MBSE is the New SE:
Establishing the New Culture in the Organization

Aiste Aleksandraviciene, Dr. Aurelijus Morkevicius

Hello!

Expertise Area:

- **Model-Based Systems Engineering**
- **Model-Based requirements management**
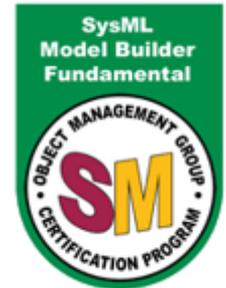
Responsibilities:

- **Spreading MBSE culture**
- **Writing papers**
- **Producing and maintaining training material**
- **Organizing webinars**

Aiste Aleksandraviciene
Solutions Architect @ No Magic Europe
aiste.aleksandraviciene@nomagic.com

What is MBSE?

Model-Based Systems Engineering (MBSE)
is an emerging approach
that applies **modeling** to support
complex system
requirements,
design,
analysis,
and **verification and validation** activities

MBSE is the New SE

SE Practices for Describing Systems

Past
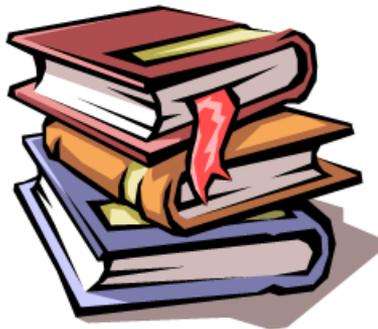
- **Specifications**

- **Interface requirements**

- **System design**

- **Analysis & Trade-off**

- **Test plans**

Future
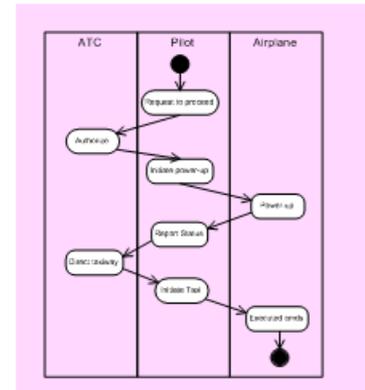
Moving from Document centric to Model centric

Towards Vision Transparency

We Deliver MBSE Solutions To...

Defense & Aerospace

Transportation

Automotive

Science

Telecommunication

Healthcare

Electronics

Security

Success Stories from…

RENAULT NISSAN — In Progress — Automotive

BOMBARDIER — SE=MBSE — Transportation

KONGSBERG — SE=MBSE — Defence & Aerospace

Typical Process for MBSE Deployment

| Believe | Understand | Build Proof of Concept (PoC) | Run Pilot | Institutionalize |

No Magic

The Truth is in the Models™
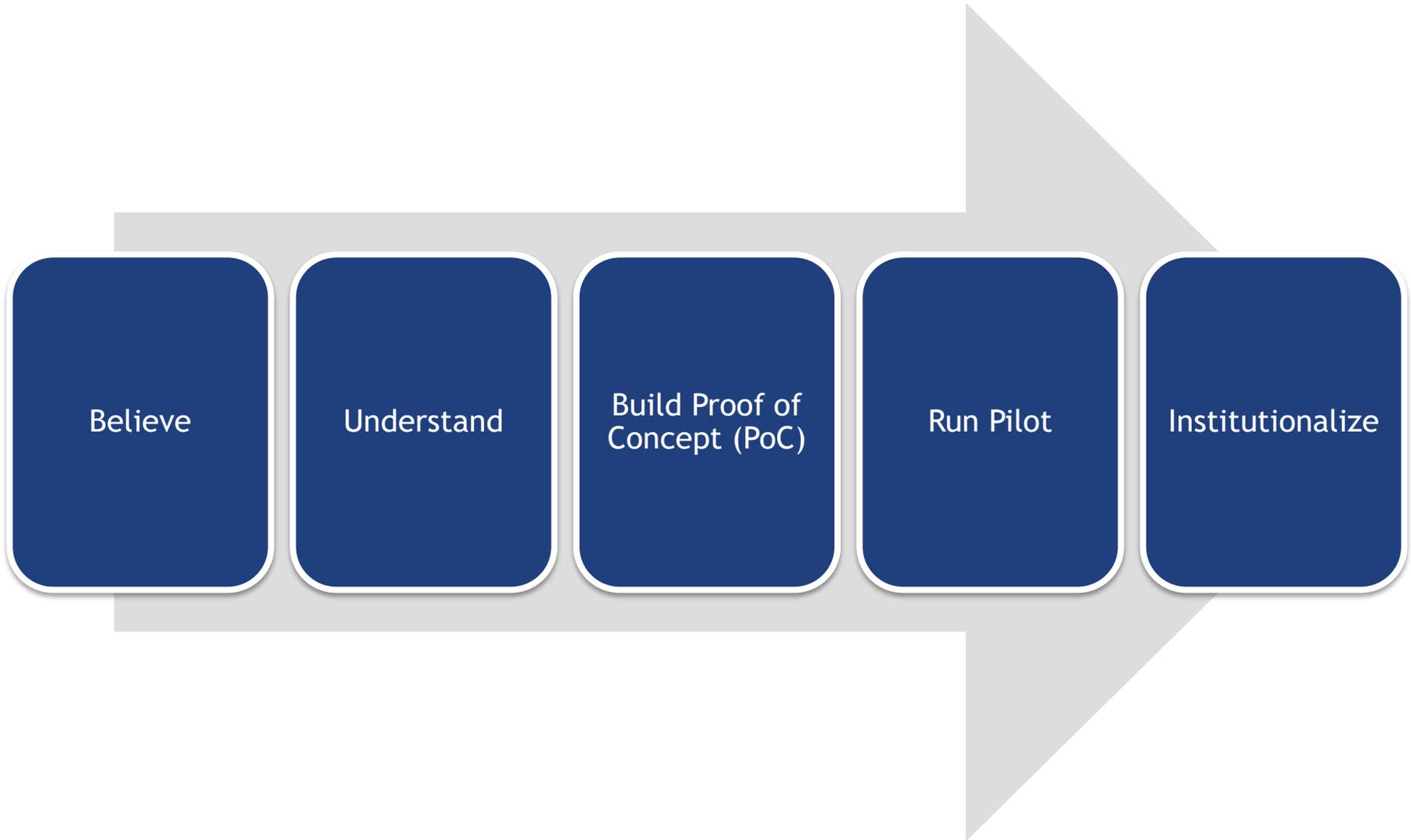
Parties Involved:

- Triggering Party
- Management

Deliverables:

- Management commitment

Showstoppers:

- No commitment from the management

Who/What Triggers the Believe?

Engineers

Innovations Group

Partnership

Growing Complexity of Modern Systems

Why Engineers at KDA Don't Like Documents?

"I cannot see a BIG PICTURE in the documents."

"It's difficult to find the info I need."

"It takes an awful amount of time to re-write them."

"It's hard to keep them up to date; information is redundant."

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MBSE Adoption at R-N – Idea from Process Team

Process Team is responsible for innovations and optimizations of work processes

The idea to move to MBSE came from them

RENAULT NISSAN

When Your Partner Uses MBSE...

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LOCKHEED MARTIN

Joint Strike Missile integration on the F-35 Joint Strike Fighter

MBSE   LOCKHEED MARTIN → MBSE   KONGSBERG
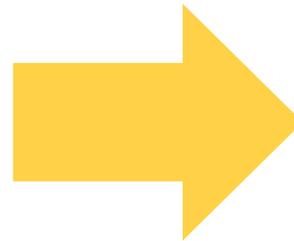
What Makes the Management Inspired?

MBSE events:

- Tool vendor events
- Exhibitions
- Conferences

Success stories
of MBSE deployment
in the organization
from the same industry

Parties Involved:

- Management
- MBSE Center of Excellence
- External experts (optionally)

Deliverables:

- Objectives and scope of MBSE adoption
- MBSE literacy (with or without external experts)

Showstoppers:

- Underestimated scope

Duration: ~ 1 month

MBSE Center of Excellence (CoE)

People from within who originally pushed the idea of MBSE adoption

It's good, when MBSE CoE includes regular employees

During the Understand and Build PoC phases, they are completely taken from their regular tasks

Later MBSE CoE train other company members, coach them, provide models reviews/audits

... is a <u>combination</u> of

a **modeling language(s)**,

a **methodology**

and a **modeling tool**

that together provide a productive infrastructure for

applying model-driven development

in the context of a particular organization

Objectives of MBSE Adoption at KDA

Early system design verification

Traceability from requirements to functions and design concepts

Interface specifications

Code generation

Verification planning

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Scope of MBSE Adoption
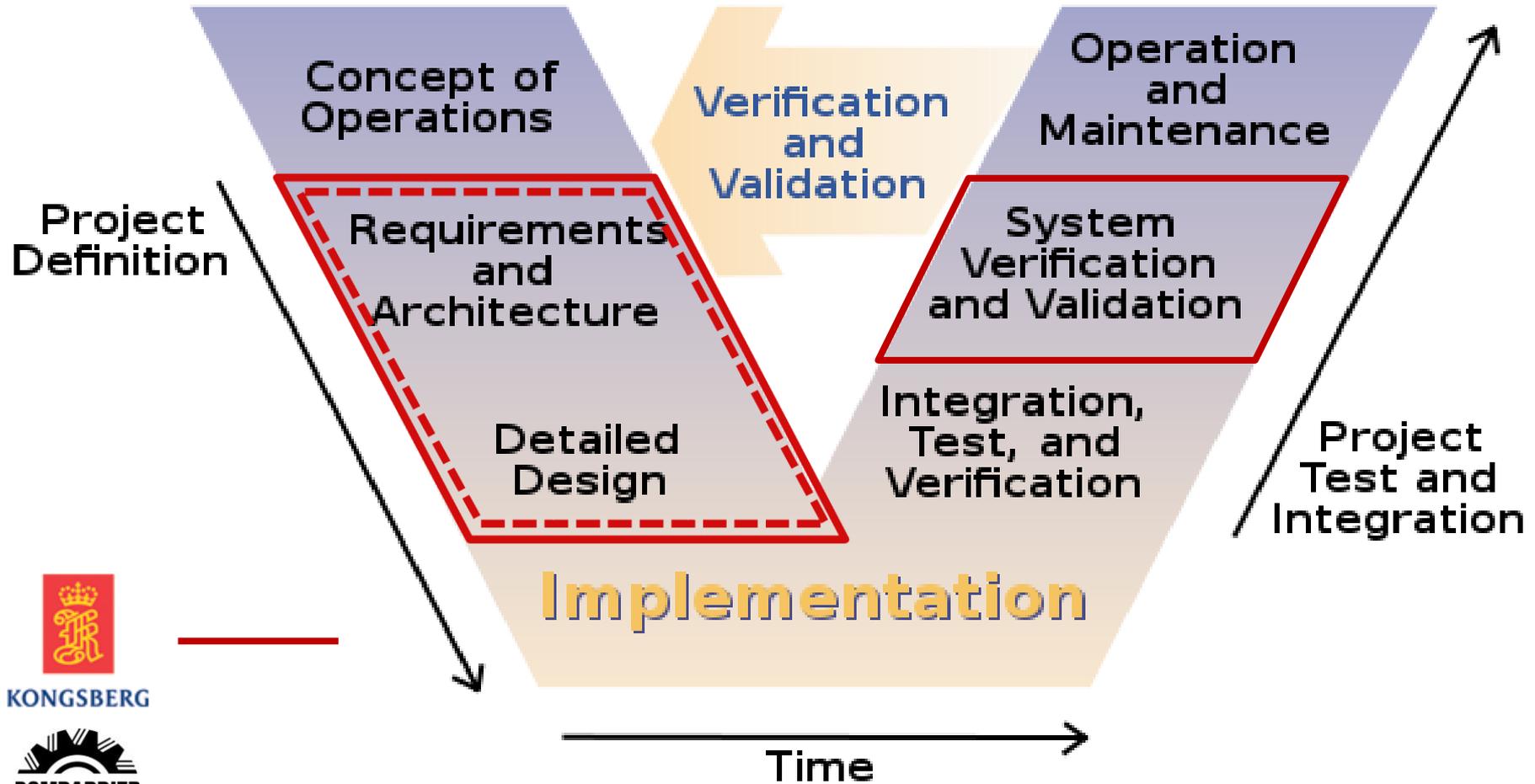
Parties Involved

- MBSE Center of Excellence
- External experts

Deliverables

- Methodology
- Toolset & Customizations
- Reference model & Modelling guidelines

Showstoppers

- Value is not proved

Duration: ~ 3 months

Methodology

Operational Analysis	Functional Analysis	Technical Analysis
OA - main deliverables 1. Context & scope 2. Interactions between SOI[1] and actors 3. SOI use cases including their detailed behavior	**FA - main deliverables** 1. Functional architecture 2. System of interest decomposition 3. Allocation of Functional Blocks to the SOI's parts	**TA - main deliverables** 1. Technical breakdown structure 2. Technical architecture 3. Allocation of functional blocks to technical blocks

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Pillar			
	Requirements	Behavior	Structure	Parametrics

Layer of Abstraction		Requirements	Behavior	Structure	Parametrics
Concept		**C1** Stakeholder Needs	**C2** Use Cases	**C3** System Context	**C4-P4** Measurements of Effectiveness
Problem		**P1** System Requirements	**P2** Functional Analysis	**P3** Logical Subsystems Communication	
Solution		**S1** Component Requirements	**S2** Component Behavior	**S3** Component Structure	**S4** Component Parameters

R (Requirements level): What shall the system do?

F (Functional level): How shall the system work?

L (Logical level): How shall the system be constructed?

P (Physical level): How is the product assembled?

Integrated Tool Chain at BT

Requirements Management Tool

Safety information

Hazard Analysis Tool

Requirements

Design

MagicDraw (SysML)

Docs
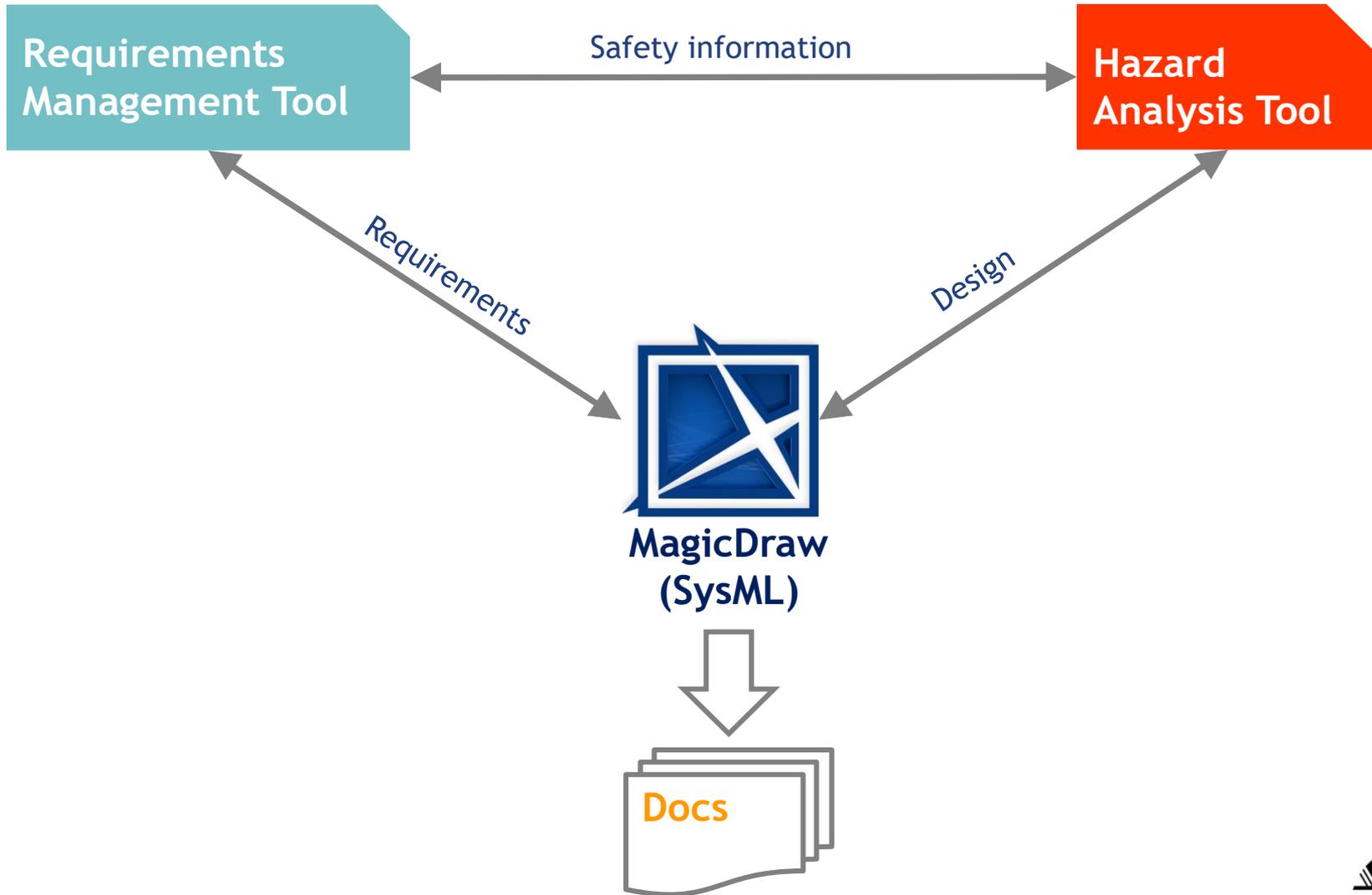
PLM Tool-Centric Tool Chain at KDA

Requirements Management Tool

R

RFL

RFL

P

PLM Tool for MBSE (RFLP)

CAD Tools

MagicDraw (UML)

MagicDraw (SysML)

Docs

MBOM
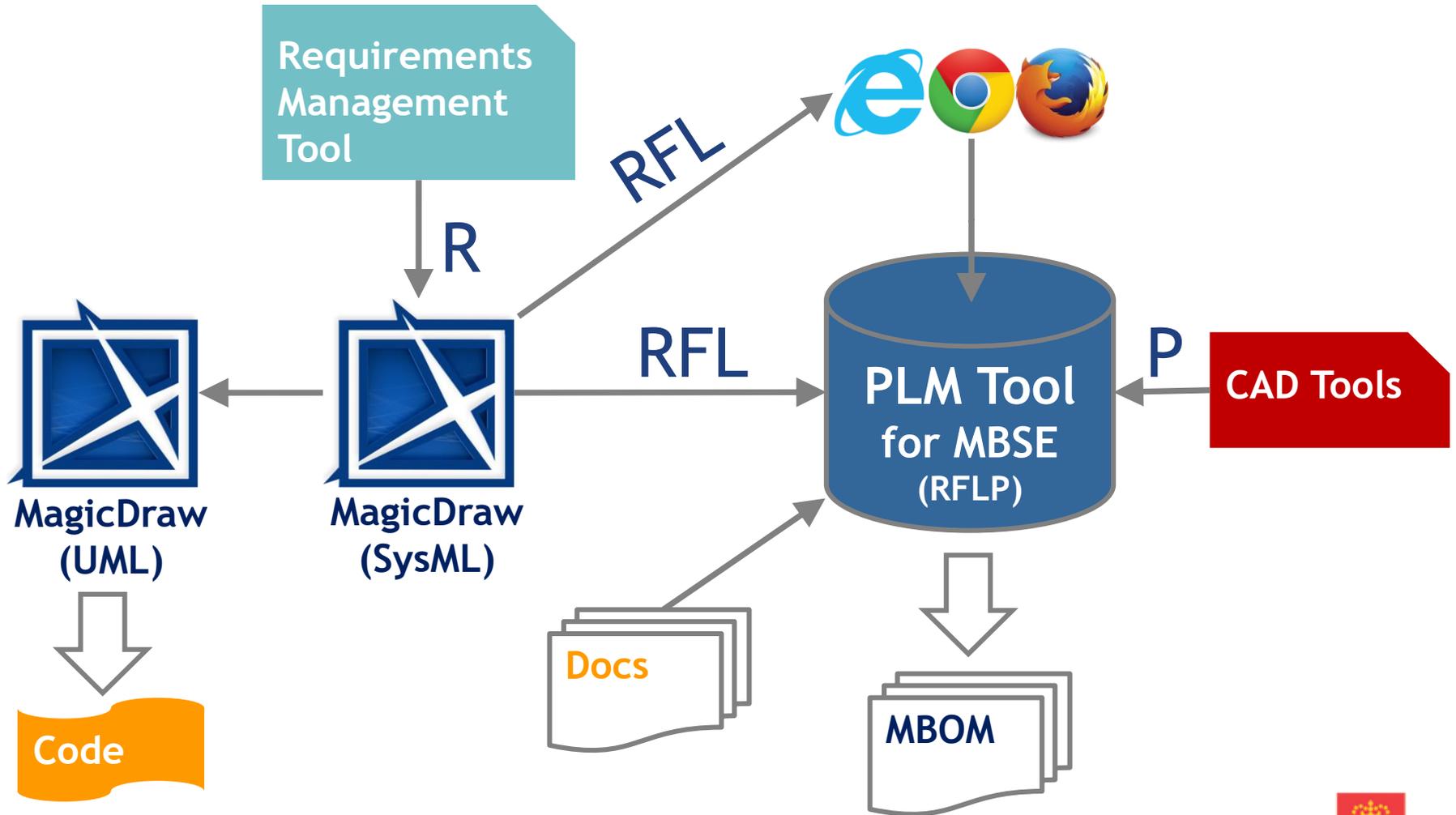
Code

RFLP = Requirements-Functional-Logical-Physical

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Characteristics of Good Modeling Tool

Fully supported modelling language standard (e.g., SysML)

Excellent tool support and extendibility (customizations)

Integration with requirements management tool

Supported change impact analysis

World-wide data accessibility

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Why Reference Model?

Helps to define:

- Modeling methodology

- Typical structure of the model

- Subset of modeling language (e.g., SysML)

- Tool and language customizations

Can be used for training and presentations

What is a Good Reference Model?

Stripped down version of existing product

Cover all modeling aspects/principles in the real product

Evolves in parallel with methodology and product development

Reference Model of KDA: Functional Analysis (1)

Functional Break-Down
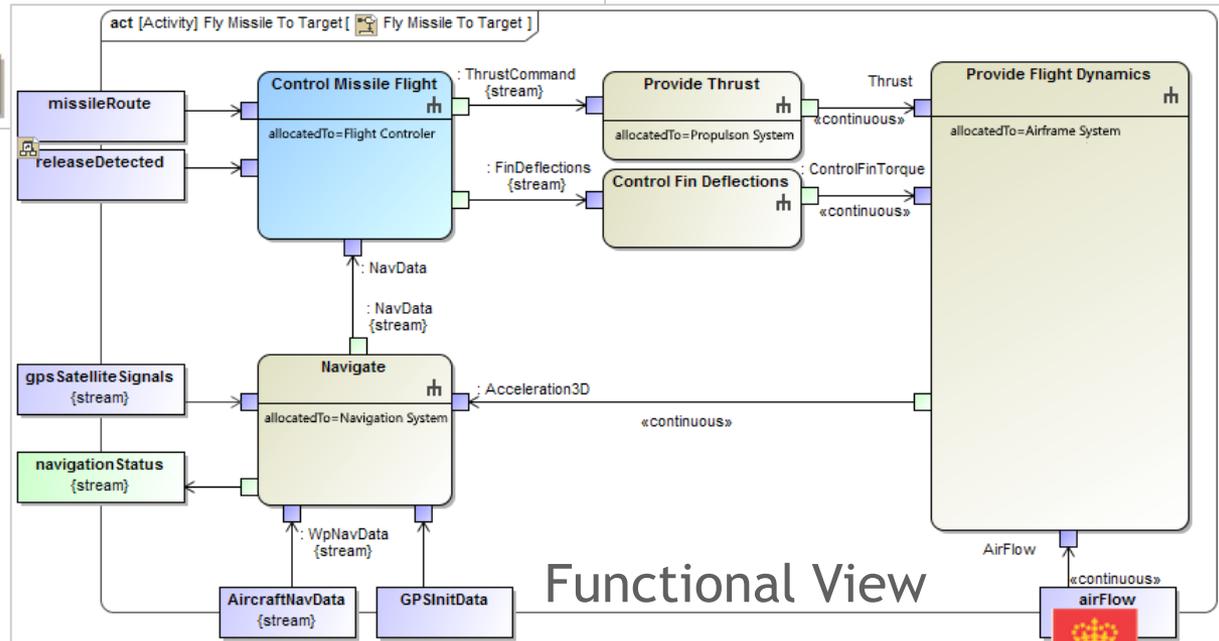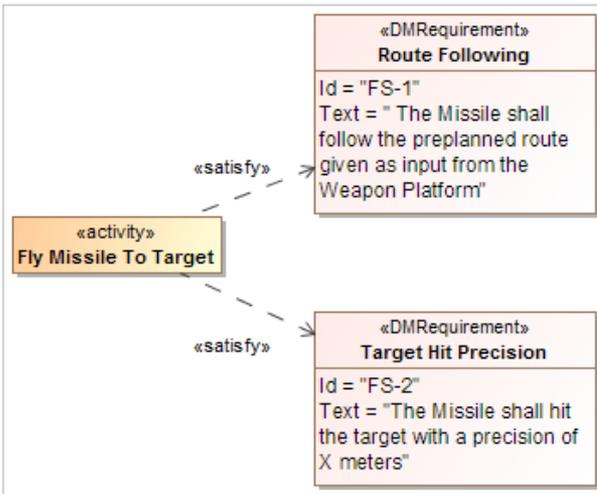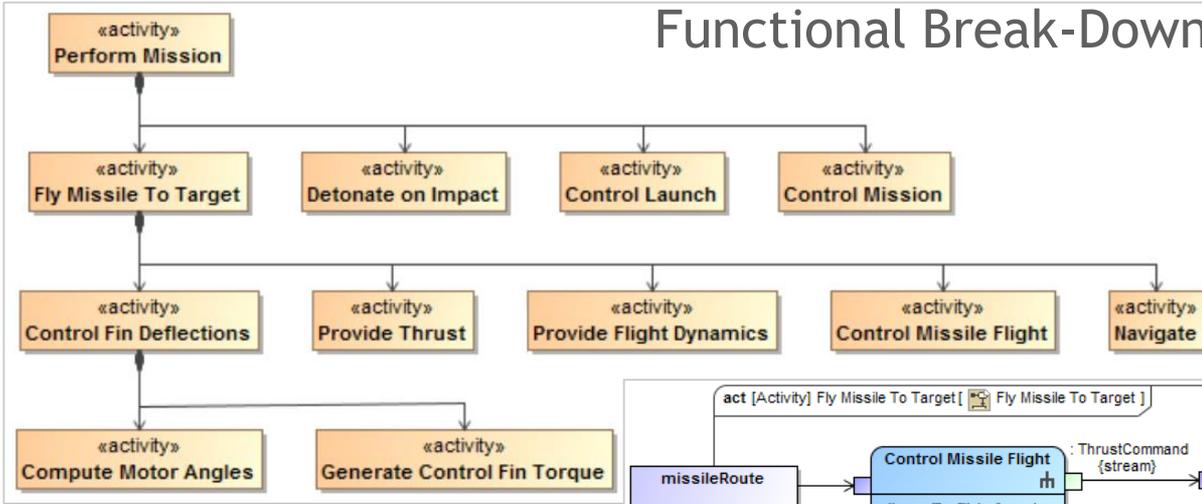
Functional View

Requirements Traceability

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Reference Model of KDA: Functional Analysis (2)

act [Activity] Fly Missile To Target [Fly Missile To Target]

Control Missile Flight
allocatedTo=Flight Controler

missileRoute
releaseDetected

: ThrustCommand {stream}

Provide Thrust
allocatedTo=Propulson System

Thrust

«continuous»

Provide Flight Dynamics
allocatedTo=Airframe System

: FinDeflections {stream}

Control Fin Deflections

ControlFinTorque

«continuous»

: NavData

: NavData {stream}

Navigate
allocatedTo=Navigation System

gpsSatelliteSignals {stream}

: Acceleration3D

«continuous»

navigationStatus {stream}

: WpNavData {stream}

AircraftNavData {stream}

GPSInitData

Functional Structure

Functional View

IFlightController

«Specification» «SoftwareComponent» **flightController**

IThrustController

thrustControl

«FunctionalSystem» «Specification» **propulsionSystem**

thrust

«FunctionalSystem» «Specification» **airframeSystem**

ILaunchEventReceiver

IFinController

finControl

«Specification» «ProgrammableLogicComponent» **finActuatorController**

motorAngles

angle

«Specification» «ElectroMechanicalComponent» **finActuator [4]**

ntrolFinTorque [4]

navData

INavigationDataReceiver

«FunctionalSystem» «Specification» **navigationSystem**

missileMovement

No Magic

30

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Reference Model of BT:
Change Impact Analysis
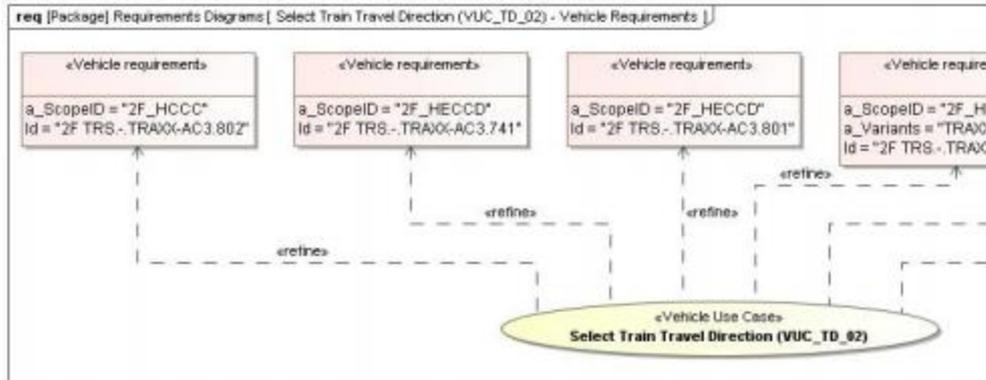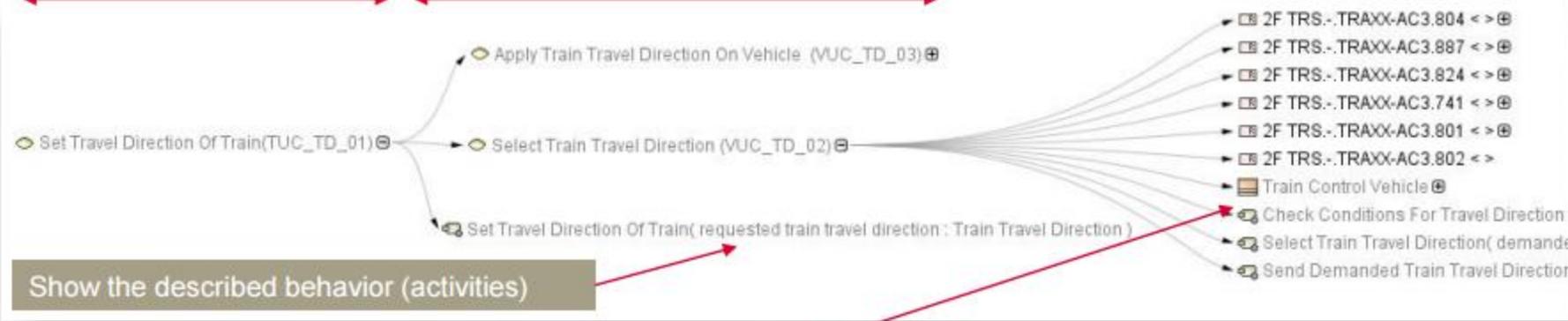
Parties Involved

- MBSE Center of Excellence
- Regular employees

Deliverables

- Employee acceptance
- Methodology evolution

Showstoppers

- Actual value is not proved
- Resistance to cultural change

Duration: ~ 12 months

Running Pilot

Modeling methodology was established on small parts of the product

Invested in trainings and mentoring of regular employees

It took several years (including the Institutionalize phase) to get the modeling methodology mature:

- 10 Workshops and trainings (2-3 days)
- Extensive mentoring (external experts)

Modeling guidelines is a must

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Parties Involved:

- MBSE Center of Excellence
- Regular employees

Deliverables:

- **MBSE is the New SE**

Duration: 6-18 months

Institutionalization

Applies the modelling methodology on the entire product

Shares the best practices of MBSE deployment with other departments and organizations

Participates in worldwide-known events on MBSE and hosts a few of them

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Lessons Learned

Define modelling guidelines

Think BIG, start SMALL

Choose suitable tools

Follow standards

Provide structured training courses

Coach, support, and audit frequently on site

Invest for the long term

Continuously improve the MBSE approach

Summary: Deliverables of MBSE Deployment

- MBSE CoE
- MBSE literacy

- Employee acceptance
- Methodology evolution

Believe	Understand	Build Proof of Concept	Run Pilot	Institutionalize

Management commitment

- Methodology choice (reference model, modeling guidelines)
- Tool choice
- Tool customizations

SE = MBSE
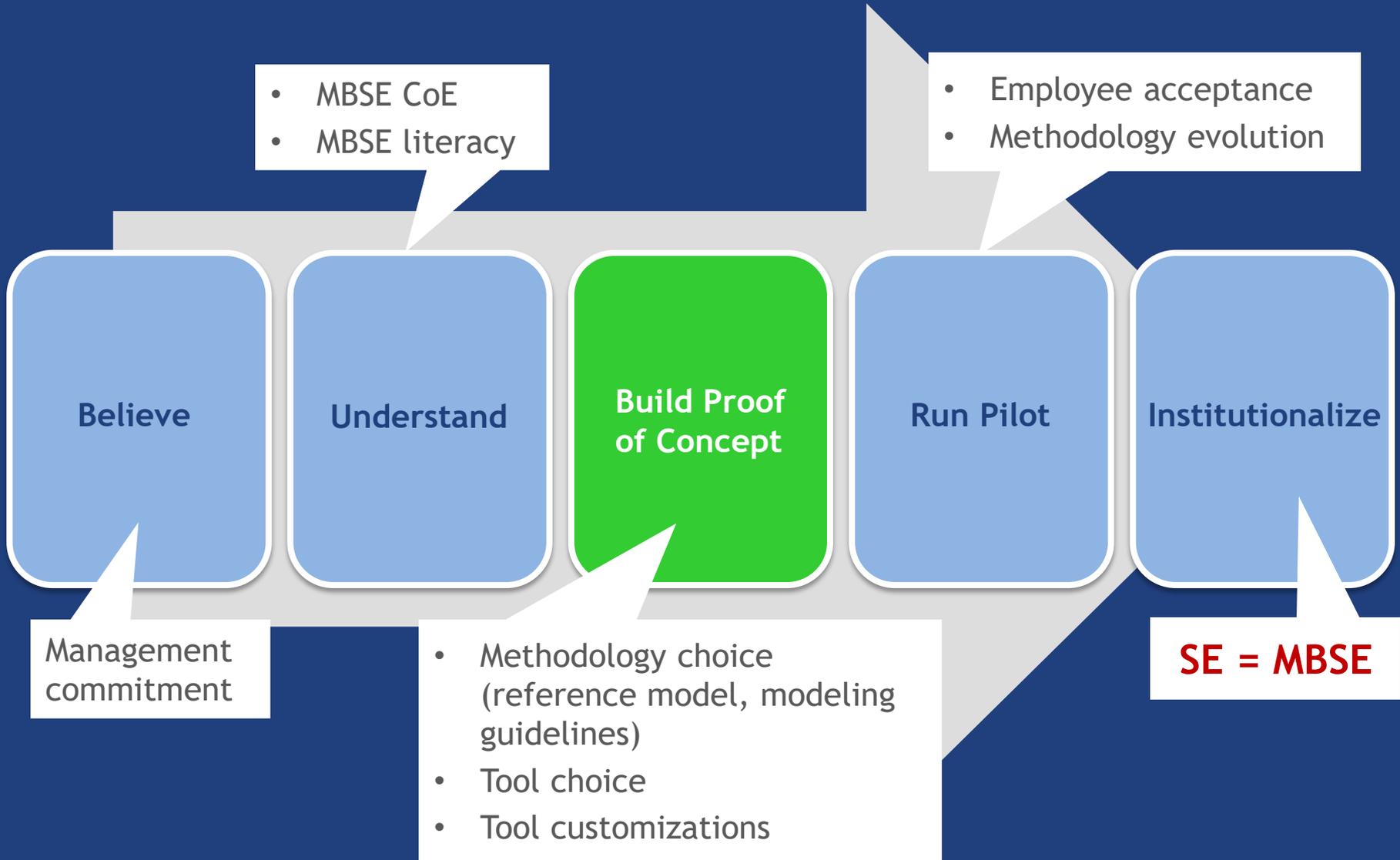
Innovation Drives Success ;)
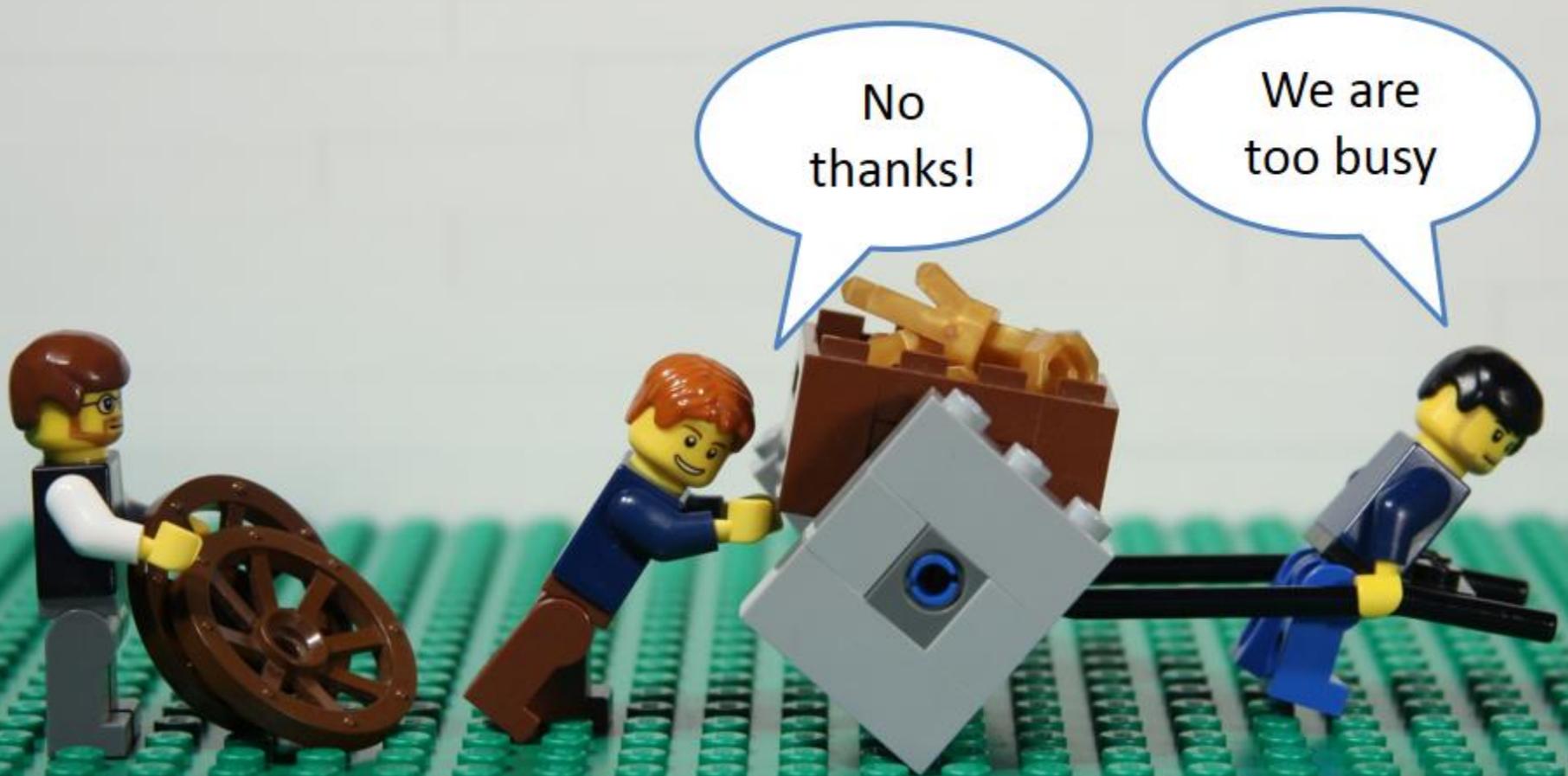
Thank you!

Aistė Aleksandravičienė
aiste.aleksandraviciene@nomagic.com