# Naval Information Warfare Center Atlantic

## Model-Based Systems Engineering / Digital Engineering / Model Based Engineering

### *Where We've Been & Where We're Headed*

# NIWC Atlantic
# Technology Focus Areas (TFAs) circa 2021

Utilizing overarching DoD, naval, and NAVWARSYSCOM strategic plans, investment budgets, and formal naval needs and gaps statements, NIWC Atlantic will soon release a revised Technical Strategy which has revised the list to include Artificial Intelligence and Cybersecurity.

**Artificial Intelligence:** Provide warfighters with analytics-driven, data-informed, and technology-empowered capabilities to drive decision advantages and optimal mission outcomes. (Rob Keisler)

**Assured Communications:** Addresses the demand for resilient, and sometimes covert, wired and wireless communications in degraded and/or denied environments. (Ann Rideout)

**Cloud Computing:** IT modernization and digital transformation for resilient infrastructure, platform and software services. (Ann Rideout/Kathryn Murphy)

**Cybersecurity:** Provides protection from unauthorized use of and/or defends electronic data, hardware, software from disruption or of the services they provide (Hank Osborne)

**DevSecOps:** Refers to replacing siloed Development, Security and Operations to create multidisciplinary teams that collaborate with shared and efficient practices and tools. (Kathryn Murphy)

**Mobility:** Provide Wireless Technology and enterprise access for the warfighter to engage with a mobile environment and applications, anytime, anyplace (Ann Rideout)

**Model-Based Systems Engineering (MBSE):** Technologies used to support the development, management and application of virtual constructs of varying fidelity across the spectrum of systems engineering. (Paul Walter)

**On-Demand Manufacturing:** Produce products and/or components, when or as they are required at the point of use, using additive and/or traditional manufacturing methods. (Steve Lariviere)

# Why Model-Based Systems Engineering?



"Our current defense acquisition system applies industrial age processes to solve information age problems."

  ▪ LtGen Robert D. McMurray, AFLCMC/CC

## Practices and Challenges in Today's World

**1** Mission complexity is growing faster than our ability to manage it . . . increasing mission risk from inadequate specifications and incomplete verification.

**2** System design emerges from pieces, rather than from architecture . . . resulting in systems that are brittle, difficult to test, and complex and expensive to operate.

**3** Knowledge and investment are lost at project life cycle phase boundaries . . . increasing development cost and risk of late discovery of design problems

**4** Knowledge and investment are lost between projects . . . increasing cost and risk: dampening the potential for true product lines.

### Exceeding the capabilities of traditional approaches

• System scale

• Mission complexity

• Solution technologies

• Project team complexity

• Dynamic complexity


A WORLD IN MOTION

3
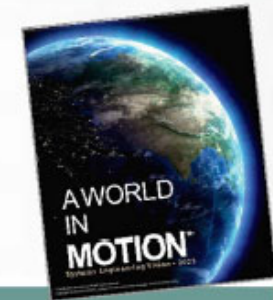
# MBSE Measures of Success
## June 2018 vs Dec 2019

| Category | Measure | Stretch Goal (Dec 2019) | June 2018 | Dec 2019 |
|---|---|---|---|---|
| Capable Workforce | # employees certified in OMG Certified System Modeling Professional (OCSMP) | 15 | 0 | 18 |
| Capable Workforce | # employees trained in MBSE AND have advanced MBSE tool access | 75 | 0 | 94 |
| Doing MBSE | # employees who are MBSE COI members AND are applying MBSE practices | 50 | 5 | 56 |
| Doing MBSE | # successful MBSE pilots | 16 | 0 | 19 |

# MBSE Goals & Objectives
## CY2020 & 2021

⭐ Metrics tracked

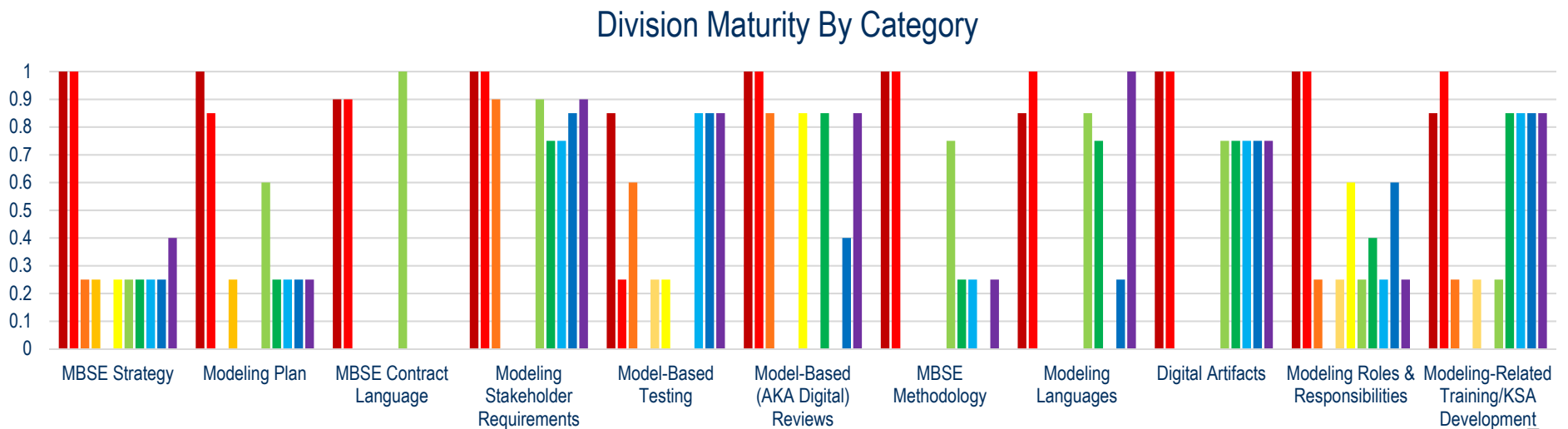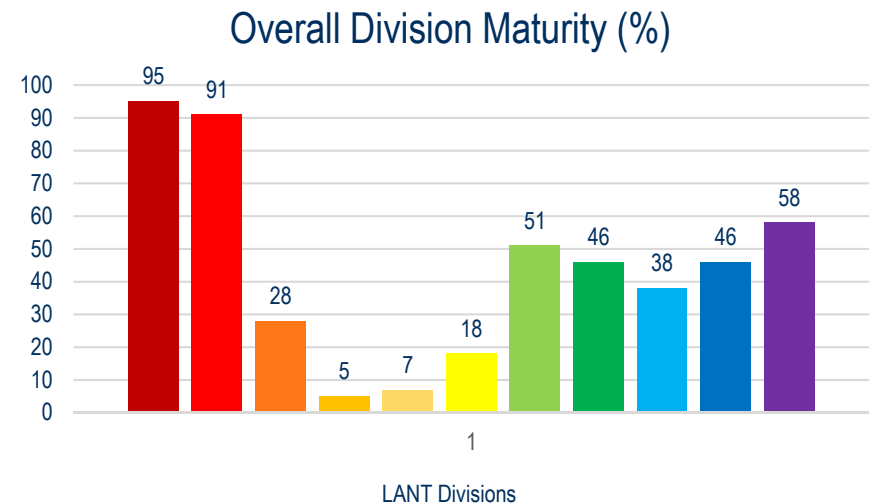| Goal | Obj # | Due Date | Objective |
|------|-------|----------|-----------|
| **NIWC LANT MBSE GOALS & OBJECTIVES** | | | |
| Data-Driven Decisions | 1.1 | 2020 | Share successes from PM tools or BI tools that has saved time, money, etc. at the Project and IPT levels across the Command for consideration of investment |
| | ⭐1.2 | 2021 | Establish initial LVC environment capability that addresses focus on C4ISR |
| Model Use & Reuse | ⭐2.1 | 2020 | Identify which programs/projects should be be adopting MBSE practices |
| | ⭐2.2 | 2020 | Increase # artifacts that are generated/updated from and to (system) models |
| | ⭐2.3 | 2020 | Increase # of projects/IPTs that have captured requirements in requirements diagrams in the Naval IME |
| | 2.4 | 2021 | Increase # of reference model patterns for use in developing system models |
| | 2.5 | 2021 | Determine how model-based approach can be used to ultimately reduce amount of manual testing conducted and increase scope/accuracy of testing |
| | ⭐2.6 | 2021 | Increase # of IPTs that (in any capacity) are reviewing models vice artifacts for reviews (any type - PMR, SETR, HIR-like, other technical review) |
| | 2.7 | 2021 | Capture metrics associated models that qualify as true "digital twins" (i.e. incorporate some form of real-time feedback mechanism from operational system to model) |
| Organizational MBSE Maturity | ⭐3.1 | Annual | Understand the modeling practices and associated modeling tools currently in use at NIWC Atlantic |
| | ⭐3.2 | 2020 | Establish mechanism to reward MBSE successes and smart failures & Establish communication plan for MBSE success stories |
| | ⭐3.3 | Annual | Conduct an MBSE Challenge. The Problem Statement for the FY20 MBSE Challenge is How does NIWC Atlantic best manage end strength while still meeting customer needs? |
| | ⭐3.4 | 2020 | Help teams execute MBSE methodologies |
| | ⭐3.5 | 2021 | Use MBSE language from MBSE Guidebook in contracts |
| | ⭐3.6 | Annual | Continue annual reconsiderations of what training needed for workforce and how it gets paid for (852, NISE, POH) |
| | ⭐3.7 | Annual | Maximize the syncronized use of NISE, 852, POH and direct funds for MBSE-related innovation |
| | 3.8 | 2021 | Improve our ability to field and provide model-based services (e.g. model development, model analysis… for various project types, modeling domains) |
| | 3.9 | 2021 | Establish a collaborative MBSE environment / modeling war room in Charleston |
| | ⭐3.10 | 2020 | Collaborate with DoN M&S to establish central repositor(ies) where non-SysML models will go; Establish connective tissue b/t Naval IME and other modeling environments |
| MBSE Guidance | ⭐4.1 | 2020 | Develop MBSE Guidebook v2.0 |
| | ⭐4.2 | 2021 | Develop MBSE Guidebook v3.0 |

5

# MBSE Engagement
## Department and IPT Reporting

| #IPTs Reporting Some Level of MBSE Engagement | | | | |
|---|---|---|---|---|
| Department or T1 Competency | #Divisions Reporting Engagement | % | #IPTs Reporting Engagement | % |
| Enterprise Systems VACANT (5 DIVISIONS) (18 IPTS) | 5 | 100% | 11 | 61% |
| Expeditionary Warfare Ashlee Landreth (4 DIVISIONS) (20 IPTS) | 4 | 100% | 10 | 50% |
| Fleet C4I & Readiness Greg Lancaster (9 DIVISIONS) (38 IPTS) | 6 | 67% | 10 | 26% |
| Shore C2ISR & Integration Bruce Carter (6 DIVISIONS) (25 IPTS) | 4 | 67% | 9 | 36% |
| COMMAND (BY IPT) | 22 | 81% | 40 | 40% |



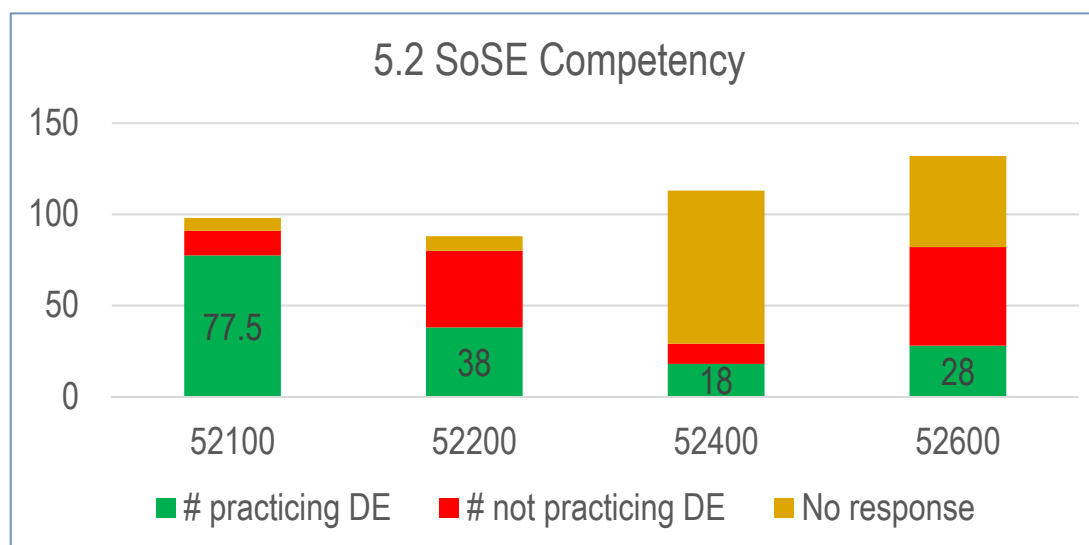#IPTS REPORTING MBSE ENGAGEMENT (AUG 2021)
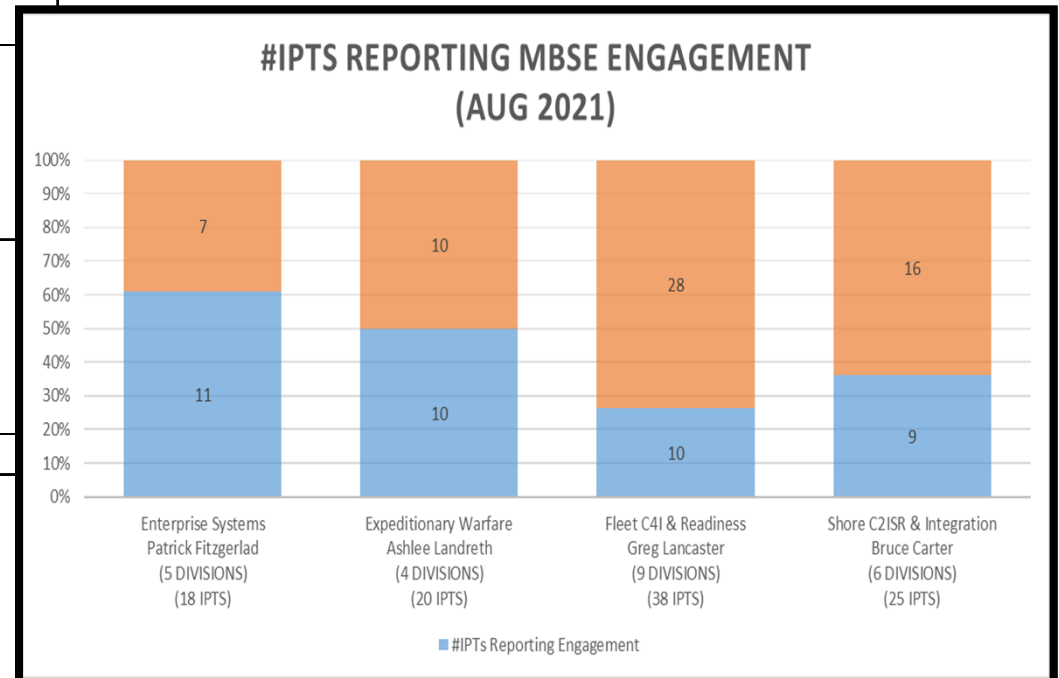
# MBSE Maturity
## By Division & IPT

▼ **11 Divisions & 34 IPTs surveyed across 3 Departments**

▼ **Average Division Maturity: 44%**

▼ **Average IPT Maturity: 39%**

▼ **IPT Maturity by Category:**

- Success in Requirements (53%), Digital Artifacts (54%), and Training (57%)

- Less Mature in Contract Language (21%) and Methodology (22%)

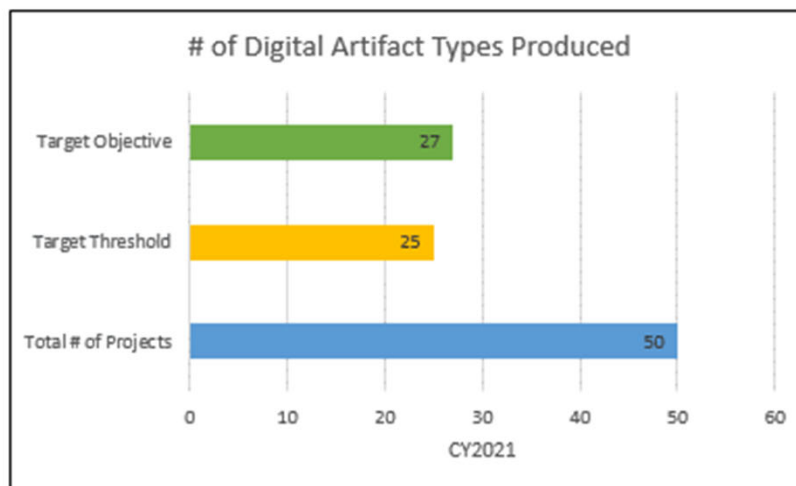### Overall Division Maturity (%)



LANT Divisions

### Division Maturity By Category



7

# Model Based Practices
## within the SoSE Competency (as of Feb 2022)



5.2 SoSE Competency

■ # practicing DE   ■ # not practicing DE   ■ No response

8

**Naval Information Warfare Center**

**ATLANTIC**

# Digital Artifacts



# of Projects Producing Digital Artifacts

| | |
|---|---|
| Target Objective | 40 |
| Target Threshold | 33 |
| Total # of Projects | 54 |

CY2021

# of Tools Used

| | |
|---|---|
| Target Objective | 8 |
| Target Threshold | 6 |
| Total # of Projects | 16 |

CY2021

# of Digital Artifact Types Produced

| | |
|---|---|
| Target Objective | 27 |
| Target Threshold | 25 |
| Total # of Projects | 50 |

CY2021

9

# MBSE/DE
# Return on Investment

# MBSE/DE Challenge & DE Recognition
## Gauging Employee Recognition

**Naval Information Warfare Center ATLANTIC**



TOTAL # OF MBSE RELATED AWARDS - 2020 (Obj 3.2)

**2020**



# OF MBSE AWARDS GIVEN BY CATEGORY (Obj 3.2)

- NAVWAR HQ — 19
- NIWC ATLANTIC COMMAND — 6
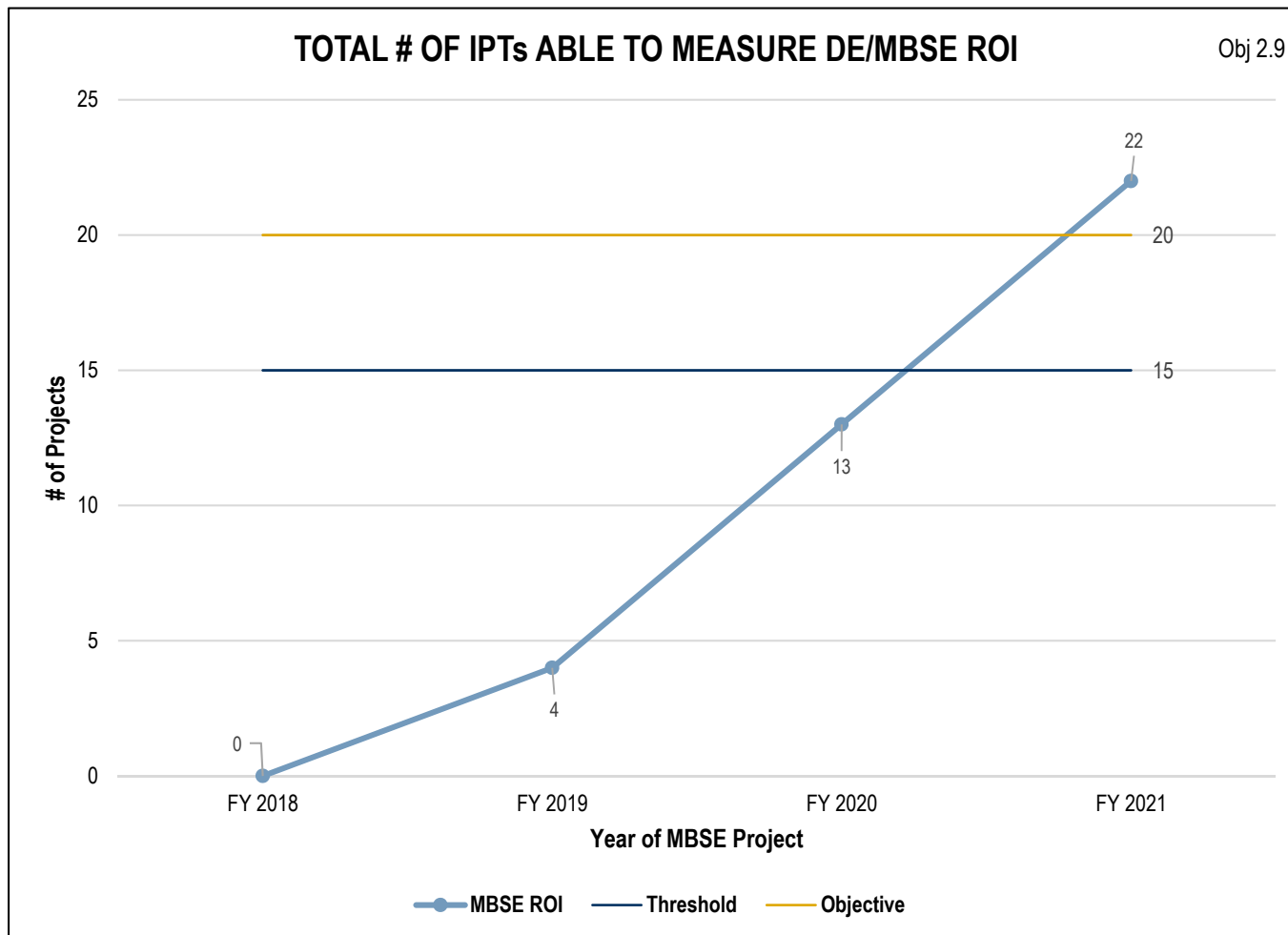- Fleet C4I and Readiness — 2
- C2ISR and Ashore Department
- Enterprise Systems — 16
- Expeditionary Warfare — 6
- Competencies
- MBSE / DE Challenges — 23
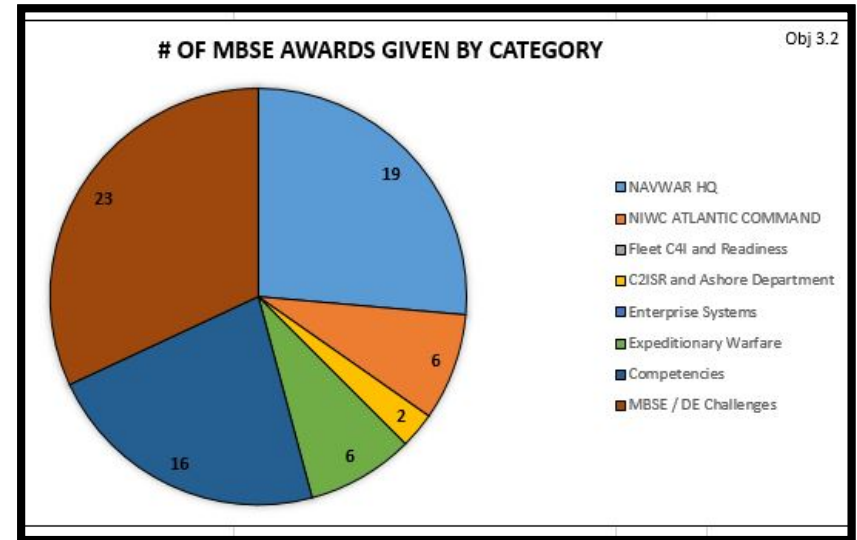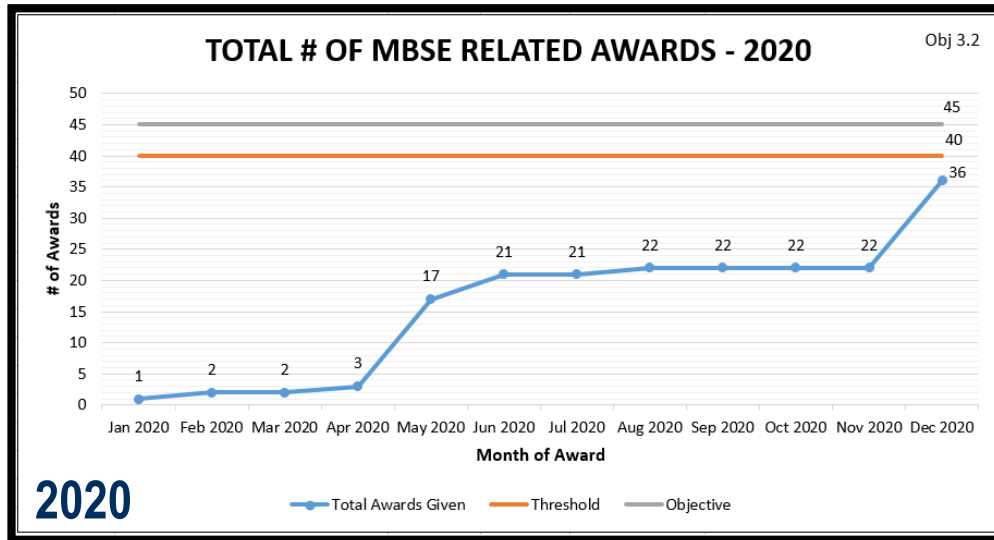
| # OF MBSE/DE CHALLENGE PROPOSALS | | |
|---|---|---|
| Year | # of Teams who submitted Proposals | # of teams selected to compete |
| Spring 2020 | 3 | 3 |
| Fall 2020 | 10 | 5 |
| Spring 2021 | 5 | 5 |
| Fall 2021 | 7 | 4 |
| Spring 2022 | 11 | 5 |



TOTAL # OF MBSE RELATED AWARDS - 2021 (Obj 3.2)

**2021**

11
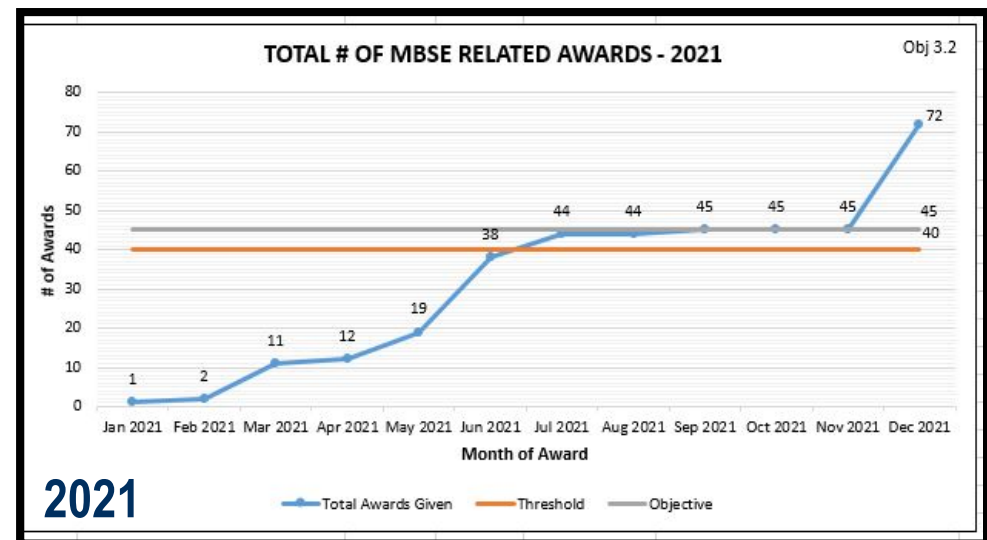
# Spring 2021 Digital Engineering Challenge

## MBSE RMF Workflow

- Problem Statement #13 – Incorporate MBSE techniques into RMF workflow (Dept: NAVWAR HQ Cybersecurity Transformation Team)

- Summary: Incorporated MBSE into RMF workflow by developing capability to incorporate PPSM (Ports, Protocols, and Services Management) CAL (Category Assurance List) & PPSM Registration Spreadsheet into a Program Model

## Team Impossible

- Problem Statement #10 – Enable Automated Ingestion of Legacy Data/Artifacts (Dept: NAVWAR HQ DE Team)

- Summary: Enabled automated ingestion of legacy data/artifacts into a model. Used readily available tools to automate converting and importing existing SE documentation into a digital model; thus, reducing cost and time needed to adapt DE principles.

## No Magic Kingdom

- Problem Statement #2 – Efficient self-reporting and transmission of system health data (Dept: Fleet C4I & Readiness)

- Summary: Used MBSE tool to model a self-monitoring, self-reporting system to transmit system health in an intermittent, low bandwidth environment. Modeled system includes a secure means of transmission and storage and depicts system message prioritization for low bandwidth situations.

## Tail Ends Refactored

- Problem Statement #1 – Simulation framework for wargaming scenarios (Dept: Expeditionary Warfare)

- Summary: Combined standard behavioral and parametric modeling with mission modeling to simulate wargaming efforts. Used MBSE tools suite to build a template for creating simulated mission thread models. Built a framework model to simulate a capability based mission thread.

## The Fax Machines

- Problem Statement #12 – Utilize 3D scanning techniques to create an accurate, data-rich, physical model (Dept: NAVWAR HQ DE Team)

- Summary: Used 3D scanning techniques to create an accurate, data-rich, physical model. Leveraged 3D scanning software and game engine to generate/incorporate 3D scans into mixed reality, allowing for realistic and accurate models that can be used for multiple applications.

# Spring 2022 DE Challenge
## The ASK

▼ The DE Challenge ASK:

- We are asking teams to demonstrate how integration of multiple DE domains can offer a superior technical solution to a relevant DoN-centric problem set.

- Teams can bring their own problem set (although you are welcome to review previous DE Challenge problem statements for ideas – see BACKUP slides for details)

- Selected teams will ultimately record a 10-15 minute that demonstrates this DE thread integration

- Each team must demonstrate the successful and seamless integration of at least two of the DE domains below.  (Note at least one of the DE domains being integrated MUST be either MBSE or MBE / Physical Modeling / 3D Modeling)

- **MBSE / System Modeling**
- **MBE / Physical Modeling / 3D Modeling**
- Product Lifecycle Mgt / Product Data Management (PLM/PDM)
- Physics-based M&S
- Virtual or Augmented Reality
- Network M&S
- Mission Engineering / Mission M&S

- Manufacturing Models
- AI / ML
- Software / DevSecOps
- Management Models (e.g., cost, schedule, risk, etc.)
- HSI/HFE
- Product Support Models
- Specialty Engineering Models
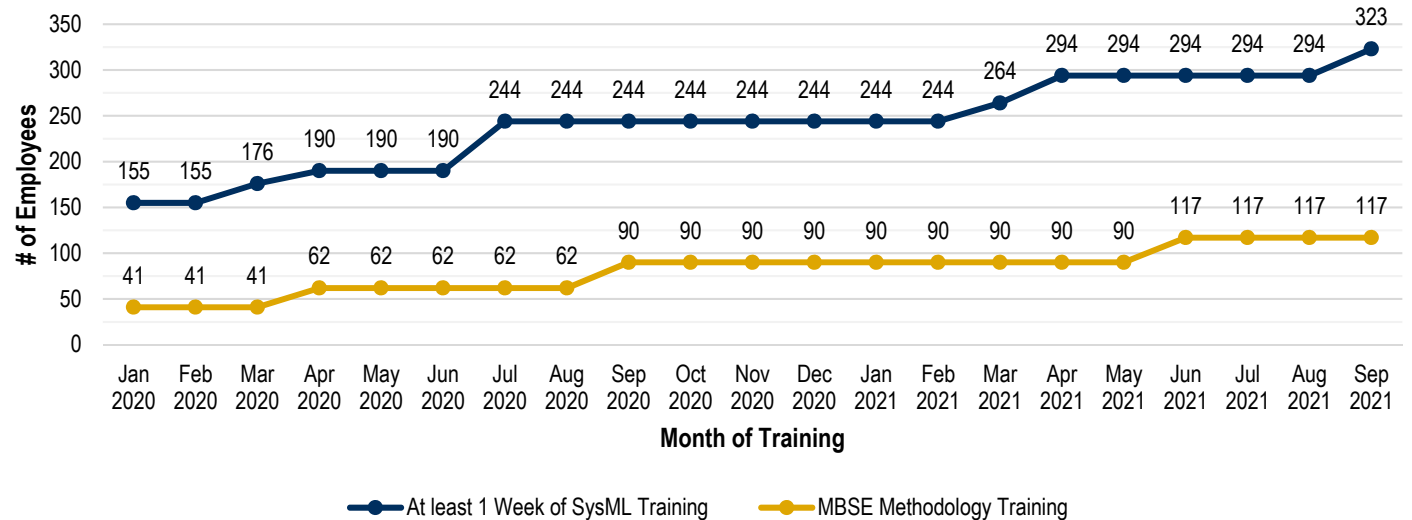- RF/Comms/Antenna M&S

# MBSE Training

## TOTAL # OF EMPLOYEES TRAINED IN INTRO TO MBSE
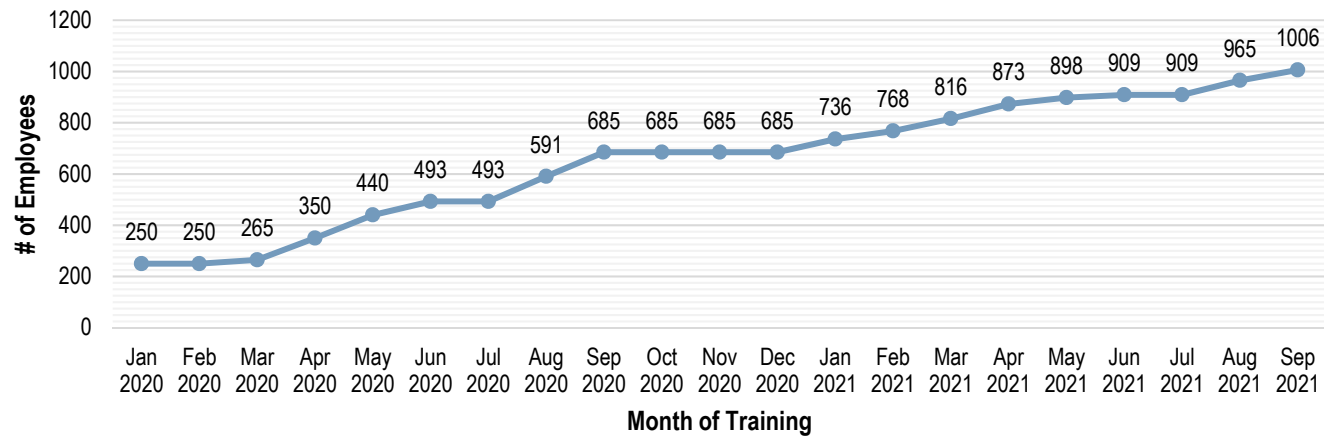


## TOTAL # OF EMPLOYEES TRAINED IN SYSML/MBSE



At least 1 Week of SysML Training    MBSE Methodology Training

# MBSE Certifications

**TOTAL # OF OMG CERTIFIED SYSTEMS MODELING PROFESSIONALS - LEVEL 1**

# of Employees

80, 70, 60, 50, 40, 30, 20, 10, 0

17  19  30  36  40  40  41  54  54  54  54  54  54  54  57  60  64  66  66  68

Jan 2020, Feb 2020, Mar 2020, Apr 2020, May 2020, Jun 2020

**TOTAL # OF OMG CERTIFIED SYSTEMS MODELING PROFESSIONALS - LEVEL 2**

# of Employees

40, 35, 30, 25, 20, 15, 10, 5, 0

7  7  15  20  22  22  23  27  27  27  27  27  27  27  27  27  30  31  34  34

Jan 2020, Feb 2020, Mar 2020, Apr 2020, May 2020, Jun 2020, Jul 2020, Aug 2020, Sep 2020, Oct 2020, Nov 2020, Dec 2020, Jan 2021, Feb 2021, Mar 2021, Apr 2021, May 2021, Jun 2021, Jul 2021, Aug 2021, Sep 2021

**Month of Certification**

OCSMP Level 2 (Model Builder - Fundamental)    Series5    Series6

**Note**: One employee has also achieved OCSMP Level 3 & 4 certifications

# Model-Based Pilots
## & Sources of Funding

**CUMULATIVE # OF PILOT PROJECTS BY CATEGORY**

| Category | Cumulative # of Pilot Projects |
|---|---|
| Mixed Reality | 17 |
| Physical Modeling | 17 |
| LVC | 8 |
| MBSE | 37 |

**CUMULATIVE # OF INNOVATIVE PILOT PROJECTS BY SOURCE OF FUNDING**

Legend: Unknown, NISE, POH, Project Dollars
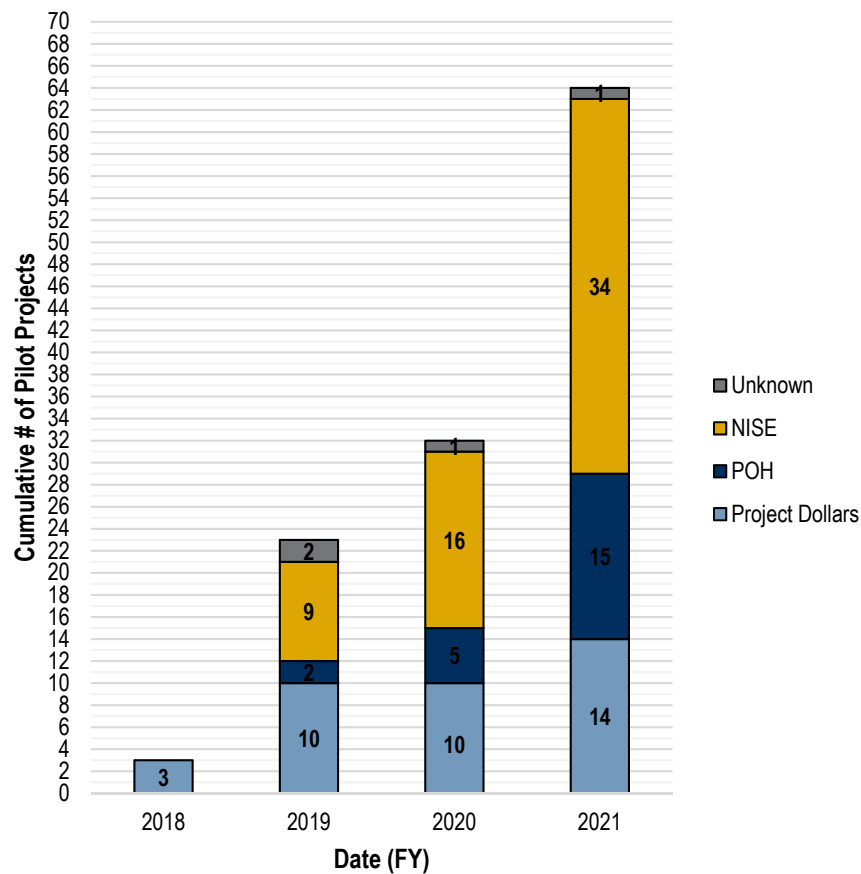
| Date (FY) | Project Dollars | POH | NISE | Unknown |
|---|---|---|---|---|
| 2018 | 3 | | | |
| 2019 | 10 | 2 | 9 | 2 |
| 2020 | 10 | 5 | 16 | 1 |
| 2021 | 14 | 15 | 34 | 1 |
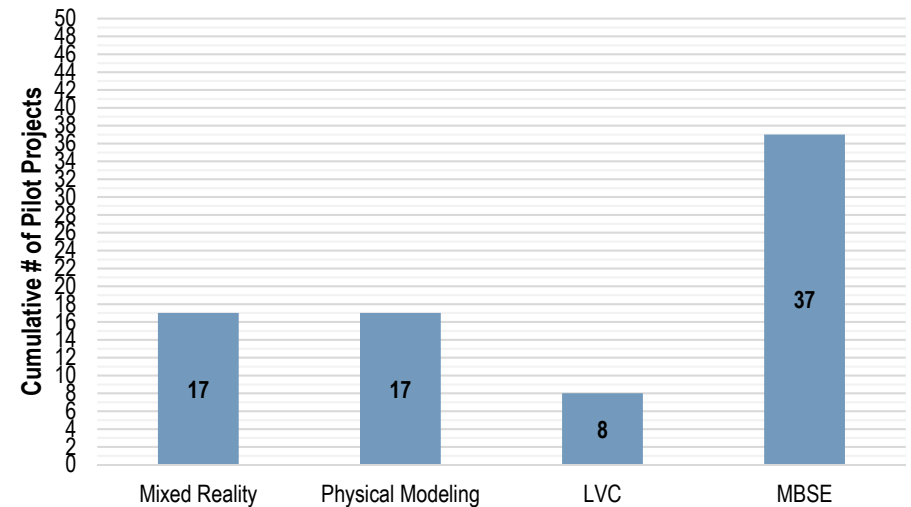
**TOTAL # OF MBSE PILOTS**

Obj 3.7

| Year of MBSE Pilot | # of Pilots |
|---|---|
| FY 2018 | 4 |
| FY 2019 | 25 |
| FY 2020 | 37 |
| FY 2021 | 74 |
| FY 2022 | 81 |
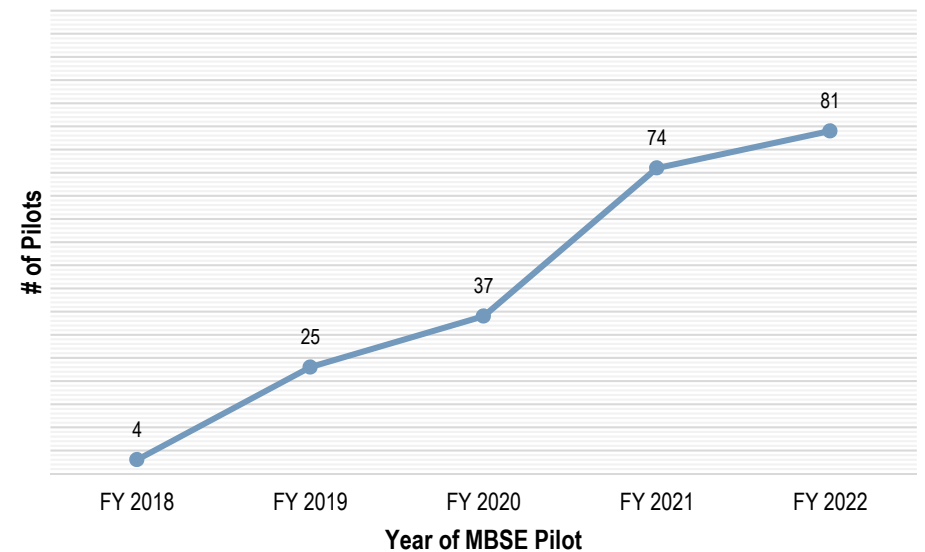
**Note**: Digital Engineering / LVC Strategic Investment Area (SIA) started in FY21

16

# MBSE Tool Access (NIPR Only)
## Cameo Systems Modeler on the Naval IME

### ACCESS TO MBSE TOOLS BY MACHINE TYPE



- NMCI: 259
- RDT&E: 90

### ACCESS TO MBSE TOOLS BY COMPETENCY

Obj 3.8



| Competency | # of Employees |
|---|---|
| 4.0 | 9 |
| 5.2 | 153 |
| 5.4 | 43 |
| 5.5 | 38 |
| 5.6 | 24 |
| 5.9 | 24 |
| 7.0 | 5 |
| Other | 50 |

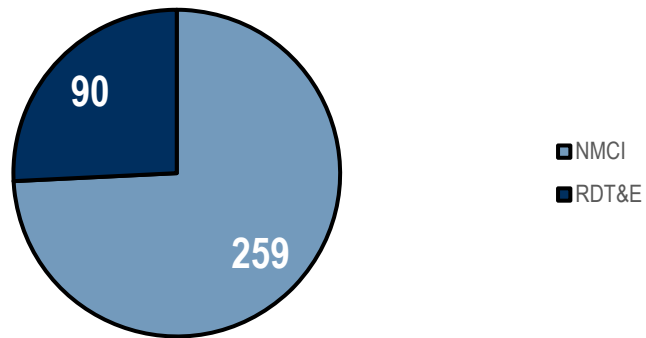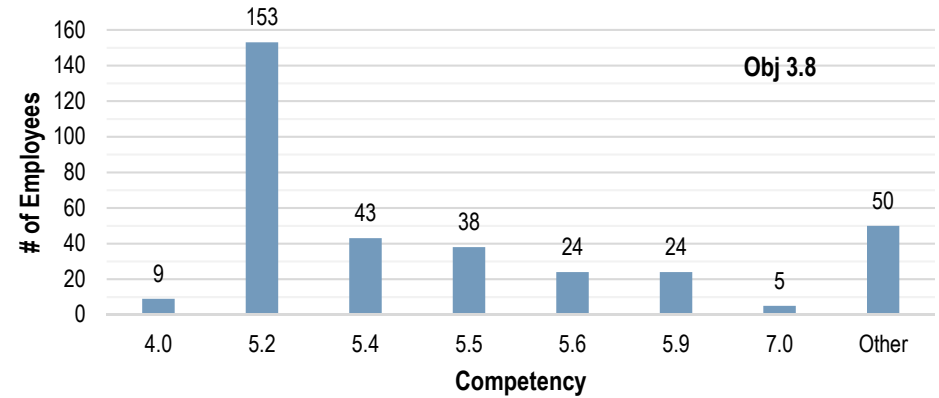### EMPLOYEES WITH ACCESS TO MBSE TOOLS



| Month of Access | # of Employees with Access |
|---|---|
| Nov 2018 | 16 |
| Dec 2018 | 24 |
| Jan 2019 | 37 |
| Feb 2019 | 52 |
| Mar 2019 | 65 |
| Apr 2019 | 78 |
| May 2019 | 85 |
| Jun 2019 | 99 |
| Jul 2019 | 116 |
| Aug 2019 | 127 |
| Sep 2019 | 149 |
| Oct 2019 | 162 |
| Nov 2019 | 168 |
| Dec 2019 | 182 |
| Jan 2020 | 190 |
| Feb 2020 | 201 |
| Mar 2020 | 220 |
| Apr 2020 | 229 |
| May 2020 | 236 |
| Jun 2020 | 242 |
| Jul 2020 | 248 |
| Aug 2020 | 255 |
| Sep 2020 | 267 |
| Oct 2020 | 270 |
| Nov 2020 | 275 |
| Dec 2020 | 279 |
| Jan 2021 | 285 |
| Feb 2021 | 290 |
| Mar 2021 | 298 |
| Apr 2021 | 306 |
| May 2021 | 317 |
| Jun 2021 | 323 |
| Jul 2021 | 332 |
| Aug 2021 | 342 |
| Sep 2021 | 348 |

# NIWC Atlantic MBSE
## Community of Interest

| MBSE COI Metrics | |
|---|---|
| # of MBSE COI Members | 485 |
| MBSE COI Page # of Views | 8368 |



# OF PARTICIPANTS AT MONTHLY COI EVENTS
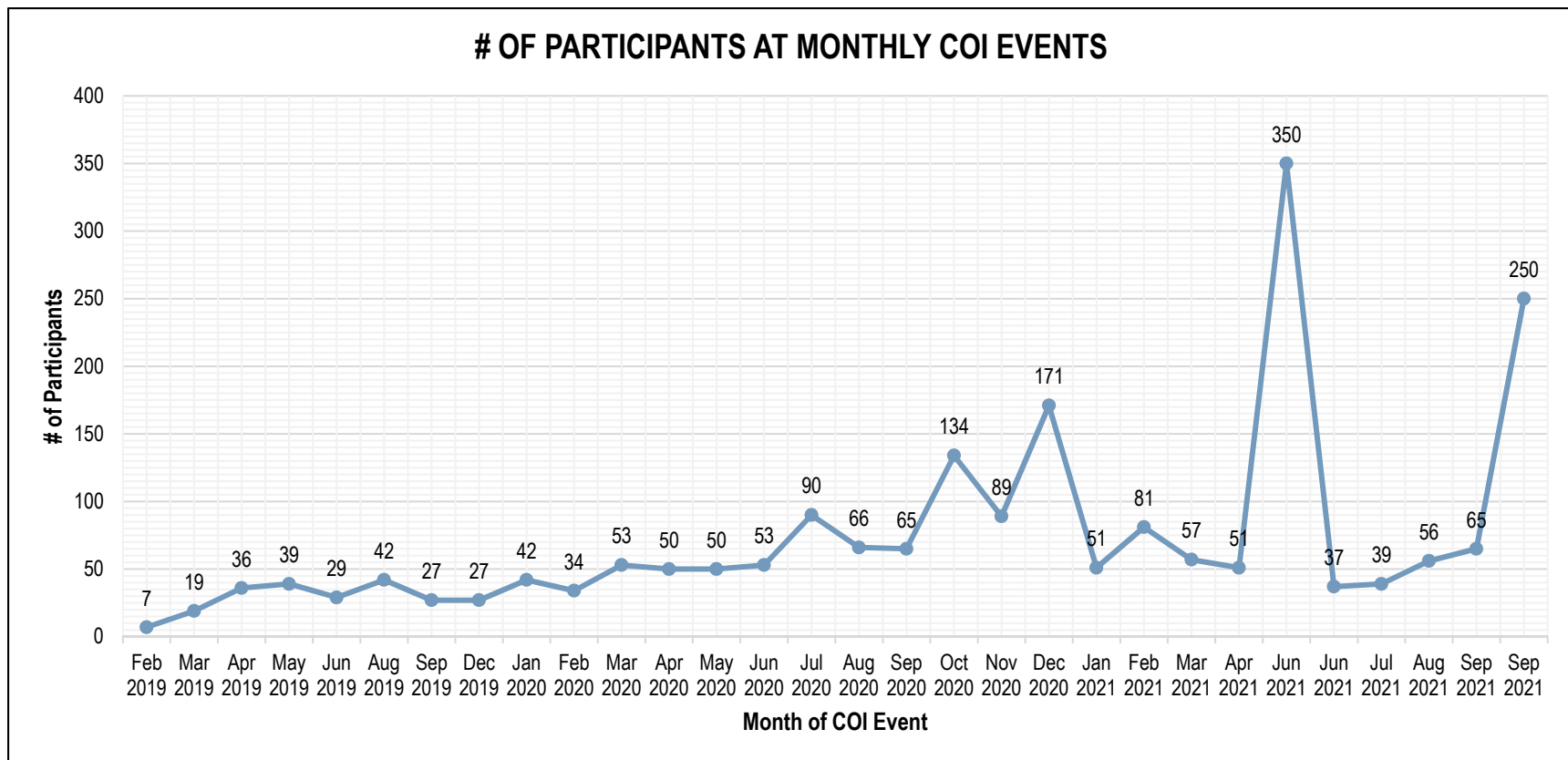
# MBSE Guidebook
## Articles of Interest

Cumulative # OF MBSE GUIDEBOOK VIEWERS FY21 Q4
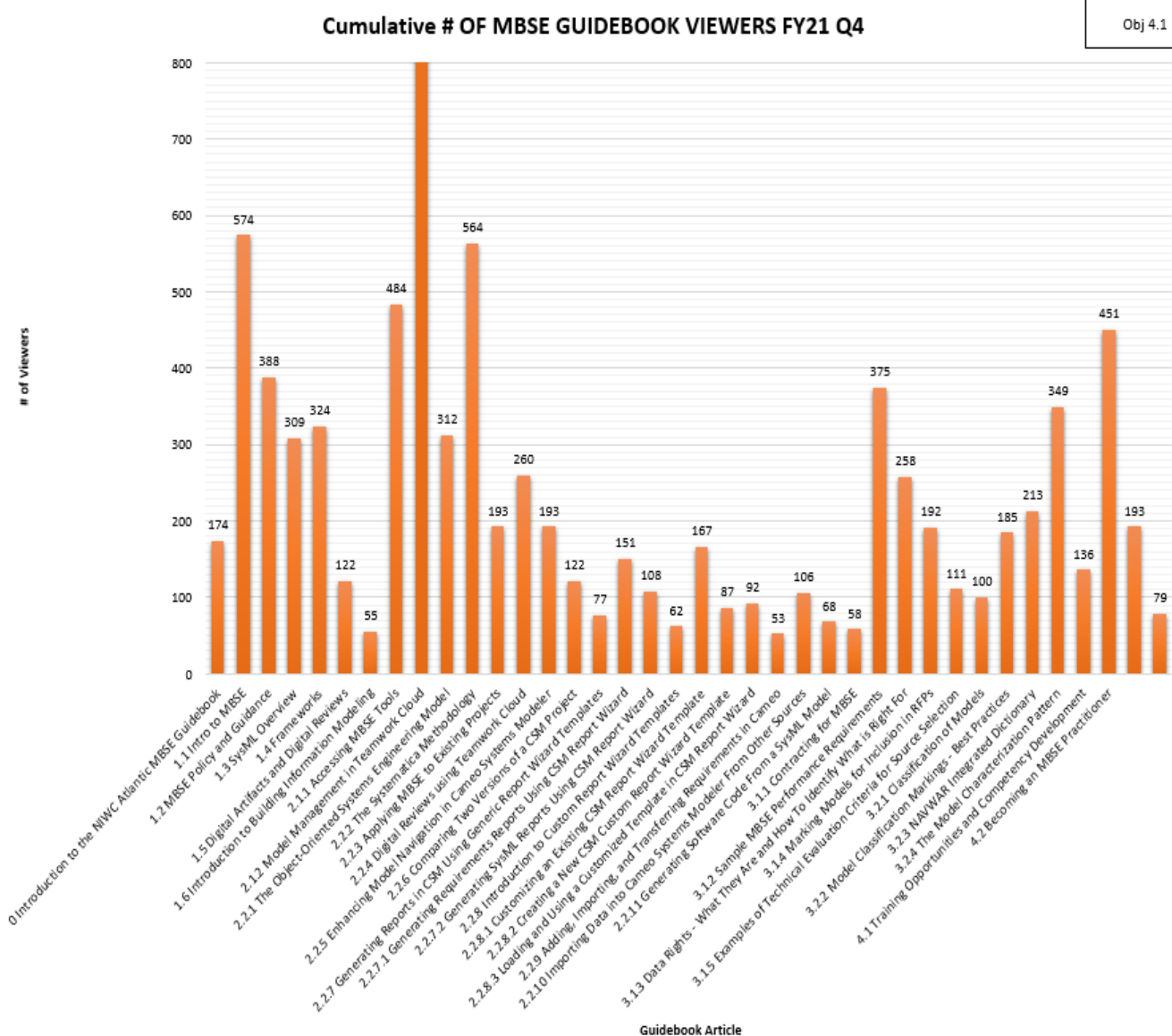
▼ Total MBSE Guidebook articles: 50

▼ New articles: 13

▼ Total views: 17,933

▼ Most popular MBSE Guidebook articles

- Intro to MBSE
- Accessing MBSE Tools
- Object-Oriented SE Method (OOSEM)
- MBSE Policy & Guidance
- Contracting for MBSE
- Integrated Dictionary
- Training Opportunities & Competency Development

19

# Naval Information Warfare Center Atlantic

## Model Based Engineering Strategic Plan

## April 2022 to March 2024

*NIWC Atlantic is part of the Naval Research & Development Establishment (NR&DE)*

# INCOSE Systems Engineering Vision 2035
## Challenges

**Applications**
1. Systems engineering contributes innovative solutions to major societal challenges.
2. Systems engineering demonstrates value for projects and enterprises of all scales, and applies across an increasing number of domains.

**Practices**
3. Systems engineering anticipates and effectively responds to an increasingly dynamic and uncertain environment.
4. Model-based systems engineering, integrated with simulation, multi-disciplinary analysis, and immersive visualization environments is standard practice.
5. Systems engineering provides the analytic framework to define, realize, and sustain increasingly complex systems.
6. Systems engineering has widely adopted reuse practices such as product-line engineering, patterns, and composable design practices.

**Tools and Environment**
7. Systems engineering tools and environments enable seamless, trusted collaboration and interactions as part of the digital ecosystem.

**Research**
8. Systems engineering practices are based on accepted theoretical foundations and taught as part of the systems engineering curriculum.

**Competencies**
9. Systems engineering education is part of the standard engineering curriculum, and is supported by a continuous learning environment.

# Digital Engineering Strategic Guidance



**INCOSE Systems Engineering Vision 2035**

**DoD Digital Engineering Strategy**

**US Naval Digital Systems Engineering Transformation Strategy**

**NAVWAR Strategic Vector**

**NIWC Atlantic Execution Plan**

**Naval Digital Systems Engineering Transformation Working Groups**

**NAVWAR Digital Engineering Policy**

# NIWC Atlantic Model Based Engineering
## Strategic Goal Areas



**Goal 1**
Model Based Systems Engineering (MBSE)

**Goal 2**
Model Based Logistics

**Goal 5**
Cross Cutting Model Based Concepts

**Goal 3**
Physical Model Based Engineering

**Goal 4**
Live, Virtual, Constructive (LVC) Engineering
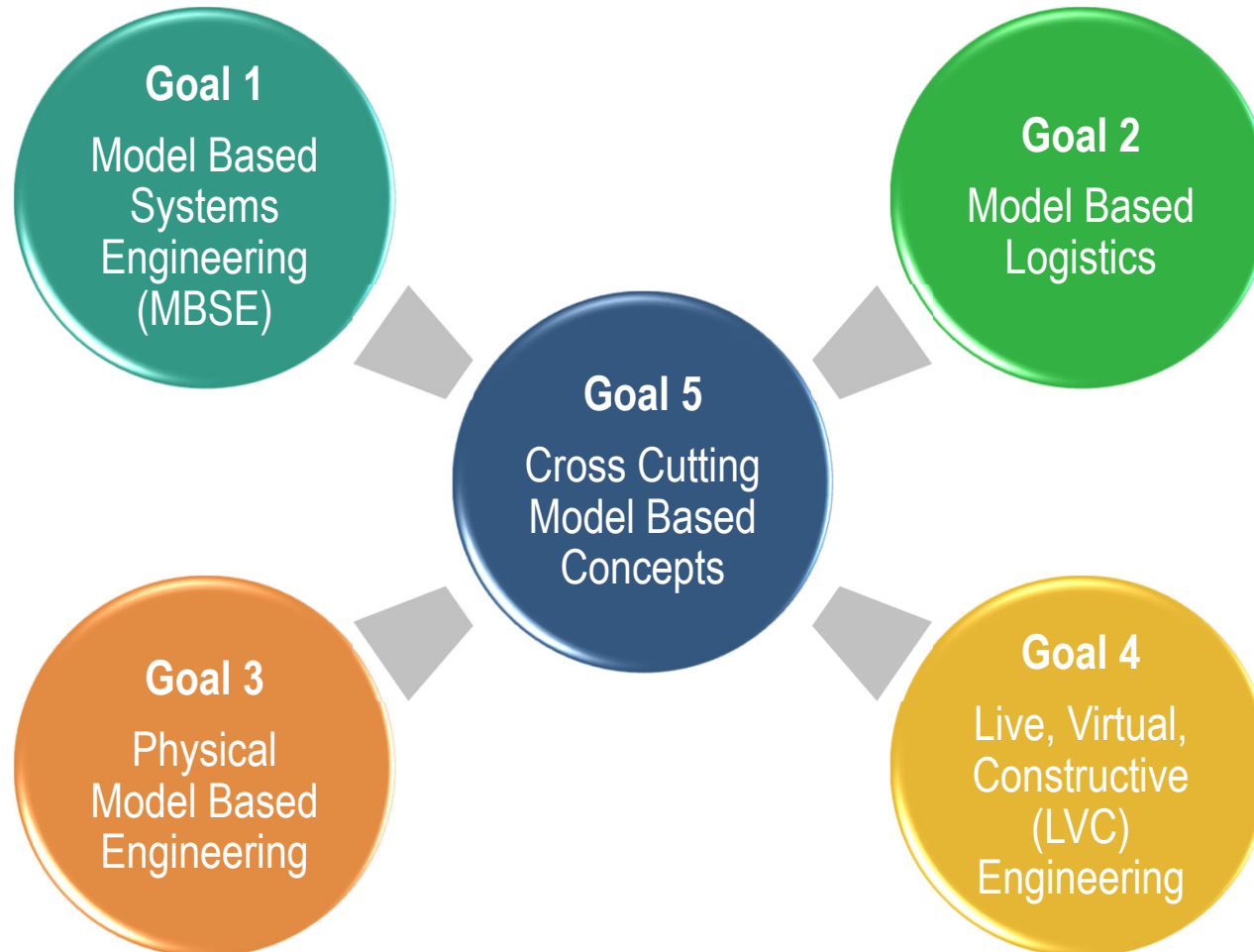
# Where does Model Based Engineering fit into the NIWC Atlantic Tech Strategy?



**NIWC Atlantic Tech Strategy**

- **Model Based Engineering (MBE)**
  - Model Based Systems Engineering (MBSE)
  - LVC / M&S / Mission Engineering
  - Model Based Logistics
  - Physical Model Based Engineering (PMBE)
  - Etc.
- **Digital Technologies**
  - Example A
  - Example B
  - Example Etc.
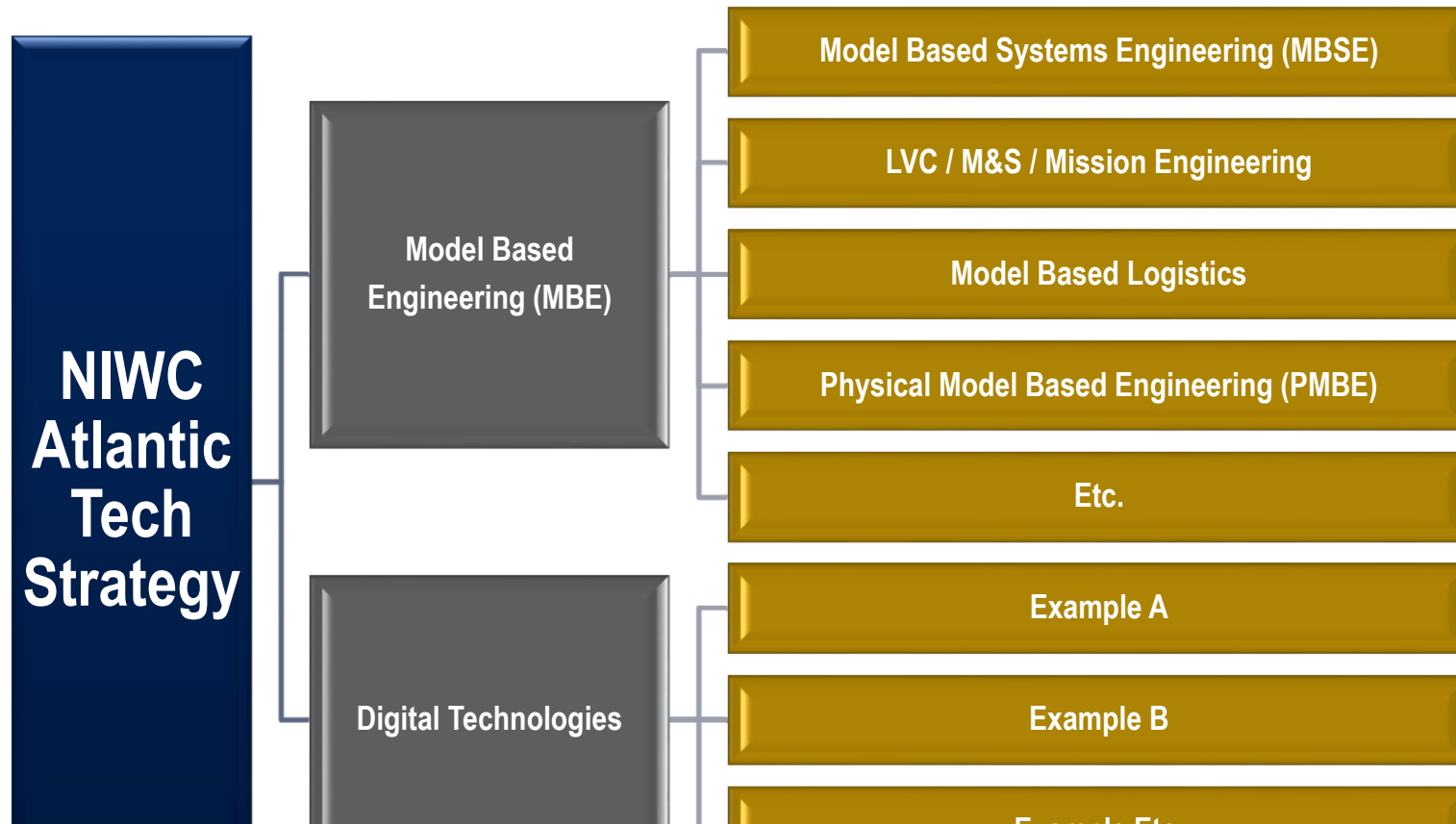
**Digital Transformation** = continually changing tools, processes & culture to embrace DE

**Digital Engineering** = continually evolving modern practices/methods/tools + integrating and delivering technology at the pace of technology change

**Model Based Engineering** is part of continually evolving modern practices/methods/tools

# MBE TFA Overview

## Model Based Systems Engineering (MBSE)

1. MBSE, Requirements, & Testing tool availability
2. Adequate Hardware platforms
3. Optimize MBSE training
4. Follow-through with MBSE adoption
5. Multi-Level Classification Environment
6. MBSE Community Engagement
7. Model templates, libraries, & shared elements
8. Requirements management & test cases

## Model Based Logistics

1. Sailor Self Sufficiency
2. NAVSEA Model Based Product Support applications
3. Supply support data to predict changes in system readiness
4. Configuration Management Control

## Physical Model Based Engineering (PMBE)

1. Increase the Adoption of PMBE Practices
2. Train and Equip the Workforce
3. Establish Model Catalog
4. Expand the Adoption of Mixed Reality
5. Improve Speed to Software Access
6. PMBE Workflows

## Live, Virtual, Constructive (LVC) Engineering

1. LVC capability status and alignment
2. Establish infrastructure requirements
3. Establish and implement workforce development strategy
4. Execute an LVC Event

## Cross-Cutting

2. Expand communication of MBE vision and value
3. Infrastructure support for MBE tooling
4. Model discoverability & reusable assets
5. NDEBoK and LANT MBSE/MBE Guidebook
6. MBE technical support desk
7. Standard MBE methodology
8. MBE tool capabilities & availability

# Goal 1: MBSE

**Objectives:**

1. Improve MBSE, Requirements, & Test Management tooling availability and services for NIWC LANT

2. Increase availability of adequate HW platforms for MBSE practices

3. Optimize MBSE training across the NAVWAR Enterprise

4. Better support follow-through with MBSE adoption across IPTs

5. Enable MBSE in a Multi-Level Classification Environment

6. Strengthen MBSE Community Engagement across NAVWAR Enterprise

7. Improve the reuse of model templates, libraries, and other shared elements

8. Increase number of projects managing requirements and test cases using a model-based approach

# Goal 2: Model Based Logistics

## Objectives:

1. Demonstrate Sailor Self Sufficiency in applicable projects.

2. Implement NAVSEA Model Based Product Support applications in Navy projects throughout LANT.

3. Leverage supply support data, applied to system models, to predict changes in system readiness (performance, risk RAM-C).

4. Demonstrate Configuration Management Control using models for projects.

# Goal 3: Physical Model Based Engineering

## Objectives:

1. Increase the Adoption of PMBE Practices
2. Train and Equip the Workforce
3. Establish Model Catalog
4. Expand the Adoption of Mixed Reality
5. Improve Speed to Software Access
6. PMBE Workflows with Responsibilities and Data Exchanges

# Goal 4: LVC, M&S + Mission Engineering

**Objectives:**

1. Identify and maintain NIWC LANT LVC capability status and alignment

2. Establish and mature infrastructure requirements for implementation to include tools, applications, and networks

3. Establish and begin implementing a workforce development strategy including LVC practices, available tools and applications, and networks/infrastructure (More understanding of tools available)

4. Execute an LVC Event

# Goal 5: Cross-Cutting Model-Based Concepts

**Objectives:**

1. Expand communication of MBE vision and value in order to promote adoption of a transformative culture based on MBE principles

2. Provide infrastructure support for MBE tooling across the range of challenges faced by NIWC LANT projects – security enclaves, networks, end-user devices, model repositories, etc.

3. Improve model discoverability and awareness of reusable model assets across all MBE domains

4. Raise awareness of and contribution to consolidated knowledge bases for MBE (NDEBoK and LANT MBSE/MBE Guidebook)

5. Provide a technical support desk that is available to answer implementation and modeling questions across all MBE domains, as well as provide limited direct support

6. Establish standard MBE methodology (style guide and modeling guidance)

7. Continue improving awareness of and maturing digital engineering tool capabilities available to LANT / Pilot knowledge platform for federation of tools and autogeneration of documentation