Naval Research Laboratory

Monterey, CA 93943-5502

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Report on the Installation and Testing of the Advanced Weather Interactive Processing System (AWIPS II) for U.S. Navy Applications

Chad Hutchins
Marine Meteorology Division

Charles Sampson
Michael Frost
Marine Meteorology Division

Efren A. Serra
Devine Consulting, Inc.
Fremont, CA

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Chad Hutchins, Charles Sampson, Michael Frost, and Efren A. Serra[1]

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14. ABSTRACT

This memorandum report was commissioned to study the feasibility of providing US Navy-specific forecasting applications and datasets within the Advanced Weather Interactive Processing System (AWIPS II). The report outlines the Naval Research Laboratory's (NRL) efforts to install the open-source Unidata version of AWIPS II, add Navy numerical weather prediction forecast to the server, the Environmental Data Exchange Server (EDEX), and display in the AWIPS client, Common Access Visualization Environment (CAVE). The report also details NRL's work in extending AWIPS II EDEX to ingest and decode a Navy movement report instructions (MOVREP) message and attempts to display a ship track on CAVE. NRL's recommendation on the use of AWIPS II for Navy specific applications is summarized in this report.

15. SUBJECT TERMS

Meteorology, Advanced Weather Interactive Processing System, AWIPS II, Navy Weather Applications, Forecasting Applications, Visualization, Numerical Weather Prediction, Unidata

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ACRONYMS AND ABBREVIATIONS

AWIPS	Advanced Weather Interactive Processing System
CAVE	Common AWIPS Visualization Environment
CAT	CAVE Annotation Tool
COAMPS	US Navy Coupled Atmospheric Prediction System
EDEX	Environmental Data Exchange Server
GODAE	Global Ocean Data Assimilation Experiment
GRIB	Gridded Binary
HDF5	Hierarchical Data Format
LDM	Local Data Manager
METOC	Meteorology and Oceanographic
NAVGEM	US Navy Global Environmental Model
Qpid	Apache implementation of the AMQP protocol

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EXECUTIVE SUMMARY

This memorandum report was commissioned to study the feasibility of providing US Navy-specific forecasting applications and datasets within the Advanced Weather Interactive Processing System (AWIPS II). The Commander, Naval Meteorology and Oceanography Command (CNMOC) recently purchased from the prime developer Raytheon, in contract with the National Oceanic and Atmospheric Administration (NOAA), AWIPS II which is to be installed at the Navy's Fleet Weather Centers in Norfolk and San Diego, as well as the Joint Typhoon Warning Center.

The first phase of this work involved obtaining a copy of the AWIPS II client, the Common Access Visualization Environment (CAVE) as well as a copy of the server, the Environmental Data Exchange Server (EDEX). The Naval Research Laboratory (NRL) was not a party to CNMOC's agreement with Raytheon and NOAA. Instead of using the commercial version, we obtained an open-source version provided by Unidata. There are minor differences between the two distributions, but those are considered negligible for the purposes of this work.

With AWIPS II installed and running, NRL proceeded to load Navy atmospheric and oceanographic (METOC) products into the system. This step was quite successful within our research environment. The details of how this step was accomplished and screenshots of Navy products in CAVE are in NAVY METOC DATA IN AWIPS II section of this report.

The next phase of this work was to assess the development environment of CAVE for supporting a Navy specific application. In consultation with FWC-San Diego we chose to work with movement report instructions (MOVREP) (MOVREP, 1992). MOVREPs themselves are relatively simple, however adding a new data type and implementing any sort of graphical interface within CAVE proved to be a difficult challenge. After several months of effort and troubleshooting with developers at NOAA, we were able to ingest a MOVREP into the server and show its availability in the system. Unfortunately we hit several roadblocks and ultimately ran out of time in our efforts to display a MOVREP on CAVE and provide any sort of user manipulation. Details of our efforts to work with MOVREPS in AWIPS II can be found in the NAVY SPECIFIC APPLICATIONS – SHIP ROUTING section of this report.

Ultimately, we were successful in ingesting and displaying Navy gridded atmospheric and oceanographic data in AWIPS II and in assessing that the Navy's ability to operationalize this capability is easily within reach. However because of the complexities with respect to the CAVE user interface and the potential difficulties in maintaining a compatible plugin as new versions of CAVE are released, we assess the ability to operationalize a Navy specific application in AWIPS II to be difficult but not out of reach if a better path forward can be found to create plugins for CAVE.

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AWIPS II GENERAL OVERVIEW AND ARCHITECTURE

The Advanced Weather Interactive Processing System (AWIPS) is a client/server suite of software created by Raytheon for the National Oceanic and Atmospheric Administrations' National Weather Service (Raytheon).

AWIPS Software Components

The core AWIPS application for data ingest, processing, and storage is the Environmental Data EXchange (EDEX) server; the primary AWIPS application for visualization/data manipulation is the Common AWIPS Visualization Environment (CAVE) client, typically resident on a workstation separate from the EDEX server.

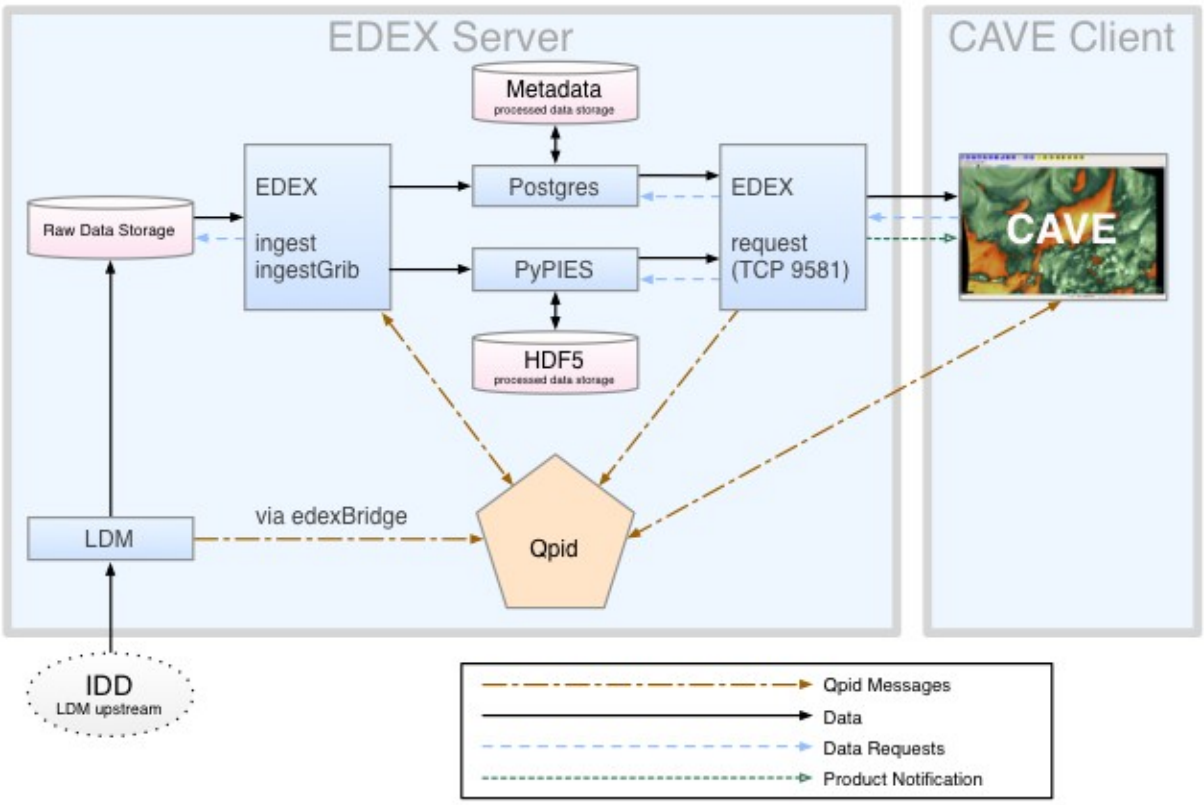

Figure 1 AWIPS II Software Components (University Corporation for Atmospheric Research, 2017)

A large portion of the functionality of EDEX is the decoding of data stored by the Local Data Manager (LDM). The default ingest server (simply named ingest) handles all data ingest other than GRIB data, which are processed by a separate ingestGrib server. To decode data, EDEX relies on data plugins.

AWIPS EDEX Flow of Control

At a high level of abstraction, the flow of control when new data arrives on EDEX is as follows:

1. EDEX, via mapping of file name pattern to data plugin decoder, de-multiplexes file name to data plugin decoder

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2. Data plugin decoder corresponding to file pattern is invoked
3. Plugin decodes data and setups internal structures for decoded data to be persisted to HDF5 via PyPIES
4. Metadata about the decoded data is stored in the corresponding PostgreSQL tablespace. There exists a table in the metadata tablespace per decoded data type.

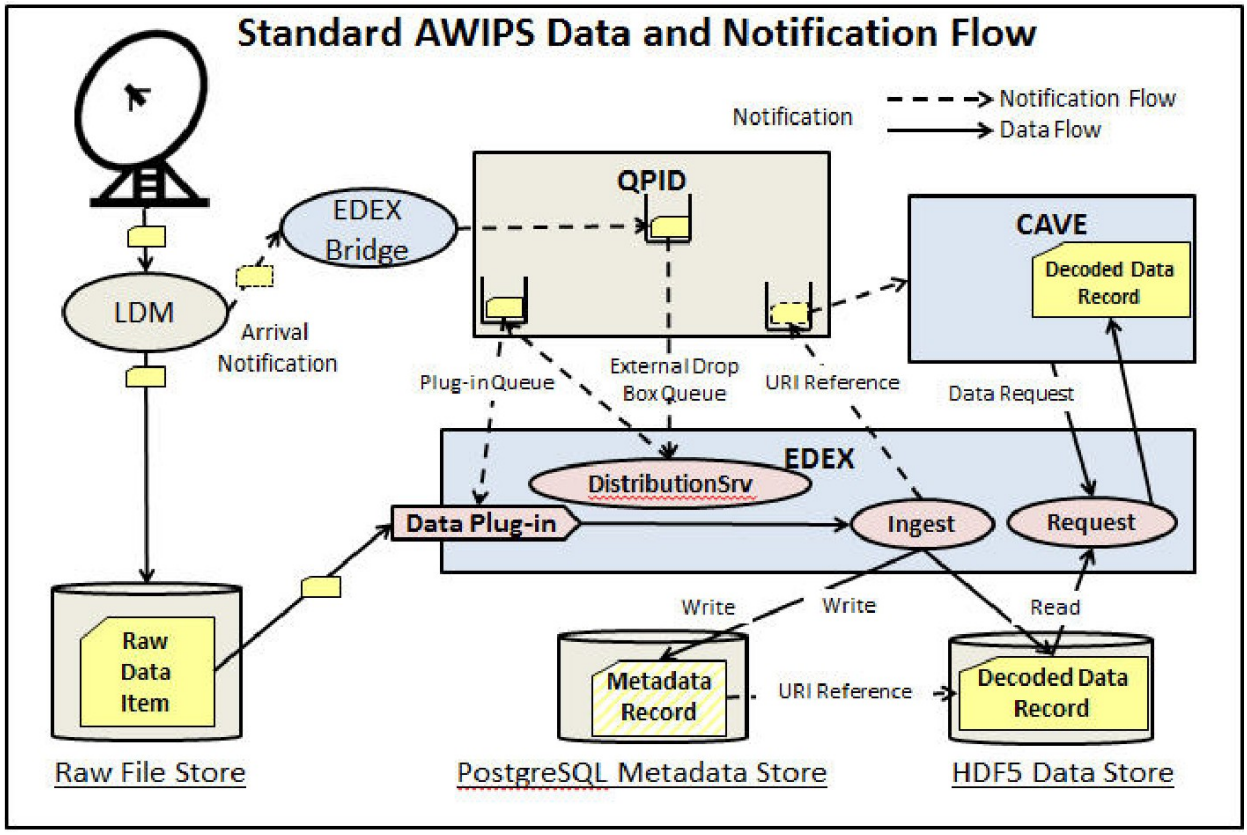

Figure 2 Standard AWIPS Data and Notification Flow. Source: Raytheon Corp.

NAVY METOC DATA IN AWIPS II

Once the EDEX is properly configured, COAMPS and NAVGEM gridded model data, surface observations, and satellite imagery could be easily ingested into AWIPS II via the LDM, without any code changes, only configuration changes.

LDM is used to provide environmental data into the AWIPS II system. The LDM can access data by the following means:

- Connection to a local NOAAPort.
- Connection to an upstream LDM host that is willing to provide
- Usage of program `pqinsert` to ingest local data

The default configuration that we experienced was the LDM was configured to access data from an LDM running at UNIDATA for the IDD feed. As a note, the IDD feed

already contains a lot of Navy products. NRL manages that GODAE project. All model data that FNMOC provides to GODAE is also inserted into the IDD making it available to application such as AWIPS II.

For locally derived environmental data the pqinsert tool, supplied as part of the LDM package, is used to ingest the data into LDM. For example, if you were to run a local forecast model and desire to add the data into AWIPS II, this tool would be used.

Major caveat, all of the above information concerns NRL's work with EDEX and LDM and do not attempt to represent what would be used in Navy operations.

Visualization of newly added gridded data, e.g., GRIB, is supported out of the box from CAVE, as long as the parameter(s) is (are) non-derived parameters such as 10 [m] wind. Derived parameters, such as dew point depression, would require customization via editing of configuration files, e.g., XML files, and implementation, e.g., Python code, of new methods and apparatuses for the computation of the derived parameters, only the former would be trivial.

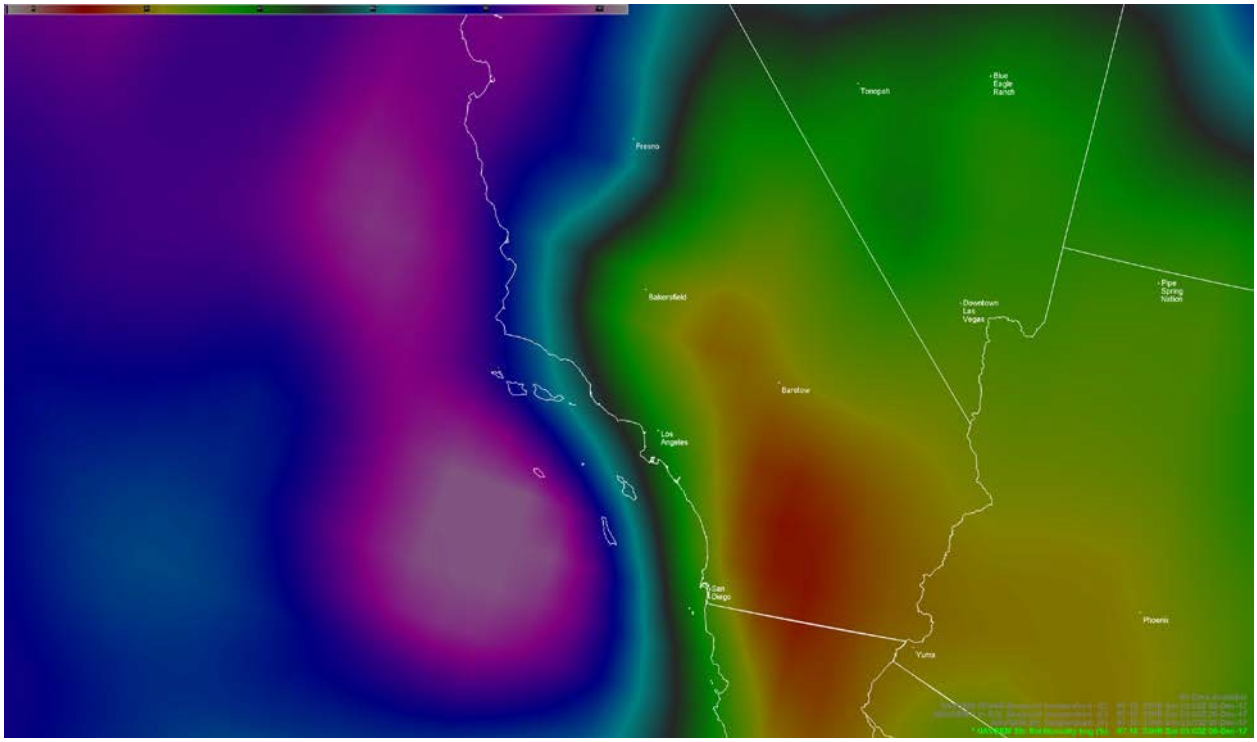

Figure 3 NAVGEM Surface Relative Humidity

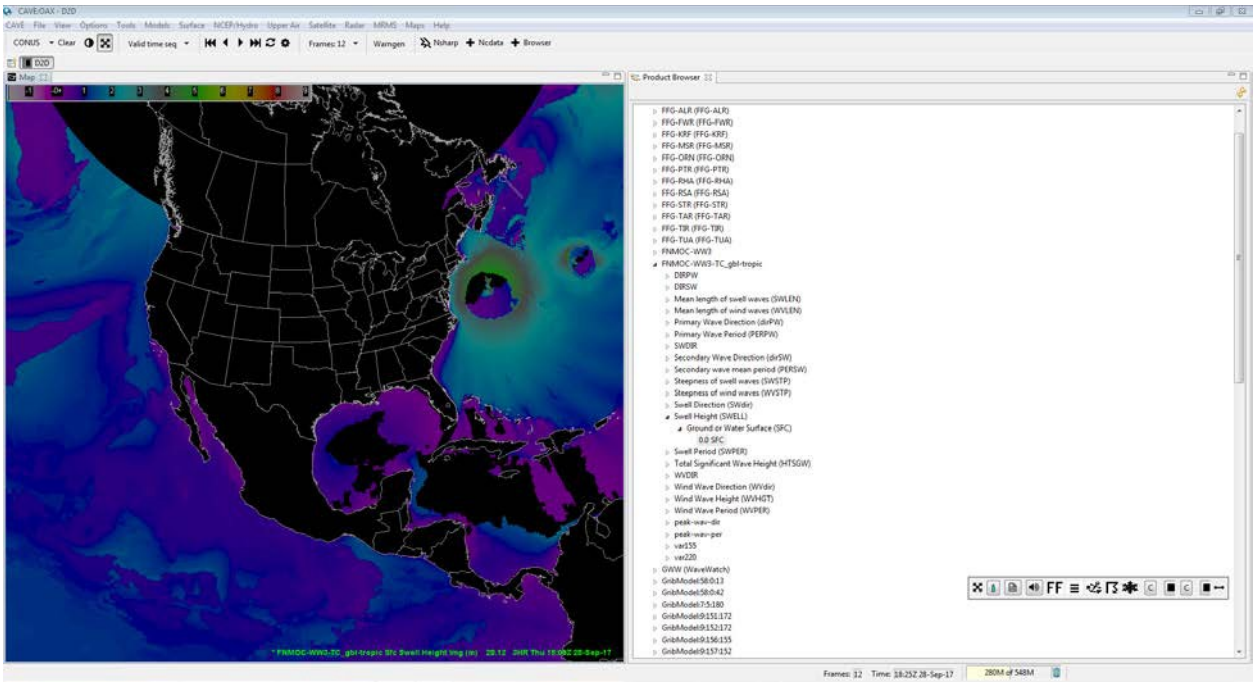

Figure 4 FNMOC WaveWatch III TC Global-Tropic Swell Height

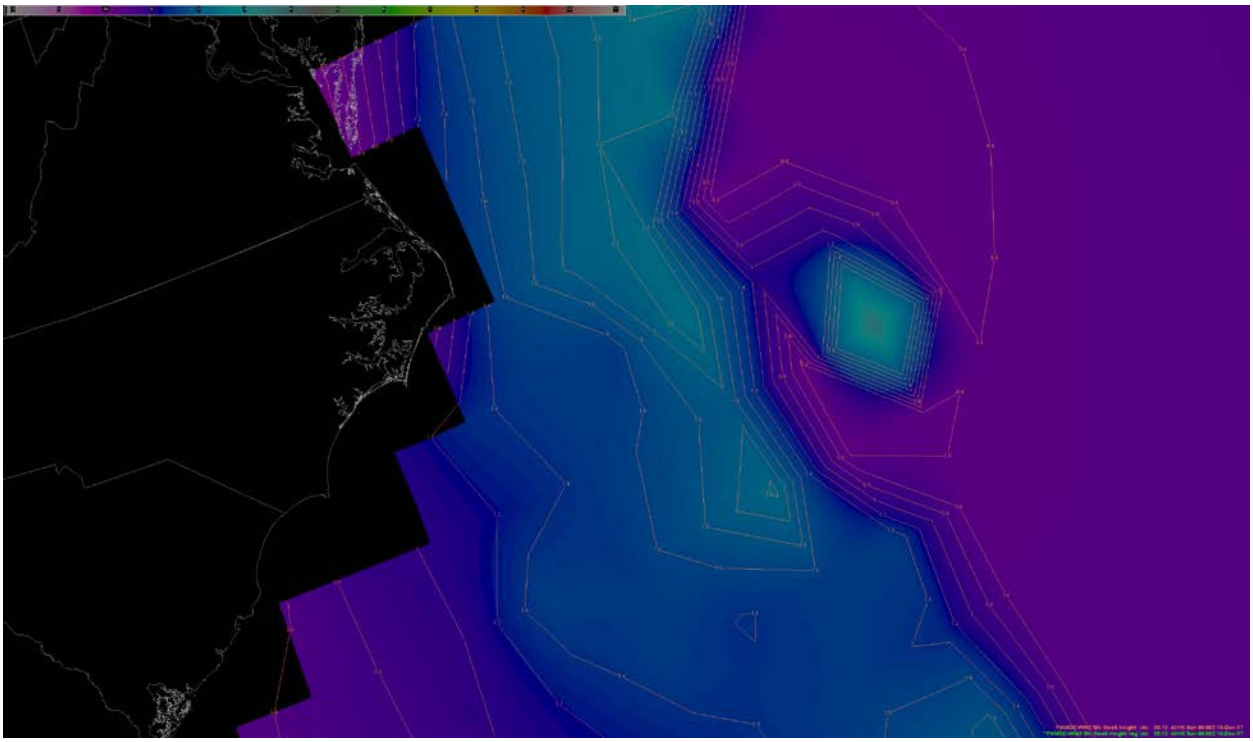

Figure 5 FNMOC WaveWatch III Swell Height (Color Fill and Line Contours)

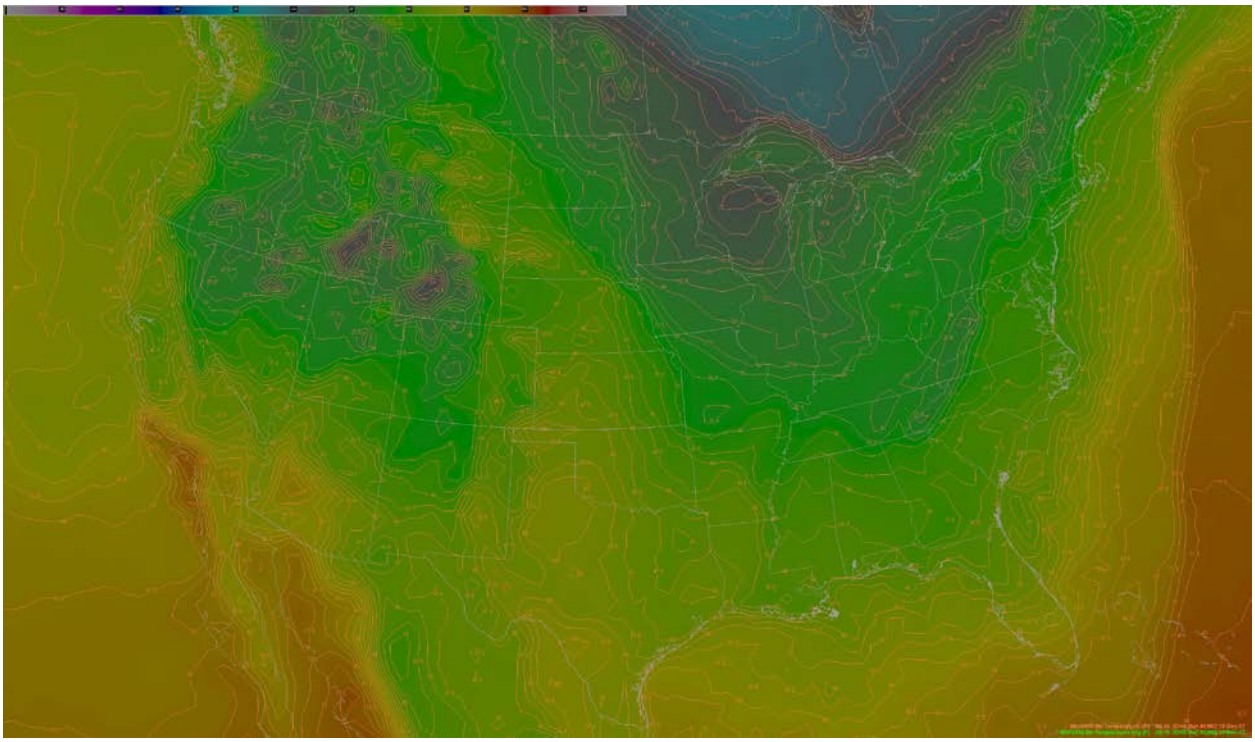

Figure 6 FNMOC NAVGEM Ground Air Temperature

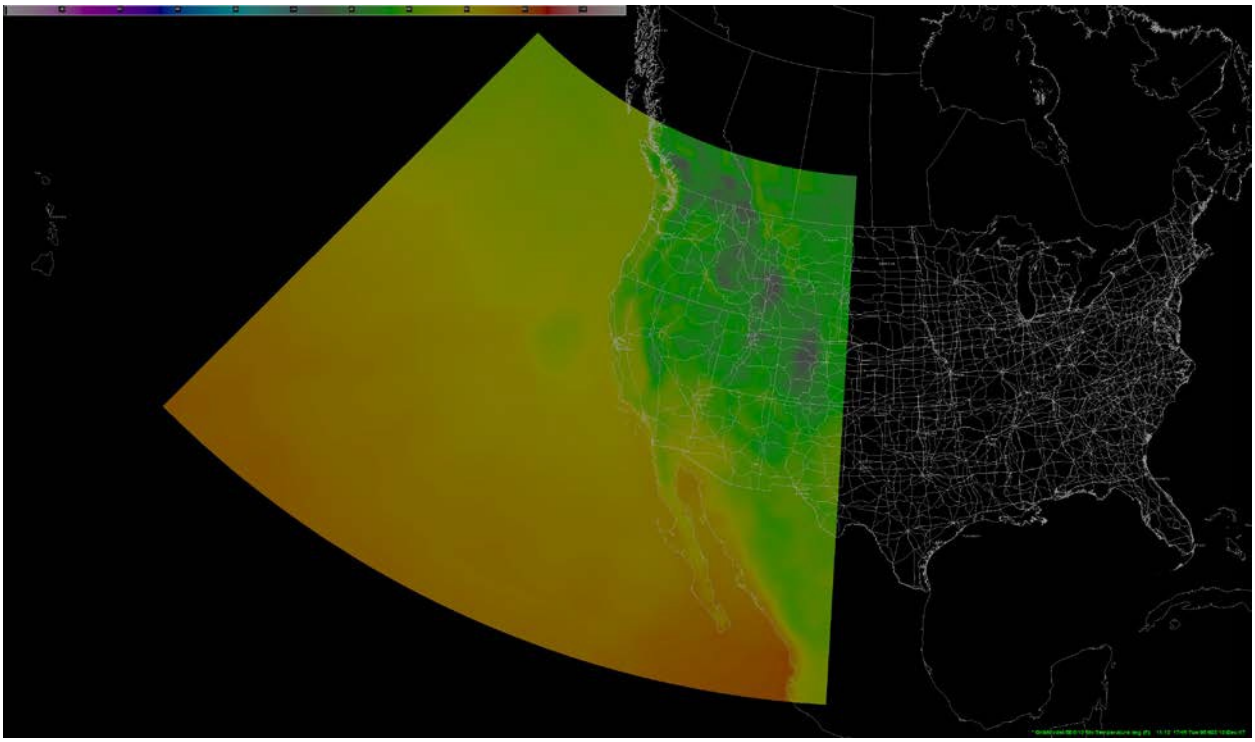

Figure 7 FNMOC COAMPS CENCOOS Air Temperature

NAVY SPECIFIC APPLICATIONS – SHIP ROUTING

To add support for US Navy-specific applications, such as ship routing, a more involved and software-centric approach, with analysis, design/architecture, implementation and unit testing, was necessary, for ship routing constituted a new data type to be ingested into EDEX.

Taking sufficient time in the first three stages for discovering "common" software components to be shared amongst CAVE and EDEX plugins is, from experience, the crux of this task. For instance, in the development of a minimal ship routing EDEX Data Decoder Plugin, for ingesting/retrieving ship route response the task partition was as follows:

- The development of the "common" portion of plugin contained 12 Java classes with 1654 lines of Java source code.
- The development of the EDEX specific portion of plugin contained 4 Java classes with 925 lines of Java source code.
- This task was more involved and time consuming than say ingesting a new gridded data type, for data decoder plugins for ship routing are NOT included in any implementation of AWIPS II.

To further expand on the work that was required to support ship routing, following plugins and code additions were created:

- Creation of a "Common Core" Eclipse Plugin for ship routing (mil.navy.nrlmry.uf.common.dataplugin.shiprouting).
- Creation of "EDEX Core" Eclipse Plugin for ship routing. (mil.navy.nrlmry.uf.edex.plugin.shiprouting).
- Creation of Python AWIPS II Data Access Framework classes for Dynamic Serialization.
- Creation of "CAVE Core" Eclipse Plugin for ship routing (mil.navy.nrlmry.uf.viz.rsc.shiprouting

Detailed information regarding the plugins can be found in APPENDIX A.

FINAL DETERMINATION AND RECOMMENDATION

This project was successful in ingesting and displaying Navy gridded atmospheric and oceanographic data in the AWIPS II system. With the knowledge gained from performing this work, we have confidence that the Navy can easily operationalize the distribution of standard METOC datasets and formats into AWIPS II.

Unfortunately as outlined in NAVY SPECIFIC APPLICATIONS – SHIP ROUTING section of this report, we experienced difficulties in our attempts to display a MOVREP in CAVE. We did have success in adding a new datatype for the MOVREP and ingesting it into the EDEX database. However due to the potential difficulties in maintaining a compatible plugin as new versions of CAVE are released, we assess the ability to operationalize a Navy specific application in AWIPS II to be difficult but not out of reach if a better path forward can be found to

create plugins for CAVE.

As an aid in truly understanding the difficulties of working with the AWIPS II system for Navy applications, we created the AWIPS Component Development Difficulty Matrix table in the subsection below. In the Recommended Deployment subsection we discuss a potential path forward for handling new CAVE releases with respect to Navy plugin applications.

AWIPS Component Development Difficulty Matrix

Table 1 AWIPS Component Development Difficulty Matrix

	Level of Difficulty on a Scale of 1-5 (1 being easiest)	**Time Span for Task Implementation**	**Comments**
Development Task			
EDEX Software Installation	1	1-2 days	
LDM Configuration		1-2 weeks	This time span is for someone with previous LDM experience.
Ingest a New Grid (GRIB)	1	1-2 days	
EDEX Data Decoder Plugin – Ingest Data Path	3	3-6 months	This time span is for someone with previous Eclipse Java Plugin Development (JPD) experience.
EDEX Data Decoder Plugin- Request Data Path	3	2-3 months	This time span is for someone with previous Eclipse Java Plugin Development (JPD) experience
EDEX Data Decoder Plugin RDBMS Table	3	1-2 days	This time span is for someone with PostgreSQL experience
CAVE – Dialog Implementation	5	6-9 months	This time span is for someone with JPD experience and Standard Widget Toolkit (SWT) experience
CAVE - Adding new Menu Items		1-2 days	
CAVE – Derived Parameters	4	6-9 months	

The level of difficulty is measured in terms of the number of days/lines of code

necessary to handle a particular task. The scale of difficulty is from 1-5, with 1 being the easiest. Please note that, in actuality, the time span for tasks is dependent upon experience.

Recommended Deployment

Due to the lack of any formal plugin process for AWIPS II, any specific Navy application for CAVE or Navy specific data type for EDEX will have to be maintained and delivered outside of the Raytheon or Unidata builds. NOAA currently employs this method to support a popular custom plugin for AWIPS II called the CAVE Annotation Tool (National Oceanic and Atmospheric Administration). The CAVE Annotation Tool (CAT) allows CAVE users to draw annotations and graphics on AWIPS II that can be exported; each release of CAT must be manually installed on each installation of CAVE and is erased whenever AWIPS II updates.

For Navy applications, a process will need to be setup for submitting plugins to an authoritative source. Submitted plugins will be tested against the Navy operational version of CAVE and EDEX before distributing to Navy AWIPS II installations. We believe this is the only method of ensuring safe delivery of new plugins.

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Ana Rivera (ana.rivera@noaa.gov) – NOAA Federal

Kenneth Sperow (Kenneth.Sperow@noaa.gov) – NOAA Affiliate

Jason Burks (jason.burks@noaa.gov) – NWS/CIRA/MDL

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Mr Greg Ramos

REFERENCES

MOVREP. (1992, September 23). *Movement Report Instruction.* Retrieved September 27, 2017, from http://www.msc.navy.mil/: http://www.msc.navy.mil/instructions/pdf/m31235j.pdf

National Oceanic and Atmospheric Administration. (n.d.). Retrieved 12 11, 2017, from CAVE Annotation Tool: https://fxc.noaa.gov/index.html

Raytheon. (n.d.). *Advanced Weather Interactive Processing System*. Retrieved 17 10, 2017, from Raytheon: https://www.raytheon.com/capabilities/products/awips/

University Corporation for Atmospheric Research. (2017, September 26). *Unidata AWIPS User Manual.* Retrieved September 27, 2017, from Unidata AWIPS User Manual GitHub: http://unidata.github.io/awips2/

APPENDIX A.

Detailed list of plugins created to enable specific ship routing information in CAVE and EDEX.

- Creation of a “Common Core” Eclipse Plugin, with plugin named mil.navy.nrlmry.uf.common.dataplugin.shiprouting and the following Java packages:
    - mil.navy.nrlmry.uf.common.dataplugin.shiprouting: contains EDEX Data Decoder plugin class OptimalRouteRecord; this class extends PersistablePluginDataObject of the com.raytheon.uf.common.dataplugin.persist Java package as described in AWIPS II SSDD by Raytheon.
    - mil.navy.nrlmry.uf.common.dataplugin.shiprouting.dataaccess: contains EDEX Data Decoder Plugin class OptimalRouteDataAccessFactory; this class extends AbstractDataPluginFactory of the com.raytheon.uf.common.dataaccess.impl Java package as described in AWIPS II SSDD by Raytheon.
    - mil.navy.nrlmry.uf.common.dataplugin.shiprouting.impl: contains implementation specific Java classes per main software architect/developer: BaseShiproutingPoint, OptimalRouteBoundsPoint, OptimalRoutePoint, and WaypointType.
    - mil.navy.nrlmry.uf.common.dataplugin.shiprouting.request: contains EDEX Data Decoder Plugin class GetRouteDataRecordRequest; this class extends IServerRequest of the com.raytheon.uf.common.serialization.comm Java package as described in AWIPS II SSDD by Raytheon.
    - mil.navy.nrlmry.uf.common.dataplugin.shiprouting.response: contains EDEX Data Decoder Plugin class GetRouteDataRecordResponse, which is annotated with common.raytheon.uf.common.serialization.annotations.DynamicSerialize Java class, and RouteDataRecord, which is similarly annotated.
    - mil.navy.nrlmry.uf.edex.uengine.tasks.shiprouting: contains EDEX Data Decoder Plugin class RouteTrack; this class extends ISerializableObject of the com.raytheon.uf.common.serialization Java package as described in AWIPS II SSDD by Raytheon.
- Creation of “Edex Core” Eclipse Plugin, with plugin named mil.navy.nrlmry.uf.edex.plugin.shiprouting and the following Java packages:
    - mil.navy.nrlmry.uf.edex.plugin.shiprouting: contains EDEX Data Decoder plugin class OptimalRouteDecoder; this class extends AbstractDecoder of the com.raytheon.edex.plugin Java package as described in AWIPS II SSDD by Raytheon.
    - mil.navy.nrlmry.uf.edex.plugin.shiprouting.dao: contains EDEX Data Decoder plugin class OptimalRouteDao; this class extends PluginDao of the com.raytheon.uf.edex.database.plugin Java package as described in AWIPS II SSDD by Raytheon.

    - mil.navy.nrlmry.uf.edex.plugin.shiprouting.handler: contains EDEX Data Decoder plugin class GetRouteDataRecordHandler; this class extends IRequestHandler of the com.raytheon.uf.common.serialization.comm Java package as described in AWIPS II SSDD by Raytheon.
    - mil.navy.nrlmry.uf.edex.plugin.shiprouting.handler: contains implementation specific Java class per main software architect/developer: OptimalRouteParser.
- Creation of Python AWIPS II Data Access Framework classes for Dynamic Serialization:
    - /awips2/python/lib/python2.7/site-packages/dynamicserialize/dstypes/mil/navy/nrlmry/uf/common/dataplugin/shiprouting/response/GetRouteDataRecordResponse.py,
    - /awips2/python/lib/python2.7/site-packages/dynamicserialize/dstypes/mil/navy/nrlmry/uf/common/dataplugin/shiprouting/response/RouteDataRecord.py
    - /awips2/python/lib/python2.7/site-packages/dynamicserialize/dstypes/mil/navy/nrlmry/uf/common/dataplugin/shiprouting/request/GetRouteDataRecordRequest.py
- Creation of “CAVE Core” Eclipse Plugin, with plugin named mil.navy.nrlmry.uf.viz.rsc.shiprouting and the following Java packages:
    - mil.navy.nrlmry.uf.viz.rsc.shiprouting: contains Activator.java plugin class; this class is first called when plugin is activated or first used.
    - mil.navy.nrlmry.viz.rsc.shiprouting.rsc: contains CAVE plugin classes RouteResource; this class extends AbstractVizResource of the com.raytheon.uf.viz.core.rsc Java package; RouteResourceData; this class extends AbstractRequestableResourceData of the com.raytheon.uf.viz.core Java package; and ShiproutingProductBrowserDataDefinition; this class extends AbstractRequestableProductBrowserDataDefinition of the com.raytheon.uf.viz.productbrowser Java package as described in AWIPS II SSDD by Raytheon.