



MBSE Benefits: Evidence from the Literature and Insights from Practitioners

Mrs. Kaitlin Henderson

8th Annual SERC Doctoral Students Forum
HOSTED VIRTUALLY ON: November 17, 2020
www.sercuarc.org



Agenda

- Motivation
- Evidence from Literature
 - Methodology
 - Results
- Insights from Practitioners
 - Survey Overview
 - Results
- Conclusions



Motivation

- Conflicting view of what the benefits of MBSE are in the literature:
 - Some say that benefits have been shown and accepted and are well known
 - Others say that benefits are not well defined and the lack of perceived value is an inhibitor for adopting MBSE

This prompts the question of ***whether MBSE really provides benefits*** with respect to a document-based approach

Holt, J., et al. (2014). "A model-based approach for requirements engineering for systems of systems." *IEEE Systems Journal* **9**(1): 252-262

Ferrogallini, M. (2015). "MBSE in Rail Transportation—Product Families and Product Lines." *INSIGHT* **18**(2): 19-21

Maschotta, R., et al. (2013). A framework for agile development of simulation-based system design tools. 2013 IEEE International Systems Conference (SysCon), IEEE.

Vogelsang, A., et al. (2017). *Should I stay or should I go? On forces that drive and prevent MBSE adoption in the embedded systems industry*. International Conference on Product-Focused Software Process Improvement, Springer



Evidence from Literature



Methodology

This review used an adapted systematic literature review approach:

1. *Formulation of research questions*
2. *Selection of data sources*
3. *Selections of keywords and Literature search*
4. *Selection and evaluation of literature*
5. *Data recording based on types of evidence*
6. *Data formatting into aggregated benefit categories*
7. *Data analysis*



Research Questions

- **Q1.** *What benefits are claimed to be associated with using MBSE in the literature?*
 - Benefits: positive consequences stemming from the use of MBSE when compared to using a document-based systems engineering approach.
- **Q2.** *What type of evidence supports such MBSE benefits claims?*
 - Evidence: the information that is used to support a benefit claim



Selection of Literature

- 20 journals and conference proceedings from the fields of Systems Engineering, Space Systems Engineering, and Engineering Design were evaluated
- Search keywords: “Model-Based Systems Engineering” OR “Model Based Systems Engineering” OR “MBSE”
- Resulting papers that included a keyword were evaluated for citations of benefits



Types of evidence claims

Measured: The benefit is measured through a defined measurement methodology.

Observed: The benefit is noticed by the authors over the course of implementation of MBSE but is not measured through any defined system of measurement.

Perceived: The benefit is expected, predicted, or perceived to be evident by the author(s) of the paper.

Reference to another source: The benefit is cited from another paper(s).



Benefit types found in literature

Improve system quality	Increased effectiveness	Improved deliverable quality	Increased efficiency	Increased precision	Better data management/ capture
Increased rigor	Better requirements generation	Reduce time	Increased transparency	Early V&V	Better decision making
Increased traceability	Increased accuracy of estimates	Improved consistency	Increased confidence	Reduce ambiguity	Better accessibility of info
Reduce errors	Improved predictive ability	Increased capacity for reuse	Higher level of support for integration	Higher level support for automation	Better knowledge management/ capture
Reduce cost	Better analysis capability	Easy to make changes	Better requirements management	Reduce burden of SE tasks	Improved architecture
Reduce risk	Improved capability	Reduce rework	Ease of design customization	Better manage complexity	Multiple viewpoints of model
Improved risk analysis	More stakeholder involvement	Reduce waste	Increased flexibility	Improved system understanding	Better communication/ info sharing
Improved system design	Strengthened testing	Increased productivity	Increased uniformity	Reduce effort	Improved collaboration



Results

Total papers evaluated: **847**

Total papers citing benefits: **360**

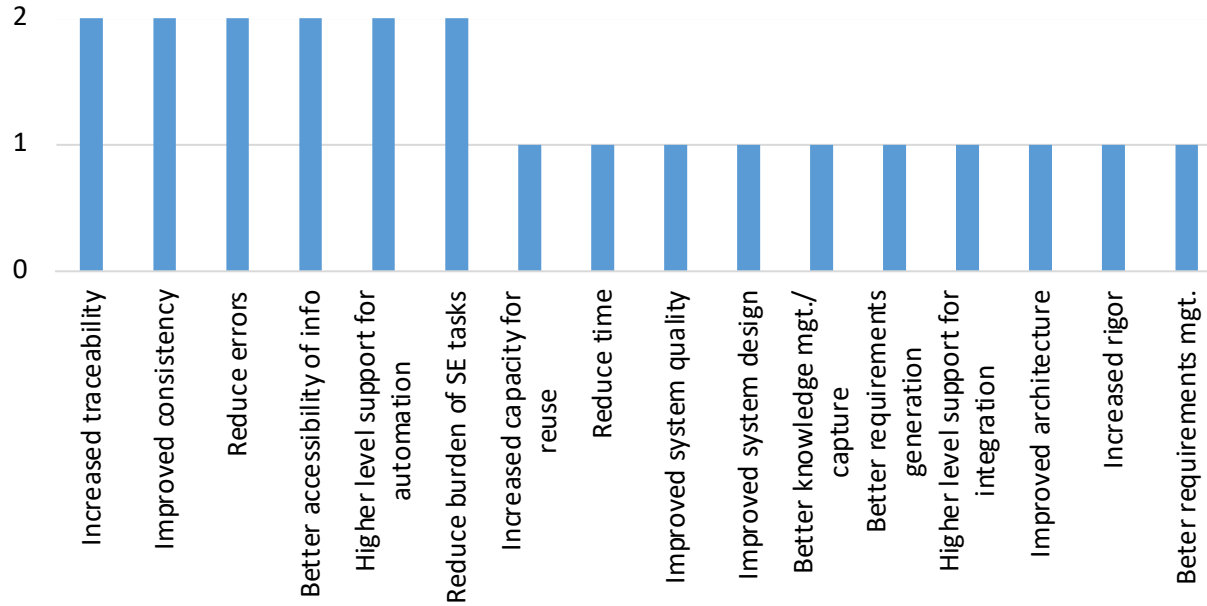
Total individual benefits: **1233**

Claim Type	Number of Papers Containing Benefits	Percentage
Measured	2	0.6%
Observed	36	10.0%
Perceived	240	66.7%
Reference	109	30.3%
Misc.	4	1.1%

Claim Type	Number of Individual Benefits	Percentage	Average Benefits per Paper
Measured	22	1.78%	11
Observed	91	7.38%	2.53
Perceived	645	52.31%	2.69
References	462	37.47%	4.24
Misc.	13	1.05%	3.25

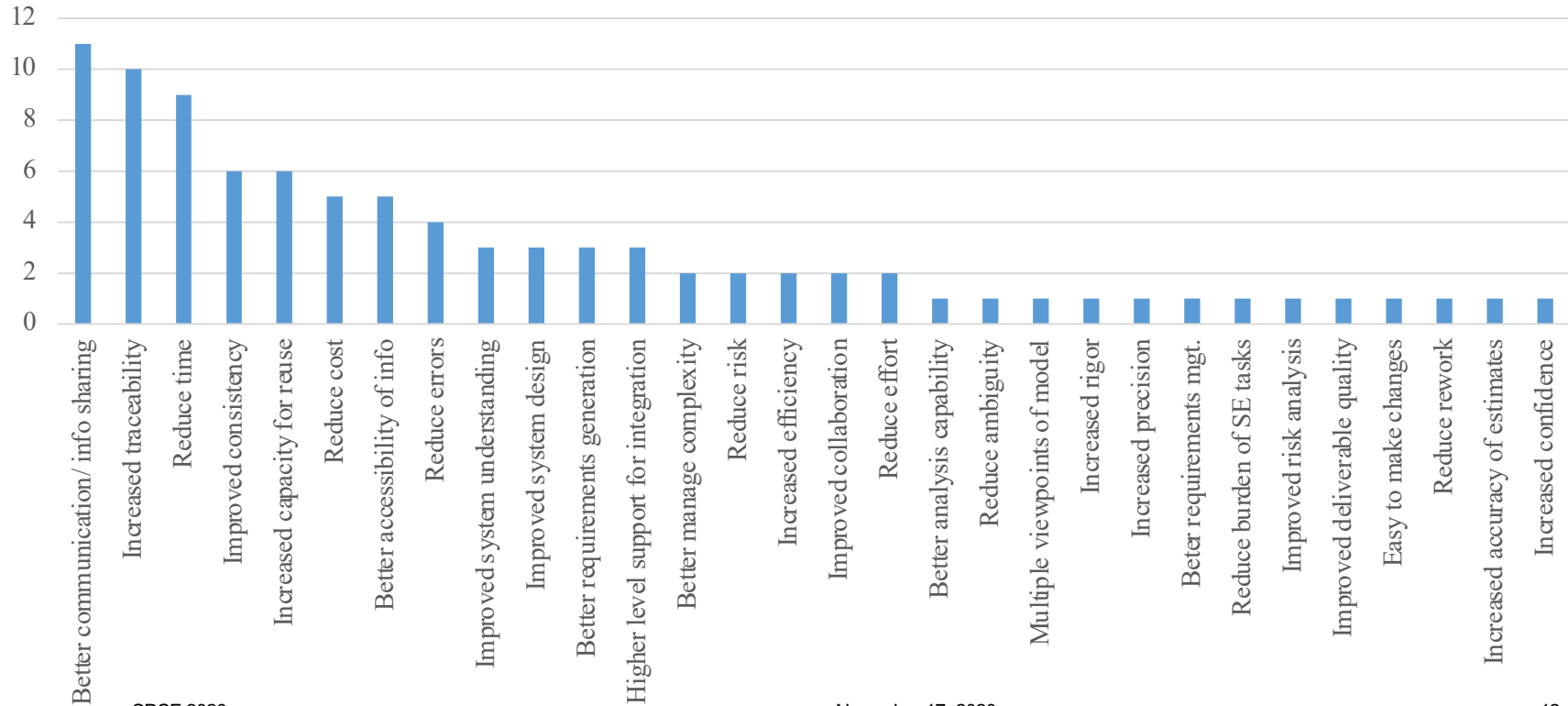


Results – Measured Claims



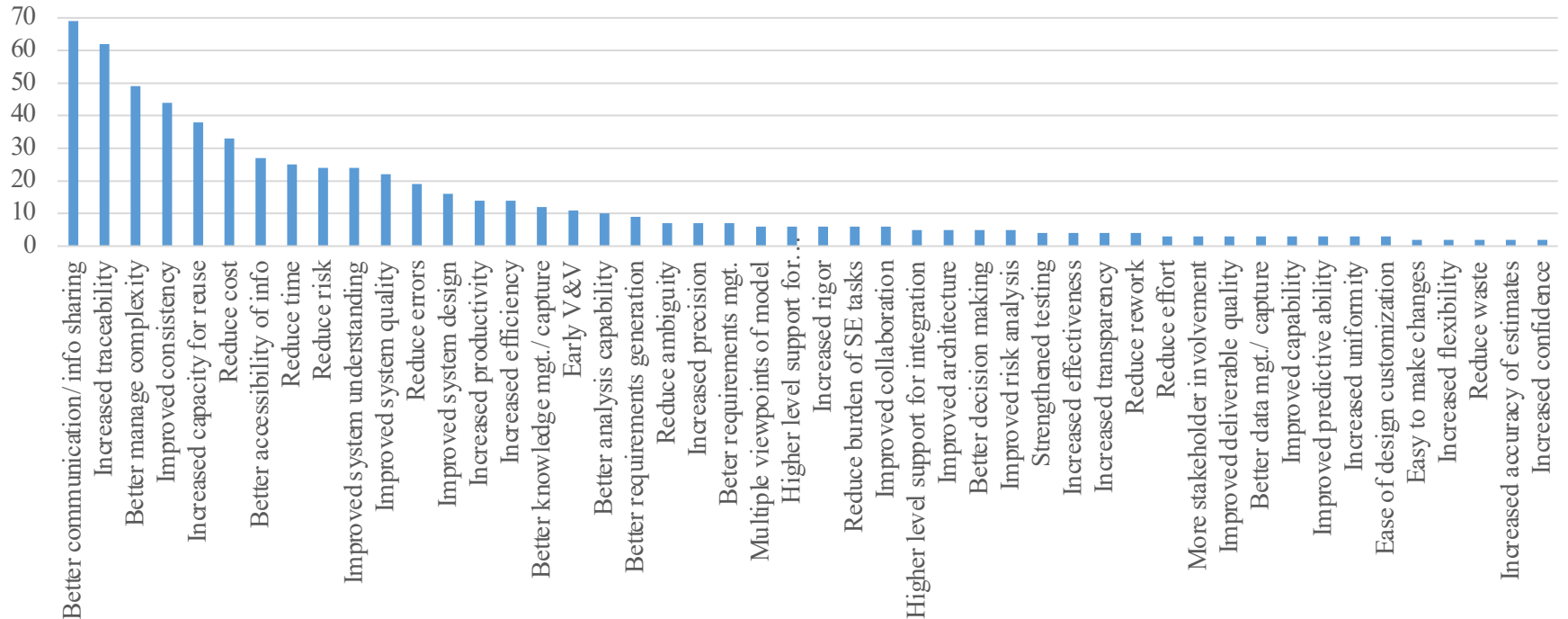


Results – Observed Claims



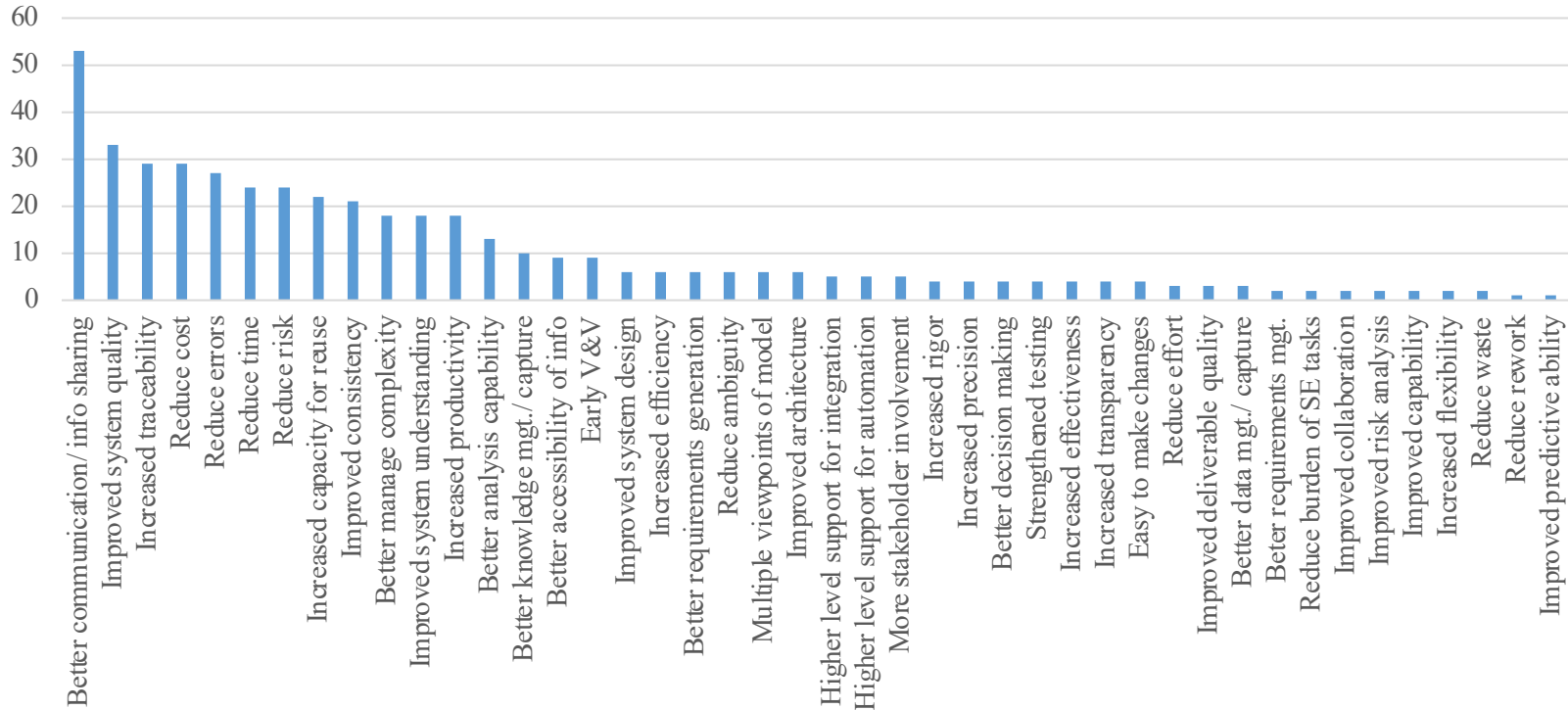


Results – Perceived Claims





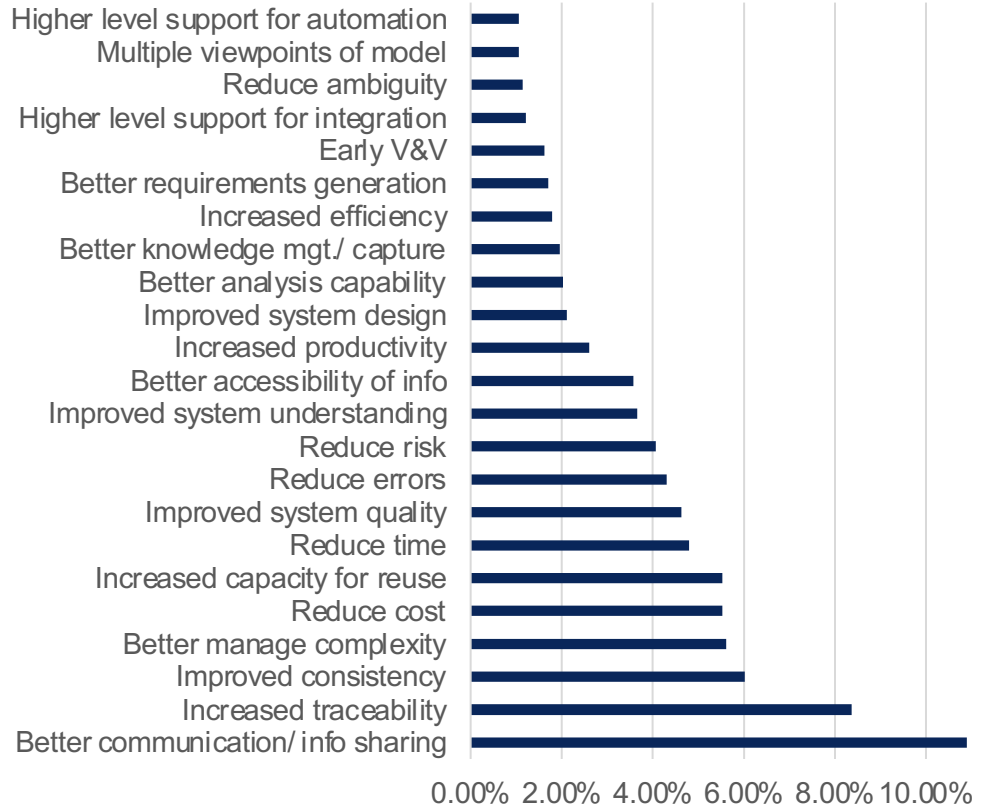
Results – Referenced Claims





Results

Total benefit types that make up at least 1.00% of the total benefits cited across all papers





Results

Measured	Increased traceability	Improved consistency	Reduce errors	Better accessibility of info	Higher level support for automation	Reduce burden of SE tasks	
	2	2	2	2	2	2	
Observed	Better communication / info sharing	Increased traceability	Reduce time	Improved consistency	Increased capacity for reuse	Reduce cost	Better accessibility of info
	11	10	9	6	6	5	5
Perceived	Better communication / info sharing	Increased traceability	Better manage complexity	Improved consistency	Increased capacity for reuse	Reduce cost	Better accessibility of info
	69	62	49	44	38	33	27
Reference	Better communication / info sharing	Improved system quality	Increased traceability	Reduce cost	Reduce errors	Reduce time	Reduce risk
	53	33	29	29	27	24	24



Results - Measured Papers Qualitative Analysis

Criteria	(Maurandy, Helm et al. 2012)	(Bayer 2018)
Use of a defined process for measuring benefits.	A measurement <u>process is described</u> .	A measurement <u>process is described</u> .
Extent to which the assessment was driven by specific metrics or it was absent of preconceptions as to which benefits were going to be found.	Metrics seem to have been <u>chosen based on experience</u> , but no formal approach for selecting metrics is provided.	Metrics were selected based on challenges encountered in prior projects.
Measurement instrument	<u>Measurement is based on personal, qualitative scoring and estimations of individuals.</u>	<u>Measurement is based on personal, qualitative scoring of individuals.</u>
Extent to which the application of MBSE was the main independent variable impacting the datasets.	Identification of other factors is <u>not described</u> in the paper.	Identification of dependent and independent variables, as well as of potential factors, is <u>not described</u> in the paper.
Extent to which the assessment methodology can be replicated based on the information presented in the paper	The measurement methodology is <u>not described with sufficient level of detail to enable replication</u> , in particular with respect to qualitative determination of scores.	The approach <u>could be replicated to some extent</u> on several projects, although without being able to assess/characterize external conditions and side factors.



Insights from Practitioners



Survey

Model-Based Systems Engineering Maturity Benchmark Survey

This survey is intended to assess the value and effectiveness of MBSE adoption for improving business outcomes. It is also intended to develop a profile of current MBSE use and expectations across the systems engineering life cycle.





Survey

Benefits:

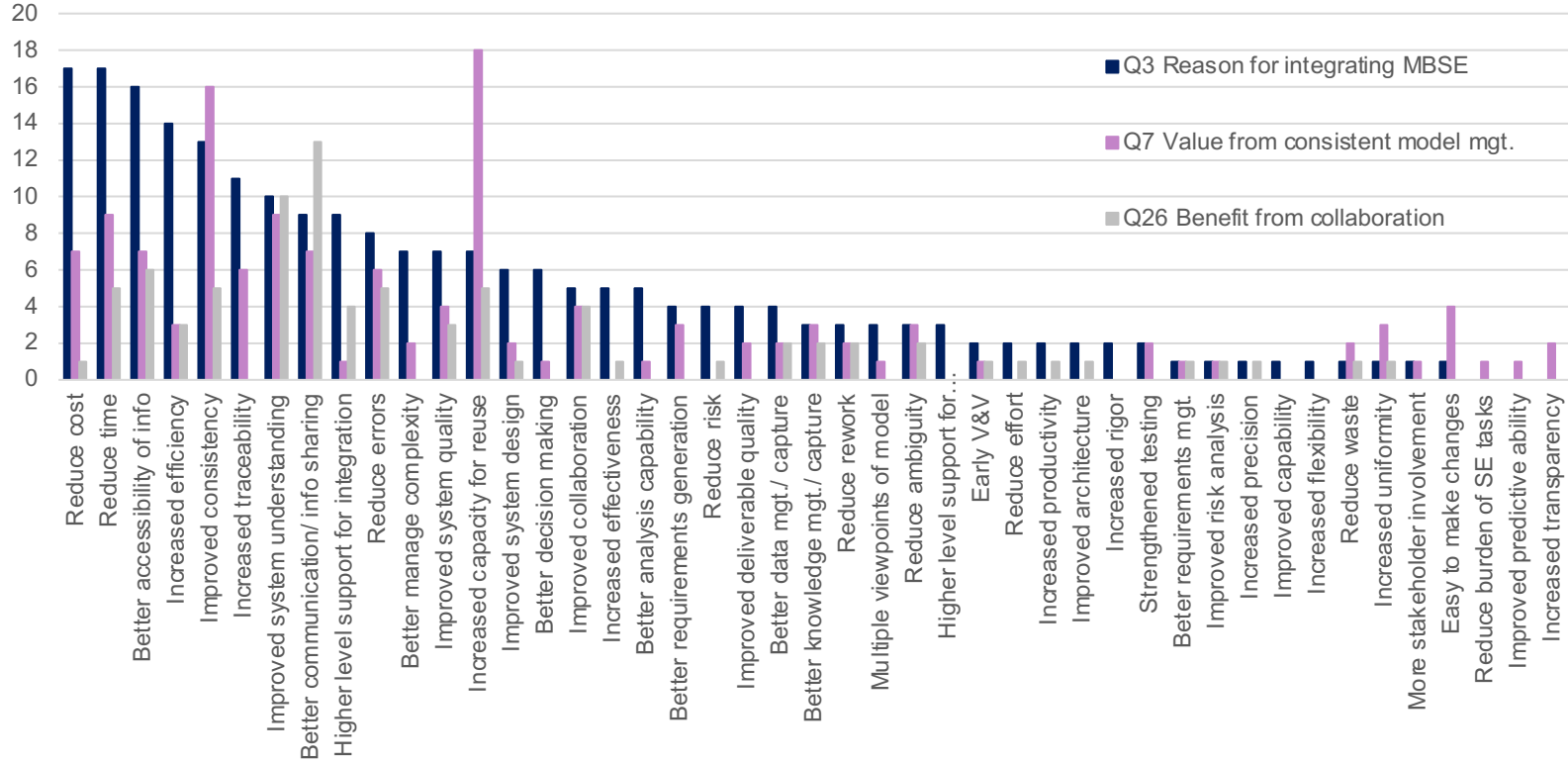
- Q3. What do you see as the most important **reasons for integrating MBSE processes** with program and business management processes
- Q7. Please provide one or more descriptions of the **business value** you are realizing **from consistent model management** processes and tools
- Q26. Please identify any **additional benefits** you find **from collaborating on models** across disciplines

Metrics:

- Q13. Please identify any **metrics** that have proven to be useful for measuring the performance of your MBSE activities

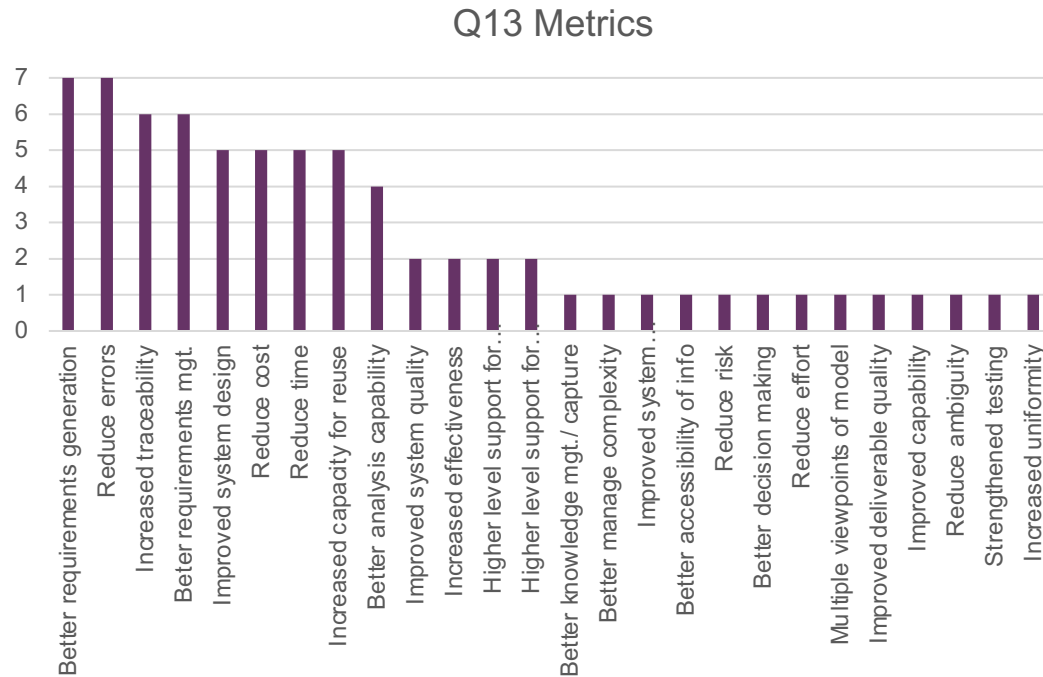


Survey Questions on Benefits





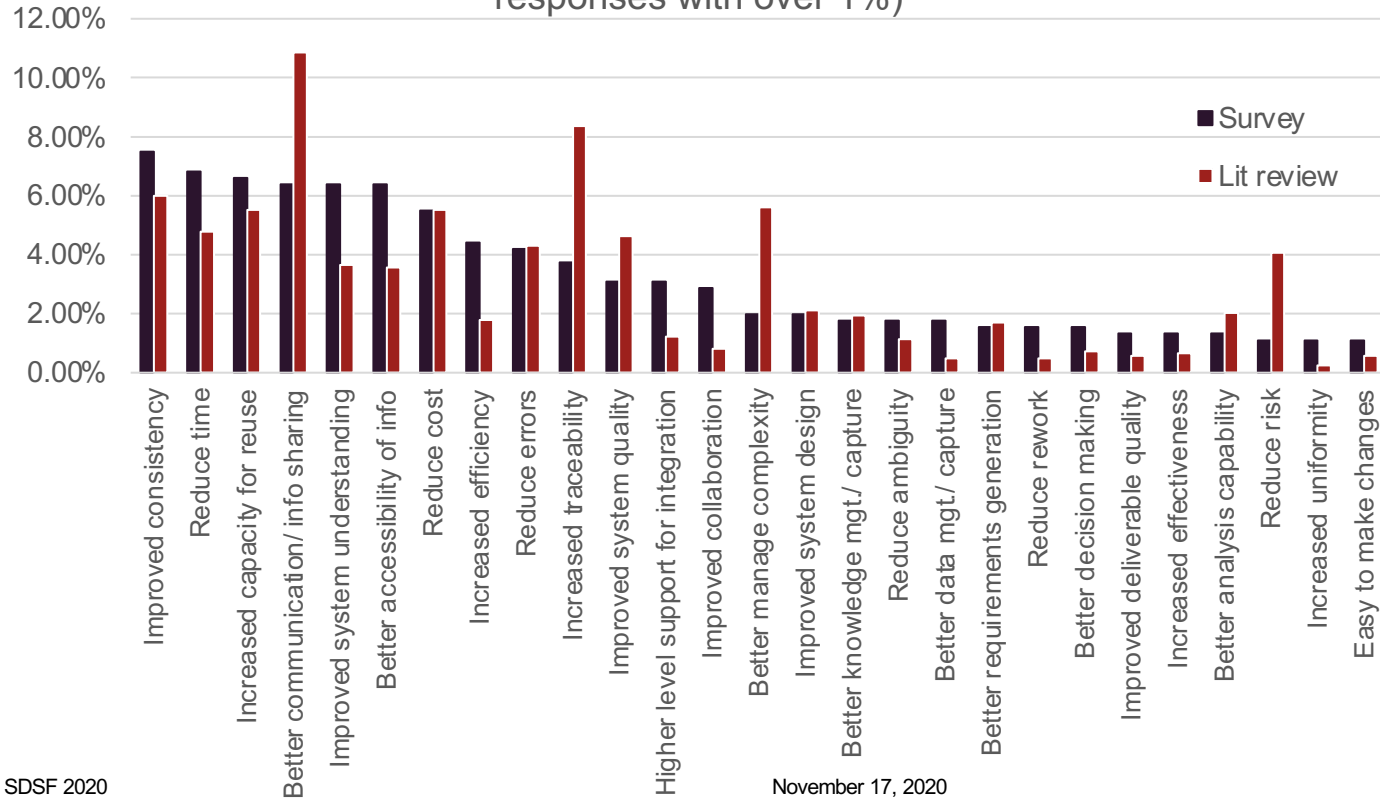
Results – Metrics Question



- 33 responses indicated no metrics were in use
- 17 responses indicated metrics were used to evaluate the adoption process of MBSE but not the actual performance
- 21 benefit types from the literature review had no corresponding metrics responses



Survey v. Lit review benefit occurrence in percentage (Survey responses with over 1%)





Conclusions

- **There is not significant empirical evidence of benefits of MBSE in the literature**
 - Only 2 of 360 papers used measurement to support their claims, and these have several methodological weaknesses
 - Majority of benefits are based on perceptions and expectations
- **There is little agreement on what the benefits are across literature and amongst practitioners**
 - The occurrence of benefits are widely distributed across benefit categories in the literature and survey results
 - The most frequently cited benefit in the literature makes up just over 10% of all total benefits



Additional References

Bayer, T. (2018). Is MBSE helping? Measuring value on Europa Clipper. 2018 IEEE Aerospace Conference, IEEE

Maurandy, J., et al. (2012). 11.5. 3 Cost-Benefit Analysis of SysML Modelling for the Atomic Clock Ensemble in Space (ACES) Simulator. INCOSE International Symposium, Wiley Online Library.

McDermott T, Van Aken E, Hutchison N, Salado A, Henderson K, and Clifford M. (2020), Technical Report SERC-2020-SR-001, Benchmarking the Benefits and Current Maturity of Model-Based Systems Engineering Across the Enterprise: Results of the MBSE Maturity Survey, March 19, 2020