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Model-Based Integrated Decision Support Key: A Standardized Approach to Mitigating Decision Support Challenges During Acquisition Test and Evaluation

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Abstract

Providing timely decision support to decision-making authorities during the various phases of an acquisition program is critical for the on-time delivery of operationally effective weapon systems that meet the needs of the warfighter. To ensure decision-makers are equipped with the necessary test and evaluation (T&E) data to inform decisions, the Department of Defense (DoD) recently mandated the use of the Integrated Decision Support Key (IDSK) as a tool to encapsulate (i.e., succinctly record) a program's decisions and the T&E data necessary to support the decisions. Therefore, an approach that utilizes digital engineering, specifically model-based systems engineering (MBSE) as a means to standardize the linkage of test data to decisions presents a significant value proposition for decision-making authorities—linking data from a program's system, design, and test planning models to key acquisition decisions. An overt value of this approach is the resulting digital thread that connects data sources (i.e., digital models) into an authoritative source of truth to both inform and validate decisions. Hence, this paper presents a Model-Based Integrated Decision Support Key (MB-IDSK) Reference Architecture (RA) that integrates and links data from multiple digital models to a standardized set of acquisition, technical, and T&E decisions. The MB-IDSK RA provides a standardized pattern and approach for developing program-specific MB-IDSKs to support program acquisition and T&E decision-making.

Keywords: Acquisition Decision Support, IDSK, Model-Based Systems Engineering, Reference Architecture

Introduction

Department of Defense (DoD) decision-making authorities across acquisition programs are expected to make decisions that are consistent, coherent, and timely to build and maintain enduring advantage in the delivery of weapon systems to the warfighter. To support timely decision-making, program and mission-critical vulnerabilities involving test planning, test prioritization, and the testing capabilities of test facilities and ranges must be identified and mitigated prior to key decision points. In order to accelerate the delivery of systems that work, it is necessary to create tools and processes that optimize integrated T&E and support the proliferation of information to decision-makers as early as possible in the acquisition lifecycle. Moreover, within the context of shrinking error margins, shorter decision-cycle times, and in the face of a growing attack-surface, providing decision support in the form of accurate and trusted data at the speed of need becomes critical.

To better support decision-making across a program's lifecycle, the traditional Integrated Decision Support Key (IDSK) was developed as a framework to identify and specify critical T&E data required to inform defense acquisition program decisions. In addition, it specifies relevant information about a program's decision-making process throughout the acquisition cycle to support decision-makers as stated in the DoD Instruction 5000.89 document (Executive Services Directorate, 2020). As a consequence of this directive, the Director, Operational Test and Evaluation (DOT&E) outlined a key strategy—accelerate the development of solutions that enable digital representations of numerous T&E tools and artifacts including a digital IDSK (Guertin, 2022). This strategy underscores a critical need which this work seeks to address by developing a digital engineering artifact in the form of a Model-Based IDSK (MB-IDSK) Reference Architecture (RA) that, when instantiated, will seamlessly integrate into the digital engineering ecosystem. The MB-IDSK RA proposed in this work provides consistency, integrity, balance, and practical guidelines for program-specific implementations. Specifically, an MB-IDSK will improve the decision-making process by making it compatible and interactive with the systems engineering models for the system under development (SUD). Additionally, a library of standardized tailorable IDSK table templates that are fully consistent with the traditional paper and table-based IDSKs used in other programs within the DoD are generated to support test planning and decision-making. The rest of the paper is organized as follows: A brief background on the IDSK is presented in Section II, while the value proposition for an MB-IDSK RA is outlined in Section III. The proposed MB-IDSK RA is described in Section IV, while an overview of how the MB-IDSK RA can be instantiated by an acquisition program is summarized in Section V. Conclusion and Future Work are presented in Section VI and Section VII.

Background

A number of research studies have been conducted on best approaches to support acquisition T&E decision-making. Beers et al. (2013) reported on the developmental test evaluation framework which describes a logical thought process involving defining an evaluation framework, building analytically test programs to generate data, and evaluating data in order to inform decisions. Also reported by Beers (2022) was the use of a digital IDSK, which focuses on gathering data to evaluate operational and technical capabilities in order to inform acquisition and operational fielding decisions. Collins and Beers (2021) explored the concept of applying the IDSK during the post-mission engineering phase in order to evaluate capabilities and inform operational fielding decision-making. Additionally, Werner and Arndt (2023) reported on the development of digital engineering artifacts to support decision-making. In more recent development, DOT&E defined a Baseline IDSK for use by acquisition programs. The Baseline IDSK comprises a series of tables in the form of *IDSK-long and IDSK-short tables, Dictionaries*, *Resource tables*, which can be implemented using a range of different technologies based on the purview of the program office (PO) and vendors involved in executing the program.

Although most research studies examined involve various approaches for improving acquisition T&E decision-making, none adequately addressed the standardization of these decisions in a repeatable consistent manner and the linking of decisions to data resident in program digital models. To the best of our knowledge, there is currently no published research work that exploits Model-Based Systems Engineering (MBSE) methods for IDSK development. We address this gap by aligning our model-based approach with best practices from within the DoD and the systems engineering and modeling community to provide data-driven decision support using MBSE and systems modeling language (SysML).

The Value Proposition of an IDSK RA for DoD Acquisition Programs

The motivation behind defining an RA for the IDSK is based on the premise that an architecture should reflect the organization of the owning enterprise (Army Aviation and Missile Command Fort Eustis, VA [AMCOM], 2022). Therefore, for a hierarchical organization such as the DoD/DOT&E enterprise, developing an IDSK RA presents a critical first step towards preventing conflicting business objectives for programs of record (PoR) by serving as a medium to flow down the overarching business objectives for a PoR IDSK as perceived by the DoD/DOT&E authorities. Specifically, the IDSK RA represents an essential tool to facilitate communication and alignment efforts of current and future IDSK architectures. Figure 1 depicts the IDSK architecture strategy as adapted from the DoD Comprehensive Architecture Strategy.

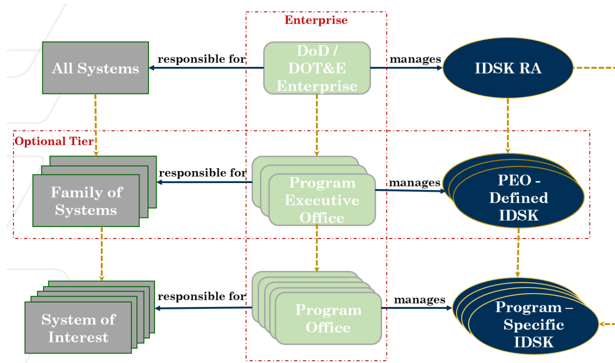


Figure 1. IDSK RA Architecture Strategy (AMCOM, 2022)

Equipping DoD acquisition programs with overarching guidance on how to leverage digital engineering for decision support is critical to achieving the enterprise-wide business and mission objectives of providing weapon systems at the speed of need and relevancy. An RA provides a method for focusing all architecture and design decisions with the intent to enforce common applicable standards and providing a tailorable architectural structure (AMCOM, 2022; Muller & Hole, 2007). The IDSK RA is developed to demonstrate and provide guidance on how the T&E enterprise and acquisition programs implementing digital engineering could leverage existing digital models created during the various acquisition phases as real-time data sources to inform key program decisions and improve decision outcomes. Figure 2 describes the role of the IDSK RA relative to program-specific IDSKs.

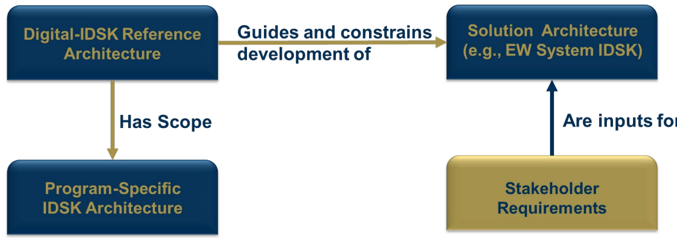


Figure 2. The Role of the IDSK RA to Program-Specific IDSKs

The three crucial characteristics that underpin the IDSK RA approach include

1) The creation of a digital thread that links acquisition and test data resident in missions, systems, and test models to metrics and key decisions.
2) Key decisions and decision classes that are standardized across acquisition T&E programs which help define expectations, formalize processes, and create accountability for programs.
3) A library of tailorable IDSK table template types—highlighted in Figure 3—and model navigation syntax in the form of query elements that are easily modified based on a program's specific implementation of the MB-IDSK RA.

IDSK RA Standardized Table Formats		
	Table Type	Count
1	IDSK RA Dictionary Standardized Table	Ten (10)
2	IDSK RA Test Resources Standardized Table	Eight (8)
3	IDSK Crosswalk Standardized Table	Eleven (11)
4	IDSK RA Key Decision Standardized Table	Five (5)

Figure 3. IDSK RA Standardized Table Types and Count

The IDSK RA

The MB-IDSK RA captures the essence of the decision support domain relative to the needs of acquisition T&E decision-makers. Specifically, it represents an instantiable pattern developed using MBSE principles and best practices to provide guidance for the development of new and/or extended versions of program-specific MB-IDSKs. In this section we describe briefly the key business and architecture drivers of the MB-IDSK RA, multiple architecture views, and a set of standardized IDSK tables generated from instantiated notional IDSK architecture exemplars.

Identifying the IDSK RA Key Business and Architecture Drivers

The intent of Key Business Drivers (KBDs) is to convey stakeholder vision, guidance, and critical business concerns; they answer "why" the architecture is needed (AMCOM, 2022). Two MB-IDSK RA KBDs—*link to digital models* and *lightweight architecture*—were determined by analyzing and prioritizing stakeholder concerns, primarily those aligned with the second pillar—*accelerate the delivery of weapons that work*—of the DOT&E strategy (Guertin, 2022). Notably, the need to leverage existing digital models (i.e., the resources of a program's digital engineering ecosystem) as data sources to provide timely decision support is a critical business concern of both acquisition programs and the T&E enterprise. Mapping of KBDs to stakeholder concerns are shown in Figure 4.

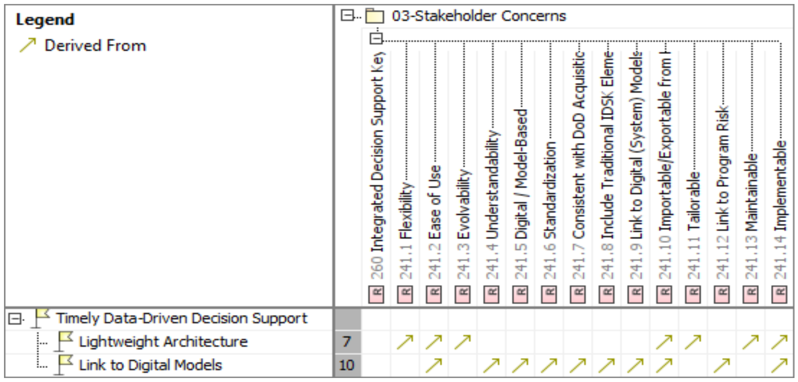


Figure 4. Derivation of KBDs From Stakeholder Concerns

Portrayed in Figure 5 is a tiered layout of selected MB-IDSK RA KBDs and key architectural drivers (KADs). KADs—usually expressed as architectural requirements—are a combination of business, operational (functional), quality attributes (nonfunctional) requirements, and constraints which are critical to the success of a given entity. In the case of the IDSK RA, top-level KADs—*data integration, standardization*, and *flexibility*—are vital to ensuring successful deployment (i.e., its acceptance and use by programs). Consequently, the MB-IDSK RA is able to maintain a flexible posture by fostering evolvability and responsivity and maintainability quality attributes.

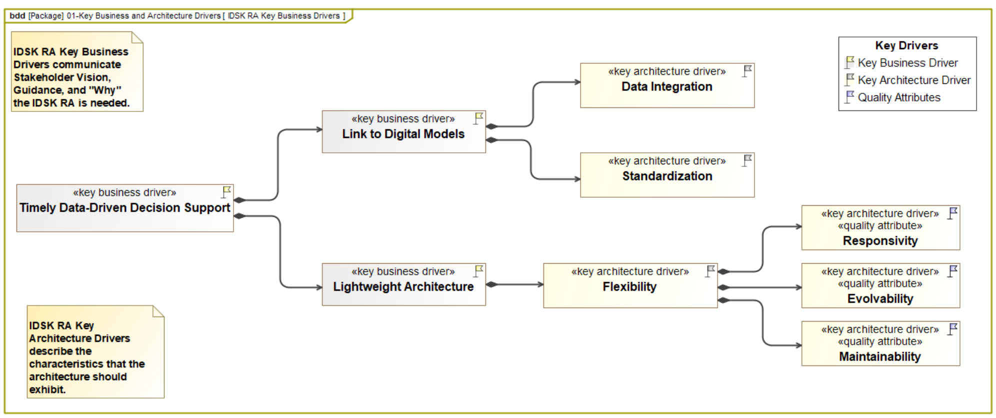


Figure 5. IDSK RA KBDs and KADs View

A. Enabling Data-Driven Decisions: Standardized IDSK Table Views

The set of standardized IDSK table formats generated from the MB-IDSK RA are the primary decision support artifacts of the IDSK RA. These table are generated from the various views specified in the IDSK RA model and collectively represent the integration of information, knowledge, capabilities, and data necessary to support decision-making by POs and the T&E enterprise to achieve their strategic objectives. A major benefit of this model-based architectural approach to decision support is the latitude it affords in generating views that can be tailored and configured based on the needs of the decision-making authority. Notional examples of several IDSK table formats are presented in this subsection. Currently, a total of 26 acquisition test planning and decision-related table views make up the model-based IDSK Tables Library.

IDSK Dictionary Standardized Format. IDSK dictionary tables defined in the IDSK RA capture information regarding key IDSK elements and their corresponding descriptions as portrayed in Table 1. Dictionary table views can be tailored to highlight additional data fields as shown in Table 2.

Table 1. Metric Dictionary Table (Notional)

#	Name	Metric Type	Metric Description
1	reliability	EW System Reliability	Metric Description/documentation goes here.
2	suitability	EW System Suitability	Metric Description/documentation goes here.

Table 2. Decision Dictionary Table (Notional)

#	Name	Decision Type	Decision Question	Decision Category
1	ctr	EW SUT Critical Performance Indicator Decision	Decision question goes here	*Critical Technical Performance Decision*
2	ctr	EW SUT Critical Performance Indicator Decision	Decision question goes here	*Critical Technical Performance Decision*
3	mpc	EW SUT Operational Availability Indicator	WILL THE SYSTEM MEET OPERATIONAL AVAILABILITY NEEDS?	*Programmatic Decision*

IDSK Test Resource Standardized Format. IDSK test resource tables capture important test planning data required to support acquisition T&E planning and decision-making. Notional examples of the IDSK RA *Test Event Resource* and *Test Article Resource* tables are depicted in Table 3 and 4.

Table 3. Test Event Resource Table (Notional)

#	Name	Test Event Quarter & Fiscal Year	Type of Test	Test Number	Test Objective	Test Range
1	Missile SUT Test Event	Q1FY24	Developmental Test (DT)	4.3.2	Determine if the system requirement can be met by the current design.	Missile Test Range Facility

Table 4. Test Article Resource Table (Notional)

#	Name	Test Article (SUT)	Quantity (SUT)	Support System(s) Required for Test	Quantity (Support System)	Duration_Hour	Dollar Cost	Dollar Cost Total
1	EW SUT Test Event	EW SUT Alpha	5	Test Aircraft	2	10	3000	30000
2	Missile SUT Test Event	Missile SUT	2	Nuclear Submarine	1	5	20000	65000

IDSK Crosswalk Standardized Format. IDSK crosswalk tables capture cross-cutting views which expose important dependencies between key IDSK elements, giving a holistic view of T&E data to support timely decision-making. Table 5 and Table 6 depict examples of *Decisions Crosswalk* and *Metrics Crosswalk* tables.

Table 5. Decisions Crosswalk Table (Notional)

#	Name	Metrics	Operational Requirement	Data Element	Threshold	Objective	Test Data Collected	Test Data Quantity Required	Data an Analysis URL	Current Estimate
1	EW SUT Sensor Requirement Decision	EW System Suitability	229.2 EW SUT Compute Target ID	TestResult1 : VerdictKind = inconclusive dataElement3 : Real = 300.0 dataElement4 : Real = 150.0	42.0 55.0	45.9 56.0	34 22	40 22	www.idsk.com www.idsk.org	4.5 6.7

Table 6. Operational Metrics Crosswalk Table (Notional)

#	Name	Operational Requirement	Operational Requirement Type	Derived Technical Requirement	Key Decision	Tests
1	Missile System Suitability	229.1 Missile Speed Requirement	KPP	219 Missile Speed Requirement	Missile System Critical Performance Indicator Missile System Functional Review	All Scenarios Test Missile Speed Test Scenario

IDSK Key Decision Standardized Format. The IDSK RA comprises four types of decision tables to support decision-makers throughout the acquisition and T&E process. Specifically, decision tables include *Class I—critical technical requirement*, *Class II—milestone review*, *Class III—subsystem critical performance and tech maturity*, *Class IV—operational performance characteristics*, and *Class V—programmatic decisions* tables. Shown in Table 7, Table 8, and Table 9 are the IDSK Class I, II, and III decision-type tables.

Table 7. Class I Decision Table—Critical Technical Requirement Decision Table (Notional)

#	Name	Program Decision	Decision Type	Decision Category	Decision Outcome	Decision Date	Milestone Review Gate	Confidence Level Required for Decision	Applicable Requirement	System Requirement	Data Required	Data Source
1	Missile System Critical Performance Indicator	CAN THIS REQUIREMENT BE MET WITH THE CURRENT SYSTEM DESIGN?	Critical Technical Requirement Decision	CLASS I	Meets Requirement	12/1/23	Preliminary Design Review	High Confidence (> 90%)	229.1 Missile Speed Requirement	219 Missile Speed Requirement	Missile Speed Test Data	Missile Speed Test

Table 8. Class II Decision Table—Milestone/Technical Review Decision Table (Notional)

#	Name	Decision Question	Decision Outcome	Decision Category	Decision Type	Confidence Level Required for Decision	Milestone Gate	Decision Date	KSA, KPP, KPI	System Requirement	Data Source	Data Required
1	Missile System Functional Review	IS THE MISSILE ABLE TO MAINTAIN MINIMUM SPEED BASED ON ITS FUNCTIONAL DESIGN?	Inconclusive	CLASS II	Milestone B - Engineering Development	High Confidence (> 90%)	Based on Review Schedule	11/6/24	229.1 Missile Speed Requirement	219 Missile Speed Requirement	Missile Speed Test	Missile Speed Test Functional Data

Table 9. Class III Decision Table—Subsystem Critical Performance Decision Table (Notional)

#	Name	Program Decision (Class III)	Decision Category	Decision Type	Confidence Level Required for Decision	Milestone Gate	Decision Date	Decision Outcome	Technical Measure	System Requirement	Data Source	Test Data Required
1	EW SUT Sensor Requirement Decision	WILL THE EW SYSTEM SENSORS, SIGNAL PROCESSING, AND TARGET DETECTION ALGORITHMS PERFORM UP TO THE REQUIREMENTS?	CLASS III	Sensor Requirement	High Confidence (> 90%)	Based on Review Schedule	9/19/24	Level 6 or Higher	229.2 EW SUT Compute Target ID	184 EW SUT Compute Correct Target ID	Test	Sensor Test Data

Enabling Data-Driven Decisions: IDSK RA Views and Viewpoints

The perspectives of acquisition and T&E decision-makers—*IDSK stakeholders*—form the basis for the IDSK RA viewpoints and corresponding views. A viewpoint as stated in the *Software, Systems, and Enterprise—Architecture Description ISO Standard* (ISO/IEC/IEEE, 2022) establishes the conventions for creating, interpreting, presenting, and analyzing a view to address the concerns framed by a viewpoint. The IDSK-RA description is illustrated through views depicted as diagrams. These views are created to serve as digestible chunks of the complete architecture and address specific concerns of acquisition test-planning stakeholders and decision-makers as it relates to their decision support needs.

Importantly, the IDSK-RA is developed to facilitate both current and future program-specific IDSK implementations by utilizing architecting principles such as the separation of concerns, managing key interfaces, and ensuring minimal coupling between elements. Abstractions and simplification concepts are also utilized in relation to how diagram views appear and how they are presented in this work.

Defining the IDSK RA T&E Decision Support Overarching View. An overarching view of the IDSK RA is shown in Figure 6. Although several elements and relationships have been deliberately elided from the view to enhance readability, the view still provides crucial insights into the top-level composition of the acquisition T&E decision support domain. The RA links traditional elements of the IDSK—Decisions, Data, and Data Sources (e.g., Tests)—to cardinal decision-enabling elements captured within a program's digital engineering ecosystem. Some of these elements include *metrics, test personnel, decision-makers, program office artifacts, test budget, program risk,* and data captured in *requirements, system*, and *test range* models.

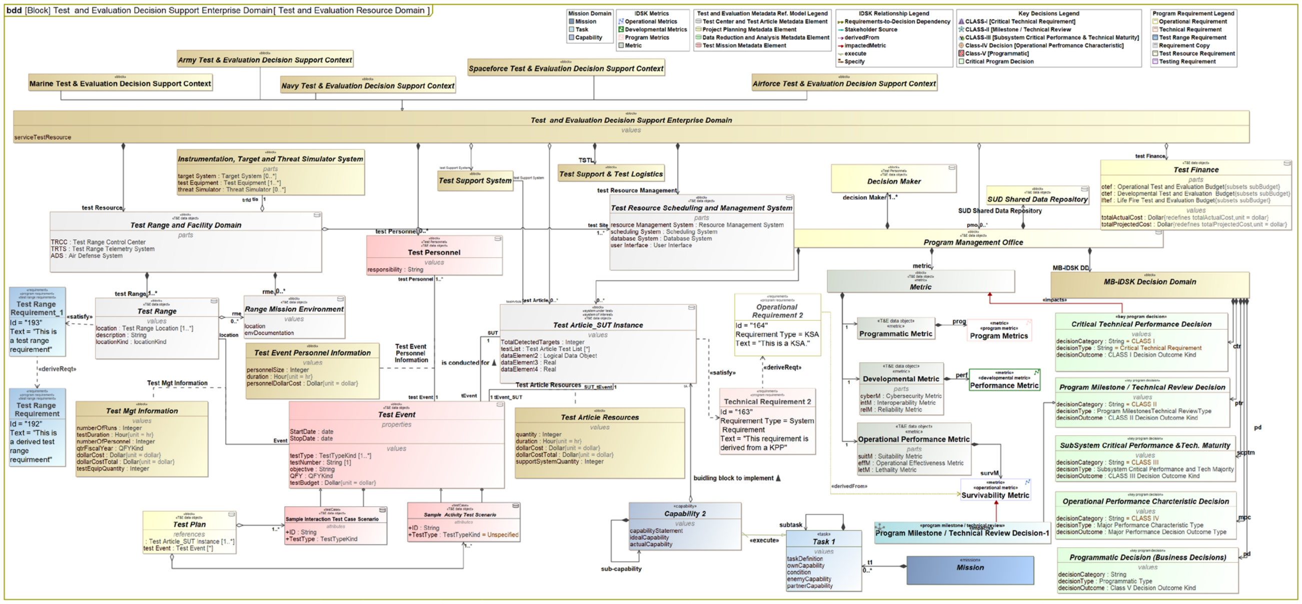


Figure 6. IDSK RA T&E Decision Support Domain View (Partial)

Key Decisions Domain Viewpoint and View. Within the context of decision-making in DoD acquisition programs, there are a limited number of critical decisions that need to be made at different times and based on different aspects of the program. These different decisions are well documented in the DoD 5000 and several other DoD acquisition process documents. To consistently make the best decisions, the availability of decisions and decision classes that are standardized across acquisition programs is necessary to help define expectations, formalize processes, and create accountability for programs.

Presently, a standardized set of program decisions grouped into five classes are defined in the IDSK RA. These decision classes provide a structured context for specifying the limited number of critical decisions that need to be made throughout the acquisition process and provide a format to link them to developmental, operational, and integrated test data needed to inform decisions. These classes are Class I, Critical Technical Requirements Decisions; Class II, Program Milestones/Technical Reviews Decisions; Class III, Sub-System Critical Performance and Technology Maturity Decisions; Class IV, Major Performance Characteristics Decisions; and Class V, Programmatic Decisions.

Figure 7 depicts the various IDSK RA categories of decisions (Class I–V) and the specific data characteristics of each decision class. Some characteristics defined as attributes include *decision question, decision outcome, confidence-level required, data source*, the specific *data required* to inform the decision, the *decision type*, and the *date* by which the decision is required amongst others. Sample instantiations of each decision class are also highlighted. The Key Decision Domain Viewpoint addresses the concern—What types of decision classes and corresponding metadata are required to support the generation of the IDSK key decision tables?

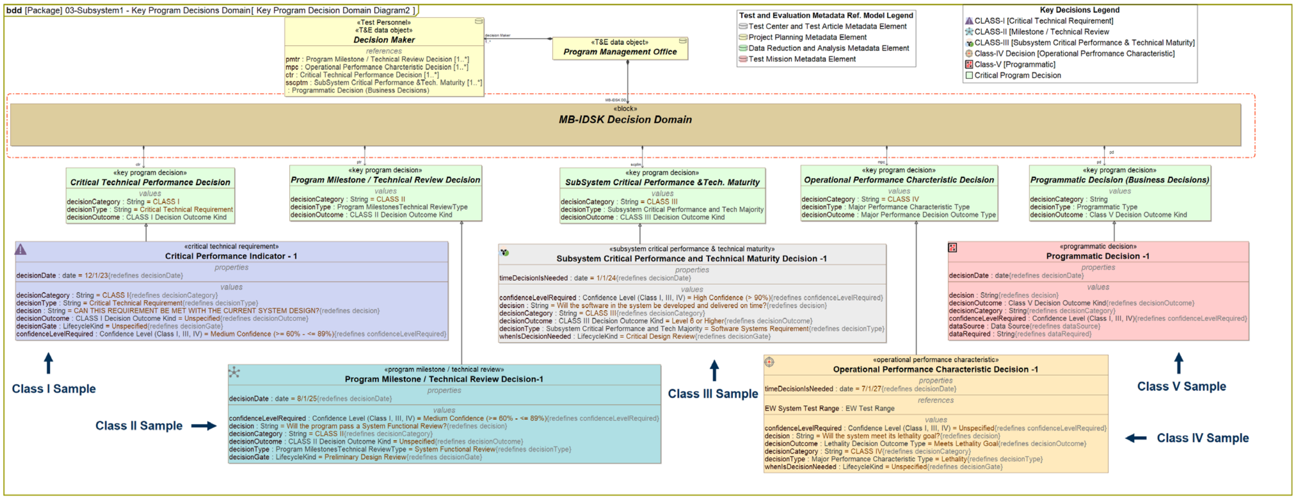


Figure 7. IDSK RA Decisions Domain View

Metrics Domain Viewpoint and View. The Metrics Viewpoint defines the IDSK RA Metrics-types required for evaluating the system under test (SUT) during the various phases of system development and test. These metrics are crucial to assisting decision-makers make the best decisions. Figure 8 highlights a Metrics View of the IDSK RA and portrays the key relationships between the Metrics and other key elements of the IDSK RA, which include the operational requirements—derived from the metrics—and the critical program decisions which impact the metrics. Three main classes of metrics currently specified the IDSK RA include *operational metrics*, *developmental metrics*, and *programmatic metrics.* The Metrics Domain Viewpoint addresses the concern—What types of metrics (i.e., operational, developmental, and programmatic) are required to support the generation of IDSK metric-based tables?

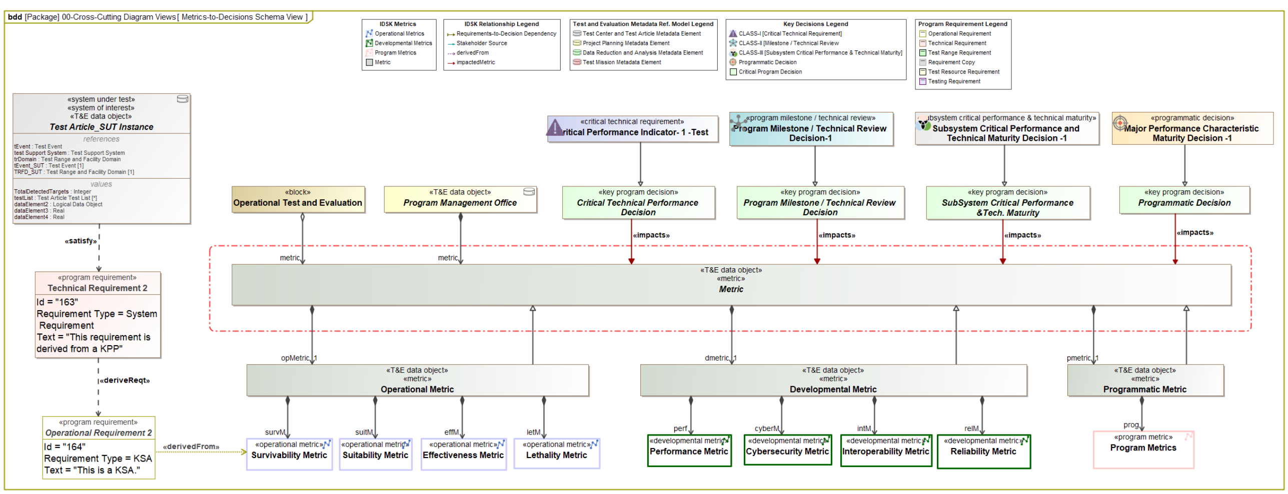


Figure 8. IDSK RA Performance Metrics Domain View

Decisions and Test Article Viewpoints and Views. Figures 9-A and 9-B depict views that portray the IDSK RA from the viewpoints of a decision class and test article with emphasis on the key relationships between these IDSK elements and those that are relevant for the generation of standardized test planning IDSK tables. These Viewpoints and corresponding Views address the concerns—What are the required relationships and structural elements needed to support the generation of the MB-IDSK *test article* and *test resource* standardized views?

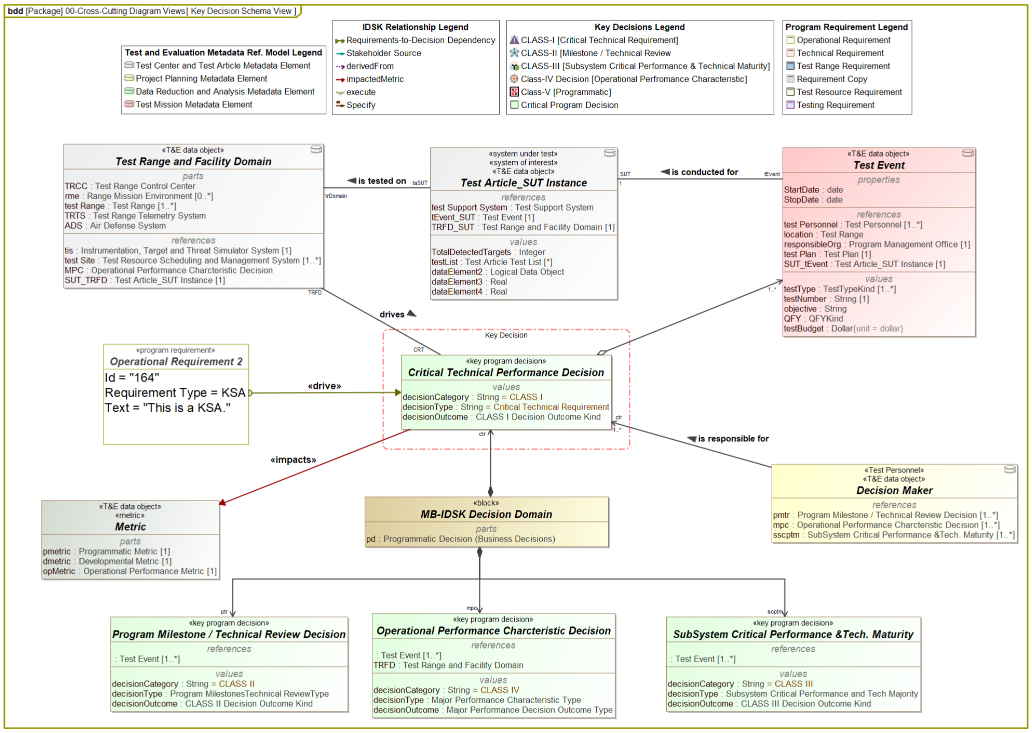


Figure 9-A. IDSK RA Class I Decision-Type View

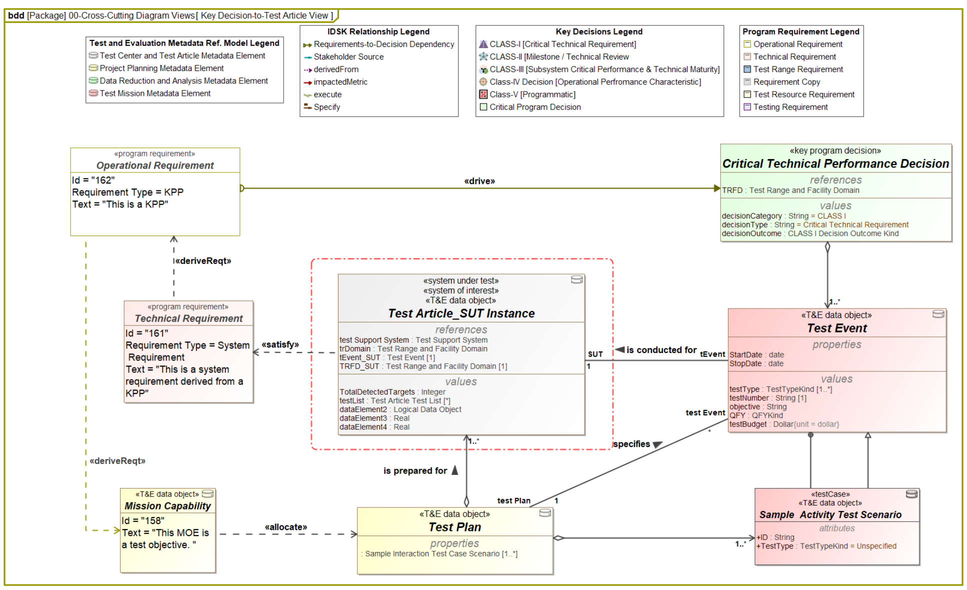


Figure 9-B. IDSK RA Test Article View

Decision-Maker and Test Planning Data Viewpoints and Views. The Decision-Maker and Test Planning viewpoints of the IDSK architecture are created to focus attention on the test planning and decision support needs and concerns of the Decision-Makers (e.g., PO) regarding the T&E of the System-of-Interest (i.e., SOI/SUT). The Decision-Makers within the PO are the primary decision-making authority and are responsible for each decision as illustrated in Figure 5. The PO is comprised of most key Decision-Makers and has ownership of the Test Article and the Decisions that need to be made. Defining the Decision-Maker viewpoint allows views to be created that provide critical insights into the relevant relationships between IDSK elements and how these relationships can be leveraged to support decision-making at each phase of the T&E process. As shown in Figure 10-A, elements specified in to the Decision-Maker Viewpoint include the *PO*, *decisions*, *metrics*, *operational requirements*, *technical requirements*, and *test article* elements respectively.

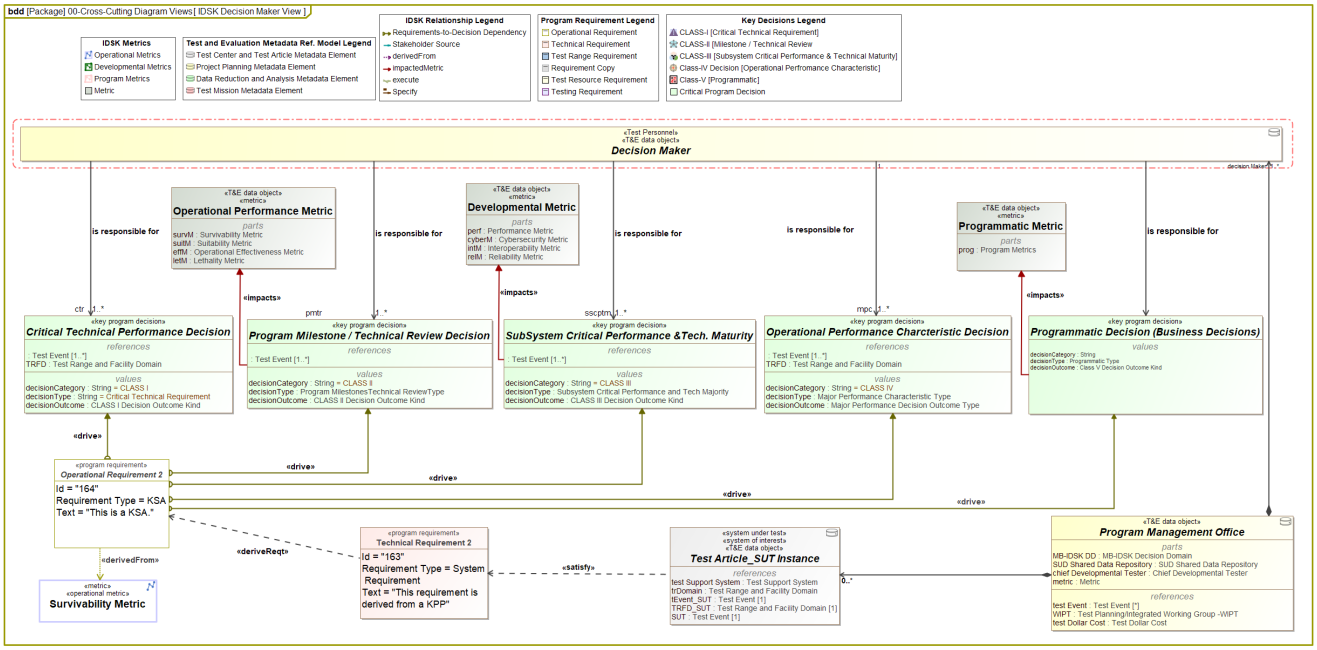


Figure 10-A. IDSK RA Decision-Maker Domain View

Figure 10-B also defines elements that represent data sources relevant to the decision space such as *test range*, *test event*, *test article*, *test personnel*, and elements that capture crosscutting data. Data elements from this view are leveraged in most of the IDSK standardized table views.

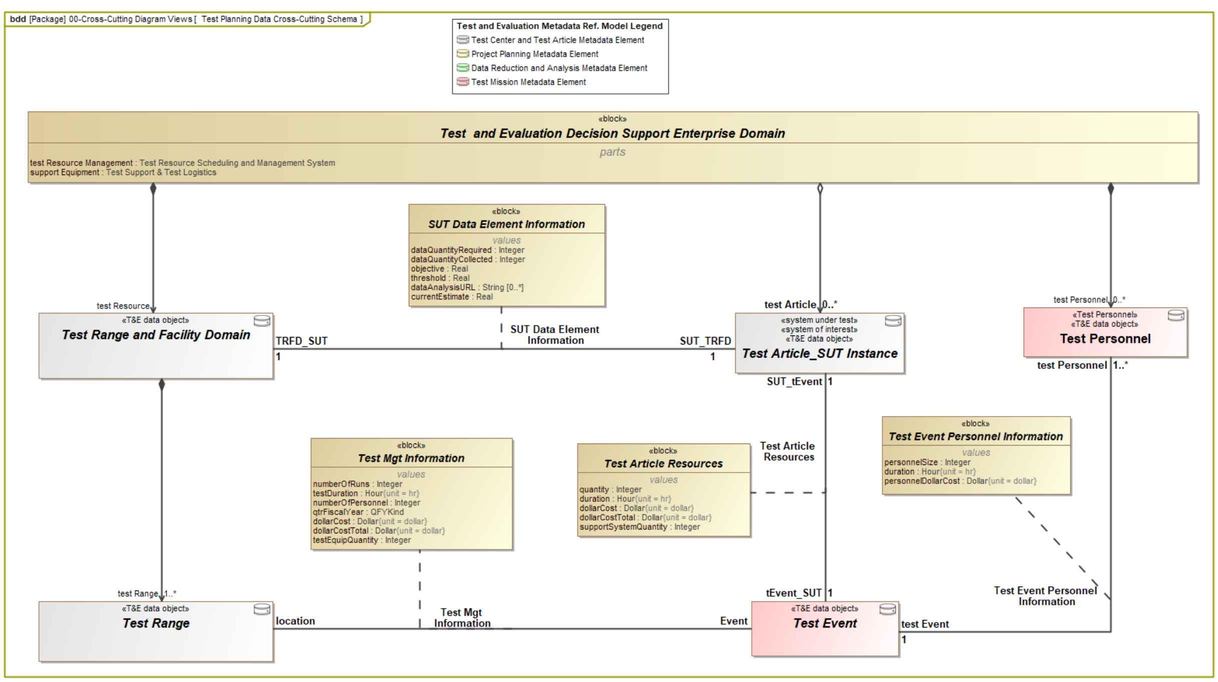


Figure 10-B. IDSK RA Data Sources View

Requirements and Mission Viewpoints and Views. The IDSK RA Requirements view depicted in Figure 11-A portrays various types of Requirements defined as part of the IDSK RA. This architectural view provides insight regarding the IDSK RA's requirements pattern/schema and how each requirement type maps to several architectural elements such as *the test range and facility domain*, *test article*, *test case scenario*, *metrics*, and *key program decisions*. As illustrated in Figure 11-A, Technical Requirements are *derivedFrom* Operational Requirements (i.e., KPPs, KSAs) while the Operational Requirements are *derivedFrom* Metrics and *drive* the Key Program Decisions. Specified test range Requirements trace to Operational Requirements and are satisfied by the test range capability required to enable testing of the systems-of-interest. It is important to note that the IDSK RA requirement view shown below does not represent all requirement types needed to support the generation of the IDSK requirements-related tables. The Requirements Viewpoint and View addresses the concern—What are the requirements, relationships, and IDSK elements needed to support the IDSK requirements-related standardized data formats? The IDSK RA Mission view depicted in Figure 11-B defines a few key elements and relationships from a Missions Viewpoint which are required for decision support during acquisition T&E.

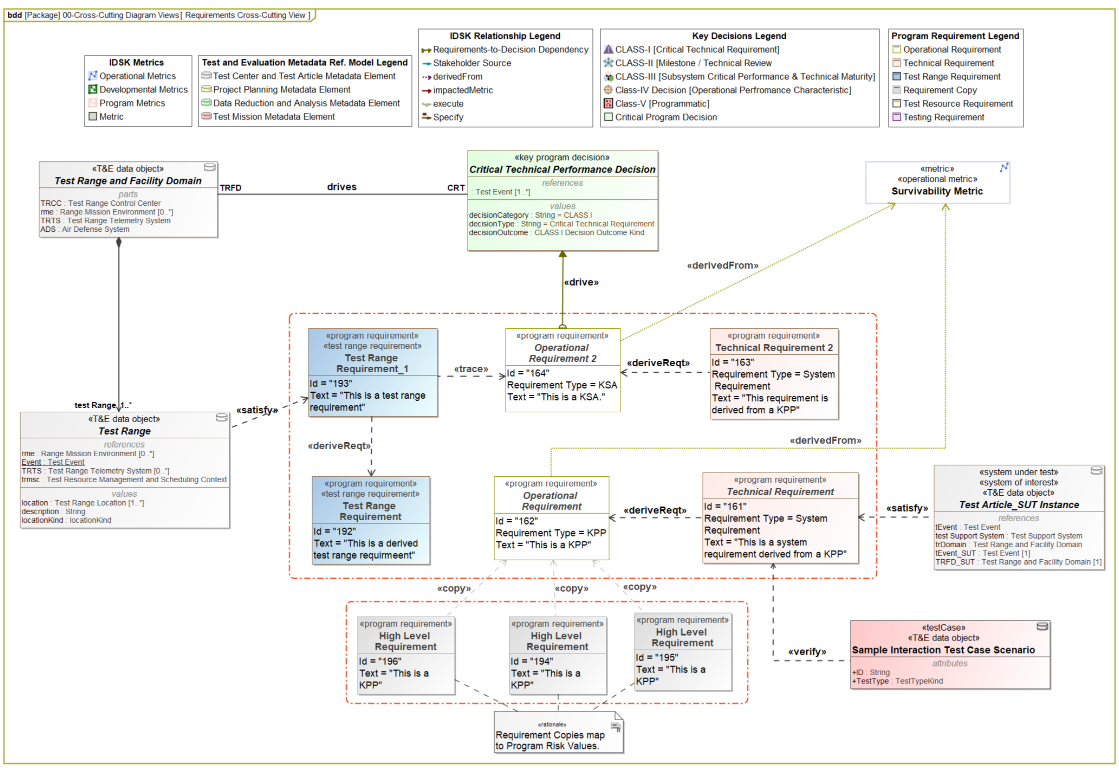


Figure 11-A. IDSK RA Requirements View

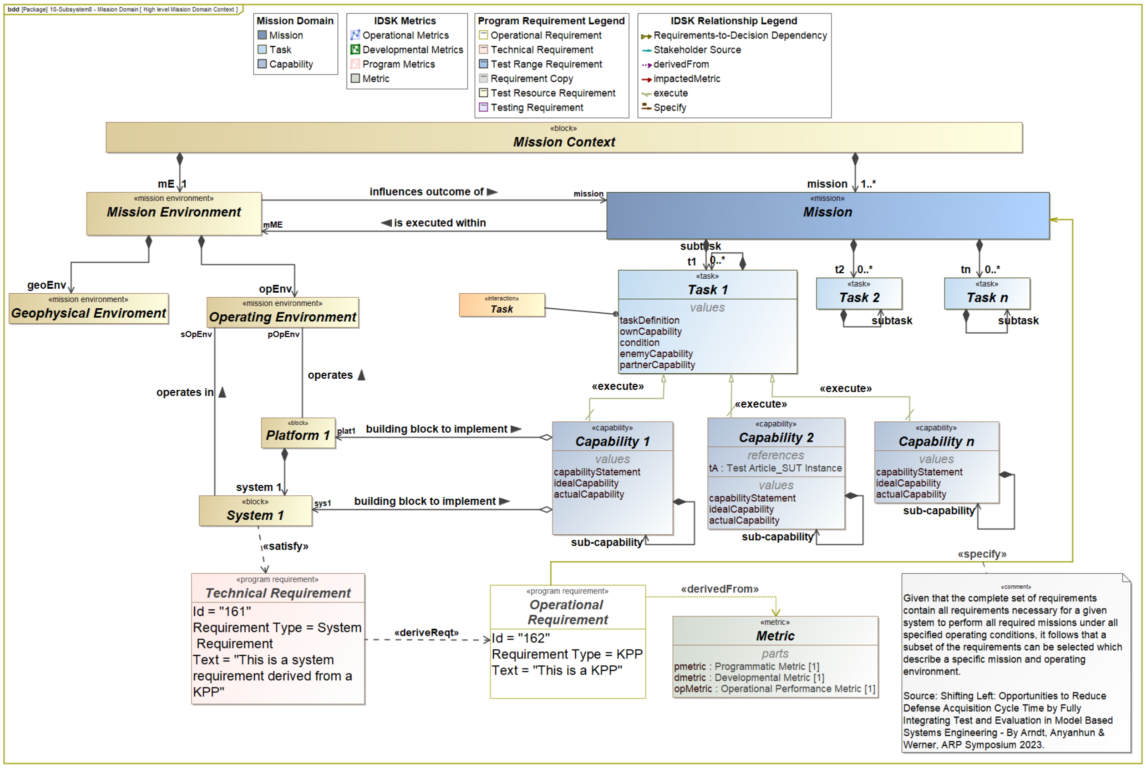


Figure 11-B. IDSK RA Mission View

Program-Specific MB-IDSK Development Process: Instantiating the MB-IDSK RA

A how-to step-by-step architecting process for developing program-specific architectures is captured as part of the MB-IDSK RA model. A high level developmental process view, which outlines the steps a PO utilizing the IDSK RA should take to achieve an MB-IDSK, is portrayed in Figure 12.

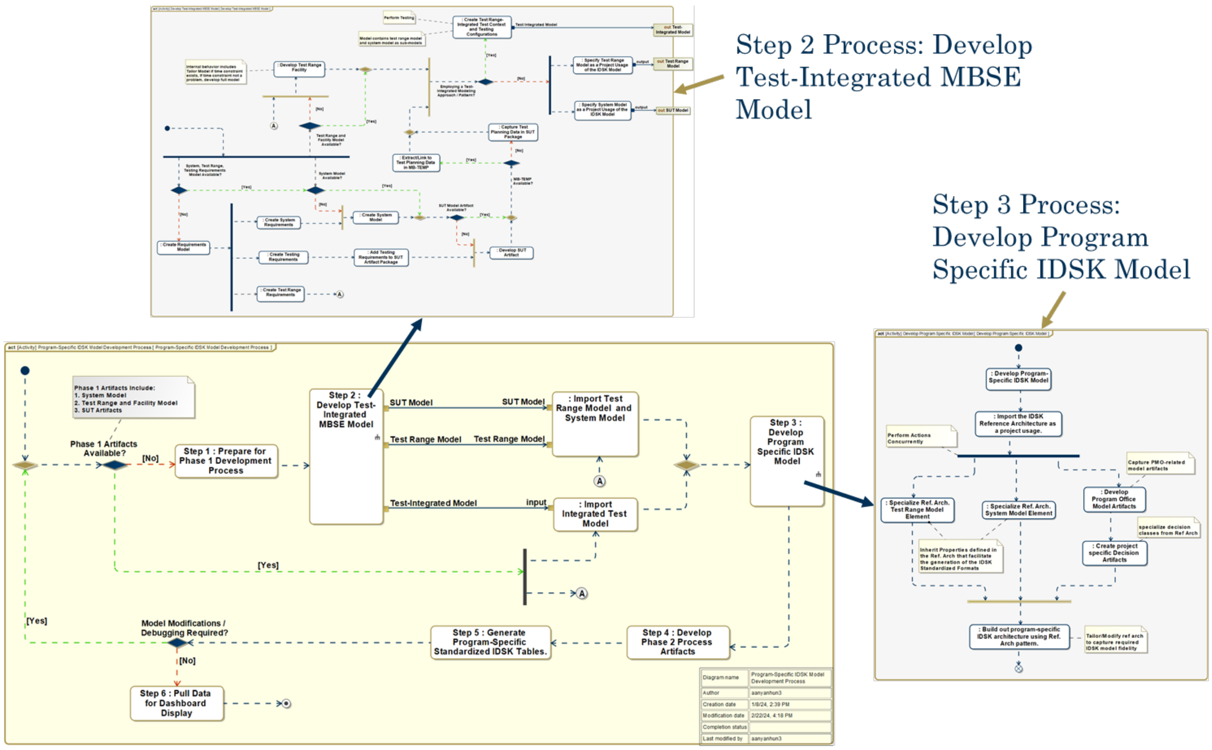


Figure 12. Program-Specific MB-IDSK Development Process

As depicted in Figure 12, the MB-IDSK development process is split into two phases with Phase 1 activities being the development of a program's digital (system) models—system model, requirements model, test model, and so forth. In the case of a program implementing MBSE, most Phase 1 artifacts may already exist, in which case the program IDSK lead need only focus on (1) developing the program-specific IDSK artifacts of Phase 1 and (2) Phase 2 activities, which include generating the standardized IDSK table views.

Figure 13-A describes the model package setup for a program-specific IDSK. As illustrated, the MB-IDSK utilizes data and artifacts from already existing digital (system) models as input for the IDSK. This approach prevents the duplication of data and modeling effort, as well as ensures the integrity and trustworthiness of the data on which decision-makers must depend for making decisions. Although a profile containing stereotypes and customization elements was created as part of the RA to extend the SysML, the use of the inheritance mechanism via the generalization/specialization relationship—shown in Figure 13-B—is the primary means by which concrete implementations realize the properties and relationships already specified in the RA.

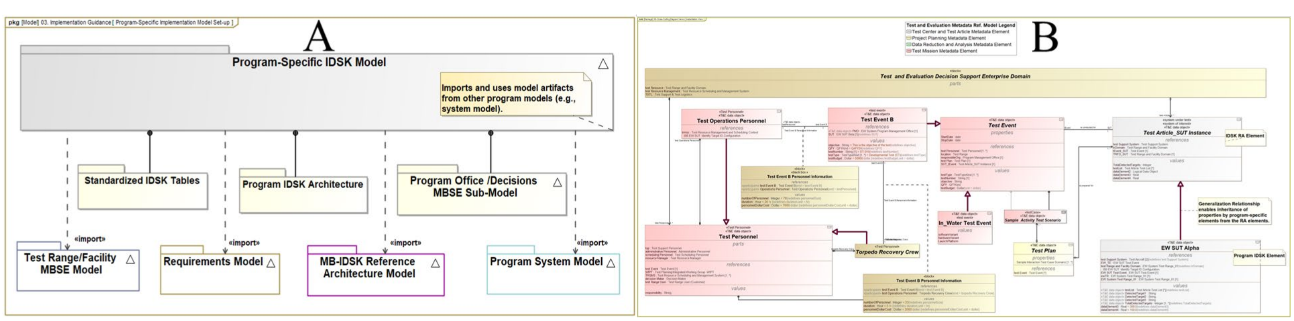
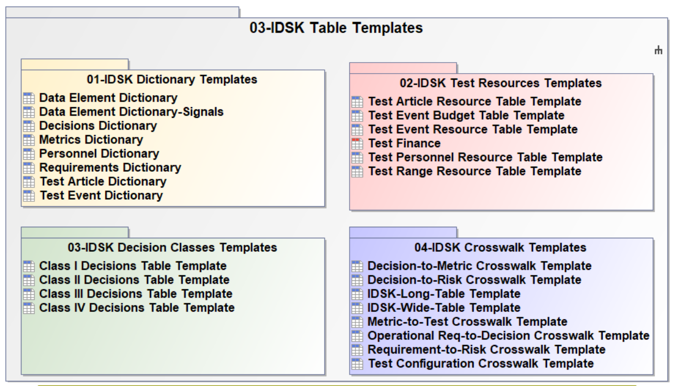


Figure 13-A. Program IDSK Model Setup & Figure 13-B. IDSK RA Instantiation View

Model artifacts developed to assist programs in developing the IDSK include a model library with sets of table templates and query mechanisms as shown in Figure 14-A and 14-B, an IDSK SysML profile, a conceptual and logical data model, a standardized set of tailorable and extendable key decisions (Class I, Critical Technical Requirements; Class II, Program Milestones/Technical Reviews; Class III, Sub-System Critical Performance and Technology Maturity; Class IV, Major Performance Characteristics; and Class V, Programmatic Decisions), and a format for collecting data about these decisions and other enabling resources that together help shorten the architecture development cycle time for program-specific implementations.



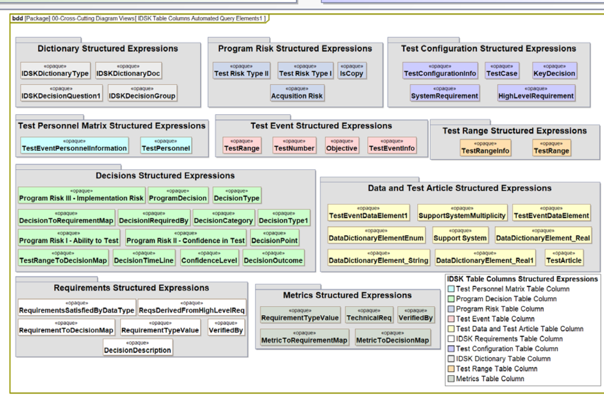


Figure 14-A. IDSK Table Templates & Figure 14-B. IDSK Library of Query Expressions

Exemplar Electronic Warfare System IDSK Architecture and Tables

The architecture view shown in Figure 15 portrays the IDSK decision support domain for an Electronic Warfare (EW) system program developed to support decision-making and test planning for a *Detect Target Id* Test Event. To generate the necessary IDSK standardized tables, the *generalization* relation is used between the more general RA elements and those shown in Figure 15. This modeling approach enables the elements of the EW System T&E Decision Support Domain to inherit and redefine properties and relationships already defined in the IDSK-RA.

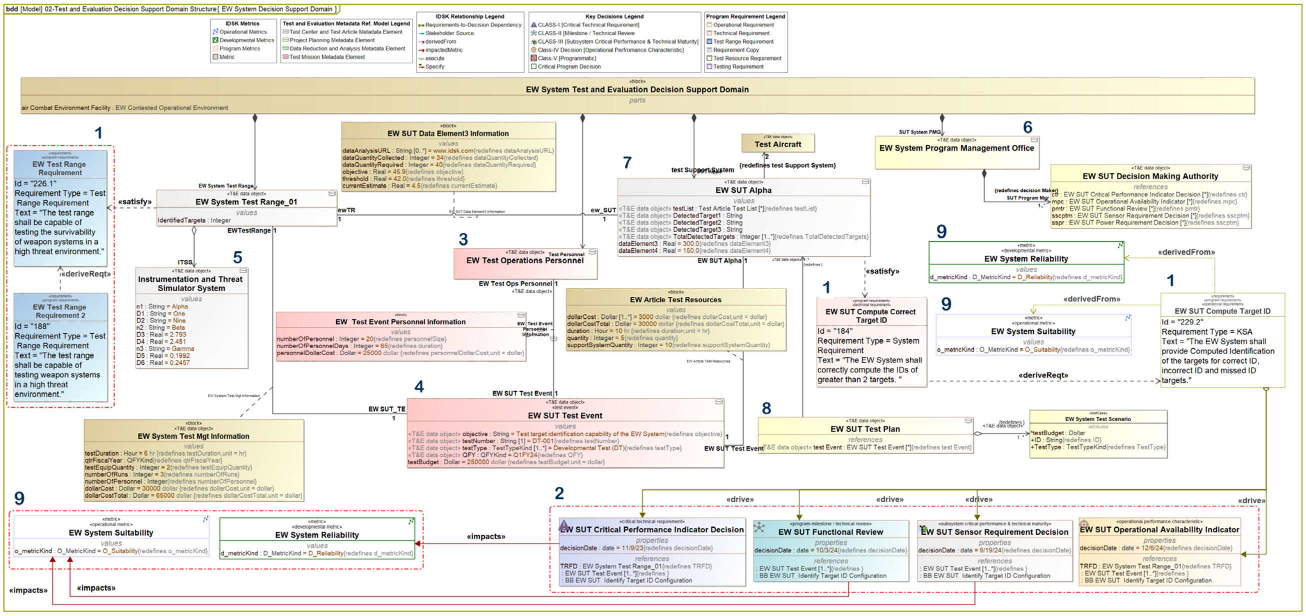


Figure 15. EW System T&E Decision Support Domain View

IDSK architecture elements defined for the EW system exemplar include (1) Requirements, (2) Decisions (Class I–IV), (3) Test Personnel, (4) Test Event, (5) Test Range Instrumentation, (6) Program Office (7), Test Article (EW System), (8) Test Plan, and (9) Metrics. To support the generation of decision support views from a model-based test execution and analysis context, an EW system *Detect Target Id* test context adapted from Arndt et al. (2023) was developed.

The test context was created and used to perform a simple black box test execution of two test case scenarios. Figure 16-A and Figure 16-B describes the testing configuration (1) consisting of the EW SUT, test range, test instrumentation, and test personnel respectively; (2) the SUT behavior modeled using an ACT diagram; and (3) and (4) two test cases executed per test run.

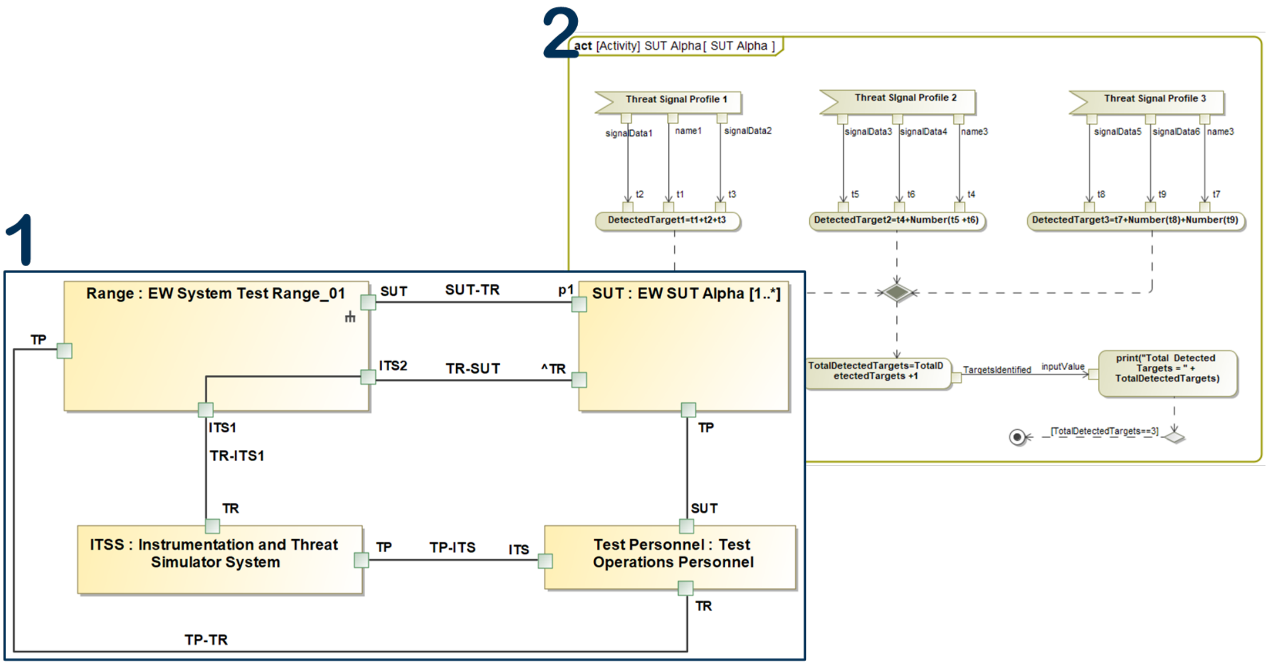


Figure 16-A. EW System Detect Target Id Test Configuration

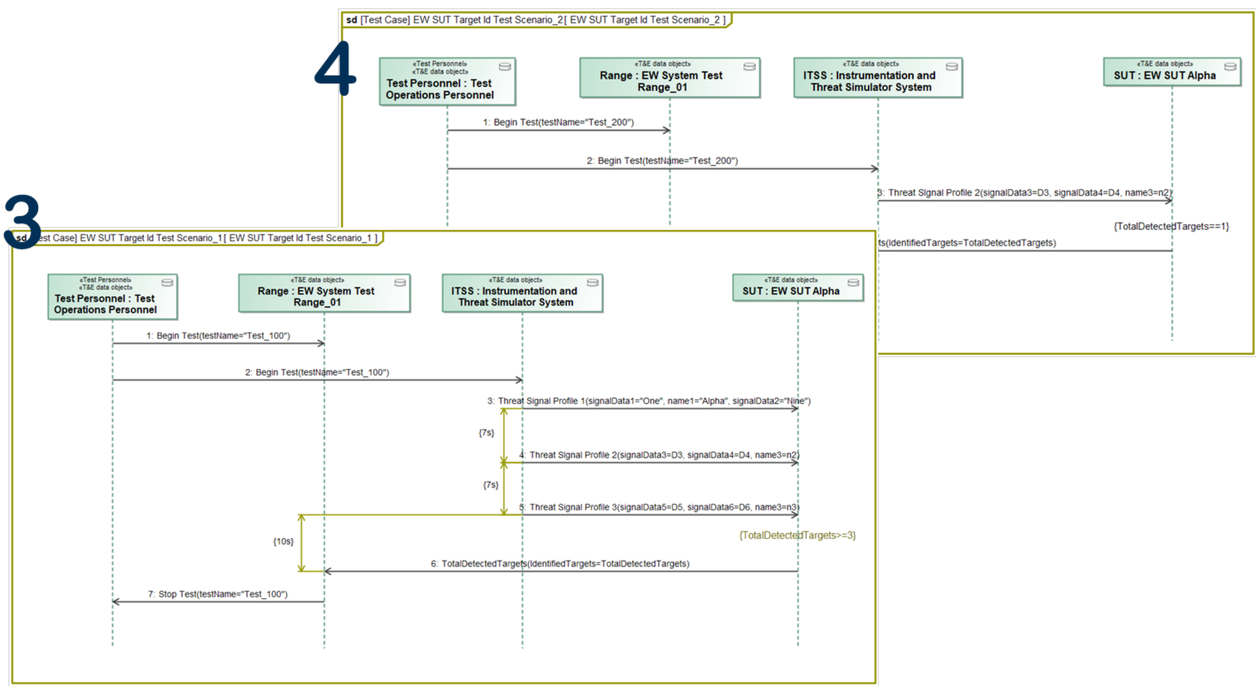


Figure 16-B. EW System Detect Target Id Test Scenarios

EW System *Detect Target Id Test* IDSK Tables. The IDSK data formats portrayed in Tables 10–15 are generated from the EW System IDSK model using the standardized decision and test planning templates created as part of the IDSK-RA library. IDSK decision views are portrayed in Tables 10–12. Table 13 portrays a Test Personnel Resource table, while Table 14 and Table 15 illustrate an exemplar IDSK wide table and a Test Configuration Crosswalk table respectively.

Table 10. Detect Target Id Class I Decision Crosswalk Table (Notional)

#	Name	Program Decision	Decision Type	Decision Category	Decision Outcome	Decision Date	Lifecycle Point	Confidence Level Required for Decision	Operational Requirement	Technical Requirement	Data Required	Data Source
1	EW SUT Critical Performance Indicator Decision	Decision question goes here	Critical Technical Requirement	CLASS I	Inconclusive	11/9/23	Milestone B	Unspecified	229.2 EW SUT Compute Target ID	184 EW SUT Compute Correct Target ID	Total Detected Targets	Test

Table 11. Detect Target Id Class II Decision Crosswalk Table (Notional)

#	Name	Program Decision	Decision Category	Decision Type	Confidence Level Required for Decision	Lifecycle Point	Decision Date	Decision Outcome	Operational Requirement	Technical Requirement	Data Source	Data Required
1	EW SUT Functional Review	DOES THE DESIGN MEET THE FUNCTIONAL REQUIREMENT NEEDS?	CLASS II	Milestone A - Technology Development and Risk Reduction	High Confidence (> 90%)	Critical Design Review	10/3/24	Pass Review	229.2 EW SUT Compute Target ID	184 EW SUT Compute Correct Target ID	Analysis	Data required goes here

Table 12. Detect Target Id Class IV Decision Crosswalk Table (Notional)

#	Name	Program Decision (Class IV)	Decision Category	Decision Type	Confidence Level Required for Decision	Lifecycle Point	Decision Date	Decision Outcome	Operational Requirement	Technical Requirement	Applicable Test Range	Test Data Required	Data Source
1	EW SUT Operational Availability Indicator	WILL THE SYSTEM MEET OPERATIONAL AVAILABILITY NEEDS?	CLASS IV	Operational Availability	High Confidence (> 90%)	Critical Design Review	12/6/24	Unspecified	229.2 EW SUT Compute Target ID	184 EW SUT Compute Correct Target ID	EW System Test Range_01	Data Required type goes here	Test

Table 13. Detect Target Id Test Personnel Resource Table (Notional)

#	Name	Test Personnel Type	Number of Test Personnel	Duration (Hours)	Personnel Dollar Cost
1	EW SUT Test Event	EW Test Operations Personnel	20	65	25000

Table 14. Detect Target Id IDSK Wide Table (Notional)

#	Name	Metrics	Operational Requirement	Data Element 3	Data Element 4
1	EW SUT Sensor Requirement Decision	EW System Suitability	229.2 EW SUT Compute Target ID	300.0	150.0

Table 15. Detect Target Id Test Configuration Crosswalk (Notional)

#	Name	TestResult1 : VerdictKind	TestResult2 : VerdictKind	SUT : EW SUT Alpha	SUT.TotalDetectedTargets : Integer	Test Personnel : Test Operations Personnel	Test Event_1.testType : TestTypeKind	Test Event_1. testNumber : String	D1 : EW SUT Critical Performance Indicator Decision	D3 : EW SUT Sensor Requirement Decision	Range : EW System Test Range_01
1	EW System Test	pass	fail	sut[1] : EW SUT Alpha sut[2] : EW SUT Alpha	3 1	: Test Operations Personnel	Developmental Test (DT)	1001	: EW SUT Critical Performance Indicator Decision	: EW SUT Sensor Requirement Decision	: EW System Test Range_01

Conclusion

The pivot to a digital engineering approach for IDSK development through the use of MBSE accelerates the delivery of data needed to inform acquisition and T&E decision-making. The MB-IDSK RA approach presented in this paper provides decision support in the form of standardized decisions and test planning data formats, to adequately equip decision-makers with data needed to inform critical decisions. As a decision support tool, the MB-IDSK RA pulls/aggregates data from other digital (system) models within a program's digital engineering ecosystem to equip decision-makers with timely pertinent data from trusted data sources required to make the best decisions. Primarily, the MB-IDSK RA is a lightweight RA created to foster flexibility and evolvability as its key quality attributes to ensure it is easily realizable, adaptable, and can guarantee its usefulness and practicality to program offices and the T&E enterprise. Moreover, the RA enables the development of tailorable program-specific architectures from which IDSK table views can be realized. Specifically, the table formats generated using the IDSK RA include tables that may be classified as either an IDSK Dictionary, IDSK Resource, IDSK Crosswalk, or IDSK Decisions table respectively. Additionally, a standardized set of program decisions and a format for collecting data about these decisions are developed as part of the IDSK RA. Consequently, the approach to decision support and test planning demonstrated in this work is a critical missing link in the race to deliver advanced systems to warfighters at the speed of need. Most importantly, it facilitates accelerated delivery of T&E data to decision-makers to inform decision-making.

Future Work

The adoption of MBSE by a wide range of DoD programs has led to a number of significant improvements in the acquisition development lifecycle. The development of the MB-IDSK RA is a great example of these improvements. Notwithstanding, although the

IDSK RA allows for the specification of complex relationships between decisions, data, testing, and a number of different program elements—for decision-makers—the complexity of an MB-IDSK could be a problem. An additional challenge within the existing DoD workforce is the apparent lack of MBSE modelers with the requisite skillset and expertise required to create, populate, and maintain an MB-IDSK. To make the different aspects of the complex multidimensional relationships easier for decision-makers to understand, additional work needs to be done in the development of visualization tools. Furthermore, organizations like program offices tasked with the responsibility to develop the MB-IDSK would benefit from simple data entry utilities that would enable programs and T&E personnel with little understanding of SysML models to simply populate the different parts of the MB-IDSK.

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