



A SysML profile for conceptual, creative and human-centered aspects of system design

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Motivation

This paper is intended as a basis for discussion about a SysML profile that explicitly supports concepts of the early conceptual and creative phases of system design. The primary goal of that is to expand the advantages of model-based systems engineering from an essentially technical approach to a wider view that includes the system-relevant aspects of product design and human concerns.

In particular, the following proceedings are to be supported:

- Allow for enhanced implementation of **User-centered Design** by explicitly supported integration of user-related elements such as user models, environments, cognitive functions or psychological dimensions
- Improve **Agile Product Development** by direct integration of product-related elements and their relations to technical components in the model
- Support the ideas of **Human Systems Integration** by direct implementation of concerns and artifacts of additional stakeholders (e.g. conceptual designers, operators, strategists, or teachers) using their language and their mental models
- Generally encourage **System Thinking** not only in regards to engineering aspects but also in regards to scenario analysis and creative design aspects

The SysML profile introduced in this paper adheres to the following conditions:

- Full compatibility to SysML
- Feasibility with prevalent tools
- Exclusion of specialized (i.e. non system-relevant) aspects

Please note that the following pages only introduce the general concepts and provide a set of examples. The exact selection of stereotypes, the definition of their tagged values, and the choice of creative methods are subject to discussion and extension.



Approach

The basic approach is to define a set of SysML stereotypes which reflect methods used by conceptual designers, content developers and creative teams in a 1 to 1 way. Future versions of MuSys may also include rules for relations between system elements, process definitions, and SysML diagram types.

The newly defined stereotypes cover five areas:

- Humans (e.g. «persona» or «mood»)
- Environment (e.g. «weather» or «culture»)
- Containers for conception («scenario» and «user story»)
- Creative processes
- Input for conception («target market» and «objective»)

There are different ways of integration and usage of conceptual elements in the system model. Each of these ways have particular advantages. They can also be used in parallel.

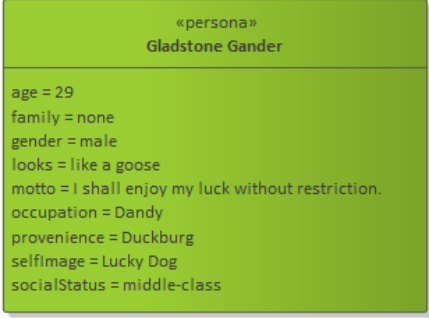
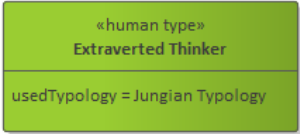
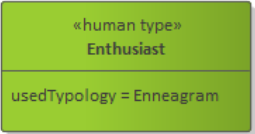
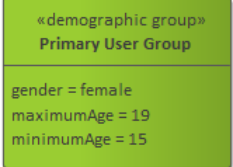
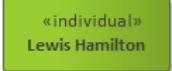
- Adding conceptual elements to the system model leads to an ***Integrated Conceptual View*** of the system. This simple method already promotes:
 - Team work (e.g. through coordinated shared access to the model and common language for internal communication)
 - Proper status management (e.g. through assigned responsibilities, priorities, and development status information)
 - Agility (e.g. through transparency and real-time updates and extensions provided by the product owner in the model)
- MuSys supports ***Model-based Scenario Development***. Defining scenarios or user stories with conceptual elements promotes creativity and system thinking for product design. New designed scenarios generate conceptual elements, and already identified conceptual elements form new scenarios.
- Engineering with ***Conception-Architecture-Models*** which define relations (e.g. refinements, derivations, flows or usages) between conceptual elements and the system architecture with its functional and structural elements promotes product-related, human-centered and interdisciplinary engineering.



Stereotypes for humans

The role of humans who interact with the system can be modelled using the SysML standard stereotype «actor», but human-centered design requires more information on the human than just the role.

Four stereotypes are proposed to model characteristics of humans. They can be associated to an «actor». A model may contain several elements for humans (e.g. for different roles or different target groups).

Stereotype	Description	Examples
« persona »	A fictitious individual who is used to stimulate creative and human-centered design thinking	
« human type »	A subset of humans based on a typology of humans such as the typology according to C.G. Jung or the typology of the Enneagram	 
« demographic group »	A simple subset of humans based on age and/or gender	
« individual »	An actual individual for whom the system shall be designed (e.g. a specific driver of a Formula-1 car)	

Stereotypes for additional human characteristics

It is helpful to introduce additional stereotypes for central human aspects. As part of the conceptual work, all occurrences of a specific type can be identified and added to the model. The elements can later be reused (e.g. when designing the structural architecture or when doing safety analysis or when defining system tests).

Stereotype	Description	Examples
« handicap »	A temporary or permanent handicap of a human in regards to interaction with the system	<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; background-color: #f4a460; padding: 5px; text-align: center;">«handicap» Deaf</div> <div style="border: 1px solid black; background-color: #f4a460; padding: 5px; text-align: center;">«handicap» Intoxicated</div> </div>
« mood »	Any kind of emotion, notion, psychological disorder, opinion etc., which influences human interaction with the system	<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; background-color: #f4a460; padding: 5px; text-align: center;">«mood» Bipolar</div> <div style="border: 1px solid black; background-color: #f4a460; padding: 5px; text-align: center;">«mood» Shy</div> </div>
« skill »	A human skill, which is required to interact with the system	<div style="border: 1px solid black; background-color: #f4a460; padding: 5px; text-align: center; margin-bottom: 5px;">«skill» Knowledge of TCP/IP protocols</div> <div style="border: 1px solid black; background-color: #f4a460; padding: 5px; text-align: center;">«skill» Empathy</div>
« mistake »	A potential mistake of a human who interacts with the system	<div style="border: 1px solid black; background-color: #f4a460; padding: 5px; text-align: center; margin-bottom: 5px;">«mistake» Confusion of left and right</div> <div style="border: 1px solid black; background-color: #f4a460; padding: 5px; text-align: center;">«mistake» Being frozen for 3 seconds</div>



Stereotypes for the Environment

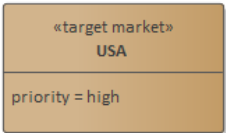
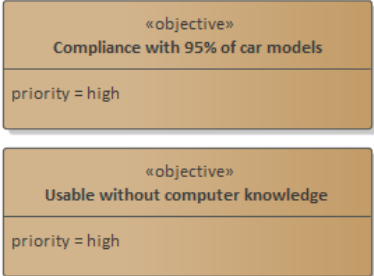
All agents of the system (i.e. humans, artificial intelligences or subsystems) interact in certain environments. Several stereotypes are introduced to model environmental factors.

Stereotype	Description	Examples
« weather »	A weather condition in which the system shall be functional	<div style="border: 1px solid black; padding: 5px; background-color: #e0f0ff;"> <p>«weather» Monsoon</p> <p>extraordinaryCondition = windy maximumTemperature = 40° Celsius minimumTemperature = 30° Celsius precipitation = up to 250mm</p> </div>
« time of day »	A time span of the day during which the system shall be functional	<div style="border: 1px solid black; padding: 5px; background-color: #e0f0ff;"> <p>«time of day» German Footballshow</p> <p>begin = 6pm end = 8pm</p> </div>
« language »	A language used by a human who interacts with the system	<div style="border: 1px solid black; padding: 5px; background-color: #e0f0ff;"> <p>«language» Spanish (Mexico)</p> </div>
« culture »	A cultural peculiarity in a target market of the system	<div style="border: 1px solid black; padding: 5px; background-color: #e0f0ff; margin-bottom: 5px;"> <p>«culture» Saying NO is unfriendly</p> </div> <div style="border: 1px solid black; padding: 5px; background-color: #e0f0ff;"> <p>«culture» Political Correctness</p> </div>
« compliance »	A required compliance to a law, a standard, a guideline, a religion, a tradition or any comparable regulation	<div style="border: 1px solid black; padding: 5px; background-color: #e0f0ff;"> <p>«compliance» ISO 26262</p> </div>



Stereotypes for input from strategy or marketing

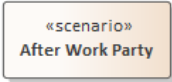
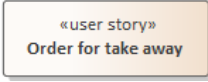
Prior to the creative work, some input from strategy or marketing departments may lead the way. To see the complete chain in the model (strategy -> product design -> system design), it is recommended to provide stereotypes for that input as well.

Stereotype	Description	Examples
« target market »	A geographical region or subculture for which the system shall be designed	
« objective »	An economic, technical, ethical or otherwise defined objective that the system shall meet	



General Stereotypes for conception

MuSys introduces two stereotypes to organize and combine the conceptual elements.

Stereotype	Description	Examples
« scenario »	A generic container for a scenario which is defined through a collection of conceptual elements such as humans, environments, usage time, motivations or use cases	 A rectangular box with a light beige background and a thin border. It contains the text «scenario» on the top line and "After Work Party" on the bottom line.
« user story »	A more structured linear activity known from human-centered design	 A rectangular box with a light beige background and a thin border. It contains the text «user story» on the top line and "Order for take away" on the bottom line.

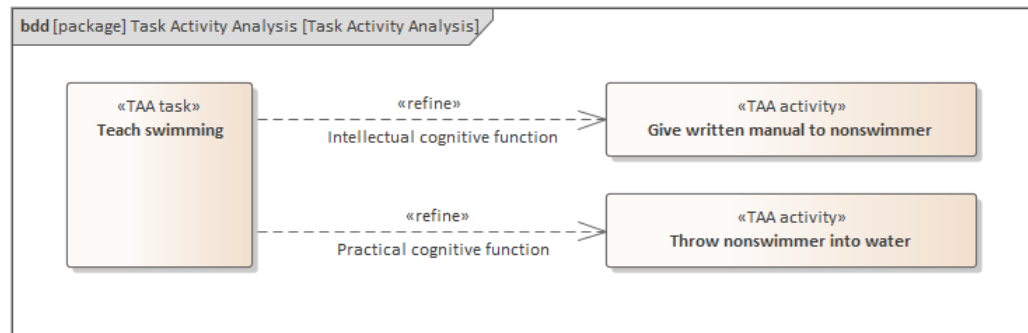


Stereotypes for creative processes: Task-Activity-Analysis

Further stereotypes are to be defined to support modelling of specific creative methods which might be used in certain domains, projects or companies. As an example, two stereotypes are introduced for Task-Activity-Analysis (see e.g. "Tangible Interactive Systems" by Guy André Boy).

Stereotype	Description	Examples
« TAA task »	Something that shall be reached by interacting with your system	«TAA task» Find your path in the dark
« TAA activity »	Something that a human actually does	«TAA activity» Use Smartphone as flashlight

Cognitive functions (i.e. the transformation of a task into activities) could then be modelled with a standard SysML connector.

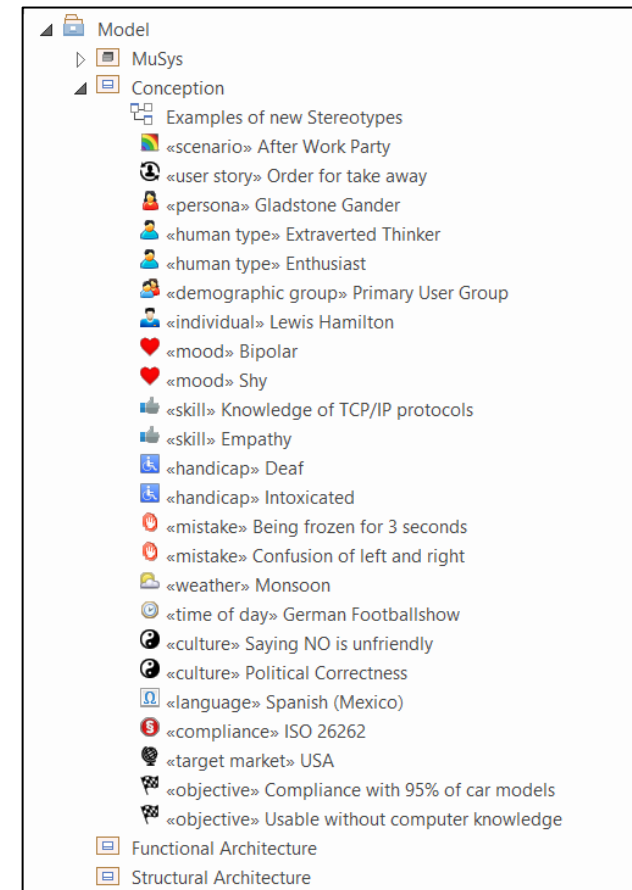


Usage of the profile: Status management

The following pages provide three examples of how the defined stereotypes could actually be applied.

The first and easiest, but nevertheless a very advantageous method is simply to administer the conceptual elements in the model. In particular, this provides the following improvements:

- Easy access to the up-to-date results (-> Requirements) and ongoing changes (-> Agility) of the creative work to all interested team members such as engineers, interface designers or product managers
- Implied provision of the model's status management concepts to the system elements of the conception work
- Implicit or explicit automatic organization and graphical representation in the model browser for quick review at a glance
- Easy implementation of status reports and individual queries (e.g. based on designated responsibilities or levels of completion)
- Enhanced internal communication by using a common form (system model as known by engineers) and a common language (wording as used in the creative team)



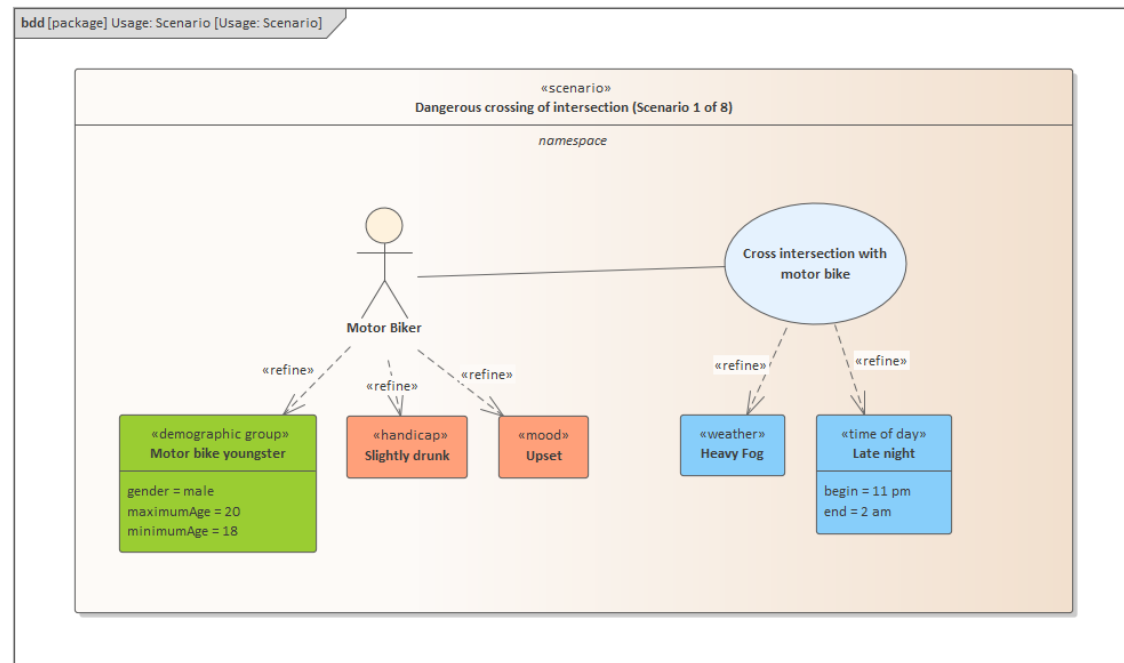
Usage of the profile: Scenarios

The proposed stereotypes allow for a model-based definition of scenarios or user stories as a set of model elements. In general, two directions of development are possible:

- If the creative work starts with the development of scenarios, the aspects of the scenario automatically transform into system elements.
- If the creative work starts with the definition of conceptual elements (such as lists of supported user types, relevant cultural peculiarities or expected environmental conditions), scenarios can easily be defined through combination of the conceptual elements.

Both methods can give valuable insights and inspiration for the product conception.

Here is an example in the scope of developing driver assistance systems for motor bikes.

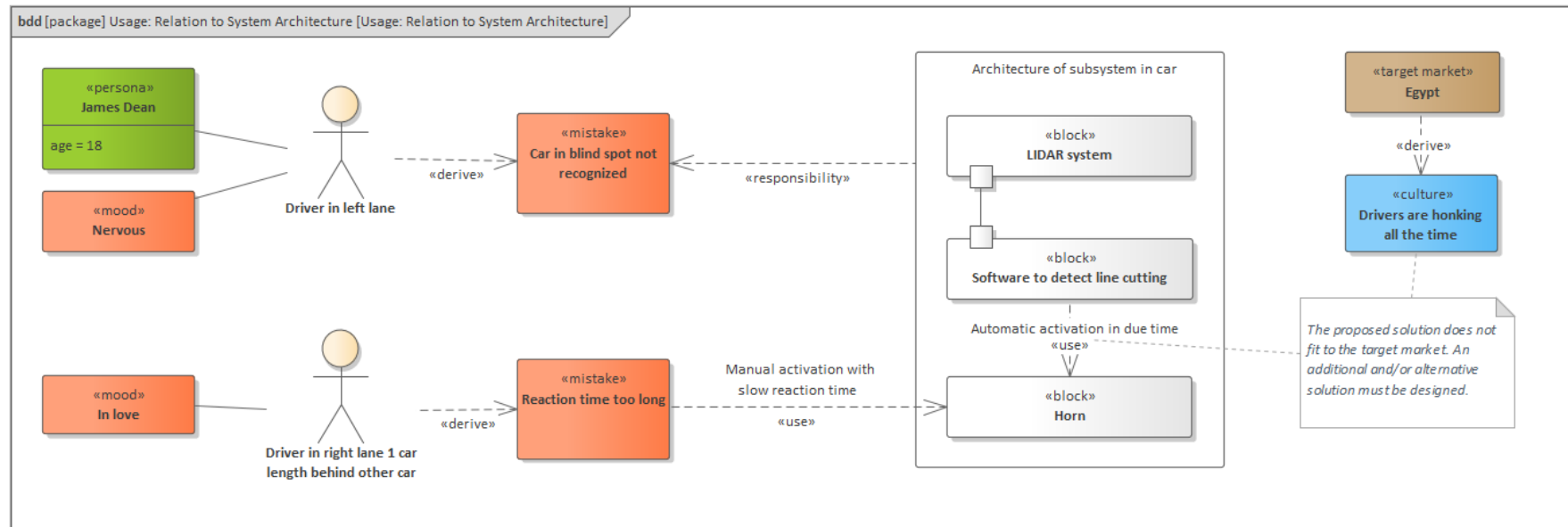


Usage of the profile: Relation to system architecture

The third method of applying the conceptual elements is modelling their relations to the actual functional and structural system elements. Again, two directions are possible:

- Particularly in earlier stages of the development, modelling the relations between identified conceptual elements and potential elements for the future system architecture can be a driving factor for a creative and optimized system design process through out-of-the-box identification of alternatives and variants.
- Particularly in later stages of the development, it can be ensured through the model that the designed system functions, technical components and system tests cover all identified conceptual elements.

To illustrate this type of application, the following diagram provides a small cut-out of the conception for a system to minimize traffic accidents due to improper changing of lanes on wide roads. It is to be understood as a snapshot in the early stage of the system design process.



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