Evolving DODAF: An Integrated Training Enterprise - Delivery Architecture Framework

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ABSTRACT

This paper describes an approach to help enable 21st Century transformation of military training organizations using an integrated enterprise-delivery architecture framework (IEDAF). This architectural framework is currently being used to model the U.S. Army Training Support System (TSS) and has promising application to the Joint National Training Capability (JNTC), as well as other enterprise domains. The current Department of Defense Architecture Framework (DODAF) has limitations when applied to training enterprise development. Although many DOD framework products have been applied to other enterprise domains, the views, relationships, and associated data types were originally intended to develop Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems. C4ISR and other similar systems map well to current DODAF operational, systems, and technical standards views. In contrast with such operational systems, a military training support enterprise can be described as a complex system of endeavors within national security and defense environments, enabling delivery of highly integrated training capabilities to meet warfighter mission needs. The DODAF is not as well suited to model such enterprise systems, which conduct life cycle activities resulting in a full range of deliverable systems and services. These enterprises need to frame concepts including; customer-driven deliverable use cases, deliverable system views, enterprise business practices, and enterprise system infrastructure. Relationships between these concepts need to be defined, as well as characteristics including; enterprise to deliverable interactions, modes of delivery, and deliverable types. To address these needs, IEDAF extends DODAF by incorporating both an "enterprise" dimension and a "deliverable capability" dimension in its framework. Five views and associated schema extensions are specified involving; deliverable operational and implementation views, enterprise business practice and system views, as well as a technical standards view. In the military training domain, this is enabling the development of a fully integrated, interoperable training support enterprise driven from planned delivery of military operational and training capabilities.

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THE 21ST CENTURY TRAINING ENTERPRISE ENVIRONMENT AND CHALLENGES

In order to help provide more effective forces and capabilities in support of 21st century operations, the defense community is re-examining and evolving legacy arrangements and interrelationships among business practices, components, and information flows. One defense business area critical to this evolution is the training support necessary to enable operationally relevant training environments. As a key partner in the Joint Team, the U.S. Army (2004) has stated "we must treat Soldiers themselves as the ultimate combat system, and to this end, conduct a holistic review and analysis of individual Soldier institutional and unit training, equipping, and readiness needs."

One way to address such holistic training evolution is through an enterprise architecture modeling approach. An enterprise can be defined as a system of business endeavor within a particular business environment (Interoperability Clearinghouse, 2003) and as an organization created to provide products and/or services to customers (Eyefortransport, 2004). Such products and services can be viewed as enterprise *deliverables* provided to meet *customer needs* as a central enterprise mission focus. An enterprise architecture (EA) is a design for the arrangement and interoperation of business components (e.g., policies, operations, infrastructure, information) that together make up the enterprise's means of operation (Interoperability Clearinghouse, 2003).

Although focused on information technology, the Office of Management and Budget (OMB, 2003) further describes an EA as the explicit description and documentation of the current and desired relationships among business and management processes and information technology. An EA should describe current and target architectures (including rules, standards, and *systems life cycle* information) and a target architecture transition strategy to optimize and maintain the environment. OMB directs the creation of enterprise architecture frameworks incorporating linkages between enterprise mission needs, information, and technology capabilities, as well as describing enterprise business processes, information flows and relationships, and technology infrastructure.

Given these definitions of enterprise and enterprise architectures, a military training support enterprise can be described as a complex system of endeavors within the national security and defense environment, enabling *delivery of highly integrated training capabilities* to meet *warfighter mission training needs.* In the training support domain, the idea of an enterprise deliverable can be mapped to the concept of deliverable training support capabilities or product lines. Also, the concept of enterprise customer needs translates well to warfighter mission training needs.

As a key initiative to help transform Army training support for joint operations in the 21st century, the Army Training Support Center (ATSC) is coordinating development of the Army Training Support System (TSS). The TSS is envisioned to be an enterprise system of systems that provides the networked, integrated, interoperable training support necessary to enable an operationally relevant training environment for warfighters (ATSC, 2004). Even though the Army currently has training support system capability, preliminary analysis indicates existing system components will not meet 21st Century training requirements and typically compete for limited resources. The TSS can be a critical enabler for the Joint Operational Environment, addressing the following training stovepipe issues:

- Streamlining training support management practices across service boundaries
- Conservation of manpower and dollars
- Providing relevant training enablers to support joint force readiness
- Synchronization of training support from concept deployment to capability fielding

In order to conduct holistic review and analysis to support TSS enterprise development, the Virginia Modeling, Analysis and Simulation Center (VMASC) is developing a virtual model for the TSS. The virtual training support system of systems (VTS3) is an

integrated, executable enterprise architecture model whose purpose is to enhance TSS business practice, information flows and relationships, and technology infrastructure. VTS3 is not viewed as a static one-time architecture description, but a living executable enterprise model, in line with the concept of iterative architecting (Software Productivity Consortium, 2004).

ASSESSMENT OF THE FEAF AND DODAF FOR ARCHITECTING THE TRAINING ENTERPRISE

In the process of developing a tailored training enterprise architecture framework, assessments were conducted of relevant architecture frameworks. The two most relevant frameworks were the Department of Defense Architecture Framework (DODAF) and the Federal Enterprise Architecture's Business Reference Model, Version 2.0. Assessment areas included applicability of architecture structures for training enterprises, as well as gaps and interrelationships between existing frameworks.

DODAF Assessment for the Training Enterprise

DoDAF clearly needs to be the foundation for DoD enterprise modeling, due to leadership directives and DoDAF current use guidance. DoD and Chairman of the Joint Chiefs of Staff instructions, such as the Operation of the Defense Acquisition System (Department of Defense, 2003) and JCIDS (CJCS, 2004), specify the use of integrated architectures to optimize DoD warfighting and business capabilities. The DoD Architecture Framework Working Group (2003a) defines DoDAF products that allow the description of capability-based integrated architectures intended to support such optimization. The DoDAF Deskbook (DoDAF Working Group, 2003b) portrays business process reeningeering and capability needs determination as two of six DoD supporting process which can be addressed by DoDAF.

A limitation of DoDAF for training enterprise evolution is its characterization as a static front-end enterprise description. DoDAF is currently intended for use as a representation of a current or postulated "real-world" configuration of resources, rules, and relationships (DoDAF Working Group, 2003a). Once the representation enters the design, development, and acquisition portion of an enterprise's development life-cycle process, the architecture description is intended to be transformed into a real implementation of capabilities and assets. DoDAF does not currently address this representation-to-implementation transformation process.

The major DODAF perspectives (i.e., views) also have limitations when applied to training enterprise development. Current DODAF views are the Operational View (OV), Systems View (SV) and Technical Standards View (TV). Although many DOD framework products describing these views have been applied to other enterprise domains (e.g., Sowell, 2000), the three view framework, along with its relationships, and associated data types were originally intended to develop Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems. Therefore, DoD C4ISR and other similar operational systems map well to current DODAF operational, systems, and technical standards views. However, the view framework is not as well suited to model DoD enterprise systems, which conduct life cycle activities resulting in a full range of deliverable systems and services. These enterprises need to frame concepts including; customer-driven deliverable use cases, deliverable system views, enterprise business practices, and enterprise system infrastructure. Relationships between these concepts need to be defined, as well as characteristics including; enterprise to deliverable interactions, modes of delivery, deliverable types, and enterprise customers.

Another limitation of DoDAF for enterprise frameworks is the limited technical focus concerning enterprise structure and standards. There is a broader range of organizational as well as technical structure related to complex enterprise systems, including enterprise guidance, plans, and business standards for compliance.

Business Reference Model Assessment for the Training Enterprise

Analysis of the FEA Business Reference Model (BRM), version 2.0, highlights important enterprise architecture framework concepts not emphasized in DoDAF. The BRM serves as the foundation of the FEA, describing Federal Government lines of business (Federal Enterprise Architecture Program Management Office, 2003). As previously stated, a main component in the definition of an enterprise is the concept of providing deliverable products and services to fulfill enterprise customer needs. The BRM's top level layers contain a Services for Citizens area, which describes the mission and purpose of the United States government in terms of the services (i.e., BRM deliverables) it provides both to and on behalf of the

American citizen (i.e., BRM customer). Version 2 of the BRM further emphasizes the concept of deliverable, by adding a new Mode of Delivery layer, which describes mechanisms the government uses to achieve the purpose of government. The new layer was added to highlight key relationships between enterprise business practice and delivery of services including functional "methods" by which enterprises accomplish deliverable goals.

The Interagency FEA Working Group (2002) further emphasized the dimension of the enterprise customer and deliverable by portraying two tiers above the BRM: users/types of use and access options. *Users* include citizens, non citizens, public sector, business, foreign government, and employees. *Types of use* portray various categories of deliverable service interactions including; information, analysis, interactive processes, transactions, and collaboration. *Access methods*, including mail, face to face, phone, web, system to system, and future categories are included to ensure comprehensive, consistent service no matter how access is achieved.

The previously described enterprise concepts represented at the top level of BRM framework are not adequately framed in DoDAF. These critical BRM enterprise concepts include; deliverables, customers, and relationships between enterprise activities and deliverable goals (e.g., mode of delivery). These areas represent additional DoDAF enterprise modeling limitations, which need to be addressed in order to more effectively use DoDAF for training enterprise modeling, as well as enterprise modeling in other domains.

THE INTEGRATED ENTERPRISE-DELIVERY ARCHITECTURE FRAMEWORK (IEDAF)

In order to more fully address the modeling aspects involved in enterprise architecting, an Integrated Enterprise Delivery Architecture Framework (IEDAF) has been developed. This was accomplished by applying FEA-driven enterprise concepts to extend DODAF. As shown in Figure 1, IEDAF incorporates both an "enterprise" dimension and a "deliverable capability" dimension in its framework at the top level. Five IEDAF views are also specified.

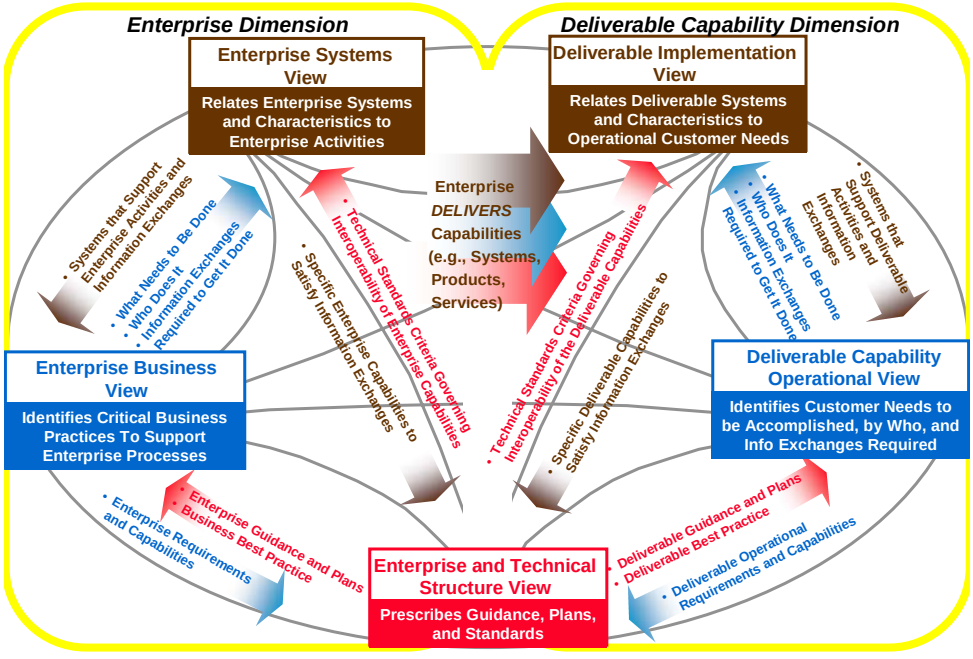

Figure 1. Integrated Enterprise Delivery Architecture Framework (IEDAF)

The "deliverable capability" dimension of IEDAF, incorporates both deliverable operational and implementation views. This IEDAF dimension relates to the definition and modeling of interrelated deliverable capability activities, information, actors, systems, products, and services provided to support delivered capabilities directly fulfilling customer needs.

The "enterprise" dimension of IEDAF, incorporates both business practice and enterprise system views. This IEDAF dimension relates to the definition and modeling of interrelated enterprise business practice and systems activities involving processes, information, actors, and systems provided for indirect life cycle support (e.g., planning, development, production, and assessment) of delivered capabilities. The fifth view is an enterprise and technical structure view which applies to the entire IEDAF.

We can explain distinctions between IEDAF dimensions and associated views using a metaphor. In a restaurant, the customers arrive at the dining area and receive products and services: the seating, the menus, and attention given by the wait staff. Using this example, the delivery capability dimension of IEDAF involves direct interface between the restaurant and the customer. The modeling of the customer's experience, including dining room activities, information exchanges, and organization of the wait staff are part of the deliverable capability operational view. The products and systems provided to the customer for fulfillment of needs are part of the deliverable implementation view including; delivered food and beverage products, place settings, menu, and payment artifacts.

The enterprise dimension of IEDAF involves indirect activity occurring to support the customer's dining experience. The modeling of such critical business practice, including support activities and enterprise organizational support structures, is done in the enterprise business view. In the kitchen and office areas, cooks, cooks assistants, administrative employees, and managers conduct such "enterprise" business processes including; receiving vegetables and meat needed for cooking, ordering and receiving utensils, developing administrative activities to organize the cooking processes according to the menus, conduct meal production activities, building construction/upgrades, and organizing the business. Systems and products used to support these enterprise life cycle support activities are modeling under the enterprise systems view, including order systems, kitchen appliances, refrigeration, and cleaning equipment.

There are also enterprise and technical structure aspects to the restaurant enterprise, which can apply to either enterprise or deliverable capability dimensions. This structure can take the form of guidance, plans, and standards for compliance. Examples include wait staff rules, fire regulations, and technical interface standards between automated restaurant systems.

Relationships between IEDAF dimensions are now further explained. Typically, enterprise goals and missions are iteratively defined as part of enterprise business practice including; support of overarching external mission needs, identification of enterprise customers, and determining deliverable capabilities to meet customer needs. These high-level goals and mission needs of the enterprise drive initial modeling of current and future deliverable implementation dimension views. The deliverable implementation dimension in turn drives lower-level enterprise dimension modeling; using defined customer needs to determine current and future enterprise business practice and enterprise support systems.

Deliverable flow and view linkages for IEDAF are also shown in Figure 1. A key concept is that various types of deliverable capabilities (e.g., systems, products, services) flow from the enterprise to the customer. Within the deliverable dimension, the deliverable operational view defines direct customer interface participants, activities, and information exchanges used in identifying deliverable systems and characteristics to fulfill customer needs in the deliverable implementation view. Upon delivery of identified capabilities to the customer, these deliverables support customer activities and information exchanges. Deliverable implementations are actually evolved, implemented, and assessed as part of the enterprise business view, through life cycle and other enterprise business practices. Within the enterprise dimension, the enterprise business view defines indirect life cycle business participants, processes, and information exchanges used in identifying enterprise support systems contained in the enterprise systems view. Upon enterprise deployment, these systems support enterprise business processes. Requirements and capabilities from both dimensions feed into the enterprise and technical structure view, which returns guidance, plans, best practice, and technical standards criteria.

THE ARMY TRAINING SUPPORT SYSTEM (TSS) IEDAF IMPLEMENTATION AND LESSONS LEARNED

In the military training domain, application of IEDAF is enabling the development of a fully integrated, interoperable training support enterprise driven from planned delivery of military training support capabilities. Figure 2 shows an initial draft schematic IEDAF depiction to accompany an All Views 1 (Overview and Summary Information) of the TSS enterprise. The schematic shows overarching external operational practice mission needs which drive TSS missions.

When viewed in terms of the IEDAF deliverable capability dimension, TSS missions are defined in terms of delivering integrated training support capabilities to effectively enhance joint operational training of the warfighter. This training is conducted in institutional, operational, and self development domains, which are modeled under the deliverable capability operational view. The TSS delivers training support product line capabilities, as shown in the deliverable implementation view, which enable the conduct of training and education. They consist of training information infrastructures (TII); training aids, devices, simulators, and simulations (TADSS); training products; training facilities and land; and training services (ATSC, 2004). TSS also delivers activities that directly support training such as training evaluation or preparation of unit training.

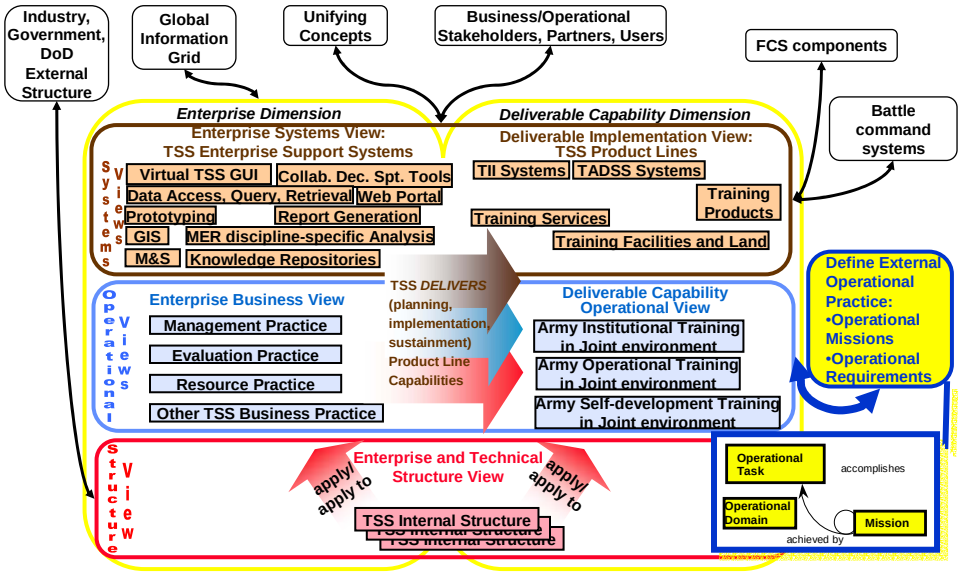

Figure 2. Initial Schematic to accompany TSS All Views 1 (AV-1)

As shown in the IEDAF enterprise dimension, there are many indirect "enterprise" activities and life cycle processes which support the delivery of TSS capabilities. These are represented under the enterprise business view and categorized into management, evaluation, and resource (MER) practices. MER processes are best business practices to plan, implement, and sustain the TSS. They are the overarching business practices that enable informed training support decisions in support of training requirements (ATSC, 2004). Examples of such business practices include the conduct of training analysis; and the identification of future (5-25 years) training requirements, concepts, strategies, and plans for training the future Army.

Top-level draft functional requirements of TSS enterprise support systems are shown under the enterprise systems view. These functional requirements include: a virtual TSS model-based graphical user interface with representation of work process TSS components, interrelationships, and resourcing; collaborative decision support tools; distributed data access, query, and retrieval; management, evaluation, and resource, discipline-specific tools; training event management; training support scheduling and deconfliction tools; GIS visualization; linked knowledge respositories; modeling and simulation; virtual prototyping; web portal; and report generation capabilities. These enterprise system requirements are being driven from static and dynamic architecture analysis of TSS

deliverable capability views and the enterprise business view. This modeling effort is also populating TSS enterprise and technical structures involving guidance, plans, and technical standards.

An external view is also shown in Figure 2 with key external influencing elements outside the yellow TSS boundary. External elements include: external structure; information technology initiatives, such as the Global Information Grid (GIG); DoD unifying operational concepts; external stakeholders; and operational systems, such as the Future Combat System and battle command systems.

In order to implement IEDAF as an executable architecture, the CORE® product and process engineering solution, from Vitech Corporation is being used. The object-based DoDAF schema in CORE® was tailored and extended to model IEDAF views. Some examples of these extensions are now described. An ActorUnit class was created, similar to the All-DoD Core Architecture Data Model (CADM) "node" to model customers and enterprise support providers. However, ActorUnits, such as a deliverable customer have a flow attribute, similar to information flows, in order to be transformed by various deliverable activites. An example is a TSS trainee customer, transforming from an untrained to trained state by flowing through a deliverable training event activity. An InformationUnit class was created, similar to CADM "information assets" to model information flows, but attributes of this class include the ability to trigger the initiation of activities. The CORE® schema also contains system engineering classes, including functions, systems, interfaces, and links. This enables architecture description classes to be mapped to system engineering classes during a transformation of enterprise architecture classes to engineering classes, which is needed for enterprise system design. A very important addition was the DeliverableUnit class, containing systems, facility, and service subclasses. This allows the modeling and execution of TSS deliverable system functional model threads, early in a training support system life cycle. Finally, selected class relationships were added, including an exemplified by/exempliflies relationship. This was important to compare general models, such as an "as is" implementing unit training activity/data flow, to specific "to be" use cases, such as a Future Combat System live/virtual/constructive training event activity/data flow.

Figure 3 shows an example of a "to be" executable business practice view, using a CORE® enhanced function flow block diagram (EFFBD), with business process activity and information flow relationships. The business processes are rectangles, with sequencing and duration attributes, enabling simulation execution. Information flows are also reflected, which can also act as "triggers" influencing initiation of processes during simulation. Figure 3 models a proposed "to be" evolution of the "as is" System Training Plan (STRAP) development into Initial Capabilities Training Plan development, which can feed system training support requirements to an Initial Capabilities Document (ICD) early in the acquisition process. This business practice model also identifies enterprise system functional requirements, including a TSS workflow interface and a distributed collaborative information environment.

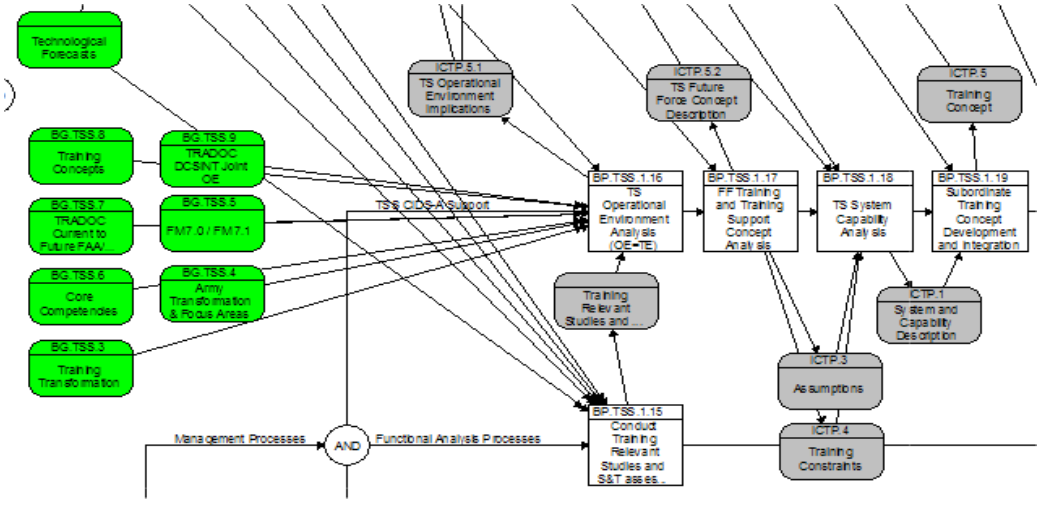

Figure 3. Example "to be" TSS business practice model

IMPLICATIONS FOR JNTC AND OTHER ENTERPRISE DOMAINS

We believe the IEDAF approach has applicability to joint training support enterprises, such as the Joint National Training Capability (JNTC), with its associated Joint Management Office (JMO) as well as other supporting joint and service directorates. Figure 4 shows a possible IEDAF mapping to the JNTC enterprise. The JNTC deliverable capability dimension contains a JNTC operational view describing the Joint Event Life Cycle (JELC) involving what needs to be accomplished, by whom, and information flows for joint training events, experimentation, testing, or mission rehearsal. JELC use case attributes could include; JELC activities and information flows, event domain descriptions, Joint Tactical Tasks (JTTs) addressed, system requirements (e.g., LVC, C4ISR, and operational), data set needs, and JELC organization and actors. There is also a JNTC deliverable system of systems view relating JNTC deliverable systems and characteristics to training needs. JNTC SoS use case attributes could include; systems (LVC, C4ISR, Operational), functions, components, data set generation, interfaces, repositories, and distributed facilities.

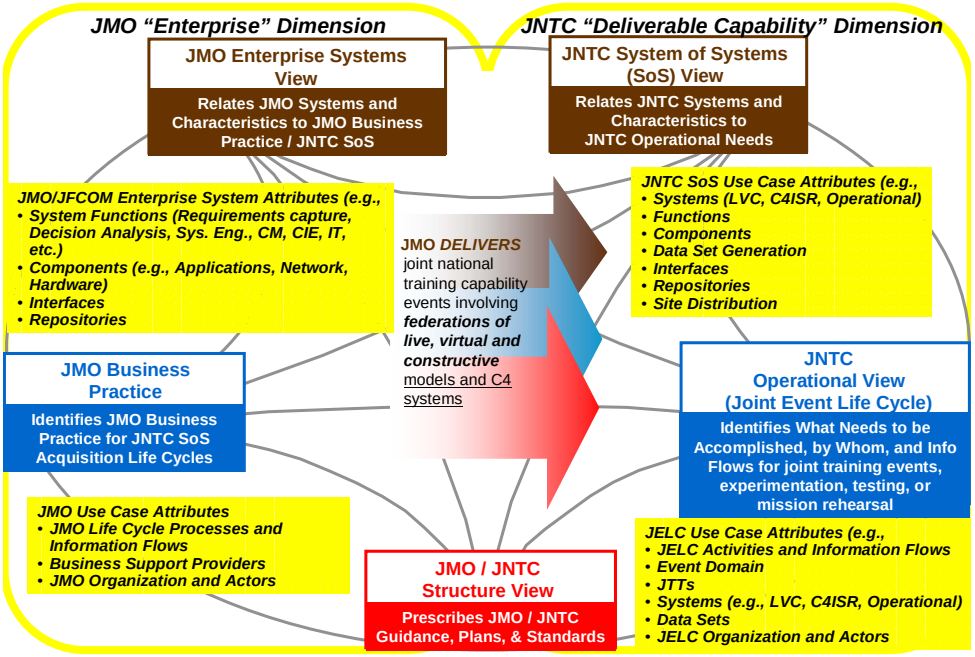

Figure 4. Possible IEDAF Mapping to JNTC

The JNTC enterprise dimension contains Joint Management Office (JMO) business practice, including JNTC system of system acquisition life cycle processes. JMO use case attributes could include; JMO life cycle processes and information flows, business support providers, and JMO organizations and actors. The JMO enterprise systems view relates JMO systems and characteristics to JMO business practice, as well as the JNTC deliverable system of systems. JMO/JFCOM enterprise system attributes could include: system functions involving requirements capture, decision analysis, system engineering, configuration management, collaborative information environments, and information technology; enterprise support components (e.g., applications, network, hardware), interfaces, and repositories

CONCLUSIONS

This paper has described perceived limitations, concerning DODAF use for enterprise modeling, including issues with its overall framework, insufficient enterprise and executable data elements, and narrow technical standards focus. These issues limit the DoDAF's ability to describe and model enterprise systems, which conduct life cycle activities resulting in a full range of deliverable systems and services for customers. We then presented the integrated enterprise-delivery architecture framework (IEDAF) and described positive results in using IEDAF to model the U.S. Army Training Support System (TSS) enterprise. Results of TSS IEDAF modeling efforts are enabling the development of a fully integrated, interoperable training support enterprise driven from planned delivery of military

operational and training capabilities. Such an approach is believed to have promising application to the Joint National Training Capability (JNTC), as well as other enterprise domains.

ACKNOWLEDGEMENTS

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