Massachusetts Institute of Technology

Model-Based Systems Engineering: Documentation and Analysis

Week 1: What Is MBSE?

Project

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Instructions

Before you begin, you should save your project on your local drive. We recommend the following format:

Lastname_Firstname_Course3_Week1

Please note: You will not be able to re-download your file after submission; therefore, please keep this file in a central location for future reference.

The work in the project deliverable is **individual**.

After you submit your project, you will self-assess your work. If you have any questions, feel free to contact a TA in the Discussion Forum.

Although work is strictly individual, sharing ideas and concepts with other students is encouraged.

Note: edX has a 10MB file size limit for document submission. If you have selected large image(s), you may need to resize before submitting, OR you may simply include a web URL for the image in the image location. Be sure to submit your assignment at least one hour before the deadline to provide time for troubleshooting.

Once the deadline passes, you will not be able to upload the document and therefore will not be able to submit and complete the assignment.

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Week 1 Project

Overview

Choose a system on which you will propose an MBSE approach. This system can be anything you want, although it will likely be more useful for you to choose something from your work. Please ensure that the system has at least a medium or high level of complexity -- such as a car, satellite, enterprise server, or open-source software.

If you are working in a team, one person in the group needs to be a domain expert for the model that the group selects.

After you have chosen a system, answer the questions in the following slides.

REQUIRED STEPS

Step 1: Choose system and define scope

Step 2: Define MBSE approach

Step 3: Define MBSE purpose

Step 4: List major tenets of MBSE

Step 5: Identify the most important qualities of great models

Step 6: Identify systems engineering tasks

Step 7: Submit and self-assess your project

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Step 1: Choose System and Define Scope

What is your system? What is in scope for the MBSE effort for your chosen system?

System: Electronic Power Assist Steering (EPAS) System

The EPAS systems is a complex electro-mechanical device whose main function is to minimize driver efforts when steering a vehicle. The system measures the torque input on the steering wheel and provides assistance to the driver by using a motor. With the use of an electronic control unit (ECU) it is also possible to have additional features that help in the driving experience. The system should also meet other functions such as provide road feedback, deliver diagnostics in case of faults, and be robust enough to environmental conditions.

For this project MBSE should help manage the development of the system throughout its life cycle and provide a common language in which other teams (e.g., suspension, vehicle electronics, and brakes teams) can clearly understand the interfaces to the EPAS system.

In terms of the scope the Steering Systems Team aims to model the mechanical structural components, the electronic components, the main software that produces assist, and high-level interactions to other teams. What is not in the scope of the model are outside chassis components or any additional software features.

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Step 2: Define MBSE Approach

How would the approach to this project change with MBSE?

The Ground-up Approach would be used in this project. This is because currently there are no available models for the EPAS system.

Currently, the existing approach is to separate the steering group into mechanical, electrical, and software teams. Each team work on creating documents to propose requirements that will address the main steering design. For example, the mechanical team will create requirements to meet loads, durability, and geometry of the system. On the other hand, the software team creates requirements to meet the controllability of the vehicle at different speed. This process happens with some interaction between teams but it is very difficult to understand where common faults might happen or how requirements should be cascaded among teams. The MBSE approach aims to address the issue of change propagation and help in the creation of requirements because there would be a common repository of information.

Using MBSE can also avoid having to create several documents when describing different aspects of the system. In the existing approach, each team develops their own documentation and there is always issues with version control. MBSE would reduce the amount of work teams needs to do when developing these documents and by extracting the information from the source, there won't be an issue with version control.

Finally, the MBSE approach can provide flexibility during integration with other features. Many software features are already modeled and with a modeling approach it would be easy to drop/remove features for upcoming projects.

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Step 3: Define MBSE Purpose

What are the purposes of your MBSE effort? Describe the financial and non-financial benefits you expect.

The high-level purpose of having a MBSE approach is to manage the complexity of the system. However, there are many additional benefits to this:

Enhance Communication: By using a single source of information, all teams will have an easier time communicating requirements, design actions or even failure modes of the system. For example, models can be use between electrical and software teams when discussing about the right hardware. This is a non-financial benefit that can help the organization to be more efficient.

Improves Productivity: MBSE can help in the development of documentation and reports. This can allow all teams to concentrate in improving the fidelity and/or optimize the model. Similarly, by using models the teams can quickly and efficiently find discrepancies between various parts of the design. This is a non-financial benefit that can be easily translated in something financial by freeing up valuable resources and automating portions of the design process.

Improves Quality: Using MBSE can help in the detection of inconsistencies and contradictions. Catching these early in the life cycle is critical to avoid warranties or recalls in the long run. For example, it is important to have consistency between the structural geometry and the motor of the system. This is a financial benefit since the organization can save in warranty or recall costs

Facilitates Reusability: By implementing a MBSE approach, future projects can benefit by having a good starting point. The idea would be to have modular models that can be implemented in future system designs. This is a financial benefit since the organization can leverage previous designs and models and avoid incremental costs.

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Step 4: List Major Tenets of MBSE

Describe how will you model the system. Briefly describe your approach to each of the major tenets of MBSE.

Central Model: A central model will provide all members of the steering team a one-stop shop for information. That way, the mechanical, electrical, and software designs are always clear and consistent. A good example would be the interaction between the electrical and mechanical hardware, so that teams fully understand the intended design.

Model Views: This will allow the teams to extract their required information without having to dig through several repositories. For instance, the mechanical team will have their CAD available while the electrical team will have their schematics ready to process.

Model Repository or Library: As stated previously, a modular approach would help the organization in the design of future steering systems. An example would be the software, which can be set up as a library to be reused with other mechanical or electrical devices. Similarly, the mechanical system will contain the required dynamics to produce a good steering feel which can be parametrized for future uses.

Standards and Patterns: In the automotive industry there are a lot of standards that need to be followed. By using a MBSE approach, these standards can be implemented and checked easily. Similarly, patterns can be created to fill in mechanical and electrical aspects such as loads, maximum voltage/current, geometry, etc.

Model Checking: The model will be set up to check for consistency, completeness, and to avoid contradictions. For instance, The model can verify that the system meets the mechanical constraints for loads and weight or that the software is meeting all use cases.

Ontology: This is used to maintain a level of definitions and terminologies common to all teams. For instance, when discussing the mechanical design, the teams will refer to the subsystems (ECU, Rack & Pinion, Sensors) or at a lower level, the teams can refer to components (motor, bushings, seals, micro-controller). Together the ontology defines the entire steering system concept.

MBSE Methodology: Using Object-Oriented Methodology with SysML the teams can form a top-down approach of their subsystems while maintaining a good level of integration to the overall system. This methodology will provide the team the ability to support their specifications, analysis, and design verification.

Step 5: Identify the Most Important Qualities of Great Models

Reflect on the qualities of great models – what are the top three you are concerned about for your MBSE approach?

Usability – Understandable & Well Organized
One of the main concerns is making sure that the models implemented are understandable and that the organization of the models is actually implemented. The concerns is probably the fear of using a new methodology but with proper training and exercises the teams can understand the importance of the models.

Implementation – Elegant
One of the main concerns is to find the "perfect" model. The teams will have to balance how complete the model can be and trying to model every single aspect of the system. Since this is the first time implementing an MBSE approach, it would be beneficial to have an external contractor to guide the teams through the process. The goal of the MBSE approach would be to have an economy of description which can also be modularized to provide a good template for future projects.

Decisions – Linked to Decision Support
Another major concern is the use of the model to support the decision making processes. Since most engineers in the various teams are used to using other tools and methods as part of their decision making process, it can be difficult to understand the value of models for such tasks. This goes hand in hand with the consistency of the models and the use of self-checking tools. The way to address this concern would be to show, during training exercises, how models can provide a good trade off between different design parameters.

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Step 6: Identify Systems Engineering Tasks

Systems engineering has a variety of different tasks depending upon its role in the organization such as interface management, change management, facilitate information transfer. Which of these or other tasks in your view are applicable to your chosen MBSE strategy?

Systems Engineers in the project will have several tasks at hand:

Facilitate Collaboration
One of the main tasks of Systems Engineering is to understand the major interfaces from/to the system and facilitate collaboration between the external interfaces and the internal components of the system. The models and the different views or representations will serve to facilitate that communication to the external teams and if necessary management. Similarly, Systems Engineering requires the full and complete understanding of the entirety of the model to provide an objective view to all members of the steering team.

Employ Analysis
A really important task of Systems Engineering is to employ the use of analysis for the design of the system. It does this by having a good abstraction of the model, meaning that each model is consistent and relevant for its application; and also by having a good layer of automation. The automation can help team members understand the input/output relationships of the entire model and how changes on their particular component or subsystem affects the complete design of the EPAS system.

Manage Changes
Finally, one of the most important tasks of System Engineering is to manage changes, not only changes to the model, but also to the underlying documentation that arises from such models. By managing changes at both levels it is easy to transfer information among teams and to ensure that all teams are working on the latest version of the model, something very helpful to avoid delays and inconsistencies.

Step 7: Submit and Self-Assess Your Project

- Submit your completed Week 1 Project file
  - Note: The maximum file size that can be submitted is 10MB.

- Assess your completed Week 1 Project
  - A scoring rubric can be downloaded from the Project Instructions page.