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GPS OCX BLOCK 1 NETCENTRIC INTERFACES

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ABSTRACT

In today's hyper-connected world, where almost everything can be viewed as a node on some network, it is essential to be able to share information with whoever needs it – securely, quickly, and automatically. In the past, valuable GPS system information, such as timely clock and satellite position corrections, has been available only through rigid, point-to-point interfaces to a very small number of specific users. GPS OCX, although backward compatible with existing point-to-point interfaces for current users, will evolve to a single, net-centric interface that enables secure and authenticated sharing of valuable system information with a broad range of certified, net-connected users quickly and accurately when and where it is needed, significantly improving timeliness and quality of service. This paper will discuss user capabilities based on GPS OCX Block I net-centric data.

FORWARD

The GPS Next Generation Operational Control System (OCX), currently under development by Raytheon, provides major improvements on current GPS system control capabilities, including greater accuracy, integrity and availability; information assurance to protect against current and emerging cyber threats; operational control of all new civil and military signals; automation to reduce operational crew size; and flexibility to meet evolving user needs. OCX also establishes a net-centric information sharing architecture for dissemination of valuable system information, and enables future development of additional net-centric GPS capabilities. Any future content/capabilities discussed for OCX are notional and not yet approved. In support of the GPS III Net Ready Key Performance Parameter (NR KPP) certification, OCX will offer standards based net-centric data and services promoting interoperability, and understandability via the DOD Global Information Grid (GIG) for both anticipated and unanticipated users. OCX will provide modernized and secure data and services which allow backward compatibility to legacy information products and formats.

INTRODUCTION

The current GPS Operational Control Segment, also known as Architectural Evolution Plan (AEP), approach to GPS ground segment interfaces has been to develop individual point-to-point interfaces for each external system. Point-to-point interfaces are described in the DoD "Data Sharing in a net-centric Department of Defense," as brittle and inflexible[1]. As the need for new data arose, existing Interface Control Documents (ICDs) were revised or new ICDs were created. Each legacy ICD required a costly and time consuming development and arbitration cycle to enact and hence this point-to-point approach is inflexible and does not meet our current information age demands.

The OCX architecture's modern approach will enable the migration to meet the NR KPP for GPS as part of the Block 1 delivery in late-2018. The OCX architecture is aligned with the DoD tenets for both net-centric Services Strategy and Data Sharing Strategy. At the same time OCX will have backward compatibility support for the legacy,

individually negotiated point-to-point interfaces. This backward compatibility support is coupled with a transition plan that paves the way for those legacy interfaces to migrate to OCX net-centric data and services.

This paper will provide a high level discussion of the end state GPS enterprise vision and then will focus on OCX Block I data sharing strategy and its alignment with DoD Data Sharing Tenets to improve GPS user efficiency and effectiveness.

GPS ENTERPRISE VISION

When complete, GPS OCX will perform net-centric information exchanges with external systems as depicted in Exhibit 1 with dotted lines. The core capabilities are enabled by bi-directional authoritative information exchanges with External Information Providers as well as System Tasking agencies. OCX disseminates authoritative information to Civil User Coordinators (e.g. USCG NAVCEN, FAA) and Military Coordinators. Also, OCX disseminates information directly to the User Segment. The information exchanges are enabled through GIG exposed services as described in the DoD Information Enterprise Architecture (IEA) [2].

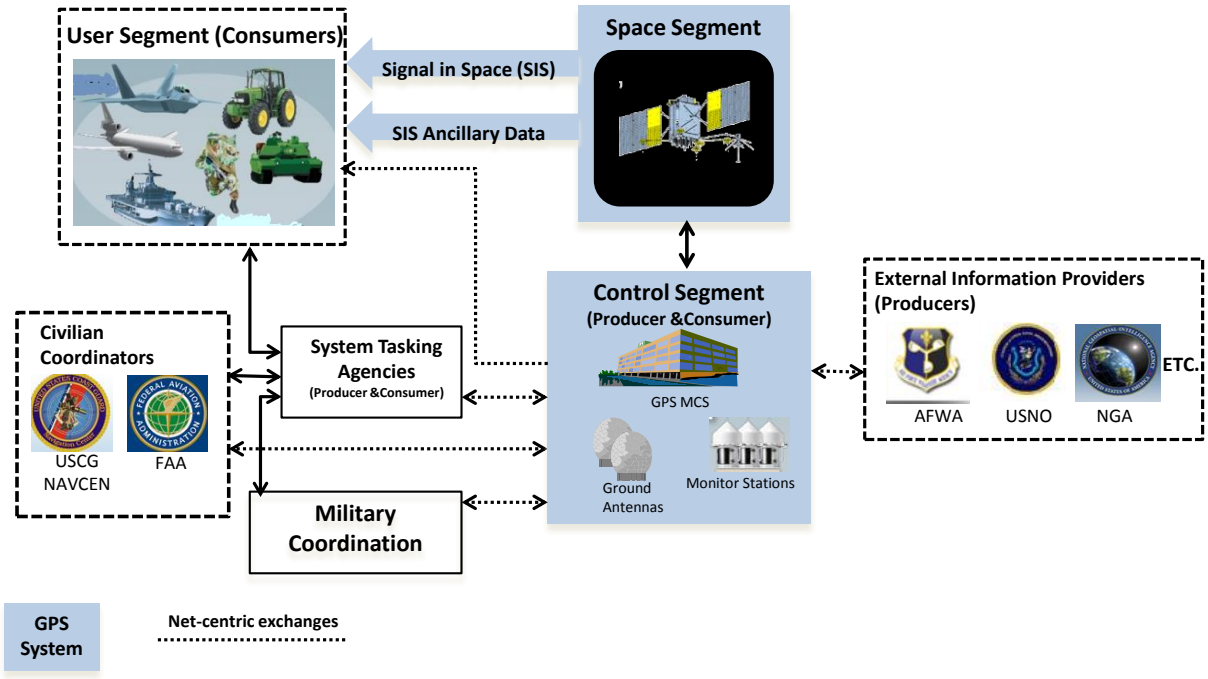

Exhibit 1: Military and Civil Relationships Supporting 3Gen GPS[3]

The IEA establishes a standards-based approach for producers to securely share authoritative data and services with consumers via the GIG. A key aspect of this net-centric data sharing strategy is that the exchanges are one-to-many; that is, an authoritative producer's data and services are interoperable and can easily be consumed by one or more authorized consumers.

The OCX net-centric strategy aims to provide GPS users with data and services that are extensible, flexible, scalable and robust. The OCX Net-centric architecture has information assurance at each layer of its architecture and complies with DoD net-centric design principles. To better support information sharing, OCX net-centric strategy supports a flexible set of Data dissemination Services in Block I. The data dissemination services will efficiently transfer data through the GIG and provide consumers at the edge with modern data products.

OCX NET-CENTRIC CANDIDATE GIG DATA DISSEMINATION SERVICES

GPS OCX establishes a flexible net-centric data exchange strategy to supports the wide variety of information exchange needs of the GPS users. This paper outlines three potential net-centric (one-to-many) machine-to-machine information exchange design patterns for consideration in exchanging authoritative data (Ref DoDD 8320.02) between OCX and GIG connected/compliant external systems. These candidate design patterns are depicted in Exhibit 2 and described below:

1) **Streaming Services**: An example use case for this service is when a user needs a notification whenever a new NANU is published. A standard efficient real-time messaging design pattern for exchanging XML messages improves interoperability.
2) **On-Demand Catalog Services**: An example use case for this service is when a user needs to search for and discover all the NANUs published over the past 12 months to assess Signal-In-Space (SIS) availability. The producer exposes services for the consumer to search/retrieve information from a historical product catalog.
3) **On-Demand Smart Pull Services**: An example use case for this service is when a user knows in advance that they only need the most current valid information (e.g. During SIS acquisition, user equipment need the most current GPS Almanac to reduce Time-To-First-Fix). This type of exchange provides user relevant information to improve operational efficiency and effectiveness.

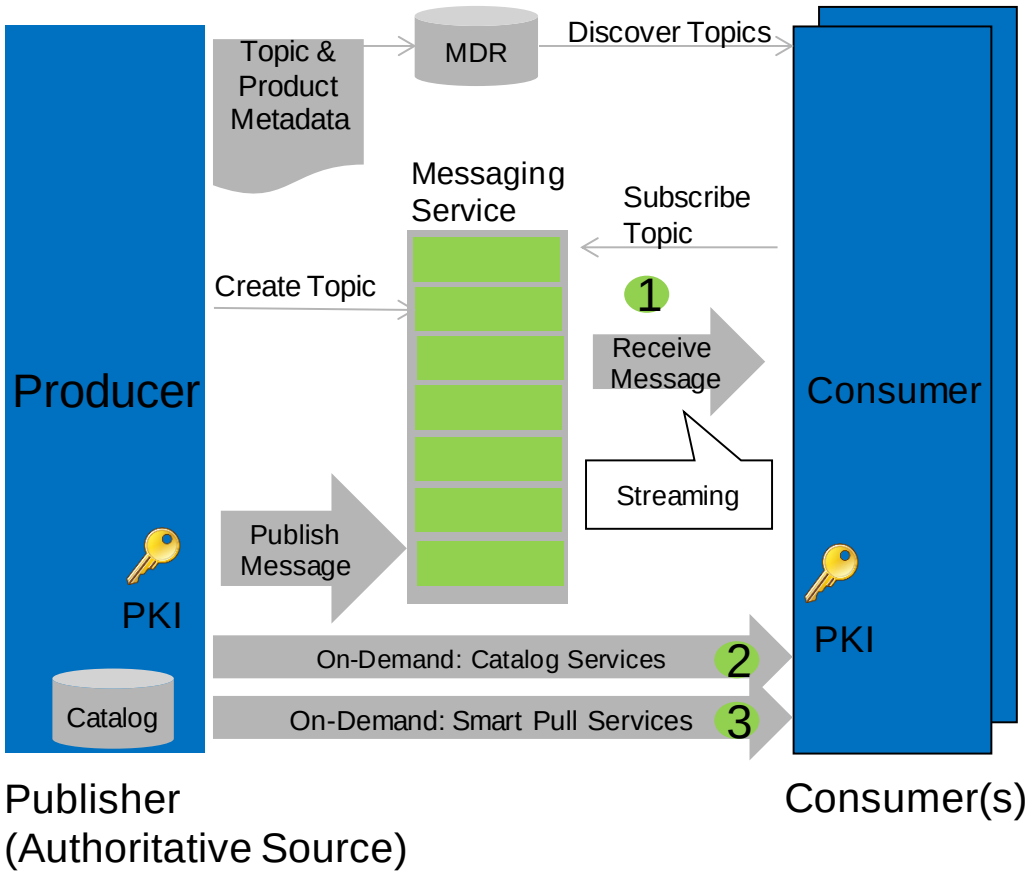

Exhibit 2: Data Access Pattern

OCX NET-CENTRIC PUBLIC DATA PRODUCTS

The GPS civil user community can benefit from the OCX modern data dissemination strategy. The OCX modern flexible architecture extends to its data products which are well aligned with DODD 8320, Data Sharing in a Net-Centric Department of Defense. OCX defines a GPS domain-specific information exchange vocabulary to better enhance integration of GPS information with other operational data and to remove ambiguities when discussing the public GPS products offered by OCX. Exhibit 3 shows a high level public GPS Ontology.

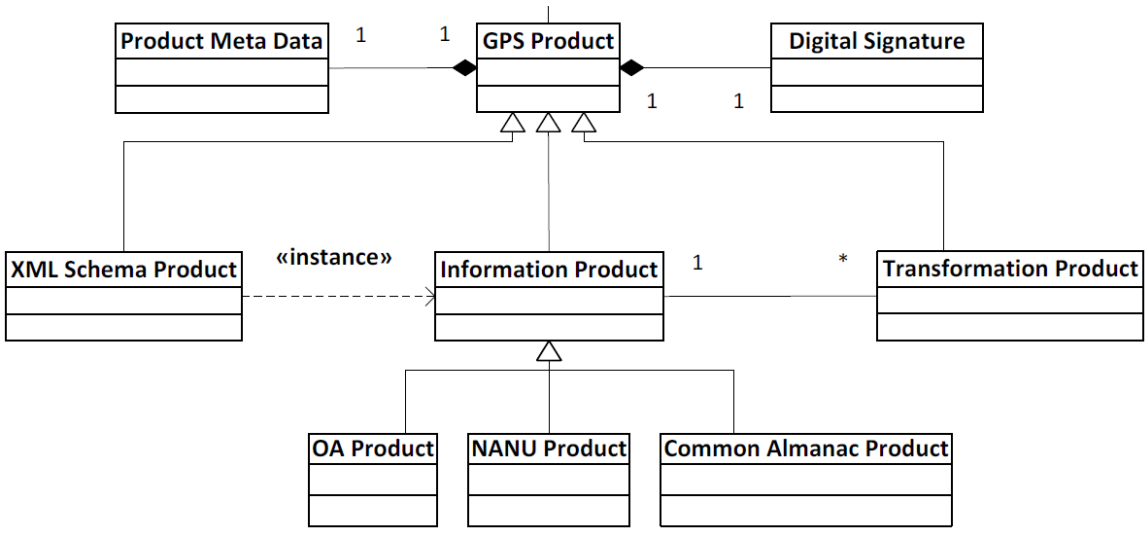

Exhibit 3: High Level GPS Product Ontology[4]

As shown in Exhibit 3 OCX publishes three categories of GPS products:

- Information Products, which provide users information about the state/status of the GPS System.
- XML Schema Products, which define the structure of an XML document associated with this interface.
- Transformation Products, which can be used to transform an Information Product into one of several formats supporting full backward compatibility with the ASCII text file formats.

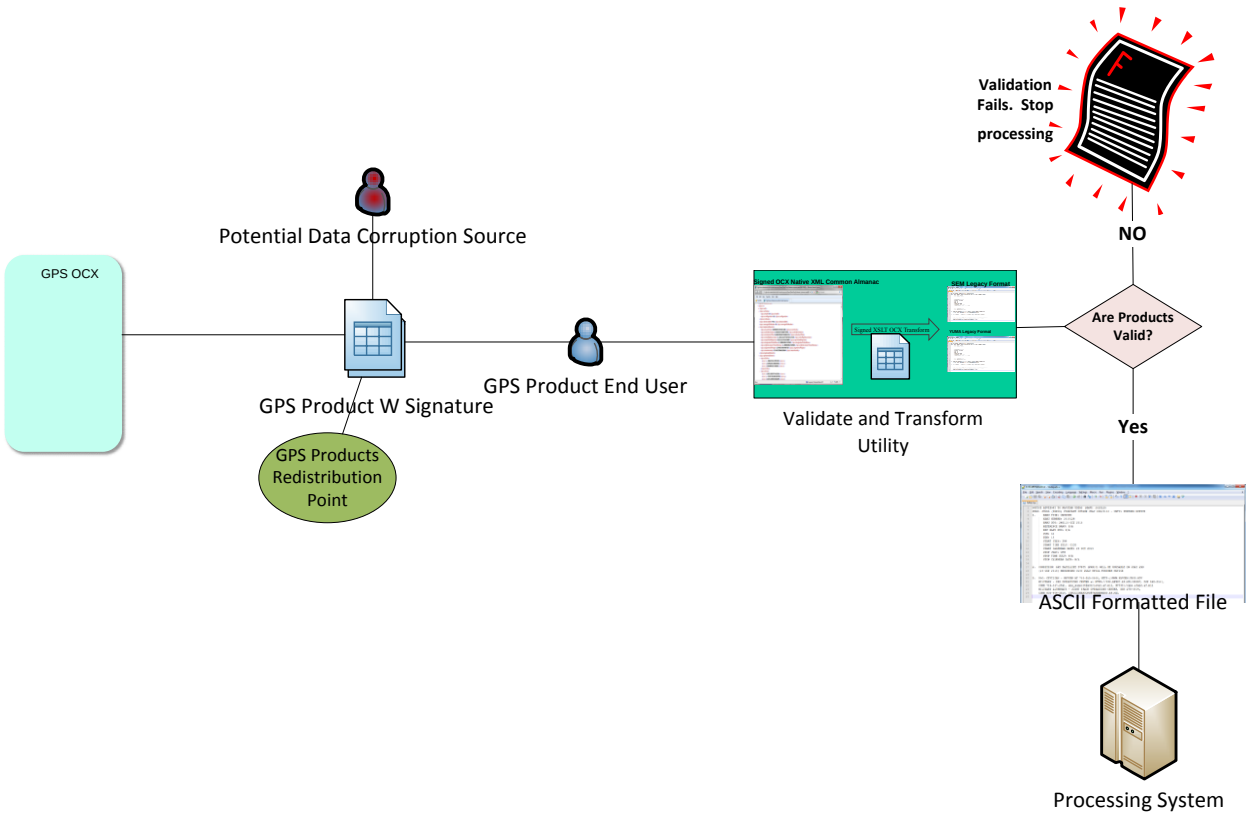

Exhibit 4: Generic GPS Product Distribution Process[4]

To ensure data integrity, confidentiality, and availability, OCX leverages DoD specified security services, including Public Key Infrastructure (PKI), encryption, and directories. OCX utilizes these services to digitally sign all data products to provide GPS users with information integrity and assurance required for mission critical applications. To extend data integrity throughout the enterprise, and ease migration of legacy systems to OCX secured and modern products, OCX provides a Validate and Transform Utility which is used to validate digital signatures. Exhibit 4 depicts a general use case for a GPS user retrieving a GPS product from redistribution node (e.g., USCG NAVCEN). As a GPS product moves between systems to the end user there is potential for intentional or unintentional data corruption. Therefore, the end user is encouraged to validate the GPS information product just before use in a Processing System (especially in mission critical applications). The Validate and Transform Utility shown in Exhibit 5 is designed with ease of use in mind and the basic steps for utilizing it are:

- Validate - an optional step performed by the end user to ensure that the GPS Products have not been corrupted through the process of redistribution to ensure data integrity at rest
- Transform - an optional step performed by end users who may need information in the legacy ASCII text file formats before processing
- Process – use the GPS Information typically ingesting files using an end user Automated Information System (AIS)

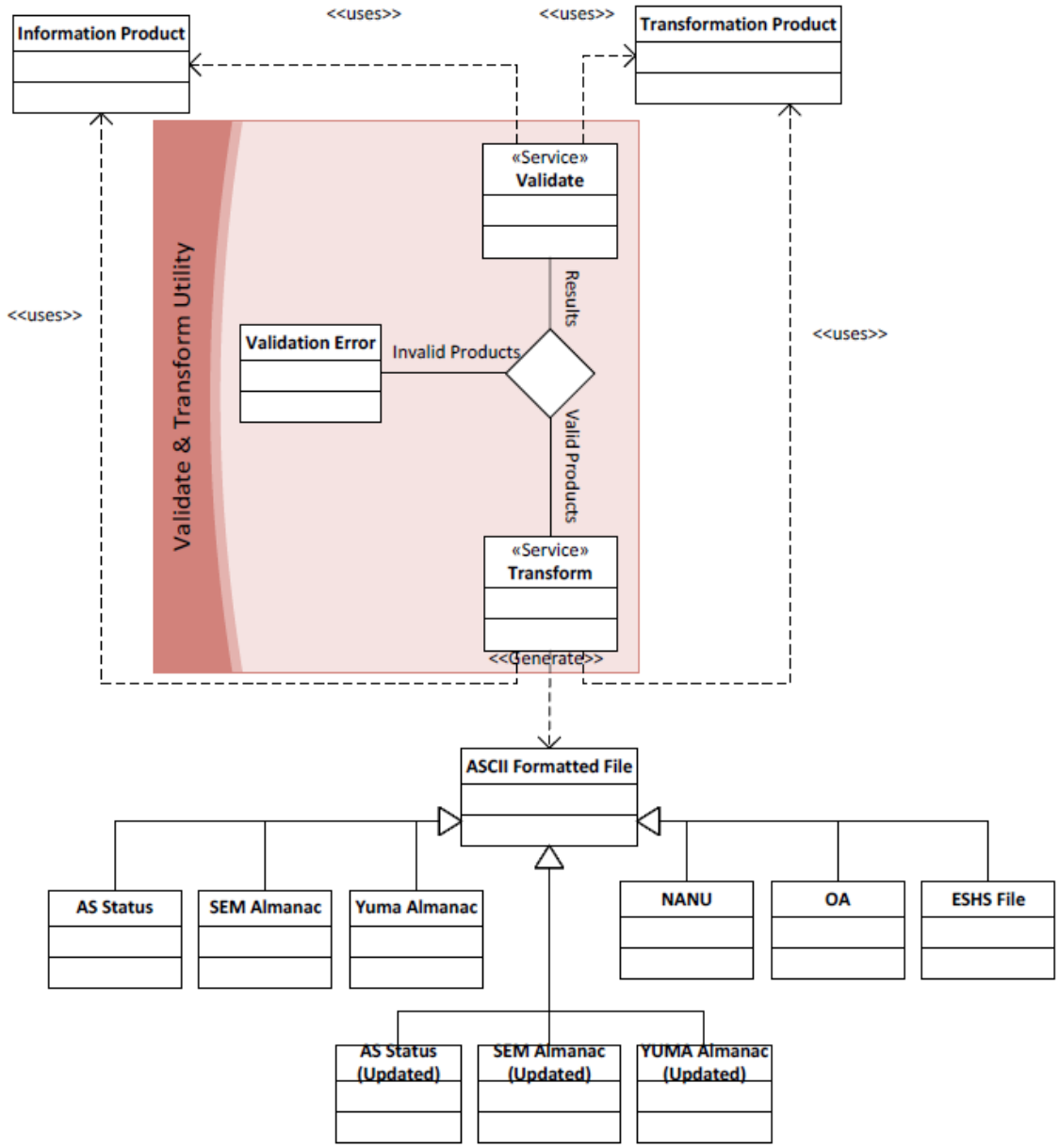

Exhibit 5: Validate and Transform Utility[4]

GPS data products have many users who span multiple domains such as agriculture, aviation, transportation, etc. The majority of GPS users are not familiar with GPS ICDs and therefore OCX has made its data products accessible, interoperable, and understandable by using standards and adhering to DoD net-centric Data Strategy Tenets. Exhibit 6 depicts how GPS information products are defined and the modern standards they adhere to. Further Exhibit 6 shows how OCX information products implement DoD net-centric Data Strategy Tenets to achieve both interoperability and understandability so that unanticipated users can utilize them to form improved GPS situational awareness.

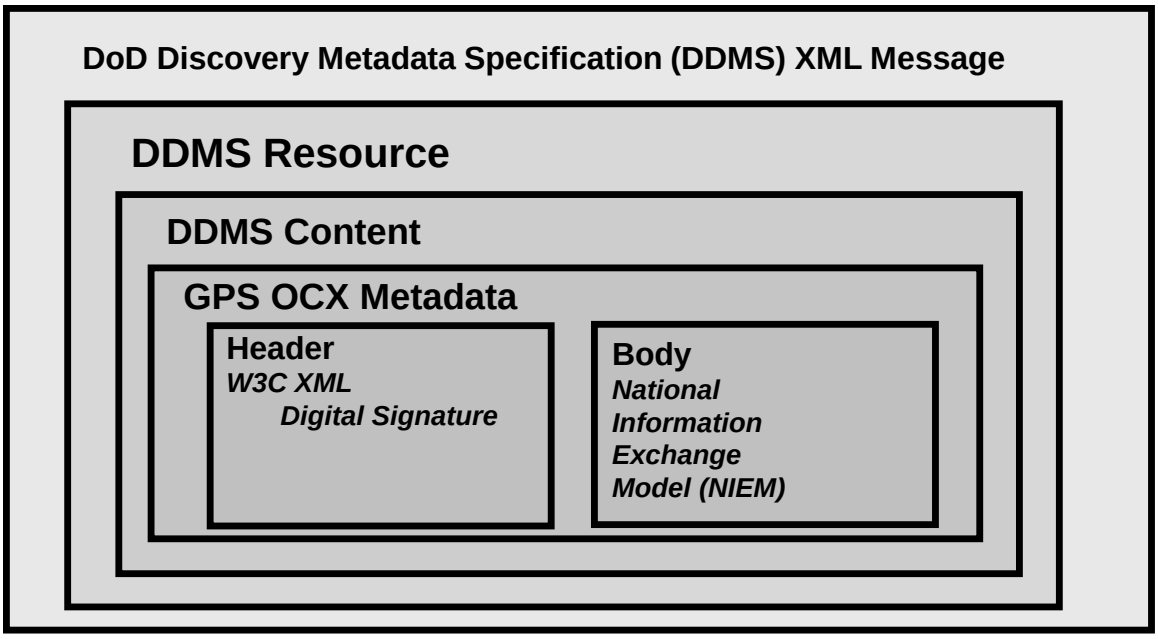

Exhibit 6: GPS Information Product Structure

DoD Net-Centric Data Strategy Tenets (DoD Directive 8320.02)	OCX Implementation Approach
Data visibility: Can the user find the data?	DDMS – DoD Discovery Metadata Specification to make data discoverable
Data accessibility: Can the user access the data?	Intelligence Community Information Security Marking (IC-ISM) Standard to provide access to authorized users
Data understandability: Is data understandable?	(Candidate) Standard for product body implement National Information Exchange Model (NIEM) Standard to provide common ontology to enhance understandability

Exhibit 7: Alignment with DoD Net-Centric Tenets

Transitioning to OCX modern product

OCX has laid out a transition strategy to ensure low risk migration of users from the legacy OCS/AEP era to modern OCX era products and services. This transition strategy also paves the way for an agile, low cost process for OCX to provide new products to meet future GPS users' needs. Below are some of the key steps for OCX transition strategy as described in ICD-GPS-870

- The Control Segment (CS) may introduce new products and standards, yet will provide a means for supporting backward compatibility.
- New users and early adopters will be encouraged to adopt new products and features.
- Existing products within the ICD which are planned for retirement will be deprecated prior to being retired thus providing advance warning for users to initiate and complete migration away from the deprecated products.
- Users are encouraged to plan a migration to use the new GPS Products "as is" and thus eliminate the need for transition utilities.

- The GPS CS will still be required to coordinate a specific timeframe or process in a public ICWG for the removal of a deprecated product or service with a minimum of 12 months' notice.

CONCLUSION

This paper has outlined the GPS OCX net-centric architecture and its modern standards and products to better support GPS user capabilities. The goal of OCX architecture is to provide users with standards based secure net-centric data and services promoting interoperability, understandability and at the same time ensure smooth transition to these modern products and services.

ACKNOWLEDGMENTS

This work was completed in association with GPS OCX contract (FA8807-10-C-001) issued by the GPS Directorate of the Air Force Space Command's Space and Missile Systems Center.

[1] DoD Directive 8320.02, "Data Sharing in a Net-Centric Department of Defense,"
[2] DoD Information Enterprise Architecture v2.0
[3] Enabling Concept for the Third Generation Global Positioning System (3Gen GPS) 11 February 2013
[4] ICD-GPS-870 RevB (24 Sep 2013) Navstar GPS Control Segment to User Support Community Interfaces