SYM-AM-25-419

Excerpt from the Proceedings of the Twenty-Second Annual Acquisition Research Symposium and Innovation Summit

Volume III

Productionizing Data Science at Sea Capabilities

Published: May 5, 2025

The research presented in this report was supported by the Acquisition Research Program at the Naval Postgraduate School.

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Productionizing Data Science at Sea Capabilities

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Abstract

Delivering software capabilities to the operators has never been more challenging, nor has there ever been as much infrastructure and tooling to achieve this objective. This paper outlines an effort to take Fleet-developed operational prototypes and rapidly productionize the capabilities to scale out to afloat and ashore units. The Data Science at Sea initiative is a Fleet effort whereby operators and analysts develop capabilities that are required for recurring operations. The Data Science at Sea Software Factory seeks to establish developer guidelines and a software engineering environment that enable uniformed developers to develop more mature prototypes that can be rapidly containerized, ensure cyber compliance, and provide availability for deployment to any Naval unit that desires the Fleet-developed capability. The Data Science at Sea initiative requires sustainment to provide continued prototyping and production support to proliferate and scale applications to the broader Naval warfighting community.

Introduction

The Data Science at Sea (DS@S) initiative is a Fleet effort whereby operators and analysts develop capabilities that are required for operations and have not been provided in a sustainable manner from the acquisition community. The DS@S initiative kicked off in 2021 on the Carl Vinson (CVN-70) in support of CSG-1 operations. A mixed uniform and civilian data science team developed operational capabilities that have yielded operator time savings and provided new ways to analyze and display data. These operator-developed and informed tools have not had to go through a protracted requirements and POM process to field and can proliferate organically to establish wide operator adoption. The DS@S is warfighting capability innovation at the edge. The DS@S Software Factory effort is focused on supporting the proliferation of these capabilities to other CSGs and warfighting units where the manpower may not be as trained or equipped to take advantage of DS@S innovation.

Delivering software to the operators has never been more challenging nor has there ever been as much infrastructure and tooling to achieve this objective. This paper outlines an effort to take Fleet-developed operational prototypes and rapidly productionize the capabilities to scale out to afloat and ashore units. The DS@S initiative is a Fleet effort whereby operators and analysts develop capabilities that are required for recurring operations.

The overarching objectives of the DS@S initiative include man, train, and equip DS@S teams based on Naval Information Forces (NAVIFOR) Requirements and resource the “Uniform Digital Talent” to ensure that there is a pipeline of personnel. Secondary to the Fleet-driven need to develop required capabilities in-situ is converting the DS@S operation prototypes to

containerized applications that can be deployed across the Fleet from the Project Overmatch Application Arsenal.

There are currently four organizations actively supporting the Fleet's DS@S initiative:

- Center for Naval Analysis (CNA): Provides personnel to support DS@S tools, and supports prototype development and operation.
- Office of Naval Research (ONR) Tech Solutions/PMW150: Supports the on boarding of DS@S capabilities to the DS@S Software Factory and supports the software engineering from prototypes to scale capability releases to Naval units.
- Project Overmatch/Warfighting Data Services (WDS): Provides the DS@S Toolkit and personnel to support the development and implementation of operational prototypes.
- STRATCOM Global Data Initiative (GDI)/ACE-M: Provides GUNNS/ACE-M platform for running DS@S tools and applications and curates data that is disseminated via broadcast.

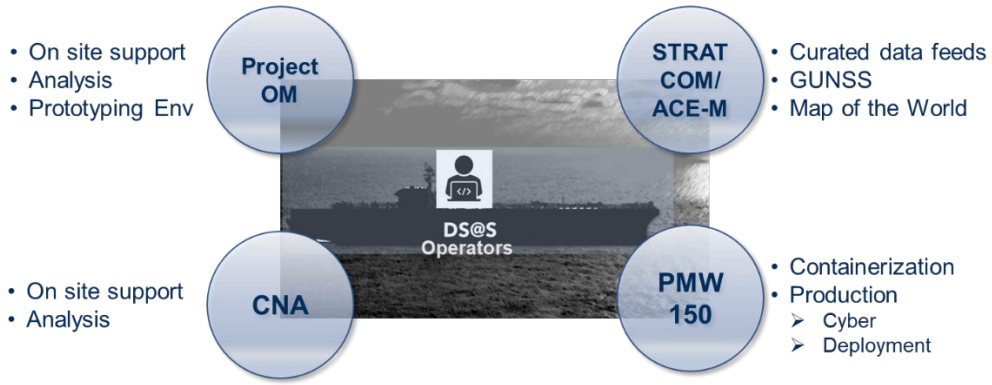

Figure 1. Organizations Supporting the DS@S Initiative

The DS@S-support teams are depicted in Figure 1 in conjunction with the functions that each provides. A biweekly stakeholder update has been established to articulate the status of the ONR Tech Solutions Topic 1000, Productionizing DS@S Capabilities. In addition to conveying status, the biweekly session facilities cross-organization collaboration to minimize redundancies across the efforts as well as establish synergies across the teams moving forward.

DS@S Software Factory Objectives

The purpose of the DS@S Software Factory is to facilitate converting Fleet-developed prototypes to cyber-secure, containerized applications that can be put through a production software engineering environment such as the Overmatch Software Armory (OSA) and deployed via the Overmatch Application Arsenal.

A software factory is a structured environment that uses standardized tools, processes, and reusable components to accelerate and improve software development, aiming for efficiency and quality through automation and assembly-line techniques. A software factory should reflect the desired process, incorporate recommended tools to implement the process, and host those tools in an environment that is both cost-effective and accessible to software developers, testers, and integrators.

A software factory supports the following concepts:

- Structured Approach: Software factories adopt a systematic approach to software development, mirroring manufacturing processes with defined workflows and standardized practices.
- Standardized Tools and Processes: Leverage a collection of tools, templates, and methodologies to streamline the development life cycle, from requirements gathering to deployment.
- Reusable Components: Software factories emphasize the reuse of code, modules, and other assets to reduce development time and effort.
- Automation: Automation is a key aspect of software factories, automating tasks like testing, deployment, and code generation to increase speed and reduce errors.
- Continuous Delivery: Software factories are often designed for continuous integration and delivery (CI/CD), allowing for frequent releases and updates.
- DevSecOps and Agile Principles: Software factories are often rooted in DevSecOps and agile software development principles, promoting collaboration, feedback, and iterative development.

The benefits of software factories can lead to increased efficiency, higher quality software, faster delivery times, and reduced costs.

Productionizing DS@S Pilot

The ONR Tech Solutions Office has initiated a Productionizing DS@S Capabilities Topic at Fleet request. This proof-of-concept pilot works with DS@S Officers-in-Charge (OICs) to prioritize the most mature and impactful DS@S operational prototypes. The DS@S OIC prioritized capabilities included Pelican which supports geospatial correlation for weapon-target pairing, and HORUS which supports the visualization of find, fix, track, target, engage, and assess (F2T2EA) kill webs.

The ONR Tech Solutions effort was broken down into three distinct phases to establish a pilot DS@S Software Factory for productizing DS@S capabilities. These phases are shown in Figure 2 and described by:

- Phase I:
  - Develop SOPs for containerizing and ensuring cyber compliance for DS@S capabilities
  - Demonstrate the SOP for select DS@S applications
  - Improve workflow automation and data ingest
- Phase II:
  - Demonstrate interoperability with the MTC2 Tactical Planning Tool and the CANES/ACS CJMTK Common Mapping Service
- Phase III:
  - Productionize capabilities through the OSA
  - Release capabilities to the Fleet via OSA's App Arsenal

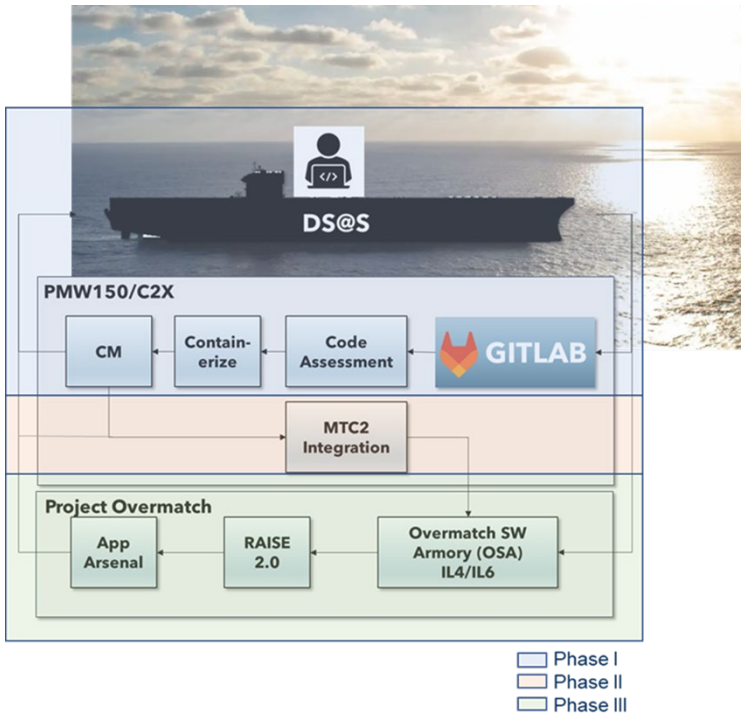

Figure 2. Phases for ProductionizingDS@S Capabilities

During Phase I of this effort a digital twin of the operational environment has been established in the PMW150 Command and Control Experimentation (C2X) facility. The digital twin reflects the capabilities that are included in the DS@S Toolkit and includes the ERSI ArcPro environment for running DS@S geospatial tools and JUYPTER for running the python implemented prototypes that have been developed. The digital twin also supports the STRATCOM ACE-M baseline including the NGA Map of the World that is used in the deployed environment. As part of the Phase I objectives, DS@S capabilities are assessed to decouple data from the code base and determine where automation can be incorporated into the prototype to improve the workflow. By decoupling sensitive data from the code base the code can be transferred via a Data Transfer Request (DTR) to the IL4 development environment so that a broader set of developers can have access to mature the capability.

Table 1 lists the components of the digital twin along with other software that reflects the run-time time environment for geospatial analytics.

Table 1. The Digital Twin Along with Supporting Run-Time Tools

VM	OS	Software	Version
C2XACAS	RHEL7	Nessus	8.13.1
c2xansible8yum	RHEL8	nginx	1.14.1
c2xarcgis	RHEL8	ArcGIS Enterprise	10.9.1
c2xacem	CentOS 8	ACE-M	2.X
		Map of the World	3.68.1
		Khonsu (Python)	1.0.7
dsas-jupyternb	W10	Python	3.12.4
		JupyterLab	4.2.4
		ArcGIS Pro	3.2.0
		Khonsu (ArcGIS Pro)	2/18/2025
		Horus	1/7/2025
		Pelican	1/7/2025
		Sahara	1/7/2025

The objective of Phase II is to demonstrate interoperability between select DS@S-developed capabilities and PMW150 PoRs and Project efforts. For example, synergies can be realized between the PMW150 Maritime Tactical C2 (MTC2) Tactical Planning Tool (TPT) with DS@S geospatial analytics to convey a spatial-temporal planning model on single pane of glass. These capabilities have been submitted as part of the FY27 Program Objective Memorandum (POM27).

The focus of Phase III efforts is to put select DS@S capabilities through the OSA software engineering production environment. The MTC2 PoR Leads are facilitating putting select DS@S capabilities through OSA as a MTC2 sub project. This includes meeting the MTC2 PoR on-ramp requirements.

DS@S Software Factory Process

The DS@S Software Factory process was developed to take sailor and analyst developed operational prototypes and provide software engineering to mature them as candidate capabilities to take into a production environment. The discrete steps are readily incorporated into a dashboard reflecting the status for each DS@S-developed capability. The current focus is to provide capabilities that are fielded in an afloat environment and hosted by CANES/Agile Core Services (ACS). The process can be easily tailored for other environments including shore-hosting and other Programs of Record (PoRs) production environments.

The current DS@S Software Factory process is delineated by:

1. Sailors and analysts develop capabilities afloat
2. Capability is posted to Collaboration at Sea as an agreed-upon communication channel for supporting Fleet submissions

3. Program or Project Transition team downloads from Collaboration at Sea to the digital twin intermediary staging environment
4. DS@S software is installed on the digital twin, evaluated against a set of submission checklists and evaluation reports. A submission report is generated, and the code is checked into CM
5. Refactor and rearchitect code as needed. Run validation testing and update CM
6. Post artifacts including Code, Documentation, Test Reports, and Briefs to the Navy Lift DS@S Collaboration site
7. Fleet validation—receive operator feedback via an on-prem instance
8. Incorporate Fleet updates
9. Containerize, scan, and test to align with target PoR. Update CM
10. Conduct OSA Onboarding TEM
11. Instantiate OSA project with the containerized capability
12. Develop CI/CD scripts and customize tooling
13. Execute the RAISE 2.0 process
14. Implementation on OpenShift, service mesh and ACS integration
15. Expose DS@S containerized capability in Application Arsenal (AA)
16. Operators pull DS@S capability from AA to install

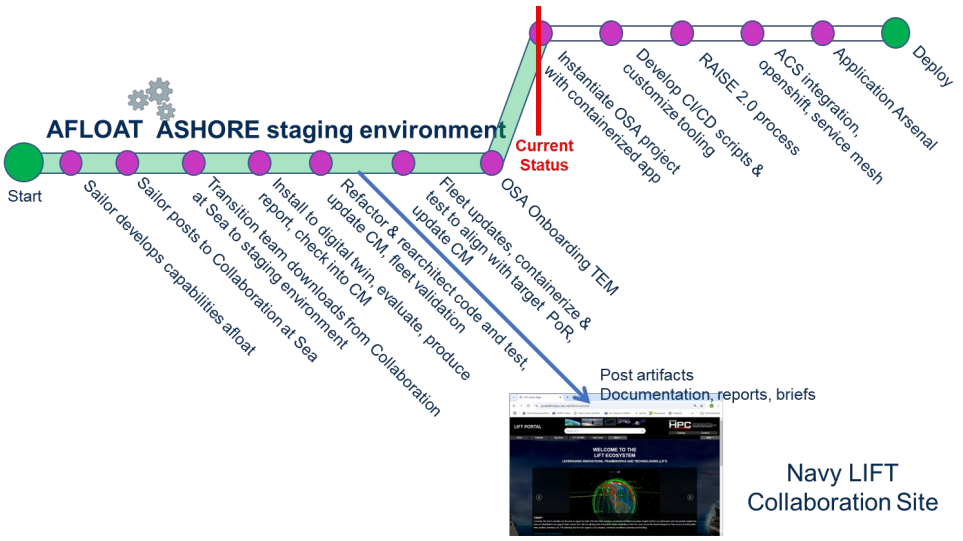

Figure 3. The DS@S Software Factory Process

DS@S Software Factory Implementation

The DS@S Software Factory has been implemented as a combination of the DS@S Toolkit, the GUNSS/ACE-M platform, a Test Manager tool, a Test Deployment environment, and leverages the Navy Lift collaboration software engineering environment. These components are shown DS@S Software Factory box in Figure 4.

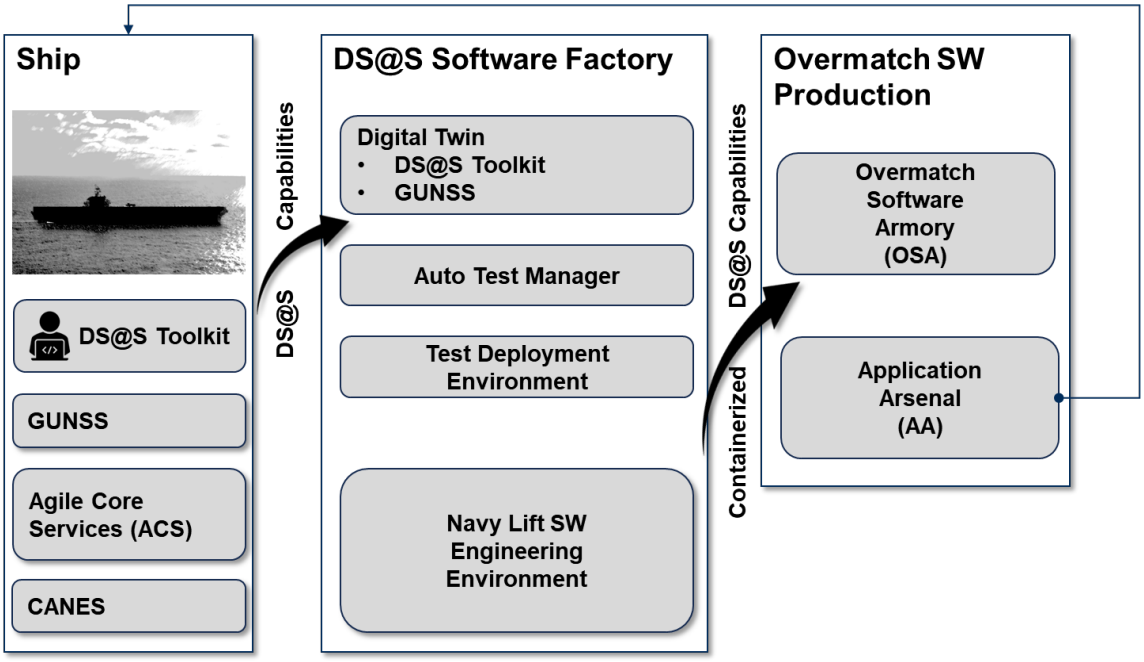

Figure4. The DS@S Software Factory Components and Workflow

It is noted that that this pilot project sought out a software engineering environment that is cost-effective, has a low barrier to entry for participating developers, and provides collaboration tools. For the current effort, Navy Lift meets most of the desired criteria by supporting common toolsets used in other DevSecOps environments.

Navy Lift provides a set of software engineering tools including Bitbucket, Artifactory, and Jenkins to support continuous integration and continuous deployment (CI/CD). It also provides SonarQube for static code analysis. Other tools for conducting container and Web-application vulnerability scans are being explored as potential add-ins for Lift or implementation in the DS@S Software Factory lab environment as an interim solution. These products are implemented in a manner to align to the Project OSA software engineering pipeline.

Once the DS@S Software Factory process is complete, DS@S-developed capabilities are delivered to a production environment. For deployed applications that run on CANES/ACS, OSA provides a Rapid Assess and Incorporate Software Engineering (RAISE) Platform of Choice (RPOC) to ensure cyber compliance by inheriting the security controls of the platform that has an Authorization to Operate (ATO).

An automated Test Manager (TM) is incorporated into the DS@S Software Factory to support the conversion of Fleet-developed prototypes into cyber-secure, containerized applications. Its automated test execution capabilities ensure that these prototypes are thoroughly tested for security and functionality before being integrated into production environments like the OSA. The TM leverages a comprehensive suite of technologies and tools, including GUI capture and playback, message generation and reception, scenario control, reporting, and traceability. These standardized tools streamline the testing life cycle, from requirements gathering to deployment. The TM emphasizes the reuse of test scripts, modules, and other assets, reducing development time and effort. This aligns with the software factory's goal of efficiency through reusable components. Automation of tasks like test execution, reporting, and traceability increases speed, reduces errors, and supports continuous testing. The automated TM provides increased efficiency via repeatable processes resulting in higher

quality software and reduced delivery times. The TM is provided to the DS@S Software Factory under a cost-free license model and is implemented in the on-prem environment.

Conclusion and Next Steps

DS@S operational prototyping is the epitome of speed to capability and provides immediate utility to Fleet operational needs. Productionizing capabilities ensures a cyber compliant application posture while scaling to Naval platforms. The approach and methods outlined in Productizing DS@S capabilities is aligned with the USN Information Superiority Vision to innovate and scale as well as follow modern development practices to deliver operational capabilities at speed and scale via DevSecOps practices with integrated security measures at the early phases of the software development life cycle.

There is a need to grow the cadre of Uniform and in-situ developers. The DS@S Production environment has been selected by the Naval Postgraduate School (NPS) as an OPNAV-submitted research topic for the 2025/26 academic year. Other avenues being investigated include collaboration with emerging Naval Software Factories. These collaborations could converge software engineering pipelines and practices in conjunction with other Sailor (and Marine) developers. Finally, the DS@S tenets could be followed to support establishing a Data Science at the MOC (DS@M) initiative.

Both Uniform-driven development and the resulting Fleet-developed warfighting products require sustainment to provide continued prototyping and production support to proliferate and scale applications to the broader Naval warfighting community. While sustainment of select capabilities has been submitted for POM consideration, the sustainment of the DS@S baseline operational prototyping capability and production pipeline requires dedicated initiative.

Acknowledgements

This work was sponsored by ONR Tech Solutions under Topic 1000. The DS@S Production Pilot development and engineering team included Nick Abuzalaf, Jesse Chen, Doug Miller, Zach Vaughter, Nick Keele and Roger Kelly who contributed to this effort.

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