

Requirement diagramming in SysML

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## Introduction

This paper describes requirement diagramming in the Systems Modelling Language (SysML). The first part starts with the description of the goals of SysML, followed by a description of the procedure with the used notation and the needed performing development activities. Subsequently, the creators of SysML are discussed. The second part of this paper will elaborate on an example of SysML in the context of requirement diagramming. The third consists of a literature review. The fourth and last part will show a process deliverable diagram, where the steps of

Friedenthal, Moore and Steiner (2014, p. 31) describe SysML as “a general-purpose modelling language that supports the analysis, specification, design, verification, and validation of complex systems.” These complex systems may consist of hardware, software, data, personnel, procedures facilities. SysML can be helpful when a system engineer tries to improve precision and efficiency of the communication with other co-workers and stakeholders (SysML Forum, 2015). The modelling language can be traced back from the unified modelling language (UML) and took elements from it, namely: sequence, state-machine, use case, and package diagrams. SysML also extended and created requirements and parametric diagrams (Santos Soares & Vrancken, Model-driven user requirements specification using SysML., 2008).

For diagramming requirements with SysML, a box can be used with the stereotype on top (<<Requirement>>) and the title below. It can be extended by adding a text, id or other information below, just like a UML class diagram. Requirements can have relationships among other requirements and can therefor be linked to each other. These relationships can be more specific with the type of the relationship, this can be hierarchy, derive, satisfy, verify, refine and trace (Santos Soares & Vrancken, 2007).

Another important factor in system design is requirements traceability, it “helps in identifying the sources, destinations and links between requirements” (Santos Soares & Vrancken, Model-driven user requirements specification using SysML., 2008, p. 61). Theretofore a table is useful where the Id, name, type, the relationship with other requirements and how it relates can be stored. The format of the table is not set and can be extended if necessary.

Use cases are not necessary with requirement diagramming, but can be helpful to represent the requirements to each stakeholder. Use case diagramming in SysML is the same as in UML and is not modified or extended. It can easily show which stakeholders are interacting with different parts of the system.

SysML was in 2003 created by the SysML Partners, which was founded by Cris Kobryn. SysML Partners is an informal association of experts in system engineering and software modelling tool vendors (SysML Partners, 2015).



### Example

In this part an example of requirement diagramming in SysML will be discussed. In total two deliverables will be shown and explained: The SysML requirement diagram and the requirements table. The case will be part of an online ticketing system. An online ticketing system has several concerns like handling the many customers when an event is popular. There is a maximum of how many visitors a system can handle per second and therefore customers shall have a waiting screen when the system has too much visitors. Customers also want to see how many tickets there are left. And at last, a customer must be able to buy a ticket. Figure 2 shows how these requirements can be drawn in SysML.

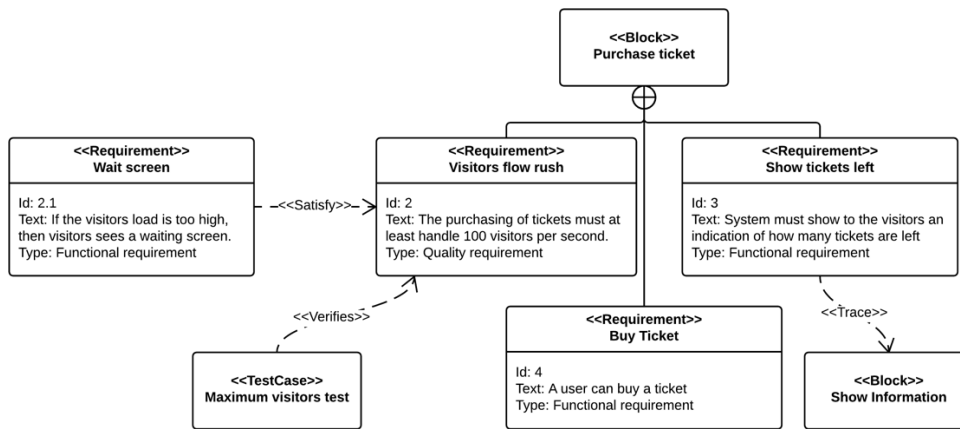


Figure 2: Deliverable 1, the requirements diagram of the ticketing system

The Purchase Ticket block is a part of the system. It can be seen as a black box, how the system looks is not further detailed. The block has some requirements though, the first is Visitors flow rush, which is a quality requirement and has the wish for the system to handle at least 100 visitors a second. The test case of Maximum visitors test should verify if this is possible. The Wait screen satisfies the Visitors flow rush when there are too many visitors. Show tickets left has a traceability to the system that always shows information. Another representation of the requirements diagram is the table, table 1 shows the requirements with other elements of the ticketing system.

Requirements table ticketing system

Id	Name	Relates To	Relates How	Type
1	Purchase Ticket			
2	Visitors flow rush	1		Quality requirement
2.1	Wait screen	2	Satisfy	Functional requirement
3	Show tickets left	{1, 6}	{6, Trace}	Functional requirement
4	Buy Ticket	1		Functional requirement
5	Maximum visitors test	2	Verifies	
6	Show information			

Table 1: Deliverable 2, the requirements table of the ticketing system

### Related Literature

The literature review will elaborate critique, research and developments in requirement diagramming in SysML. Schneider, Naughton and Berenbach (2012, p. 202) are not satisfied with requirement diagramming in SysML and state that the language “focus on the technical description of the envisioned system, and not on the upstream rationale for the requirements.” Another critique came from Ringert, Rumpe and Wortmann (2012). Although they elaborate that SysML can be used for requirements in general, SysML is not suitable for modelling the behaviour requirements of cyber physical roboting systems. What the solution will be for this problem remains unknown and need to be investigated further.

On the other hand, there are also positive findings. Scanniello, Staron, Burden and Heldal (2014) compared requirement diagramming in SysML with UML use case diagrams. The experiment, held on students from Italy and Sweden, showed that the understanding on specification documents of complex systems improves, without affecting time. Although the results are in favour for SysML, the experiment is only conducted in universities and not in the field. Sung and Kim (2012, p. 534) state that “SysML requirements diagram can facilitate the transformation of user requirements into system requirements and improve the requirements’ traceability throughout the design life cycle.”

The modelling language itself is also under development and improvement. One of these developments are extending the language with grouping requirements and custom stereotypes (Santos Soares & Vrancken, Model-driven user requirements specification using SysML., 2008). With grouping requirements, sub requirements can easily be attached to a requirement and an extra box is grouping the requirements. Custom stereotype can be extended to describe directly what kind of requirement it concerns. The stereotype can be changed from <<Requirement>>, to <<QualityRequirement>> or other types such as functional requirements.

### Process Deliverable Diagram

The following part contains the Process Deliverable Diagram (PDD) with the corresponding tables. The PDD shows a process, modelled on the left with an activity diagram. On the right of the PDD the deliverables are modelled in a UML diagram (Weerd & Brinkkemper, 2007). The activities and concepts of the requirements diagramming technique are derived from the article of Santos Soares and Vrancken (2008).

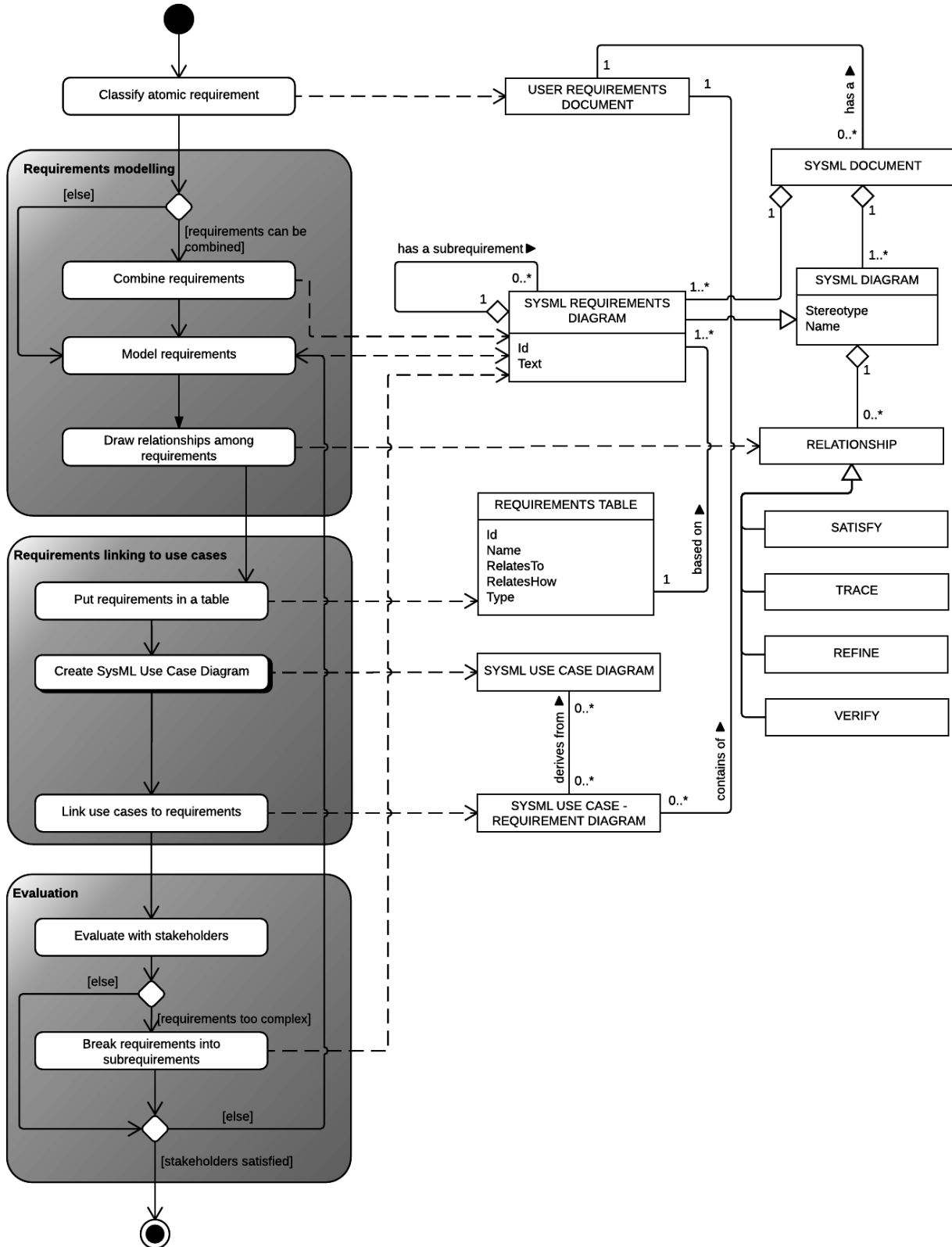


Figure 1: PDD of the Requirements diagramming in SysML technique.

<b>Activity</b>	<b>Sub activity</b>	<b>Description</b>
Classify each atomic requirement		The classification for each atomic requirement will avoid confusion of which type of requirement is written. Put this classification in the USER REQUIREMENTS DOCUMENT.
Requirements modelling	Combine requirements	Some requirements can maybe combined, that is depended on their semantics.
	Model each requirement	Each model comes in the SYSML REQUIREMENTS DIAGRAM.
	Draw relationships among requirements	Requirements can have relationships among each other, these relationships can be drawn with a (Weerd & Brinkkemper, 2007)RELATIONSHIP.
Requirements linking to use cases	Put requirements in a table	The besides the modelled requirements, the requirements must also be stored in tables, therefor the REQUIREMENTS TABLE comes in to place. Hereby the Id, the Name, the relationship with the other requirement, how it is related and the type needs to be stored. The table can also be extended with other information if it is necessary.
	Create SysML Use Case Diagram	SysML Use case diagrams can be helpful, it is not mandatory in the SysML Requirements diagramming technique, but it can helpful to trace the requirements to the use case.
	Link use cases to requirements	As mentioned before, the use cases can be linked in an extra document, namely the SYSML USE CASE - REQUIREMENT DIAGRAM
Evaluation	Evaluate with stakeholders	Evaluation is a great part of SysML. Stakeholders can give feedback on the requirements in the SYSML DOCUMENT
	Break requirements into sub-requirements	If the stakeholders do not understand some requirements or found them too complex,

		requirements can be break down into sub-requirements (Friedenthal, Moore, & Steiner, 2014, p. 175).
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Table 1: Activities of the Process Deliverable Diagram of figure 1

<b>Concept</b>	<b>Description</b>
USER REQUIREMENTS DOCUMENT	In the USER REQUIREMENTS DOCUMENT, all the requirements are stored, this can be a database or a simple word file.
SYSML DOCUMENT	All the diagrams are drawn in the SYSML DOCUMENT. This can be blocks
SYSML DIAGRAM	A SYSML DIAGRAM is diagram of a system. It can contain blocks, requirements, graphic paths, interface blocks, ports and other system parts (Friedenthal, Moore, & Steiner, 2014, p. 133). It needs a stereoptype (such as requirement or block) and a name. In this PDD only the requirement stereoptype is notated in the form of SYSML REQUIREMENT DIAGRAM.
SYSML REQUIREMENTS DIAGRAM	SYSML REQUIREMENTS DIAGRAM is an aggregation of a SYSML DIAGRAM. It contains all the requirement diagrams. Besides the properties stereoptype and name, there are also an unique Id and a text description needed.
RELATIONSHIP	The different diagrams of SysML can have relationships with each other. This can be SATISFY, TRACE, REFINE and VERIFY
REQUIREMENTS TABLE	In the REQUIREMENTS TABLE further specifications of the requirements are stated
SYSML USE CASE DIAGRAM	Use cases can be drawn in the SYSML USE CASE DIAGRAM.
SYSML USE CASE - REQUIREMENT DIAGRAM	In the SYSML USE CASE - REQUIREMENT DIAGRAM the relationships between use cases and requirements can be drawn.

Table 2: Concepts of the Process Deliverable Diagram of figure 1



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