



# U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND GROUND VEHICLE SYSTEMS CENTER

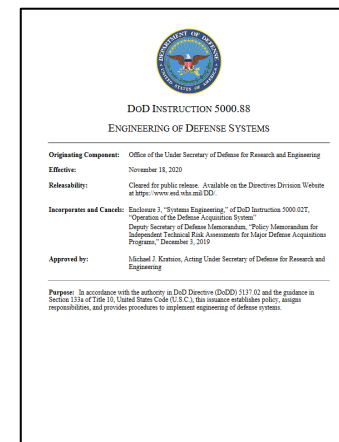
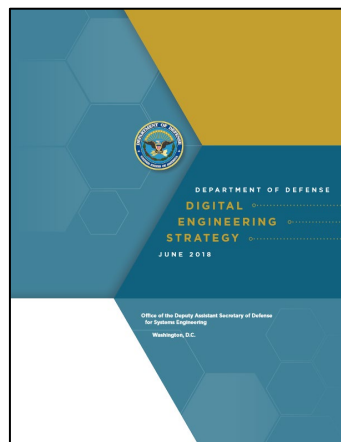
Application of the Autonomous Ground Vehicle Reference Architecture to MBSE

15 APRIL 2024

# INTRODUCTION



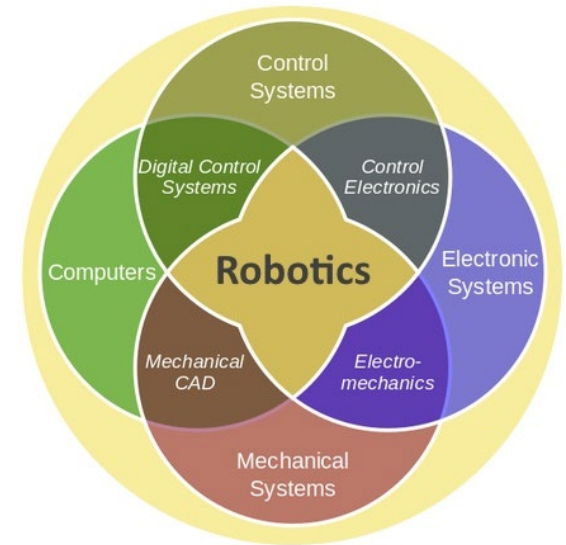
- Per DoD guidance, Model-Based Systems Engineering (MBSE):
  - Can be applied to a variety of areas
    - System Design
    - Program Planning
    - Mission Engineering
  - Is necessary for agile development with high-quality outcomes
  - Enables a Modular Open Systems Approach (MOSA) acquisition strategy



# INTRODUCTION



- Development of autonomous systems is a highly specialized/interdisciplinary field
- Autonomy-specific MBSE elements targeted to DoD Autonomous Ground Vehicle efforts help fully realize the benefits of MBSE
- Autonomous Ground Vehicle Reference Architecture (AGVRA) provides SysML model libraries and a framework to meet this need



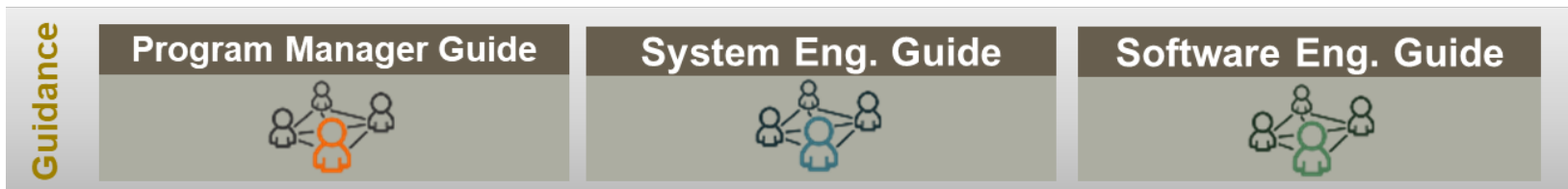
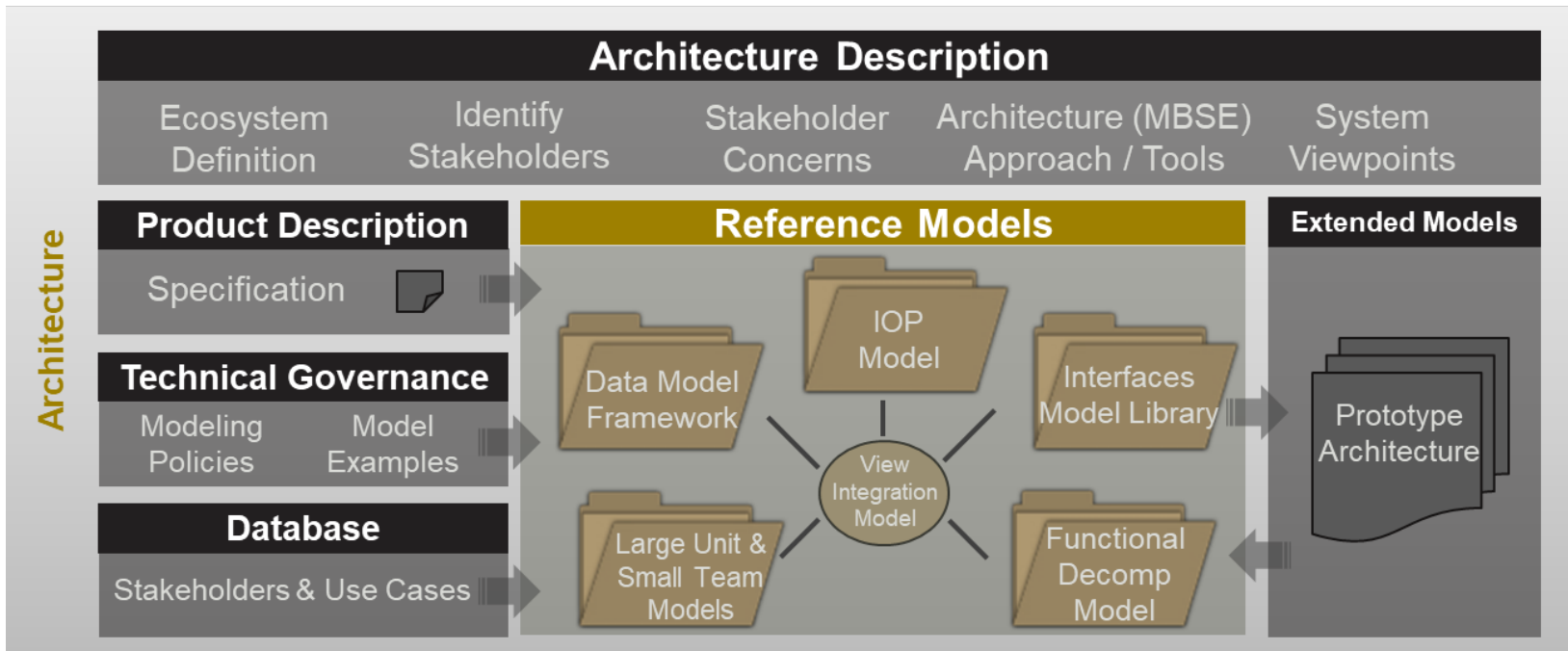
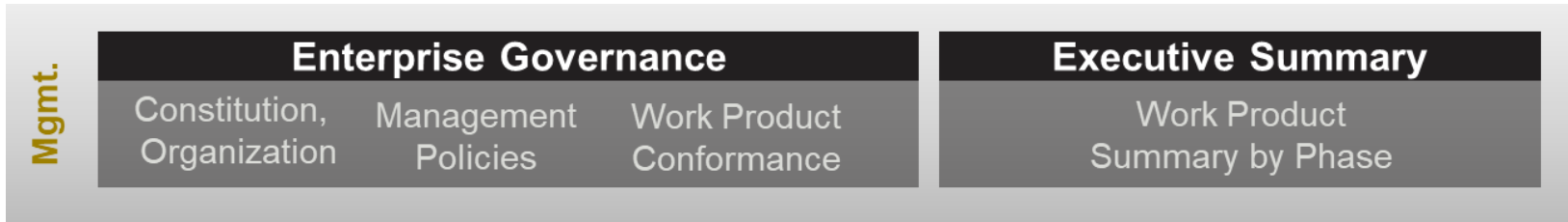
# AGVRA



***“AGVRA is the Reference Architecture for Autonomous Ground Vehicles that will provide architectural guidelines and best practices, business and technical, for the Army Robotics and Autonomous Systems (RAS) community.”***

- Provides a suite of SysML reference models, framework, and guidelines that facilitate development of an integrated MBSE system architecture for RAS
  
- Has a comprehensive set of views
  - Mission Segments
  - Data
  - Interfaces
  - Standards
  - Functional Decomposition

# AGVRA – WORK PRODUCTS

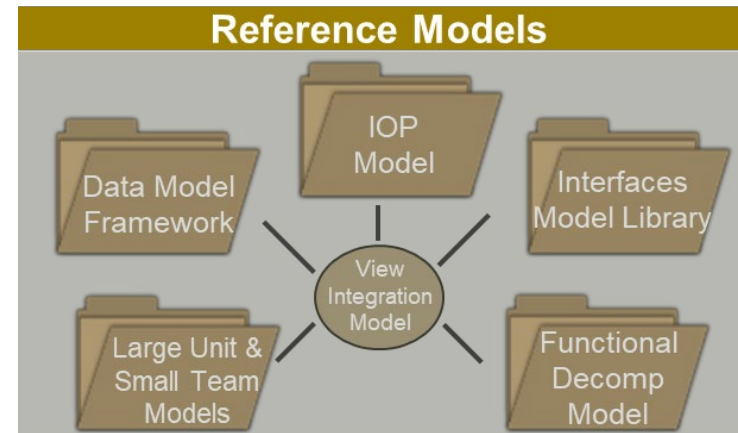


# MODELS



## ▪ Objectives

1. Provide a minimum set of model-based enablers required to support AGV system life cycle management.
2. Enable generation of physical system architectures by leveraging architecture knowledge/artifacts over AGV domain.
3. Support product line plug and play into open and compatible target architectures.



# MODELS – MISSION MODELS



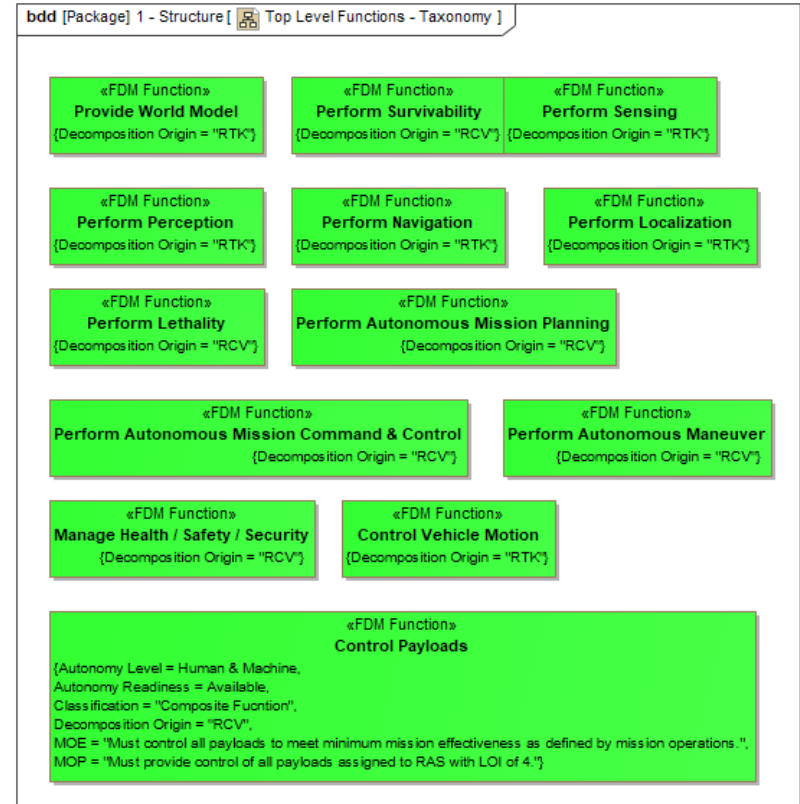
Profiles for mission engineering activities to decompose mission segment models in support of system design

Doctrine Reference (REF)	Large Unit Mission (LUM)	Small Team Model (STM)
<p>Provides support for modeling clear traceability to content in Army doctrine, international standards, and other publications</p>	<p>Provides support for modeling the top-level mission execution of Army doctrine</p>	<p>Provides support for modeling short tasks and maneuvers executed by a small team of vehicles</p>

# MODELS – FUNCTIONAL DECOMPOSITION MODEL



- Decomposition of abstracted autonomous system functions
- Provides a common language for representation of RAS-G functions
- Helps to manage obsolescence of system components

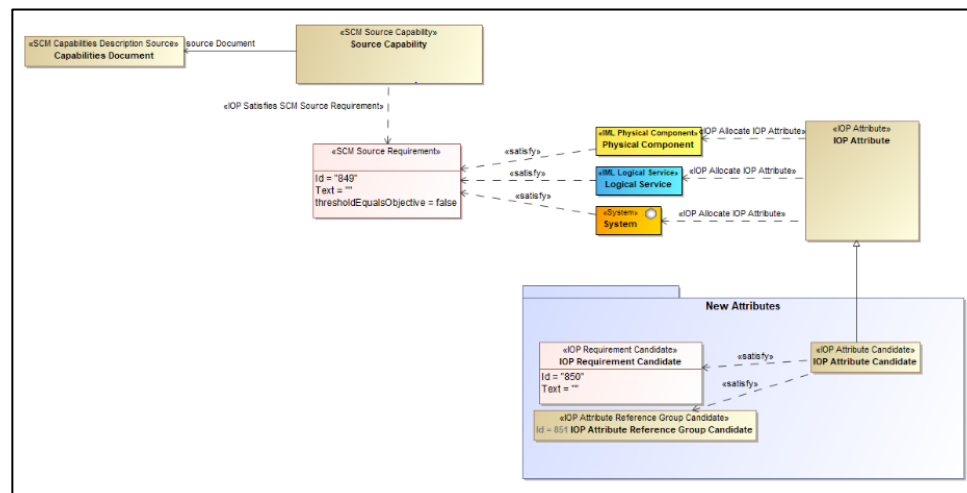




# MODELS – IOP MODEL



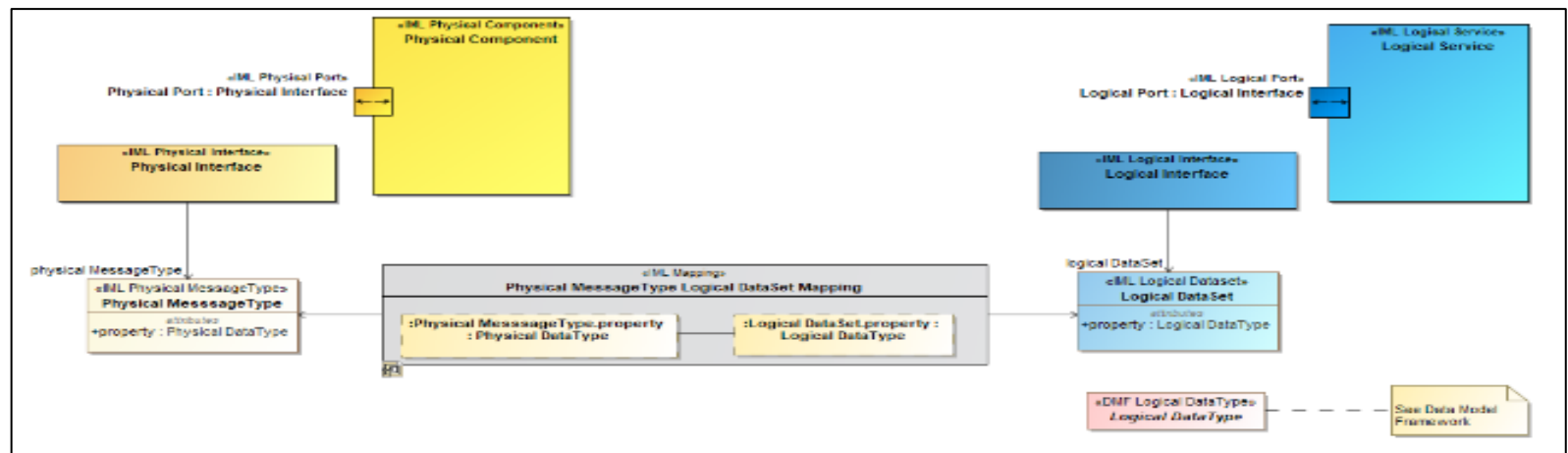
- Robotic and Autonomous Systems Ground (RAS-G) Interoperability Profile (IOP)
  - Set of documents that profile standards to define the logical, physical, and electrical interfaces between major RAS-G subsystems
  
- IOP model enables model-based representation of IOP concepts with two profiles:
  1. Source Capture Profile
  2. IOP



# MODELS – INTERFACE MODEL LIBRARY

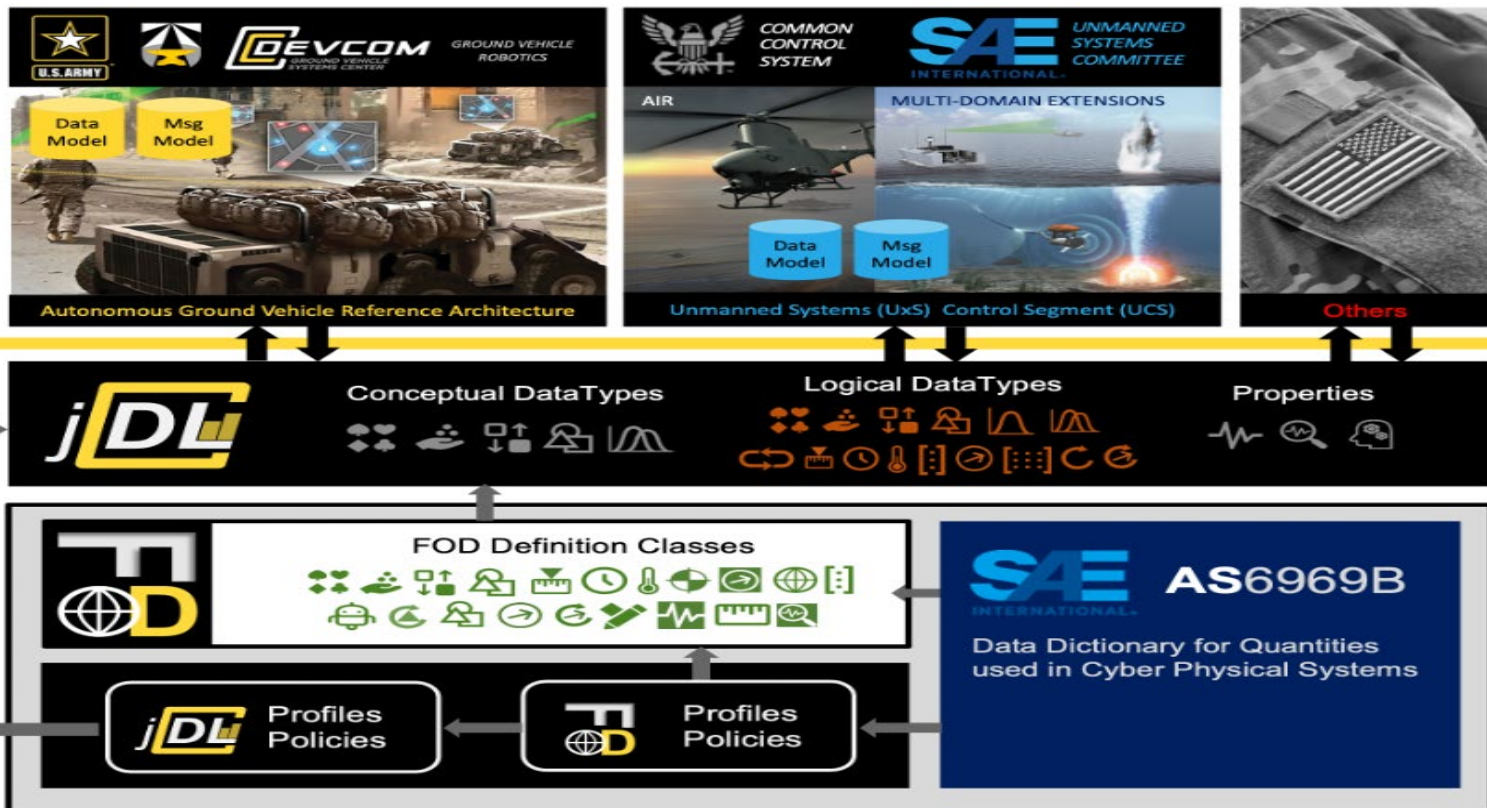


- Describes interfaces defined by standards, or used in software frameworks, commonly applied to RAS-G systems
- Defines stereotypes for describing physical and logical aspects of design elements
- Mapping models are used to show how the logical interfaces are realized to physical interfaces



# MODELS – DATA MODEL FRAMEWORK

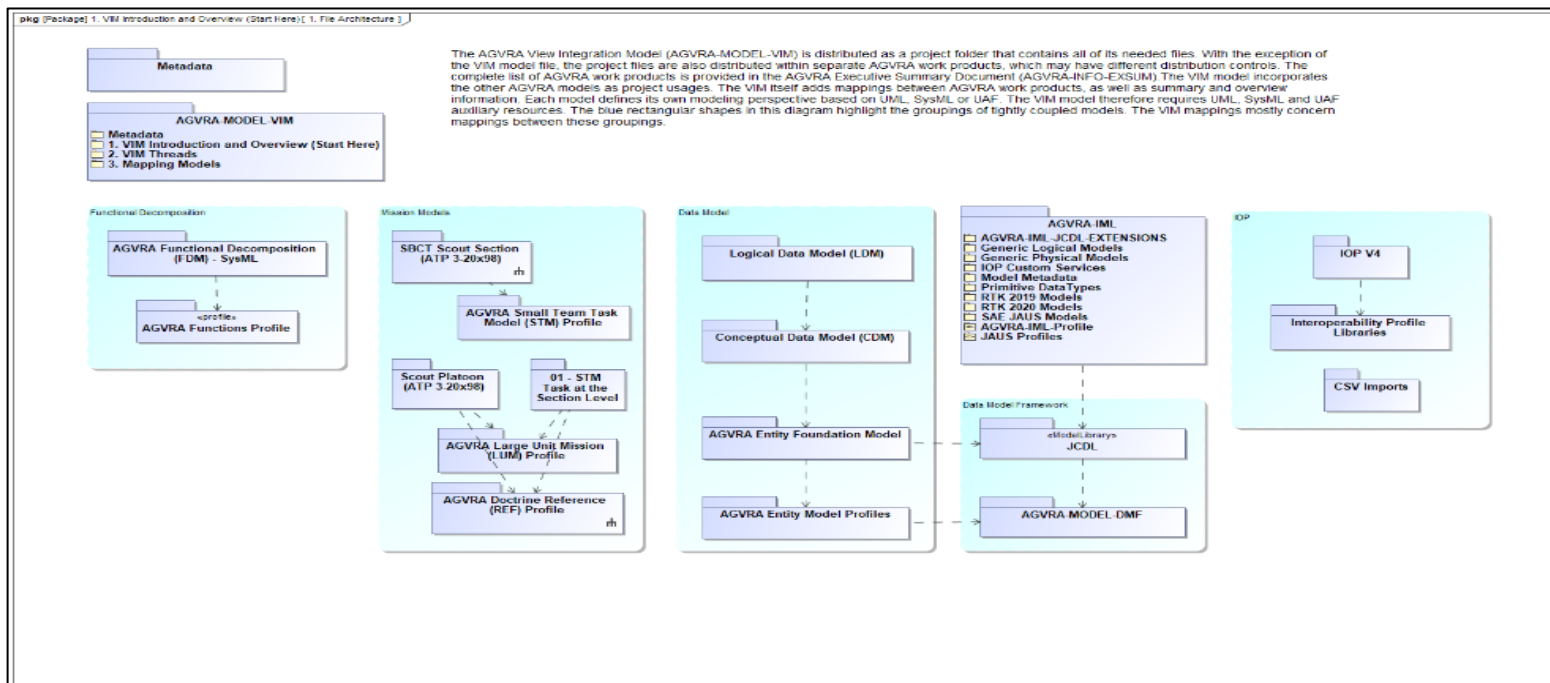
A metamodel that establishes stereotypes for various kinds of element definitions and datatypes



# MODELS – VIEW INTEGRATION MODEL



- An example of how all AGVRA model work products can be used to model a system in a mission context
- Provides a Bounding Overwatch Model that fully demonstrates a unified example of AGVRA



# APPLICATIONS OF AGVRA



- Vital to leverage reusable and vetted modeling elements in the development of RAS-G systems
- AGVRA provides a plethora of such modeling elements that can be used for RAS-G MBSE designs
- AGVRA has been utilized across multiple DoD efforts to meet MBSE needs

# APPLICATIONS - GCIA

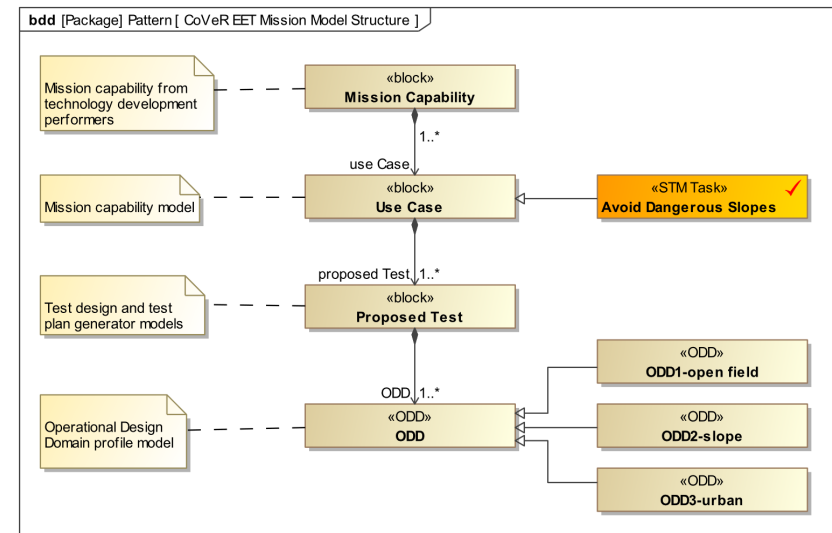


- Ground Combat Systems (GCS) Common Infrastructure Architecture (GCIA) provides
  - An objective architecture that defines the network and service infrastructure commonly required in GCS
  - A data architecture (DA) for programs and vendors to define solution architectures and designs
  
- GCIA DA models are defined using the AGVRA Interfaces Model Libraries (IML) profile and extend the AGVRA IML/AGVRA Data Model Framework
  
- Use of the AGVRA IML in the GCIA DA ties all interface definitions to the same semantic datatypes, allowing for benefits in reusability, compatibility, and design

# APPLICATIONS - COVER



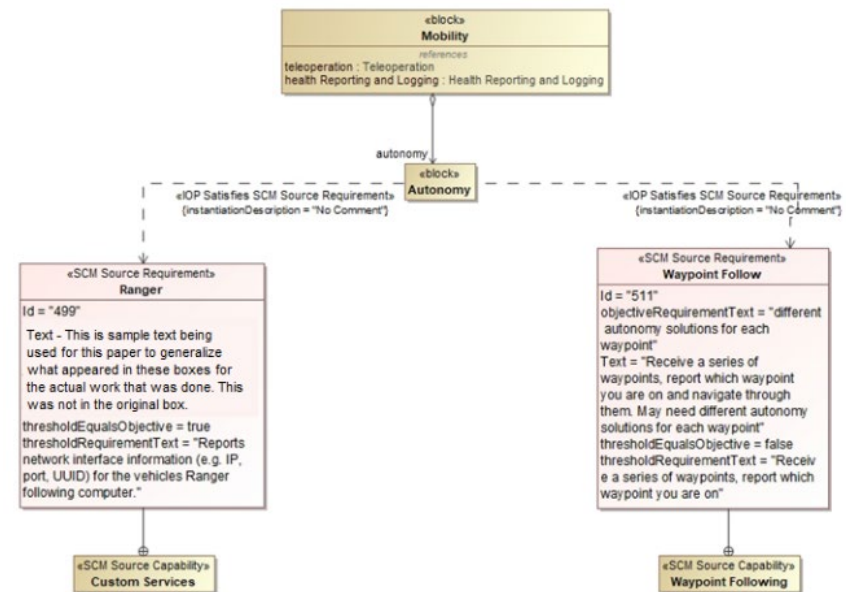
- GVSC Combat Vehicle Robotics (CoVeR):
  - Army science & technology effort focused on maturing AGV technology to operate as part of the manned/unmanned team
  
- Engineering Evaluation Test (EET) events are conducted to assess progress
  
- CoVeR EET mission models developed utilizing the AGVRA SysML reference models, frameworks, and guidelines



# APPLICATIONS – RTK IOP



- Robotic Technology Kernel (RTK)
  - GVSC's autonomous software library for AGV mobility
  - Leverages IOP bridge to communicate with robotic controllers
  
- AGVRA IOP models utilized in RTK IOP bridge updates
  
- AGVRA IOP model enabled creation of a consistent and maintainable model of the RTK IOP bridge





# APPLICATIONS – SAE STANDARDS



- SAE International:
  - Releases consensus-based standards to improve the design of aerospace, automotive, and commercial vehicles
  
- AGVRA Data Model Framework (DMF) utilized by multiple standards
  - SAE AS6969 Data Dictionary for Quantities Used in Cyber Physical Systems
  - SAE AS6518B Unmanned Systems (UxS) Control Segment (UCS) Architecture: UCS Architecture Mode
  
- SAE standards utilized in various DoD efforts
  - Navy's PMA-281 Unmanned System Common Control System
  - Army Universal Ground Control Station

# CONCLUSION



- AGVRA
  - Provides AGV specific reference architectures and models to accelerate MBSE development of RAS programs and research & development efforts
  - Utilized across the Army and Navy efforts to leverage key interfaces and open standards in a MOSA approach
  - Strives to publish and maintain the Army's RAS meta-architecture to facilitate AGV MBSE through continual development and expansion
  
- Reach out for more information at <https://agvra.org/>



THANK YOU.



**U.S. ARMY**