Directed Energy Weapons System Modular Open Systems Approach Reference Architecture (DEWS MOSA RA)

Speaker: Keegan Merkert

Contributors: Dr. Steve Davidson, Ron Kacsmar, Al Galgano, Mark Trevena, Howard Lazoff

Government Sponsors: Walter Roscello (NSWCDD), Christopher Behre (OUSD(A&S)), OUSD(R&E)

Sept 2023

Directed Energy Weapon System (DEWS) MOSA Reference Architecture

- Directed energy systems are becoming technically mature, on the verge of being more widely deployed
- Services and programs all going in their own direction – and there was no OSA for DEWS

Needs

- MOSA-based approach to “guide and constrain” development and procurement
- Well-defined, government “owned” open 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 of systems through incremental upgrades (including from third-party sources)
- Industrial base expansion and engagement → ecosystem (economies of scale)
- Aligned R&D investment
- Reuse across programs and Services

This technical data deliverable was developed using contract funds under Basic Contract No. W56KGU-18-D-0004.

Systems in Development

- Directed Energy Weapons (DEW) utilize beams of energy to destroy, damage, or disrupt a target. Examples include lasers, high power microwaves (HPM), and particle beams. They offer:
  - Potential to “Bend” the Cost Curve
  - Deep Magazines with Rapid Reload and Reduced Logistics
  - Highly reduced collateral damage
  - Precision Effects / Adjustable Effects
  - Engagement at the Speed of Light
  - Air / Land / Sea Platforms

DE-MSHORAD
Army
Laser

SSL-TM
Navy
Laser

THOR
Air Force/Army
HPM

HiJENKS
Air Force/Navy
HPM

AHEL
SOCOM
Laser

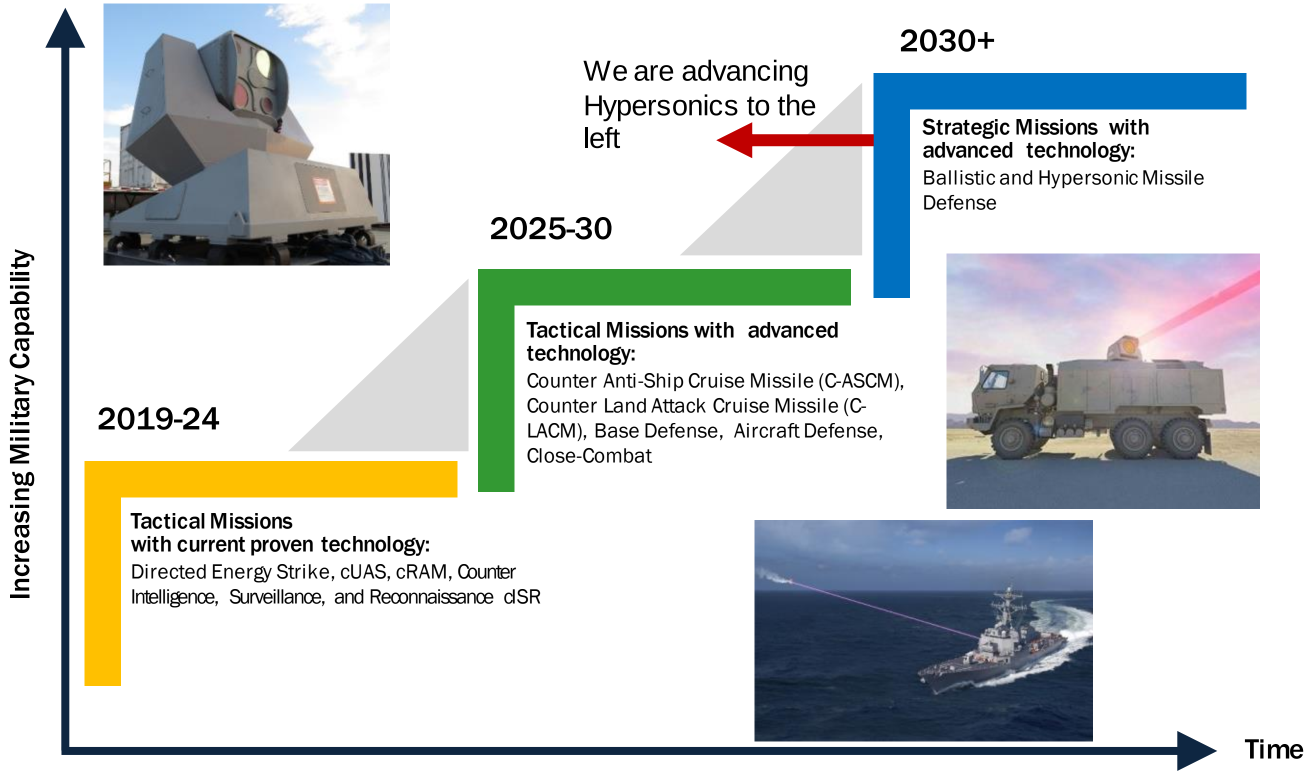
DEWS Are Arriving and Being Used

- ODIN – Optical Dazzling Interdictor, Navy
  - Low-power laser system for dazzling of Unmanned Aerial System (UAS)-mounted Electro-Optical (EO)/Infrared (IR) sensors
  - First three systems installed on DDG51 Flt IIA ships, five more to be installed through 2023
- HELIOS, Navy
  - cUAS, cFIAC, 60 kW, Lockheed
  - To be installed on DDG51 Flt IIA ship in FY22
- SSL-TM – Solid State Laser- Technology Maturation, Navy
  - cUAS, cFIAC, 150 kW, Northrup
  - Installed on USS Portland (LPD 27) in 2019, deploys in 2021
- CLAWS – Compact Laser Weapons System, Marines
  - cUAS, 5 kW, Boeing, 5 systems, in CENTCOM
  - Integrated with Army C-RAM C2 system and radar
- HELWS – High Energy Laser Weapons System, Air Force
  - cUAS, 10 kW, Raytheon
  - 1 unit in CENTCOM
- THOR – Tactical High Power Microwave Operational Responder, Air Force
  - cUAS, Raytheon, OCONUS evaluation later this year
- DE M-SHORAD – Maneuvering Short Range Air Defense, Army
  - Experimental prototype with combat capability : 50 kW-Class laser for cUAS, cRAM, cRW
  - Prototype demo FY21, 1st Platoon (4 platforms) fielded FY22
- IFPC-HEL – Fixed/Semi-Fixed Site Protection, Army
  - Lab demo FY22: 300 kW-Class laser for cUAS, cRAM, cCM will inform prototyping effort
  - Joint range demonstration with Navy HELCAP in FY23, 1st Platoon (4 platforms) fielded FY24

DEWS MOSA RA needs to grow along side of technology development

Key Aspects

- Achieve military dominance in every mission area where DEW makes technical sense
- Develop operational experience, knowledge, and confidence through operational demonstrations
- Advance and mature the technology to increase lethality, expand the mission set, and counter future adversaries
- Deliver new military capabilities with proven technology



Architecture

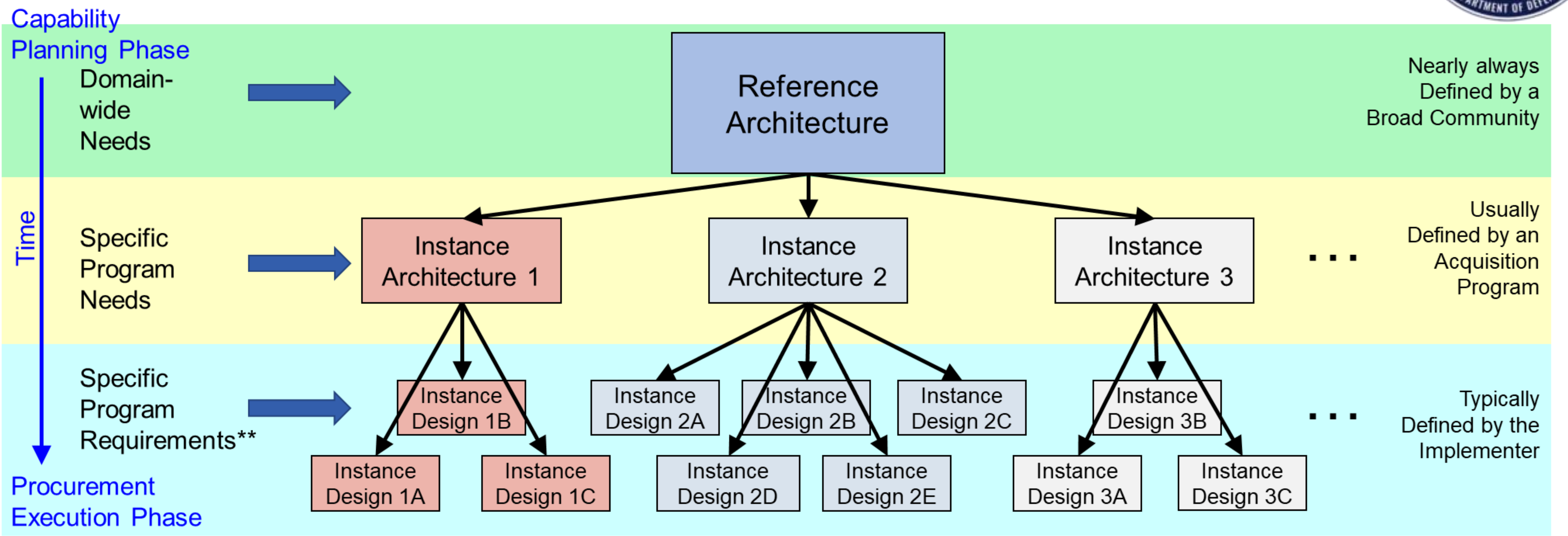
Modules

Interfaces

Architecture: “The fundamental organization of a system embodied in its <u>components</u>, their <u>relationships</u> to each other and to the environment, and the principles guiding its design and evolution*”

From ISO/IEC 42010 - IEEE Std 1471-2000 "Systems and software engineering — Recommended practice for architectural description of software-intensive systems

How a Reference Architecture fits into the Development Process



* The Reference Architecture will evolve over time as experience from its use is folded back into it

** Selection of the Implemented Design will be based on factors such as price/performance trades, SWaP, etc.

Derived from SOSA 101

MOSA: Modules Encapsulate Functions

"… functionally is partitioned into discrete, cohesive, and self-contained units with well-defined interfaces that permit substitution of such units with similar components or products from alternate sources with minimum impact on existing units."

Function A
Function H
Function C
Function M
Function Q
Function P
Function D
Function E
Function J
Function F
Function L
Function G
Function K
Function N

Module 1
Function H
Function C
Function A

Module 3
Function F
Function G
Function N

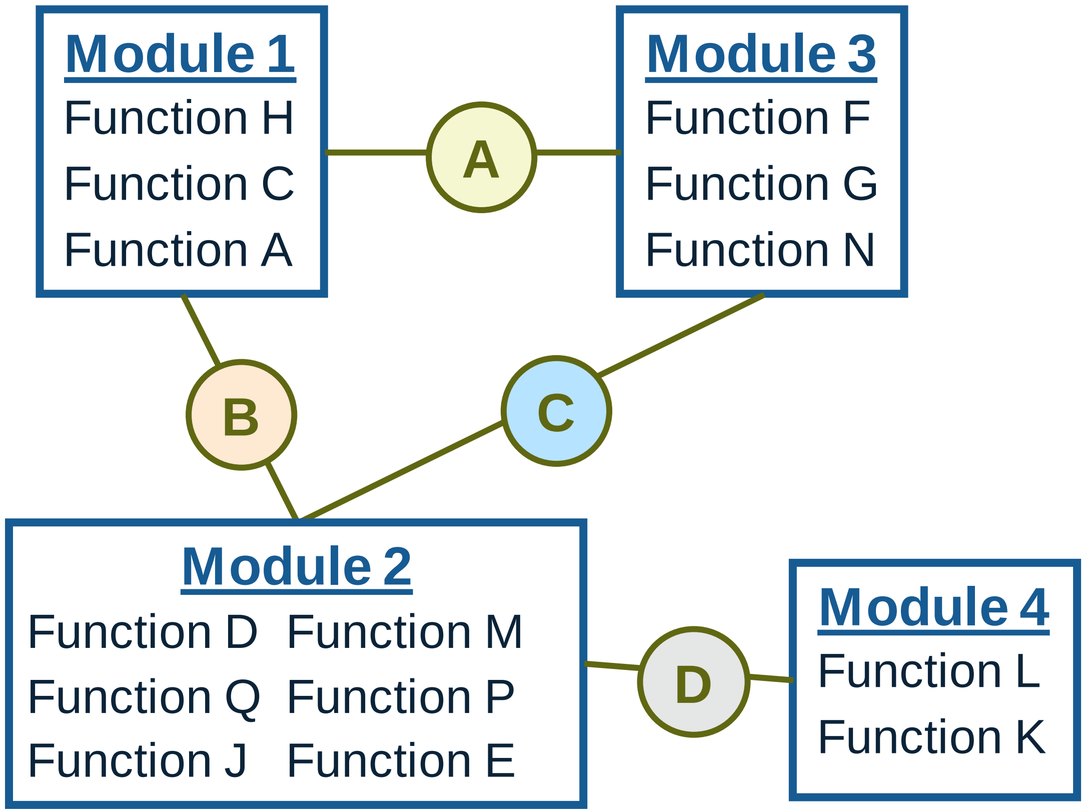
Functions are encapsulated; treat them as an integrated whole – with one set of input/outputs → interfaces

Module 2
Function D Function M
Function Q Function P
Function J Function E

Module 4
Function L
Function K

Modularity is not limited to the physical; software functionality can be modularized too

Interfaces are Made of Interactions
Interactions Enable Functions to Exchange Data



Toy Example of Interactions Documentation

Interaction on Interface	Producer Function	Consumer Function	Conveyed Signal&Data
A1	C	N	Rx Signal
A2	G	A	Tasking
A3	H	F	Interlock
B2	P	C	Enable
C1	M	G	Tracks
C3	Q	G	Cues
C4	G	E	Signal Quality
C5	J	G	Track Priority
D1	J	L	Write data
D2	K	M	Read data

Interactions between Functions within the same Modules do not appear on Interfaces

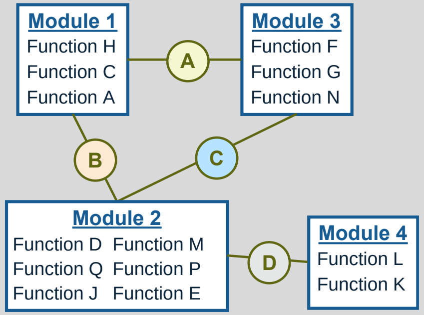
Key Points

Functions consume input
– and what they consume comes from another Function

Functions produce products
– and what they produce is consumed by another Function

Interactions exist to enable one Function's product (as Producer) to be an input to another Function (as Consumer)

An Interface consists of the (many) Interactions that cross inter-Module boundaries – a "bundle" of the constituent Interactions



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D2	K	M	Read data

One cannot credibly define Interactions without a full understanding of

1. The input needs of the consumer Function
2. The output products of the producer Function

It is critically important to define and document Interfaces in terms of Functions' Input Requirements (as Consumers) and Output Products (as Producers)

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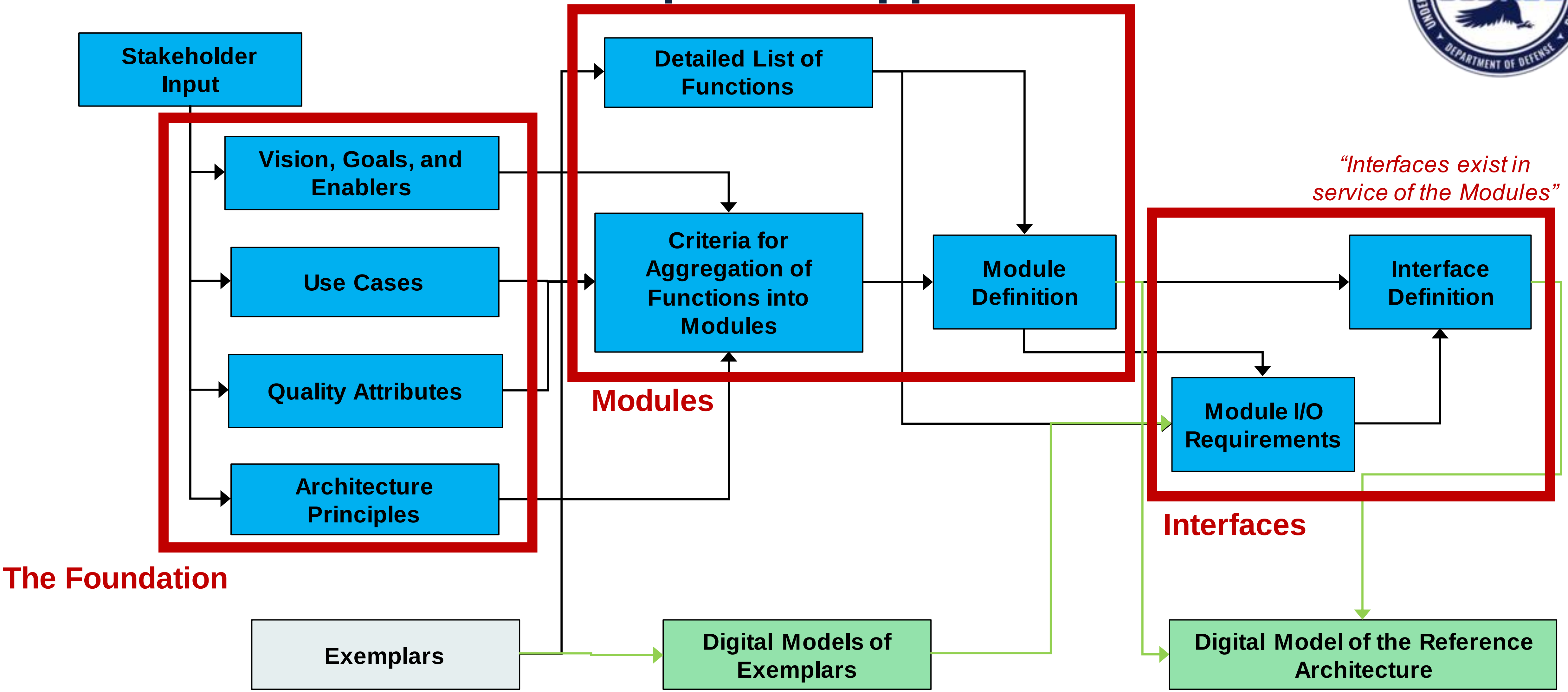
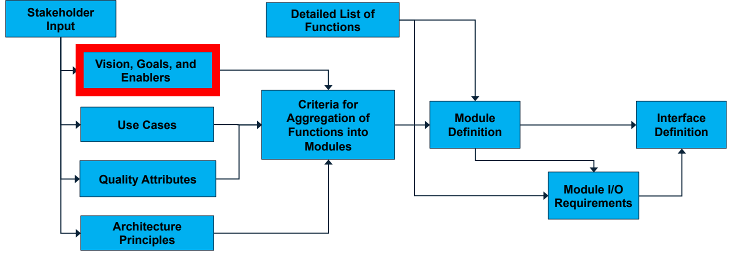
DEWS MOSA RA Development Approach



Architecture driven by Vision, Goals and Enabling Capabilities



Directed Energy Weapon Systems (DEWS) Programs of Record leverage a broadly applicable open Reference Architecture, founded on MOSA principles, that accelerates delivery of innovation, expedites acquisition and increases the reuse of standard components

Broadly Applicable

a) Stakeholder definition of CV-1, QAs, Use Cases, Architecture Principles
b) Agnostic with respect to operating environment
c) Agnostic with respect to host platform

Based on MOSA Principles

a) Leverage open/commercial standards and OSAs
b) Non-proprietary, supplier-agnostic module & interface definitions
c) Protect supplier IP and employs balanced Data Rights within modules
d) Large and small business are full partners in architecture development and governance
e) Create new only when necessary
f) Conformance Certification

Accelerate Delivery of Innovation

a) Follow "gray box" concept (architecture defines what the modules and interfaces do, not how they do it)
b) Provide alternative methods to instantiate near-term and future-focused technologies
c) Ensure small businesses- are fully enfranchised
d) Evolvability is incorporated

Expedite Acquisition

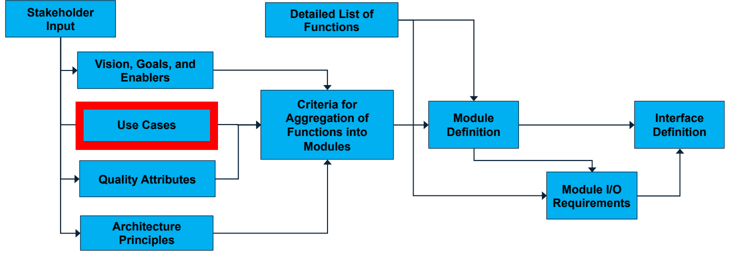
a) Reduce traditional weapon system integration & test time
b) Vendor-agnostic open reference architecture allows government to leverage multiple industry partners
c) Allow faster insertion of new tech from best of breed
d) Enable small businesses- developed enhancements at reduced costs

Increase Reuse

a) Facilitate backward compatibility
b) Open business model
c) Portable modules enables cross-weapon portfolio application to reduce design time for new systems

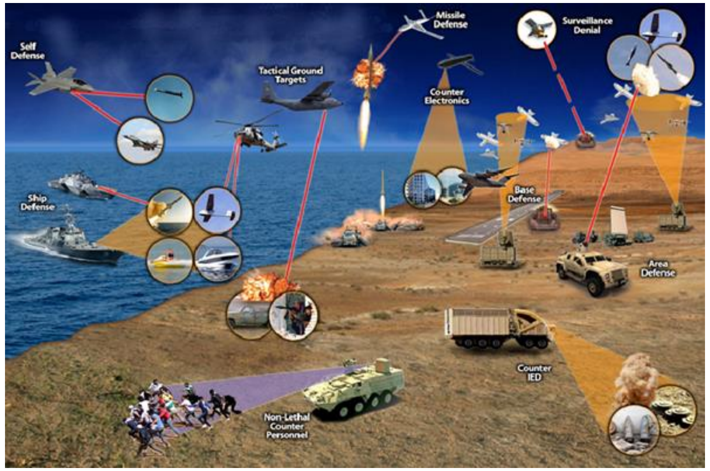
Key
Vision
Goals
Capabilities

Developed via Stakeholder Workshops



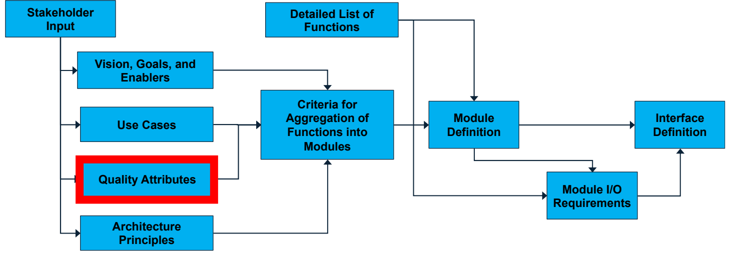
DEWS MOSA RA Use Cases

- Surface / Air C-UAS
- Ground / Air C-UAS
- Surface / Air ASCM
- Hypersonic Defense
- Ground C-IED
- Air / Air Combat
- Air / Ground HEL
- Air / Ground HPM



Purpose:

- Demonstrate capabilities needed for systems to operate effectively in various scenarios
- Encompass a wide variety of capabilities, requirements and environments
- Exercise reference architecture in multiple dimensions so it can flow down to all varieties of current and future instance architectures
- Bring to light functionality that might otherwise be overlooked
- Goal is to keep the number of Use Cases reasonable, while exposing the complete functionality needed as part of a robust reference architecture



Quality Attributes (in ranked order)

Rank	Quality Attribute Name
1	Modularity
2	Upgradability
3	Portability
4	Scalability
5	Interoperability
6	Safety
7	Reliability
8	Configurability
9	Resiliency
10	Deployability

Quality Attributes are:

- Means of estimating the "goodness" of an architecture
- Non-functional characteristics that collectively influence the overall quality of the system, and will drive many of the architectural decisions (often referred to as the "-ilities")
- A property of an architecture by which its merit will be judged by some stakeholder or stakeholders
- Based on stakeholder consensus
- Rank-ordered (so you can make decisions/trades)

Developed via Stakeholder Workshops

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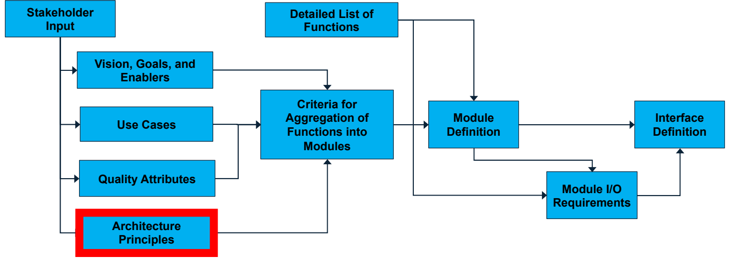
Architecture Principles (in no specific order)

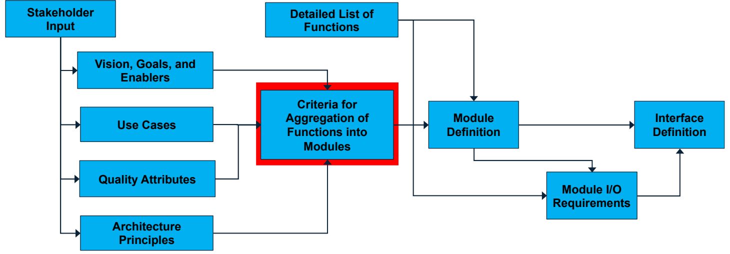


- Quality Attributes are strictly adhered to
- Interfaces are fully defined
- Options are provided
- Maximally leverages existing standards
- Broadly applicable
- Agnostic with respect to host platform
- Agnostic with respect to operating environment
- Agnostic with respect to developer technology
- Protects developer technology and intellectual property

Architecture Principles are:

- General rules and guidelines that guide/inform and support the development and maturation of an architecture
- To be enduring and seldom (if ever) amended
- Form a basis for decision-making
- Govern the architecture process, affecting the development, maintenance, and use of the architecture

Criteria for Aggregation



Cohesion: Combine functions with high cohesion to minimize complexity of interfaces or have that have common I/O needs

Overlap: Combine functions that have a high degree of SW/HW overlap

Encapsulate IP: Encapsulate supplier IP within modules (to protect it by not exposing sensitive interfaces)

Encapsulate Change: Encapsulate functionally subject to rapid technology change (functions with high likelihood of obsolescence, innovation, or changes)

Existing Standards: Maximize use of existing standards and OSAs (avoid creating unique modules and interfaces)

Cardinality: Function aggregation must take into account the need for different cardinality/multiplicity of resulting Modules instances

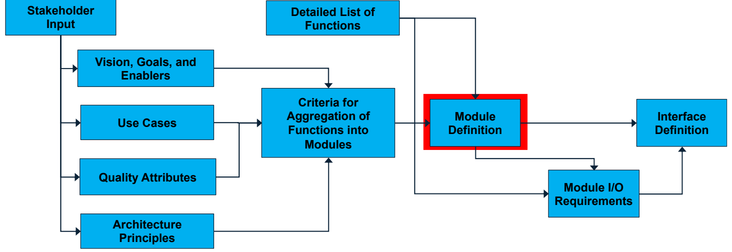
Variants: Function aggregation must support resulting Modules and Interfaces that have “small / medium / large” variants

Reuse: Maximize portability and reuse of the resulting Module (e.g., be used for HPM as well as HEL systems, and operational domains such as land/sea/air)

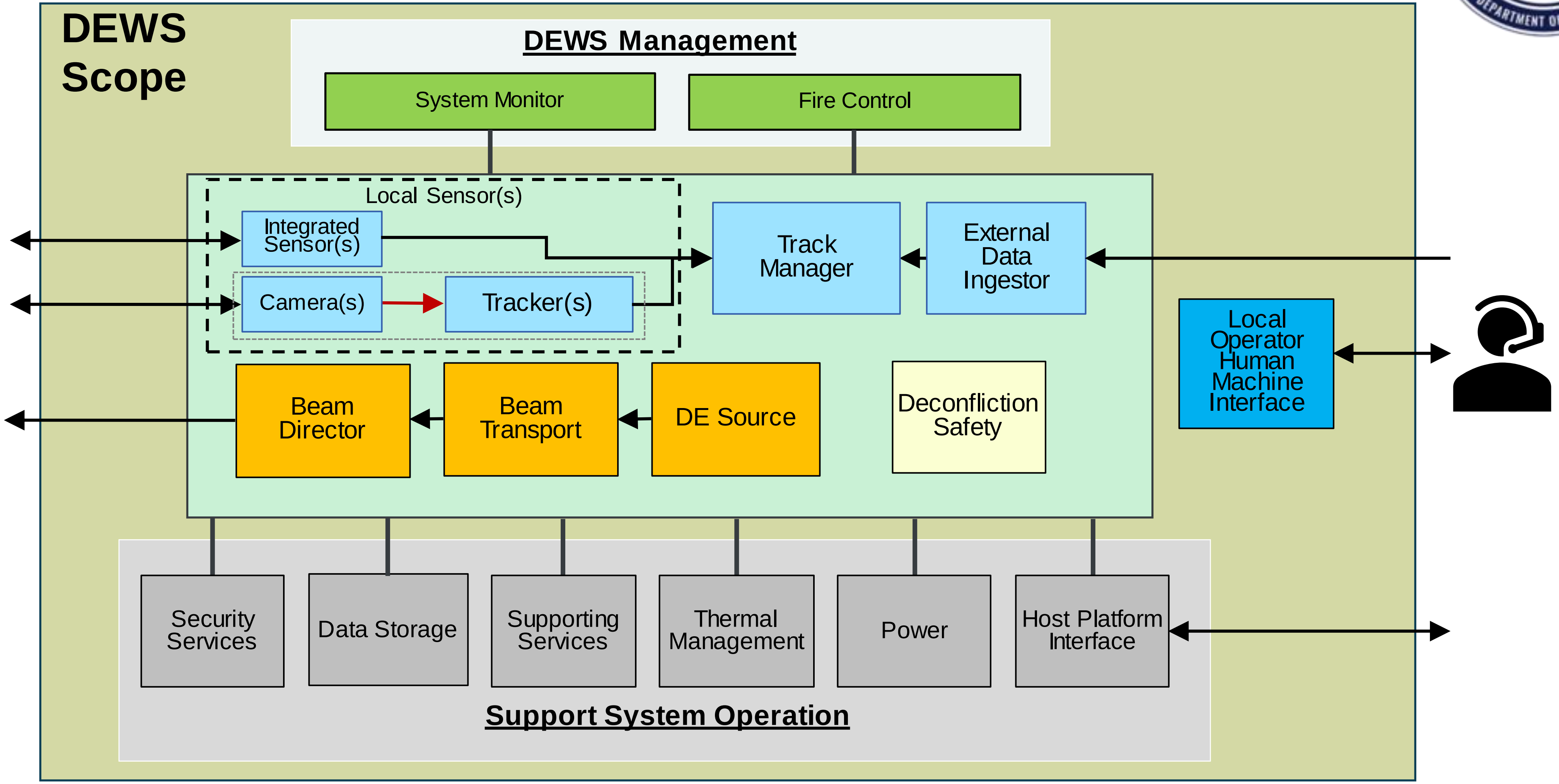
Testable: Resulting Modules are Independently testable (can be tested outside of the system, and by entities other than the OEM)

Specialized: Aggregate and encapsulate functions that require specialized test equipment (so that standards-based interfaces can be used to test them)

Environment: Separate environmentally-sensitive (requiring climate control) from insensitive functions



DEWS MOSA RA Module Pictorial



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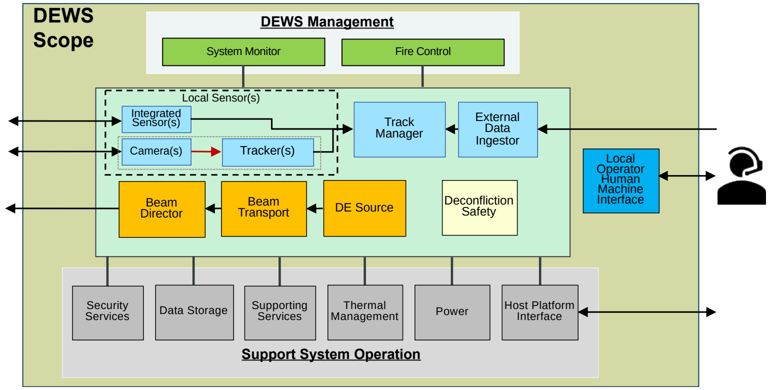
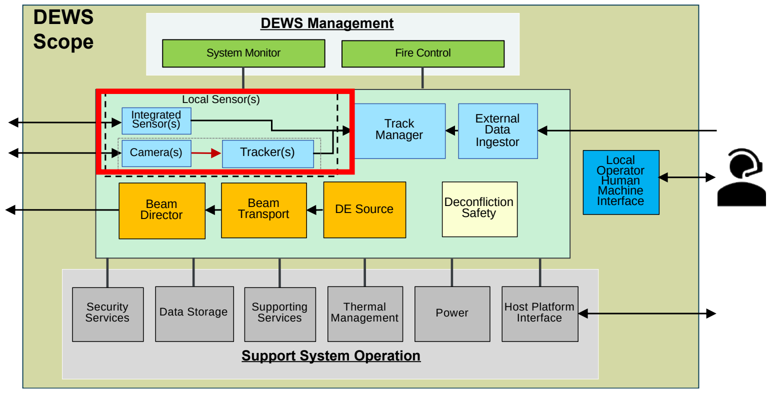
DEWS MOSA RA Modules: Management Functions



Module Name	Module Description
System Monitor Module	The System Monitor Module is responsible for the ascertainment of, and reporting on, all Modules' Health, Status, and Configuration information (including faults).
Fire Control Module	The Fire Control Module is responsible for managing the controlled release of the directed energy for the DEWS by orchestrating the DEWS Module activities related to tasking, Target engagement, mode/state selection, aimpoint, managing Local Sensor Operations, arming, and firing the directed energy.

DEWS MOSA RA Modules: Sensing



Module Name	Module Description
Camera(s) Module	The Camera Module (or Modules as there can be more than one) is a focal plane array that reads out raw image or video data that is sent directly to the Tracker Module, by way of one of the designated dedicated interfaces (e.g., Camera Link) for subsequent processing and ""sensemaking."" The Camera + Tracker Module pair is differentiated from the integrated Sensor Module in that the Camera containing the focal plane array is separate from the control electronics (the ""brains""). This is an optional Module.
Tracker Module(s)	The Tracker Module ingests focal plane images or video over a one of a finite list of specified specialized interfaces (e.g., Camera Link) from the Camera Module, and through a series of algorithms identifies discrete objects (e.g., clusters of pixels), performs computation (e.g., determine target orientation) and provides a digital output suitable for use by the Track Manager (which is responsible for maintaining the mathematical representation of the state of all objects of interest). The Tracker Module also acts as the go-between for camera settings that originate in the Fire Control Module, the Local Operator UI Module, or via the Host Platform Interface. It also serves as a proxy for the Camera Module for all management functions. As a Local Sensor for the DEWS (as is the case of any Integrated Sensor Modules present), the Camera Module + Tracker Module pair is tasked by other Modules in the DEWS or by way of the Host Platform Interface. Multiple Camera Module + Tracker Module pairs may be implemented to meet the various functions listed here.
Integrated Sensor(s)	As a Local Sensor for the DEWS (as is also the case of any Camera Module + Tracker Module pairs present) the Integrated Sensor Module (or Modules as there can be more than one) aids the DEWS in detection, track update, or boresight alignment. An Integrated Sensor is considered to be a complete sensor system (not just a focal plane array) that may be either a passive EO/IR sensor, an active EO/IR sensor, a hybrid, or a (conventional) radar. The sensor incorporates physical and functional capabilities such as imaging sensor/FPA, camera, image processing, scanning, internal tracking, error compensation, etc. -- all in service of aiding the weapon system to put energy on target. The Integrated Sensor is tasked by other Modules in the DEWS or by way of the Host Platform Interface. Multiple Integrated Sensors may be implemented to meet the various functions listed here.

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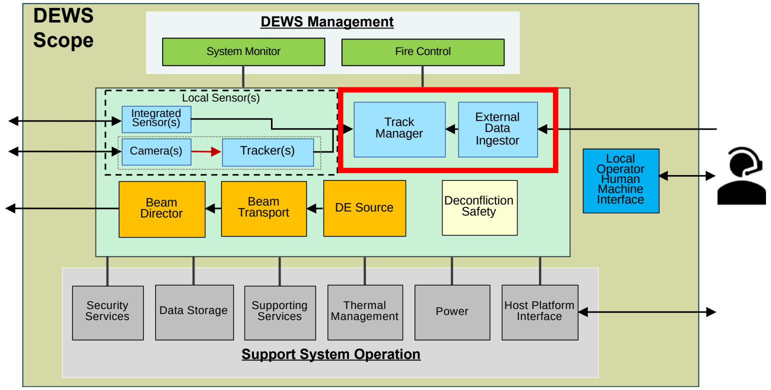
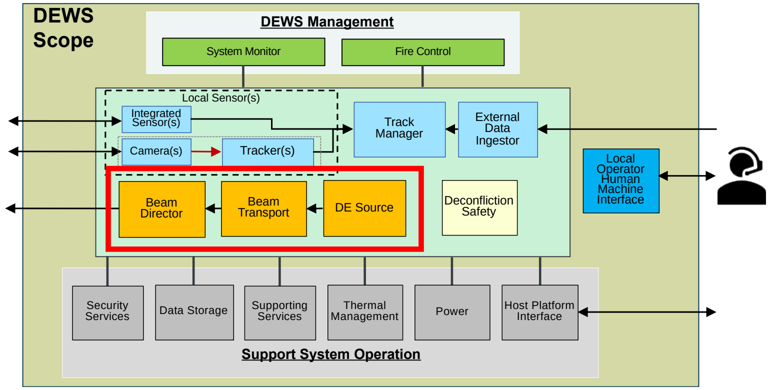
DEWS MOSA RA Modules: Tracking



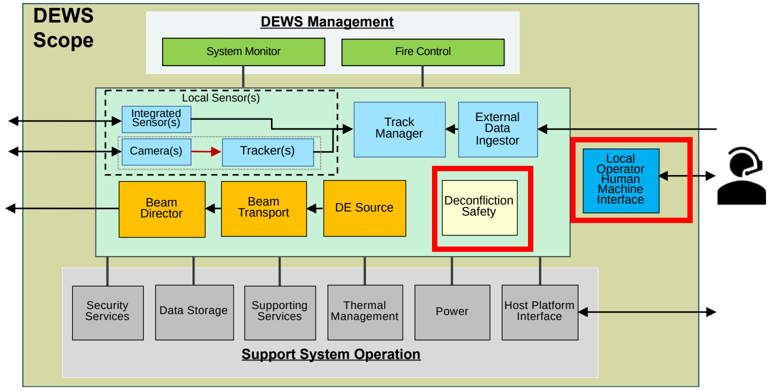
Module Name	Module Description
Track Manager Module	The Track Manager Module maintains an internal store of the mathematical representation of objects of interest (hereafter known as Tracks). It correlates new (or newly provided) detections (either generated locally or from an external source) with existing 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.
External Data Ingestor Module	The External Data Ingestor takes in detection, track, and other (unspecified at this point) data from sources other than the Host Platform and converts them to a format that is compatible with the DEWS. Because the data may be supplied over-the-air, an External Data Ingestor may include an interface to a radio or other communications device on the outbound side, therefore, like the Host Platform Interface, only the DEWS-facing interfaces are defined in this Reference Architecture.

DEWS MOSA RA Modules: Beam Functions



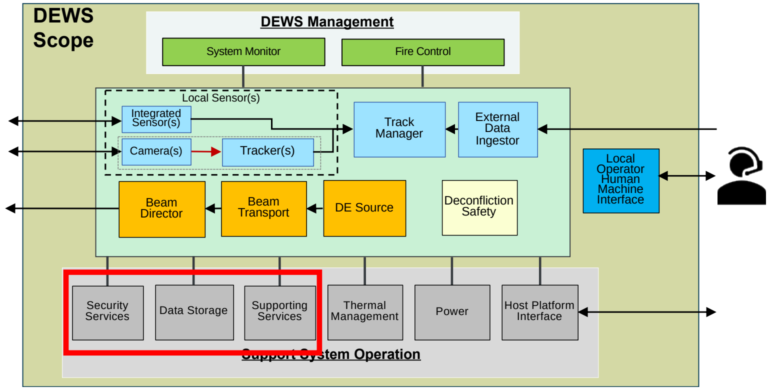
Module Name	Module Description
DE Source Module	The DE Source Module generates the electromagnetic energy that will be directed at the Target.
Beam Transport Module	The Beam Transport Module ensures that the DE Source module radiated energy safely passes through the system without degradation or damage, and optionally provides fine steering control, mode change, and/or wavefront correction.
Beam Director Module	The Beam Director Module is responsible for impedance matching the beam path with that of free space, and ensuring that the directed energy impinges on the target.

DEWS MOSA RA Modules: Interface and Safety



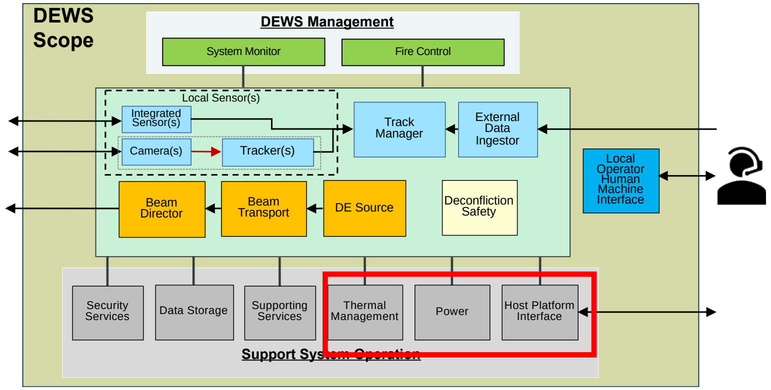
Module Name	Module Description
Local Operator Human Machine Interface Module	The Local Operator Human Machine Interface (HMI) Module is the internal graphical user interface, (which may be graphical, physical, and/or a combination) for displaying DEWS data and for controlling/managing the DEWS. This Module is the analog for what would otherwise exist on the other side of the Host Platform Interface (either on the Host Platform or remote). It is expected that local automation (use of AI/ML) be implemented through the Local Operator HMI or its equivalent through the Host Platform Interface. The Local Operator HMI is an optional Module; if operation of the DEWS is to be performed from the Host Platform Ð or by way of the Host Platform Interface Ð then the operator is external to the DEWS and this Module is not needed.
Deconfliction Safety Module	The Deconfliction Safety Module ensures that the directed energy does not cause damage to own-ship, friendlies, satellites, or objects in an operator-defined region of space by determining the spatial (angular) and temporal windows where and when it is safe to fire, thereby supporting both engagement planning and real-time clear-to-fire indications. It can accept files in P/A Approval Message (PAM) and Pointing and Lasing Cut-Out (PLCO) formats as source data.

DEWS MOSA RA Modules: Support Services (1 of 2)



Module Name	Module Description
Security Module	The Security Module is the service that performs authentication (confirming that an entity has the rights to do what it intends, such as using Role-Based Access Control methods), authorization (controls access for privileged functions based on authentication confirmation), logs security-relevant events, manages cryptologic devices, the DEWS firewall functions, ensures zeroization when necessary, and monitors the internal DEWS network for evidence of intrusion detection. Agents of the Security Module reside in the other Modules and respond to, and perform functions under the control of the Security Module -- in effect, Security is a distributed activity even if it is orchestrated by this primary Module.
Data Storage Module	The Data Storage Module is a service used by all the other Modules in order to maintain a single source of DEWS data (mission data as well as log data). The Data Storage Module accommodates unclassified as well as (encrypted) classified storage.
Supporting Services Module	The Supporting Services Module provides essential infrastructural data to the rest of the Modules. The services are time (and frequency) keeping and distribution, and navigation (position, velocity, acceleration, and orientation) data and services.

DEWS MOSA RA Modules: Support Services (2 of 2)



Module Name	Module Description
Thermal Management Module	The Thermal Management Module is responsible for providing proper heating/cooling of the Modules (to keep them in their designated range) for current thermal load and operational mode. This Module manages and orchestrates thermoregulation by way of head exchangers positions in/on/coresident with (design-dependent) the other Modules.
Power Module	The Power Module either adapts Host Platform power to the power requirements of the DEWS Modules (e.g., converting between AC to DC, making voltage changes, etc.) or generates its own power for the DEWS. The Power Module is also responsible for power conditioning and storage.
Host Platform Interface Module	The Host Platform Interface is the singular point of interaction between the Host Platform and the DEWS; all communication with the Host Platform goes through this Module, as well as (if needed) Host-provided power (conveyed to the Power Module) and thermal support (conveying fluids to/from the Thermal Management Module). The Host Platform Interface's primary function is adapting the DEWS to the uniqueness of the Host Platform. One of these adaptations is translation to/from the DEWS Data Model using formats and protocols native to the DEWS (on the internal interface) and native to the Host Platform (on the external interface). The HPI also optionally serves as the pass-through for remote operator input (substituting for the Functions provided by the Local Operator HMI Module when that Module is absent).

Example of Functions Encapsulated in one Module

ID	Name	Description
21.11	Display Situational Awareness Data	Displays map of system tracks relative to host platform. May include symbology (e.g., MIL-STD-2525), overlays, etc. Display sources include result of the current track store, Local Sensors, primary aperture, or direct feed from External Sensor or Host Platform. This display is also a user interface for functions such as designating tracks. If a track is to be designated for attack, the designated object is tagged as the target
21.13	Display Video	Displays Integrated Sensor video feeds to DEWS operator for use in carrying out engagements. The feeds may be real-time or pre-recorded. The operator display allows the replay, pause, rewind, fast forward, etc. (so-called TiVo functionality) permitting reconstruction and analysis.
21.14	H&S Status Update	Requests and receives system H&S from the System Monitor
21.15	Display and Control Status	Provides visual display of system status (received from Fire Control), view and control states/modes (conveyed to Fire Control),system power on/off, fault conditions and alarms (including the ability to drill-down to gather more detail, and clearing alarms)
21.16	Initiate BIT	Requests that the System Monitor Module that a Built-in Test (BIT) to be performed

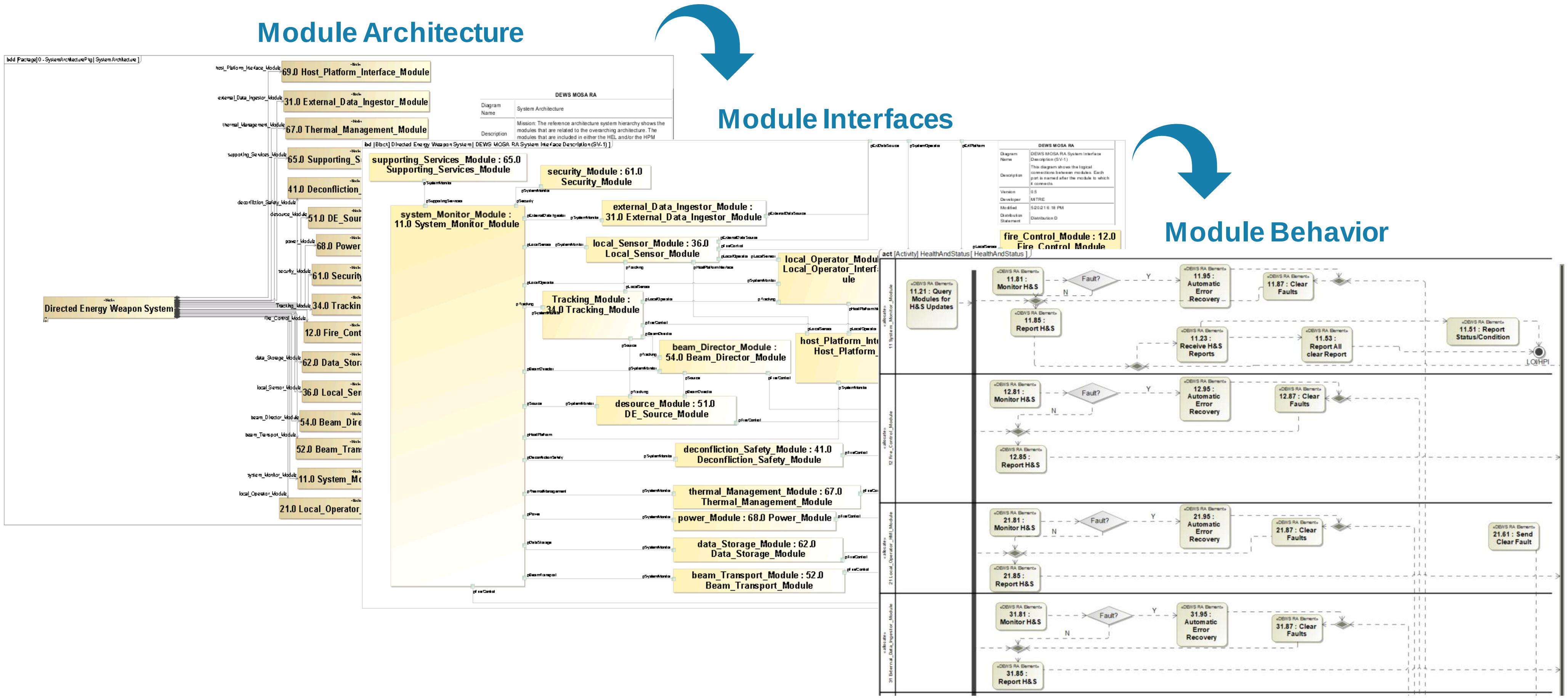
Mapping Functions → I/O Needs → Inter-Module Interactions

ID	Name	Input Needs	Input Source	Product Produced	Product Destination
21.11	Display Situational Awareness Data	Track Data (tracks and kinematic data)	Track Manager Module	Data in display format	Fire Control Module
21.13	Display Video	Video data	Local Sensor Module (real-time) and Data Storage Module (playback)	Video in display format	(local operator display)
21.14	H&S Status Update	H&S status report	System Monitor Module	Status request	System Monitor Module
21.15	Display and Control Status	System status data,	Fire Control Module	Data in display format, Control messages	(local operator display), Fire Control Module
21.16	Initiate BIT	Operator input	(controls internal to this module)	Request to initiate BIT	System Monitor Module

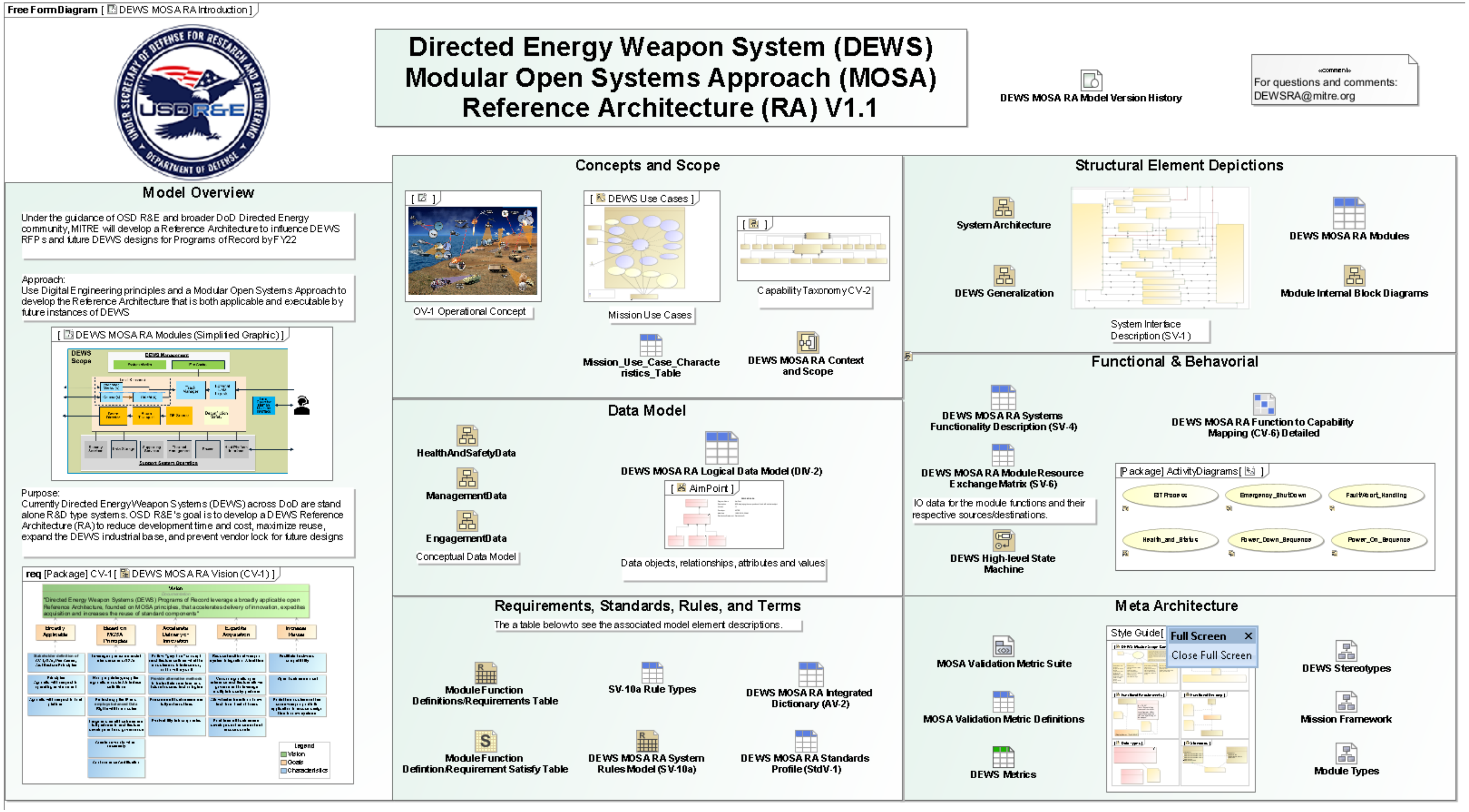
Only showing five of the 26 functions for Module 21 (Local Operator HMI)

DEWS MOSA Reference Architecture Model

- The DEWS MOSA RA will be provided as a Digital Engineering product, directly usable as a base for implementing programs
- Accompanying documentation will provide guidance on use, including with other standards



DEWS RA Landing Page



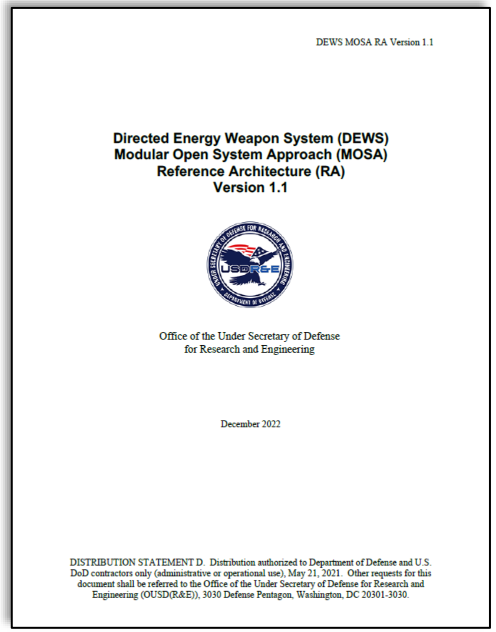
Published version DEWS MOSA RA 1.1

Version 1.1 of the Reference Architecture

- Reference Architecture Document 1.1
- Magic Draw Digital Model

Supplemental Material

- Implementation Guidance
- DEWS RA Assessment
- Acquisition Framework


DEWS MOSA RA Version 1.1

Directed Energy Weapon System (DEWS)
Modular Open System Approach (MOSA)
Reference Architecture (RA)
Version 1.1

Office of the Under Secretary of Defense
for Research and Engineering

December 2022

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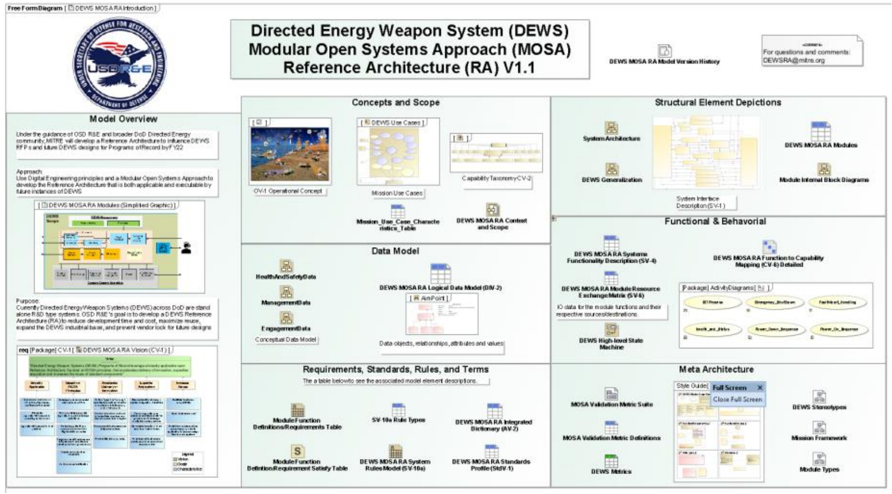
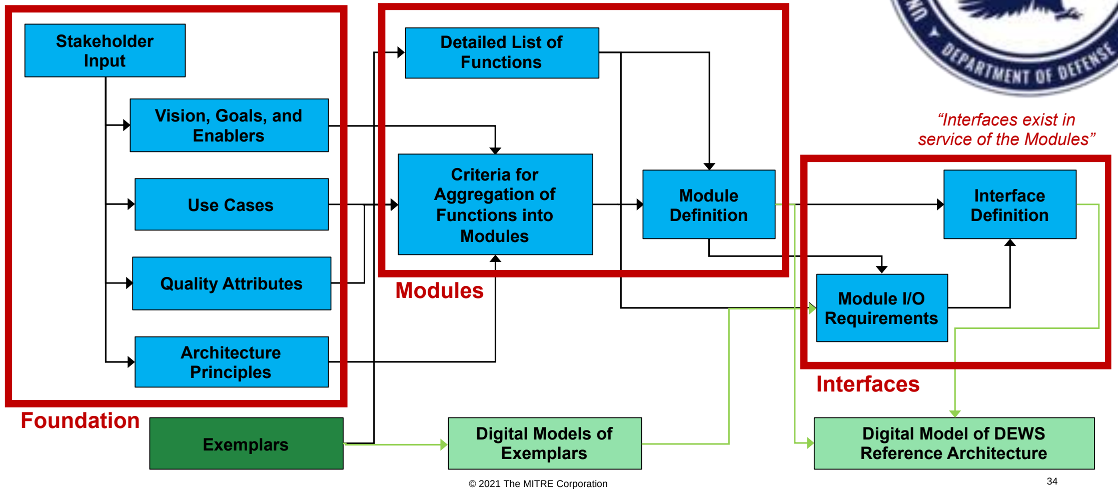


Options to View DEWS MOSA RA

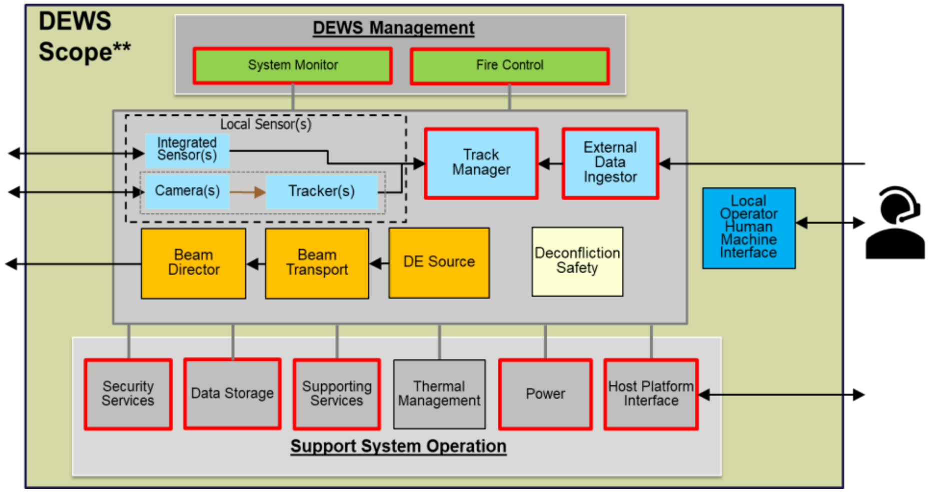
RA Document	The RA complete with imported tables, charts, graphics, and descriptions will be made available in an MS Word Report
HTML Extract	Export of MBSE model diagrams and data will be provided in HTML extract for users without access or familiarity with the Cameo software
Cameo zip file	Users will unzip all files to a folder and use Cameo to open the "DEWS_MOSA_Reference_Arch.mdzip" file. Cameo is a generic name for Dassault Systems CATIA Cameo Enterprise Architecture 19.0 SP4 also known as Magic System of Systems Architect (MSOSA) 19.0 SP4

Summary

- Background: Directed energy systems are becoming technically mature, but Services are all going their own way
- Need: MOSA-based approach to increase reuse, accelerate technology innovation, and expedite acquisition
- Approach: Develop a modular ("building block") architecture that incorporates Quality Attributes like Upgradability, Portability, and Scalability



Foundation → Module Definition → Interface Definition → Digital Model



Red outline = to be harmonized with SOSA

Products:

- DEWS MOSA RA Document
- DEWS MOSA RA Digital Model
- DEWS Acquisition Framework
- DEWS MOSA ICD
- DEWS MOSA Implementation Guide

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Keegan Merkert

Kmerkert@mitre.org

Linkedin.com/in/keegan-Merkert-653bb118

SOLVING PROBLEMS FOR A SAFER WORLD®

Backup

MOSA is …

"An integrated business and technical strategy that employs a modular design and, where appropriate, defines key interfaces using widely supported, consensus-based standards that are published and maintained by a recognized industry standards organization."

"A Modular Open Systems Approach (MOSA) to Acquisition," Open Systems Joint Task Force (OSJTF)

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

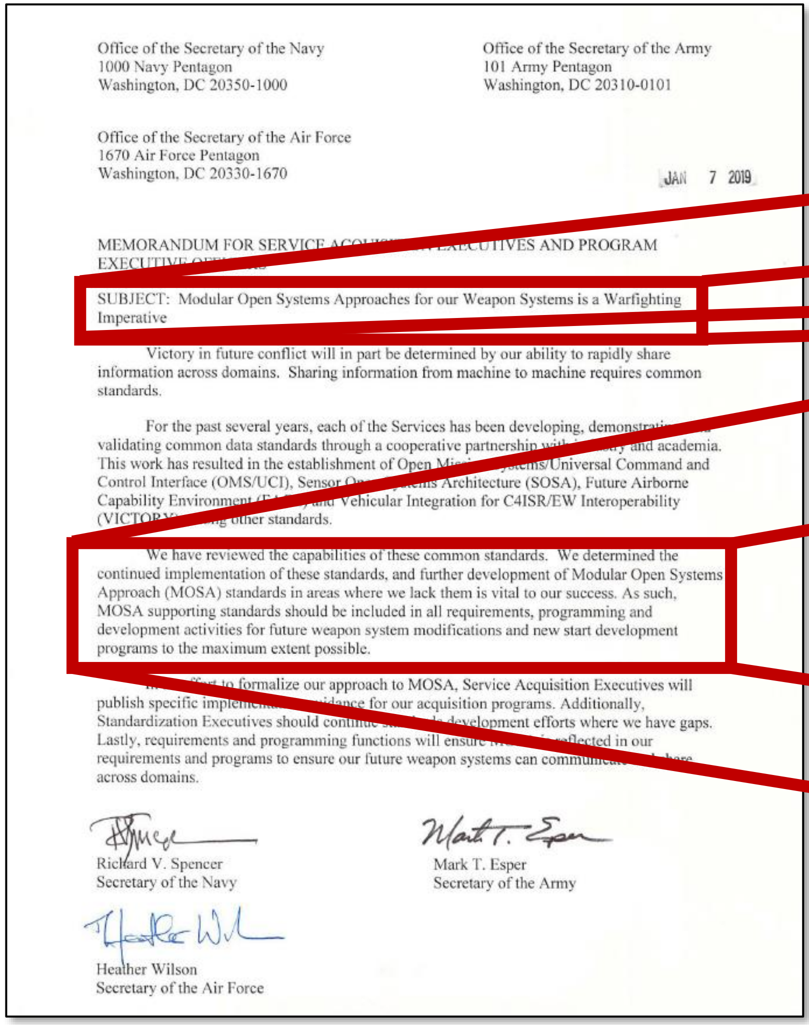
Facilitate technology refresh – delivery of new capabilities or replacement technology without requiring change to all elements in the entire system.

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.

Tri-Service Secretaries Memorandum: MOSA as a Warfighting Imperative (Jan 7, 2019)



Office of the Secretary of the Navy
1000 Navy Pentagon
Washington, DC 20350-1000

Office of the Secretary of the Army
101 Army Pentagon
Washington, DC 20310-0101

Office of the Secretary of the Air Force
1670 Air Force Pentagon
Washington, DC 20330-1670

JAN 7 2019

MEMORANDUM FOR SERVICE [illegible] EXECUTIVES AND PROGRAM EXECUTIVE [illegible]

SUBJECT: Modular Open Systems Approaches for our Weapon Systems is a Warfighting Imperative

Victory in future conflict will in part be determined by our ability to rapidly share information across domains. Sharing information from machine to machine requires common standards.

For the past several years, each of the Services has been developing, demonstra[illegible] validating common data standards through a cooperative partnership [illegible] and academia. This work has resulted in the establishment of Open Mi[illegible]stems/Universal Command and Control Interface (OMS/UCI), Sensor [illegible] Architecture (SOSA), Future Airborne Capability Environment [illegible] Vehicular Integration for C4ISR/EW Interoperability (VICTOR[illegible] other standards.

We have reviewed the capabilities of these common standards. We determined the continued implementation of these standards, and further development of Modular Open Systems Approach (MOSA) standards in areas where we lack them is vital to our success. As such, MOSA supporting standards should be included in all requirements, programming and development activities for future weapon system modifications and new start development programs to the maximum extent possible.

[illegible] to formalize our approach to MOSA, Service Acquisition Executives will publish specific imple[illegible] for our acquisition programs. Additionally, Standardization Executives should conti[illegible] development efforts where we have gaps. Lastly, requirements and programming functions will ensure [illegible] reflected in our requirements and programs to ensure our future weapon systems can communi[illegible] across domains.

Richard V. Spencer
Secretary of the Navy

Mark T. Esper
Secretary of the Army

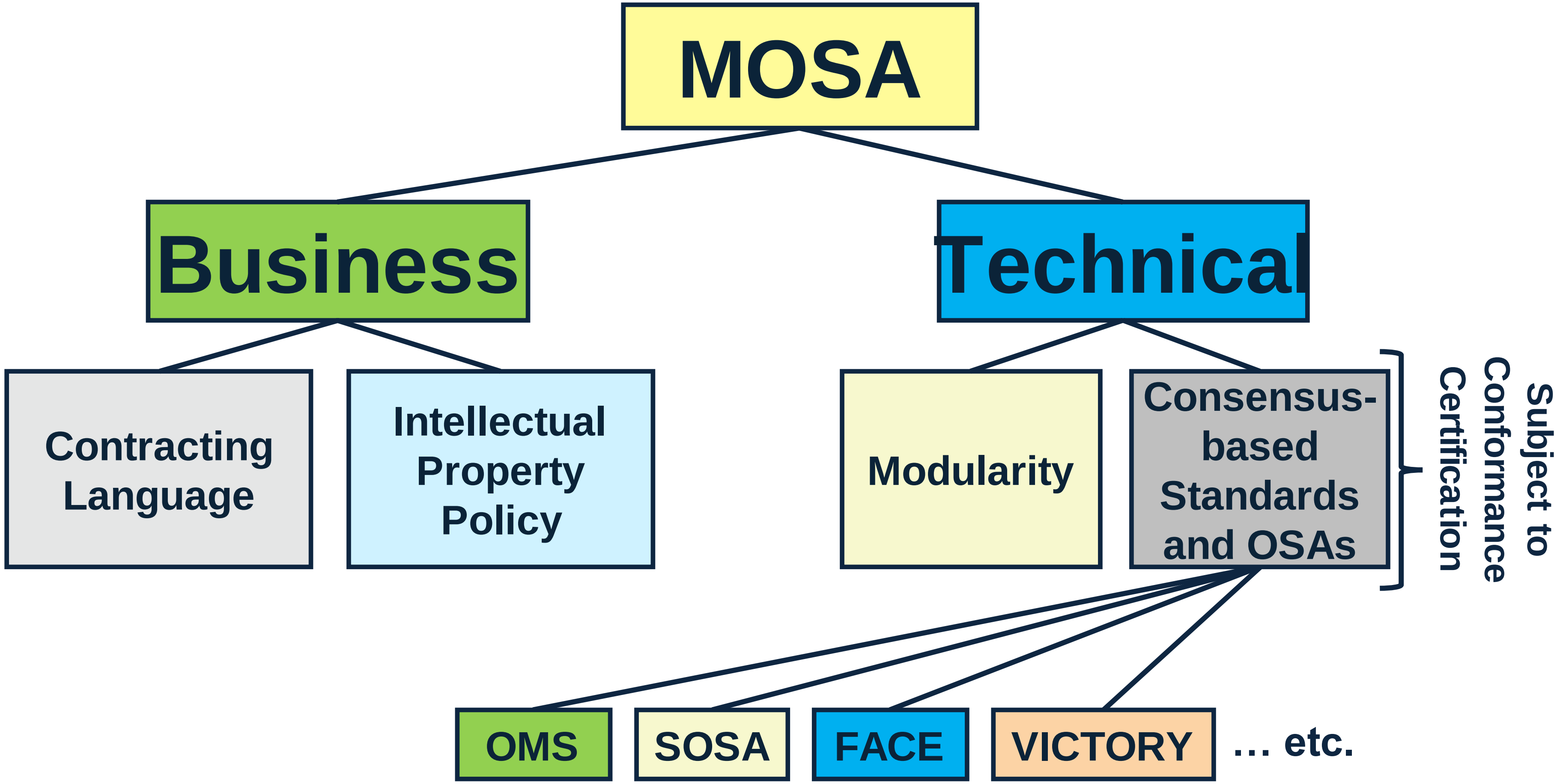
Heather Wilson
Secretary of the Air Force

SUBJECT: Modular Open Systems Approaches for our Weapon Systems is a Warfighting Imperative

We determined the continued implementation of these standards, and further development of Modular Open Systems Approach (MOSA) standards* in areas where we lack them is vital to our success. As such, MOSA supporting standards should be included in all requirements, programming and development activities for future weapon system modifications and new start development programs to the maximum extent possible.

* OMS/UCI, SOSA, FACE and VICTORY

Decomposing MOSA

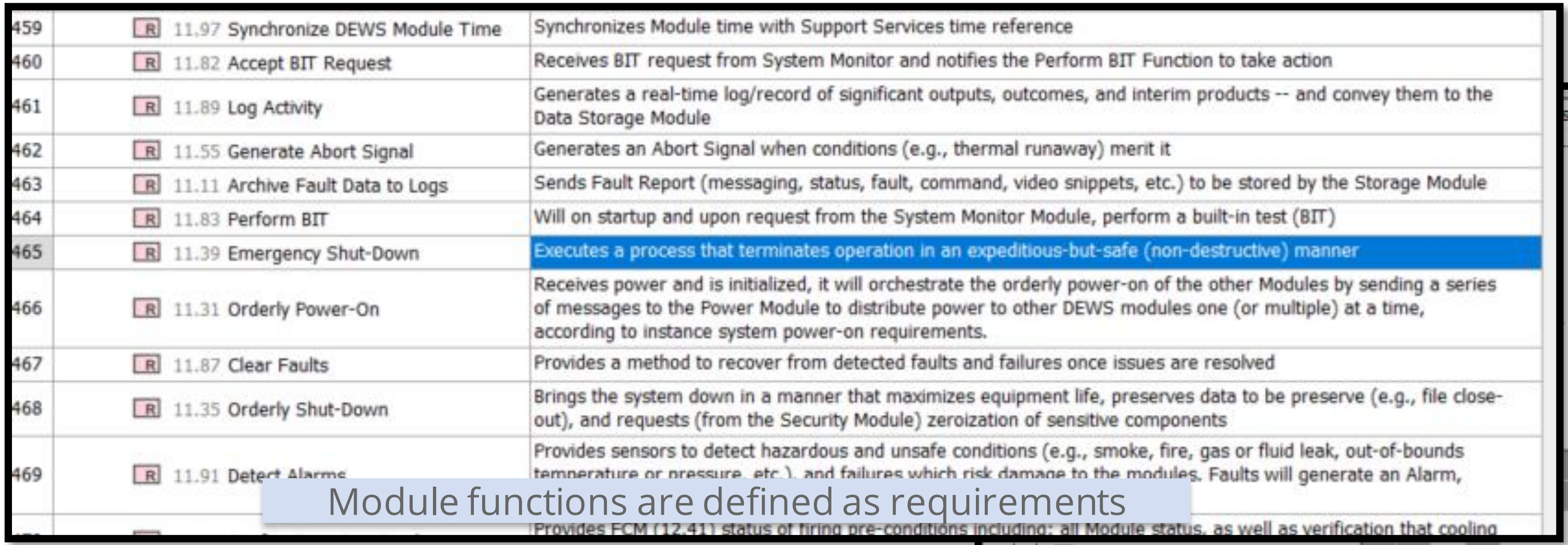


Derived from “SOSA 101”

Learn from Systems under Development

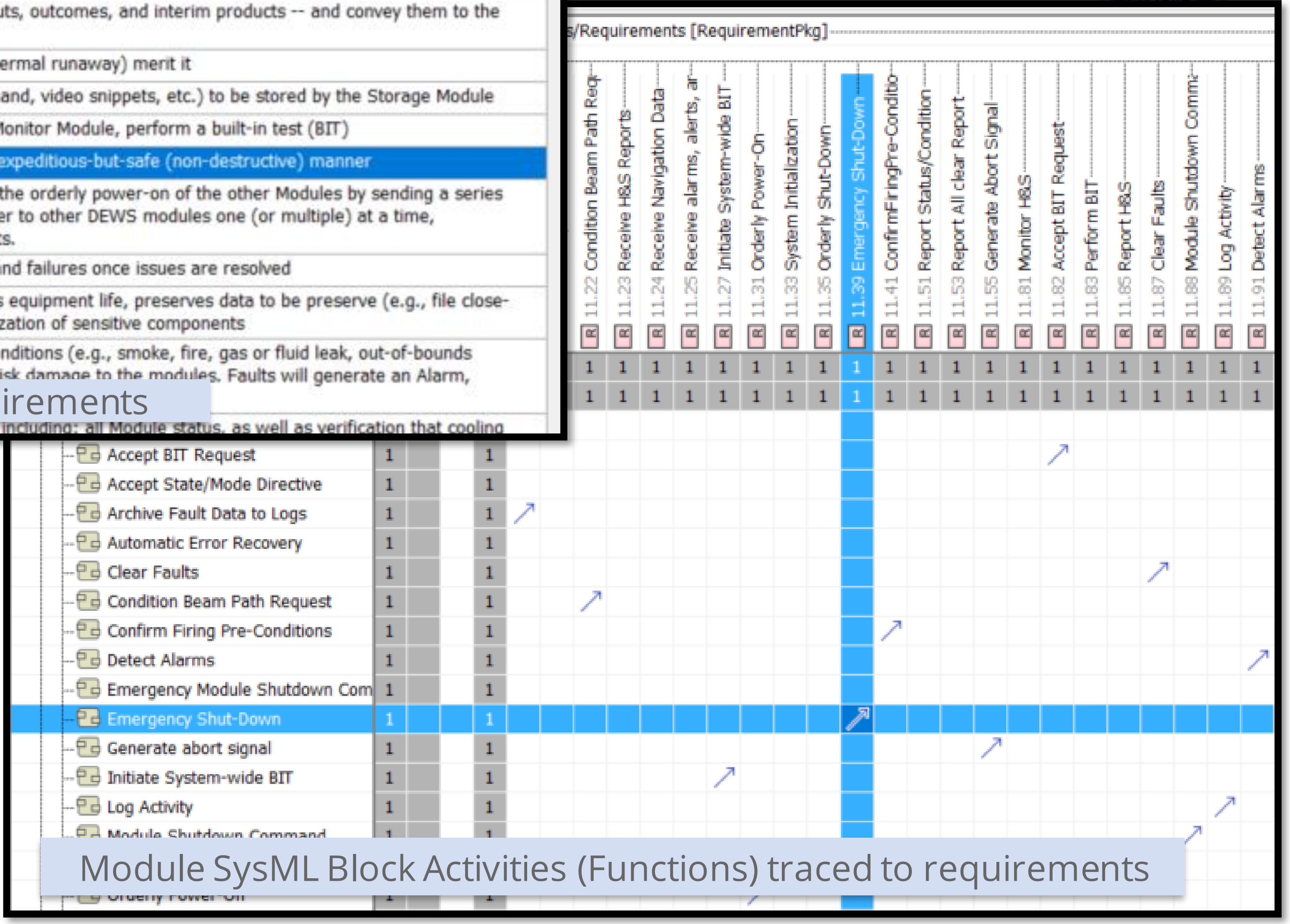
Program Name	Service	Type	Domain	Government Lead	Industry Partners
Bane	Navy	HPM	Land	Dahlgren DEW Office (DEWO)	
Tactical High-Power Microwave Operational Responder (THOR)	USAF	HPM	Land	AFRL	BAE Systems (BAE), Leidos, Verus Research
DE-Maneuver Short Range Air Defense (MSHORAD)	Army	HEL	Land	Army RCCTO	Kord Technologies (Kord)
Indirect Fire Protection High Energy Laser (IFPC-HEL)	Army	HEL	Land	RCCTO, OSD, SMDC	Dynetics (a Leidos Co.), Lockheed Martin Corporation (LMC), MZA Associates Corporation (MZA)
High Power Joint Electromagnetic Non-Kinetic Strike (HiJENKS)	Navy: ONR USAF: AFRL	HPM	Air	Dahlgren /Kirtland	LMC
Self-protect High Energy Laser Demonstrator (SHiELD)	USAF	HEL	Air	AFRL	LMC
Airborne High Energy Laser (AHEL)	USAF	HEL	Air	AF Special Operations Command (AFSOC)	
High Energy Laser with Integrated Optical-dazzler and Surveillance (HELIOS)	Navy	HEL	Sea	PEO IWS 2	LMC
Layered Laser Defense (LLD)	Navy	HEL	Sea	ONR	LMC
Solid State Laser Technology Maturation (SSL-TM)	Navy	HEL	Sea	Dahlgren	Northrop Grumman

Functional and Interface Requirements



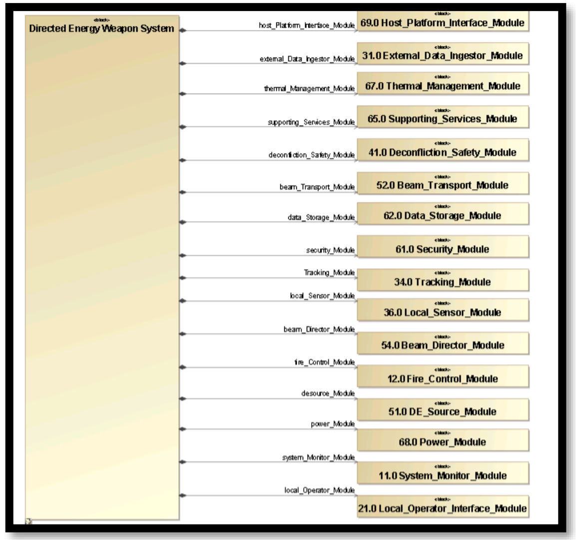
459	11.97 Synchronize DEWS Module Time	Synchronizes Module time with Support Services time reference
460	11.82 Accept BIT Request	Receives BIT request from System Monitor and notifies the Perform BIT Function to take action
461	11.89 Log Activity	Generates a real-time log/record of significant outputs, outcomes, and interim products -- and convey them to the Data Storage Module
462	11.55 Generate Abort Signal	Generates an Abort Signal when conditions (e.g., thermal runaway) merit it
463	11.11 Archive Fault Data to Logs	Sends Fault Report (messaging, status, fault, command, video snippets, etc.) to be stored by the Storage Module
464	11.83 Perform BIT	Will on startup and upon request from the System Monitor Module, perform a built-in test (BIT)
465	11.39 Emergency Shut-Down	Executes a process that terminates operation in an expeditious-but-safe (non-destructive) manner
466	11.31 Orderly Power-On	Receives power and is initialized, it will orchestrate the orderly power-on of the other Modules by sending a series of messages to the Power Module to distribute power to other DEWS modules one (or multiple) at a time, according to instance system power-on requirements.
467	11.87 Clear Faults	Provides a method to recover from detected faults and failures once issues are resolved
468	11.35 Orderly Shut-Down	Brings the system down in a manner that maximizes equipment life, preserves data to be preserve (e.g., file close-out), and requests (from the Security Module) zeroization of sensitive components
469	11.91 Detect Alarms	Provides sensors to detect hazardous and unsafe conditions (e.g., smoke, fire, gas or fluid leak, out-of-bounds temperature or pressure, etc.), and failures which risk damage to the modules. Faults will generate an Alarm,
		Provides FCM (12.41) status of firing pre-conditions including: all Module status, as well as verification that cooling

Module functions are defined as requirements

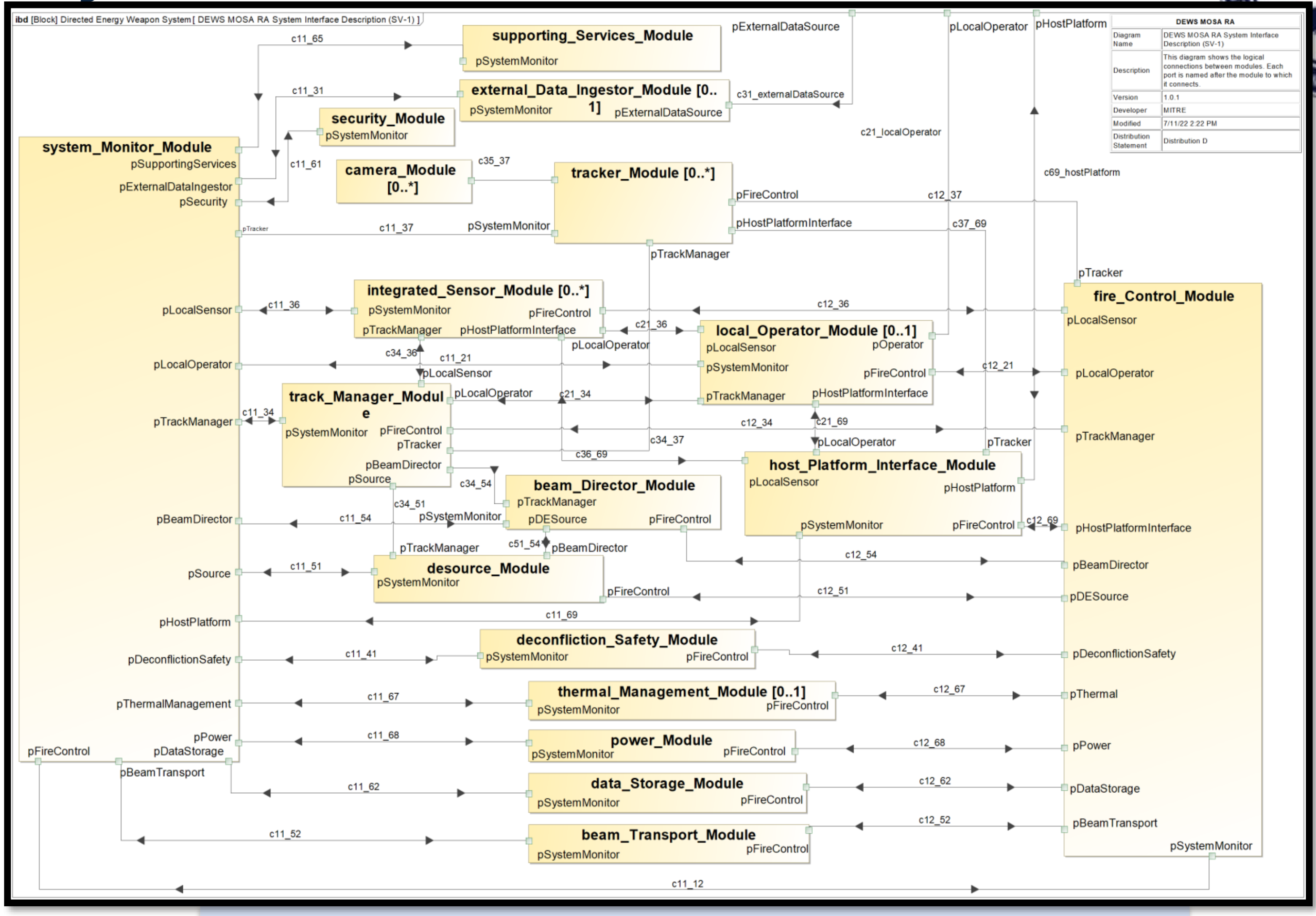


Module SysML Block Activities (Functions) traced to requirements

DEWS RA Module System Architecture

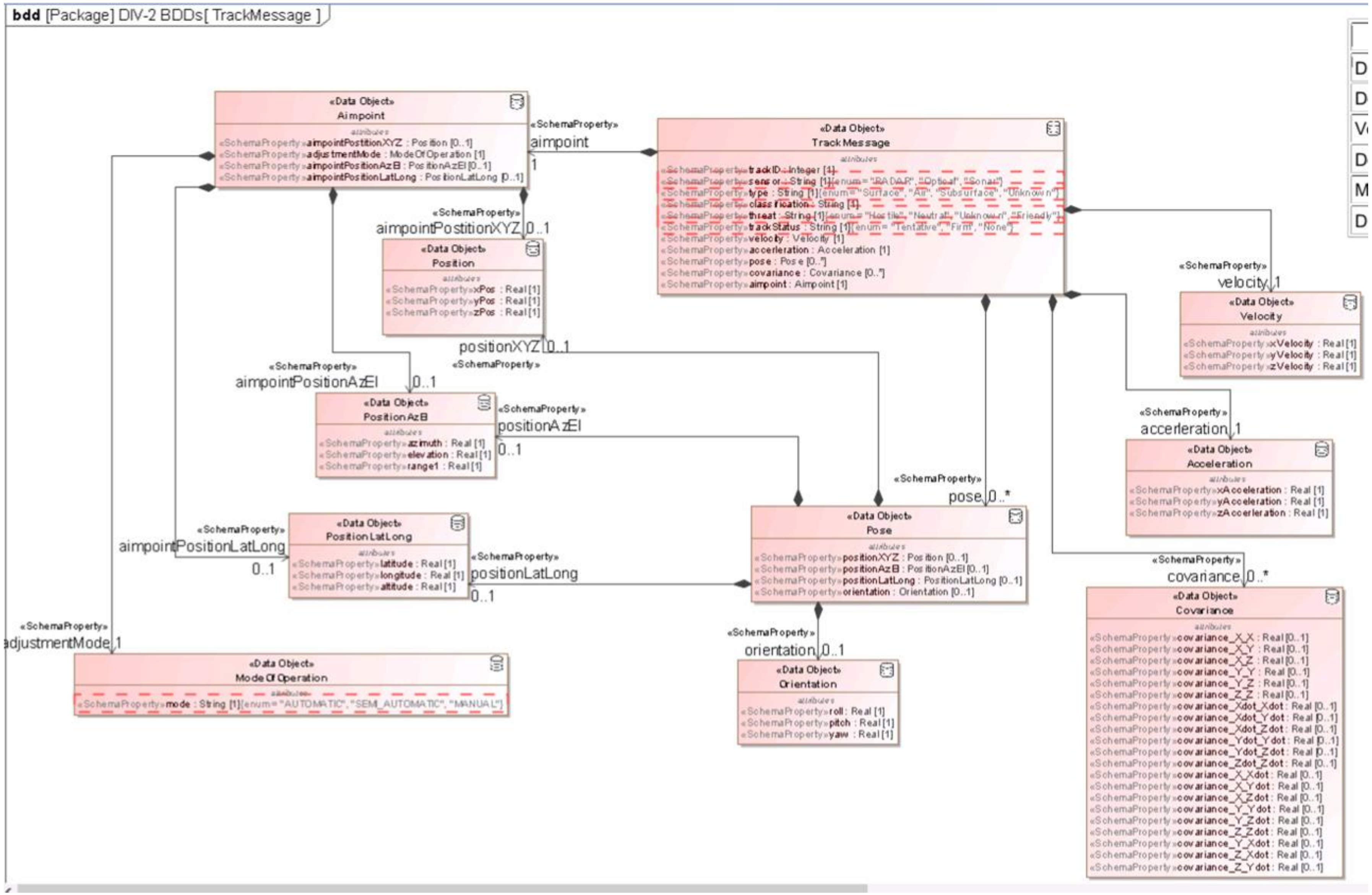


Module Definitions



Module Blocks connected via ports with interface definitions

DEWS RA Data Model – Track Message Data Object



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DEWS RA Data Model – Track Message Definitions

API Object	Data Object Description	Name	Documentation	Type	Multiplicity	Minimum	Maximum	Enumeration
Acceleration	Three dimensional acceleration	xAcceleration	Acceleration of the x-component of an XYZ_ENU axis; if no reference point is specified, reference point should be the center of ownship/host; (units: Kilometers/Second^2)	Real	1			
Acceleration	Three dimensional acceleration	yAcceleration	Acceleration of the y-component of an XYZ_ENU axis; if no reference point is specified, reference point should be the center of ownship/host; (units: Kilometers/Second^2)	Real	1			
Acceleration	Three dimensional acceleration	zAccerleration	Acceleration of the z-component of an XYZ_ENU axis; if no reference point is specified, reference point should be the center of ownship/host; (units: Kilometers/Second^2)	Real	1			
Aimpoint	Aimpoint used by tracker	aimpointPostitionX	Three dimensional position of aimpoint	Position	0..1			
Aimpoint	Aimpoint used by tracker	adjustmentMode	Adjustment mode of the aimpoint	ModeOfOperation	1			
Aimpoint	Aimpoint used by tracker	aimpointPositionAz	Three dimensional position of aimpoint	PositionAzEl	0..1			
Aimpoint	Aimpoint used by tracker	aimpointPositionLatLong	Three dimensional position of aimpoint	PositionLatLong	0..1			
ModeOfOperation	Indicates the mode of an operation	mode	Indicates the mode of an operation	String	1			AUTOMATIC SEMI_AUTOMATIC MANUAL
Orientation	Three dimensional angular offset	yaw	Angular offset for pitch (units: Degrees).	Real	1			
Orientation	Three dimensional angular offset	pitch	Angular offset for pitch (units: Degrees).	Real	1			
Orientation	Three dimensional angular offset	roll	Angular offset for roll (units: Degrees).	Real	1			
Pose	Object position and orientation	orientation	How the object is placed or pointed	Orientation	0..1			
Pose	Object position and orientation	positionAzEl	Horizontal coordinate system position	PositionAzEl	0..1			
Pose	Object position and orientation	positionLatLong	Latitude and Longitude position	PositionLatLong	0..1			
Pose	Object position and orientation	positionXYZ	Three dimensional position	Position	0..1			

Showing only a sample of the Track Message Definitions

DEWS RA Activity Diagram (Power On Sequence)

Power Module: Receive Host Provided Power

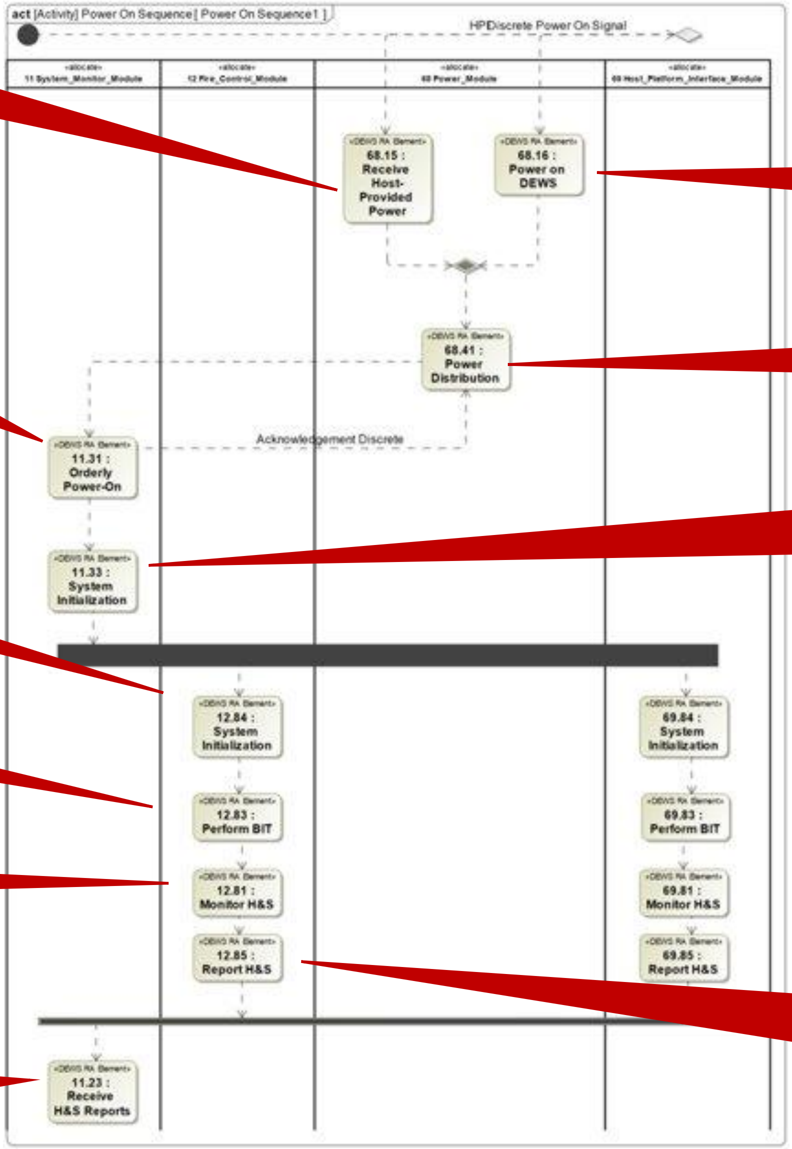
System Monitor Module: Orderly Power On

Fire Control Module: System Initialization

Fire Control Module: Perform BIT

Fire Control Module: Monitor H&S

System Monitor Module: Receive H&S Reports



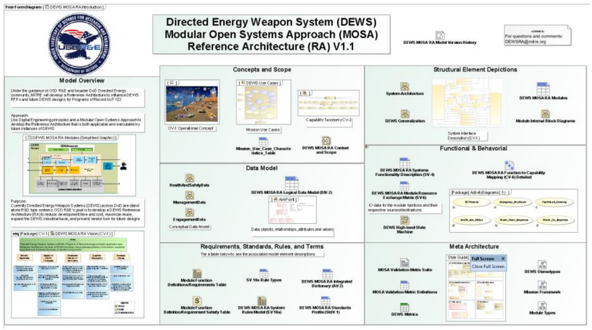
Power Module: Power on DEWS

Power Module: Power Distribution

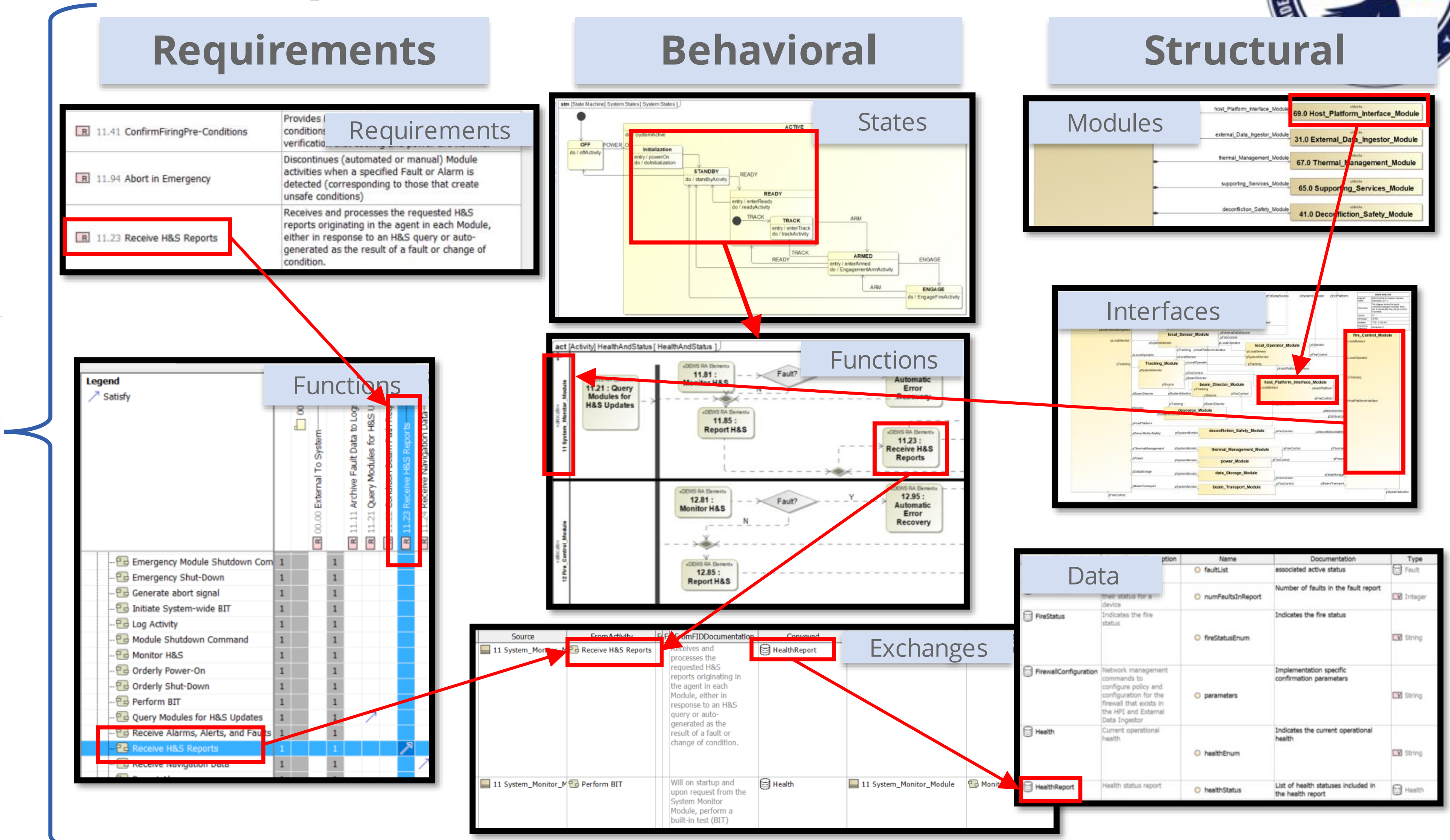
System Monitor Module: System Initialization

Fire Control Module: Report H&S

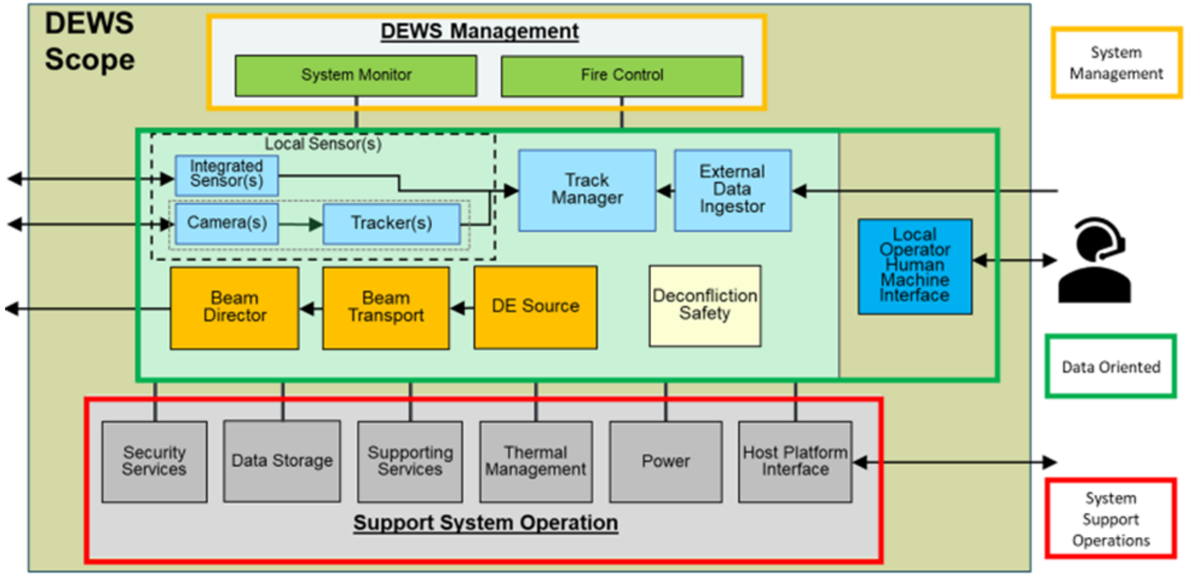
DEWS RA Model Components

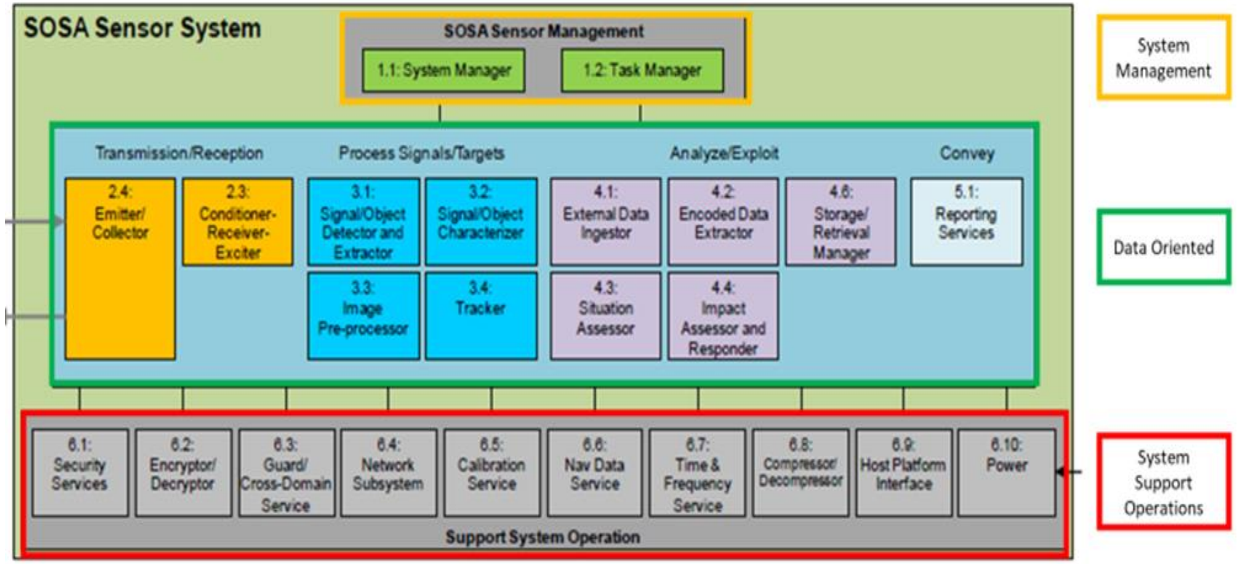


Landing Page to Navigate the Reference Architecture

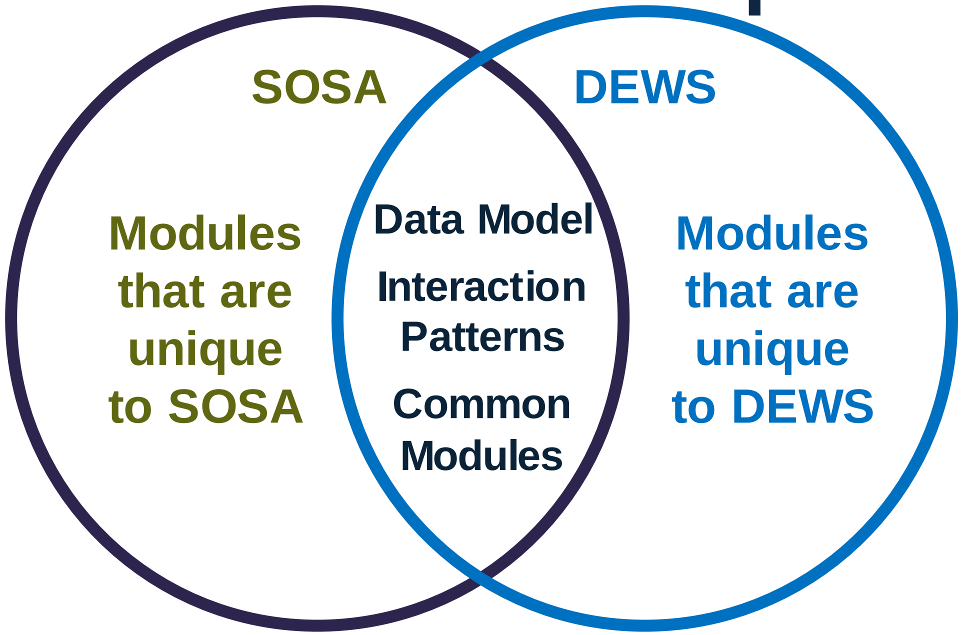


DEWS MOSA RA integration with SOSA





SOSA-DEWS Comparison/Relationship



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

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

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

MITRE

SOSA-DEWS Comparison/Relationship

DEWS_ID	DEWS Func	DEWS Description	SOSA Function
68.13	Generate Power	In cases where the DEWS operates independently of Host-provided power, generate its own power internally. This Function is optional	
68.15	Receive Host-Provided Power	In cases where the DEWS doesn't generate its own power, receive input electrical power (e.g., 440VAC, 120 VAC, etc.) from Host Platform Interface Module. This is an optional function.	**Convert between different power characteristics - From Host Platform Interface**
68.16	Power on DEWS	A discrete (an external button or key) to turn on the entire DEWS. After powering up, this function will request power distribution (68.41) to SMM to begin DEWS initialization	Power-on process for DEWS is different from that of SOSA (which is very chassis-oriented)
68.21	Power conversion	Transform prime power to match requirements for each DEWS Module (including DC/AC conversion, high voltage, spike protection, etc.)	**Convert between different power characteristics**
68.23	Provide Storage of Electrical Power	Stores energy (for example, in a battery) for use when needed by system modules	**Store power for intermittent input power loss** **Store power to provide long-term power to loads without input power**

This element should be eliminated from DEWS as a functional requirement

Use of storage is different between DEWS (which is focused on energy surge) and SOSA (which is to coast through intermittent source outages)

Showing only a sample of the Power Module Functions

SOSA-DEWS Comparison/Relationship

DEWS_ID	DEWS Func	DEWS Description	SOSA Function
68.41	Power Distribution	Discharges energy as needed to support DEWS modules, based on system condition and individual module needs	**Distribute power from power supplies to power loads**
68.55	Power Conditioning	Delivers power at the proper voltage and current characteristics by protecting against high/low voltage or current conditions, filter noise, transient impulse suppression, etc.	**Condition/filter power**
68.61	Accept Remote Control	Provides a digital interface to Local Operator and/or Host Platform to enable remote management and control of all functions	**Provide a digital control interface**
			Protect against voltage and over-current conditions

Consider adding this to Power Conditioning and remove as a separate function. Need clarification if this is internal to SOSA (protecting the sensor) or external (e.g., breaker on host to keep wiring from catching on fire)

Showing only a sample of the Power Module Functions

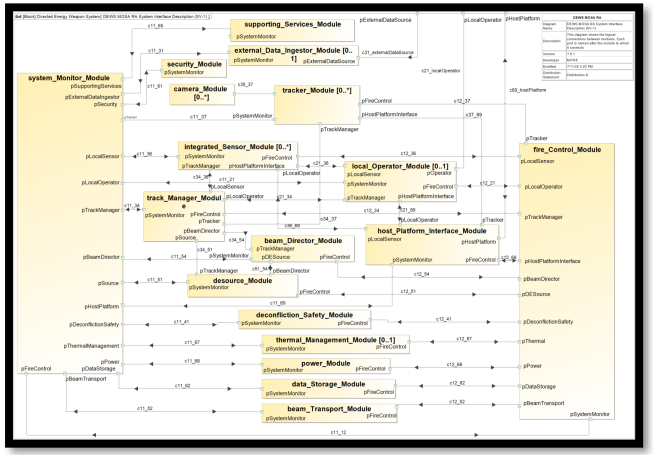
Summary

Modular Open Systems Approach will accelerate development of Directed Energy Weapon Systems (DEWS)

- DEWS are becoming technically mature, but no OSA currently exists for these systems
- The DEWS MOSA RA will enable rapid, cost-effective, and supportable DEWS fielding

Digital Engineering and model-based systems engineering (MBSE) provides an efficient means of standardizing a modular approach

- Digital products can be directly used by supporting programs
- Views can be adapted depending on a specific user's needs
- Technical updates are made in a single location in the digital model



The DEWS MOSA RA is actively aligning modules with analogous SOSA module definitions

- Standardizes technical requirements under a common OSA