How MBSE is used in Rail

INCOSE International Workshop
25-28 Jan 2014

Dr. Mike Brownsword
Atkins

Plan Design Enable
Overview

• Introduction
  • Company overview

• Using MBSE
  • Process definition
  • Requirements
  • Architecture
  • V&V/assurance

• Delivering MBSE
Introduction

Model-based Systems Engineer - Rail
• London Underground,
• Network Rail,
• HSL Zuid,
• MARTA.

Atkins Consultant
• Requirements, Architecture, Information, Architecture Frameworks, Process definition.
Company overview
At a glance

Atkins is one of the world’s leading design, engineering and project management consultancies.

We have the depth and breadth of expertise to respond to the most technically challenging and time-critical infrastructure projects and the urgent transition to a low carbon economy.

In 2013 Atkins is celebrated 75 years in business.
Our clients

Revenue by client type

Key Transport clients include:
Network Rail
Texas Dept of Transportation
UK Highways Agency
Florida Department of Transportation
Transport for London
Trafikverket
BAM Group (UK)
Banedanmark (RailDenmark)

New York City Transit
MTR Corporation Ltd
Etihad Rail Company PJSC
Jernbaneverket (Rail Norway)
Ministry of Municipality & Urban Planning (MMUP) Qatar
Crossrail
MARTA
Detailed design of twin bored tunnels, and design and specification Tottenham Court Road and Custom House stations and Plumstead depot.
Birmingham New Street Station
United Kingdom

Lead consultant, design management and urban planning

Image courtesy of Network Rail
European Rail Traffic Management System
Denmark

Client advisor for the design, implementation and testing of ERTMS on the entire Danish rail network (3200km)
Using MBSE

Process Modelling
Process definition

Aim
- Identify the right process
- Understand the information and activities to be delivered
- Ensure consistency between activities and information
- Focus on Activities not documents

Approach
- Take multiple views of a process
- Combine/contrast views to provide consistency.
- Be pragmatic regarding rigour and maturity of information.
- Expect repetition of processes, not one shot.
Process definition

Process List

Process

Requirements Planning
Requirements Elicitation
Requirements Development

Process Flow

Requirements Management
- Processes, Guidance and Examples Document
- Guides elicitation

Context
- Contains

Source Documentation
- Standards
- Project Documentation
- Previous project documentation
- Requirements Elicitation Stakeholders
- Checklists and aids for elicitation

Requirements Elicitation Output
- Defines methodology for eliciting

Requirements Management Plan
- Assumes, Dependencies and Caves
- Requirements
- Trace

Repository
- Stores and enables management of documents

Elicitation Record

Process Information
Process definition

Benefits

• Cross domain application
• Enables balance between generic process and specific technique.
• Relevant to people with differing levels of expertise.
• Consistent activities and information
Using MBSE
Requirements Modelling
Requirements Analysis

Aim

- Ensure requirements have a home
- Understand the essence of the requirements
- To support the development of the whole set of requirements – not just individual statements.
- Understand the problem and whether it is being solved.
- Differentiate between different types of requirement (Stakeholder vs System)

Approach

- Provide relationships between requirements within a set
- Clearly separate requirements into contexts
Identifying Complexity
The Tail of the Brontosaurus
Comparing contexts

Safety Officer's Requirements Context

- Ensure Safety
- Ensure Safety of Equipment
- Ensure Safety of People
- Analyse Context
- Analyse System
- «Stakeholder» Systems Engineer
- «Stakeholder» Escapologist

Systems Engineer's Requirements Context

- Engineer System
- Demonstrate Usefulness of Modelling
- Show Systems Approach
- «Stakeholder» Safety Officer
- «Stakeholder» Marketing

Escapologist's Requirements Context

- Look Great
- Don't Die
- Escape
- «Stakeholder» Film-maker
- «Stakeholder» Assistant
- Set-up
- Get-out
- Make People Sweat
- «Stakeholder» Audience

Marketing Requirements Context

- Create leads
- «include»
- Promote Services
- «include»
- Be interesting
- «include»
- Promote tools
- «include»
- Promote SysML
- «include»

Assistant «Stakeholder»

Analyse Context

Ensure Safety

Ensure Safety of Equipment

Ensure Safety of People

Analyse System
The Tail of the Brontosaurus
Requirements Analysis

Benefits

- Enables well structured requirement sets to be developed
- Enables visualisation of requirements including relationships between functional and non-functional.
- Model-based view validates text
- Improves communication and engagement with stakeholders
- Enables conflict resolution
- Enables levelling of requirements
Using MBSE
Architecture Modelling
Architecture

Aim
- Facilitate development of and capture design information
- To answer specific stakeholder questions/issues/concerns, i.e. How do we migrate?
- Deliver facts aligned with fuzzy pictures
- Ensure it isn’t ‘just‘ another railway
- Understand boundaries and interfaces
- Ensure structure and function are consistent

Approach
- Deliver information in the best way for the stakeholder to understand.
- Provide multiple representations of information where appropriate.
- Ensure consistency between information.
Many Views make lite work
Architecture

Benefits

- Enables confidence in design
- Facilitates focused technical discussion.
- Enables re-use of information
- Provides consistency
- Supports demonstration of performance
Using MBSE
V&V/Assurance
V&V/Assurance

Aims
• Ensure all requirements are met
• Reduce manual application of traceability
• Increase consistency

Approach
• Provide rich traceability
• Integrate Requirements and Architecture
Tracing distributed systems

Each of these links must be independently verified for full technical assurance.

Requirement
Minimise environmental impact
type a)

Requirement
W10 structure gauge
type b)

Requirement
No impact piling near Mr X’s house
type c)

Physical
OLE Production Unit GW/00

Physical
OLE Structure GW/00/00

Physical
OLE Structure GW/00/00/01

Physical
OLE Production Unit GW/00/02

Physical
OLE Structure GW/00/02/01

Physical
OLE Production Unit GW/01

Physical
OLE Structure GW/01/01
Multi-level applicability of requirements

- Requirement Type a) requirement
  All elements
  traces to
  Physical T00 Generic design element

- Requirement Type b) requirement
  All elements of type
  traces to
  Physical T03 OLE Structure

- Requirement Type c) requirement
  location specific
  traces to
  Physical GW/00/01 structure
Inferred applicability

Inference:
If ‘Signal Head’ traces to ‘Requirement 1’
and ‘colour light signal’ is a type of ‘Signal Head’
then a ‘colour light signal traces’ to ‘Requirement 1’
V&V/Assurance

Benefit

• Integrates Architecture and Requirements
• Enables re-use and normalisation information
• Provides consistency of traceability and approach
• Delivery of information to conform with stakeholder need
Delivering MBSE
Information Modelling
Information Modelling

Aim
- Understand the information required
- Understand the relationship between the information
- Understand how it all fits together
- Enable successful delivery to stakeholders.

Approach
- Organise information for the business
- Use the businesses terminology
What are the Views

The Context of a set of information

- **Discipline View Set**: Defines the hierarchy of the elements.
- **Technical View**: Shows relationships between the elements as pictures, tables and matrices.
- **Functional View**: Defines need for the requirements of the element.
- **Asset Breakdown View**: Shows what the element does and the information flow between elements.
- **Agent**: Considers transition to
- **Asset Migration View**: Considers transition to
- **Physical View**: Defines functions of
- **Interface View**: Shows relationships between
- **Functional Needs View**: Defines the requirements of the element.
What is the Information Asset Function Technical requirement Interface is performed by relates to defines need for communicates information to The problem the asset has to solve Requirement Satisfaction Requirement Traceability Asset decomposition Functional decomposition Asset Interaction The things the element does Functional allocation Asset Interaction The way the information is passed
Information Modelling

Benefit

- Enables consistent information definition
- Enables Impact analysis
- Assessment of information maturity
- Enables consistency of approach
- Brings together process, Architecture, Requirements and Assurance
Questions

mike.brownsword@atkinsglobal.com