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RECOMMENDATIONS FOR CREATING CROSS-AGENCY ENTERPRISE DESIGN SPECIFICATIONS

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The Need for Enterprise Cross-Agency Design Specifications

The Intelligence Community (IC) needs to be able to manage computing and technology at the same pace as our adversaries and do so in an integrated way across the enterprise. Unintended structural and cultural barriers inhibit integration and interoperability and should be removed to achieve decision advantage. A unifying IC enterprise approach to developing cross-agency specifications is currently lacking. Integrating information technology (IT) systems across agencies that have different policies, standards, and guidelines; missions and needs; and lexicons further compounds this challenge. Without common design specifications, cross-agency interoperability is at risk, hindering data access and sharing needed to support leadership decision making.

We propose a tailorable framework for agencies to follow in the collaborative development of enterprise integration design specifications, ensuring systems and capabilities can seamlessly interoperate across the broader enterprise. This cross-cutting approach can be used for different engineering activities, including data, cybersecurity, and interface engineering.

The front cover illustrates this approach. It involves forming a core team and sub-teams of subject matter experts (SMEs) representing participating agencies. The core team is a multidiscipline team responsible for producing the design specifications. The sub-teams focus on the specific expertise areas (e.g. user needs, architecture, system engineering, network). These sub-teams produce the capability design specification artifact inputs to the core team such as user stories, use cases, concepts of operations (CONOPS), requirements, and proofs of concept (PoCs).

Roles and responsibilities for establishing enterprise integration capabilities are shared, spanning senior leadership to Specification Design Teams (SDTs). Teams can be structured to support different aspects of the strategy, with senior leadership setting strategic enterprise goals. Key tailorable framework process areas include governance, strategic guidance, requirements, solutions alternatives and analysis, exploration, and PoC validation.

Implementing a tailorable, repeatable framework increases the probability of successful delivery and deployment of cross-agency capabilities and provides multiple benefits. For example, the Zero Trust cybersecurity strategy cannot be successful if the data is not tagged at the same granularity with the same rules for the same data within and across agencies. Common design specifications, along with a common reference architecture, simplify system architectures, enable data-centricity through timely data access and sharing, and protect resources (data, assets, applications, and services) against adversary exploitation. By working as a collective community developing enterprise solutions, the IC can reduce development and sustainment costs by minimizing rework.

Enterprise Integration Challenges

Lack of design specifications with sufficient fidelity for developing cross-agency integrated capabilities and services is a continuing problem for the IC and the federal government. Agencies have traditionally developed systems to achieve their mission objectives with little cross-agency integration. Integration has been accomplished only by developing point-to-point customized solutions that enable agencies to achieve their integrated objectives. Today, agencies need to change their culture from a silo mentality to one of integrated enterprise solutions. However, agencies are experiencing challenges changing this culture, including:

- Individual agencies' unique social cultures, which often have implicit processes that rely on "who you know" to guide you through the processes
- Organizational politics within and across organizations and agencies that sometimes cause distrust
- Power struggles
- Different performance criteria
- A critical principle of agency objectives first and community goals second

One way to mitigate these cultural challenges is to incorporate incentives that support the desired outcome of cross-enterprise integration and interoperability. Program Managers (PMs), for example, are motivated by delivering on time and within budget. This is more easily accomplished when resources and dependencies are within the PM's control. However, this control can perpetuate the "not invented here" mentality. A change in incentives, focused on increasing efficiency without sacrificing quality and functionality through reuse (e.g., code base, software libraries, containers), may be considered an incentive enabler for integration and interoperability.

Accelerating technology advancements, exploding volumes of data, high-speed networks, and sophisticated attacks mean agencies need to adapt their cultures to create integrated enterprise solutions to achieve mission decision advantage.

The Office of the Director of National Intelligence and the Department of Defense (DoD) publish strategies[1] that state what needs to be accomplished through goals and objectives with an accompanying implementation plan or road map. Design specifications, in most cases, are left to each agency's systems engineer or contractors. Developing agency-specific design specifications becomes a risk when developing interoperable cross-agency services or applications. The absence of standard procedures and a unifying process for developing integrated enterprise cross-agency design specifications results in enterprise integration projects that fail to deliver capabilities that satisfy requirements.

Attempting to develop cross-agency design solutions without a standard process and guidance is difficult to impossible, especially considering that most agencies have different system capability design methodologies and procedures. The lack of standard processes also exists within agencies, where elements may implement similar functions with different designs. For example, one organization may implement a dissemination function using a pull design while another implements a push or notification design, which could cause intra-agency interoperability issues. The methodologies for architecture design may also differ.

In many instances, the right stakeholders are not represented during development of user stories, use cases, CONOPS, functional requirements, or capability design. Incorrect stakeholder representation leads to gaps in requirements and to systems not meeting user needs. Defense Intelligence Agency Chief Information Officer Doug Cossa stated at the 2019 Department of Defense Intelligence Information Systems (DODIIS) Worldwide Conference that 70 percent of the IT systems developed did not meet customer requirements. (DODIIS Worldwide Conference, 2019)

Zero Trust (ZT) is an example of a strategy that can benefit from a standardized enterprise integration process. The ZT architecture comprises a set of integrated capabilities across the enterprise that provides functions such as access to data, assets, applications, and services. Detailed design specifications are critical to ensure enterprise capabilities satisfy requirements, and that Application Program Interfaces are configured correctly to support security and interoperability across the enterprise. Such guidelines provide a road map, built on best practices, for realizing cross-agency enterprise design specifications.

A New Approach

When implementing integrated or shared enterprise capabilities, multidisciplined SMEs from across agencies would benefit from joint design specification development. Enterprise multidisciplinary, multi-agency teams can be structured to produce CONOPS, use cases, requirements, and system architectures, and to perform PoCs to verify assumptions and demonstrate functionality to inform design specifications.

Figure 1 identifies process areas and artifacts necessary to develop design specifications for agencies to follow in building and delivering enterprise capabilities. It highlights five key process areas: Governance & Guidelines, Requirements; Solutions Alternatives and Analysis; Exploration; and Proof of Concept Validation. Each key process area identifies a recommended set of associated artifacts needed as prerequisites for capability design specification development. Resources and Roles & Responsibilities are process enablers.

Figure 1 is read clockwise, starting with Governance & Guidelines. The slices are read from the outer rings to the inner rings, culminating with Capability Design Specifications. The entities composing the diagram will be addressed in the following sections.

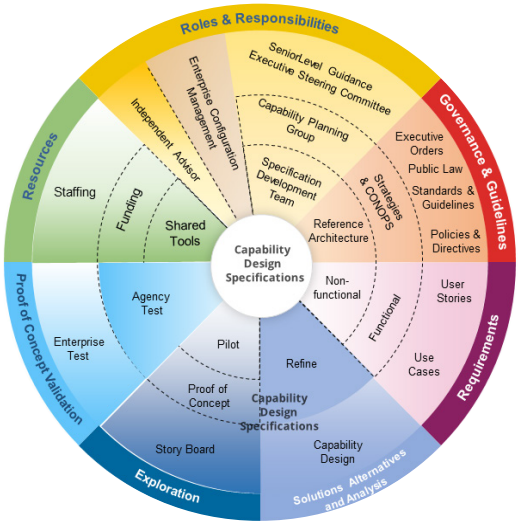

Figure 1. Realizing Cross-Cutting Enterprise Design Specifications

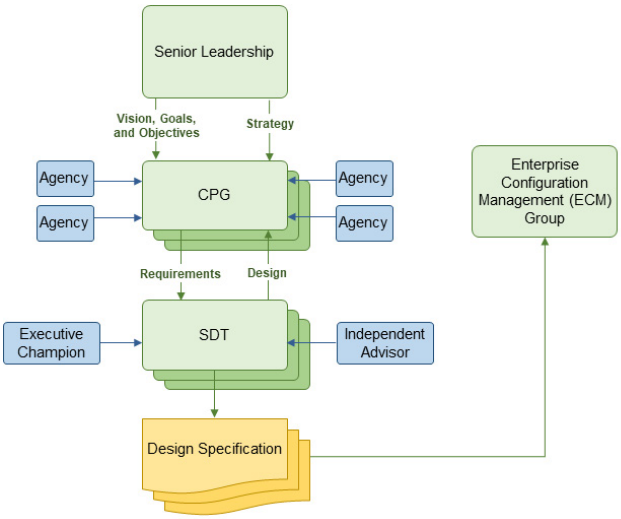

Figure 2. Governance—Focus Areas

Roles & Responsibilities

Roles and responsibilities needed to establish integrated enterprise capabilities span senior leaders to designers. Figure 2 depicts a proposed cross-agency governance structure and highlights focus areas formed by multidisciplinary, multi-agency teams.

The Capability Planning Group (CPG) and the SDT are established for a specific time and purpose. The CPG is a joint decision-making body that oversees the SDT and performs an initial needs assessment across the participating agencies. The SDT and various working groups develop the requirements and design specifications.

Senior-Level Guidance—Senior leadership and any associated executive committees set strategic enterprise goals and objectives—that is, what needs to be accomplished, such as Enhanced Resilience or ZT Initiatives.

Capability Planning Group—The CPG is a multidisciplinary, cross-agency decision-making body established for a specific time and purpose for a technical area (e.g., users, devices, application and workload, data, network/environment, automation, orchestration, visualization, analytics). It is recommended that participants be members of the government or military. The CPG will meet with various SME groups across the participating agencies (e.g., mission owners and mission analysts, chief engineers, system designers) to understand their capability needs, resource abilities, and availability to participate in developing capability design specifications to achieve strategic objectives. The CPG supports the SDT and performs project reviews at major milestones. A CPG will be retired once all supporting SDTs have been retired.

Specification Development Team—One SDT team will be established to develop design specifications for each enterprise capability. SDTs will function as intrapreneurial project teams with autonomy and authority to achieve the objectives within parameters set by the CPG (e.g., budget, timeframes, standards, policies). Each SDT's period of performance will be negotiated with the CPG. Each SDT will be retired once it achieves its assigned outcomes.

- All SDT lead positions are filled by the government or military. Contractors can fill support roles.
- SDT members will approve each key deliverable through consensus. If consensus cannot be reached, the team charter will specify procedures for resolving non-consensus (e.g., majority rule, escalation to CPG).
- Core SDT SMEs are expected to work with their counterparts in other agencies to gain understanding of the operational environments, as well as collect IT requirements. This ensures that the technology solutions developed using the specifications are compatible/interoperable with agency IT capabilities and satisfies customer needs.
- An SDT's systems engineer should capture mission user stories, use cases, and functional requirements. Activities should start with reviewing all relevant documents as well as actively working with missions and stakeholders to capture current and proposed future capability user stories, use cases, and requirements (both functional and non-functional) across the agencies.
- SDTs may establish unique SME area sub–working groups (e.g., system analysts, chief engineers, data scientists, security engineers, architects) to capture agency SMEs' insights and requirements.
- SDTs should respond to for-profit vendors' and agencies' design specification questions to ensure successful enterprise capability development.

Independent Advisor

An independent trusted advisor can be assigned to an SDT to perform multiple actualization support roles. Based on the type and level of support required, the independent advisor can be a government employee, military service member, federally funded research and development center, university affiliated research center, or systems engineering and technical assistance contractor. The independent advisor will report to the CPG. The independent advisor can perform three main activities:

- Actualize enterprise processes and procedures by developing or guiding development of the charter; establishing operational procedures; and selecting tools for managing team activities.
- Support project management activities including project planning, defining information formats for capture, monitoring progress, and facilitating meetings.
- Provide subject matter expertise by proposing solutions and design alternatives, concept testing, evaluating industry capabilities, and reviewing materials produced for quality and completeness.

Enterprise Configuration Management (ECM)

An ECM organization should be established to maintain a repository of design specification artifacts for all enterprise capabilities. SDT key artifacts that should be maintained in the repository are:

- Enterprise processes and procedures
- Project management tools and licenses
- All user stories, use cases, reference architectures, requirements, and design specifications
- Proofs of concept and pilot software and test results

The Enterprise Configuration Management Database is accessible by all agencies for establishing enterprise capabilities within their organization and for ensuring they seamlessly integrate within the enterprise as described by the design specifications.

We propose a tailorable framework for agencies to follow in the collaborative development of enterprise integration design specifications, ensuring systems and capabilities can seamlessly interoperate across the broader enterprise.

Governance & Guidelines

Several types of references provide sources of technical and non-technical requirements, including Executive Orders, public law, Strategic Concepts of Operations, policies and directives, technical standards, and guidance. In some cases, reference documents are directive in nature (e.g., policies and directives), while others can be adopted for use (e.g., standards and guidelines). Publishing organizations maintain electronic libraries where individuals can access their guidance, often free of charge. In some cases, communities have an authoritative information repository to host references that apply to the community members.

Reference Architectures

The DoD defines a reference architecture (RA) as an authoritative source of information about a specific subject area that guides and constrains the instantiations of multiple architectures and solutions. RAs are critical to achieving cross-enterprise design specifications. Developing and using RAs:

- Enable agencies, organizations, and enterprises to align their needs, goals, objectives, and requirements to:
  - Assist in overseeing and integrating policies, acquisitions, and integrations across programs.
  - Influence and serve as a basis for investment planning decisions.
  - Inform acquisition, evolution, innovation, improvement, modernization, protection, and transformation initiatives.
- Promote and encourage adherence to common architectural patterns and reuse to:
  - Collaborate across and within organizations to identify key capabilities, functions, and services.
  - Concentrate on capability concepts unconstrained by implementation details in delivery of systems, services, and solutions.
  - Serve as a tool for providing common information, lexicon, guidance, approaches, and direction to guide and constrain architectures and solutions.
- Achieve value when the RAs are repeatedly used to guide and constrain solutions.

Reference architectures should not be confused with Architecture Frameworks (e.g., DoD Architecture Framework) or reference models (e.g., Federal Enterprise Architect).

Requirements

SDT systems engineers lead the effort to identify and maintain functional and non-functional requirements by first capturing user stories. Systems engineers use various methods for collecting requirements (e.g., interviews, workplace observations, focus group meetings).

An SDT can create user stories to develop use cases that address what the capability should do. Functional and non-functional requirements are derived to support the user stories and/or use cases. Proposals to improve user stories, use cases, and requirements will occur during all phases of capability specification development. It is imperative that each user story, use case, and requirement be labeled for traceability (backward and forward) as it is iterated and updated.

User Stories

A user story is a technique used in Agile software development to capture a description of a software feature from an end-user perspective. It is a short, plain language description of a feature that describes what the user wants to achieve and why. User stories provide many benefits: they keep the focus on the user, enable collaboration between the SDT and stakeholders, and drive creative solutions. User stories can contribute to input for use cases that describe how the system behaves.

Use Cases

Use cases ensure developers have fully thought through all aspects of development. Use cases provide a structure for the SDT to develop details for implementation, system goals, possible issues, and various business variants. The enterprise needs to develop a standard format(s) for capturing and documenting user stories, use cases, and requirements.

User stories and use cases can provide input for developing a CONOPS.[2] CONOPS help in development of operational and systems functions and characteristics.

Functional and Non-Functional Requirements

Functional and non-functional requirements are two types of need descriptions for capability development.[3] Functional requirements define what the system does and must not do. Non-functional requirements specify how the system should do it, such as the performance and quality attributes.

Functional requirements define system behaviors, while non-functional requirements drive the technical architecture of the system. The SDT utilizes user stories and use cases to develop functional and non-functional requirements. Requirements can include various attributes based on the type and degree of detail needed.

The American National Standards Institute Electrical and Electronics Engineers (IEEE) Guide to Software Requirements STD 830-1984 states requirements must begin with a “shall” statement and must be unambiguous, complete, verifiable, consistent, modifiable, traceable, and usable during the operation and maintenance phase.[4]

Solutions Alternatives and Analysis

The SDT develops various solution design alternatives utilizing user stories, use cases, CONOPS, and requirements. Next, the SDT analyzes the pros, cons, risks, and assumptions for each alternative, and down-selects the alternatives to those most feasible.

Capability Design

Enterprise capability system design is one component of the reference architecture that identifies the capability sub-components and their functions, interactions, and dependencies. Design specifications will be identified for each component. Capability system designs do not include technology/tools. Rather, application developers will select the technology/tools to include when implementing the capability.

All aspects of the capability design specifications will be reviewed and refined throughout the end-to-end process of capability design specification development.

Exploration

There are various methods for exploring the feasibility of the design alternatives from several perspectives (e.g., user interaction, assumption validation, risk mitigation). PoCs are a practical process for validating enterprise integration capability ideas, feasibility, assumptions, risks, potential challenges, and roadblocks, and for determining whether an alternative is worth further pursuing. PoCs can be accomplished by developing software, using screen mockups and story boards, and so forth. Story boards are an inexpensive option for demonstrating and learning how to design a friendly user interface.

In other words, PoCs validate the feasibility of the unknown aspects of a proposed enterprise capability. For example, a PoC can be developed to validate the assumption that a fake image can be identified in 3 seconds with 100 percent accuracy.

Pilot studies aim to minimize the impact of capability deployment and provide valuable feedback. Pilots can validate whether a capability will function as expected. Pilots should not be production grade. Pilots can be mostly manual processes—for example, file and analyst results can be manually transferred.

Proof of Concept Validation

PoCs and pilot validation test the feasibility of key assumptions and mitigate program/project risk. Test measurements are determined before prototypes and pilots are planned and designed.

Integrated capability requirements vary between agencies and the enterprise. Therefore, testing should be performed from both the enterprise and agency perspectives. Enterprise testing includes interoperability testing across agencies, domains, and cloud environments.

Agencies participating in producing capability design specifications are expected to review PoCs, pilot results, and related documentation. When possible, agencies can test proofs of concept within their IT environments to ensure design specifications meet their unique needs.

Necessary testing can vary based on the capability design complexity and number of assumptions being validated. Based on needs, testing may focus on, for example, functionality, interoperability, or cybersecurity.

Resources

Staffing

It is recommended that the CPG membership and all SDT lead positions be limited to government civilians and military service members from the participating agencies due to inherent government responsibilities. The SDT can include contractor SMEs in support roles.

The CPG recommends core members and a government executive champion for each SDT. An executive champion serves as the SDT advocate to remove roadblocks and gain support as necessary.

The CPG and the SDT together request required SME staffing from agencies interested in developing the capability design specifications. Team members should be confident, committed to innovations, and passionate about the work. They will be expected to make effective and timely business and technical recommendations and decisions.

An independent advisor, who will report to the CPG, may be selected for each SDT.

Shared Tools

The team should consider following digital engineering practices, such as Model-Based Systems Engineering and modeling and simulation (M&S), to support engineering activities (e.g., capture requirements, design architectures, evaluate solutions). There are many tools, both commercial-off-the-shelf and government-off-the-shelf, available to support these activities, such as digital engineering platforms that provide a host of technical capabilities and M&S tools, such as the Advanced Framework for Simulation, Integration and Modeling (AFSIM, developed by Air Force Research Laboratory [AFRL]). Infrastructure capabilities, such as cloud and on-premises development environments, can be used to develop prototypes and proofs of concept.

The CPG, SDT, and interested agencies determine how to acquire the tools. Alternatives are one or a combination of:

- Agencies volunteer needed tools and infrastructure.
- Licenses and so forth are acquired as needed.
- Non-Disclosure Agreements are established to trial emerging technologies.

Deliverables, Design Specifications, and Artifacts

The SDT will produce and deliver key artifacts that system developers will use to build production enterprise capabilities including:

- User stories
- Use cases
- CONOPS
- System requirements (functional and non-functional)
- Proofs of concept, pilots, and test results
- Capability design specifications

Summary, Benefits, and Way Ahead

When developing cross-agency or cross-organization capabilities, we recommend the following tailorable steps for the development of enterprise design specifications:

- Establish and leverage a governance structure that engages senior leadership:
  - The Capability Planning Group for each relevant technical area, staffed by the government, provides capability recommendations to senior leadership.
  - The Specification Design Team develops the design specifications staffed from team members across the agencies or organizations, with an executive champion and independent advisor(s) providing programmatic support.
  - The Configuration Management Team manages all design specifications and supporting artifacts at the enterprise level.
- Leverage strategic guidance as constraints and generate CONOPS and reference architectures as needed.
- Capture requirements for developing user stories, use cases, and functional and non-functional needs.
- Perform an Analysis of Alternatives for various capability designs and refine with feedback.
- Explore design feasibility and risk mitigation through proofs of concept and pilots.
- Standardize Proof of Concept Validation steps at both the enterprise and agency levels.
- Ensure the government and contractors can sufficiently staff identified roles.

Each of the recommended steps can be adjusted based on the capability complexity, timeline, resources, and funding. When developing cross-cutting enterprise capabilities, it is critical to develop enterprise design specifications driven from a shared reference architecture, resulting in loosely coupled interoperable components.

The major benefits of these guidelines are related to development risk and cost mitigation through:

- Facilitating cross-agency capability interoperability and increasing the probability of successful delivery and deployment
- Reducing development and sustainment costs by minimizing rework and using standardized interfaces
- Reducing time to field, resulting in more timely access to new capabilities
- Facilitating the delivery of high-quality technology products

The following actions are recommended as the “Way Ahead”

- Issue a policy endorsing these guidelines when developing cross-agency or cross-organization capabilities to ensure integration and interoperability.
- Ensure funding is available to support development of cross-agency capability design specifications.
- Ensure capability design specification artifacts developed by the SDTs are brought under Configuration Management with required security protections.

Appendix A: Glossary

Term	Definition
Enterprise	An enterprise is: 1. One or more organizations sharing a definite mission, goals, and objectives to offer an output such as a product or service. (ISO 15704 2000) 2. An organization (or cross-organizational entity) supporting a defined business scope and mission that includes interdependent resources (people, organizations, and technologies) that must coordinate their functions and share information in support of a common mission (or set of related missions). (CIO Council 1999) 3. A term that can be defined in one of two ways. The first is when the entity being considered is tightly bounded and directed by a single executive function. The second is when organizational boundaries are less well defined and there may be multiple owners in terms of direction of the resources being employed. The common factor is that both entities exist to achieve specified outcomes. (MOD 2004) 4. A complex, (adaptive) socio-technical system that comprises interdependent resources of people, processes, information, and technology that must interact with one another and their environment in support of a common mission (Giachetti 2010).[5]
Executive Champion (Executive Sponsor)	An executive champion is a person who serves as an advocate for a specific activity, function, or center of excellence in an organization.
Functional Requirement	Functional requirements define what the capability, service, or system does or must not do, such as the features and tasks of the product. A functional requirement must have an observable function (what); with measurable performance (how well); and a statement of conditions such as triggering events, environments, states, or modes.[6]
Independent Advisor	Independent advisors are individuals or firms trusted by the sponsor to perform work and have no vested interests in the products or services they recommend.
Mission Owner	A mission owner is a senior federal executive who specifies the business need or mission to the federal sponsor or to the organization. An executive sponsor is also responsible for allocating and/or designating the funding for the business need.[7]
Non-Functional Requirement	Non-functional requirements specify how the capability, service, or system will achieve the functional requirements, such as the performance and quality attributes of the product. Non-functional requirements drive the technical architecture of the capability. They are commonly referred to as the "-ilities."
Pilot	A pilot study, often referred to as a pilot project, is essentially a small-scale version of a project that tests the viability of executing the project at full scale. Before diving head-on into a new, untested project idea, a pilot study can help stakeholders determine whether the project is likely to succeed.
Proof of Concept	A proof of concept is a realization of an idea or technology to demonstrate its feasibility.[9]
Proof of Concept Validation	Proof of concept validations are used to validate assumptions and illustrate that a new product or idea can be successful. Concept validation is used to make data-driven decisions on whether the design and/or development process of a solution should be adopted.
Reference Architecture	A reference architecture focuses on technical capabilities. It is not a complete architecture and lacks any implementation details.[10]
Systems Engineer	The systems engineer assigned to the SDT actively works with missions and stakeholders to capture current and proposed future capability user stories, use cases, CONOPS, and requirements (both functional and non-functional) across the agencies.

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