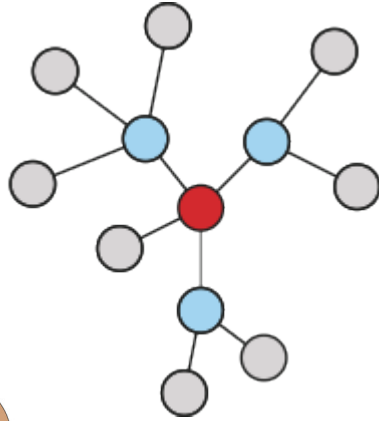# Introducing MBSE

by applying Systems Engineering principles when changing process
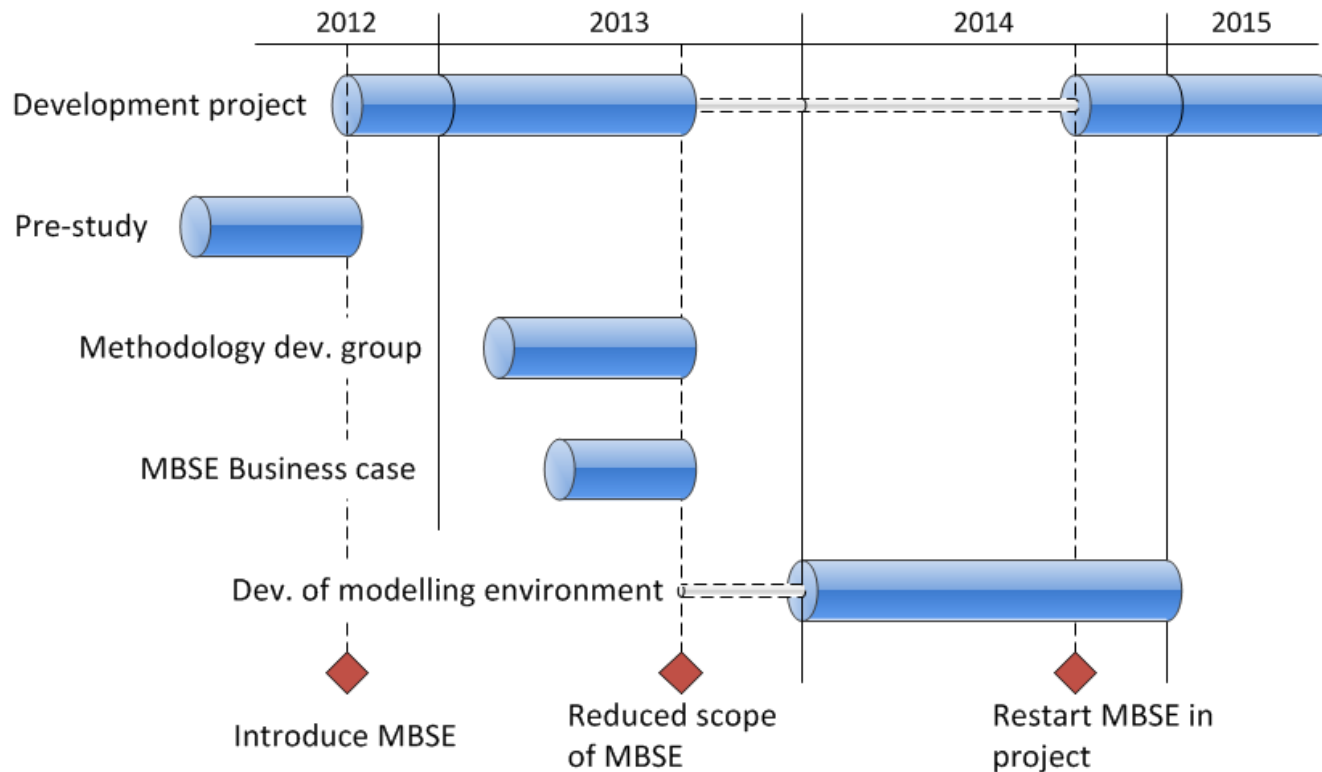
Jonas Hallqvist, Jonas Larsson

Context

Our story

WHY Model based systems engineering ?

- Rationale to investigate MBSE
  - Difficulties in documenting architecture and design in a good way
  - A model can integrate several domains in a consistent, traceable and reuseable format in a better way than the corresponding document-based solution (one model vs several documents)
  - Information that is collected in a standardized way facilitates communication and reuse
  - Enhanced traceability improves impact and change analysis

Getting started

Pillar	Our Choice	Rationale
Method	OOSEM (Object Oriented Systems Engineering Method)	-Compatible with Management System -Supported by INCOSE -Used in pilot test within organization
Language	SysML	-Standardized language for modelling of systems
Tool	Enterprise Architect	Good tool expertise in our investigation team

These were used to try to model a part of our existing system, i.e. to validate the choices.

Decision was taken to use these alternatives and start implementing MBSE.

Clouds on the horizon

- Conflicting ambitions regarding scope
- Unclear decision. What do we mean with "Introducing MBSE?"
- Inadequate management and control over the change

- Low progress causes need for risk analysis and mitigation plan

Back to the roots

What were we trying to accomplish?

Was this the right way?

What has other organisations achieved?

Analysis, vision, risks and roadmap were initiated

Analysis conclusion

- We recognize the benefits of change from a strictly document centric method to MBSE

- No one succeed with a large introduction of MBSE for complex product development

- Benchmarking reported the need for a careful and well planned change

- We wanted to continue

Think BIG

Start Small

And EVOLVE

BE CAREFUL
Watch your step

The MBSE vision

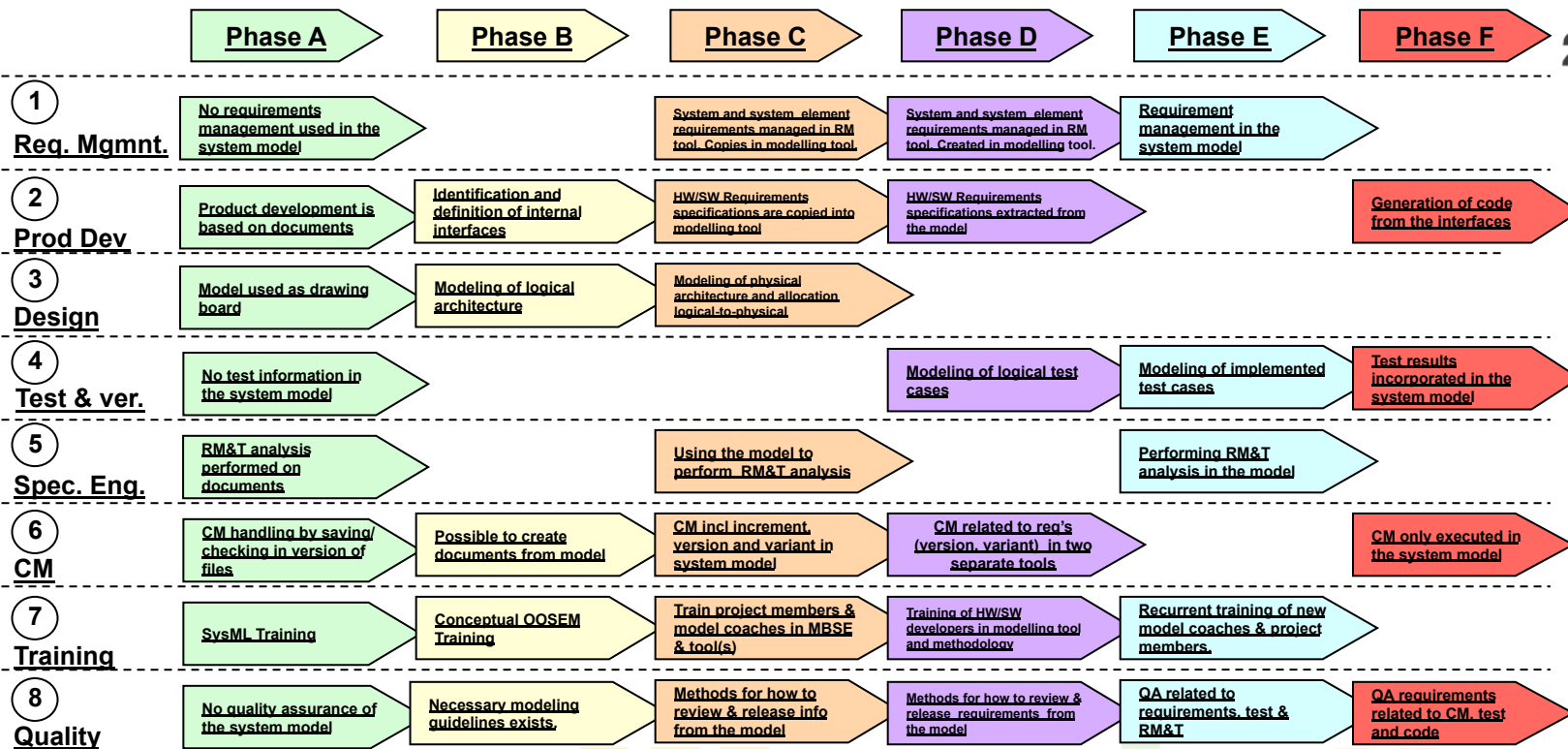Model Based Systems Engineering (MBSE) is the primary way to perform Systems Engineering activities during the product life cycle, with the system model as the primary source of information. The Model Based Systems Engineering has well defined interfaces with other disciplines such as Mechanical Engineering, Electrical Engineering and Software Engineering, making transitions between the disciplines seamless.

MBSE roadmap

|	Phase A	Phase B	Phase C	Phase D	Phase E	Phase F
1 Req. Mgmnt.	No requirements management used in the system model		System and system element requirements managed in RM tool. Copies in modelling tool.	System and system element requirements managed in RM tool. Created in modelling tool.	Requirement management in the system model	
2 Prod Dev	Product development is based on documents	Identification and definition of internal interfaces	HW/SW Requirements specifications are copied into modelling tool	HW/SW Requirements specifications extracted from the model		Generation of code from the interfaces
3 Design	Model used as drawing board	Modeling of logical architecture	Modeling of physical architecture and allocation logical-to-physical			
4 Test & ver.	No test information in the system model			Modeling of logical test cases	Modeling of implemented test cases	Test results incorporated in the system model
5 Spec. Eng.	RM&T analysis performed on documents		Using the model to perform RM&T analysis		Performing RM&T analysis in the model	
6 CM	CM handling by saving/ checking in version of files	Possible to create documents from model	CM incl increment, version and variant in system model	CM related to req's (version, variant) in two separate tools		CM only executed in the system model
7 Training	SysML Training	Conceptual OOSEM Training	Train project members & model coaches in MBSE & tool(s)	Training of HW/SW developers in modelling tool and methodology	Recurrent training of new model coaches & project members.	
8 Quality	No quality assurance of the system model	Necessary modeling guidelines exists.	Methods for how to review & release info from the model	Methods for how to review & release requirements from the model	QA related to requirements, test & RM&T	QA requirements related to CM, test and code

Risk identification

- Tool integration / Req Mgt in modelling tool

- Document generation

- Configuration management

- Transfer of model information to/from the model

- Decision-making when not entire organization has access to, or understands, the model

- Quality assurance of model (reviews)

- And the ever predominant risk of too much modelling, the ”MB” replaces, instead of enhances, the ”SE”

Cost analysis
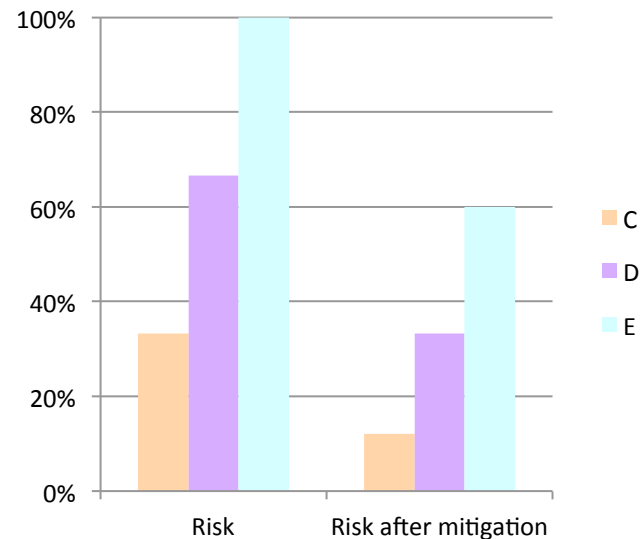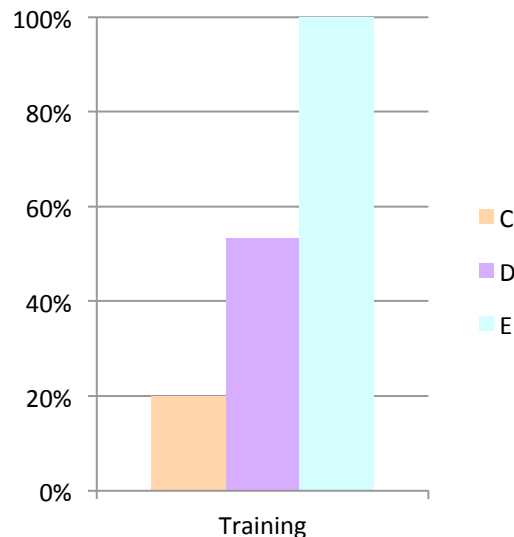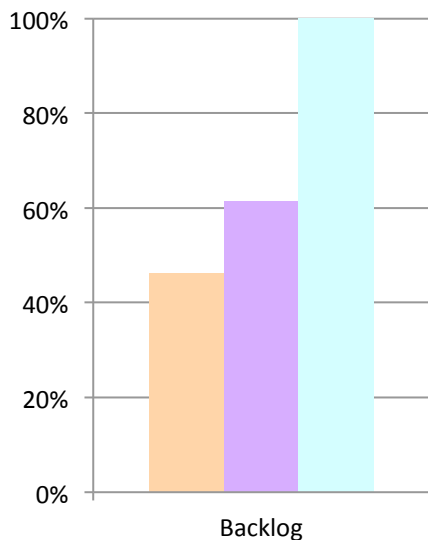
Summary of business case

- Key issues used as decision base for phase C
  - Focus the modelling on Architectural Design, which will result in the most effective improvement
  - Maturity in different parts of the organization (e.g. system, SW, electronics, mechanics, test etc)
  - Training needs (i.e. an indirect measure of change)
  - Risk increases significantly for each phase in the roadmap

- Result
  - Changed level of ambition
  - Risk awareness by management

Observation of the status

- Weaknesses within the model and its structure:
    - Lack of consistency
    - Expected information is missing
    - Difficult to extract requested information

- Conclusion:
    - In spite of having competent systems engineers it is noted that it is very difficult to perform the work as it was defined.
    - The defined method is unnecessary complex

- Suggestion:
    - Perform analysis and re-evaluate the methodology
    - Investigate an alternative modelling method
    - Find a less complex method requiring less effort in the modelling

Overview of activities
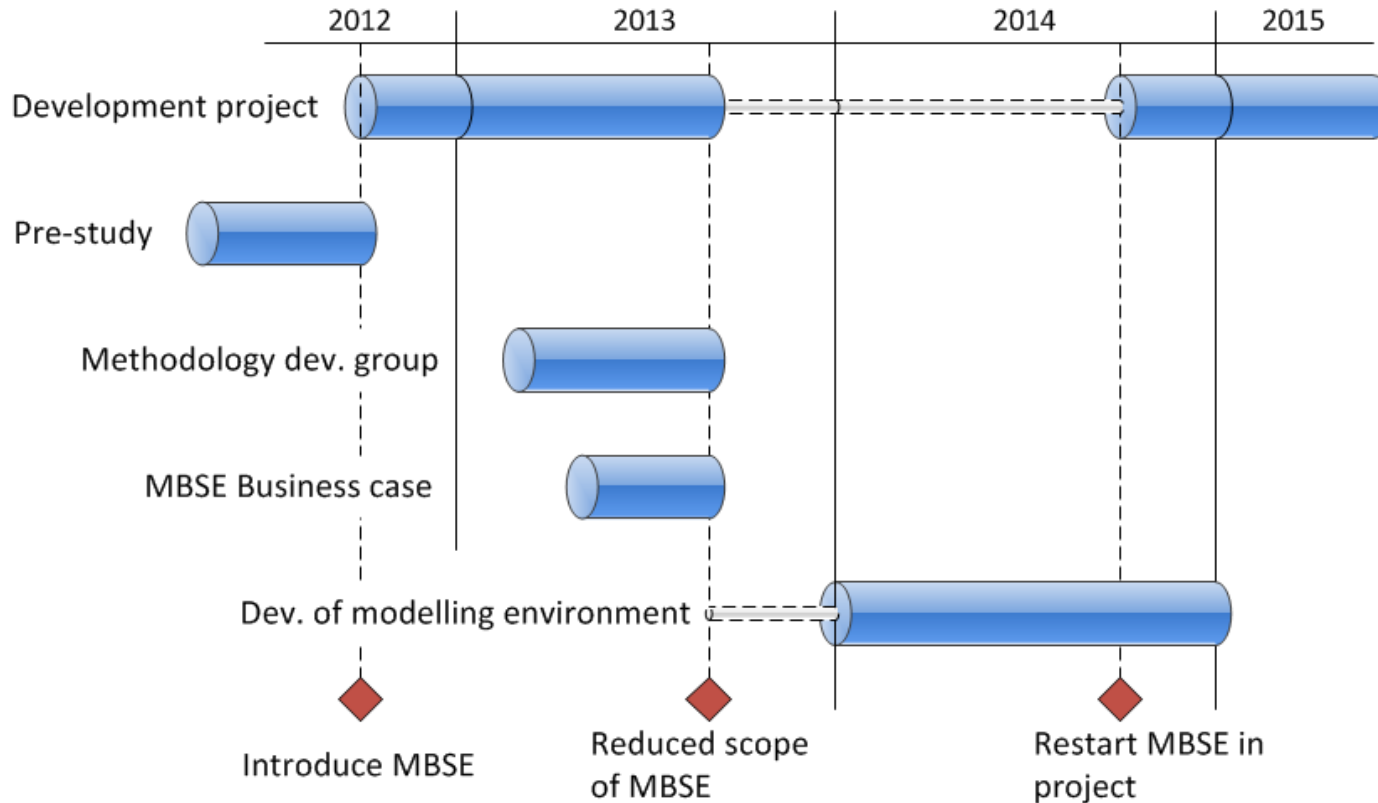
Stakeholder analysis

CM
-Status-, version- and variant information on products and documents
-Correlation of baselines model vs generated documents

Management
-Measure progress

Corporate Management System
-Specific documents shall be generated
-Technical reviews shall be performed

System Integration
-Understand the system design incl how it will be incrementally developed

System Design
-Document req on the system and its elements
-Document the system architecture
-Describe the system design

QA
-Evaluate if we have achieved the correct quality?

Subsystem Design / HW/SW development
-Clear definition of the system element
-Easily understood requirements and design information

Test & Verification
-Good quality on the requirements
-Requirements Management

Concept evaluation

Evaluation Criteria	Weight	Concepts				
		Current	**New**	**Document**	**Modified**	**Document with diagrams**
(Brief description)		*Adaption based on OOSEM*	*Architectural views*	*No model*	*Changed "OOSEM" adaptation*	*Using SysML diagrams*
Document generation	5	S	+	++	S	++
Modelling complexity	9	S	+	--	S	-
Support product structure	7	S	++	++	S	++
Impact analysis	7	S	+	-	S	-
Maintainability	7	S	+	-	+	-
Consequences time schedule dev program	1	S	+	--	S	S
Risk	5	S	+	--	-	-
Communication	9	S	++	+	+	+
Cost	5	S	S	S	S	S
Configuration Management	5	S	S	++	S	+
Training effort	1	S	S	+	S	+
Reuseability	3	S	+	-	S	S
Quality assurance	5	S	S	+	S	+
Methodology development	1	S	-	+	S	+
WEIGHTED SCORE		**0**	**68**	**3**	**11**	**17**
Σ ++		0	2	3	0	2
Σ +		0	7	4	2	5
Σ S		14	4	1	11	3
Σ -		0	1	3	1	4
Σ --		0	0	3	0	0
RANK		**5**	**1**	**4**	**3**	**2**

Statement

- Our chosen modelling methodology is currently not the best suited way to solve all our problems, even if it may be possible to do it.

- Always chose a model that is appropriate for its purpose

- Our purpose is to describe different views of the systems architecture and design by using SysML in a modelling tool

- Our model shall therefore not be used for:
  - Formal requirement traceability
  - Development of processing algorithms etc
  - Code generation
  - Modelling test cases and test results

- ➤ We introduced a fundamental change:
  - Communication is made through diagrams, not the database
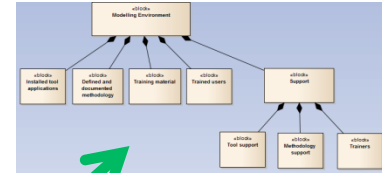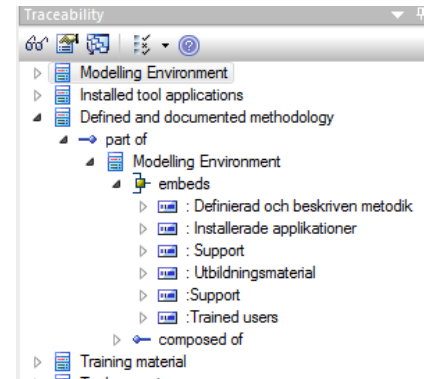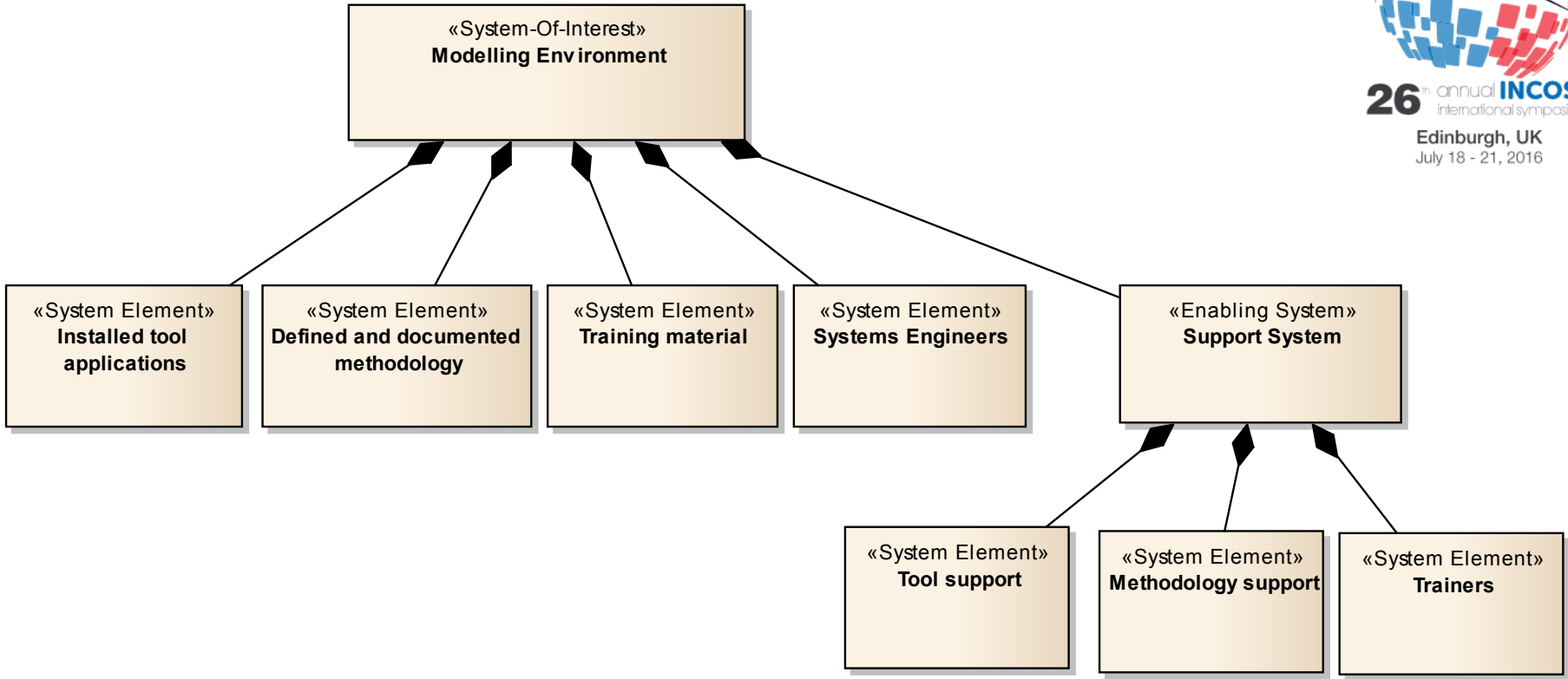
System life-cycle
(SOI=Modelling environment)

| Initial Studies/ Concept	Development	Production	Utilization & Support
Identify problem / need	Define methodology and compile instructions	Train users	Continuous support
Identify requirements	Establish tool knowledge	Perform migration	Train new users
Define conceptual solutions	Compile training material Train trainers	Establish all support	Sustain tool environment (new releases)
Cost and time estimate	Establish tool environment	Roll out tool environment	Sustain methodology
	Identify migration activities		

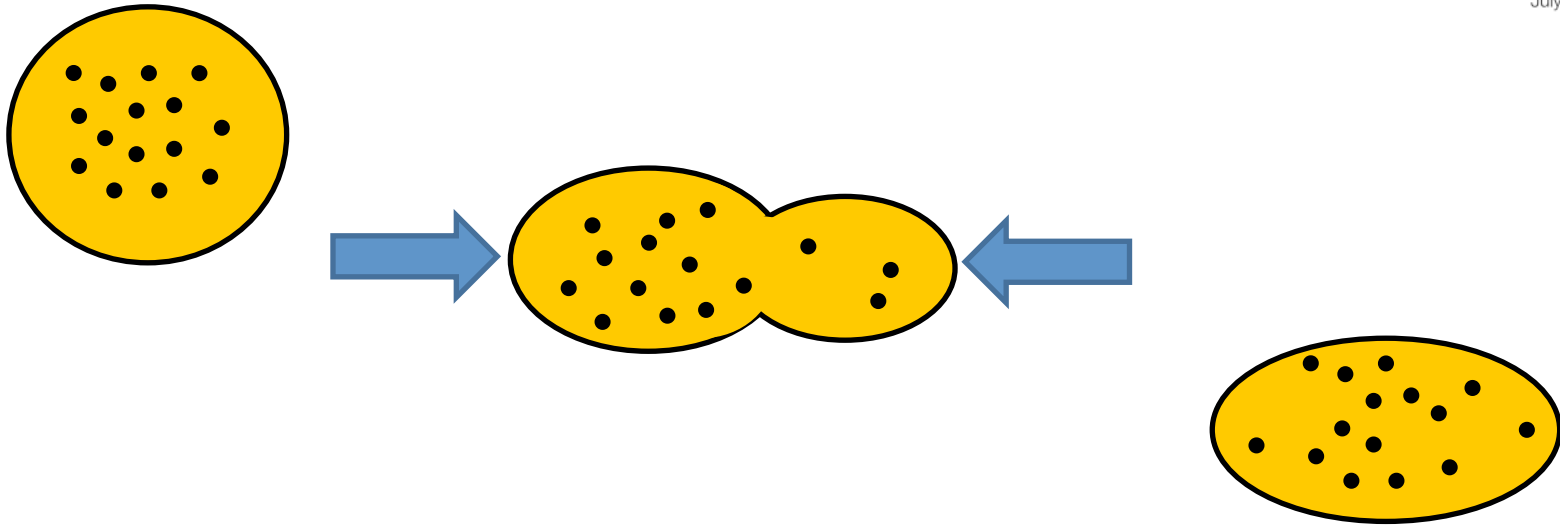# Introducing new ways-of-working

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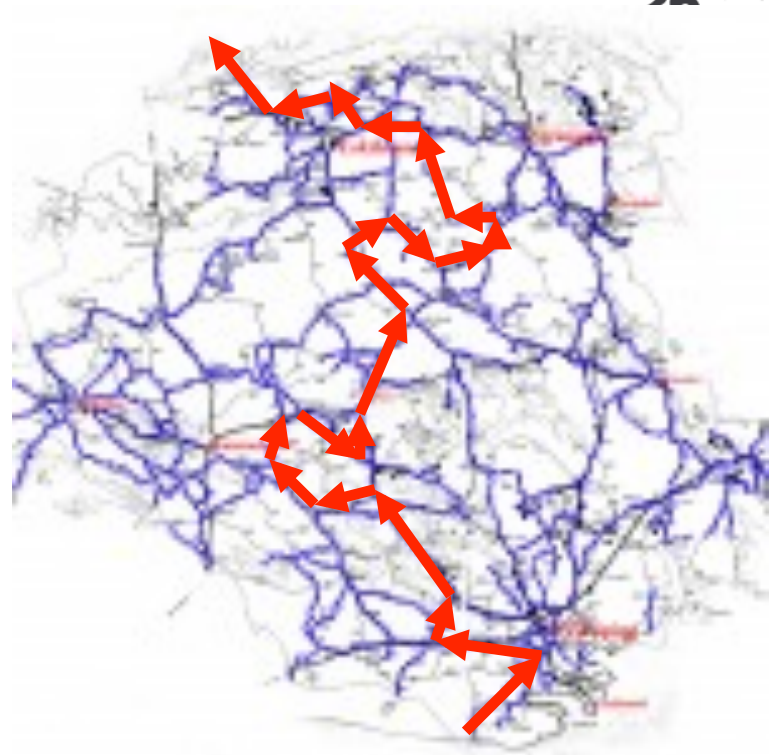
A too common result
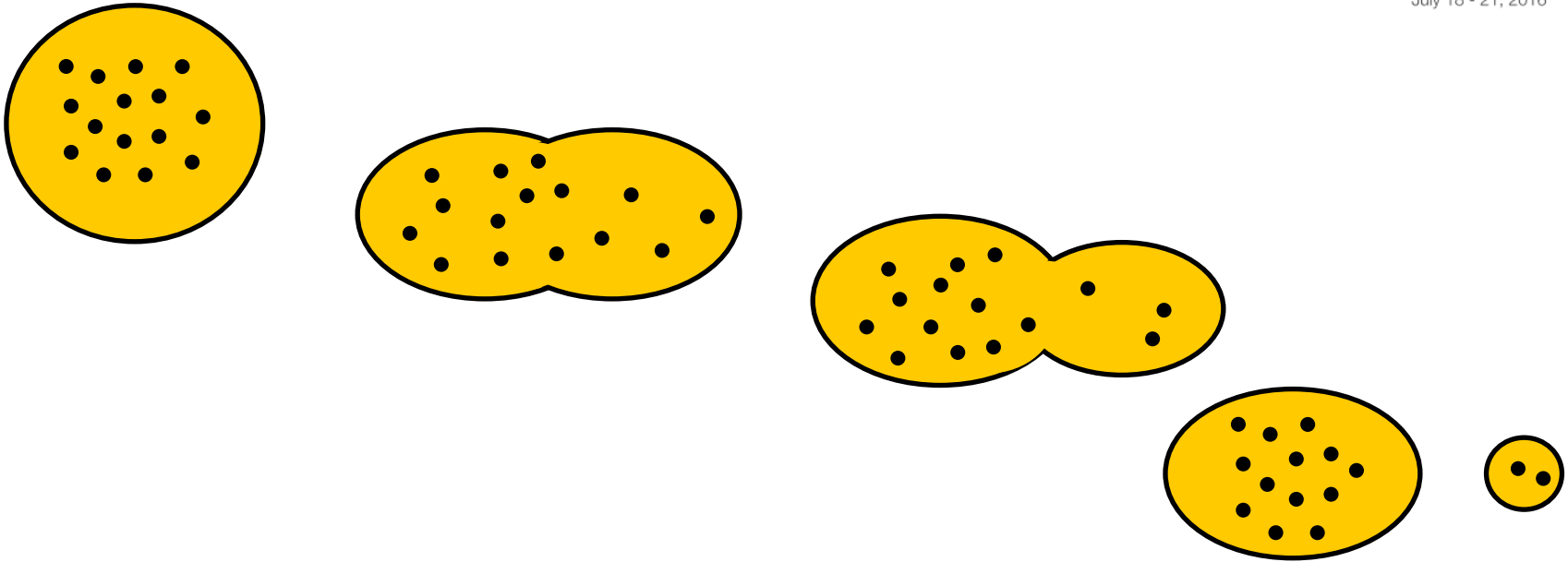
Leadership responsibility

Successful changes

- Major changes requires a holistic view and planned introduction
- Keep the focus on the purpose of the change. Changes must emanate from "What do we need to change?" and not from "What can we do with this?"
- Prototyping vs scaling
- Adress all stakeholders
- Changes requires expertise both in the specific topic and in managing changes. Previous experience from similar process increase chance of success
- Changes will not be successful and persistent without leadership present

Key issues

- No one succeed with a large and fast introduction of MBSE for complex product development
- All organizations report the need for a careful and well planned change
  - ✓ Identify the need and what problem that is expected to be solved by working with models
  - ✓ Plan the transition into MBSE careful
  - ✓ Perform small steps and evaluate
  - ✓ And always remember the original need and problem
- Provide time to develop methods in sync with introduced change
- Provide time to increase competence base in sync with introduced change

MBSE Roadmap

Year X
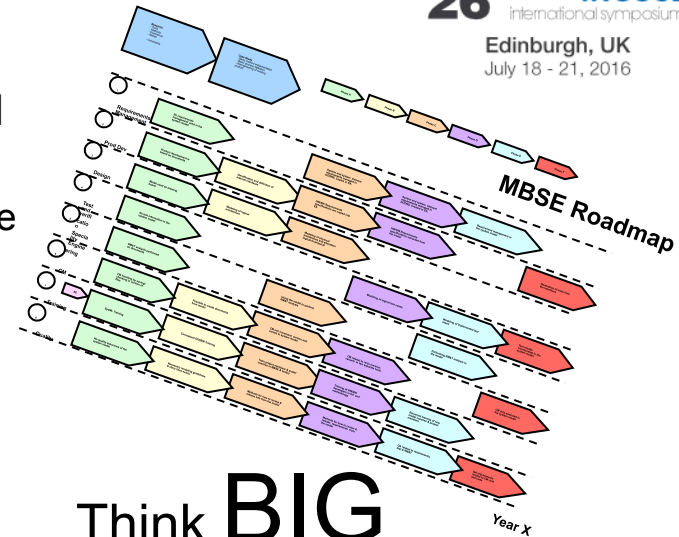
Think BIG
Start Small
and EVOLVE

Always start with the WHY

the WHAT and HOW comes later

Questions ?

Jonas Hallqvist
Jonas.Hallqvist@saabgroup.com

Jonas Larsson
Jonas.Larsson@syntell.se