The JCGV Ground Systems Architecture Framework (GSAF)

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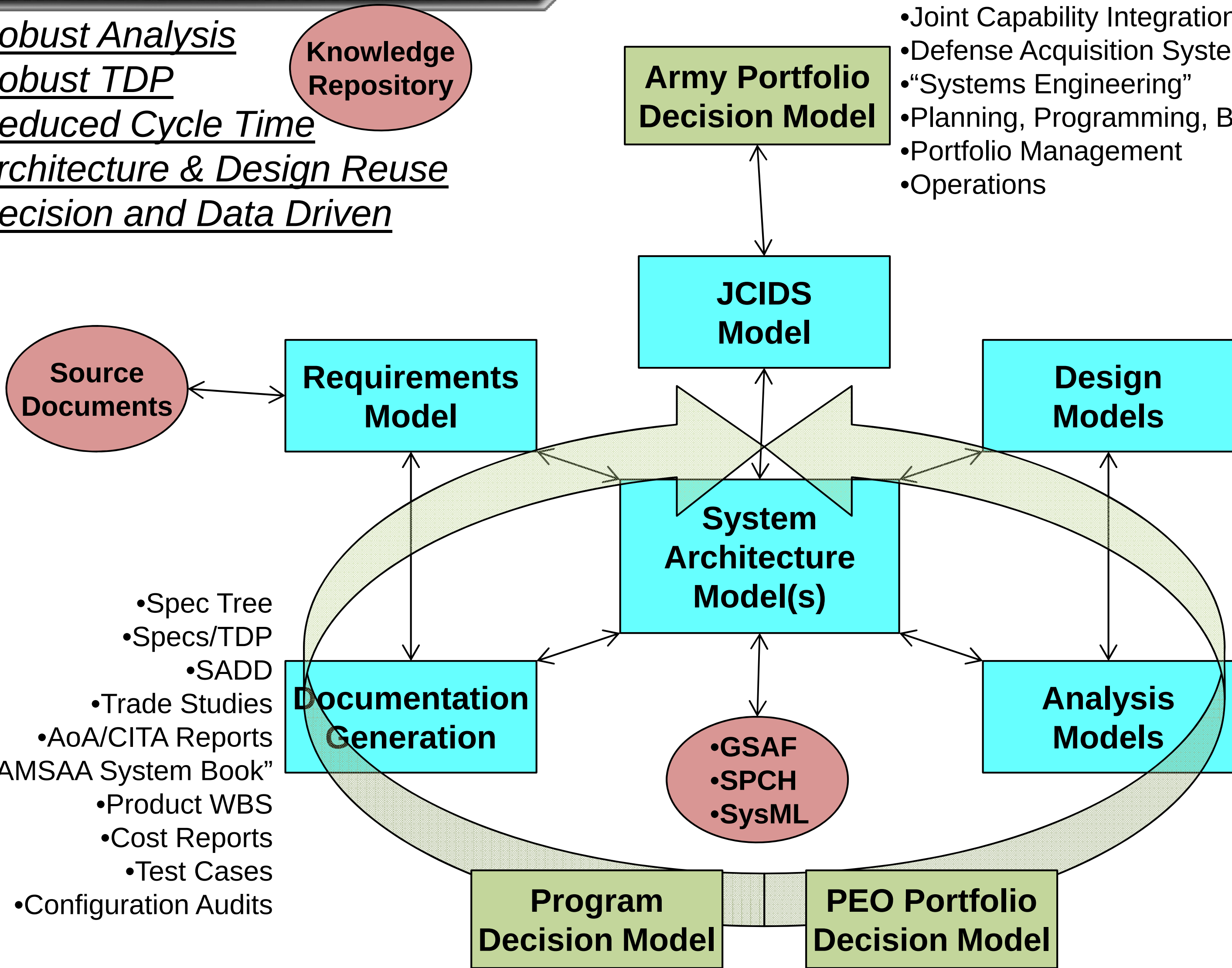
Background

- Problem
  - Diversity of ground system missions, acquiring organizations, and developers often lead to unique hardware fulfilling common portfolio requirements.
  - Common components are often mandated without consideration for acquisition and sustainment impacts.
- Approach
  - Use enterprise architecture concepts of business modeling, systems modeling, and common standards identification within a systems engineering framework.
  - Establish a framework for unifying all the enterprise models into a single “environment”.

Think enterprise-wide!

TARDEC Objective Model Integration Framework

- *Robust Analysis*
- *Robust TDP*
- *Reduced Cycle Time*
- *Architecture & Design Reuse*
- *Decision and Data Driven*



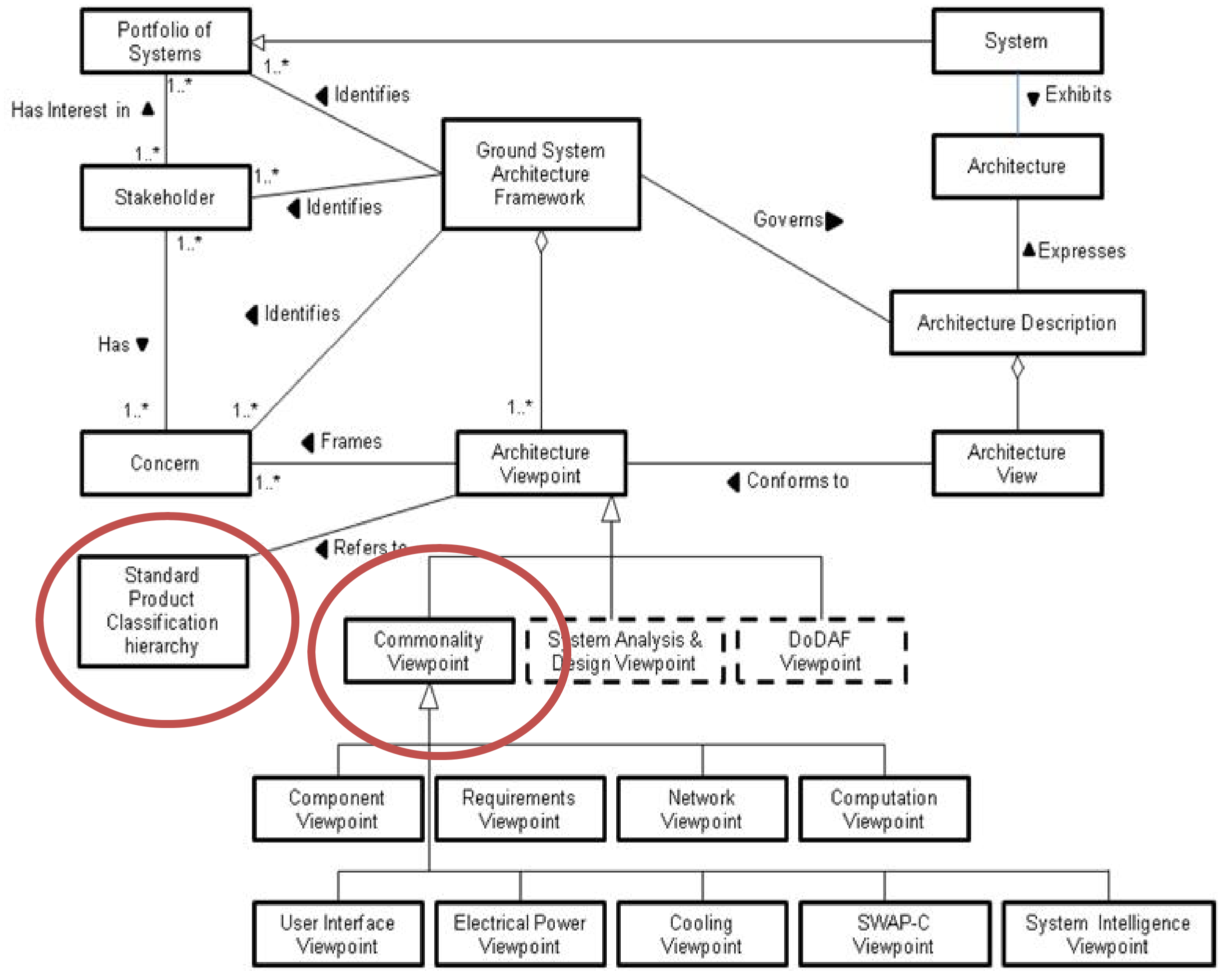
- Joint Capability Integration and Development System
- Defense Acquisition System
- "Systems Engineering"
- Planning, Programming, Budgeting & Execution
- Portfolio Management
- Operations

- CAD Concepts
- User Interface Concepts
- CAD Design
- IBOM/PBOM
- Hardware Design
- Software Design

- Blast
- Thermal
- Ride Dynamics
- Mobility Reference
- COEA
- Requirements
- Architecture
- Behavior
- Risk
- Technology Readiness
- Technology Trades
- Parametrics
- Constraints (e.g. RAM)
- Workload
- Industrial Base

- Spec Tree
- Specs/TDP
- SADD
- Trade Studies
- AoA/CITA Reports
- "AMSAA System Book"
- Product WBS
- Cost Reports
- Test Cases
- Configuration Audits

- Based on ISO/IEEE/IEC 42010:2011 - Systems and software engineering -- Architecture description
- Emphasizes the generation of the System Architecture Description Document (SADD) consistent with the requirements of the GSAF
- Requires that the SADD contain all program required architecture viewpoints
- Includes a Modeling Guide to assist programs in developing the viewpoints
- Identifies requirements for viewpoint integration
- SADD required for Program of Record mission equipment



Standard Product Classification Hierarchy (SPCH)

- Objective: Define a standard product structure that can apply to and unify all product abstractions from systems engineering through product sustainment.
- Use Cases:
  - Use as a Data Element Dictionary and hierarchy guide for Product WBS.
  - An ordering of technologies and technology combinations that can be used for a comprehensive technology assessment.
  - A hierarchical ordering of architectural bins for requirements that can be used to create a Specification Tree and associated Specification Tables of Content.
  - A set of physical components that can be used to create a system architecture model linked to attributes (technology selection and parameterization).
  - An ordering of products that can be used for the Indenture in a BOM.
  - A hierarchical ordering of parts/components that can be used in a classification and/or coding schema for organizing technical data, maintenance and parts management.
- Single System Benefits:
  - Remove ambiguity, improve consistency and gain comparative insight.
  - Reuse of structures & definitions for time/cost efficiency and improved quality.
- Multiple System Benefits:
  - Improve integration through the life cycle phases with consistent product definition and data interchange.
  - Integrated product data for enterprise knowledge.

SPCH – Key Concepts

- Define a categorization of physical abstractions suitable for multiple use cases.
  - Be able to construct or define any system in consistent terms.
  - Find a bin for any component or technology.
  - Reflect the way work and products are actually decomposed and executed.
  - Allow for integrated assembly and consistent breakdown of integrated assemblies.
- Reflect the total integrated system: vehicle and mission equipment
- Create a hierarchy suitable for complex system (can be collapsed for simpler systems).
  - System Segment
    - Major Assemblies
      - Subsystems/Sub-assemblies
        - » HWCIs/CSCIs
          - » CI Sub-assemblies/CSCs
            - » Part/CSU Categories
- Abstractions detailed to the point of attribution.
- Define Intelligence linked to information management for all applications.
- Explicit definition of System Management & Control.
  - Effective capture of capability that drives system electronic integration.
  - 1st Order system specification consideration.
- Represented in SysML (based on UML).
  - Includes *GSAFProfile* defining applicable stereotypes and tags.
  - Available as an XMI file for import into COTS tools.

SPCH Top Level Structure

Structures	Survivability	Sys Mgmt & Ctrl	Tactical C3
• Hull, Frame, Body, Cab • Turret Assembly • Tow Attachments • Assemblies & Installations	• Ballistic Protection • Detection Avoidance • Hit Avoidance • Resource Protection • Assemblies & Installations	• Data Control & Distribution • Computing Resources • Power Distribution & Control • User Interface • System Intelligence • Assemblies & Installations	• Radio Systems • Intercom • Tactical Network • Tactical C3 Intelligence • Assemblies & Installations
Mobility	**Armaments**	**ISR/EW**	**Special Equipment**
• Power Package/Drive Train • Steering & Suspension • Prime Power Gen & Storage • Automotive Auxiliary • Driving Intelligence • Assemblies & Installations	• Primary Armament • Fire Control • Auxiliary Weapon • Missile Launchers • Mortar Launchers • Loading System • Armament Auxiliary • Fire Intelligence • Loading Intelligence • Assemblies & Installations	• Sensors • Control Elements • Interrogators • Signal Jammers • Signal Detectors • ISR/EW Intelligence • Assemblies & Installations	• Force Projection • Sustainment Systems • CBRN Equipment • Stowage • Spotlights • Secondary Vehicles • Payloads/Manipulators • Assemblies & Installations

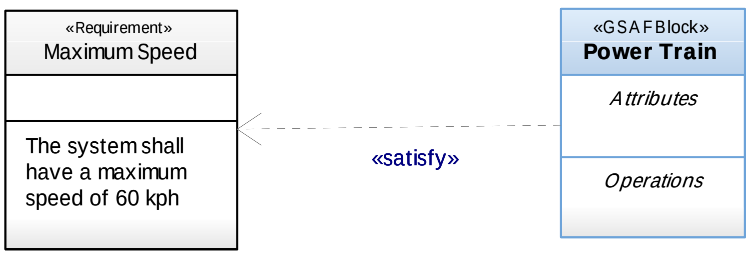
- 9 commonality viewpoints defined to address key stakeholder concerns:

Stakeholder Concerns	Commonality Viewpoints: Component Viewpoint	Requirements Allocation Viewpoint	Network Viewpoint	Computation Viewpoint	User Interface Viewpoint	Electrical Power Viewpoint	Cooling Viewpoint	SWAP-C Viewpoint	System Intelligence Viewpoint
Does the system design comply with all mandated standards and components?			✓	✓		✓	✓		
Does the system maximize usage of components that are, or will be, common across the portfolio and thereby minimize redundant development costs and minimize acquisition and sustainment costs?	✓							✓	
Does the system facilitate the integration of new and or updated components and thereby minimize the acquisition cost of future system upgrades to address obsolescence, commonality, software updates, or increased capability?			✓	✓		✓	✓		✓
Does the system design effectively address the systems design constraints (i.e., size, weight, power, cooling, availability, etc.)?								✓	
Do the warfighter-machine interfaces of the system allow for the execution of all tasks within required timelines?					✓				
Does the system address all of the user's needs that have been expressed in the system functions and requirements specifications?		✓							
Is the requirements allocation consistent with the specification tree and traceable to the systems specification?		✓							

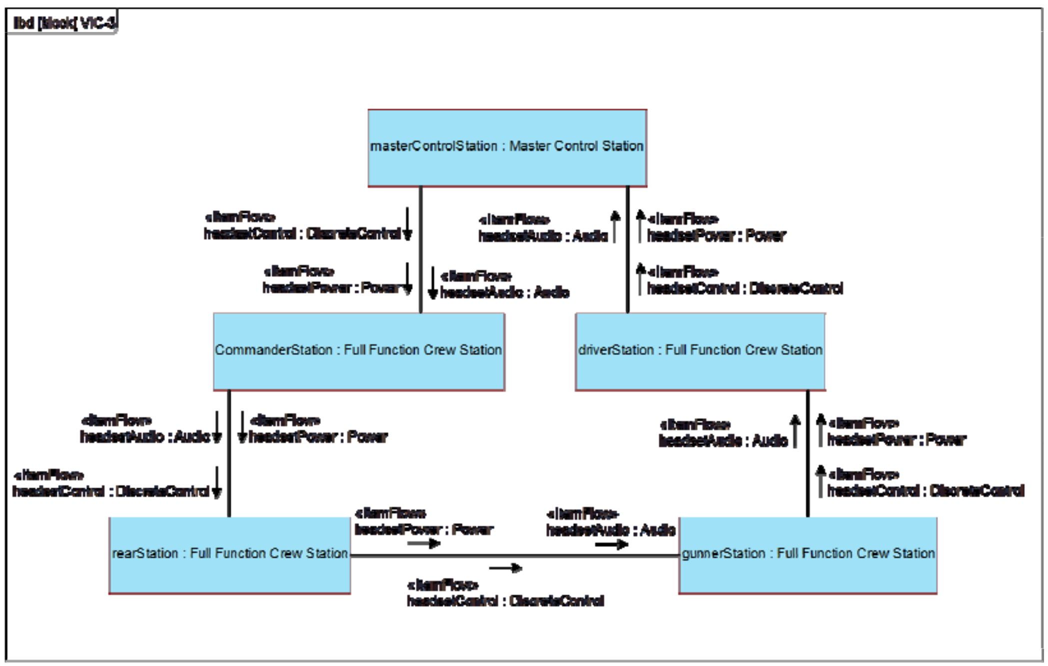
- Component Viewpoint (3 variants)
  - Identifies each component of the system as an instance of a specific block within the SPCH:
    - *SPCH Viewpoint* - presents the data aggregated by the SPCH Generalization Fully Qualified Name and optionally by Model Block Fully Qualified Name. Since the top-level packages in the SPCH are the system segments, the SPCH Viewpoint shows the system components aggregated by system segment.
    - *Product Work Breakdown Structure (PWBS) Viewpoint* - presents the data aggregated by Mil-Std-881C WBS Number and optionally by SPCH Generalization Fully Qualified Name and Model Block Fully Qualified Name.
    - *Bill of Material (BOM) Indenture Viewpoint* – presents the data ordered as an assembly-part hierarchy replicating the BOM indenture (i.e. drawing tree).
  - Presentation:
    - Listing of components and their SPCH block.

SPCH Generalization Fully Qualified Name	# Instances in Model
SPCH::GroundVehicleSystem	**1**
AMPV::AMPV	1
SPCH::SystemManagementAndControlSystemSegment::ComputingResources::Processor::DigitalSignalProcessor	**5**
SPCH::SystemManagementAndControlSystemSegment::ComputingResources::Processor::DigitalSignalProcessor	5
SPCH::SystemManagementAndControlSystemSegment::ComputingResources:Computer	**5**
AMPV::TacticalC3SystemSegment::Vic3::FullFunctionCrewStation	4
AMPV::TacticalC3SystemSegment::Vic3::MasterControlStation	1
SPCH::SystemManagementAndControlSystemSegment::DataDistributionAndControl::DiscreteDataInterfaceAdapter::AudioDataInterfaceAdapter	**8**

- Requirements Allocation Viewpoint
  - Identifies the requirements allocated to each component of the system.
  - Presentation:
    - Requirements traceability table or SysML requirements diagram.



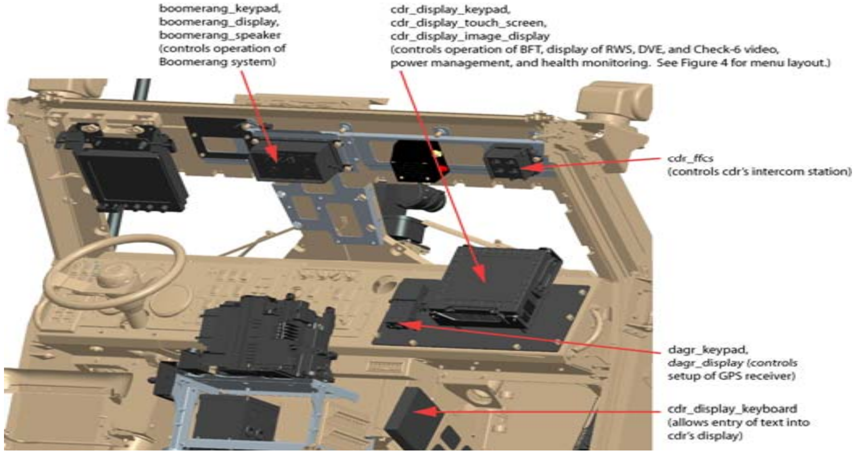
- Network Viewpoint
  - Identifies the mechanisms used to distribute data between components.
  - Presentation:
    - SysML diagram depicting system blocks consuming or producing data and their interconnects. Each interconnect is annotated with the physical media type and protocol.

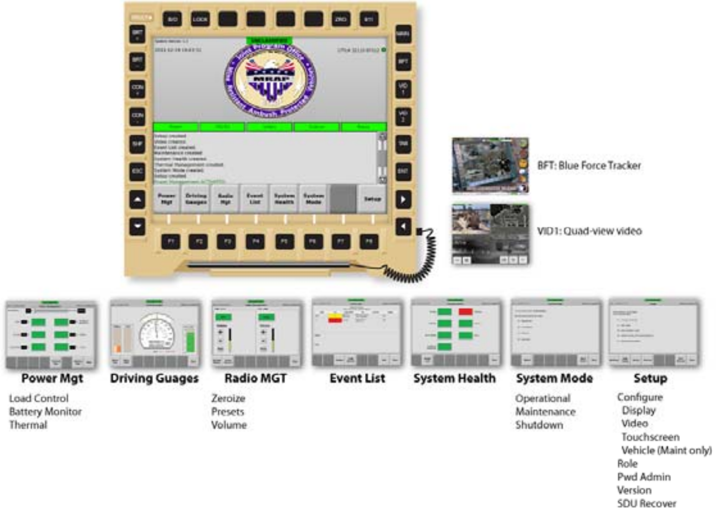


- Computational Viewpoint
  - Identifies the computing elements, operating environments, and application programs of a ground system.
  - Presentation:
    - Listing each computing component in the system in a table and identifying:
      - Processing unit
      - Memory size
      - Operating system used
      - Any middleware used
      - Each application program running on the computing component.

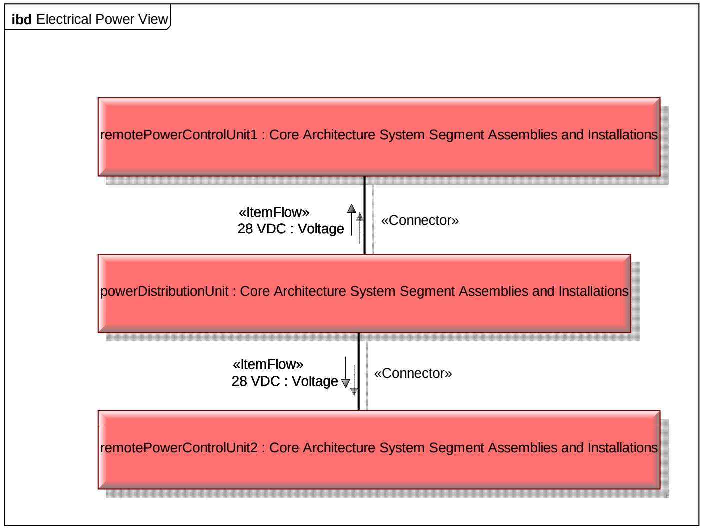
Computing Element Name	Standard Product Classification	CPU	CPU Features	Main Memory	Operating System	Middleware	Applications/ Executables
c2_computer	Core Architecture System Segment Assemblies and Installations	Intel L2400 Core Duo @1.66 GHz	2 MB L2 Cache Intel Virtualization Technology Intel SpeedStep Technology	2.0 Gbytes	Linux 4.2	Motif X Windows	C2App
cdr_display	Core Architecture System	Intel T2300 Core	2 MB L2 Cache	2.0 Gbytes	Red Hat	LibOE	App1

- User Interface Viewpoint:
  - Identifies all of the controls and displays of a ground system by crew position and identifies what is controlled or displayed by each component.
  - Presentation:
    - Graphical depiction of each ground system crew position.
      - The view identifies the name of each control or display component for each crew position and identifies the equipment or application controlled.
      - Multifunction displays are annotated with the high-level window/menu layout .

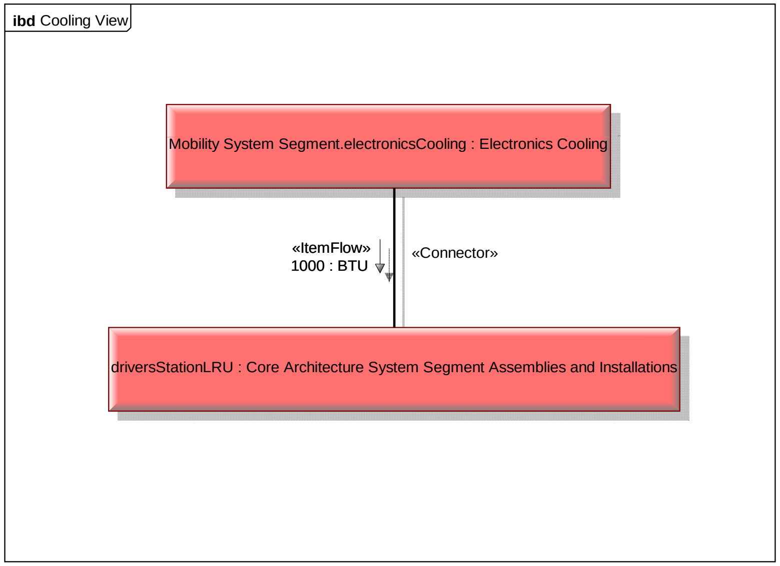




- Electrical Power Viewpoint:
  - Identifies the mechanisms utilized to generate, store, and distribute power to the components of a ground system.
  - Stakeholder Concern(s):
    - *Does the system design comply with all mandated standards and components?*
    - *Does the system facilitate the integration of new and or updated components?*
  - Presentation:
    - SysML diagram depicting each producer, consumer or storer of power and their interconnections. Each interconnect is annotated with the output voltage and current capacity.



- Cooling Viewpoint:
  - Identifies the mechanisms utilized to provide cooling for the components of a ground system.
  - Presentation:
    - SysML diagram depicting each component that generates or consumes cooling and their interconnections. Each interconnect is annotated with the cooling capacity.

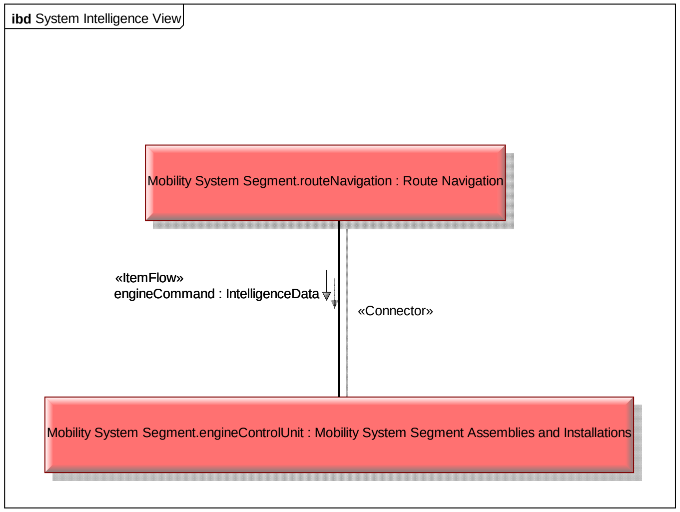


GSAF Commonality Viewpoints

- SWAP-C Viewpoint:
  - Identifies the size, weight, power usage, and cooling usage of each component of the ground system.
  - Presentation:
    - A listing of each component in the system in a table identifying:
      - Volume and maximum height, width, and depth of the component
      - Weight of the component
      - Required voltage level and typical/peak current draw of each power input of the component
      - Typical heat load on the cooling system from the component.

		Space				Weight	Power			Cooling
Component Name	**Standard Product Classification**	**Volume (in3)**	**Width (In)**	**Height (In)**	**Depth (in)**	**Weight (lb)**	**Voltage Input**	**Amps (Typ.)**	**Amps (Peak)**	
xyz_mast	ISR/EW System Segment Assemblies and Installations	20649.2	19.0	57.2	19.0	5.0	na	na	na	tbd
xyz_electronics	ISR/EW System Segment Assemblies and Installations	308.4	9.3	5.8	5.7	10.0	28 VDC	0.7	1.3	tbd

- System Intelligence Viewpoint:
  - Identifies components that support or enable System Resource Management (i.e., power management, BIT, CBM, etc.), Vehicle System Tactical Command, Embedded Training and Rehearsal, and Remote System Operation of the ground system and their relationships to other system segment intelligence components.
  - Presentation:
    - A SysML diagram depicting each component that provides core architecture system segment system intelligence capabilities interconnected with each component utilizing this support.



- Provides 15 rules and guidelines for documenting GSAF-based views in SysML.
  - Provides examples of each SysML-based GSAF view.

- Describes SysML representation of the SPCH and the GSAFProfile.
  - Package structure.
  - Inheritance relationships.
  - Stereotypes and tags.

Modeling Rules

1. The system model must be expressed in SysML 1.3. This is significant when modeling network, electrical, and other interconnections. In particular, flow ports and flow specifications, defined in SysML 1.2, are deprecated in SysML 1.3 and should not be used.
2. A GSAF-compliant system model must model a physical architecture. A physical architecture model is a decomposition of a system into a tree of physical components (a parts explosion), each of which is an element that is specifically hardware, software, or data, or a composition of such elements.
3. The system model must contain information from which the allocation of system requirements to physical components can be determined.
4. Every component in the physical architecture must be represented by a SysML block stereotyped as a ≪*GSAF Block*≫.
5. The decomposition of the ground system must be represented by SysML part properties among the blocks representing the physical components.
6. The lower and upper bounds of the multiplicity of a part must be equal, so that the number of components in the decomposition of the ground system is determined.
7. Connections must be modeled as SysML connectors between parts or ports. Each type of matter, energy, or data that flows over a connector must be modeled as an item flow.

8. All flows of data, electrical power, and cooling between LRUs must be represented in the physical architecture as flow items over connections between the LRUs.
9. All flows of data to and from any block that specializes a block within the SPCH package *System Management and Control System Segment::System Intelligence* must be represented in the physical architecture as flow items over connections between that block and the communicating blocks.
10. Every block in the physical architecture must either specialize an SPCH block or be an SPCH block. The system as a whole must be represented by a block that specializes SPCH *GroundVehicleSystem*.
11. The decomposition must contain all the ground system's LRUs. Every leaf component of the system decomposition must either be an LRU or be part of an LRU. An LRU must not be part of another LRU. Every component that is an LRU must specialize the SPCH block *LineReplaceableUnit* in addition to one other SPCH block that represents its function.
12. Every component that is a computer (an integrated assembly consisting of one or more processors, memory, application software, and possibly an operating system and middleware) must specialize the SPCH block *Computer*.
13. All value properties in the physical architecture that have non-zero minimum multiplicity must be assigned values.

14. The package structure of the physical architecture must parallel the package structure of the SPCH. If a block *A* in the physical architecture specializes SPCH block *B*, then block *A* must be contained in a nested set of packages in the physical architecture corresponding to the nested set of packages in the SPCH that contain block *B*.
15. If a program's WBS differs from MIL-STD-881C, then each block representing a physical component of the ground system must have the appropriate value for the *pWbsNumber* tag, based on the program's WBS.

Architecture Descriptions

- All programs required to have a SADD
  - An identification of the ground system and the phase of development it is in.
  - A brief description of the entire architecture and a definition of the scope and context of the architecture.
  - A list of system-specific stakeholders based on the general list defined in the GSAF.
  - A list of system-specific stakeholder concerns other than those identified in the GSAF.
  - An architecture view that conforms to each of the commonality architecture viewpoints.
  - One or more architecture views that conform to the system analysis and design viewpoints.
  - All DoDAF architecture views of the ground system required by acquisition guidance.
  - A viewpoint integration and model correspondence mapping that identifies interdependencies between the commonality viewpoints and the provided system analysis and design and DoDAF viewpoints.

Tool Support

- Baseline SPCH exists as a spreadsheet and is maintained in a commercial requirements management tool.
  - Change control board manages changes.
- Representation exists in XMI to facilitate the creation of SPCH-based models in commercial SysML tools.
- GSAF plug-in has been created for a commercial SysML tool to generate the SPCH component views.

Applications and Future Work

- TARDEC is working with vehicle programs to promote wide-spread adoption.
- Currently working with an established ground vehicle program to develop a SysML model for the vehicle based on the Bill of Materials.
- Phase II effort being defined with focus on integration of SysML and Computer-aided design models.
  - Goal to achieve full traceability from requirements -> architecture -> detailed design.

GSAF Version 1.0 is complete

Available Products

- Joint Center for Ground Vehicles (JCGV) Ground System Architecture Framework (GSAF), Version 1.0, June 26, 2012.
- Integrated System Architecture Modeling Guide (ISAMG), Version 1.1, 19 September 2013.
- Standard Product Classification Hierarchy XMI Model.

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