# SEMA System Modeling and Analysis Course

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|---|---|---|
| day 1 | introduction to modeling | exploring the case |
| day 2 | sample customer space | functions and parts |
| day 3 | customer space analysis | quantification and concepts |
| day 4 | business and life cycle | integration and reasoning |
| day 5 | modeling | wrap-up |

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## Abstract

The SEMA course System Modeling and Analysis is a 5 day course. Core of the course is Architectural Reasoning Using Conceptual Modeling. This course uses the CAFCR+ model with 6 views. Qualities connect all views. Threads-of-reasoning capture the architectural reasoning across views and qualities. Conceptual models visualize and capture the context, the system and its design. Quantification is a means to make problem and solution space tangible.



version: 0.4 status: draft October 3, 2016

# 1 Introduction

The SEMA course System Modeling and Analysis is a 5 day course. Core of the course is Architectural Reasoning Using Conceptual Modeling. This course uses the CAFCR+ model with 6 views. Qualities connect all views. Threads-of-reasoning capture the architectural reasoning across views and qualities. Conceptual models visualize and capture the context, the system and its design. Quantification is a means to make problem and solution space tangible.

# 2 Course description

Modeling is one of the core techniques in Systems Engineering to facilitate amongst others communication, discussion, exploration, and validation of system specification and design. Modeling can be applied at all levels, from detailed design simulations to high level context models. In practice we struggle with finding the appropriate models and the appropriate level of abstractions. Quite often designers keep on extending and detailing their models. But is the additional effort worthwhile? Is the extended, more complex model better than the previous simpler model? Can we trust the outcome of our models? Should we integrate all aspects in one integrated model?

Let's look at some real life scenarios:

**Scenario:** *The complex not trusted model.* The pre-development team has made an extensive model of the system with tens of parameters and possible design options. Unfortunately, designers don't really trust the model, because of its complexity. Since they don't understand what the model does, they don't trust the results. What to do to escape from this cul-de-sac?

**Scenario:** *Assessing system performance from subsystem models.* For three different subsystems models have been made to explore performance for a few different design choices. The system designers face the challenge to combine the results into an integral system performance assessment. By making a fourth system level model they trigger the communication between the subsystems and facilitate system-wide design discussions.

**Scenario:** *Overoptimistic performance prediction.* During system integration the design team observes behavior and performance that is completely different than expected from previous system and subsystem models. They discover that several housekeeping tasks of the system have not been modeled and have been underestimated significantly.

**Scenario:** *Introduction of Model Based or Model Driven engineering.* The development organization has scheduled a transition to model based engineering. The expectations from management are high. Engineering teams are sent to education. Unfortunately, after 2 years of development the team discovers that there are plenty of detailed models, but that system characteristics "emerge", because system level models have not been made.

**Target audience:** (sub)System engineers, designers, and architects who create, maintain or use models. This course looks especially at multi-disciplinary models.

**Prerequisites:** at least bachelor in engineering or science and some practical experience in design and engineering.

**Course Objectives** The objective of the course is to teach system engineers and architects methods and techniques for achieving an effective transformation from requirements and business drivers to technology and product design.

After this course students will be able to:

- understand what is a model, types of models, purpose of models
- understand the need for quantification and understand the limits of quantification
- be able to transform loose facts into an insightful model, to be used as input for requirements discussions and system design and verification
- be able to use scenario analysis as a means to cope with multiple alternative specifications and or designs
- apply problem-driven light-weight simulations and understand their value and purpose in early design decisions
- understand and be able to apply the threads-of-reasoning method as a means to communicate about, and discuss the linkage between, business needs and technological decisions
- be able to analyze dependability qualities, such as reliability, safety and security
- be able to analyze the impact of changes; change and variation cases
- understand the value of rapid prototyping for: requirements, potential design issues, modeling inputs
- be able to manage expectation level of different stakeholders

## 2.1 Educational objectives

- teach system engineers and system architects how to model and analyze their system under design, and evaluate alternative design options
- teach them to understand the complexity of this task

- provide them with adequate methods, knowledge, techniques, and methods to be applied in their daily job

## 2.2 Course duration and format

The course takes 5 full days. Participants taking the course for credits have to do a 10 week project afterwards. During the course participants work on real-life cases, preferably from their own domain. Theory and exercises alternate continuously. The models created during the course are limited models, since creating real simulations would take too much time. The exercises provide even more value when multiple participants from the same company participate. We recommend to send a small team to the course, if possible. Course content

During the course we address the following questions:

1. Why do we model? What are the indicators that show that modeling and analysis beyond the level of "business as usual" is needed? What questions do trigger modeling and analysis?

2. What do we model? What kinds of views do we need to consider (4+1, DoDAF, Zachman, CAFCR)? Do we model everything that appears in the relevant views?

3. When do we model? What models are needed at various points in the project life cycle?

4. What is the appropriate type of model? Formulas, visualizations, simulations/emulations (replay of (aspects of) the system), executable models (the model is the system).

5. What is the required accuracy of the model? How do we achieve the desired risk mitigation?

6. What is the appropriate level of abstraction? Model economics: How much details have to be taken into account versus how much effort can we afford?

7. How to calibrate models? Models are based on facts and assumptions. The model outcome depends strongly on these input data. Note again the tension between effort to make and calibrate versus the value in terms of risk mitigation.

8. How to use models? What is the working range, what are restrictions to model validity? What is the credibility of the model?

This course focuses at system level and the multi-disciplinary design. We strongly emphasize the objectives of the modeling effort: Most modeling effort supports the decision process of the project, such as what are feasible requirements and what is the impact of design choices. The modeling effort itself helps the designers to understand their system much better. Since a model is a simplification of reality, we need to calibrate models with the real world by performing measurements.

The course is based on several complementary principles:

- continuous iteration and time-boxing
- gradual refinement from coarse estimates to well-supported results
- visualization of problems and solutions
- quantification of problems and solutions
- complementary representations such as formulas, graphs, tables and diagrams

## 3 Course program

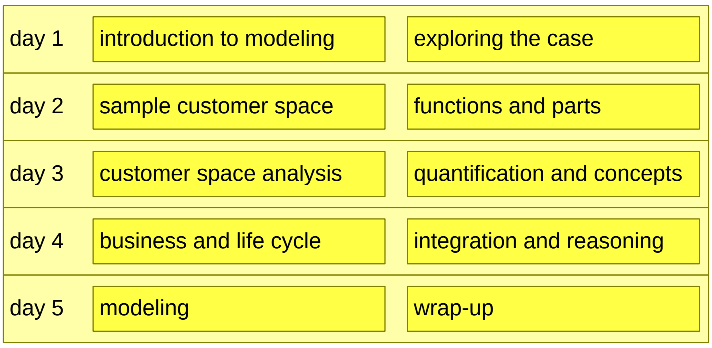


Figure 1: SEMA program

Figure 1 shows the program. The SEMA course starts with an example of modeling. Next step is the introduction of *Multi-View Architecting* based on the CAFCR+ model. Multi-view is the foundation for the later (quantified) *Modeling and Analysis*.

## 4 Preparation for the Course

Figure 2 shows the preparation for the course. Participants send an email to the teacher at least one week before the course start to give an indication of the case they want to work on and the team they envision.

Participants may read through the material, see the section on course material. Especially recommended as reading material before the course is ”Architectural

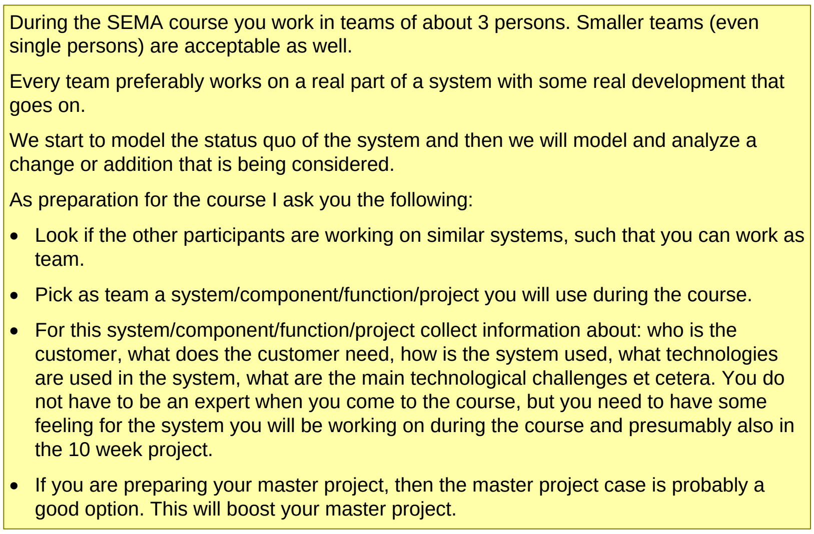


Figure 2: Preparation for the Course

Reasoning Explained" `http://www.gaudisite.nl/ArchitecturalReasoningBook.pdf`. This book explains the CAFCR model and provides a case study.

## 5 Assignments during the course

Figure 3 shows the succession of assignments during the course.

## 6 Course material

Figures 4 to 12 show the course material for the sessions.

## References

[1] Gerrit Muller. The system architecture homepage. `http://www.gaudisite.nl/index.html`, 1999.

**History**
**Version: 0.4, date: 14 October 2014 changed by: Gerrit Muller**

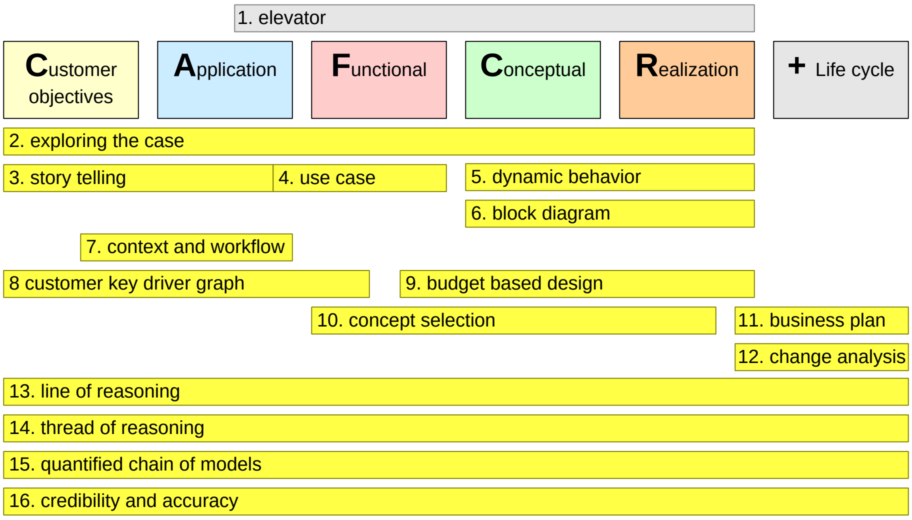


Figure 3: Assignments during the Course

- added split design material in 2 sessions
- moved customer space analysis material

**Version: 0.3, date: 28 July 2014 changed by: Gerrit Muller**

- added wrap-up course material
- moved homework assignment to separate document SEMAhomeworkAssignment

**Version: 0.2, date: 27 July 2014 changed by: Gerrit Muller**

- updated text version
- added submission instructions
- changed status to draft

**Version: 0.1, date: 26 July 2014 changed by: Gerrit Muller**

- complete redesign
- removed 6201 from title
- added assignments during the course
- added slides with course material
- added preparation
- adapted the group and individual assignments

**Version: 0, date: 21 September 2009 changed by: Gerrit Muller**

- derived from CAFCR and MA course descriptions *core*

SEMA System Modeling and Analysis Course
http://www.gaudisite.nl/info/SEMAcourse.info.html
SEMA Basic Philosophy
http://www.gaudisite.nl/info/SEMAbasics.info.html
Physical Models of an Elevator
http://www.gaudisite.nl/info/ElevatorPhysicalModel.info.html

*optional*

Teaching conceptual modeling at multiple system levels using multiple views
http://www.gaudisite.nl/CIRP2014_Muller_TeachingConceptualModeling.pdf
Understanding the human factor by making understandable visualizations
http://www.gaudisite.nl/info/UnderstandingHumanFactorVisualizations.info.html
Dynamic Range of Abstraction Levels in Architecting
http://www.gaudisite.nl/info/DynamicRangeAbstractionLevels.info.html

Figure 4: Course Material Introduction

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SEMA Method Overview
http://www.gaudisite.nl/info/SEMAmethodOverviewSlides.pdf
Short introduction to basic "CAFCR" model
http://www.gaudisite.nl/info/BasicCAFCR.info.html
InitialCAFCRscan
http://www.gaudisite.nl/info/InitialCAFCRscan.info.html

*optional*

Architectural Reasoning Explained
http://www.gaudisite.nl/ArchitecturalReasoningBook.pdf
Architectural Reasoning
http://www.gaudisite.nl/ArchitecturalReasoning.html
Iteration How To
http://www.gaudisite.nl/info/IterationHowTo.info.html
Modeling and Analysis: Iteration and Time-boxing
http://www.gaudisite.nl/info/MAiterationAndTimeboxing.info.html

Figure 5: Course Material CAFCR Scan

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Story How To
http://www.gaudisite.nl/info/StoryHowTo.info.html
Use Case How To
http://www.gaudisite.nl/info/UseCases.info.html

*optional*

Story Telling in Medical Imaging
http://www.gaudisite.nl/info/MIstories.info.html

Figure 6: Course Material Sample CA

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Methods to Explore the Customer Perspective

http://www.gaudisite.nl/info/MethodsToExploreTheCustomerPerspective.info.html

Key Drivers How To

http://www.gaudisite.nl/info/KeyDriversHowTo.info.html

*optional*

Medical Imaging Workstation: CAF Views

http://www.gaudisite.nl/info/MIviewsCAF.info.html

Figure 7: Course Material Customer Space

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Modeling and Analysis: Budgeting

http://www.gaudisite.nl/info/MAbudgeting.info.html

Concept Selection, Set Based Design and Late Decision Making

http://www.gaudisite.nl/info/ConceptSelectionSetBased.info.html

*optional*

The Tool Box of the System Architect

http://www.gaudisite.nl/info/ToolBoxSystemArchitect.info.html

Figure 8: Course Material Design

*core*

Simplistic Financial Computations for System Architects.

http://www.gaudisite.nl/info/SimplisticFinancialComputations.info.html

Modeling and Analysis: Life Cycle Models

http://www.gaudisite.nl/info/MAlifeCycle.info.html

*optional*

How to present architecture issues to higher management

http://www.gaudisite.nl/info/ArchitectManagementInteraction.info.html

Figure 9: Course Material Business and Life Cycle

*core*

Qualities as Integrating Needles

http://www.gaudisite.nl/info/QualityNeedles.info.html

Threads of Reasoning

http://www.gaudisite.nl/info/ThreadsOfReasoning.info.html

Threads of reasoning illustrated by medical imaging case

http://www.gaudisite.nl/PresentationMITORSlides.pdf

Figure 10: Course Material Integration and Reasoning

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| Modeling and Analysis: Reasoning Approach |
| http://www.gaudisite.nl/info/MAreasoningApproach.info.html |
| Modeling and Analysis: Analysis |
| http://www.gaudisite.nl/info/MAanalysis.info.html |
| *optional* |
| Modeling and Analysis: Measuring |
| http://www.gaudisite.nl/info/MAmeasuring.info.html |
| ASP Python Exercise |
| http://www.gaudisite.nl/info/ASPpythonExercise.info.html |

Figure 11: Course Material Modeling

| *core* |
|---|
| Consolidating Architecture Overviews |
| http://www.gaudisite.nl/info/ConsolidatingArchitectureOverviewsSlides.pdf |
| SEMA Homework Assignment |
| http://www.gaudisite.nl/info/SEMAhomeworkAssigmentSlides.pdf |
| *optional* |
| Guidelines for Visualization |
| http://www.gaudisite.nl/info/VisualizationGuidelines.info.html |
| Granularity of Documentation |
| http://www.gaudisite.nl/info/DocumentationGranularity.info.html |
| Light Weight Review Process |
| http://www.gaudisite.nl/info/LightWeightReview.info.html |
| Cookbook A3 Architecture Overview *by Daniel Borches* |
| http://www.gaudisite.nl/BorchesCookbookA3architectureOverview.pdf |
| How to Create an Architecture Overview |
| http://www.gaudisite.nl/info/OverviewHowTo.info.html |

Figure 12: Course Material Wrap-up