Fundamental Enablers

As with traditional Systems Engineering, MBSE requires some fundamental enablers to ensure successful implementation:

Process

MBSE requires an appropriate process. This should complement an organisations existing Systems Engineering process rather than being a substitute for it. The model is not a goal in itself, but a resource used in existing Systems Engineering activities. Standard processes include:

- INCOSE: Object-Oriented Systems Engineering Methodology (OOSEM)
- IBM: Telelogic Harmony Systems Engineering
- IBM: Rational Unified Process for Systems Engineering (RUP-SE)
- Vitech: Model-Based Systems Engineering Methodology
- Weilkiens: Systems Modelling Process (SYSMOD)

Tools

As a model is not merely a collection of representations but an integrated repository of project knowledge, one or more tools are typically required. These tools must not only provide the necessary capability in terms of language support but should also integrate with each other to ensure completeness, correctness and consistency across the project.

Standard Techniques and Representations

MBSE is most effective when standard techniques and representations are employed. The use of standards improves consistency and facilitates interoperability of tools, people and process.

People

Ensuring the appropriate capabilities in modelling languages and tools does not have to be limited to project personnel. MBSE provides the maximum benefit when no translation of the model is required for the stakeholders. Where necessary, training and support must be provided.

Common Misconceptions

It is about SysML

A representation should use the most appropriate notation. SysML is a very powerful modelling language, however other languages also exist and should be chosen on their individual merits.

It is just about drawing

A representation (whether graphical, textual or other) should be connected to the underlying model in order to realise the maximum benefits of MBSE (correctness, completeness, consistency etc.). This implies the tools used must have the appropriate capabilities.

It is just about simulation

A representation can be either static or dynamic (simulation), descriptive or predictive, all of which are useful.

It is just one of the Systems Engineering activities required on a project

MBSE is an integrated approach to Systems Engineering in which all activities should reference the model in order to realise the maximum benefits.

This leaflet is intended as a brief introduction to the Model-Based Systems Engineering approach.

For further information, advice and links to helpful websites go to: www.incoseuk.org where you can download copies of this leaflet and other Systems Engineering resources.

For more information about the worldwide Systems Engineering professional community, go to www.incose.org

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What is Model-Based Systems Engineering?

MBSE is an approach to Systems Engineering and it is therefore recommended that the reader is familiar with the contents of Z1 "What is Systems Engineering?" before reading this guide.

MBSE is

The formalised application of modelling to support:

- System requirements
- Analysis
- Design
- Verification & Validation

Beginning in the conceptual design phase and continuing throughout development and later lifecycle phases.

(INCOSE)

A complementary definition focusing on the nature of the model is:

"An approach to realising successful systems that is driven by a model that comprises a coherent and consistent set of representations that reflect multiple viewpoints of the system".

(Holt & Perry – SysML for Systems Engineers)

MBSE Concepts

Model
An abstraction of a system of interest constructed from one or more representations. The model is the total recorded knowledge of the project i.e. a single point of reference. Ideally it will be in one place but in practice may be distributed across multiple tools or repositories.

System of Interest
The subject of the Systems Engineering endeavour. It may cover any or all of: the problem (environment), project (people and processes) and solution spaces.

Representation
A partial description of the system of interest (sometimes called a view). It may be a diagram, text, a table, or some other layout using one or more of: graphical language (e.g. SysML), mathematics, natural language (e.g. English) or another notation as appropriate. Representations reflect a particular viewpoint and may be static or dynamic (i.e. simulations), the latter used to predict system behaviour.

Viewpoint
The purpose of one or more representations. A viewpoint helps to manage complexity by addressing only those aspects relevant to associated concerns. Different viewpoints are used to separate problem analysis from solution specification or structural descriptions from behavioural descriptions etc.

Quality Criterion
A measure of some aspect of the model used to determine if it is fit for purpose at a particular point in the lifecycle. Examples include: correctness, completeness and consistency.

Concern
Something a stakeholder wishes to know or ensure about the system of interest. Each concern is addressed by one or more viewpoints.

Stakeholder
A person or group that has one or more concerns with the system of interest.

MBSE Concepts notated in SysML

Figure 1 is a different representation of the MBSE concepts described above using the SysML modelling language.

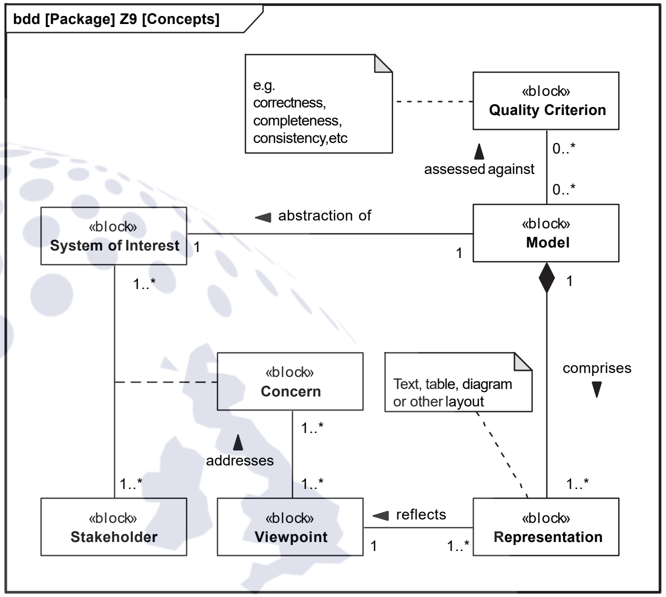

Figure 1 MBSE Concepts

Benefits of using MBSE

Traditional (sometimes called document-centric) Systems Engineering results in the creation of a set of stand-alone documents. Their loosely connected nature and sometimes overlapping content makes it difficult to assess the entire set against any defined quality criteria since it is reliant on manual inspection and management.

MBSE uses a single point of reference (the model) to which the quality criteria can be applied. The connected nature of the model means it is possible to automatically query or verify it in ways too complex or otherwise impractical by manual inspection. The result is an abstraction of the system of interest which is of higher quality and more insightful. The benefits include:

Reduced risk
- Improved cost estimates
- Early and on-going requirements validation through inspection, and design verification through the use of simulation and automatic verification
- Improved systems assurance
- Fewer errors during integration and testing

Improved communication
- With project stakeholders
- Between engineering disciplines
- Across spoken language barriers

Improved quality
- Improved requirements specification and allocation to subsystems
- Early identification of requirements issues
- More rigorous requirements traceability
- Enhanced system design integrity
- Consistent documentation, both within and across projects

Increased productivity
- Improved impact analysis of requirements / design changes
- Improved interaction across a multi-discipline team
- Reuse of existing models to support design and technology evolution
- Automated generation of documentation
- Common definitions means changes are made in fewer places