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NASA SIMULATION BASED ACQUISITION (SBA) GLOSSARY

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NASA Simulation Based Acquisition (SBA) Glossary

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1.0 Introduction

This document describes the definitions and concepts necessary for understanding the NASA Exploration Systems Mission Directorate (ESMD) Simulation Based Acquisition (SBA) goals and terminology. The ESMD strategy for SBA is described in the SBA Implementation Strategy[1] Document. An excerpt from the strategy document reads:

> **2.3. Functional Characteristics of the SBA Infrastructure**
>
> The SBA infrastructure provides the capabilities necessary to enable enterprise personnel to effectively do their jobs. Its functional characteristics include:
>
> - All information needed for product development activities, including analysis, modeling & simulation (AM&S)-based design and assessment is readily available from a user's desktop. This information is configuration managed, authoritative, coherent, and understandable.
> - A robust tool kit of validated analysis modeling and simulation capabilities is available in a timely manner to assist the professionals that must deal with the complexity of system acquisition. The tools assist in design (e.g., integrated architecture modeling, CAD, assembly planning), assessment (e.g., FEA, CFD, human factors, mission, cost), and management (e.g., workflow, risk assessment). These capabilities may be provided by individual analyses, models and simulations (operating separately or serially) or federations of simulations that operate together (executing in parallel). The simulations may be constructive (all software), virtual (human operators in simulated working environments), or live (humans and real system components operating in a simulated environment, in a lab or on a test range).
> - Other supporting software applications provide a means to collaborate, weigh measures (figures) of merit, make decisions and record decision rationales.
> - Efficient communication networks allow the rapid exchange of data among users, tools and data repositories.
> - Security mechanisms, including user identification and encryption, provide access control and prevent information exploitation or corruption.
> - Adequate computational power and human interface devices (e.g., displays) support the above

The descriptions above utilize several terms. Many of these terms have been defined within the engineering community, though not in an entirely consistent manner. The ESMD SBA Support Office (SBA SO) has developed expanded definitions to many of these terms to add

[1] ESMD SBA Office, "Simulation Based Acquisition Implementation Strategy", NASA ESMD-RQ-005, 2004

context and detail specific to the ESMD SBA implementation vision. These expansions are listed after each "common" definition in the following section.

2.0 Definitions

Tools

Generic term used to refer to the underlying computer codes used to construct Analysis Models and perform Assessments and Simulations.

ESMD SBA Types of Tools

- ***Engineering Analysis Tool**:* A discipline-specific computer code that predicts the performance, cost, risk or other discipline specific attribute of a sub-system, system, architecture.

Models

According to the Defense Modeling and Simulation Office (DMSO) glossary of terms, a ***Model*** is "A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process." [2, item 331] The Modeling and Simulation Information Analysis Center (MSIAC) further expands on this definition: "There is no movement in a *model*. Think of a plastic replica of an airplane or a car, or a mathematical equation that predicts the probability of an event occurring. These are examples of *models*."[3]

In the context of ESMD, a *model* is further defined as producing a single set of outputs for a single set of inputs. This definition includes the situation where the *model* in question is operated in the context of optimization or stochastic analysis. Thus, the inputs and outputs may be deterministic (single-valued) as well as stochastic. *Models* may be "driven" by utilities for trade space exploration, sensitivity analysis or by engineering simulations. Driving a *Model* means to vary its inputs in order to obtain a set of results that encompass a range of expected situations. "Driving a model" is equivalent to "simulating", and the result is a simulation.

ESMD SBA Types of Models:

2 Defense Modeling and Simulation Office Terms and Definitions https://www.dmso.mil/public/library/policy/guidance/p500059m.pdf

3 Modeling and Simulation Resource Center Modeling and Simulation Primer http://www.education.dmso.mil/ ms_primer.asp?a=s4&b=view&c1=272

- ***Analysis models****:* An *Analysis Model* is a set of one or more *engineering analysis tools* that operate in conjunction with one another. *Analysis models* may be capable of automated execution or may require user-in-the-loop/interactive operation. The *models* typically estimate system performance according to an engineering discipline such as aerodynamics or cost. However, because a *model* may involve more than one discipline *engineering analysis tool* the complete *model* may yield attributes across multiple disciplines. Creating such multi-tool *models* is particularly helpful when multiple disciplines within a system strongly interact with each other. The fidelity level of analysis *model* results may be very low (conceptual level) or may be very high (detailed design level).
- ***Part models****:* A *Part Model* describes a function-performing component or system. In its most fundamental form, a *part model* describes the geometry of the part, component or system in question. Early in the design process, a *part model* may be a crudely defined vehicle sub-system. As concept development progresses, fidelity is added in the form of information regarding the characteristics and performance of the part. The difference between a *Part Model* and an *Analysis Model* is that a *Part Model* tracks all discipline parameters that are relevant to a particular part/component, while an *Analysis Model* can be executed to determine the performance of several components for a particular discipline or group of disciplines.
- ***Architecture models****:* The combination and coupling of *Analysis Models* and *Part Models* results in one form of an *Architecture Model*. It not only defines the complete physical and functional configuration, but it also defines composite performance and characteristics of the system or architecture. An *architecture model* contains *analysis models* that are used to assess performance parameters. It can be thought of as everything that can be driven, visualized and observed in a large-scale system simulation. A second form of *Architecture Model* is a high-level, functional description of a system that may at a later date consist of *Part* and *Analysis Models*.

Simulations

The DMSO glossary defines a ***simulation*** as: "A method for implementing a model over time."[2, item 462] The MSIAC expands: "It shows how the model works. It is a technique used for testing, analysis, or training, where a model can represent "real world" systems or concepts. A *simulation* moves. You can see the *model*(s) in the *simulation* moving—whether it shows military units moving across a battlefield or engine parts moving in a simulated car engine."[3]

The purpose of a *simulation* is to exercise a *Model* or set of *Models* according to an input set that either expresses an operational range of interest or an anticipated operational scenario.

ESMD SBA Types of Simulations:

- ***Engineering Simulations****: Engineering Simulations* expose *Analysis* and *Part Models* to a set of sequential inputs in order to characterize the performance of a concept. These *simulations* may or may not incorporate time as an independent variable. They encompass sensitivity analysis, trade space exploration and performance envelope characterization.
- ***Mission Segment Simulation****:* A *Mission Segment Simulation* varies the inputs to *Analysis* and *Part Models* in accordance with an anticipated portion of the concept mission. Time is the independent variable in a ***Mission Segment Simulation***. *Mission Segment Simulations* incorporate as many *Analysis* and *Part Models* as is needed to predict the total performance of a concept during a segment of the anticipated mission. These ***models*** are exposed to input sets that represent events as a function of time.
- ***Large-scale System Simulations****:* A *Large-scale System Simulation* predicts the performance of multiple concept entities during multiple mission segments. This type of *simulation* predicts interactions between concept entities and their environment by incorporating the concept elements as well as external elements.
- ***Vehicle motion/flight simulations****:* A *vehicle motion simulation* couples a *large-scale simulation* to physical hardware. This typically consists of vehicle and facility interiors with flight controls, access points and sensory cues. These simulations are used to characterize the interaction between human operators and the concept in question.

Ontology

An ***Ontology*** is an expression of entities and the relationships among those entities in order to communicate a concept. It is more general than a hierarchy because it is not limited to a strict tree structure. An *ontology* describes an identifiable set of data classes and the influence of each class on one other. An *ontology* differs from a schema in that an ontology defines the nature of relationships amongst data.

Schemas

The DMSO glossary defines a ***schema*** as: “Descriptive representation of data and/or data requirements that describe conceptual, internal, or external views of information/data needs."[2, item 449]

Environments

The DMSO glossary defines an ***environment*** as: "The texture or detail of the natural domain, that is terrain relief, weather, day, night, terrain cultural features (such as cities or farmland), sea states, etc.; and the external objects, conditions, and processes that influence the behavior of a system (such as terrain relief, weather, day/night, terrain cultural features, etc.)."[2, item 182]

An *environment* extends beyond the physical world. The ESMD SBA SO extends the definition of an *environment* to include anything that influences an activity or concept that is not considered part of that activity or concept.

ESMD SBA Environments:

- ***Engineering environments****:* *Engineering environments* provide the computer hardware and software systems that support *Model*, *Tool*, and *Simulation* execution. They provide the framework for coherent data transfer between the *models* and *simulations* in the *environment*. They also serve to capture and archive all relevant analysis data and meta-data. The *environment* manages the data exchanges and processes between disciplines and mission segments as well as archiving all the generated information.
- ***Data Presentation, Visualization and Animation Environments****:* These *environments* provide representations of *model* and *simulation* results. Variations in the coupling of these *environments* to *Engineering Environments* enable functionality that ranges from report-centric post-processing to real-time animation.
- ***Physical environments****:* *Physical environments* are the tangible *environments* that the vehicle architecture will be subject to during the segments of the mission.

Systems

The DMSO glossary defines a *system* as: "A collection of components organized to accomplish a specific function or set of functions."[2, item 501] The ESMD SBA SO considers all architecture members as part of the system. This includes ground components and facilities in addition to the flight hardware.

Architectures

The DMSO glossary defines an *architecture* as: "The structure of components in a program/system, their interrelationships, and the principles and guidelines governing their design and evolution over time."[2, item 26] The NASA SBA Office expands on this by defining two types of architecture:

- ***Development Architecture****:* The Development Architecture is the "factory" and processes that result in the Product Architecture. The Development Architecture is the organizations, activities, systems, interactions and standards that comprise the development environment in which a desired end item (e.g., space exploration system) is produced.
- ***Product Architecture****:* The Product Architecture is the system of systems that satisfies the requirements and strategy of the ESMD. This includes flight hardware, ground systems, operations and infrastructure.

Processes

The DMSO glossary defines a ***process*** as: "Processes affect entities. Attrition, communications, and movement are examples of processes. Processes have a level of detail by which they are described."[2, item 401]

ESMD SBA Types of Processes:

- ***Engineering Assessment Processes****:* An *Engineering Assessment Process* is the execution of one or more *Analysis Models* or *Simulations* and the reporting of the resulting data into an *engineering environment*. *Engineering Assessment processes* dictate an ordered execution of *Analysis Models* and *Simulations*. An *engineering assessment process* may involve the series or parallel execution of multiple *Analysis Models* and *Simulations*. There are three sub-categories of these assessment processes:
    - ***Architecture assessment processes****:* *Architecture assessment processes* perform a comprehensive evaluation of the figures of merit for an architecture.
    - ***Technology assessment processes****:* *Technology assessment processes* perform a comprehensive evaluation of the figures of merit for a particular technology (or suite of technologies) when applied to an architecture.
    - ***Configuration*** *or* ***component assessment processes****:* A *configuration or component assessment process* assesses a single discipline or sub-system.

Measures of (e.g. Effectiveness)

The DMSO glossary defines a ***measure of effectiveness*** as: "A qualitative or quantitative measure of the performance of a *model* or *simulation* or a characteristic that indicates the degree to which it performs the task or meets an operational objective or requirement under specified conditions."[2, item 318]

It should be noted that *Tools*, *Models*, *Simulations* and *Processes* can be aggregated into groups and assembled into hierarchies. That is, several *Models* may be aggregated to form a new *Model*. Several *Processes* may be aggregated to form a new *Process.*