MOSA Industry & Government Summit & Expo
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September 18-19, 2023

DEPS Directed Energy Systems Symposium
Hyatt Regency Monterey Hotel, Monterey, CA
November 13-17, 2023

Directed Energy Weapon Systems (DEWS) MOSA Reference Architecture (RA) – Sensor Open System Architecture™ (SOSA) Integration – Greater than the Sum of the Parts

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Purpose and Agenda

Purpose:

To share the experience of developing the Directed Energy Weapon System (DEWS) MOSA Reference Architecture (RA) and then its integration into the Sensor Open System Architecture™ (SOSA) Consortium

Agenda

- **Significance of DEWS and MOSA**
- **Brief overview of the DEWS MOSA RA**
- **Brief overview of the SOSA**
- **DEWS RA – SOSA Commonalities**
- **Parting thoughts for RA development**

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What is a DEWS

DOD's Joint Publication 3–13 Electronic Warfare[1], describes directed energy (DE) is as:
An Umbrella term covering technologies that ***produce a beam of concentrated electromagnetic energy or atomic or subatomic particles****. A DE weapon is a system using DE primarily as a direct means to* ***disable, damage or destroy adversary equipment, facilities, and personnel****. DE warfare is military action involving the use of DE weapons, devices, and countermeasures to either cause direct damage or destruction of adversary equipment, facilities, and personnel, or to determine, exploit, reduce, or prevent hostile use of the electromagnetic spectrum (EMS) through damage, destruction, and disruption.*

DE weapons include:

- **High-Energy Lasers (HEL)**
- High-power radio frequency devices
- **High-Powered Microwave (HPM) devices**
- Charged or neutral particle beam weapons

Artist's concept of a HELIOS laser system aboard a U.S. destroyer. Lockheed Martin Image

Specialized Portable Electromagnetic Attack Radiator (SPEAR)

[1]*Department of Defense Joint Publication 3-13.1, Electronic Warfare (Washington, DC: Department of Defense, 2012)*
Extracted from: "Directed Energy Weapons Are Real . . . And Disruptive" By Henry "Trey" Obering, III,
https://ndupress.ndu.edu/Media/News/News-Article-View/Article/2053280/directed-energy-weapons-are-real-and-disruptive/

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Directed Energy Weapon Systems are Now and Across all DoD!

Army Technology

News | June 1, 2023

US Pentagon integrates directed-energy air defence systems

The Pentagon plans to integrate directed-energy weapon systems across the entire US armed forces.

By John Hill

POPULAR MECHANICS

Military > Weapons

The Navy Is Getting Really Into Lasers

Soon, nine destroyers will carry directed energy weapons.

BY KYLE MIZOKAMI PUBLISHED: APR 9, 2021

C4ISRNET

The Space Force wants to use directed-energy systems for space superiority

By Nathan Strout Jun 16, 2021

CNN

US Navy is developing directed energy systems to counter hypersonic missile threats from China and Russia

By Oren Liebermann and Ellie Kaufman, CNN
Published 4:36 PM EDT, Fri August 26, 2022

JOINT INTERMEDIATE FORCE CAPABILITIES OFFICE
U.S. DEPARTMENT OF DEFENSE NON-LETHAL WEAPONS PROGRAM

NEWS | July 30, 2022

Marines Corps ARV to Be Armed With New Laser Weapons

By Kris Osborn

TASK & PURPOSE

The Air Force's new directed energy weapon is ready to blast drone swarms out of the sky

Zzzzzzzap!

BY JARED KELLER | PUBLISHED MAY 19, 2023 2:19 PM EDT

BREAKING DEFENSE

AIR WARFARE, LAND WARFARE

'Bullet made out of light': Army to field first Stryker-mounted combat laser in next 45 days

In addition to the directed energy system for the Stryker, the Army is looking at a small laser for a smaller vehicle.

By ANDREW EVERSDEN on August 10, 2022 at 4:26 PM

U.S. ARMY ✓

AMERICA'S NAVY ✓

U.S. AIR FORCE ✓

MARINES THE FEW. THE PROUD. ✓

UNITED STATES SPACE FORCE ✓

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Why MOSA is All the More Important

Government Executive

SLOW *and* STEADY IS LOSING *the* {DEFENSE ACQUISITION} RACE

National DEFENSE
NDIA's Business & Technology Magazine

JUST IN: U.S. Falling Behind China in Critical Tech Race, Report Finds

7/17/2023

By Josh Luckenbaugh

ASSOCIATION OF THE UNITED STATES ARMY

MODERNIZATION SPEED CRITICAL TO US MILITARY SUCCESS

"What keeps me up at night is not North Korea, but the fear that the U.S. has lost its ability to go fast."

- Gen John Hyten, U.S. Strategic Command Commander

"The 2018 National Defense Strategy (NDS) acknowledges that DoD is in a race to develop and integrate cutting-edge technologies before its competitors do the same… ***The reality is that our competitors can iteratively field new systems in faster cycles, rapidly eroding our military, economic, and technical superiority****."*

Extracted from: Modigliani, P., Ward, D., (April 2019) Accelerating Defense Acquisition - Faster acquisitions produce a stronger force [The MITRE Corp]

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General State of MOSA Implementation

RealClear Defense

Is The Pentagon Serious About Implementing Open Systems Architectures?

April 6, 2021

By Dan Gouré

"Implementing MOSA across the force makes a great deal of sense. DoD talks a good game, but ***there is little evidence that there is a real institutional commitment to open systems after more than two decades***. Without that, ***sustainment costs will continue to rise, innovation will be slowed, and the risk of obsolescence of systems and platforms will increase."***

Appendix VI summarizes seven provisions from the National Defense Authorization Acts for Fiscal Years 2017, 2018, 2020, 2021, and 2022 specifically related to modular open systems approaches (MOSA).

GAO GAO-23-106059 | June 2023

Weapon System Annual Assessment:

Programs Are Not Consistently Implementing Practices that Can Help Accelerate Acquisitions

This year, we also looked at programs' implementation of a MOSA. MOSA can facilitate innovation by enabling acquisition programs to more easily add, remove, and replace components over the life cycle of the system to meet emerging threats. We found that, ***while most programs told us that they were using a MOSA, they were not consistently implementing certain recommended practices to help ensure their MOSA works as intended.***

One focus of forthcoming guidance will be MOSA-related contract language…Some programs described using broad contract language that ***delegated decisions about the specifics of MOSA implementation to the contractor***. USD(R&E) officials stated that delegating key MOSA decisions to contractors puts the program at risk of acquiring a system that is effectively proprietary and misses opportunities for program executive offices and the military departments to strategically implement a MOSA across programs.

Implementing open standards and conducting verification testing are important building blocks to achieve the intended benefits of a MOSA. However, many programs reported that they ***have yet to implement these practices.***

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MOSA Mandate - It is not just a good idea, it is the law

National Defense Authorization Act (NDAA) for FY2017:

§2446a. Requirement for modular open system approach in major defense acquisition programs; definitions

"(a) MODULAR OPEN SYSTEM APPROACH REQUIREMENT.—A major defense acquisition program **(MDAPs)*** that receives Milestone A or Milestone B approval after January 1, 2019, **shall be designed and developed, to the maximum extent practicable, with a modular open system approach** to enable incremental development and enhance competition, innovation, and interoperability.

National Defense Authorization Act (NDAA) for FY2021:

Expands the statutory requirement… by **requiring all other defense acquisition programs** to be designed and developed, to the maximum extent practicable with a modular open system approach to enable incremental development and enhance competition, innovation, and interoperability.

**MDAP: By law, the MDAP cost threshold is an estimated eventual total expenditure for research, development, test, and evaluation of more than $300,000,000*

Improve interoperability – severable software and hardware modules that can be changed independently.

Facilitate technology refresh – delivery of new capabilities or replacement technology without requiring change to all elements in the entire system.

Enhance competition – open architecture with severable modules, allowing elements to be openly competed.

Incorporate innovation – operational flexibility to configure and reconfigure available assets to meet rapidly changing operational requirements.

Enable cost savings/cost avoidance – reuse of technology, modules, and/or elements from any supplier across the acquisition life cycle.

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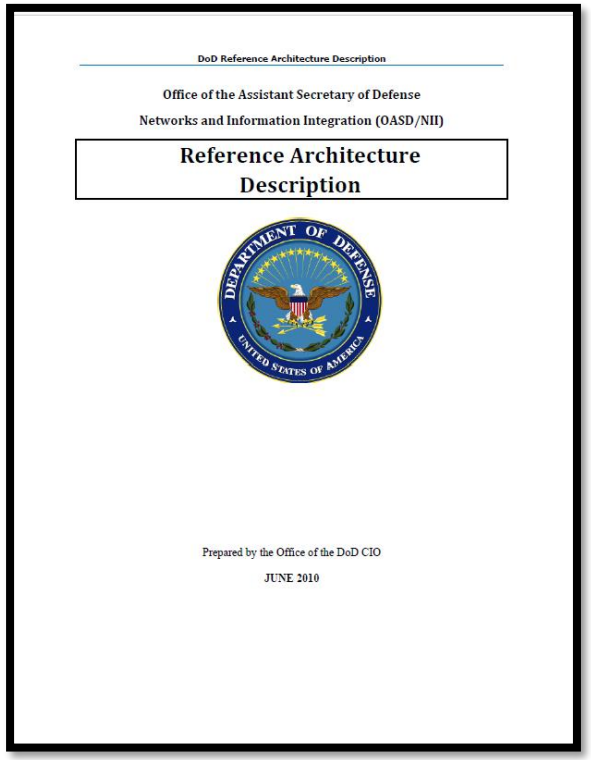
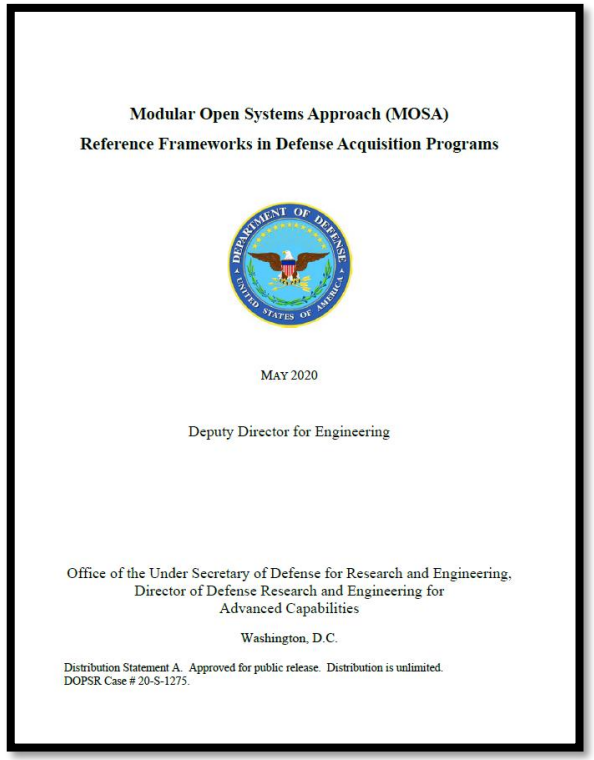
Helpful Reference Architecture Starter Resources



Office of the Assistant Secretary of Defense Networks and Information Integration (OASD/NII) Reference Architecture Description Prepared by the Office of the DoD CIO JUNE 2010



Modular Open Systems Approach (MOSA) Reference Frameworks in Defense Acquisition Programs MAY 2020 Deputy Director for Engineering Office of the Under Secretary of Defense for Research and Engineering, Director of Defense Research and Engineering for Advanced Capabilities

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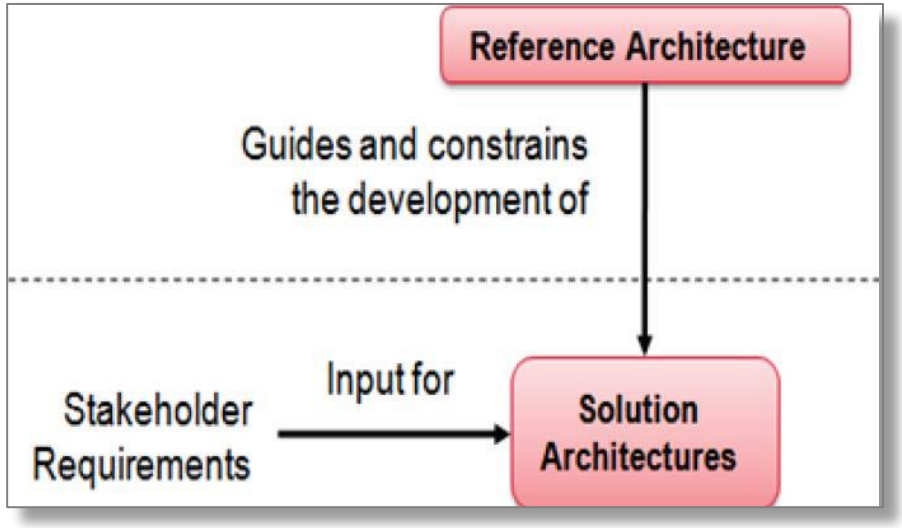
About reference Architectures

- A common theme among the definitions of a reference architecture is that the primary purpose of an RA is to **guide and constrain the instantiations of solution architectures**
- A Reference Architecture is used for:
  - Providing **common language** for the various stakeholders
  - Providing **consistency of implementation of technology** to solve problems
  - Supporting the **validation of solutions** against proven Reference Architecture
  - **Encouraging adherence to common standards**, specifications, and patterns



- **DoD definition for Reference Architecture is:**
  - ***An authoritative source of information about a specific subject area that guides and constrains the instantiations of multiple architectures and solutions.***

**Ref: DoD Reference Architecture Description - Office of the Assistant Secretary of Defense, June 2010*

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Key Elements of a DoD Reference Architecture*

- **Strategic Purpose** – Identifies **goals and objectives of the Reference Architecture** and **describes the specific purpose of and the problem(s) to be addressed** by the Reference Architecture.
- **Principles** – Sufficient high level foundational statements of **rules, culture, and values that drive technical positions and patterns**.
- **Technical Positions**– **Technical guidance and standards**, based on specified principles that need to be followed and implemented as part of the solution.
- **Patterns (Templates)[1]** – **Generalized architecture representations** (viewpoints, graphical/texal models, diagrams, etc.) **that show relationships** between elements and artifacts specified by the technical positions.
- **Vocabulary** – **Acronyms, terms, and definitions** that are used in the Reference Architecture and relevant to architectures and solutions that are guided and constrained by the Reference Architecture.

[1] ***Patterns*** *is the most commonly used term to describe these kinds of abstract models and diagrams and will be used in place of Templates.*

**Ref: DoD Reference Architecture Description - Office of the Assistant Secretary of Defense, June 2010*

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Catalyst for a DEWS MOSA Reference Architecture

Current State

- Directed energy systems are becoming technically mature, heading for operational employments
- Services and programs going in their own direction with no architecturally consistent framework

The Sodium Guidestar at the Air Force Research Laboratory Directed Energy Directorate's Starfire Optical Range.

The High Energy Laser Mobile Demonstrator, or HEL MD, is the result of U.S. Army Space and Missile Defense Command research (U.S. Army)

Needs

- MOSA-based approach to "*guide and constrain*" development and procurement
- Well-defined, government "owned" *open standardized interfaces between modules*
- *Developer-independent modules*
- Service- and Host Platform-*independent* OSA

To Enable

- Rapid, cost-effective, *and supportable DEWS fielding* (reduced time from R&D, to prototyping, to integration, to DT and OT)
- *Extend service life and effectiveness* of systems through *timely modernization* (including from third-party sources)
- *Industrial base* expansion and engagement → ecosystem (economies of scale)
- Aligned R&D investment
- *Reuse, Reuse, Reuse* across programs and Services

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DEWS MOSA RA – DoD Objectives

- Providing common language across all stakeholders
- Providing common modules ("building block") and interface definitions across DEWS domains
- Aligning to common standards, specifications, and patterns
- Providing a means of determining DEWS solution architecture compliance with the established standard
- Adhering to both the letter and spirit of the MOSA Mandates, as well as senior leader requirements

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DEWS MOSA RA Government Stakeholders

Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E))	**Naval Surface Warfare Center Dahlgren Division (NSWC DD)**
Air Force Life Cycle Management Center (AFLCMC)	**NAVSEA Naval Systems Engineering (NAVSEA 05Z)**
U.S. Air Force Materiel Command (USAF AFMC)	**U.S. Naval Research Laboratory (NRL)**
Air Force Research Laboratory - Directed Energy Directorate (AFRL RD)	**U.S. Army Space and Missile Defense Command (Army SMDC)**
Army Rapid Capabilities and Critical Technologies Office (Army RCCTO)	**DOD: Missile Defense Agency (MDA)**

Note broad services interest

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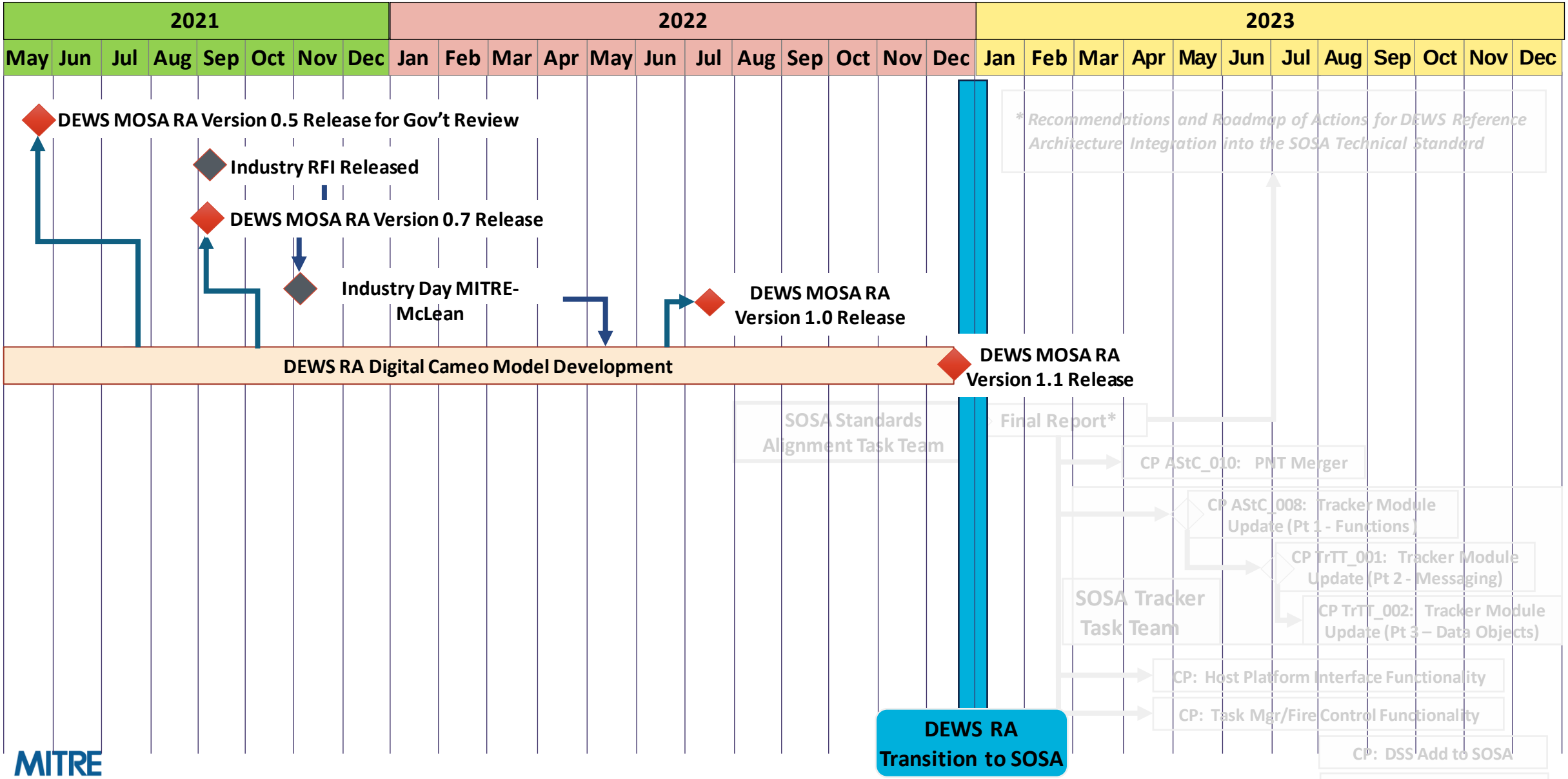
DEWS MOSA RA Timeline



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DEWS MOSA RA Request for Information (RFI)

Industry was invited to provide commentary and recommendations to the RA in addressing, in broad terms:

Received 300+ comment From 13 corporations

- **Components modularity**
- **Aggregated modular functionality and allocation**
- **Standardization of physical and logical interfaces**
- **Standardized messaging (e.g., command and control, safety monitoring, alerts, etc.)**
- **Standardized data model**
- **MBSE model and methodology (RA structure and behaviors)**
- **Adherence Strategy**

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Industry Day Objectives

- **Provide interactive sessions for reviewing different aspects of the DEWS MOSA RA:**
  - **Module structure – Are structure and definitions appropriate?**
    - **Functional decomposition**
    - **Interface definition and standardization**
  - **Model elements, behaviors, etc.**
  - **How to use the model**
  - **What conformance looks like**

- **Solicit real-time discussion from government and industry stakeholders**

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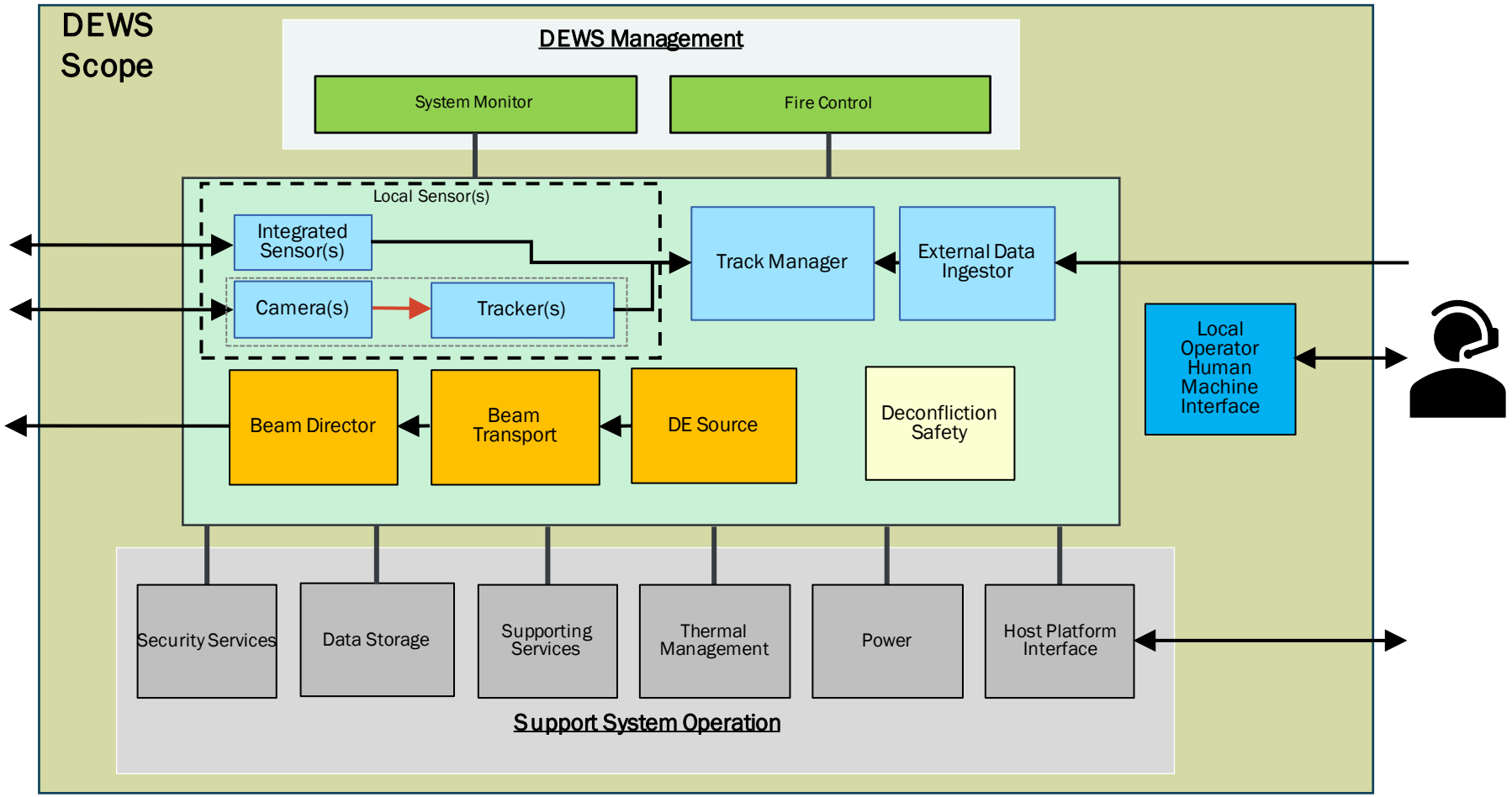
DEWS RA Modules



Each module defined in the RA by Module Description, Functions, and Function descriptions along with initial I/O

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Sensor Open Systems Architecture™ (SOSA)*

SOSA is intended to counter current Department of Defense (DoD) C4ISR challenges that include:

- Long lead times
- Cumbersome improvement processes
- Lack of reuse
- Platform-unique design
- Extensive testing requirements

Which results in **higher costs** and the **inability to deliver capabilities to the war fighter in a timely manner.**

SOSA mainly reflects sensors for:

- Communications (Comms)
- Electro-Optical/Infra-Red (EO/IR)
- Electronic Warfare (EW)
- Radar
- Signals Intelligence (SIGINT)

However, much of the foundational structure of a SOSA sensor is highly aligned to components of DEWS

Technical Standard for SOSA ™ Reference Architecture, Edition 1.0, Snapshot 3

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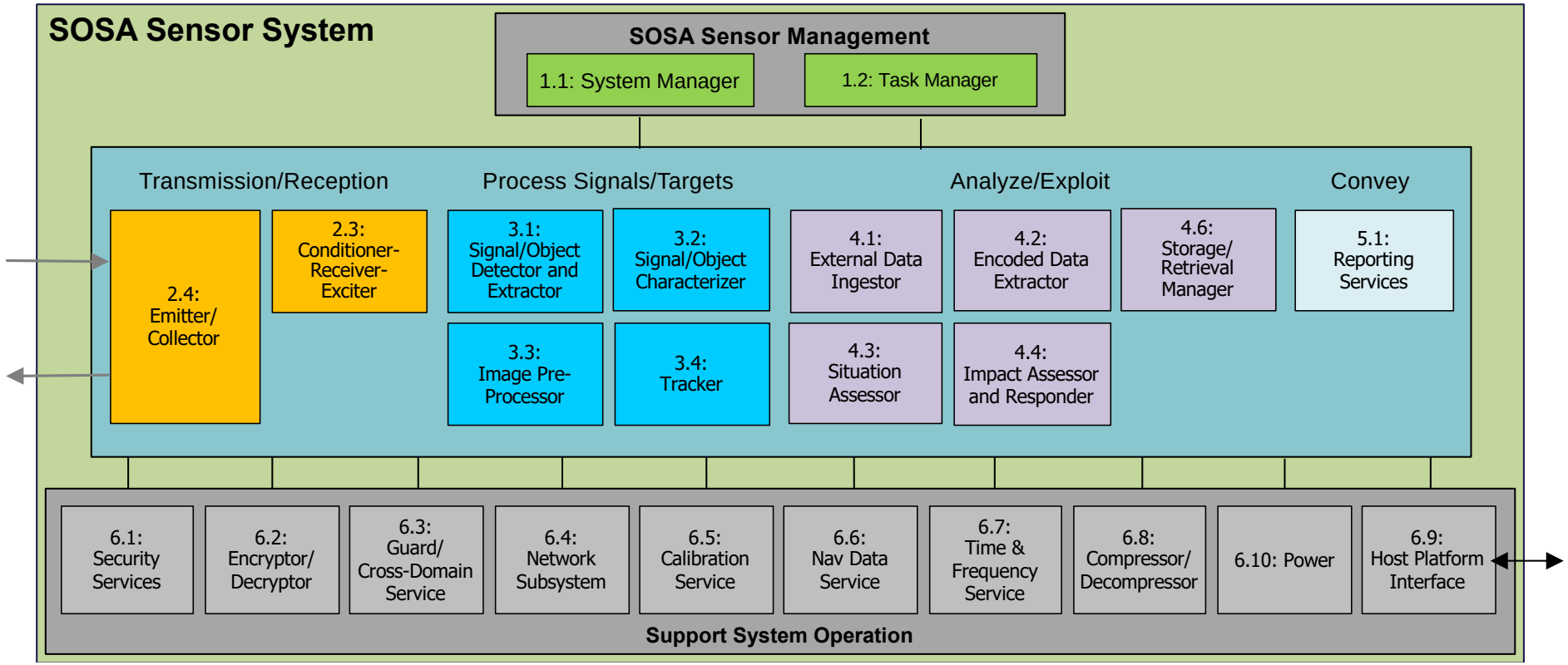
SOSA Modules



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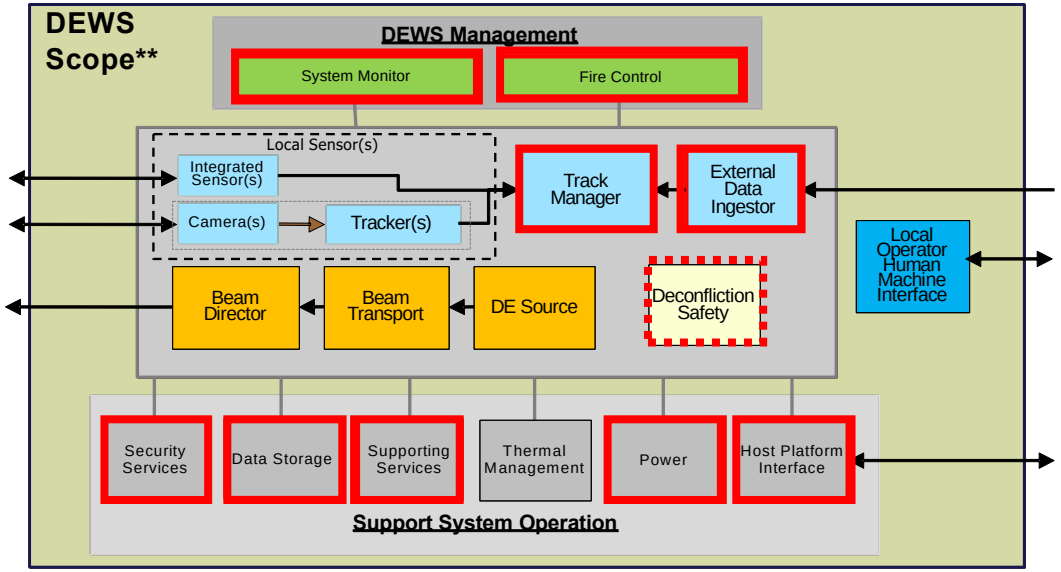
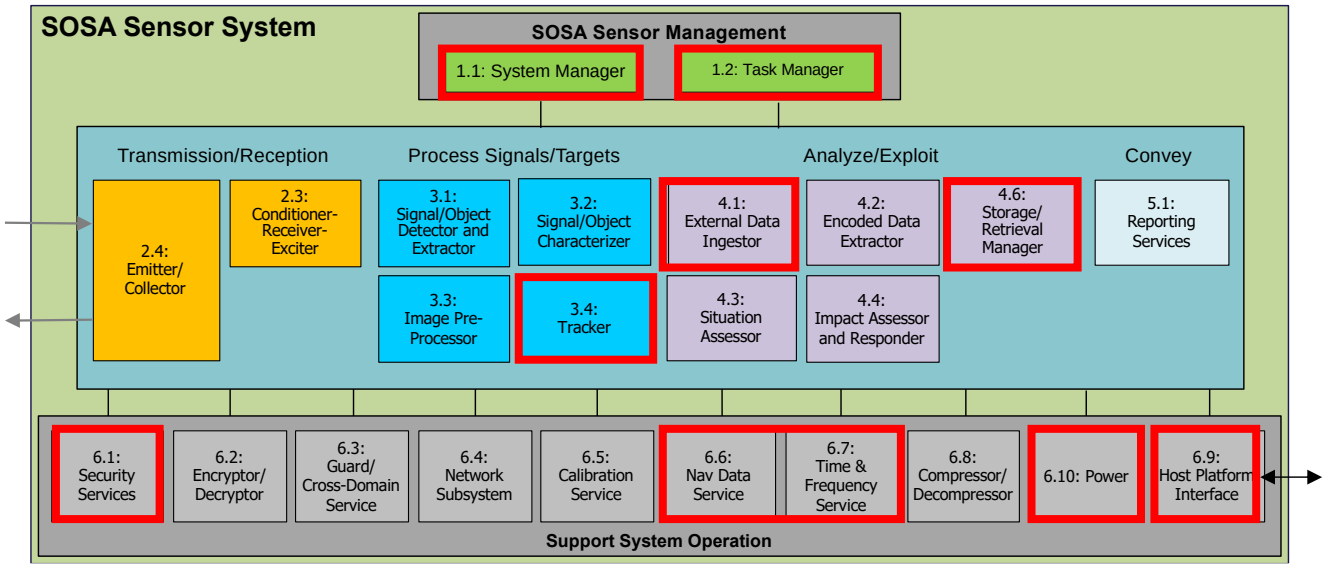
DEWS MOSA RA integration with SOSA





Modules common between DEWS and SOSA are outlined in RED

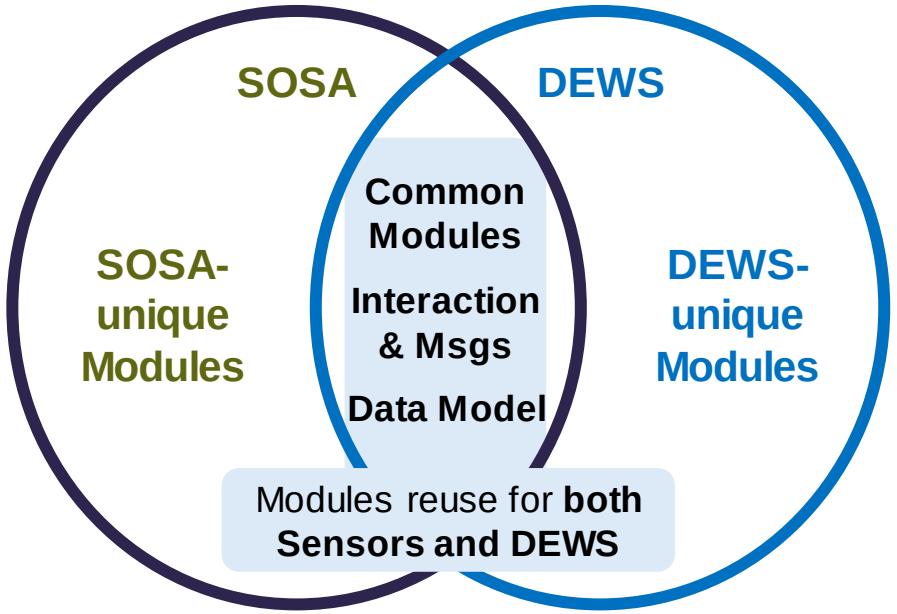
DEWS MOSA RA – SOSA Integration Timeline

SOSA-unique Modules

Emitter / Collector
Conditioner-Receiver-Exciter
Signal/Object Detector and Extractor
Signal/Object Characterizer
Encoded Data Extractor
Situation Assessor
Impact Assessor and Responder
Reporting Services
Guard / Cross-Domain Service
Network Subsystem
Calibration Service
Compressor/Decompressor

Other SOSA Modules for potential DEWS Adoption

- **Reporting Services**
- **Encryptor/ Decryptor**
- **Network Subsystem**
- **Calibration Service**
- **Compressor/ Decompressor**



Common Modules

Tracker / Track Manager
Task Manager / Fire Control
System Manager / System Monitor
Host Platform Interface
External Data Ingestor
Storage-Retrieval Manager / Data Storage
Nav Data and Time & Frequency Services / Supporting Services
Security Services
Power
Deconfliction Safety
(Recent add)

DEWS-unique Modules

Local Operator HMI
Local Sensor(s)
~~Deconfliction Safety~~
DE Source
Beam Transport
Beam Director
Thermal Management

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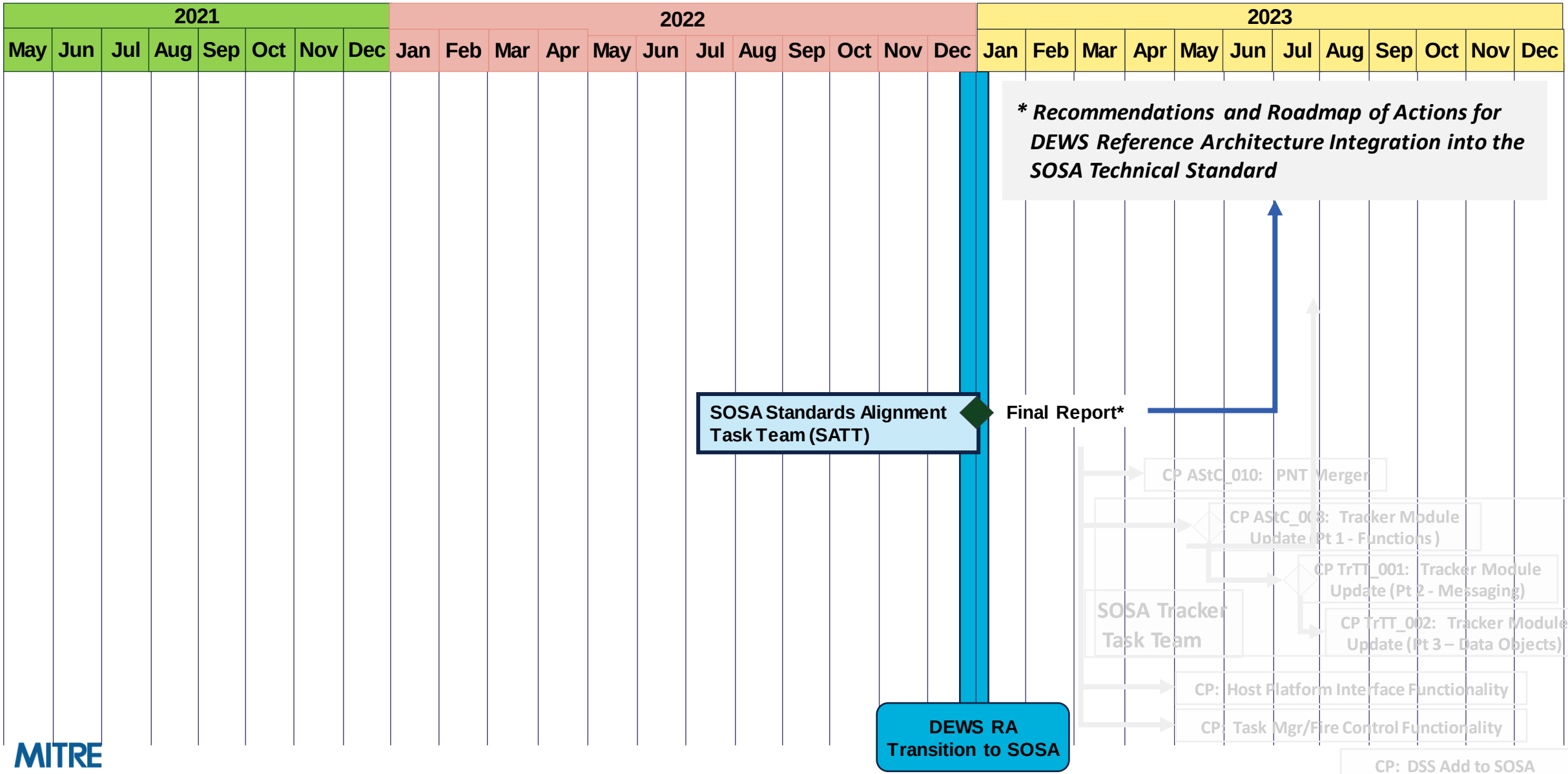
DEWS MOSA RA – SOSA Integration Timeline



Recommendations and Roadmap of Actions for DEWS Reference Architecture Integration into the SOSA Technical Standard

- **Purpose: Provide recommendations and a roadmap of actions to be executed by the SOSA DEWS Subcommittee and other SOSA committees to merge DEWS modules of common functionality with the respective SOSA modules.**
- **In some cases, SOSA modules require only slight refinement and added functionality to account for required DEWS functionality.**
- **In other cases, where SOSA common modules are not yet well defined, recommendations are made for the SOSA Consortium to adopt the DEWS module in place of the SOSA module.**

Contents

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Crosswalk Exemplar: DEWS Track Manager with SOSA Tracker

Table 6-7. Track Manager (DEWS RA) / Tracker (SOSA TS) Module Descriptions	
DEWS RA Description	**SOSA TS Description**
The Track Manager Module maintains an internal store of the mathematical representation of objects of interest (hereafter known as Tracks). It **correlates new (or newly provided) detections** (either generated locally or from an external source) **with existing Tracks**, or **creates new Tracks** if the new detections do not correlate. It can receive Tracks (not just detections) from external track reports. The core functionality of the Tracker is **data association, track initiation, track drop, track update, and uncertainty (e.g., covariance)** of the Track. **Estimation of relative position or location (geolocation)** may also be performed. There is only one Track Manager in a DEWS.	The Tracker module **correlates detections and tracks** over time, **forming new** or updated tracks. It is responsible for all track management functions and producing track reports. The core functionality of the Tracker is **data association, track initiation, track drop, track update, state and covariance estimation**, and split track handling. **Estimation of relative position or location (geolocation),** when feasible, is also included in this function.

Common
Not common

Revised SOSA Tracker Module Description

New **Split Tracks Function** added

The Tracker Module maintains an internal store of the mathematical representation of objects of interest (hereafter known as Tracks) for any given detection source. It associates new (or newly provided) detections (either generated locally or from an external source) with existing Tracks or creates new Tracks if the new detections do not associate. It can receive both tracks and detection from external sources. The core functionality of the Tracker is data association, track initiation, detection and track filtering in accordance with threshold parameters, track drop, track update, and uncertainty (e.g., covariance) of the Track. Estimation of relative position or location (geolocation) may also be performed.

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DEWS Fire Control Functional Crosswalk with SOSA Task Manager

Functionality – 22 additional functions for the SOSA Task Manager Module

SOSA Task Manager Functions

Function	Definition
Process External Tasking	The action of accepting, starting, pausing, resuming, or cancelling a mission task or tasks.
Report Mission Tasking Status	The action of reporting the status of a specific mission task or tasks.
Notify Mission Product of Interest	The action of informing processing modules of the intended output products to be generated for a given mission.
Control Receiver/ Exciter Action	The action of starting, pausing, resuming, or cancelling a Conditioner-Receiver-Exciter task or tasks.
Notify Processing Modules	The action of informing processing modules of a Conditioner-Receiver-Exciter task or tasks.
Control Calibration Action	The action of initiating calibration events to calibrate the Conditioner-Receiver-Exciter and Emitter/Collector.
Manage Mode/State Changes	The action of managing the configuration, state, and mode of the other SOSA modules based on mission tasking.

DEWS Fire Control Functions

ID	Function
12.11	**Manage Engagement Order**
12.12	**Receive Task Order**
12.13	**Set Engagement Parameters**
12.15	**Compute Engagement Parameters**
12.17	**Provide Engagement Status data**
12.18	**Receive Track Data**
12.19	**Receive Alignment Feedback**
12.21	**Task Local Sensor**
12.22	**Receive DEWS Modes/States**
12.23	**Manage Modes/States**
12.24	**Receive Navigation Data**
12.25	**Disseminate Mode/State Information**
12.29	**Send Order to Calibrate**
12.31	**Receive Aimpoint Adjustment**
12.33	**Receive Input to Adjust Track Manager Modules Settings**

ID	Function
12.35	Update Track Manager Module with Adjusted Settings
12.37	Receive Integrated Sensor Settings
12.38	**Receive Off-Load Signals**
12.39	Update Integrated Sensor Settings
12.41	**Confirm Firing Pre-conditions**
12.43	**Determine Engage-ability**
12.45	**Confirm Safe to Fire**
12.51	**Arm DEWS**
12.53	**Fire DEWS**
12.54	**Obtain Current Track Data**
12.55	**Obtain Predicted Track Data**
12.59	**Abort DEWS**

12 of 27 DEWS functions are directly related to Firing

6 of 27 DEWS functions are support Firing

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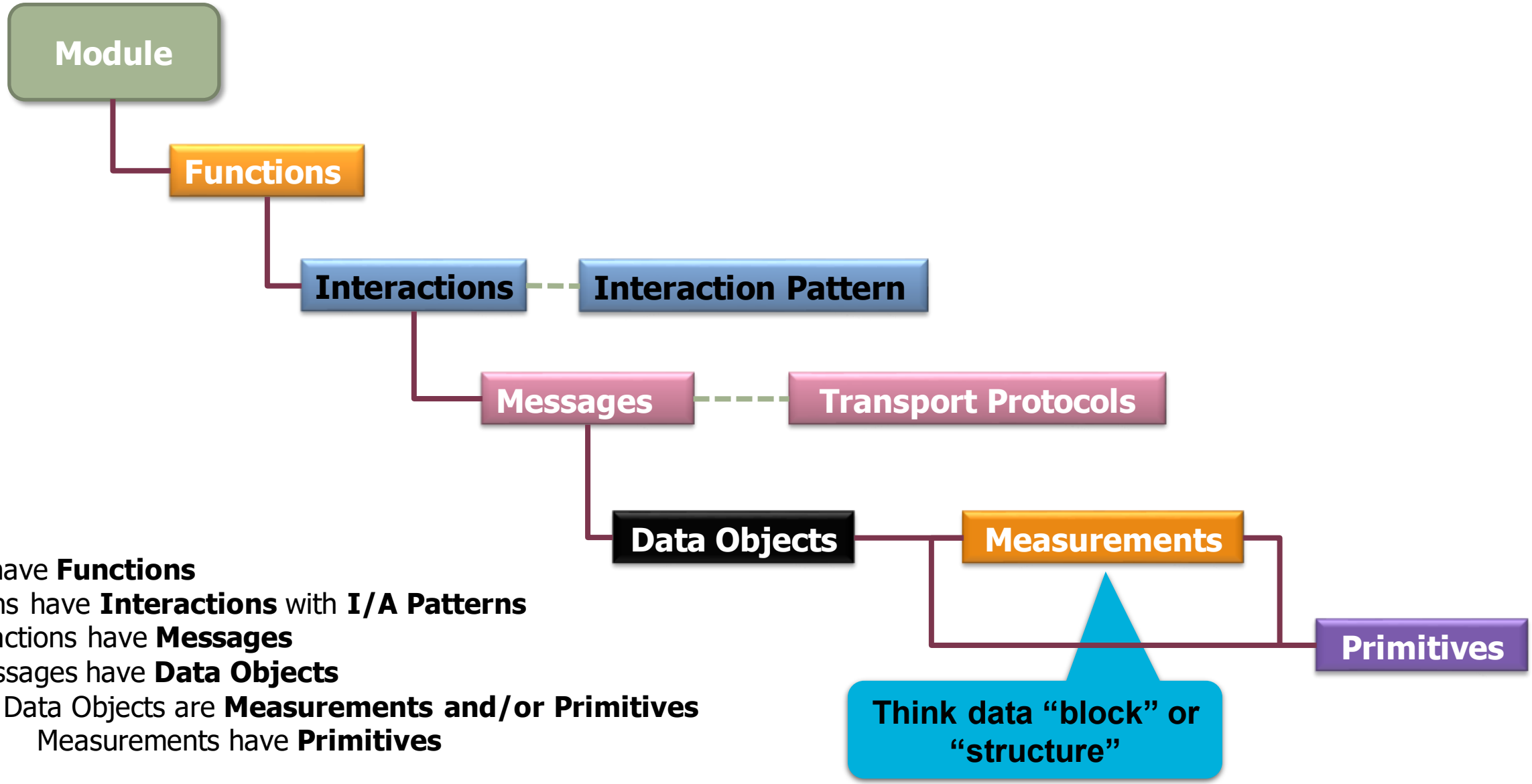
General SOSA Technical Definition Hierarchy



Modules have **Functions**
Functions have **Interactions** with **I/A Patterns**
Interactions have **Messages**
Messages have **Data Objects**
Data Objects are **Measurements and/or Primitives**
Measurements have **Primitives**

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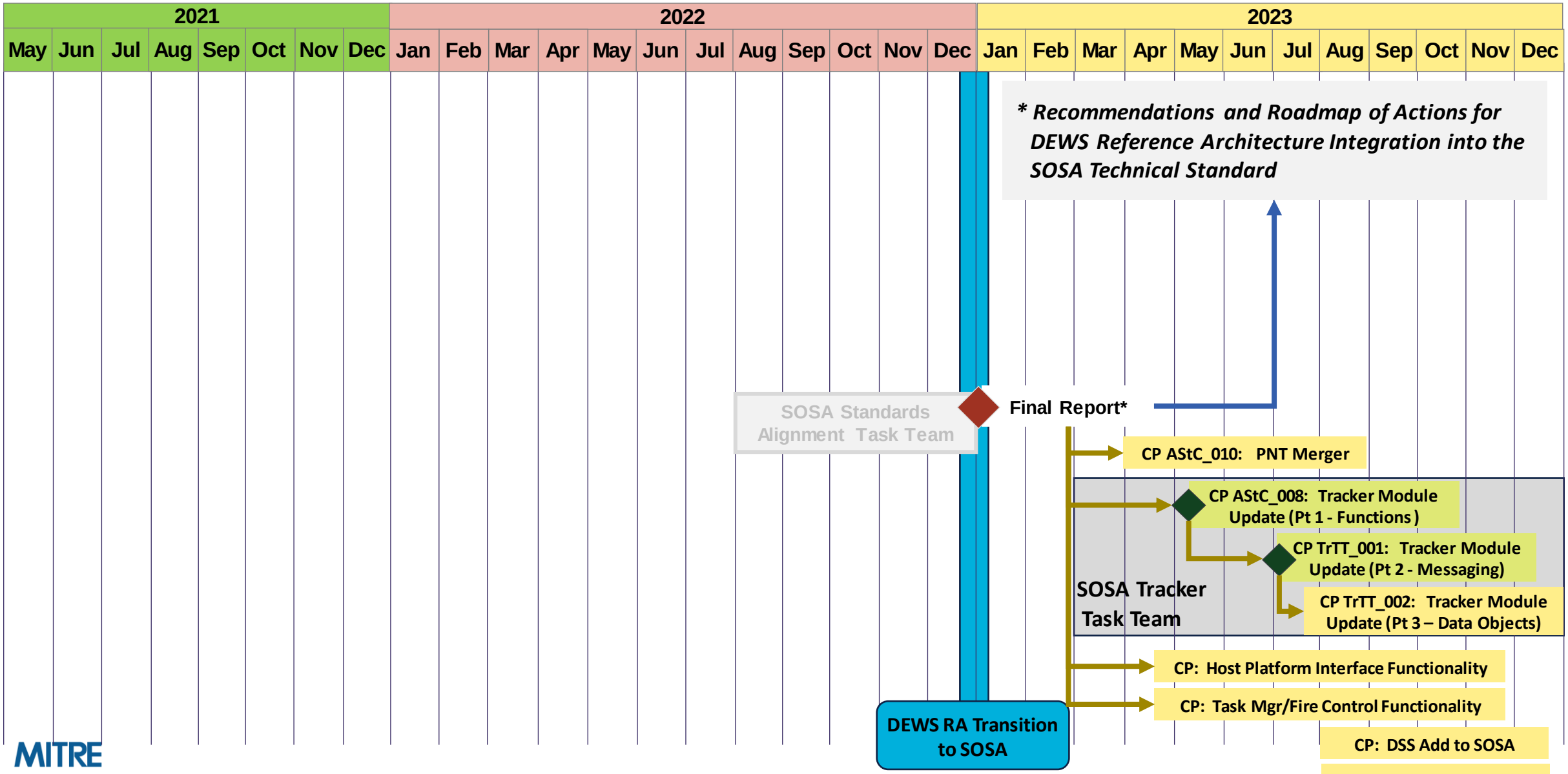
DEWS MOSA RA – SOSA Integration Timeline



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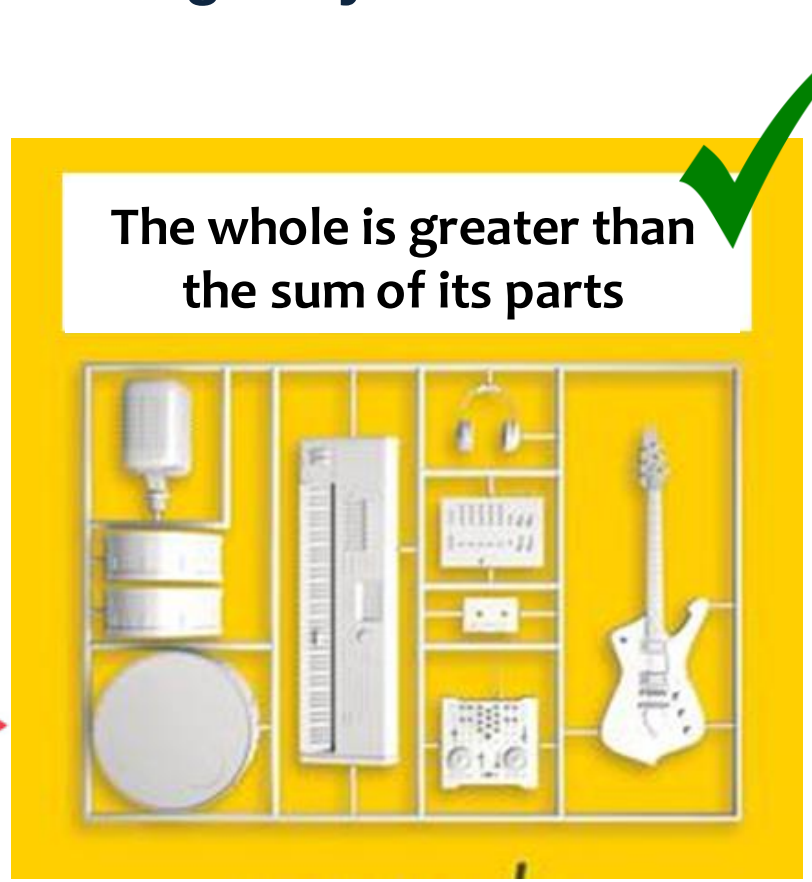
Summarizing the DEWS RA – SOSA Integration Continuing Way Forward

SOSA → DEWS RA



For each of the DEWS-SOSA Common Module:

- Reconcile the module description
- Merge module functions
- Define interactions (module-to-module message containers)
- Allocate messages and their endpoints to interactions
- Define the data objects contained in each message

And down the road…

- Adapt DEWS-unique modules to their new SOSA module components
- Help shape conformance

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Parting Thoughts: Roadmap/checklist for Building a MOSA Architecture

1. Document the PROBLEM(S) being experienced, with details, the RA is intended to respond to
2. Identify STAKEHOLDERS (government and industry) and involve them in the process (RFI/Industry Day) for consensus-based guidance and oversight
3. Document the intended PURPOSE of the RA in response the problem – *can't just cure world hunger*
4. Document CORE USE CASES… avoid trying to address the universe
5. Document RA DEVELOPMENT TENETS AND METHODOLOGIES (e.g., arch attributes, etc.)
6. Document the intended "SYSTEM BOUNDARY" with boundary conditions and interfaces
7. Document LIMITATIONS, RESTRICTIONS, CAVEATS, CONCERNS
8. Identify and engage with similar EXEMPLAR SYSTEMS (don't reinvent, relearn, re-mistake where not necessary)
9. Document all KEY SYSTEM FUNCTIONS
10. Apply FUNCTION GROUPING AND ENCAPSULATION APPROACH and iteratively implement to SHAPE MODULE FRAMEWORK
11. Shape out FUNCTIONAL INPUT AND OUTPUT expectations
12. Seek INTERFACE AND DATA STANDARDS to apply

For additional information about the DEWS MOSA RA see these other briefings later today:

- **Keegan Merkert: DEWS MOSA RA**
- **Al Galgano: DEWS MOSA RA Cameo Model**

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Get Involved – Help Shape the Future

Check to see if your organization a SOSA Consortium member:

https://www.opengroup.org/sosa/members

If not, the process for an organization to join is described here:

https://www.opengroup.org/sosa/join

Once the organization is a member, you can be “onboarded:”

https://www.opengroup.org/sosa/onboarding

The final step is selecting the parts of SOSA Consortium you want to work with. We recommend, at the very least, the DEWS Subcommittee (under the Technical Working Group).

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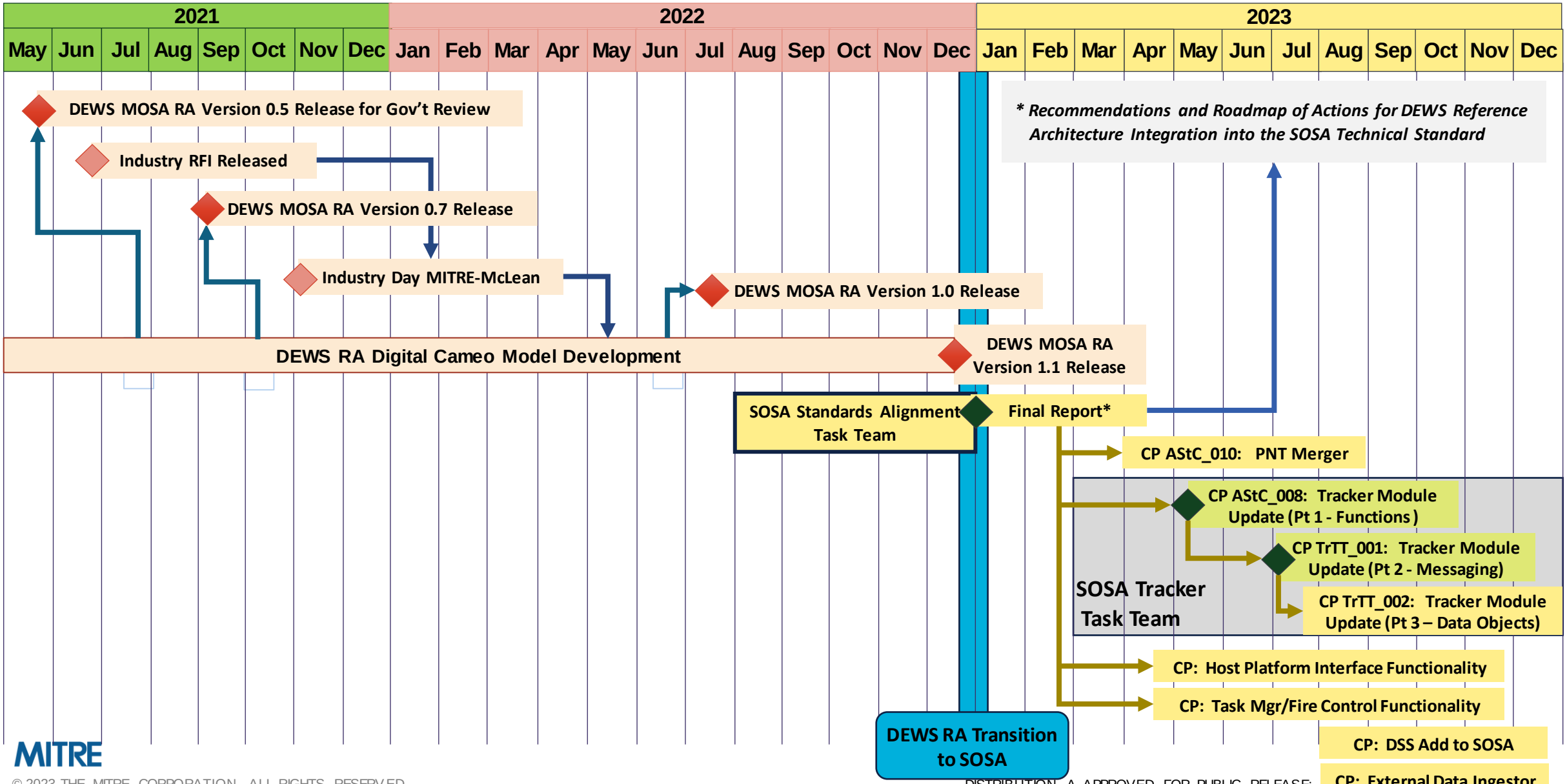
Holds

DEWS MOSA RA – SOSA Integration Timeline



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