Net-Centric Sensors and Data Sources (N-CSDS) Ground-based Electro Optical Deep Space Surveillance (GEODSS) Sidecar

Principal Author: David Richmond
Lockheed Martin

CONFERENCE PAPER

1. ABSTRACT SUMMARY

Vast amounts of Space Situational Sensor data is collected each day on closed, legacy systems. Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL) developed a Net-Centric approach to expose this data under the Extended Space Sensors Architecture (ESSA) Advanced Concept Technology Demonstration (ACTD). The Net-Centric Sensors and Data Sources (N-CSDS) Ground-based Electro Optical Deep Space Surveillance (GEODSS) Sidecar is the next generation that moves the ESSA ACTD engineering tools to an operational baseline. The N-CSDS GEODSS sidecar high level architecture will be presented, highlighting the features that support deployment at multiple diverse sensor sites. Other key items that will be covered include:

1) High Level N-CSDS Architecture
2) Data Engineering Working Group process used to define data exposed
3) N-CSDS Data Dissemination using publish/subscribe and request/responses
4) The Web Browser interface to perform searches of historical data
5) System Management enhancements

2. INTRODUCTION

The Extended Space Sensors Architecture (ESSA) Advanced Concept Technology Demonstration (ACTD) has been very successful in proving the viability of exposing sensor data net-centrically. However, maintenance and sustainment is typically not emphasized for a technology demonstration system. Additionally, a demonstration system's focus is to prove the viability of a concept and increase the Technology Readiness Level (TRL), with the understanding that additional features will be required to make the capability operationally ready. Our team gained experience with the ESSA ACTD by working cooperatively with Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL). We have gained experience with the sensor data and worked with operational users and other program offices by supporting Space and Missile Systems Center's (SMC's) Data Engineering Working Group (DEWG). This has resulted in the Integrated Space Situation Awareness (SSA) Prototype Developer (IPD) team developing an operational sidecar and the transition and long term maintenance approach for the N-CSDS Ground-based Electro Optical Deep Space Surveillance (GEODSS) Sidecar.

The IPD Team architected and developed the N-CSDS Sidecar as an operational version of the ESSA sidecar. A sidecar has been defined as an on-line, computer processing system that net-centrically exposes data from a host system in a non-interfering manner that effectively decouples the sidecar processing and communication paths from the host system operational string. The initial N-CSDS Sidecar was developed in support of the Space Surveillance Network (SSN). However, the N-CSDS Sidecar can support any data source. The mission of the sidecar is to provide a net-centric, one or two-way path for access to the data of a particular data source and to provide input data. The N-CSDS Sidecar effort is in response to the Net Ready-Key Performance Parameter (NR-KPP) requirements of the Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 6312.01F. The IPD Team implemented the Data Engineering Working Group (DEWG) process to ensure the disseminated data is understandable to clients.

3. N-CSDS ARCHITECTURE

The ideal N-CSDS Sidecar architecture is one with common hardware and Commercial Off-The Shelf (COTS) configurations at each operational site. Site-specific requirements will only be required at the site interface. Fig. 1 illustrates that the N-CSDS Sidecar is comprised of the Sensor Specific Processing Component (SSPC) Subsystem and the Enterprise Component (EC) Subsystem.

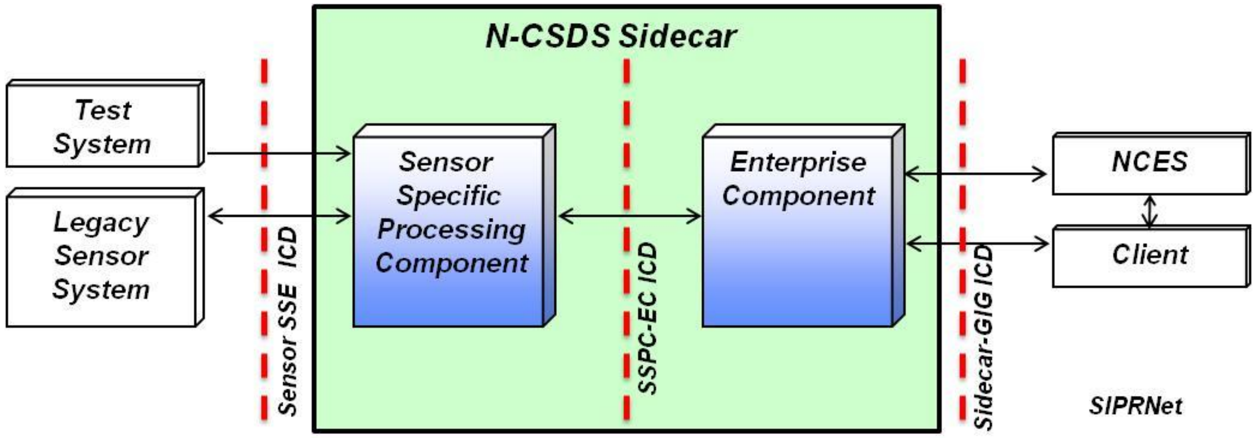

Fig. 1. N-CSDS Sidecar High Level Architecture

The SSPC subsystem is the sensor-specific, interface adaptor that will allow for data and data product extraction from the sensor without interfering with normal sensor operations, and pass the data to the EC Subsystem in a common format. The *Net-Centric Sensors and Data Sources (N-CSDS) SSPC-EC Interface Control Document (ICD)* [1] defines the common interface used to interact with the sensor. The SSPC subsystem is also capable of receiving data from the EC subsystem to provide to the sensor.

The EC subsystem provides the functional elements that are common across all N-CSDS Sidecar sites. The EC Subsystem publishes data in Near-Real Time (NRT) via the Net-Centric Enterprise Services (NCES) interface and stores the information for Request/Response queries via Web Services. The *Net-Centric Sensors and Data Sources (N-CSDS) Service Description Interface Control Document (ICD)* [2] defines the interface between the N-CSDS Sidecar and the network.

The GEODSS sensor located in Socorro, New Mexico is the first sensor that will receive the operational N-CSDS Sidecar. To facilitate future deployments, the IPD team generated two DIACAP packages. One to type accredit the Sensor Specific Processing Component (SSPC) subsystem for GEODSS sites and a second to type accredit the Enterprise Component (EC) subsystem for each N-CSDS sensor site deployment. Thus, each N-CSDS Sidecar will be deployed with a common hardware and software configuration. This will reduce the overall life cycle cost by simplifying the sparing strategy and enterprise maintenance.

4. DATA ENGINEERING WORKING GROUP

Establishment of a Community of Interest (COI) plays a key role in implementing understandable net-centric data sharing. Understandable data focuses on reaching agreement on the meaning of information between the producers and consumers. Currently, the IPD team leads the system engineering and development efforts of the N-CSDS Data Engineering Working Group (DEWG). This group has Subject Matter Expert (SME) participation to arrive at a common vocabulary, lexicon, ontology, and eXtensible Markup language (XML) data schema. IPD has helped to establish the functional, technical and internal programmatic procedures for managing the N-CSDS Data Model. The artifacts that make up the data model form a common vocabulary to exchange information between major program components developed under N-CSDS, as well as with external systems, applications and services. The N-CSDS data model consists of the following artifacts:

- Data Definitions (Logical Data Model)
- XML Schema (Physical Data Model)
- Service Description Documentations
- Web Service Description Language (WSDL)s
- Design & Implementation Guidance

The IPD team has developed processes and tools to help with the creation, adoption and maintenance of the N-CSDS data model artifacts. The IPD developed "IPT Development Process" illustrated in Fig. 2 has been adopted by the DEWG and is based around a phased schedule.

This IPT Development Process ensures that the products produced from the DEWG have been vetted through identified subject matter experts in the Space Situational Awareness community. The IPD team manages the process, while still ensuring that input from the SMEs is fed into the data model artifacts. At the end of each phase, the appropriate artifacts are updated and released to the user community, including the Command and Control Space Situational Awareness Community of Interest (C2 SSA COI), to facilitate "continuous integration" of the N-CSDS data model.

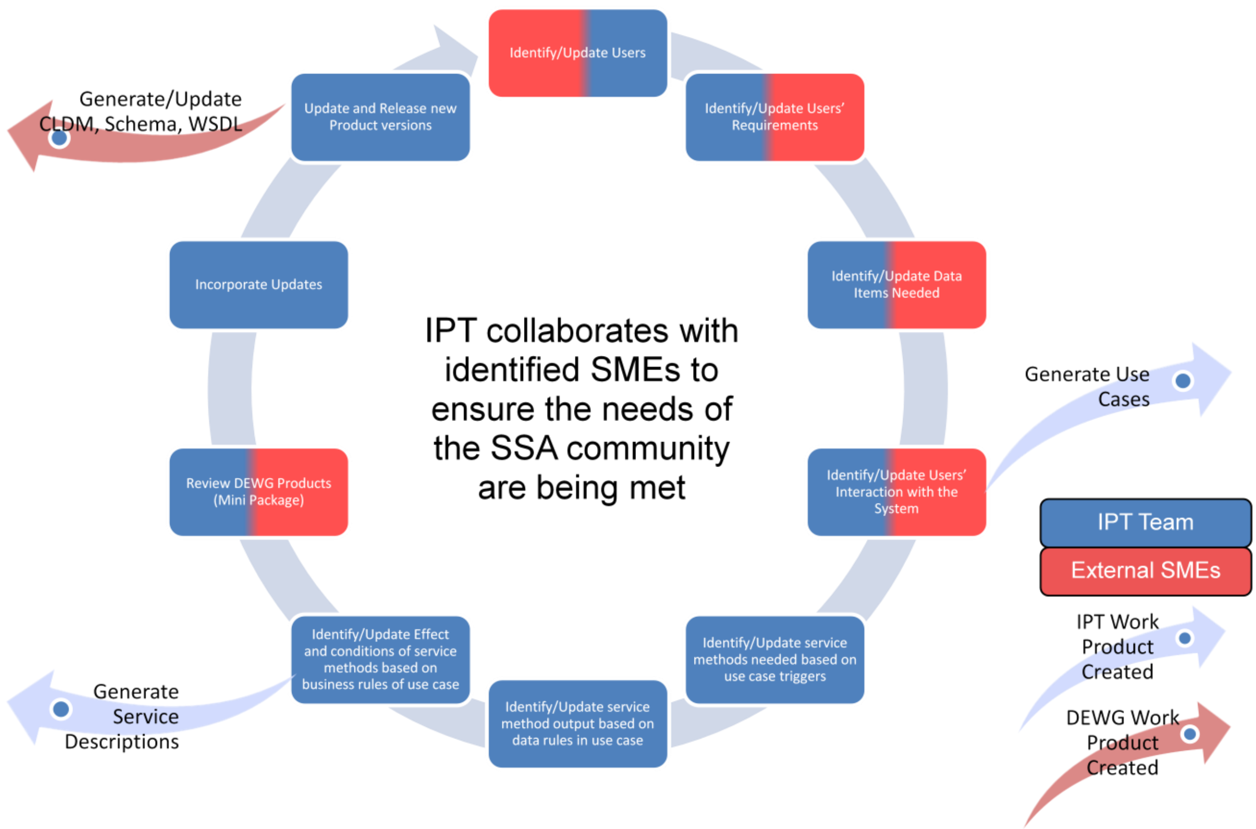

Fig. 2. IPT Development Process

The IPD team incorporated the initial ESSA messages from the ACTD sidecar effort into the N-CSDS data model. This effort included creating harmonized versions of the ESSA messages, creating a default set of web services, and creating a mapping between the original message formats and the new message formats to help with the anticipated retrofitting of the ACTD sidecars to produce N-CSDS messages.

5. N-CSDS DATA DISSIMINATION

Users can obtain the N-CSDS Sidecar data in Near-Real Time (NRT) through a Publish/Subscribe paradigm. Additionally a collection of Web Services have been defined that allow users to obtain data in a Request/Response manner.

N-CSDS Sidecar data that is published is sent to NCES with an identified topic. Clients that have subscribed to these topics will receive the data in NRT. Separate topics have been defined for Real versus Test/Exercise data and the N-CSDS Sidecar selects the topic to publish on based on its operational mode configuration. The Government will control the subscription process to NCES topics. Only data that can be published will be disseminated via the N-CSDS Sidecar. Some sensor data may not be approved for publication.

Clients can also obtain data using the Web Services Request/Response interface. Separate web services have been created for each data type and separate endpoints have been established to separate Real data from Test/Exercise data. Methods within each web service have been created for clients to perform search queries of the data or to request specific information to back fill information that may have been missed through the publication process.

Backfill Services provide methods and capabilities related to the near real time (NRT) publication of sensor sidecar data. Event driven methods, on these services, have an interface that is internal (not invoked by an external user) and are included to document the behavior related to the NRT dissemination of the data products. Optionally, these types of services may provide methods to backfill published data that was missed by routine users. These backfill methods would be available only to users permitted to subscribe to the data and have specific capabilities to deal with handling missed publication data. These backfill methods are exposed to external users, but do not support search queries.

The backfill methods of the Publication Services take in a collection of URIs that corresponds to published messages of that service. Each URI has an embedded sequence number. This sequence number will allow a user to discover when they have missed messages and provide a mechanism for them to query the missing messages from the service via the backfill method.

Further details regarding the mechanisms for subscribing and unsubscribing to sensor sidecar data can be found in the *Net-Centric Sensors and Data Sources (N-CSDS) Service Description Interface Control Document (ICD* [2].

Search Services provide methods and capabilities related to querying of sensor sidecar historical data. This includes the ad-hoc querying of published, historical data and the retrieval of non-published, historical data. These query methods are exposed to external users via the service's interface. Unlike the backfill methods of the Publication Services, usage of these services is not dependent on a user receiving published data NRT from a Publication Service.

6. N-CSDS WEB BROWSER INTERFACE

The *Web Browser Interface* provides a human interface to support ad-hoc users' quires of the N-CSDS data using the search web services. This enables authorized ad-hoc users the ability to query sensor sidecar historical data. The Web Browser Interface provides the client the ability to view and store to an XML file query results. The user selects a specific data type of interest and enters appropriate search criteria. Fig. 3 illustrates sample metric observation results obtained from the web interface.

Fig. 3. Web Interface Metric Observations

Fig. 4 illustrates the web interface presenting a collection of example observations gathered into a track. A track represents a collection of one to many contiguous metric observations of the same object.

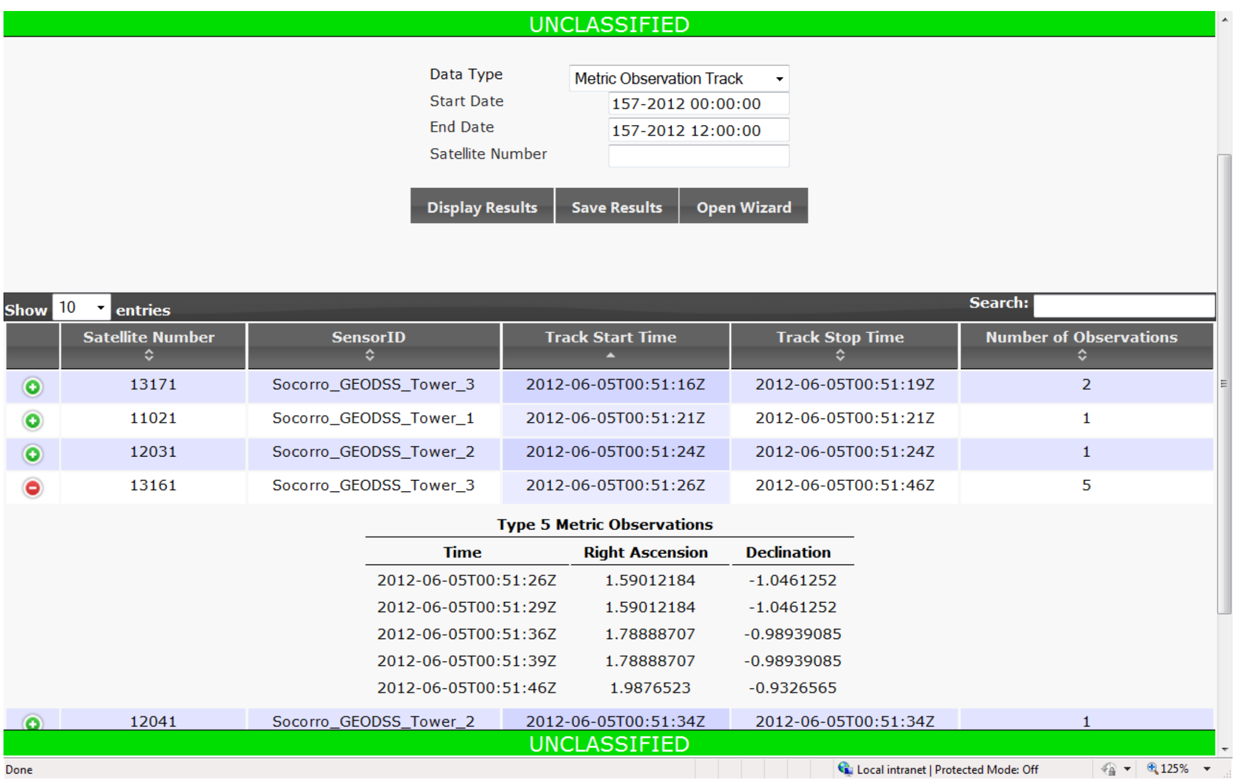

Fig. 4. Metric Observation Track Group

7. SYSTEM MANAGEMENT

The ESSA ACTD established the viability of exposing sensor net-centrically. One of the N-CSDS Sidecar enhancements was to provide a system management capability. System management within the sidecar handles all configuration, monitoring, system operations, and alerting. These System Management capabilities are handled by the Free and Open Source Software (FOSS) product Red Hat Queue (RHQ). RHQ is an enterprise management solution that provides extensible and integrated systems management for multiple products and platforms across a set of core features to include:

- Monitoring and graphing of values
- Alerting on error conditions
- Remote configuration of managed resources
- Remote operation execution
- Provisioning of software onto managed machines
- Detection of changed files

RHQ is designed with layered modules that provide a flexible architecture for deployment. It delivers a core user interface that provides audited and historical management across and entire enterprise. A Server/Agent architecture provides remote management and plugins implement all specific support for managed products. Fig. 5 illustrates the RHQ Server/Agent architecture.

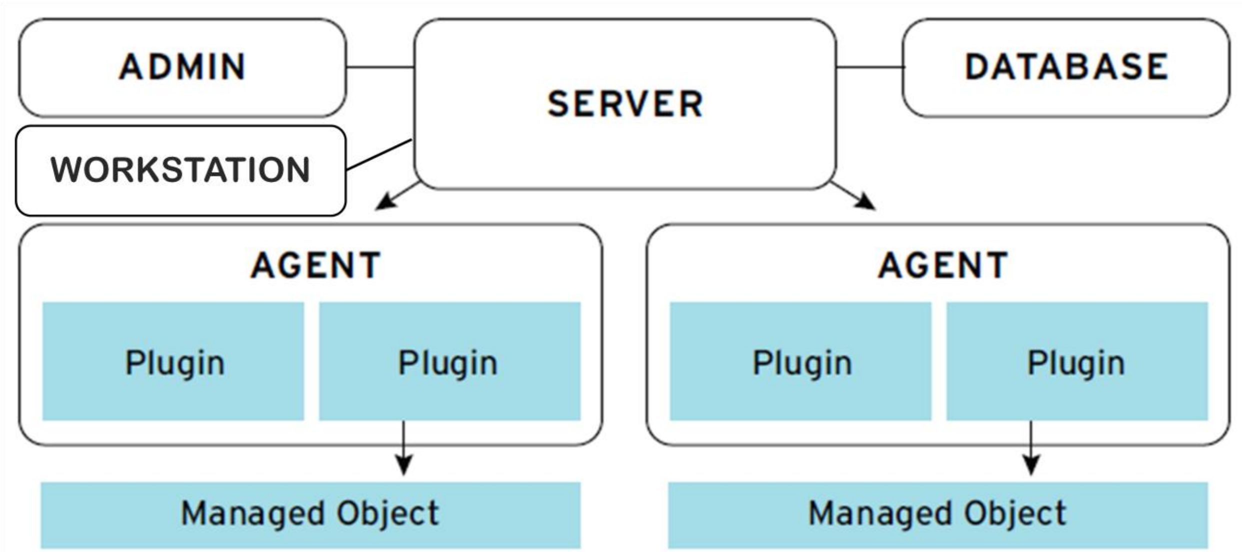

Fig. 5. System Management Architecture

A web browser interface is provided by the Admin capability. This allows the system manager to view the current enterprise status, issue configuration commands, and generate diagnostic reports. The workstation interface provides a stoplight view of the enterprise status and is intended to execute continuously.

The N-CSDS Sidecar includes custom plugin developed for deployment on RHQ agents. Each plugin defines one or more RHQ resources, representing sidecar components and contributing to custom functionality.

8. CONCLUSION

The enterprise is moving from stove-piped systems to a collection of net-centric systems. Over time this transition will support a large variety of space protection stake-holders with differing needs. Establishing common architecture components between multiple sites will reduce both development and sustainment costs. This common architecture will support deployments to both traditional and non-traditional data sources. Utilizing a common lexicon and agreed to data schemas will facilitate clients ability to understand and use the data. Thus, clients outside of the traditional set (Joint Space Operations Center) can quickly gain access and understand the available data enabling innovation of new usages for the existing data. Exposing available data sources net-centrically versus developing new sources will make necessary data available to clients faster. Exposing this data net-centrically will facilitate getting space situational awareness data into cloud computing architectures. As this data becomes available net-centrically, new and innovative uses will provide mission utility. Non-technical, as well as technical challenges are being addressed to ensure data availability.

The N-CSDS Sidecar provides a common enterprise design. The first operational N-CSDS GEODSS Sidecar will be deployed this year. Future deployments of the N-CSDS Sidecar are being evaluated for traditional and non-traditional sensors. The common lexicons and data models have been established to support future deployments. Deploying the N-CSDS GEODSS Sidecar to the remaining GEODSS sites could be achieved with minimal effort.

9. REFERENCES

1. Livie, V. and Richmond, D., *Net-Centric Sensors and Data Sources (N-CSDS) SSPC-EC Interface Control Document (ICD)*, Lockheed Martin IPD program, Valley Forge, Pennsylvania, 2012.
2 Livie, V., McKeown, J., and Reyes, G, *Net-Centric Sensors and Data Sources (N-CSDS) Service Description Interface Control Document (ICD)*, Lockheed Martin IPD program, Valley Forge, Pennsylvania, 2012.