# MBSE and MDA; what are they and how do they interrelate?

# 2016 03 03 INCOSE UK MBSE WG Julian Johnson



© Holistem Ltd 2016

#### So how do MBSE and MDA relate?





#### **MBSE** visualisation





#### **Current Practice to Future Practice**

International Workshop 25 Jan – 26 Jan 2014 Torrance, CA, USA



#### MBSE

- An approach to performing SE
- Based around models as a fundamental way of capturing, structuring and exploiting information
- Contrasted with conventional or document-based SE (DBSE)
- Requires a different skill set and tools to DBSE
- Domain: any context in which systems engineering may be applied – development of complicated / complex products or services



# Seeds of MDA – raising the levels of abstraction, of re-use



#### **MDA** visualisation



Source omg-03-06-01 MDA Guide Rev 1.0.1



Figure 6-1

Source ormsc-14-06-01 MDA Guide Rev 2.0



"A metamodel is simply a model of a modelling language. It defines the structure, semantics and constraints for a family of models."

*JJ: Note computer science distinguishes between: abstract syntax, concrete syntax and semantics.* 

"Central to MDA is the notion of creating models at different levels of abstraction and then linking them together to form an implementation". *JJ: "to form an implementation" has a software/IT slant; in principle you can link models together for other than implementation e.g. validation (fit for purpose.)* 



Quotes from MDA Distilled, Mellor et al

#### Models are not just about software



Source: Model-based tool support for Tactical Data Links: an experience report from the defence domain, Suraj Ajit, Chris Holmes, Julian Johnson, Dimitrios S. Kolovos, Richard F. Paige, Softw Sys Model, DOI 10.1007/s10270-015-0480-2, 2015



© Holistem Ltd 2016

#### Real world, instances, models



Figure 3-1 Abstraction, classification, and generalization



© Holistem Ltd 2016 Source: MDA distilled, Mellor et al

#### Models and metamodels





Figure 4-2 Metamodel in relation to developer models

<sup>©</sup> Holistem Ltd 2016 Source: MDA distilled, Mellor et al

11

#### Is MDA vapourware? No, but...

SPARX	🛞 Enterprise Architect 👔 Products 🧭 Resources 🐾 Forum 🥐 Support 🌼 Services 💼 Login
SYSTEMS	🗢 UML Tutorial 🥼 About Us 🍹 Buy View / Checkout Search Sparx Systems 🗸 🔎 🛞 🚱
Index Model Transformation	Search User Guide Go
Transform Elements Built-in Transformations	Model Transformation
Edit Transfor Write Transfor	nsformations
The Enterprise Archit	tect installer includes a number of basic built-in transformations, including:
<ul> <li>C#</li> <li>C++</li> <li>DDL table eler</li> <li>EJB Entity Bei</li> <li>EJB Session E</li> <li>Java</li> <li>PHP</li> <li>VB.Net</li> <li>XSD</li> <li>Data Model to</li> <li>Entity Relation</li> <li>Sequence diag</li> </ul>	ments an Bean o Entity Relationship Diagram (ERD) inship Diagram (ERD) to Data Model

#### **Customized Transformations**

You can modify the built-in transformations or define your own, using Enterprise Architect's simple code generation template language. This involves little more than writing templates to create a simple intermediary source file; the system reads the source file and binds that to the new PSM.



website.

#### Model in MDA e.g. any model structured via a metamodel





meta-

model

model

Source: Model-based tool support for Tactical Data Links: an experience report from the defence domain, Suraj Ajit, Chris Holmes, Julian Johnson, Dimitrios S. Kolovos, Richard F. Paige, Softw Sys Model, DOI 10.1007/s10270-015-0480-2, 2015

#### Generic tools for models, transformation, DSLs

**Epsilon** is a family of languages and tools for code generation, model-to-model transformation, model validation, comparison, migration and refactoring that work out-of-the-box with EMF <u>and other types of</u> models.





Source <a href="http://www.eclipse.org/epsilon/doc/">http://www.eclipse.org/epsilon/doc/</a>

#### Model in MBSE: e.g. Intercax Total System Model



Where the domain of the 'model' could be that appropriate to any systems engineering development...

#### Example use of DSLs - 1



holistem

holistic perspectives, your systems 16

#### Example use of DSLs - 2





#### Example use of DSLs - 3





© Holistem Ltd 2016 Source http://www.abstractsolutions.co.uk/XUML/dsl.php

### MDA

- Originated in software engineering OMG
- An approach to developing applications / solutions through a combination of models and transformation of models
- Based around models as a fundamental way of capturing, structuring and exploiting information
- Contrasts with conventional software development (CSD: requirements capture, design, coding, testing, acceptance) and other approaches (Agile, SCRUM...)
- Requires a different skill set and tools to CSD
- Domain: any domain where information handling and / or software development would apply to address business problems, or give business advantage



## So how do MBSE and MDA relate?

- What's common?
- Do they overlap in domain?
- Does one support the other?
- Are they mutuallysupportive?





#### What's common

- Concept of 'a model' is common, and central to both
- Model in each means similar things
  - Representing some aspect of the problem / solution domain, with a degree of rigour, as an reusable asset, and about which you can reason
- But 'model' in each has different emphasis, focus, or domain...



# Different interpretations of model

#### MBSE

- 'a systems model' or 'total system model' or 'unifying model'
- Generally not a detailed highfidelity model, or a technology domain model (electrical, structural, hydraulic...)
- Strong relationship to the metamodel of the SysML (and UML) profile
  - Blocks, activities, transitions, requirements,...

#### MDA

- Model represents a particular domain
- High, medium or low level of abstration
- High or low fidelity
- Aspect or recognisable discipline area
- Structured by an appropriate metamodel (captures the concepts and interrelationships of the domain)



#### JJ Interpretation

- MDA is more generic in its interpretation of model [than in MBSE]
- MDA is more of an enabling approach (wide applicability) cf MBSE which has the 'SE' focus
- MDA could be viewed as an enabler to cross-disciplinary, cross-domain integration – and complementary to other technologies like OSLC, XML, java...





#### Domain expertise – an under-exploited union?



## Summary

- MBSE and MDA are complementary
- MDA is more of an enabling approach (wide applicability) cf MBSE which has the 'SE' focus
- COTS SE tools do increasingly reference MDA
- MDA is much more than PIM -> PSM;
- MDA about DSLs, transformations etc.
- Domain expertise across systems engineering and software engineering – an underexploited union?



# questions



#### Sources - MBSE

Source and ref	Value, significance
Systems Engineering with SysML/ UML, Tim Weilkiens, 2007	Unusual in the SysML books in having a strong process perspective (of sorts).
A Practical Guide to SysML, Friendenthal, Moore, Steiner, 2012	The 'definitive' SysML text book. A lot of detail.
SysML Distilled, 2014	A useful gallop through SysML, much lighter weight than Friendenthal et al,
	but gets the essence, and a useful complement to that book.
Engineering Complex Systems with Models and Objects, Olvier, Kelliher,	Description of systems engineering making use of models, without using the
Keegan, McGraw-Hill, 1997	phrase or acronym MBSE. Includes both process and information models
Engineering Complex Systems with Models and Objects - EngComplexSys.pdf	associated with a view on systems engineering.
http://oldsite.incose.org/ProductsPubs/DOC/EngComplexSys.pdf	
Model-based Systems Engineering (MBSE) 101, Elyse Fosse, NASA Jet	Contains useful presentation material organised around 13 FAQ's on the
Propulsion Laboratory, California Institute of Technology, presented at	topic of MBSE.
INCOSE IW California, January 2014.	
ISO 15288:2015, System life cycle processes	International consensus view on the activities as functional areas of the
ISO.	discipline of systems engineering.
INCOSE Systems Engineering Handbook, 4 <sup>th</sup> edition, Wiley, 2015.	Further elaboration of the process areas of systems engineering outlined in
	ISO 15288:2015.
Model-based-Systems-Engineering-MBSE-101.pptx,	2014 Jan INCOSE IW – relatively recent.
In "C:\Users\Julian\Documents\ref materials\MBSE"	Visualisations of shared models (slides 10, 14, 20, 21).
OMG MBSE Wiki	Focal point for INCOSE MBSE work, including
http://www.omgwiki.org/MBSE/doku.php?id=mbse:incose mbse iw 2016	<ul> <li>Info presentation at IS and IW meetings from 2011 to date;</li> </ul>
(and previous years IS and IW)	<ul> <li>Challenge Teams – basically tackling challenges in different industry</li> </ul>
	sectors (Space Systems, biomedical, Telescope modelling);
	<ul> <li>Activity Teams – cross-cutting themes (MBSE Usability, Methodology</li> </ul>
	and Metrics, Model Management, Modeling Standards, Ontology,
	System of Systems/Enterprise Modeling, Model Based Test)



#### Sources – MDA -1

Source and ref	Value, significance
ormsc-14-06-01 MDA Guide Rev 2.0 http://www.omg.org/cgi-bin/doc?ormsc/14-06-01	15-page, dated 01/6/2014, explanation of MDA and its capabilities and potential advantages, albeit with a bias towards the positives. Does acknowledge more upfront effort is likely <u>cf</u> conventional development, but with less coding and debugging. Also MDA adoption can be incremental, rather than all or nothing. Introduces (some of) the MDA-enabling standards. Some curious changes of emphasis between software-centric and system- centric (multi-technology) views. Tends to ignore non-OMG standards that are also fundamental to MDA, like XML, XSD (XML Schema). Only 1 diagram: PIM -> PSM, transform and transform specification. References the MDA Foundation model.
ormsc-10-09-06 MDA Foundation model http://www.omg.org/cgi-bin/doc?ormsc/10-09-06	Explanation of the main concepts underlying MDA, including system (OMG MDA definition), model, transformation, meta-model, viewpoint, view, etc.
omg/2003-05-01 MDA Guide version 1.0 http://www.omg.org/mda/mda files/MDA Guide Version1-0.pdf.	62 pages, Version 1 dated 1/5/2003. Has conventional PIM -> PSM via transformation. Many diagrams. Reference to use of Patterns, and Marked PIMs. Multiple transformations, hiding detail via abstraction. No reference to a 'Foundation Model', but references other things, like CORBA, Component Model, UML Profile Large number of contributors
MDA home at OMG http://www.omg.org/mda/index.htm	Home of MDA at OMG, contains large body of information if you dig. Links to specifications, presentation and papers. However, some material can be quite old e.g. ~2002.
MDA Distilled: principles of Model-Driven Architecture, Mellor, Scott, Uhl, Weise http://www.amazon.co.uk/MDA-Distilled-Integration-Architecture-Addison- Wesley/dp/0201788918/ref=sr 1 fkmr0 1?ie=UTF8&qid=1455781132&sr=8- 1-fkmr0&keywords=MDA+Distilled%3A+principles+of+Model- Driven+Architecture	A much deeper and comprehensive explanation of MDA than in the two recent OMG documents referenced elsewhere in this table.



#### Sources – MDA -2

Source and ref	Value, significance
Model Driven Architecture with Executable UML,	Excellent account of domain models, and of linking of domain models.
Raistrick, Francis, Wright, Carter, Wilkie	
http://www.amazon.co.uk/Architecture-Executable-Raistrick-published-	
University/dp/B00EKYJ1EI/ref=sr 1 3?ie=UTF8&gid=1455781243&sr=8-	
3&keywords=Model+Driven+Architecture+with+Executable	
Model Driven Engineering and Ontology Development,	This covers MDE with an Ontology and knowledge management
Gasevic, Djuric, Devedzic	perspective. Chapters 4 and 5 are quite good at covering Model Driven
http://www.amazon.co.uk/Model-Driven-Engineering-Ontology-	Engineering and Modelling Spaces as a complement to the OMG materials.
Development/dp/3642002811	Later chapters (e.g. 7) look at an MDA approach to bringing the RDF(S)
	(from knowledge engineering) and MOF together.
Model-Driven software development	A useful summary presentation on MDA. However, does seem to focus on
http://www.ida.liu.se/~chrke55/courses/SWE/F16-MDA.pdf	only the PIM -> PSM -> code perspective of MDA.



#### reserves



#### STEP ISO 10303 Product Data Exchange

The STEP APs can be roughly grouped into the three main areas design, manufacturing and life cycle support.

Design APs:

- Mechanical:
  - AP 207, Sheet metal die planning and design
  - AP 209, Composite and metallic structural analysis and related design
  - AP 235, Materials information for the design and verification of products
  - AP 236, Furniture product data and project data
  - AP 242, Managed model based 3d engineering
- Connectivity oriented electric, electronic and piping/ventilation:
  - AP 210, Electronic assembly, interconnect and packaging design. The most complex and sophisticated STEP AP.
  - AP 212, Electrotechnical design and installation.
  - AP 227, Plant spatial configuration
- Ship:
  - AP 215, Ship arrang
  - AP 216, Ship mould
  - AP 218, Ship structu
- Others:
  - AP 225, Building ele
  - AP 232, Technical de
  - AP 233, Systems en
  - AP 237, Fluid dynan

- Manufacturing APs:
- AP 219, Dimensional inspection information exchange
  - AP 223, Exchange of design and manufacturing product information for cast parts
  - AP 224, Mechanical product definition for process plans using machining features
  - AP 238 Application interpreted model for computer numeric controllers
  - AP 240, Process plans for machined products
- Life cycle support APs:
  - AP 239, Product life cycle support
  - AP 221, Functional data and schematic representation of process plants
  - AP 241, Generic Model for Life Cycle Support of AEC Facilities (planned)



