



Model Based Systems Engineering 'The State of the Nation'

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Introduction

- Right from the very first meeting in 2012 of the Model Based Systems Engineering Working Group it became apparent that:
 - The term “Model Based Systems Engineering” (MBSE) is not very well defined or understood.
 - Some Systems Engineers (SEs) hold the view that there is no (or little) distinction between MBSE and what they refer to as “Good Systems Engineering”.
 - Many SEs currently utilise diagrams and simulations in their work but do not consider they are doing MBSE.
 - It is not clear if MBSE is just an academic theory, the tool vendor’s sales pitch or whether organisations are successfully using MBSE to realise measurable benefits on real SE projects.

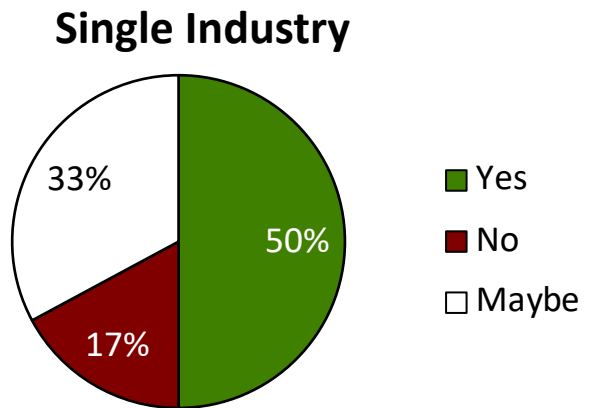
Mission Statement

- The aims of the MBSE WG are to:
 - Promote the use and understanding of MBSE,
 - Facilitate and improve communication between System Engineers practicing MBSE,
 - Identify and catalogue the Tools, Techniques and Languages used,
 - Provide guidance on how to best apply MBSE techniques across the lifecycle, and
 - Support the MBSE Initiative run by INCOSE Central and the OMG.

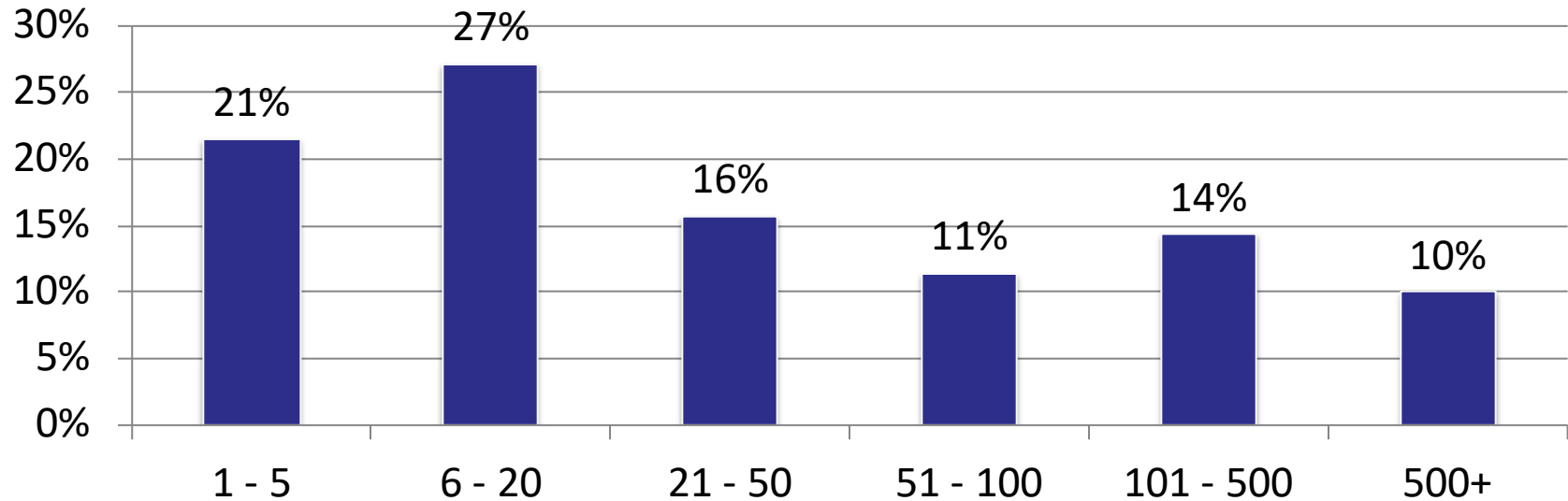
MBSE Survey

- Online Survey covering 4 areas:
 - The respondent and their organisation (3 questions)
 - General Modelling (6 questions)
 - Model Based Systems Engineering (10 questions)
 - Simulation (9 questions)
 - I will not be presenting the results of the Simulation section today
- Initially only publicised to members of the WG (17/05/13)
 - After first 3 months only 4 responses received!
- Subsequently advertised to all UK membership (30/09/13)
 - 70 responses received when closed on 18/10/13
 - 29 responses received in last 24 hours.

Q1.1 – Your Industry



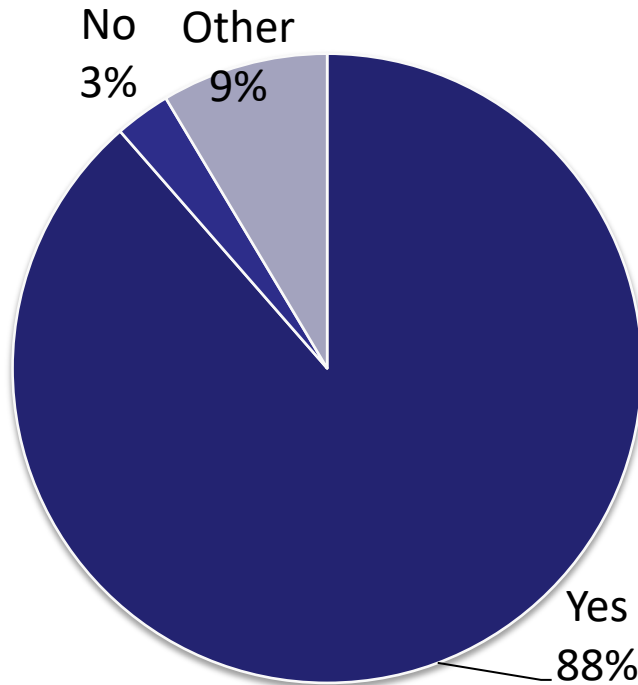
Q1.3 – How big is the SE function within your organisation?



1 to 20 = 48%

1 to 50 = 64%

Q2.1 – Do you use modelling in your work?

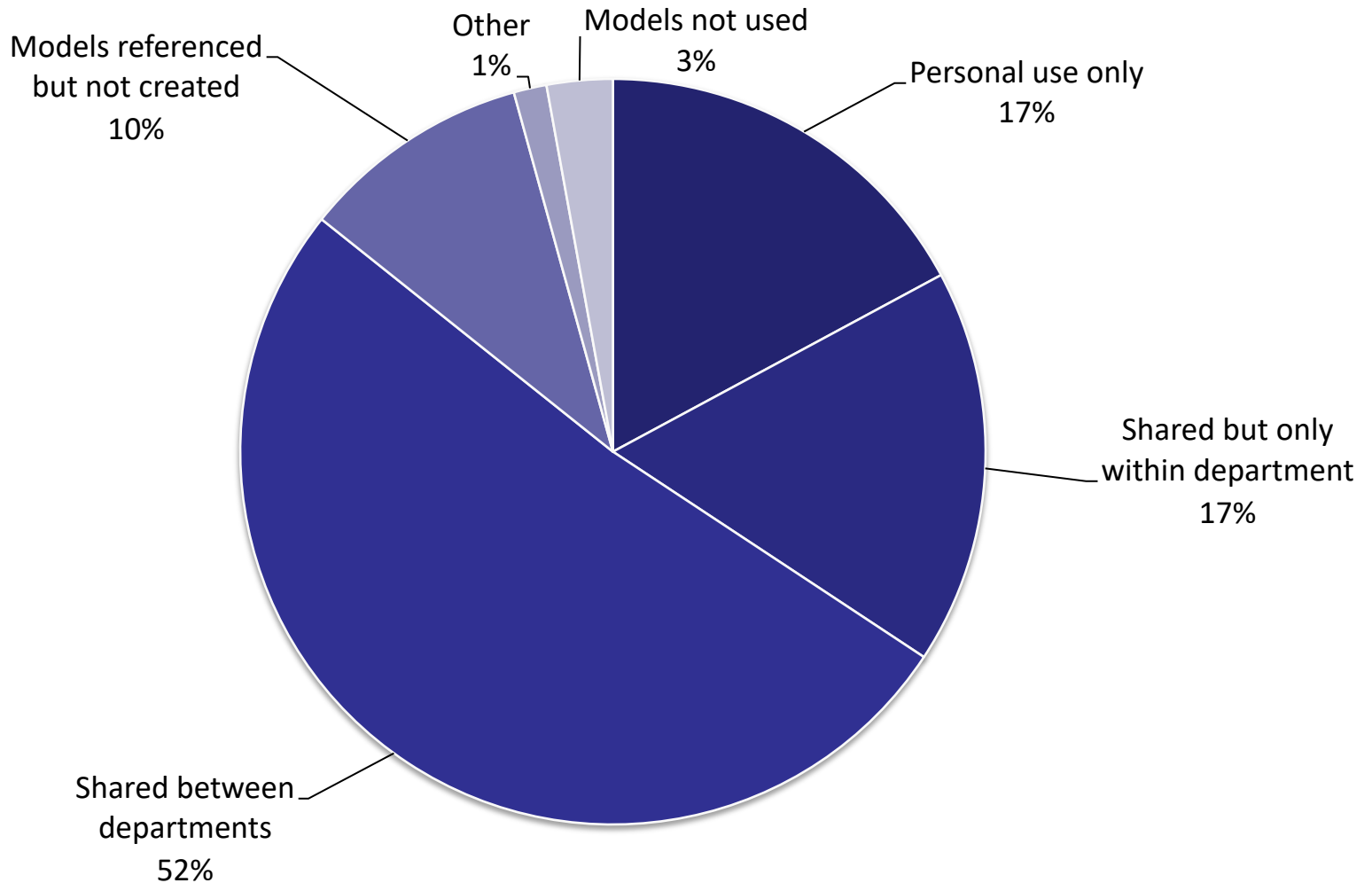


Other responses:

- On some assignments, depending upon client
- Limited use
- I own the tools and specify strategy & process
- Occasionally
- Sometimes
- If relevant

Conclusion:
Respondents were self selecting to those who currently use modelling in their work

Q2.2 – Model Sharing



Q2.4 - In which SE activities do you use modelling?



- Respondents were offered 11 SE activities to choose from:

Activity	Number	%
Analysing System Requirements	57	81%
Defining System Requirements	53	76%
Defining Logical Architecture(s)	48	69%
Scenario Modelling	48	69%
Analysing Stakeholder Needs	47	67%
Capturing Stakeholder Needs	47	67%
Verification & Validation	41	59%
Trade-off Studies	34	49%
Life Cycle Cost Analysis	27	39%
RAMS Analysis	18	26%
Synthesising Allocated Architecture(s)	18	26%
Other	11	16%

Q2.4 – SE activities (continued)

- Some of the other activities given include:
 - 3D modelling of civil infrastructure for clash detection at contractor interfaces
 - Asset management
 - Defining system architectures
 - Design decision making
 - Develop the contextual construct
 - Dynamic systems models
 - Modelling engineering and business processes
 - Situation Awareness (e.g. 'intelligence' to support military operations)

Q2.5 – What modelling languages do you use?

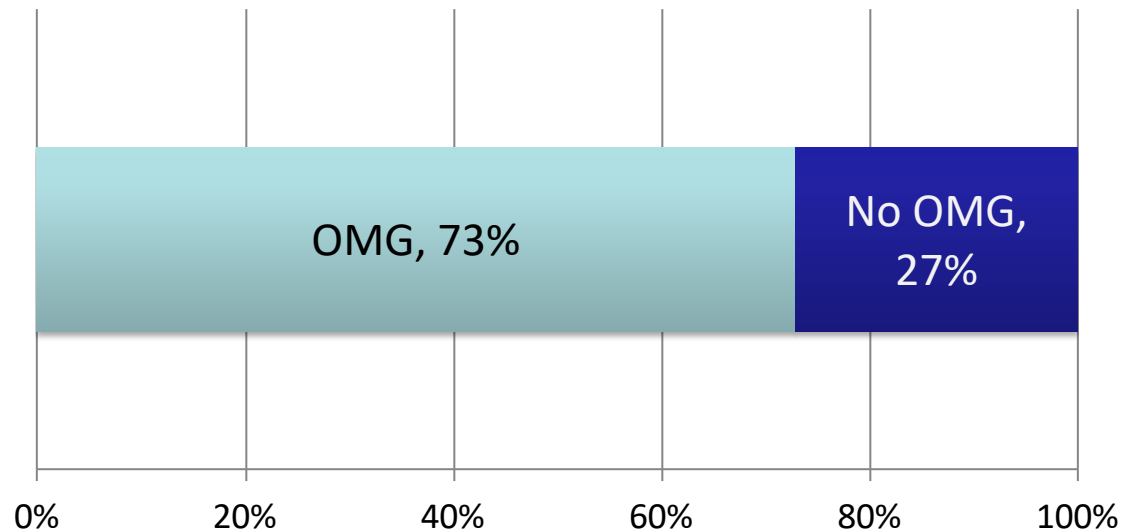
- Respondents were offered a selection of 25 languages with the option to record any others
 - 19% of respondents recorded one or more additional language not on our list
 - At least 10 additional ‘languages’ were recorded in total (although some of these were actually architectural frameworks)
- The maximum number of languages selected by a single respondent was 11 with the mean number being 5.5
 - Some overlap exists between the languages e.g. UML, State Machines & Flow Charts
- The list included “Natural Language (Text)” however only 30% of respondents selected it
 - I suspect this is because most respondents don’t equate writing text with modelling

Q2.5 – most widely used languages

Language	Number	%
Unified Modelling Language (UML)	47	67%
Flowcharts	45	64%
Context Diagrams	43	61%
System Modelling Language (SysML)	42	60%
Fault Trees	28	40%
Data Flow Diagrams (DFDs)	27	39%
Rich Pictures	24	34%
Natural Language (Text)	21	30%
Entity Relationship Diagrams (ERDs)	20	29%
State Charts / Finite State Machines	20	29%
Business Process Modelling Notation (BPMN)	14	20%
IDEF	13	19%
Goal Structuring Notation (GSN)	12	17%
Behaviour Trees	9	13%

Q2.5 – OMG v Other

- The ratio of respondents who indicated the use of languages defined by the Object Management Group (UML, SysML or BPMN) compared to those that didn't is:



Q2.6 – What software tools do you use?

The top 6 tools were as follows:

Tool	Number	%
Microsoft - Visio	40	57%
Sparx Systems - Enterprise Architect (EA)	31	44%
IBM- Rhapsody	17	24%
Atego - ARTiSAN Studio	15	21%
MathWorks - Simulink	13	19%
Mood International - Mood	10	14%

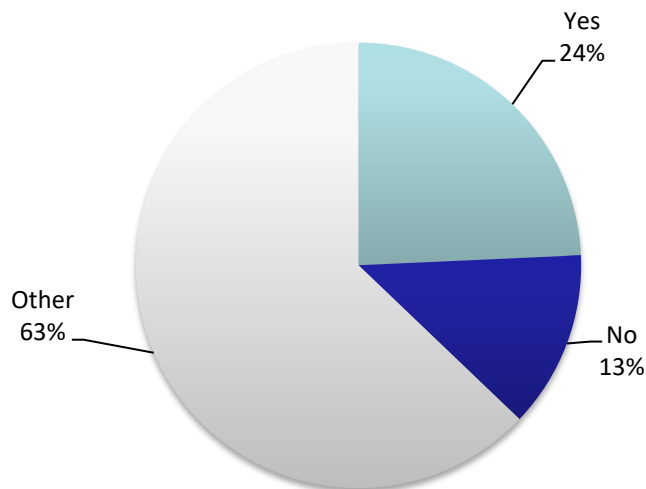
A further 40+ other tools were listed each with a minority (< 7%) usage

19 respondents (27%) indicated they used a single tool:

Visio (9), Enterprise Architect (3), ARTiSAN Studio (3), Rhapsody (1), Mood (1), Simulink (1) & STELLA (1)

Mean number of tools used per respondent: 2.6

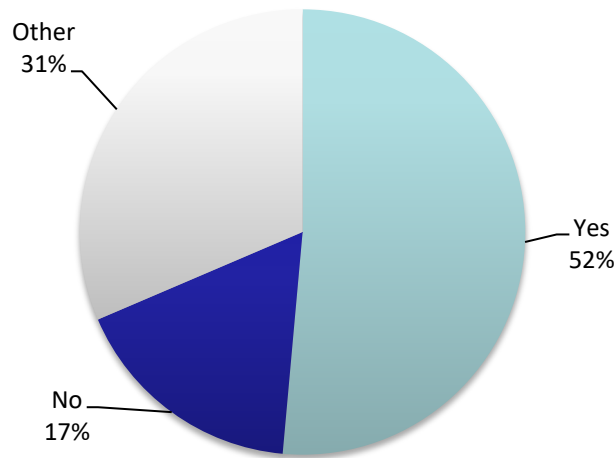
Q2.7 - Is MBSE just the use of models by the SE function of an organisation?



Other responses included:

- MBSE should be used throughout the entire organization.
- It is engineering where the model is central to the engineering activity. Creating models as part of SE does NOT mean that you are doing MBSE.
- Should be conducted by an integrated team in the same way that SE should.
- Refers to process & deliverables across all stages of the life cycle.
- MBSE should inform and support PM functions in their role.
- MBSE could be used by other functions.
- Modelling can be used by other parts of the organisation.
- MBSE is a subset of Model Driven Engineering that is used by all engineers.
- Model based engineering rather than MBSE.
- MBSE impacts all disciplines across the project.
- Used as part of a suite of processes.

Q2.8 - Do you believe your organisation implements MBSE?



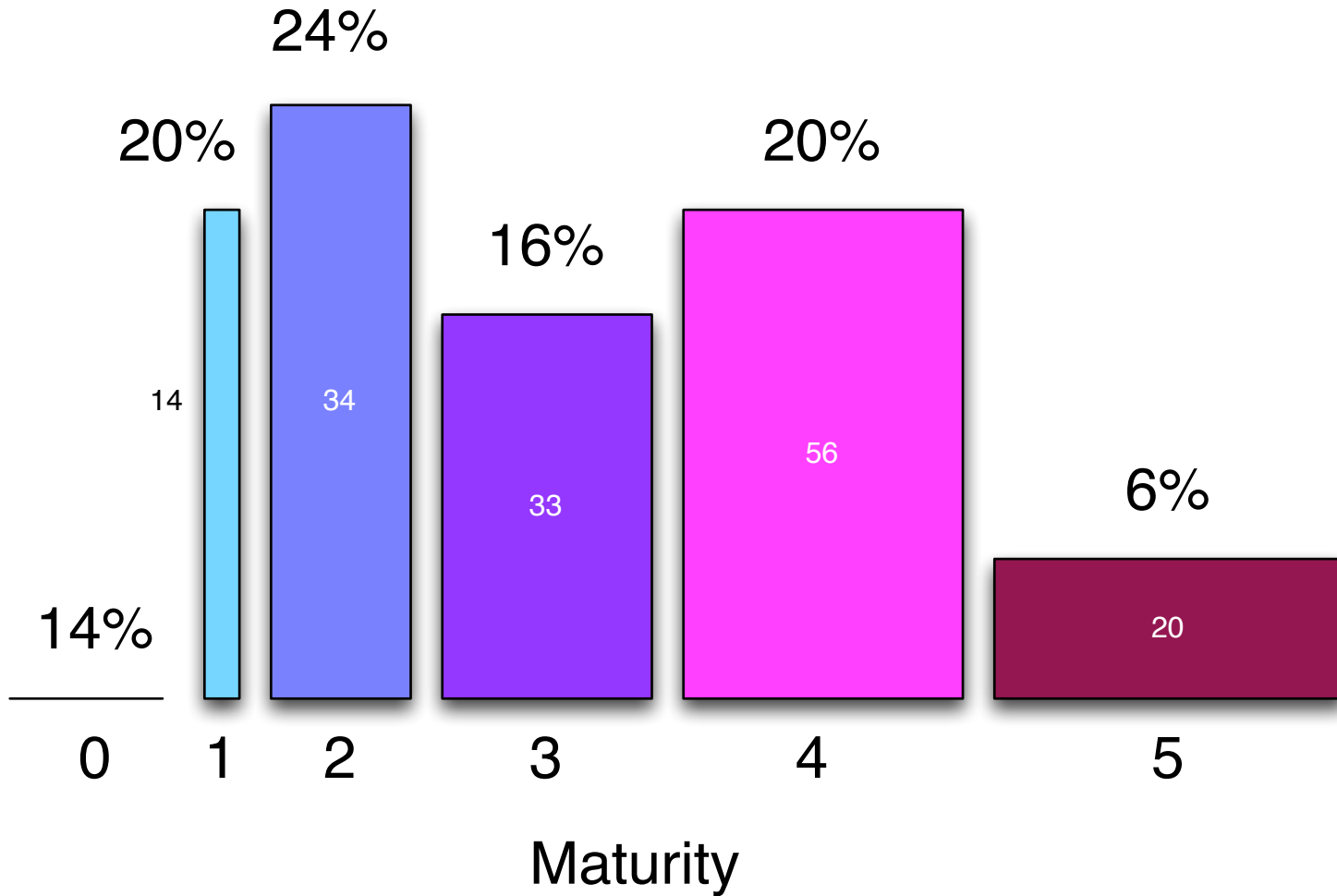
Other responses included:

- Adoption is in its infancy
- In some specific parts/projects only
- A little only
- On project by project basis
- Occasionally
- Lacklustre use
- To an extent
- Change of culture difficult
- Partly and want to expand but there is a knowledge gap
- Not extensively
- We are at the very beginning of implementation
- It's patchy
- Growing in significance

Q2.9- How mature is MBSE within your organisation?

- Stage 0: Not used
- Stage 1: Rarely used, ad hoc use by individuals within departments
- Stage 2: Minor use by departments, but not used across departmental boundaries
- Stage 3: Regular implementation, although not mandatory
- Stage 4: Major implementation, mandatory on specific projects
- Stage 5: Fully implemented, embedded within the culture

Q2.9 Maturity (cont.)



Q2.10 & Q2.11

- Q2.10 asked:
“Which departments use MBSE within your organisation?”
- Q2.11 asked:
“In which life cycle stages does your organisation use MBSE?”

We were unable to succinctly summarise the responses to these questions so they are omitted for brevity.

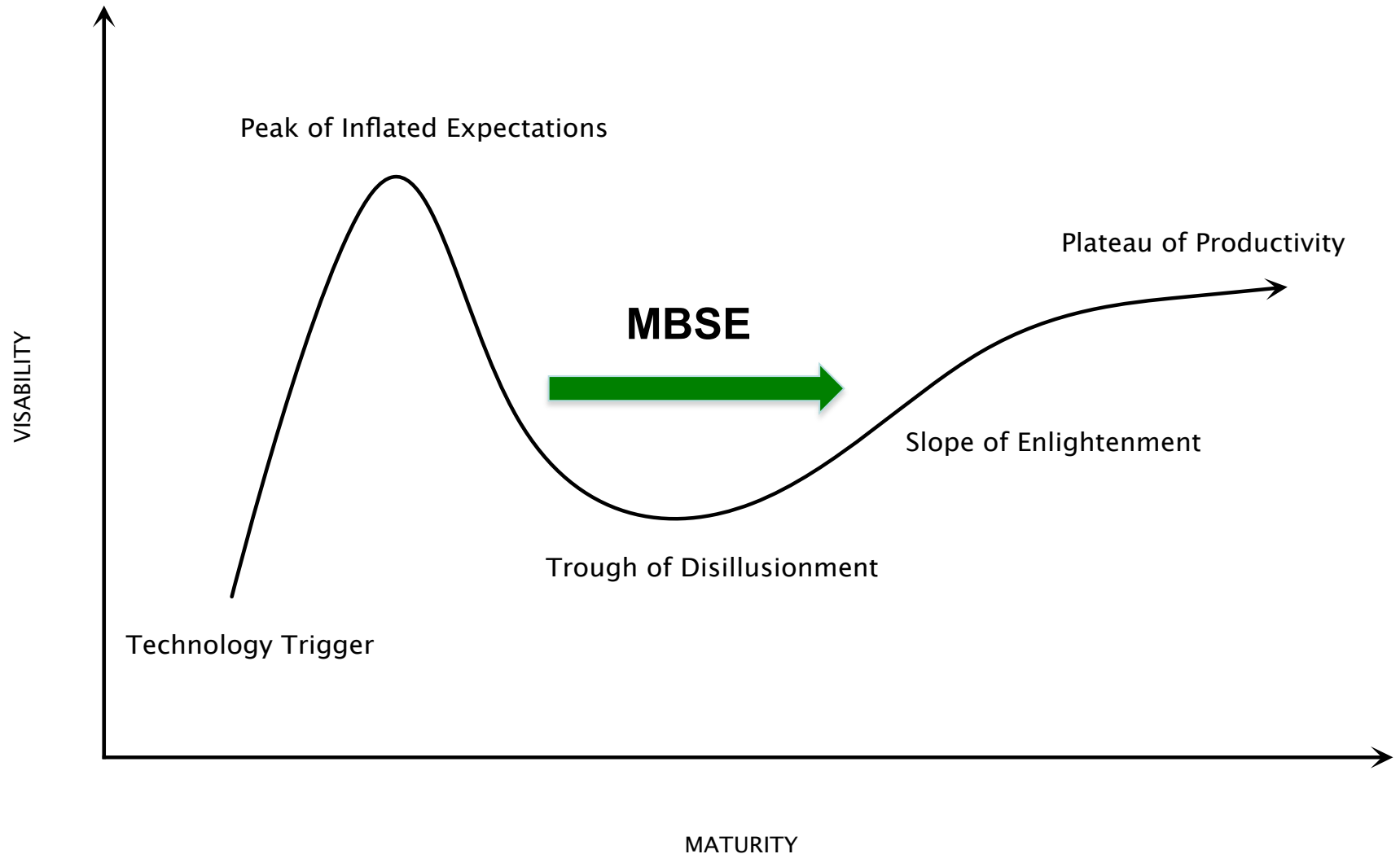
Q2.12 MBSE Processes

“What MBSE Processes / Standards do you use within your organisation or in your customer organization?”

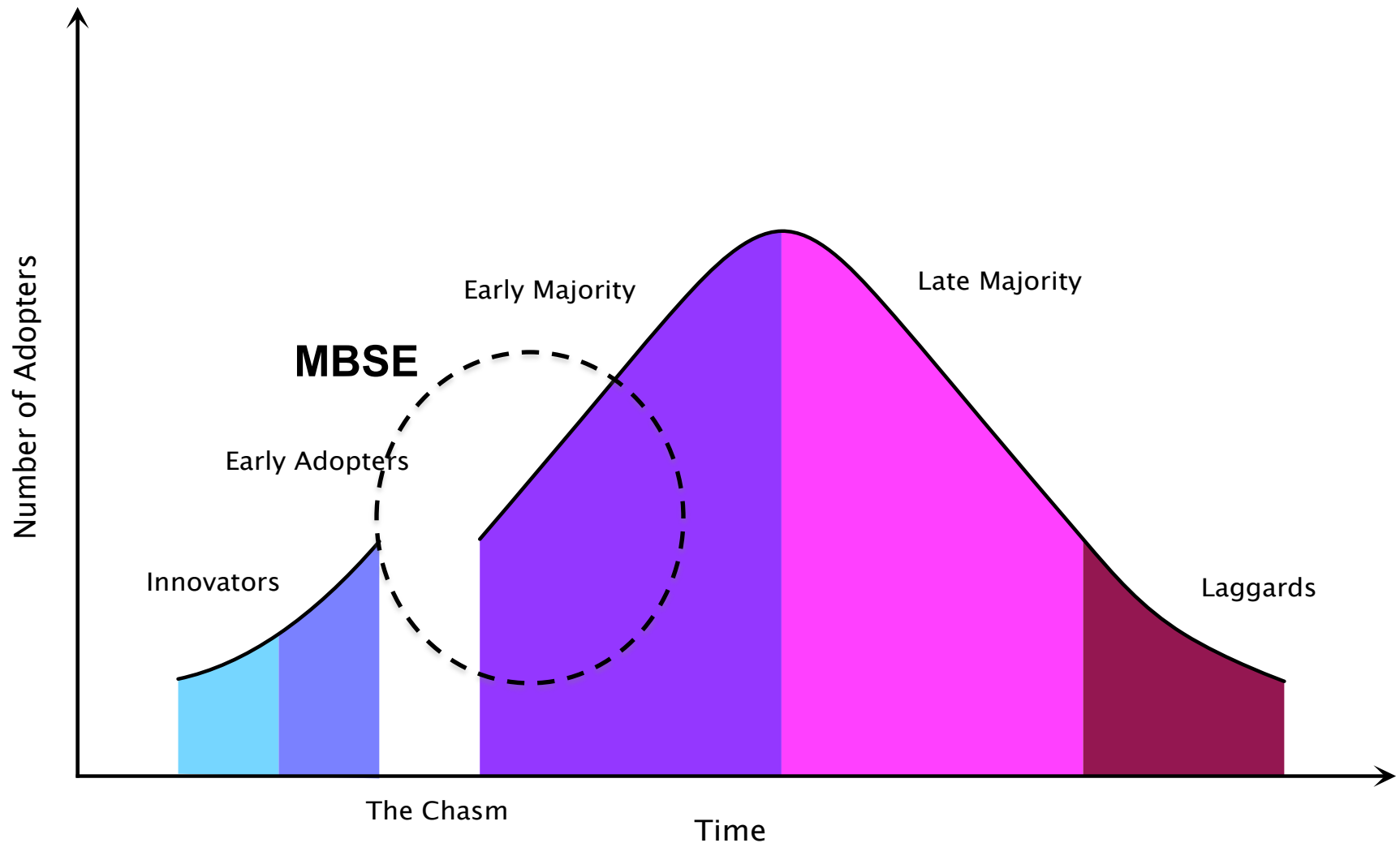
Process	Number	%
None	30	43%
Proprietary	11	16%
IBN Rational Unified Process for Systems Engineering (RUP-SE)	8	11%
INCOSE Object-Oriented Systems Engineering Method (OOSEM)	6	9%
<i>Architecture Frameworks</i>	4	6%
IBM Rational Teleological Harmony-SE	4	6%
Weilkiens Systems Modelling Process (SYSMOD)	4	6%
ISO 15288	2	3%
VITECH Model-Based Systems Engineering (MBSE) Methodology	1	1%
Other	10	14%

ANALYSIS & CONCLUSIONS

Gartner's "Hype Cycle"



Technology Adoption Cycle



Next Steps

- Further analysis of the data
 - Categorise and count the textual answers to questions such as Advantages, Disadvantages and WG Objective
 - Quantify MBSE maturity for using a weighted formula and using answers from multiple questions
 - We can then repeat this in the future to detect any change
 - Look for differences in subsets of the data e.g. by sector, by organisational size etc.
- Ensure the objectives of the WG are aligned and prioritised with the findings from this work

QUESTIONS

Acknowledgments

- The author wishes to thank the following individuals for their assistance with this work:
 - Gonçalo Esteves (Independent) who constructed and published the survey
 - Tom Riley (Thales UK) who provided additional material and feedback

Survey Data

- The complete set of survey data can be obtained by either:
 - Downloading it from the MBSE Working Group Wiki (which can be located via the INCOSE UK website)
 - Contacting the author at james.towers@object-flow.com

