

The basic formalism of the GFM OFSC is the tree graph; see **Figure 1**. This was described in the original OFSC document.[16] The following information updates several of the original concepts. Because of the nature of *leadership-based* organizations like the military, tree graphs are valid structures for their representation. This is because, regardless of one's position in the structure, there is always someone in charge. This leadership may be a consequence of the lawful authority of command or the informal leadership applied at echelons below those of a commander. In any case, there is an explicit command lineage for everyone in the DoD that can be represented via a path through a tree graph.

Graphs are composed of nodes and links. **Figure 1** illustrates a simple tree graph composed of 23 nodes (A-W) and 22 links. In the OFSC, the nodes are called *organizations*. There is no intrinsic interpretation for organizations beyond the fact that they are aggregation points. The interesting feature is that organizations do not physically exist; they are simply mental groupings of physical and non-physical entities as determined by someone's perception. As a result, they reflect an individual perspective, and it is highly unlikely that two persons will aggregate items in the same way, or more pragmatically, it is improbable that two persons will

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[13] *Construct*: A concept, model, or schematic idea: *a theoretical construct of the atom*. From http://dictionary.reference.com. It does not refer to a particular organization tree.

[14] Chamberlain, Sprung; A Unifying Strategy for Data Integration for Global Force Management; *Proceedings of the 2004 Command and Control Research and Technology Symposium*; Loews Coronado Bay Resort, San Diego, CA; 15-17 June 2004. see: http://www.arl.army.mil/~wildman/PAPERS/c2rt04.html

[15] Recommended at the 19 Jan 06 GFM-COI by a member from the Joint Staff/J-3.

[16] Chamberlain, *Default Operational Representations of Military Organizations*; Army Research Laboratory Technical Report: ARL-TR-2172; February 2000; see: http://www.arl.army.mil/~wildman/PAPERS/tr2172.html

create the same organization chart for the same organization. In small communities this is rarely a problem, but as one strives to track large complex organizations, like the deployed forces of the DoD, the lack of rigorous definitions and constructs makes the task pragmatically impossible for automated information systems, especially when quick results are required.

Nodes are only half of a graph; the other half is represented by the links. For a given set of nodes there are many alternative ways to link them together. Therefore, many different graphs can be produced for a set of nodes by connecting them together in different configurations. In the OFSC, links represent the *associations* between two organizations, and often, the associations are as important, and more interesting, than the nodes themselves. In the OFSC, the tree graphs that result from connecting together organizations are called *units*; that is, units are organization tree-graphs (org trees). Using this vernacular, many different units can be created from a set of organizations simply by re-linking them via different associations. The OFSC adds guidelines to the process of representing units by adding rigor to the specification of building and interpreting organizational structures composed of organizations (nodes) and associations (links).

Force structure ties everything together. This is the fundamental tenet of the GFM DI strategy. The ultimate use of the OFSC is to direct the populating of OSs with default operational organization data that is readily available in a form useful to anyone who uses force structure data in their information systems - which means everyone within DoD. The strategy is to use this minimal set of common data as the starting point for everyone, thus it provides one avenue to relate disparate data via the core framework of force structure. Although the structure of real-world forces is very dynamic, some pieces of the structure are relatively stable[17]; that is, the nodes are relatively stable while the links are very dynamic. Using this vernacular, one would say that the composition of units is dynamic, but the organizations from which they are built are relatively stable. It is the set of the associations between organizations that is changing rapidly to create new units. Thus, the strategy is to carefully develop a set of relatively stable organizations (i.e., aggregation points) in the OSs that can be used by a diverse set of applications to create, or *task organize*, units to fulfill desired capabilities.

The set of relatively stable organizations maintained within the OSs is called the Default Operational Organizations (DOO). However, DOOs are clearly not sufficient. To maintain the tree graph property within the OS, the DOOs must be connected by a set of default associations. These default associations serve as the starting point for creating myriad real-world units, such as orders of battle, deployment suites, or budget configurations. As one transitions from organizations (nodes) to units (graphs) the resulting semantic options quickly become rich with options and nuances.

Because the origin of any force structure development is the authorization process, this is chosen (actually, prescribed[18]) as the basis for creating the DOO structure and relationships. Therefore, within the OS, the default data will describe authorizations. This includes authorized personnel,

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[17] Relatively stable data, coined *stationary* data, means data that has a known periodicity that is long enough to treat the data as static (i.e., maintained in a server) even though it is not. Force structure authorization data fits into this category as it is typically updated a few times per year.

[18] By Congress via US Code, namely, Title 10.

more commonly known as manpower, and equipment (or material). By traversing the resulting org-trees, one can find the default aggregation points required to conduct operations (i.e., organizations), and the *authorization inventory* of personnel and equipment associated with the aggregation points. Not all organizations in the org-tree have authorization inventory associated with them; some have only manpower, some only equipment, some both, and some none. It must be emphasized that an OS contains no information about real people or equipment, only authorized types of personnel and equipment. Other information systems download copies of the default org-tree from the OS and use it as the basis to relate real people and equipment to the default structure.

An organization that has associated authorization inventory is categorized as an ***inventory*** organization. In the OFSC, two types of organizations have been defined that are always in this category:

Billet (Organization): created for the purpose of employing a single person. A manpower authorization is always associated with a billet that specifies the required qualifications of the billet. Equipment authorizations may also be associated with the billet (i.e., the equipment necessary to fulfill the billet's function) but are not required.

Crew (Organization): created for the purpose of employing a piece of materiel that requires one or more persons to operate and transports those persons. An equipment authorization is always associated with a crew. This equipment authorization must not be misconstrued as the actual equipment.

There is a third type of organization that may or may not have associated inventory:

Doctrinal Organization: created for the purpose of employing doctrine, tactics, techniques, or procedures.

An organization is classified as an ***accountable*** organization when it has one or more inventory organizations as subordinate organizations somewhere in the tree below it, called *descendants*. In other words, an organization is accountable when it has people or equipment authorized somewhere within its descendants.

An ***active*** organization is an accountable organization that has personnel authorizations somewhere within its descendants. By definition, any *active* organization must have a default leadership billet identified that is in charge of the manpower below it. This is required because, in the military community, there is always someone in charge.

With these terms defined, one can now describe the semantics of the default associations of the OFSC required to provide consistent interpretations for the construction and traversal of the org-trees.

In the OFSC, there are currently three classes of associations defined: *composition*, *leadership*, and *reporting*. The fundamental purpose of an org tree is to define aggregation and composition of units; therefore, *composition associations* serve as the primary associations in an OS. The basic interpretation of composition associations is read "is-composed-of." In **Figure 1**, one would say that node B "is-composed-of" nodes D and E. In this manner, an OS org-tree provides a decomposition of the authorizations for a specified unit. Building on this concept, a set of

composition associations defines a *command structure*, defined earlier as: "The organizational hierarchy through which command is exercised."[19] Using this vernacular, one would state that *a unit is composed of a set of organizations (doctrinal, crew, and billet) connected by a command structure*. Informally, it is permissible to refer to this org-tree as a command structure. An important ramification is that billets are always terminal (or leaf) nodes in a command structure because they can not be composed of any other organizations.

In the case of an OS, the set of DOOs is connected via a default command structured to provide a default unit from which other units can be created. This large unit, rooted by an organization named DoD, can be considered the default organizational structure of the DoD. This does not imply that the default structure of the DoD is static, but only that the *default* structure evolves slowly enough to maintain it in OS. Conversely, the actual "task organized" structure of the DoD is dynamic and elusive. However, in the vast majority of cases, it is composed of the same set of organizations (nodes) maintained in the OS, but with the organizations rearranged as different units (tree graphs).

To prevent confusion, the distinction between a *link* and a *path* in a graph must be defined in operational terms. In **Figure 1**, a path exists between nodes A and U via nodes B and E using links (A,B), (B,E), and (E,U). This means that one can reach node U from node A via a set of links; in this example, the path is of length three because three links are traversed. [One of the properties of a tree is that only one path exists between any two nodes.] Technically, a path may be of any length one or greater; that is, a path is composed of one or more links. Therefore, one must be able to distinguish between a path of length one and the single link that defines the path.

Whereas a link denotes an OFSC *association*, a path of any length denotes an OFSC *relationship*. Therefore, associations and relationship are two different entities and are differentiated by different qualifiers. This means that a relationship of length one and the association that defines it are two different notions that are defined with different attributes. In an OS, only associations are represented explicitly while relationships are derived from the associations using org-tree traversal algorithms. In the next section, association and relationship qualifiers will be introduced and rules will be presented to define the relationship between two organizations when a variety of associations make up the path between them. In summary, by definition (in **Figure 1**), an association (or link) exists between nodes A and B, B and E, and E and U, while a relationship exists between any two of these nodes.

Another implication of leadership-based organizations (and a reason that tree graphs work for this application) is that any non-billet organization[20] must have a designated leader when it is active. In other words, in the military, a group of people or equipment always has someone in charge of it. In the OFSC this is represented by a second class of associations called *leadership* associations whose basic interpretation is read "is-led-by." A leadership association connects an internal node

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[19] Chamberlain, *op cit.*, originally, a command structure was defined as a set of command *relationship*. This approach was abandoned, in part, to prevent conflicting interpretations with the JP 1-02 definition of command relationships provided on page 3.

[20] Nodes in a tree graph are classified as either non-terminal (internal) or terminal (leaf). Non-terminal means any node in the tree-graph with a descendant. Conversely, billets are always terminal, or leaf, nodes.

that is the root node of a unit (an org tree) to the billet that, by default, is in charge of the unit. An algorithm is available that allows one to traverse a command structure (made of composition associations) and use the leadership associations to create a new tree structure composed only of billets called a "chain of command."[21] The associations of a chain of command are named *reporting* associations and they are read as "reports-to."[22] Together, these three classes of association (composition, leadership, and reporting) enable a command structure to be predicated upon the concept of designated leadership authority that reflects the basic military premise that anytime people are present, someone is in charge. However, note that in an OS, only composition and leadership associations are included while reporting associations and all relationships are derived.

3. Default Associations in Organization Servers.

To formally specify the semantics of the data provided by an OS, an information exchange data model (IEDM) is being used. To accomplish this, the GFM Community of Interest (COI) agreed to exploit the extensive work already expended creating the Command and Control IEDM (C2IEDM).[23] As a result, the GFMIEDM is an augmented subset of the C2IEDM and additions or modifications were made only when necessary. A concerted effort was made to use existing C2IEDM features whenever possible.

In the C2IEDM, organization tree graphs are represented via two entities. Organizations (the nodes) are represented via the *object-item* entity, with *organisation* being a sub-class, and associations (the links) are represented via the *object-item-association* entity. There is a corresponding set of entities to represent the classes, or types, of organizations via organization-type tree graphs. An entity named *object-type*, with *organisation–type* being a subclass, is used for the nodes, and the associations (the links) are represented using the *object-type-establishment-object-type-detail* entity (for simplicity, we refer to this entity as just "*-detail*"). Thus, two varieties of tree graphs exist within an OS: an org-tree of real organizations, and a corresponding organization–type (org-type) tree of classes of organizations that contain substantial descriptive information about the organizations that share them.

In the C2IEDM, the *object-item-association* entity has attributes (category and subcategory codes) to further describe the links between objects, and in particular, objects that are organizations. The codes for organizational associations include words such as: Command and Control, Administrative Control, Operational Control, and Fire Unit and Combat Support, to name just a few. Whenever possible, these terms are utilized; however, due to ambiguities and added requirements, modification had to be made to create the GFMIEDM. In these cases, rather than modify the C2IEDM attributes, a corresponding new attribute was created with the prefix "gfm-" prepended to the existing C2IEDM attribute name. For example, in the GFMIEDM, within the entity *organisation–association*, a new attribute named *gfm-category-code* resides along with the existing C2IEDM attribute named *category-code*. The new attribute contains all the existing values from the original, plus additional values required for the GFMIEDM. This approach allows

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[21] Ibid, Appendix C.
[22] This enables a formal definition for the term chain of command that is cited on pg 2 from JP 1-02, *op. cit.*, pg 81.
[23] For detailed information, see: http://www.mip-site.org .

both models to evolve independently and facilitates easy mapping when GFM data is converted for C2IEDM use. Another simple modification to the GFMIEDM was the addition of identical category codes to the *–detail* entity of the C2IEDM (which did not exist). This allows org-type tree associations to be defined using the same attributes as org trees, a requirement of the GFM community.

For organization (*object-item*) composition associations, two existing category codes have been employed. The first is "Has under command for admin," or HSADMI, which is defined as: "The subject ORGANISATION has command responsibility for all administrative and logistic services provided to the object ORGANISATION." In short, it is referred to as a "has admin" association. The second is "Command and Control," or CMDCTL, and is defined as: "The subject ORGANISATION has a command and control association with the object ORGANISATION." A third association was added for use in the GFM community called "Combatant Command," or COCOM, with the definition: "Combatant Command (command authority - US) exercised by commanders of unified (or specified) combatant commands unless otherwise directed. The SUBJECT organisation must be a unified combatant command." These three categories are all that are currently used to define the associations within the OS.

In the C2IEDM, category codes may have accompanying sub-category codes and there are many options for organizations. However, many of the sub-category terms are heavily overloaded among their diverse users, and consequently, they were rendered ineffective as was demonstrated by the debates that ensued within the GFM community. Examples are the values "assign", "attach", "organic", and "full command". As a result, a new sub-category was defined.

To ensure the unambiguous nature of the GFMIEDM semantics, and the data within the OS, a new sub-category was defined for GFM use entitled "Default," or DEFALT, with the definition: "The subject ORGANISATION(-TYPE) is the default parent of the object ORGANISATION(-TYPE)." This sub-category code can be defined only within an OS. We then clarify the allowable interpretations of the meaning of *DEFALT* by the rigorous specification of the accompanying business rules. In summary, there are four category/sub-category combination of organization associations currently present in the GFM OS: three composition associations *HSADMI/DEFALT* (pronounced "Has admin default"), *CMDCTL/DEFALT* and *COCOM/DEFALT*, and one leadership association, *ISLEDB/DEFALT*. These will be denoted by HAD, CCD, COD, and ILD, respectively, and are defined in detail in the next sections.

3.1 Has Admin Default and Is Led By Default Associations

The primary command and support *relationship* maintained in the OS is administrative control, or ADCON.

Administrative Control: (DoD) Direction or exercise of authority over subordinate or other organizations in respect to administration and support, including organization of Service forces, control of resources and equipment, personnel management, unit logistics, individual and unit

training, readiness, mobilization, demobilization, discipline, and other matters not included in the operational missions of the subordinate or other organizations. [24]

From the perspective of the OFSC and GFMIEDM, ADCON is a relationship between two organizations that is defined by the associations between them. In the OFSC (and in the OS), the ADCON relationship is defined via the HAD association with tight coupling to the ILD association. The HAD associations define the default command structure within an OS. The HAD associations with the ILD associations provide the means to convert the default command structure into a default chain of command. Therefore, the HAD associations are the primary connectors between the set of stable nodes that reside in the OS. (Recall that a command structure connects all types of organizations, while a chain of command connects only billets.)[25]

Within the OS, the HAD association indicates that all of the authorities defined in the official definition of ADCON exist between the two organizations it connects. Consequently, one can say that the HAD association implies the ADCON relationship. More formally, we stipulate that:

[1] ASSOC(A,B,HAD) → RELAT(A,B,ADCON) {→ denotes "implies"}

This is read: "A HAD association between organizations A and B implies an ADCON relationship between organizations A and B." This format emphasizes that associations are links while relationships are paths (in a tree) and that they are distinct entities with different qualifiers (e.g., HAD versus ADCON). Furthermore, the ADCON relationship is transitive via the HAD associations. More formally, we stipulate that:

[2] ASSOC(A,B,HAD) ∧ ASSOC(A,C,HAD) → RELAT(A,C,ADCON) {∧ denotes "AND"}

Thus, the ADCON relationship propagate down the administrative command structure within the OS via the explicit HAD associations.

The minimum requirement for an OS is that an ADCON relationship exists between the root organization (DoD) and every inventory node. This means that there is a sequence of HAD associations (a path) from the root organization to every inventory node. This ensures that by traversing the HAD associations, one will discover all organizations contain personnel and/or equipment authorizations and/or that are used routinely to conduct expected operations. This includes all billets and crews and most doctrinal organizations (exceptions are covered in the next section that describes the command and control default association).

There are two additional characteristics of the OFSC ADCON relationship that transcends the official definition. First, it is echelon independent, meaning that it can be used between any two organizations within a command structure. Thus, it can be used for any default leadership role, such as to denote that an infantry fire team is ADCON to an infantry squad. Second, it also includes the characteristic of the operational control[26] (OPCON) relationship in the absence of any

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[24] See: http://www.dtic.mil/doctrine/jel/doddict/data/a/00057.html.

[25] A command structure will produce a single chain of command, but an infinite number of command structures may be created from a chain of command. See Chamberlain, *op. cit.*

[26] OPCON: (DoD) Operational control includes authoritative direction over all aspects of military operations and joint training necessary to accomplish missions assigned to the command. …
See: http://www.dtic.mil/doctrine/jel/doddict/data/o/03856.html

other OPCON relationships. Since there are no OPCON relationships in the OS (i.e., no CMDCTL/OPCON associations are present), this allows one to represent complete default command authority via the default command structure using just the HAD associations. This is important because the OS includes the operational organizations routinely used to conduct the unit's tasks. Outside of the OS, the rules of the OFSC tree traversal algorithms are not affected by adding complementary OPCON associations in parallel to the HAD associations to achieve the same goal, but by the OFSC definition of HAD, this would be redundant.

Pragmatically, the purpose of the ADCON relationships is to provide two basic capabilities to the default org-tree of the OS; the first is to identify, account for, and enumerate all personnel and equipment authorizations via the organization to which they are correlated (e.g., manpower with billets or equipment with crews), and the second is to identify and enumerate the organizational leadership of the active organizations of the unit.. The first capability requires that *all* billet and crew organizations have an HAD association to them that defines an ADCON relationship that extends to the top of the DoD org-tree. The second capability requires that any organization with descendants that contain personnel authorizations (i.e., a crew or doctrinal organization) has a default superior identified. If an organization is not active, like a non-habitual crew of an aircraft, then it is not required to have a leadership billet identified (although it must have a HAD relationship to it). However, once billets are assigned beneath the crew, a superior must be identifiable.

Currently, only HAD associations are required inside the OS; however, adding explicit ILD (*ISLEDB/DEFALT*) associations between active organizations and their default leadership billets is very useful because it allows the inherent chain of command to be quickly (i.e., automatically) derived and displayed. Alternating between command structures and chains of command is very informative, especially at the highest echelons (e.g., Service headquarters) where many well-known but informal relationships exist. An excellent example where this is used is in defining the command structures associated with the military and civilian Service staffs.

In **Figure 2** are depicted selected components of the highest levels of the Department of the Army (DA) organization structure. Several sources were used to create this diagram and the colors surrounding the boxes indicate the source of the information. The black links represent the HAD associations and the purple (dashed) lines denote the ILD links. An interesting characteristic is that all the Services have a regulation that states that the Service Secretary delegates supervision of non-Secretariat organizations to the Service Chief.[27] Thus, a new organization appears in every Service to serve as the aggregation point for all non-Secretariat organizations (e.g., major commands) that has an ILD link to the Service chief's billet. This formalizes these regulations and makes the chain of command derivation correct; an example being that the major command commanders work for the Service Chief who works for the Service Secretary. If this organization were missing, it would appear that the major command commanders work directly for the Service Secretary. These subtle situations occur throughout the command structure when one attempts to formally represent well-known organization structures that have been informally defined for decades, usually via several different authoritative documents.

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27 Example: Army Regulation AR 10-5 a.(2)(d): *The SA [Secretary of the Army] has authorized the CSA [Chief of Staff of the Army] to exercise supervision over all elements of DA [Department of the Army] other than the OSA [Office of the Secretary of the Army].*

Similarly, it may be difficult to find official records to justify well-known, well-entrenched organizations. For example, in **Figure 2**, Headquarters, Department of the Army (HQDA), the Secretariat, and The Army Staff (ARSTAFF) are all accepted organizations within the US Army. However, they do not have unit identification codes (UICs) assigned to them. Their sub-organizations all do, but they do not. This does not prevent them from being entered into the OS, but it does cause one to carefully investigate the general criteria one uses to enter organizations into the OS. The criteria often reduces to the basic capabilities provided by the combination of HAD and ILD associations. For these reasons, the addition of the ILD associations is adamantly encouraged.

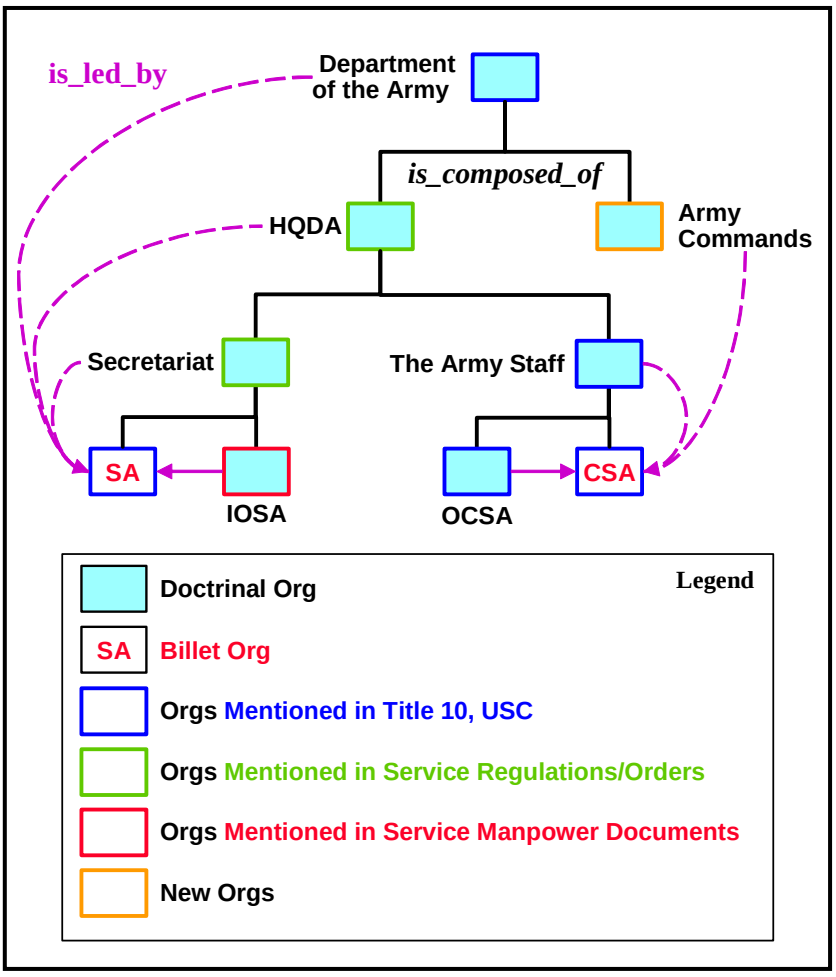

Figure 2: Top Level Structure - Dept of the Army

Note that the term "leader," and not "commander," is chosen to describe the leadership billet for active organizations. This is because legal command is only one of the types of leadership expressed by the command structure. In an OS, the command structure extends down to the billet level, allowing leadership at all levels to be depicted. Therefore, leadership (like the ADCON relationship) is not confined to official (USC, Title 10) "command."

Another interesting question is the formal definition of the US Army. There is certainly a distinction between the Department of the Army (DA) and the US Army (USA). Using OFSC definitions, the US Army is the org-tree (a unit) defined by the descendants of the organization named Department of the Army (the root node); in other words, in the OFSC, DA is an organization while the US Army is a unit. Thus, the US Army includes any descendant of the tree rooted at the organization DA that has a HAD relationship to it, which includes active and reserve component military personnel and civilians. It is interesting to note that for the National Guard, the HAD associations originate via the state government; therefore, a different association must be added to include them with the DoD force structure.

Finally, there is certainly a difference between being "in the Army" and being a member of the Army. As a DA civilian, one is a member of the US Army (i.e., within the Army command

structure), but one is not IN the Army. Using the OFSC definitions, being "in the Army" means that one is occupying a military billet within the Army command structure (or in selected cases, on a special list, such as the Retired Reserve). It is a significant challenge to find solid evidence to support these formal definitions which is an ongoing task in the GFM DI.

Identifying the US Army and US Air Force are relatively simple with an org-tree rooted at a single node. This is not so with the US Navy and US Marine Corps. To define these organizations three trees (at least) are required. In **Figure 3**, The USMC is defined by two sub-trees of the org-tree rooted at Department of the Navy (DON). Both trees are led by the Commandant of the Marine Corps (CMC), one rooted at the organization named Headquarters, Marine Corps (HQMC) and the other rooted at the organization called Marine Commands (for the same reasons explained for the US Army). Therefore, the US Navy is defined as the org-tree rooted at DON minus the two USMC trees. However, it can be truthfully said that both are under the DON. Because of the ILD associations, the chain of command is correctly derived so that the DON is lead by the Secretary of the Navy with the Chief of Naval Operations (CNO) and CMC leading all the non-Secretariat organizations within the Navy. Defining these types of command structures is significantly simplified by using the combination of HAD and ILD associations.

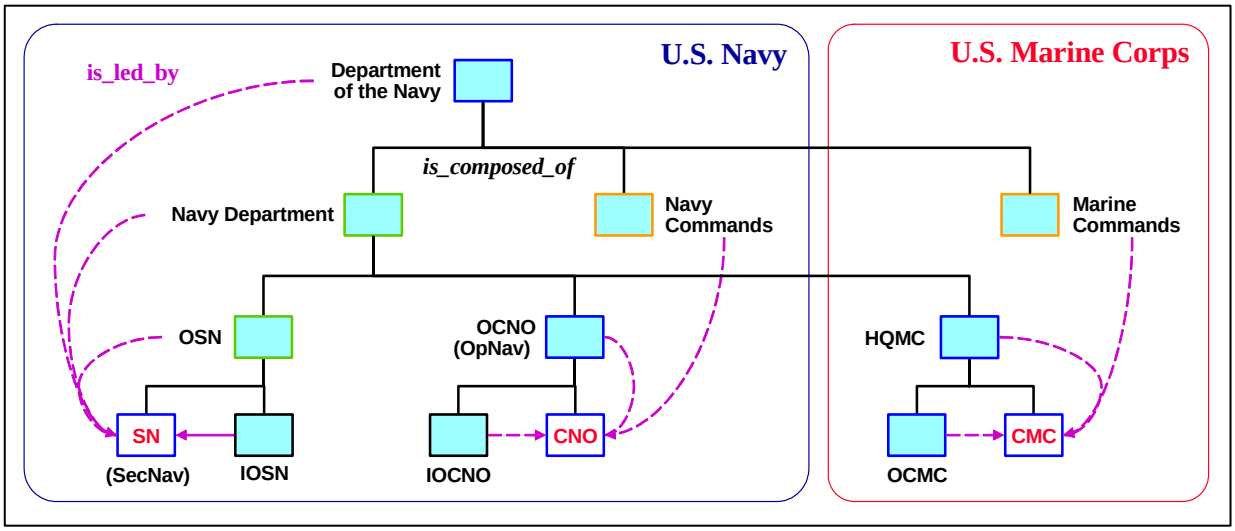

Figure 3: Organization Tree Rooted at Department of the Navy

3.2 Command and Control Default Associations

The second type of default composition association that may be present in an OS is the CCD association. The purpose of this association is to provide useful details about routine configurations when the organizations are deployed for operations. An inventory node may have a CCD association to it in addition to its required HAD association. However, org and org-type tree relationships defined by CCD associations may be void of any inventory nodes; that is, there may be no personnel or equipment authorized within an org-tree defined by CCD associations. It is perfectly allowable to build tree graphs with CCD association that have no accountable or active nodes within them. This is because all of these nodes are already accounted for via the HAD association. This allows flexibility in the use of CCD association.

The use of CCD associations can vary significantly between the Services. There are also different semantics depending upon whether they are used in the org or org-type trees within the OS. Because org-types represent classes of organizations (not actual organizations), CCD associations in an org–type tree define routine configurations without specifying an actual organization. For example, one may want to represent that, routinely, an Aegis-class cruiser crew includes a helicopter detachment. Although the helicopter detachments have a HAD association to a helicopter squadron, a CCD association allows one to see that a helicopter detachment is routinely deployed as part of a Aegis-class cruiser complement.

A common use of CCD associations in the Navy is to represent the battle bill of a crew of a ship. While HAD associations extends via the ship's departments down to all the billets, a second tree is defined via the CCD associations that represents how the ship is actually operated, or "fought." Thus, but traversing only the HAD associations the ship's administrative command structure is displayed. By traversing only the CCD links, the ship's "operational command structure" is displayed. In an OS, a battle bill org-tree has no accountable or active nodes within it. However, if duplicated in an operational system, billets from the administrative command structure can be connected to the CCD-based battle bill to create watches. Note that the HAD association to a billet (the ADCON relationship) does not vanish; instead, a CCD association is added to provide additional information without displacing any other.

In an org tree with real organizations, versus classes of organizations in the org-type tree, a CCD association represents a habitual relationship between two organizations. If one organization routinely deploys as part of another, then a CCD association is appropriate. A common Army example is the direct support relationship between a field artillery (FA) battalion and a maneuver brigade. It is common for a particular FA battalion to be associated with a particular brigade for years. In such cases, it is appropriate to include a CCD association within an OS.

The purpose of the CCD association is to denote an operational control representation in its most generic sense, regardless of echelon or type of organization (doctrinal, crew, or billet). A CCD association indicates that one organization routinely has the authority over another to assign tasks, designate objectives, and give authoritative directions necessary to accomplish a mission. Thus, it can be used as a placeholder for a formal OPCON association or as a supervisory link (such as between a billet onboard a ship and a watch station). Although it is reminiscent of OPCON, it is generic and does not require an (operations) order to create it. It is based upon routine practices.

Creating the link is only part of the implementation of the CCD association. The other is defining a common algorithm for traversing an org(-type) tree that includes CCD associations. In an OS, the HAD associations as well as CCD associations will be present. With this in mind, the tree traversal and display algorithm follows. It presumes that filtering based on time (i.e., only associations with a valid time interval are selected) is part of every step of the algorithm.

For a given organization (node):

1. Find all HAD associations with it as the parent;
2. Remove any HAD association that has a CCD association to a different parent;
3. Find all CCD associations with it as the parent.
4. The resulting set of links is the new command structure.

This algorithm traverses the command structure based upon the types of associations selected to produced the next level of the org(-type) tree. Thus, by toggling which associations are traversed, different views of a unit may be rapidly produced. Often equally interesting is the set of organizations that remain after CCD associations are applied. This can be used to display "what is left" after a unit is task organized. Similarly, the new chain of command can be derived if the ILD links were present.

3.3 Combatant Command Default Associations and Assignable Forces

The fourth, and last, default (third from the composition class) association resident in an OS is the Combatant Command Default (COD) association. A discussion of this association requires a careful and methodical interpretation of official definitions. Recall that there are two different command structures that are resident in the OS. The first is a Service administrative command structure that includes the DoD (led by the SecDef) and the Service departments (led by the Service secretaries). This is manifested by ADCON relationships that are defined by many HAD associations. The second is an operational command structure that includes the DoD and the combatant commanders.

It is important to pay particular attention to the OFSC definitions of association and relationship. Using the OFSC vernacular, a *relationship* between two organizations is composed of one or more *associations*. So it is important to discern whether one is referring to an association or a relationship (i.e., a link or a path), especially when the associations may be of different types. Further, one must be careful not to confuse the *composition* associations of a command structure that may connect together any type of organization (doctrinal, crew, or billet) with *reporting* associations found in a chain of command that connect only billets.

Combatant Command (Command Authority)[28] — Nontransferable command authority established by title 10 ("Armed Forces"), United States Code, section 164, exercised only by commanders of unified or specified combatant commands unless otherwise directed by the President or the Secretary of Defense.

- Combatant command (command authority) cannot be delegated and is the authority of a combatant commander to perform those functions of command over assigned forces involving organizing and employing commands and forces, assigning tasks, designating objectives, and giving authoritative direction over all aspects of military operations, joint training, and logistics necessary to accomplish the missions assigned to the command.
- Combatant command (command authority) should be exercised through the commanders of subordinate organizations. Normally this authority is exercised through subordinate joint force commanders and Service and/or functional component commanders.
- Combatant command (command authority) provides full authority to organize and employ commands and forces as the combatant commander considers necessary to accomplish assigned missions.
- Operational control is inherent in combatant command (command authority).
- Also called **COCOM**.

[28] JP 1-02, *op. cit.*, pg 81.

Note that the choice of words in this definition, and most definitions in the joint publications, refer to the relationships between combatant commanders and any of their subordinates. The distinction between relationship and association is important to this discussion; therefore, we make a distinction between a *COCOM relationship*, as described above, and a *COD association* that invokes the relationship.

In the OFSC and the OS, the assignment of forces is executed via a COD association between a unified command (UC) and a subordinate unit. Then, the COCOM relationship is propagated via the ADCON relationship (i.e., the HAD associations) to every descendant of the subordinate, *minus any exceptions*. It is asserted that, as a default, this formalism mimics the intent of the joint definition of COCOM. Note that a COD association always has a UC as the parent; no other type of organization can be the parent in a COD association. It is the COD association that begins the succession of HAD associations that defines the COCOM relationship to all the descendants of the subordinate organization identified via the COD association; this organization sub-tree is defined as the set of *assignable* forces. More formally, we stipulate that:

[3] $\text{ASSOC}(A,B,\text{COD}) \wedge \text{RELAT}(B,C,\text{ADCON}) \rightarrow \text{RELAT}(A,C,\text{COCOM})$

For example, each Service component command of a UC has a COD association from the UC to it. Pragmatically, this means that minus any exceptions (and there will be exceptions) all descendants with an ADCON relationship to a Service component command are assignable. Nominally, there are five Service components for each UC (each Service plus special operations); therefore, approximately 45 COD associations (9 UC X 5 associations) are used to indicate the assignable forces of the combatant commands. Therefore, given a suite of Service OS, the exact set of assignable forces can be determined instantly.

3.4 COCOM Exceptions and Assigned Forces

There are several common exceptions to the propagation of assignment via the HAD associations. The first is the removal of civilian and contractor personnel that will be present in the OS. Assigned forces are uniformed military personnel under the legal authority of a combatant command, either in individual positions or in units. Therefore, as the HAD associations are traversed, non-military "billets" are not added to the set. Even though an ADCON relationship may exist between a civilian and the organization that serves as the Service component command for a UC, the COCOM relationship does not propagate to the civilian positions.

The second common exception is a COCOM relationship to another UC. This occurs, for example, when a COD association connects a descendent in an ADCON relationship to one Service component command to another UC. For example, it is often stated that the "Unit A is also the Service Component Command (SCC) for some UC." If one visits official web pages for such units, the title reads: "Headquarters, Unit A and SCC-UC." **Figure 4** illustrates some interpretations of what this statement means. Example A (on the left) is a literal interpretation. There are two COD associations: one between MAJCOM A and Joint Forces Command (JFCOM), and one between Unit X and Central Command (CENTCOM). These two units are concurrently designated as the Service component commands for these UCs, and superficially, this makes sense and is easily understood by a human reader. However, there is another rule to be

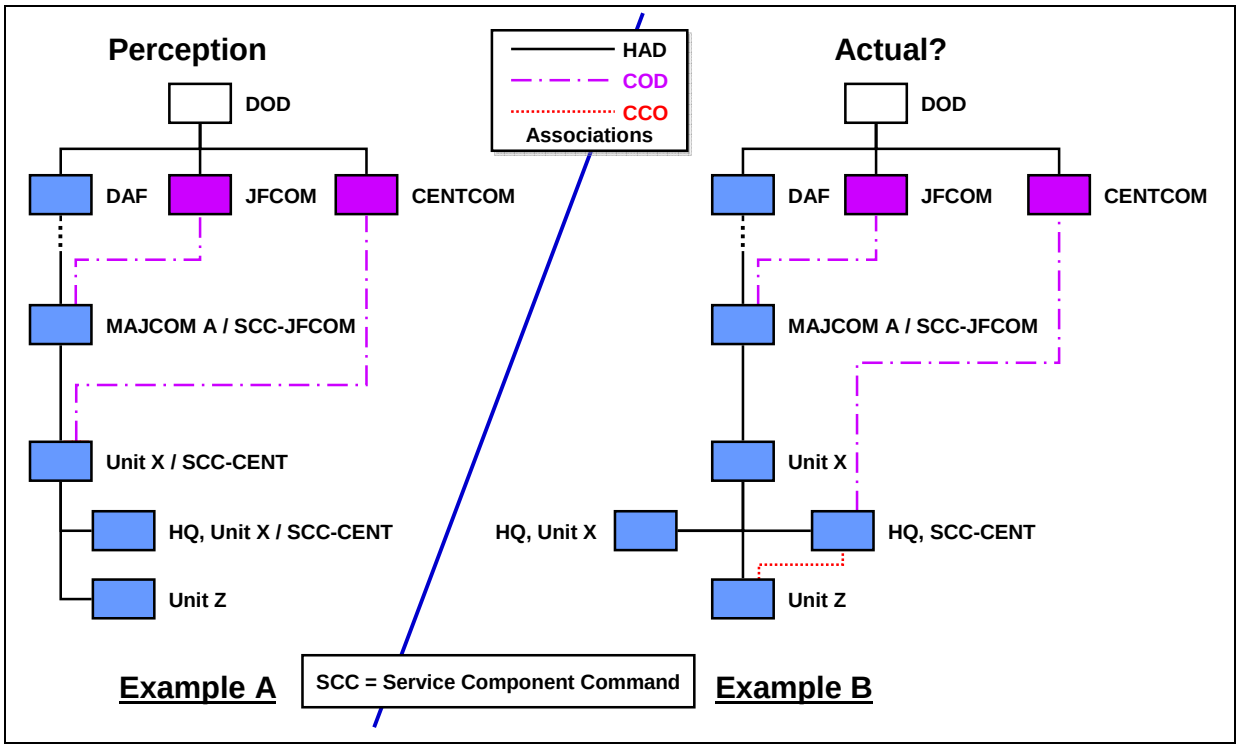

Figure 4: COD Association Overrides Existing COCOM Relationship

stated: an organization can only be assigned to one UC. This means that only one COCOM relationship can exist to any unit. This is more formally specified as:

[4] $RELAT(E,F,COCOM) \rightarrow \neg\exists_X RELAT(X,F,COCOM)$ {$\neg\exists_X$ denotes "No X Exists That"}

The problem is that Unit X/SCC-CENT has a HAD association between it and MAJCOM A/SCC-JFCOM by which the COCOM relationship from JFCOM propagates. So there is a contradiction if one asks the question: "to whom is Unit Z assigned?" The answer is that Example A is not a correct representation of the situation. Example B illustrates a suitable answer. It denotes that HQ, Unit X and HQ, SCC-CENT are actually two *different* organizations (i.e., two different aggregation points). This does not imply, for example, that both HQ can not have the same commander or overlapping personnel in billets (as this is common). It is also allowable that a HAD association exist between HQ, SCC-CENT and Unit X. However, it does require that a COD association to an ADCON descendant overrides a derived COCOM relationship via the ADCON relationship. In this example, it means that HQ, SCC-CENT and any of its ADCON descendants have a COCOM relationship to CENTCOM and not to JFCOM. This is an unequivocal definition for which an algorithm has been easily created.

It must also be emphasized that an OPCON relationship does NOT override a COCOM relationship. The assignment of forces is relatively stable and is only changed by written approval of the SecDef. When an organization is allocated to another UC for actual implementation (for example, Unit Z to CENTCOM via HQ, SCC-CENT in Example B), only the OPCON

relationship between the UCs and allocated forces is changed[29]. Unit Z is still assigned to JFCOM via a COCOM relationship even though it is allocated to CENTCOM via an OPCON relationship (i.e., using a CMDCTL/OPCON, or CCO, association). So in Example B, Unit Z is ADCON to the Department of the Air Force (DAF), COCOM (or assigned) to JFCOM, and OPCON (or allocated) to CENTCOM.

Recall from page 2 that the Services select the actual units for assignment based upon direction provided by the SecDef as to the number and type of forces to be assigned to each combatant command. Consequently, unit assignment is more fragmented then simply stating that homogeneous assignment propagates via the ADCON relationships to all descendants. Although a COD association is used to identify the Service component command, other associations are required to allow the Services to discontinue assignment propagation when exceptions to the COCOM relationship assumption are encountered. To implement this requirement, two other COCOM associations have been proposed called COCOM/UNASSIGN (COU) and COCOM/ASSIGN (COA). Depending on the stability of these associations, they may or may not be included in the Service OS. But they could be, and if not, they would be located in another authoritative data source.

The COU association halts assignment propagation and the COA reestablishes it. This is illustrated in **Figure 5** that builds on the previous features illustrated in **Figure 4**. In **Figure 5**, all the green Army organizations are connected via HAD associations that provide an ADCON relationship to the DA organization. This forms the Service administrative command structure and identifies all Army manpower and equipment authorizations. In this example, two COD associations designate Major Command M (MAJCOM M) and Unit C as the Army component commands for JFCOM and CENTCOM, respectively. In the absence of any other associations, the COCOM relationship from JFCOM to MAJCOM M continues to propagate to all the descendants of MAJCOM M via the HAD associations (ADCON relationship). Analogous to the previous example, the COD association to Unit C from CENTCOM breaks the COCOM relationship with JFCOM and initiates a new COCOM relationship for any ADCON descendants of Unit C, such as Unit Z.

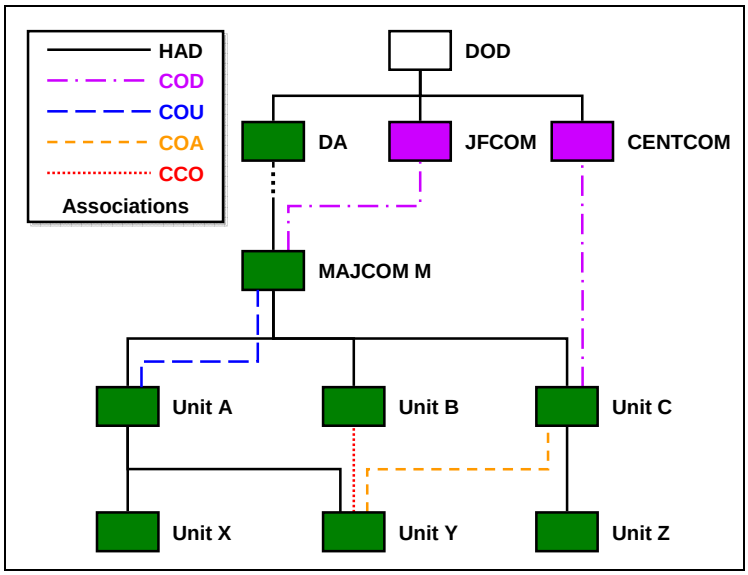

Figure 5: Use of COU and COA Associations

However, suppose that Unit A is not assigned to JFCOM. To denote this fact, a (blue) COU association is inserted between MAJCOM M and Unit A. This association is used by the org-tree

[29] OPCON relationships are not part of the Organization Server, as they are often very fluid.

traversal algorithm to remove Unit A from further exploration when identifying forces assigned to JFCOM. Thus, any descendants of Unit A will not be traversed in the absence of any other associations. To allow exceptions to this situation, a COA association may be used to reestablish a descendant of an "unassigned" ancestor to the assignment hierarchy of a UC. In this example, Unit Y, which has an ADCON relationship to Unit A, has a COA association to Unit C that has a COCOM relationship to CENTCOM. This inserts Unit Y in the assignment hierarchy of CENTCOM and org tree traversal algorithm can trivially discover this fact. Allocating Unit Y to Unit B that is assigned to JFCOM does not override the fact that Unit Y is assigned to CENTCOM. Thus, via an org-tree traversal algorithm, it can be easily derived that Unit Y is ADCON to DA, assigned to CENTCOM, and allocated to JFCOM.

Although the COD and COA/COU associations produce similar affects, they are legally different. The COD dictates COCOM authority by statute of the SecDef. Therefore, the SecDef technically controls the COD associations. Formally, this enables the whole assignment of forces process. The COA/COU associations are controlled by the Services and allow them to fine tune the assignment process to include only the necessary forces as required by the SecDef. This poses an interesting quandary for the Services. A primary exception to Title 10 §162(a)[30] is for forces fulfilling Services Title 10 responsibilities. By invoking this exception the Service retain control of their forces. However, being assigned to a UC has several stature advantages (i.e., being part of the "tooth" rather than the "tail"), especially during times of reduced budgets. Consequently, it can be advantageous to have as much of ones forces assigned to a UC as possible. To determine if forces are assigned, the three key questions are:

1. Are they uniformed military personnel?
2. Are they under the chain of command of the Service Component Command of a Unified Combatant Command?
3. Can the Combatant Commander organize and employ these forces, as he considers necessary, during peacetime operations?

If the answer to all of these questions is "yes", they are assigned forces. Otherwise, they are not. These basic rules can help he Services decide how to utilize the COA/COU associations. Once this information is inserted into an OS based system, automation can be used to quickly and easily determined and identify all assigned forces.

4. Summary

This paper has discussed the issues and constraints encountered in the GFM DI during the development of a formal representation of administrative and operational relationships within defense organizational constructs. A primary goal of the GFM DI is to be able to represent the assignment, allocation, and apportionment processes routinely used by members of the Joint Staff and the combatant commands. To do this, the GFM DI team began by defining the administrative organization structure and its associated manpower and equipment authorizations. Tree graphs are used to represent organizations (the nodes) and the associations between them (the links). Three

[30] USC Online, *op. cit.*, "… the Secretaries of the military departments shall assign all forces under their jurisdiction to unified and specified combatant commands. …"

classes of associations are introduced; the first one represents aggregation or composition. An organization tree built from this class of association is called a command structure because it represents the organizational hierarchy through which command is exercised. Relationships are then defined as paths between organizations that traverse one or more associations. This formalism enables one to define the relationships between organizations based upon the sequence of association types that exist between them. Three types of relationships are discussed and specific types of associations are introduced to represent those relationships. The relationships are administrative control (ADCON), combatant command (command authority) (COCOM), and briefly, operational control (OPCON). These relationships are derived from the associations which are explicitly represented inside Service controlled and maintained organizational databases called organization servers (OS). Using these basic semantics, precise tree traversal algorithms can be define that traverse the organization trees via their associations to answer questions about assigned, allocated, and apportioned forces and their manpower, equipment, and doctrinal structure. Finally, the administrative command structure obtained from the OS provides the starting point, or default, from which the basic GFM premise is exploited: *that force structure ties everything together*. By duplicating this default structure (i.e., downloading it into local information systems) and then linking real world entities (e.g., personnel, equipment, location, plans, budgets, etc.) to it, its reconfiguration (i.e., task organization) provides a myriad of options that can be used as a strategy to integrate between disparate items of information. That is the fundamental goal of the GFM DI.

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