Massachusetts Institute of Technology

Model-Based Systems Engineering: Documentation and Analysis

Glossary

Automation bias occurs when human operators in partially-automated systems rely excessively on automated solutions or processes without adequate monitoring and verification.

Black box model is a model that can only be viewed in terms of its inputs and outputs (or transfer characteristics), without any knowledge of its internal workings. Its implementation details are "opaque" (black) for the user.

The **change management process** in systems engineering is the process of requesting, planning, implementing, and evaluating changes to a system while supporting the processing and traceability of changes.

Cyber-physical gaps are the difference between what is happening in real life and what people get as input from systems, or what people perceive is happening in the real world.

A **database query** is a request for information from a database through one of the following three general methods:

- Choosing parameters from a menu: In this method, you choose the parameters from a list which the database system presents. This is perhaps the easiest but the least flexible method.
- Query by example (QBE): In this method, you specify the fields and values that define the query in the blank record presented by database system.
- Query language: In this method, you request information in the form of a stylized query that must be written in a special query language. This is the most complex but also the most powerful method.

A **data model** organizes elements of data and standardizes how data is connected to each other and how they are processed and stored inside the system.

Design decision is any decision that has an impact on the design or outcome of the end system is a design decision.

Design Structure Matrix (DSM) is a simple, compact representation of a system or project in the form of a square matrix. It is the equivalent of an adjacency matrix in graph theory and is used in systems engineering and project management to model the structure of complex systems or processes.

The Design Vector is a Nx1 matrix, where each component N represents degree of freedom in the system.

Empirical models are defined by mathematical equations generated by doing a regression analysis on empirical data that we have about the system. These mathematical equations, unlike the governing equations, only explain a system under certain conditions -- the ones for which we have data -- and cannot be used to reliably predict the general behavior of the system.

Failure mode and effects analysis (FMEA) is a structured and systematic technique of failure analysis. It helps identify potential failure modes based on experience with similar products and processes—or based on common physics of failure logic. This information can then be used to develop a V&V plan for testing these failure modes.

An **interface control document (ICD)** in systems engineering describes the interface or interfaces between the systems under consideration. The purpose of the ICD is to communicate all possible inputs to and all potential outputs from a system for some potential or actual user of the system.

In numerical optimization, **Lagrange multipliers** is a method to maximize or minimize functions subject to given equality constraint(s).

An **MBSE critique** is a critical review and assessment of the whole model with a defined rationale.

A **mode error** is an error where a user mistakes the situation or mode they believe the program or machine to be in and takes an action appropriate for the perceived mode, but inappropriate in the real mode. For example, editing what is believed to be a test version of the code, when in fact, the edits are making changes to published code.

Model is a mathematical construct/representation of a system that has the ability to predict the emergence of the system under some specified operating conditions.

Model-Based Engineering (MBE) is an approach to engineering that uses models as an integral part of the technical baseline that includes the requirements, analysis, design, implementation, and verification of a capability, system, and/or product throughout the acquisition life cycle. (Final Report, Model-Based Engineering Subcommittee, NDIA, Feb. 2011)

Model-Based Systems Engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. (INCOSE SE Vision 2020, INCOSE-TP 2004-004-02, Sep 2007)

Model benchmark is the process of validating against the predicted model response such as another validated model or experimental data.

Model credibility is the amount of trust that people have in the model's output to make decisions based upon it.

Model Development Process (MDP) is a rigorous step-by-step method to create a model that is ready for use.

Model fidelity is the quality of the model's output, i.e. the degree to which the model acts as a sufficient representation of the real-world system it is based on.

Model V&V is a process conducted during the development of a model with the ultimate goal of producing an accurate and credible model. It is a very important step, as generally models are approximate imitations of real-world systems. Due to this, a model should be verified and validated to the degree needed for the model's intended purpose or application.

A **model curator** is a leadership role within an organization who helps organize and classify models. He or she also helps teams pick the right models to help them achieve their end goals and helps set up model configuration related processes for the particular project. Model curators are the go-to people for any modeling-related questions and concerns within the organization.

A **model owner** is the single point of reference for making decisions for the model. Typically the model owner is the one who understands the cost of building and configuring the model and also has authority to change the model.

In a model, a **module** can be defined as a finite group of tightly coupled mathematical relationships that are under the responsibility of a particular individual or organization.

Monte Carlo methods are a class of numerical methods that relies on generating suitable random numbers.

Multidisciplinary design optimization (MDO) is a field of engineering that incorporates a number of disciplines while solving optimization design problems. MDO allows designers to incorporate the relevant disciplines simultaneously which can result in a superior design as compared to optimizing each discipline sequentially.

Nominal model covers the basic outcomes from the system without going into detail about the contingencies and emergency conditions.

The **Objective Vector** is a Nx1 matrix, where each component N represents an output of the model.

Pareto frontier is the set of non-dominated architectures within the tradespace analysis.

Physics-based models are defined by governing equations that have been proven to explain the dynamics of certain systems. The models could be discretized, continuous, or transient.

Requirement traceability is a discipline concerned with documenting the requirement and providing bi-directional traceability between various associated requirements through the life of the product.

Sensitivity is a measure of the impact on metrics caused by a given decision.

Simulation is a process that instantiates a model under a given set of operating conditions for prediction of future behavior.

Statistical process control (SPC) is a statistical quality control method applied in order to monitor and control a process. SPC can be applied to any process where the "conforming product" (product meeting specifications) output can be measured. Key tools used in SPC include control charts; a focus on continuous improvement; and the design of experiments. An example of a process where SPC is applied is manufacturing lines.

A **system** is a set of entities and their relationships, whose functionality is greater than the sum of individual entities.

Tradespace is a representation of the outputs of a design model that looks like a two (or more) dimensional plot. The axes of the plot are metrics of interest, such as "performance" and "cost". The points in a tradespace represent potential designs.

The **utopia** point is an instance within the tradespace where all analyzed metrics are maximized.

The **"V" Model** is a graphical representation of the systems development life cycle. It summarizes the main steps to be taken in conjunction with the corresponding deliverables within the system validation framework.

Validation is the assurance that a product, service, or system meets the needs of the customer and other identified stakeholders. It often involves acceptance and suitability with external customers.

Verification is the evaluation of whether or not a product, service, or system complies with a regulation, requirement, specification, or imposed condition. It is often an internal process.

Verification and Validation (V&V) are independent procedures that are used together for checking that a product, service, or system meets requirements and specifications, and that it fulfills its intended purpose.

White box model is a model where in addition to the inputs and outputs, the inner components or logic can be viewed but usually cannot be altered. These are the opposite of black box models and are sometimes known as "clear box" or "glass box".