

Homework 4

This is an individual student assignment. Due date: End of the lab session, October 18.

Visual Modeling with SysML

In this homework we will explore the use of SysML as a means of representing requirements, constraints, and models of system behavior and structure.

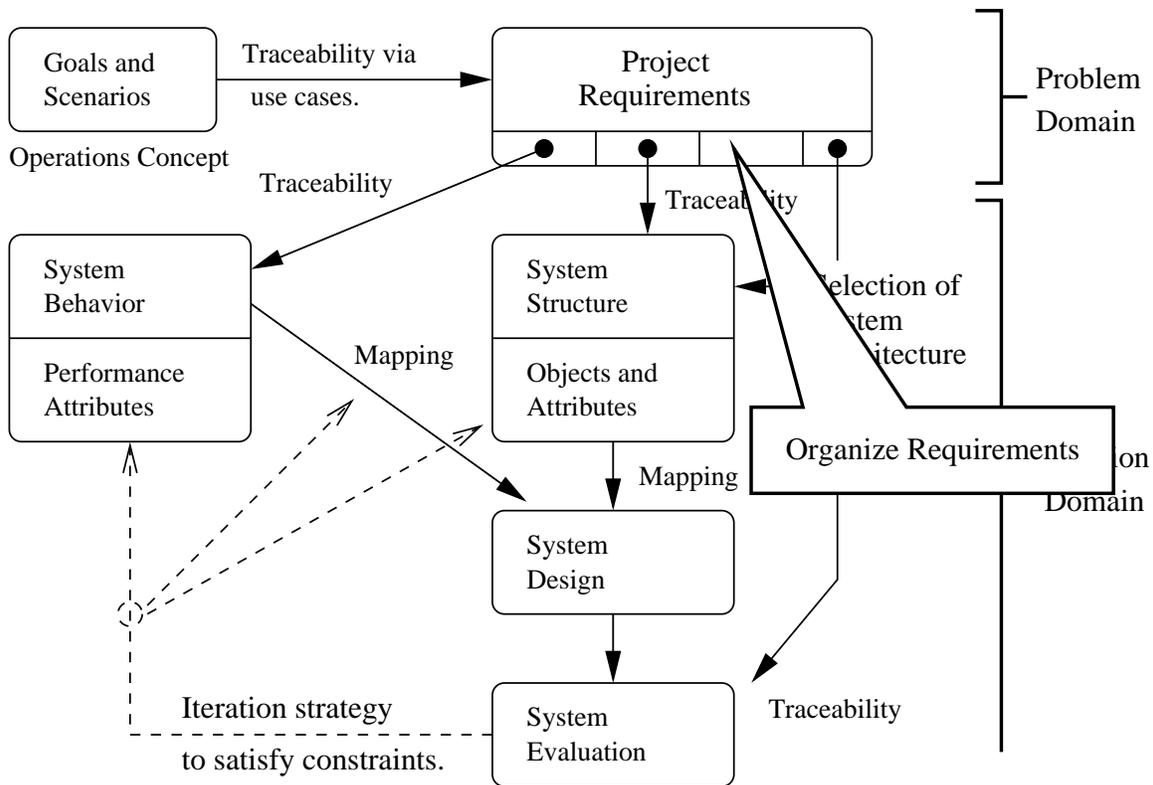


Figure 1. Requirements are organized according to the role they will play in evaluation of system behavior, the system architecture, and system testing.

Figure 1 shows the general pathway from requirements to constraints, the generation of models for system behavior and system structure, the mapping (or allocation) of behavior to structure, and system design assessment.

Visual Modeling with SysML

The SysML interpretation of Figure 1 is as follows:

- 1. Use Cases.** Use cases can be organized into a use case diagram
- 2. Textual Requirements.** Textual requirements will be represented by requirements entities.
- 3. Constraints.** Constraint entities will verify requirements (e.g., via margins of safety) and may appear in requirements diagrams. Generally speaking, acceptable levels of system performance will be described by inequality constraints (i.e., something needs to be greater than a certain amount). Equality constraints occur when we want to capture the system physics (e.g., the behavior of this system needs to satisfy physics described by $F = ma$ or, perhaps, the total system energy usage is the sum of energy consumed by the subsystems).
- 4. System Structure.** Models of system structure will be represented by block and object entities, their attributes, and relationships among blocks. They will be drawn in a block definition diagram.
- 5. System Behavior.** Models system behavior will include activity and statechart (state machine) diagrams and their attributes.

In addition, SysML supports:

- 6. Parametric Relationships.** Parametric relationships are intended to support systems analysis (e.g., performance assessment) by defining constraint blocks. A constraint block expresses a mathematical equation and its parameters, some of which may correspond to system block properties. Parametric diagrams provide a mapping between variables existing in constraints and variable existing in instances (block diagram).

SysML defines new types of associations (stereotyped dependencies) among entities:

- 1. Derive.** One or several requirements derive from a requirement.
- 2. Satisfy.** One or several model elements fulfill a requirement
- 3. Verify.** One or several model elements, e.g. a test case, verify that the system fulfills a requirement
- 4. Refine.** One or several model elements, e.g. a use case, further refine a requirement.

Companion Handout

The **companion handout** on SysML contains a variety of SysML diagrams for the system-level representation of a Satellite System.

1. Each subsystem has a weight and there is a total weight budget for the satellite of 10,000 kilograms. The propulsion, instrumentation, and control subsystems each draw electrical power from the Power-System, which can supply a maximum of 10 megawatts.
2. The requirements blocks are verified through the evaluation of formula specified in constraint blocks. See, for example, verification of WeightRequirement via evaluation of WeightMarginOf-Safety.
3. The Satellite System is defined as the composition of four subsystems: propulsion, instruments, control and power.
4. Equality constraint entities capture the power and weight balances (i.e., the total weight of the satellite is the sum of the subsystem weights).
5. The weight and power margins of safety (MOS) are evaluated by blocks that have one input port and one output port. The weight evaluation accepts a physical quantity (kilogram) input and generates a floating-point (real) output.

Individual Homework Project

The purpose of this homework will be to develop requirements to constraint relationships in SysML, and to create simplified models of system structure and system behavior for a fighter jet landing on an aircraft carrier.

Things to do:

Using the requirements and constraints developed in homework 3 as a starting point,

1. Use the MagicDraw software to develop “textual requirements to mathematical constraint” relationships for a handful of requirements and constraints relating to the plane landing on the aircraft carrier.
2. Create a “simplified” block diagram hierarchy for the subsystems making up the aircraft.
3. Create a statechart representation for the behavior of the aircraft during the takeoff, in flight, and landing phases of the plane operation.
4. Identify and model attributes of the system structure that should be present for the evaluation of performance constraints.

5. Identify attributes of the system behavior that should be modeled, either to assess the plane performance, or to indicate a transition in state (i.e., a guard condition) of the system operations.

Hand in a document summarizing your work in Steps 1-5.

Hint. Here is a statechart model for behavior of an airplane developed by Natasha Kositsyna back in 2003.

