

Enterprise Architecture as a Tool of Navy METOC Transformation

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Abstract - The Naval Meteorology and Oceanography Command (NAVMETOCCOM) is transforming its business model and processes to better align with the Naval warfighter. Information Technology (IT) is an enabler for this transformation. This paper will discuss how the transformational IT strategy based on the tenets of Net-Centric Operations and Warfare (NCOW) and Service Oriented Architectures (SOA) are being managed and applied in the NAVMETOCCOM Enterprise Architecture.

I. NAVY METOC – WHO WE ARE & WHAT WE DO

The Naval Meteorology and Oceanography Command (NAVMETOCCOM) is a third echelon Naval command whose mission is to provide environmental information to warfighters and their mission planning, command and control, and weapon systems. Environmental information is used to characterize the environmental component of the battlespace and to assess impacts to warfighter sensors, platforms, weapons, and missions. NAVMETOCCOM's functional domains include Meteorology and Oceanography (METOC), Geospatial Information and Services (GI&S), and Precise Time and Astrometry (PT&A).

In 2004, the Commander recognized a need for realignment in order to enhance responsiveness to its warfare stakeholders. In September 2004, COMNAVMETOCCOM conducted a seminal meeting that set the stage for a transformation from geographically-oriented support to knowledge-based support aligned to the Command's primary business lines, specifically, Warfare Areas. [1] The meeting formed the focus of transforming the Command tours for O-5/O-6 Naval officers from the Regional Centers/Production Centers to Command tours as Directors of Oceanography Operations (DOO), the latter conforming to the transformational business lines for NAVMETOCCOM:

- Anti-Submarine Warfare
- Navy Special Warfare
- Intelligence, Surveillance, and Reconnaissance
- Mine Warfare
- Precise Time and Astrometry
- Navigation
- Fleet Operations, Strike, and Expeditionary Warfare
- Maritime Operations
- Aviation Operations [2]

As a result of this transformation, the Commander has expressed a new Mission: "To provide an asymmetric war fighting advantage through the application of Oceanographic sciences." [3]

NAVMETOCCOM supplies a Navy strength... the ability to apply Oceanography to battle problems and challenges in order to leverage knowledge of the environment to enable asymmetric advantage. NAVMETOCCOM provides that advantage for the Navy through the application of its scientific disciplines: METOC, GI&S and PT&A. This advantage is delivered through, and made productive at the end of, an information and services supply chain managed solely for that purpose. This information/services supply chain is our Naval Oceanography enterprise.

The opportunities and challenges related to Enterprise Architecture (EA) to enable the NAVMETOCCOM transformation are several, and will be explored in the remainder of this paper. At a paramount level, the NAVMETOCCOM To-Be EA must account for the business functions that are explicitly and implicitly a part of each business line. The EA must both account for the logical and physical assets that are associated with the former Regional Centers and describe their transition to infrastructure and processes needed to support the new

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Concept of Operations, regardless of the spatial distribution of the business line functions (as well as describe the "where" of the business lines).

II. DOD/DON TRANSFORMATION DRIVERS & CONSTRAINTS

The ability of the Command to shape its Enterprise is affected, either enabled or hindered, by forces and constraints outside of the Command. The DoD and Navy are migrating to Enterprise Service Oriented Architectures; viz. the Global Information Grid (GIG) and the FORCEnet, respectively. [4] The primary impact of these constructs is a requirement for the NAVMETOCCOM Enterprise to similarly present itself as discoverable, understandable, and accessible services that can be used by Warfighters, either through DoD portals or as discovered by other DoD systems via a machine-machine interface. One negative impact - the Department of Defense Architecture Framework (DODAF) derives from an older paradigm of stove-piped systems development; it has been argued that the DODAF is not conducive to engineering an SOA. [5] As NAVMETOCCOM migrates to an SOA, the *Systems* Views from the DODAF would properly be represented as *Services* Views. [6] Also, the services that are to be provided under the GIG Network Centric Enterprise Core Services (NCES) are not yet fully available, but are needed; this leaves the Command in a position where it must provide them directly in advance. The Command's philosophy is to migrate toward a knowledge provider that utilizes DoD provided commodity hardware and services. [7]

A related factor is the existence of the Navy-Marine Corps Intranet (NMCI), a seat management initiative to provide workstations and infrastructures across the entire CONUS Navy and Marine Corps enterprise. The provision of NMCI across the NAVMETOCCOM enterprise again provides an opportunity to make use of commodity hardware. It is the Command's intent to use NMCI, when available, as the target platform for the end user's consumption of enterprise web services. However, NMCI does not yet provide a server infrastructure that is completely suitable for provisioning the services, particularly due to the requirement to reach back into NAVMETOCCOM Production Centers for extremely large data stores and leading edge supercomputing processing capacity to realize the services. Also, many of the applications that would use METOC web services are components of Tactical Decision Aid and Weapon Decision Aid systems that are not a part of NMCI.

A complicating factor is the Navy's initiative for "rationalization", viz. the reduction of its overall numbers of applications. Navy enterprise-wide, the target was 95% reduction of 100,000 applications. [8] This process was, and is being, conducted through 24 Functional Areas, each under the purview of a Functional Area Manager (FAM). [9] The FAM for Meteorology, Oceanography, GI&S and PTA is COMNAVMETOCCOM. The Navy's rationalization

approach makes sense when addressing multiple varieties of spreadsheet software, for example, but is detrimental when approaching the NAVMETOCCOM software baseline on a number-driven basis. METOC has a large number of unique applications that perform very specific scientific calculations; attempts to rationalize them are problematic simply because of the unique nature of the Command's business model (i.e. deriving METOC information products.) A final complicating factor with regard to this rationalization process is how it will be applied in a SOA environment where application boundaries will be significantly blurred across multiple enterprise boundaries.

In summary, the net-centric transformation emerging in the broader DoD community levies a requirement for process transformation within NAVMETOCCOM. Further, aligning to the SOA of the GIG requires IT transformation. These transformations have to be accomplished without additional resources.

III. IMPLICATIONS, STRATEGY, & STATUS FOR METOC INFORMATION TECHNOLOGY

As described above, broader DoD/DON transformation efforts have levied requirements on Navy METOC programs to integrate our production and service processes with emerging, net-centric processes of the warfighter. Furthermore, since we must make this transformation in the context of decreasing budgets, the METOC Enterprise must employ new management processes and supporting tools to enable more visibility into costs and effectiveness of METOC products and services. Only through such visibility will management be able to make critical business case decisions for investments and divestments. The following sections define the establishment of a NAVMETOCCOM Enterprise Architecture Framework (EAF) to support better management practices and an approach to integrating effectively with the GIG via a METOC SOA. Fig. 1 depicts a very high level IT architecture that reflects the presence of major types of METOC nodes and services, as well of recognition of the central role of the GIG in facilitating integrations across multiple IT enterprises. This high level architecture provides the context for our EA efforts and transformation to an SOA environment.

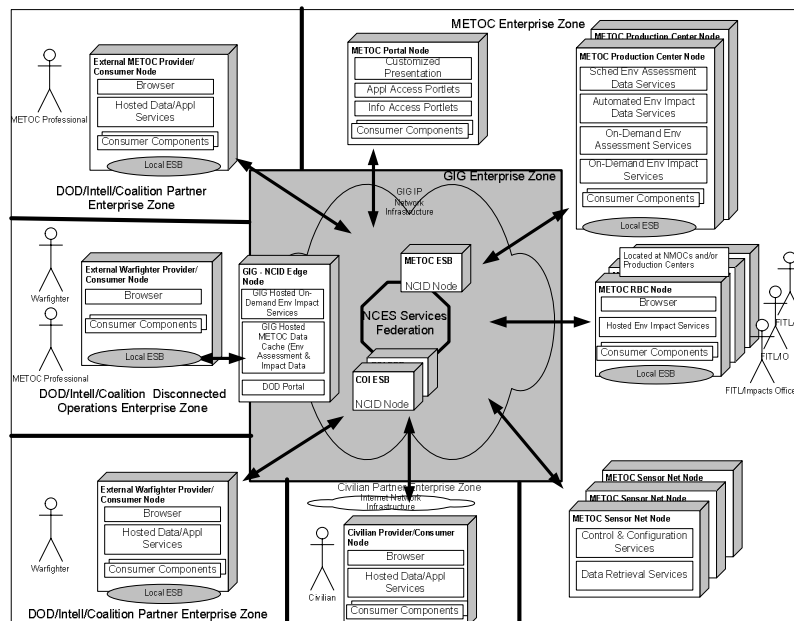


Figure 1. METOC "To-Be" Enterprise Architecture IT Context

A. Enterprise Architecture... from concept to daily tool

NAVMETOCCOM has a history of development and use of Enterprise Architecture beginning around 2000, although the supporting roots go back to the 1980s. The NAVMETOCCOM efforts at EA have been conducted at both COMNAVMETOCCOM and at its production centers. The Naval Oceanographic Office (NAVOCEANO) started developing its architecture in 2000, using the DoD C4ISR Architectural Framework (DODAF) as its structure. Over the next several years, NAVOCEANO built software and database structures to hold the information descriptors that would comprise its architecture artifacts. Key to this effort was the existence of a robust Configuration Management (CM) program for the NAVOCEANO enterprise. (CM was a legacy practice at NAVOCEANO that was formalized in the 1980s.) The NAVOCEANO CM databases contained detailed inventory information for the majority of the Office, and the information in them had been refreshed for Y2K planning. As a result the first efforts to establish an EA for NAVOCEANO began with the DODAF Systems Views. By 2002, NAVOCEANO had developed its initial EA products; specifically, there was a populated database and software application that would build the C4ISR views on the fly.

Concurrently, NAVMETOCCOM was building a coupled EA. In 2000, the Department of the Navy Chief Information Officer enlisted the Commander to participate in a demonstration of EA at an operational command. For

the next two years, DONCIO staff and contractors worked with COMNAVMETOCCOM staff and representatives from the Command to develop a C4ISR-compliant EA. In doing so, DONCIO developed a tool referred to as the Department of Navy Information Architecture Database (DIAD). The DIAD was the tool used to ingest and manage information descriptors relevant to the Operational Views of the C4ISR AF. By the end of 2002, a NAVMETOCCOM EA prototype (Operational Views only) had been populated and the results were briefed at a DONCIO-sponsored EA conference in Feb 2003. [10] During this period, the Operational Views portions of the NAVOCEANO EA were synchronized with the DIAD and the Systems Views products were maintained independently.

From 2002 to 2004, NAVOCEANO had been modernizing its architecture tools, migrating from a single-user environment deployed on Microsoft Windows platform using COTS packages, to a web based open source (Linux) environment using open source tools. [11] Additionally, the migration tool includes capability for Configuration Management, Requirements Management, and CM change tracking, in addition to the original EA. That is, the tool consolidated a number of legacy IT management databases that support the overall architecture objectives. [12] This tool provided the foundation for the current EA capability described below.

Current Enterprise Architecture Framework

The purpose of the NAVMETOCCOM Enterprise Architecture Framework (EAF) is to provide COMNAVMETOCCOM and all of its subordinate commands with a common data repository to manage the IT assets and architecture for the Naval METOC community.

The EA allows NAVMETOCCOM personnel to have a common entry point for managing IT assets, business processes, network topology, requirements, and technology standards. The EAF's initial capability combined the following separate functions:

- Identification Management (CIM) In-House database – maintains detailed inventory and configuration information about the systems that comprise the enterprise.
- Configuration Management Office (CMO) Tracking System Configuration – maintains approval and status of changes to the enterprise baseline.
- DoD Architecture Framework (DODAF) Repository – maintains multiple dimensions of enterprise views that meet the definitions of the Department of Defense Architecture Framework.
- Requirements Enterprise Architecture Documentation (READ) – maintains a database of functional and system requirements for the enterprise.

The DODAF Repository maintains data that represent the three “views” in the DODAF specification: Operational, Systems, and Technical. Operational Views (OVs) represent the business processes of the enterprise, including Processing Nodes (where work occurs), Information Elements (the information produced), Information Exchange Requirements, and Processes. The Systems Views represent the physical components (hardware, software, networks) that provide the computing capability that is used by the elements described in the OVs. The Technical Views describe the technical specifications and standards used in the items described in the SVs.

B. IT Transformation... assimilating Net-Centric & SOA Tenets

As described above, a fundamental transformation is underway in the DoD. This transformation is characterized by process transformations that embrace the tenets of Net-Centric Operations and Warfare (NCOW) and IT transformations that require DoD systems to integrate with the GIG and to embrace the tenets of an SOA. Understanding SOA and its relevance to the Naval

Oceanography Program is key to defining an effective transition strategy for our community.

Primarily, SOA is a software design model that guides software engineers to package capability into units of work that can be discovered, understood, accessed, and used by developers and systems anywhere on the GIG. It is also defined by emerging technology standards that enable its implementation, as well as design principles and management best practices that must be applied to assure it will deliver expected benefits to the warfighter.

Properly implemented, SOA will provide benefits to the warfighter. An effective SOA provides a common integration mechanism that can span multiple systems, technologies, and organizations located anywhere on the network; warfighters (and their systems) are benefited by having comprehensive but selective access to discoverable data, information, and knowledge most relevant to their decisions and operations. Further, it will improve Return on Investment (ROI) on all IT investments, including already deployed legacy applications and systems.

SOA is not only mandated by the GIG Architecture (as articulated in the NCOW Reference Model [13]), it is also embraced by every major IT vendor in the form of XML and web services solutions.

Navy METOC SOA Strategy

To become a net-centric player in the emerging DoD SOA environment, new IT technologies must be employed. Reusable software entities, called services, must be deployed and offer specific benefits to the operators and their systems. Further, new infrastructure technology must be available to host these services and support their interoperability, composition, and management. An optimal mix of projects must be identified, selected, and effectively executed to accomplish these integrations. New technical skills in the area of software design, and new management approaches to software development and reuse must be applied in these processes. These new skills and practices are not currently employed in the formulation or execution of most DoD IT projects, adversely affecting their readiness to deploy effective SOA solutions.

The Naval Oceanography Program must define and implement a strategy that accomplishes the following goals:

- transition the end-to-end enterprise to SOA compliance
- maximize IT investments that produce “visible” warfighter value on a continuing basis
- minimize required IT costs for non-core functions (e.g. internal infrastructure hardware and software)

- develop and apply the new technical skills and management best practices required for assuring SOA success
- ensure alignment of IT projects to architecture

The implementation of this strategy is embodied in the portfolio of projects that we select to meet these goals and in the mechanisms we create to achieve a tipping point of common understanding and alignment across our major IT efforts.

The remainder of this section proposes an *ideal IT Portfolio for SOA integration* into the Naval Oceanography Program, based upon the goals defined above. In subsequent sections, the status of current and planned METOC technical and managerial efforts with regard to SOA is presented.

An objective method is required to characterize the nature of an IT project that is focused around integration issues, since integration is the primary driver for SOA adoption. This method will be used to define an ideal IT Portfolio Management for SOA Integration. Fig. 2 depicts a matrix of factors that impact the complexity, cost, and risk (CCR) of an IT integration project. Projects can be placed in this matrix to give a qualitative assessment of their CCR profile. The vertical axis indicates the scope of the integration from a single application at a single node to enterprise-wide integration between nodes of different organizations. The horizontal axis indicates the type of integration from just integrating pictures to integrating diverse processes. The diagonal axis indicates the specificity of the requirement(s) driving the integration from known single requirements to infrastructure upgrades required to support many, perhaps unknown requirements.

How should the ideal portfolio of SOA Integration Projects map onto this matrix given the goals of our transition defined above? One answer is to minimize IT investment risk by focusing first on projects with lower cost and complexity; but with significantly visible benefits for the warfighter. Then, as SOA knowledge and skills mature within the Naval Oceanography Program, and as DoD/DON

infrastructure capability increases, the more challenging issues of broad scale SOA integrations could be attacked.

Fig. 3 depicts a portfolio model that defines four tiers of projects, each with an increasing CCR profile. The ideal approach would move from Tier 1-2 projects to Tier 3-4 as technical and management competence with regard to SOA develops, thereby reducing risk and focusing results on visible benefits for the warfighter. Selecting projects in Tier 1-2 first has the added benefit of focusing our early SOA integration projects where we have interested and ready warfighter partners with regard to consuming METOC web services, defined in terms they understand.

Navy METOC Technical SOA Projects Status

There are three major projects underway that are contributing to the evolution to an SOA environment. These include Fleet Numerical Meteorology & Oceanography Center's (FNMOC's) ATOS2 Project, SPAWAR's VNE-NCS, and CNMOC's Web Services/Web Portal Project. Mapping the scope and approach of each of these projects onto this matrix highlights these conclusions: the current portfolio holds more risk than the ideal model as they tackle more scope and complexity without significant experience in fielding operational web services; there is some overlap in capability, both between Naval Oceanography Program projects and with the DoD Net-Centric Enterprise Services (NCES) program [14]; there are important gaps that should be considered in near-term investment decisions. This mapping is depicted in Fig. 4.

To provide more balance in the Naval Oceanography Program portfolio and to reduce future risk in SOA implementations, projects that focus on single and specific integration requirements with clearly identified warfighter systems should be pursued. Further, we should expand the types of integration to include presentation and logic integration, as well as data services beyond the Joint METOC Broker Language (JMBL) data service.

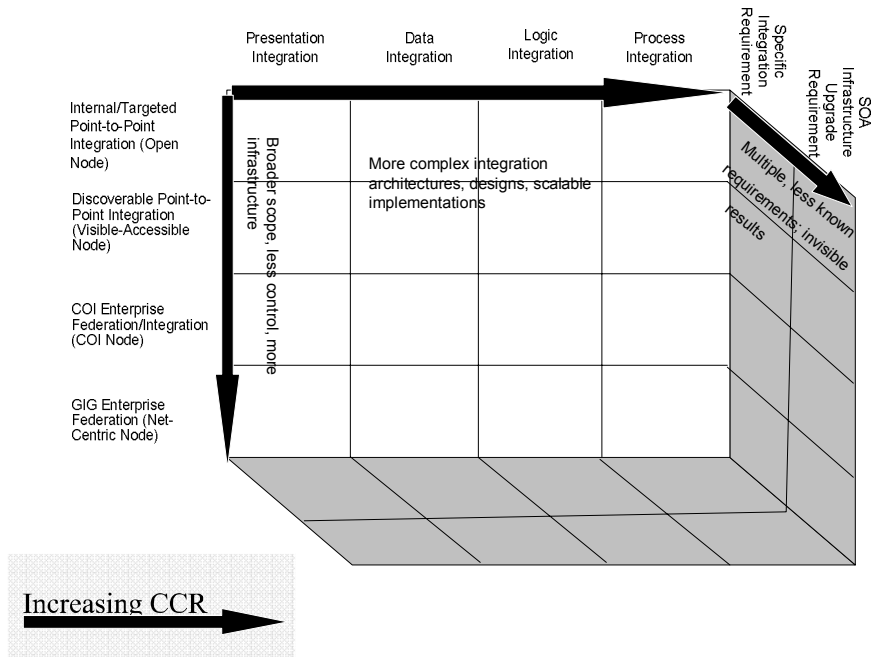


Figure 2 – Qualitative Assessment Matrix for Cost, Complexity, and Risk for Integration Projects

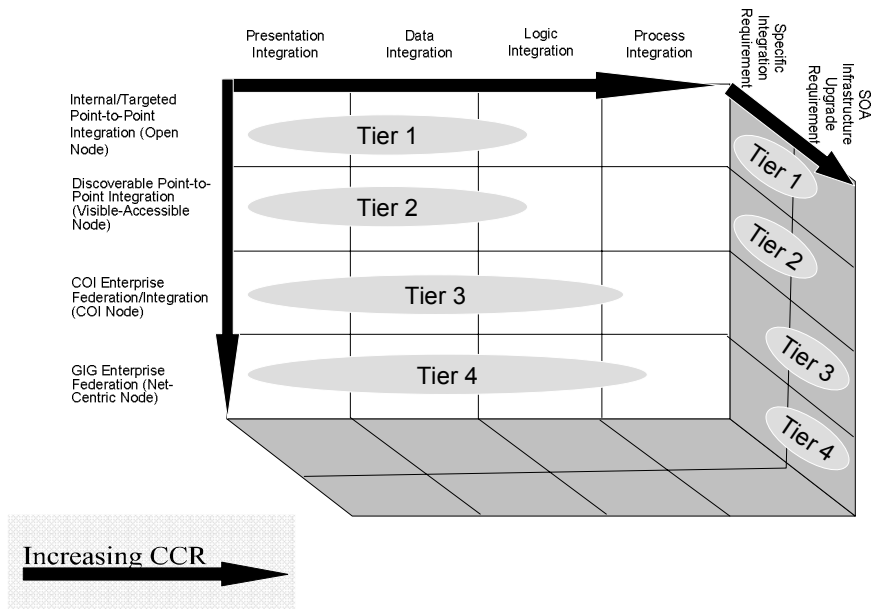


Figure 3 - Picking the right projects - Ideal CCR Profile – Incremental Investment

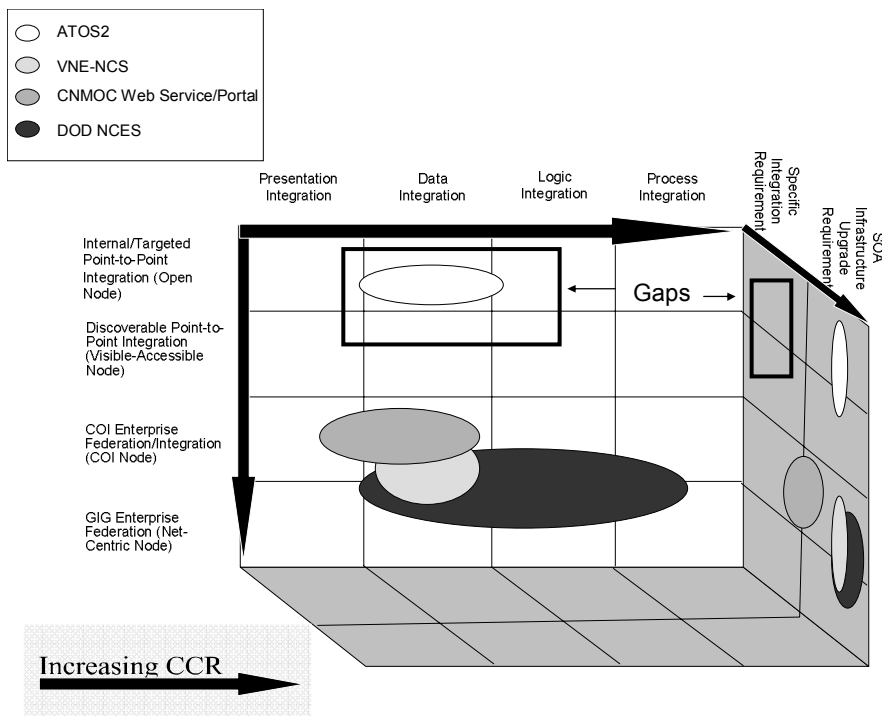


Figure 4 – METOC SOA Portfolio Gaps

Navy METOC Managerial SOA Efforts Status

There is a need to elevate the Naval Oceanography Program's Technical and Management Readiness to Implement SOA. Improved readiness will be achieved by establishing mechanisms to create and maintain common understanding of SOA integration issues, to align Naval Oceanography Program IT efforts to address these issues and to maximize interoperability, and to minimize required IT costs for functions not core to METOC value (internal infrastructure hardware and software).

The implemented mechanisms must effectively link both top-down, enterprise-wide efforts with bottom-up implementation activities. Specific linkages to be addressed include the following:

- link enterprise-wide policy/standards development & enforcement with the technical and management implications of SOA adoption
- link planned architectures to higher level guidance and to the Concept of Operations and business priorities of METOC Directorates
- link planned architectures to the implementation efforts of Naval Oceanography Program PORs; both in terms of architectural compliance and in terms of applying lessons learned to evolving architectural components
- link infrastructure investments of required, non-core IT across METOC nodes to optimize cost reduction and leveraging of technology expertise.

The most efficient way to maintain these linkages is in the form of a body of people that share a common understanding and vision of SOA and its implications. These people must be key players in influencing policy/standards, understanding how to translate business requirements into automation requirements and designs, and in the ultimate implementations of the designs. These people must be drawn from all major Naval Oceanography Program IT elements. Assuring architectural and cross-program alignment requires an empowered mechanism to promulgate common SOA knowledge and ensure compliance in implementations.

The Navy METOC Enterprise has created the METOC Architecture Team (MAT) to build a new core architecture capability within the enterprise. The goals of the MAT are:

- to build a core team of SOA technical architecture expertise
- to bring technical understanding and alignment across all acquisition and implementation programs
- to provide continual focus on "To-Be" architectures and transition strategies from "As-Is" architectures.

The role and relationships of this team to other enterprise entities are depicted in Fig. 5. These cross-cutting relationships are typical for architecture as it sits at the intersection of policy, technology, culture, requirements, etc.

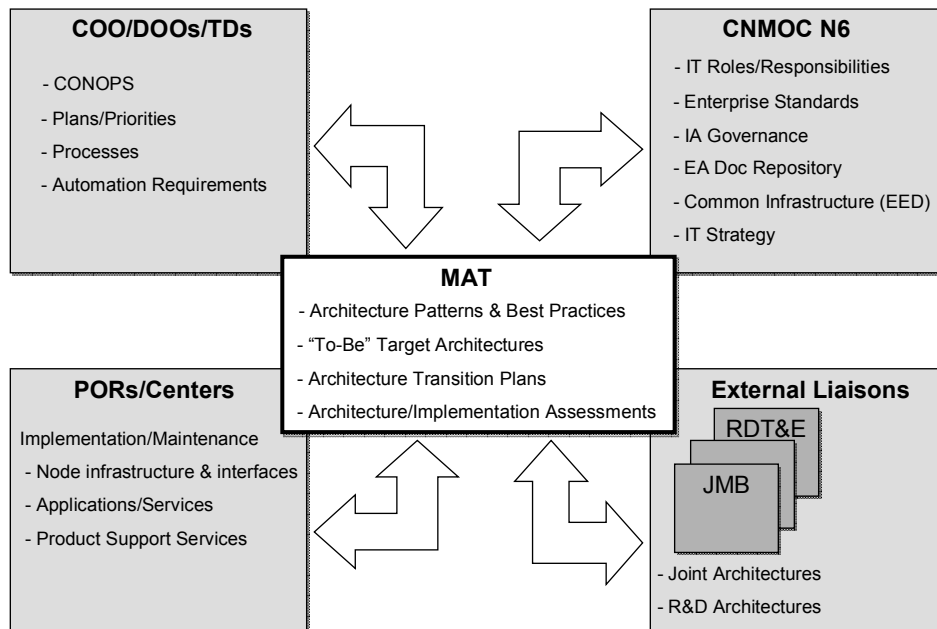


Figure 5 – METOC Architecture Team Roles & Relationships

The participating entities are defined as:

- Chief of Oceanography Operations (COO), Directors of Oceanographic Operations (DOOs), and Production Center Technical Directors (TDs) – Provides driving concepts of operations, requirements for architecture development.
- CNMOC N6 (CIO of the Navy METOC Enterprise) – Provides authoritative constraints, guidelines, and policy context for architectural development.
- Programs of Record (PORs) and Production Centers (PCs) – Provide the acquisition, systems engineering, and implementation support to realize specified architectures.
- External Liaisons – Links to critical partners and R&D efforts to assure architectural alignment to planned operational architectures.

The MAT will have core members including; Lead IT Architect/MAT Lead; Chief Engineers from implementation programs; a COO designate; and IT Governance Lead. Other CNMOC N6 Directors and DOO participants will be brought in as issues dictate. This team is required to sign off on implementation plans of all major METOC IT Projects with regard to architecture, interoperability, and integration approaches.

Early MAT efforts will be driven by the SOA transition strategy defined above. There will be a combination of top-down and bottom-up architecture development efforts. The results of all these efforts will be used to populate “To-Be”,

just-in-time “As-Is”, and transition plans in the Navy METOC EAF. The top-down efforts will develop DODAF Operational Views (net-centric CONOPS and process definitions) for each warfare area. The bottom-up efforts will evaluate high value applications for functionality that is appropriate for early SOA deployments.

The results of these analyses will contribute to the initial definition of the METOC Enterprise Service Integration Layer (MESIL), the key SOA specification. In addition, the MAT will begin evaluation of the need for a METOC Service Integration Bus (MESB) and how METOC net-centric nodes will ingrate with the MESB and the DoD ESB, called Net-Centric Enterprise Core Services (NCES). This architecture development process is depicted in Fig. 6.

Finally, it is critically important that funded IT projects move towards realization of an enterprise SOA. Each project must consider the same critical factors to assure alignment. These factors fall under the following four areas of concern:

- Build Net-Centric System Nodes
- Transition Data and Application Capabilities to Services
- Apply Technical and Management Best Practices
- Implement Reuse Project Management Practices

Fig. 7 depicts the critical considerations for each area. The MAT has created checklist questionnaires aligned with each of these areas to assist Program Managers and Technical

Project Managers in considering and assessing their level of alignment to Net-Centric and SOA concerns. These documents were created based upon authoritative guidance and review of industry best practices with regard to SOA development. Ref. [13] is a primary driver as well as the

actionable guidance from Net-Centric Enterprise Solutions for Interoperability (NESI) document set [15], and best practice review from, “SOA Concepts, Technology, and Design” by Thomas Erl [16].

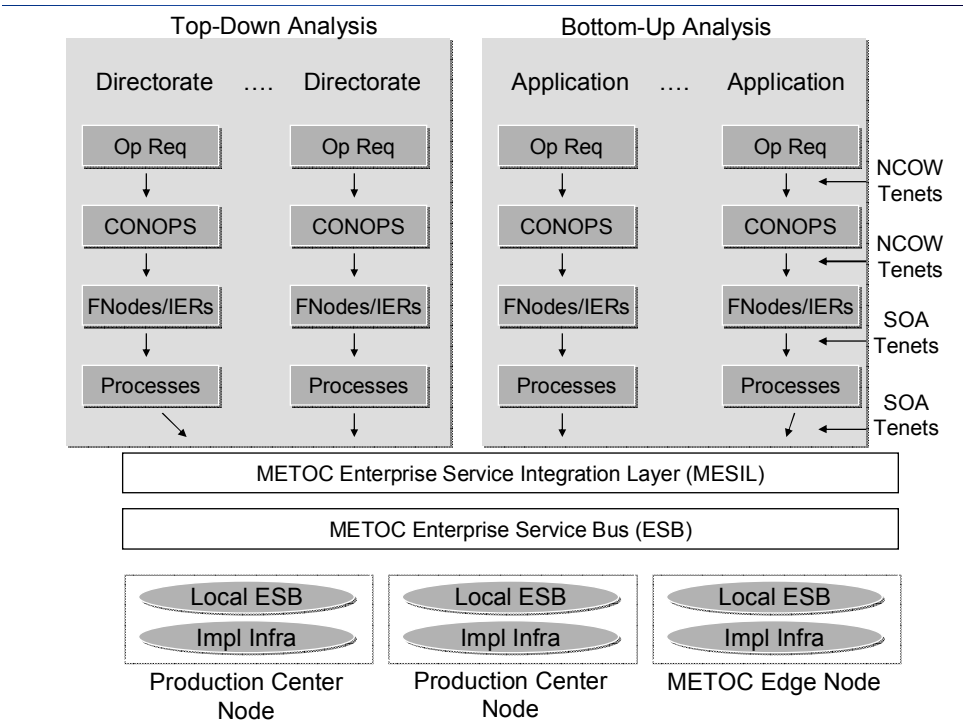


Figure 6 – MAT Analysis Approach

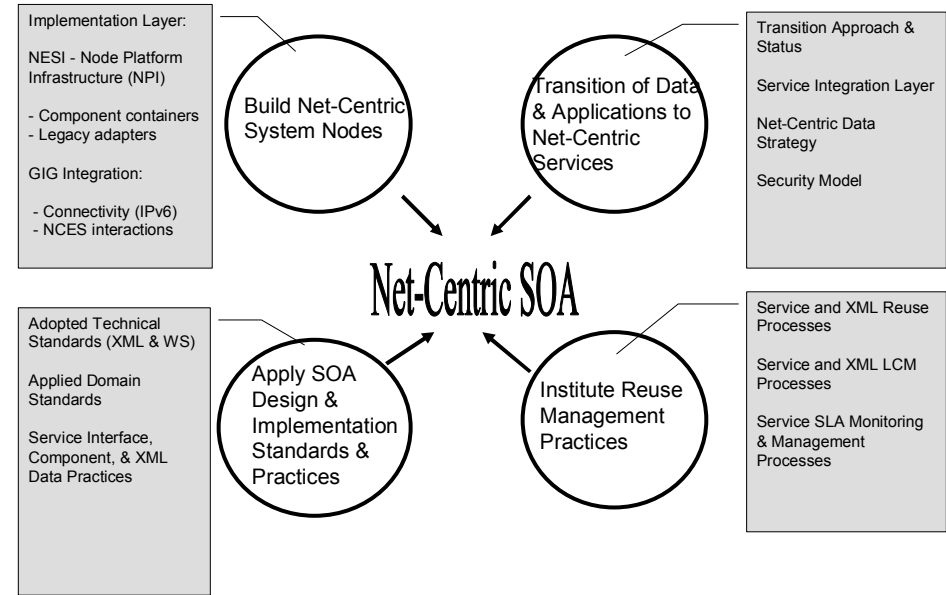


Figure 7 – Common Critical SOA Integration Project Elements

C. Navy METOC EA & SOA Summary

Because of the nature of SOA, an end-to-end SOA environment can be built incrementally. The ideal portfolio model defined above recognizes this incremental approach. By following this approach, near-term investments in SOA will offer immediate benefits in terms of observable alignment with GIG/NCOW Guidance while delivering visible value to the warfighter and their systems.

Longer term benefits will include better Total Cost of Ownership (TCO) for legacy systems, speed-to-capability through simplified integration and increased reuse, and increased ROI via broader use of METOC capabilities. However, these longer-term benefits will not be observable by management until and unless early implementation efforts affect the creation of web services that are reusable and reused. Without improved technical and management readiness with regard to SOA, these ultimate benefits may never be achieved.

The use of EA identifies critical connections and commonalities among Command production nodes, information elements, infrastructure, systems, and software. It is through the application of EA that these opportunities for migration to services and SOA can be realized.

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