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The Current State of Model Based Systems Engineering: Results from the OMG™ SysML Request for Information 2009

Mary Bone
Stevens Institute of Technology
Castle Point on the Hudson
Hoboken, NJ 07030, USA
mbone@stevens.edu

Dr. Robert Cloutier
Stevens Institute of Technology
Castle Point on the Hudson
Hoboken, NJ 07030, USA
Robert.cloutier@stevens.edu

Abstract

The Object Management Group (OMG™) initiated a Request for Information (RFI) in July 2009. Instead of the OMG's traditional approach to RFI process of publishing the RFI and posting it on their website, the OMG chose to use an online survey mechanism as the sole method of responding to the RFI. This paper discusses key findings obtained from the collected data on the current usage of SysML and model based systems engineering (MBSE). The survey based approach, along with recommendations that were extracted from the survey results are also discussed in this paper.

Introduction

The Object Management Group (OMG™) released the OMG SysML™ (SysML for the remainder of the paper) Version 1.1 in November of 2008. The scope of the SysML as stated in that version is too "...specify the language so that systems engineering modellers may learn to apply and use SysML, modelling tool vendors may implement and support SysML, and both can provide feedback to improve future versions [OMG 2008]." To facilitate the goal of modellers and tool vendors being able to provide feedback to improve future versions of SysML the OMG initiated a request for information, in the form of an online survey, of the Systems Engineering community in July of 2009. Some of the goals of the survey included determining: 1) How SysML and Model Based Systems Engineering (MBSE) is being utilized; 2) Who is utilizing SysML; 3) What do people like/dislike about SysML and MBSE; 4) What key insights could the practioners provide into SysML's methods, tools, training and metrics; 5) What tools are being used; and 6) What is working and not working with MBSE and SysML.

Methodology

The survey was conducted using a web based survey service called SurveyMonkey.com. The survey was open to all and an Internet link was distributed through various channels; which included email (both lists and individual), online forum groups, LinkedIn groups, and word of mouth. The survey generated 128 responses from 16 different countries. The responders represented 45 unique entities. The

composition of the responses included 61% Systems Engineers, 17% Software engineers and 22% others (managers, executives, other engineering disciplines, and academics).

The survey was broken into two sections. Part 1 was intended to understand the overall SysML value and effectiveness. Part 1 contained 22 questions on SysML language including language use, effectiveness, recommendations and issues. Each question also provided opportunity to recommend proposed solutions or additional capabilities. The second part was optional contained 39 questions, and focused on how SysML is being used to support MBSE which includes questions on metrics, training, tools and specific project feedback. Over 80% of the responders (104/128) chose to complete both parts of the survey. However, those completing part 2 were selective in the questions they responded to, and the highest number of responses to any one question was 63 in the second section.

The first section contained 22 questions while the second contained 39 for a total of 61 questions on the entire RFI. The RFI contained both open-ended and closed-ended questions. There were only two required questions that had to be answered on the entire survey: 1) Contact Information and 2) Do you want to continue to the next section? This means that all other questions were optional so the number of responses varied per question.

Summary of Key Findings

The analysis of the survey data key findings is presented in this section. These findings are based on the analysis of the collected data only, and do not represent the opinions of the authors except where it is made clear. In analyzing the data each question was reviewed at face value (i.e. overall 54.3% responses were "yes") then questions were cross tabulated with each other. Examples of cross tabulation that was performed include: 1) How training (type and duration) affected overall responses; 2) How responders role affected overall responses; 3) How did the type of tool being used affect overall responses; 4) How did the time at which SysML was applied in the Life Cycle affect overall responses; and 5) How did project size affect overall responses. Along with cross tabulation, responses were also filtered to see if any trends were evident. For example those that rated Block Definition Diagrams as "Low Value" were filtered to see if that group of responses were different than the overall average across all survey questions.

The key findings, in no particular order, from the survey are:

1. The perception is that MBSE models and methods have a medium-high value to the Systems Engineering team (4.23 satisfaction rating out of 5.0). The overall satisfaction with the MBSE method was given a medium-high also (3.77 out of 5.0). MBSE was also rated as having medium-high benefit on the overall project (3.89 out of 5.0). This could be interpreted that responders overall level of satisfaction with MBSE is medium-high (4.0 out of 5.0). This should be taken into consideration when making any changes. Any issues with MBSE adoption and usage may lie outside of MBSE and SysML.

2. Block Definition Diagrams (BDD's) and Internal Block Diagrams (IBD's) are used the most and valued the most. However, responses also indicate they are the most difficult diagrams for stakeholders to understand. Open-ended responses indicated that stakeholders had a hard time understanding the use of ports and

interfaces. If BDD's and IBD's are the majority of the material being presented to the stakeholders, but the stakeholders are confused with ports and interfaces, the result may be stakeholder dissatisfaction with MBSE.

3. Culture and general resistance to change was identified as the largest inhibitor (see Figure 1) to adoption of MBSE approach to systems engineering. The second largest inhibitor selected was "Other". This "Other contained many comments about tools and ease of learning all aspects needed to apply SysML. The idea that MBSE and SysML require a steep learning curve is a theme that is found throughout the survey when asked open ended questions. It was indicated that to apply MBSE one had to learn: 1) MBSE and SysML, 2) the tool, and 3) a methodology.

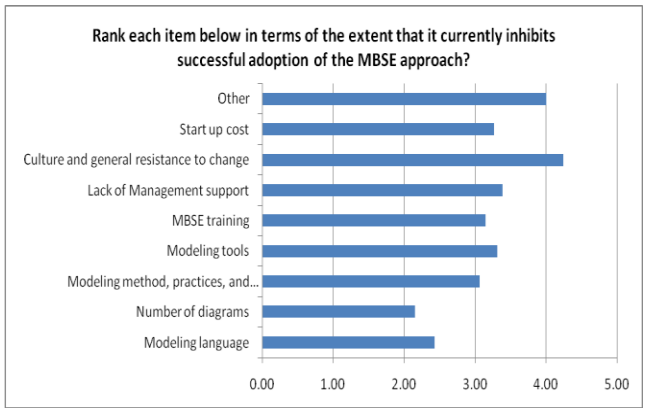

Figure 1 Inhibitors to MBSE adoption

4. MBSE is mainly (55.2%) being used as an opportunity to improve Systems Engineering efforts although companies have not officially accepted MBSE into their procedures. Survey results showed that only 4.5% of responses stated that they used MBSE due to Company procedure, which likely indicates that MBSE has not widely been integrated into company procedures. The specific application area of Systems Engineering that is driving the use of MBSE is "to improve the quality of requirements and design to reduce downstream defects" (72.9% selected this as the primary purpose of the model).

5. The amount of training or lack of training does not appear from the data to influence how the responder feels in regards to MBSE and SysML. The only difference from those that had any training from those that had no training (including self taught) is that when untrained responders were asked about inhibitors, they ranked the inhibitors on average higher than those responders that did receive training. Those that did not have training also scored the amount of support for use of SysML from customers, clients, management, and stakeholders the lowest (2.94 out of 5.0) compared to the average of responders with training, which was a 3.62 out of 5.0.

6. The benefit of MBSE to the overall project decreased as MBSE was initiated later in the project (see Figure 2). This should not be interrupted that those that started using SysML "well after the project was underway" had a worse experience overall because they had comparative answers to "Pre proposal/proposal stage" and "At the start of the project" responders to most other questions such as diagram values and tool experiences.

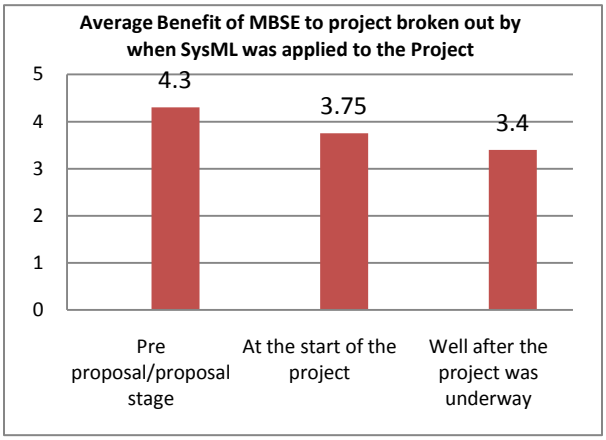

Figure 2 Average Benefit of MBSE broken out by when SysML is applied to Project

7. Over one-third (36.7%) of the responders received no training (or were self taught). As stated early though this did not seem to affect overall responses to the value and effectiveness of MBSE and SysML. Though one insight is that the responders that received no training also claimed to have lower support from their customer, clients, management, and stakeholders (see Figure 3). Which may indicate that to receive training it is important to have support from the stakeholders, management, customer, and clients. This should be further studied to determine the correlation between training and support from stakeholders, management, customers, and clients.

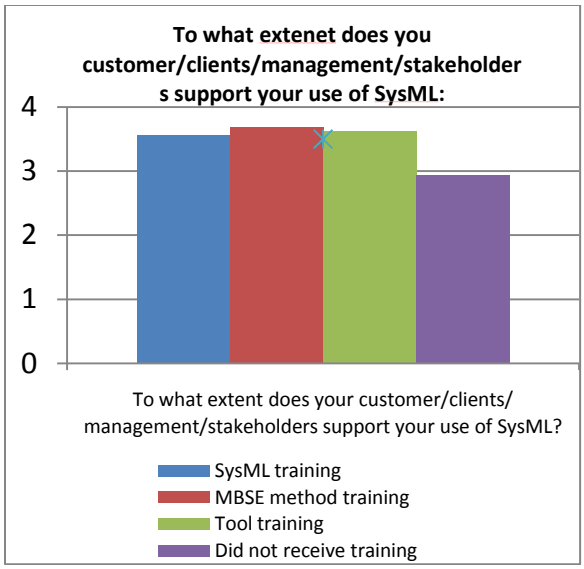

Figure 3 Support of SysML by Type of Training

8. The responders were split almost half and half (55.4% said "Yes" and "44.6%" answered "No") when asked if there should be an update to SysML in the next three years. When cross tabulated by role of the responder it showed those performing modelling, on average, encouraged an update while those who were members of the modelling team, or sponsors/manager, on average, were not in favour of an update. From the responses the authors believe the reason behind this may be due to the perceived steep learning curve that is required to learn SysML along with the concern of a revision affecting the SysML tools.

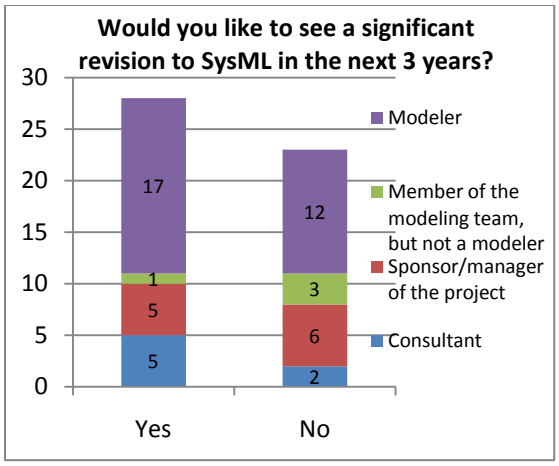

Figure 4 Response to Significant Revision to SysML in the next 3 Years

9. When asked "To what extent do you plan to use SysML in your organization in the future?" 71.3% replied that their organization was either currently or planning to integrate SysML into their practices. This shows that there is a large desire to continue using SysML in organizations. This could also be an indication into how much value those currently using SysML believe it brings to their projects.

10. The majority of responses in the survey indicate that SysML is being used on large scale systems (Aircraft, Space Systems, etc.) in the defense sector (see Figure 5). Even if the project itself was small the overall systems that were being developed or integrated into were of large scale. The type of project that SysML is being applied to is projects (67.3%) that have a maximum of 100 people or less on the project at any one time (not just the modelling portion). Project duration for projects applying SysML showed that 55.6% were between one month and three years in duration.

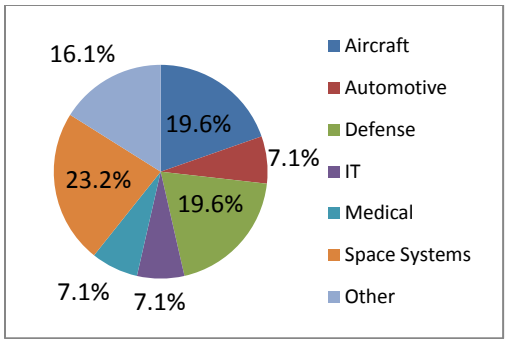

Figure 5 Application of SysML by System Type

11. The survey shows that SysML is used by more than just System's Engineers. When asked "What disciplines were involved in modelling with SysML (select as many as needed)?" 71.9% stated that Software Engineers, 43.9% said Analysts and 38.6% answered that Hardware Engineers were also involved (see Figure 6). Test Engineers came in with the lowest involvement at only 29.8%. Other disciplines represented as "write ins" were scientist and medical doctors. The fact that only 29.8% stated that Test Engineers which may indicate that SysML is not being utilized that late in the Life Cycle (Verification and Validation). This should be further investigated so that the reasons behind Test Engineers perceived little involvement in SysML can be better understood. There are other theories to this low number such as programs are cancelled prior to the testing phase or many programs of large scale have no insight into testing since it may be done by a completely different entity.

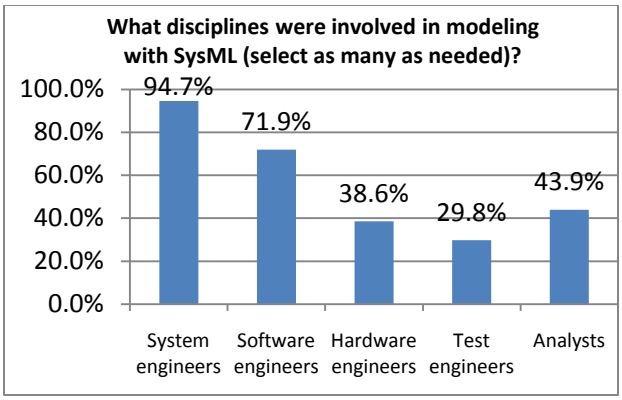

Figure 6 Disciplines involved in modeling with SysML

Recommendations

The survey suggests that one of the largest inhibitors to the adoption of SysML is the large learning curve required to understand SysML. One survey response cites that the learning curve is so large because a person must learn three separate topics to perform SysML successfully 1) the SysML language, 2) the methodology (which can be different even from project to project), and 3) the tool. Therefore the first recommendation would be to develop training that clearly teaches each of the three topics and keeps them separate enough that they are distinguishable so that the individual receiving the training can leverage it regardless of the other two. For example the method should not be tied to the tool. Another recommendation regarding the learning curve is to provide real project examples. Throughout the survey responders, via open-ended responses, suggested providing real life examples of how to apply the methodology as one way to help elevate this large learning curve. While there are a number of versions for the hybrid sports utility vehicle (HSUV) example available, the models are incomplete, and there is no narrative that describes the development of the model, or the reasoning behind the decisions made. A third recommendation would be for a source of best practices to emerge. The topic of methodology and best practices should be a top priority as it may be one of the biggest inhibitors to adoption and usage of MBSE and SysML.

Through the analysis of the data it shows that parametric and package diagrams seem to be misunderstood, in that most groups (when cross tabulated) did not agree among themselves on the value and usage of these diagrams. The parametric diagrams were also used the least of all the diagrams. With this information it would be recommended to do more research into why the results turned out this way.

Another recommendation based on the data is related to ports, allocations and stereotypes. These three features were specifically called out in open-ended responses throughout the survey as areas that were not well understood or applied correctly. Those that claimed to understand them even admitted to sometimes not being able to apply them correctly or did not know if they were applying them correctly. Therefore it would be of value to better understand what specific issues people have when trying to apply these (ports, allocations and stereotypes) or when explaining them to customers. The root cause as to why this is an issue was not uncovered in this survey; therefore further research should be taken to find out why they are such problem areas across the array of responses that were received.

Another recommendation to advance the adoption of SysML is to work with tool vendors to increase the maturity and usability of the tools. Many noted that mature tools such as Microsoft Visio were able to sufficiently perform many of the functions they needed to do MBSE therefore co-workers were not willing to switch to a SysML specific tool. Research into what users really need and want in a tool interface should be conducted.

The survey results indicated the specific choice of tool vendor did not affect the ratings of questions as they related to the effectiveness of MBSE use on a project, but it did affect the overall average of the value of the diagrams. For instance those that used InterCAX ParaMagic (MagicDraw Plugin) rated diagrams on average 4.21 out of 5.0 (where 5.0 is high value) whereas those that used IBM Rhapsody rated diagrams an average value of 3.57 out of 5.0. It is not apparent from the data why this difference occurred.

One interesting perspective this survey did uncover is that tools are overall important. While tools were the fourth highest inhibitor of the MBSE approach adoption, it was second (with first being start up cost) in terms of variables that can be directly controlled. The first two highest inhibitors were lack of management support and cultural and general resistance to change which both are variables that not able to be directly changed they can only be influenced.

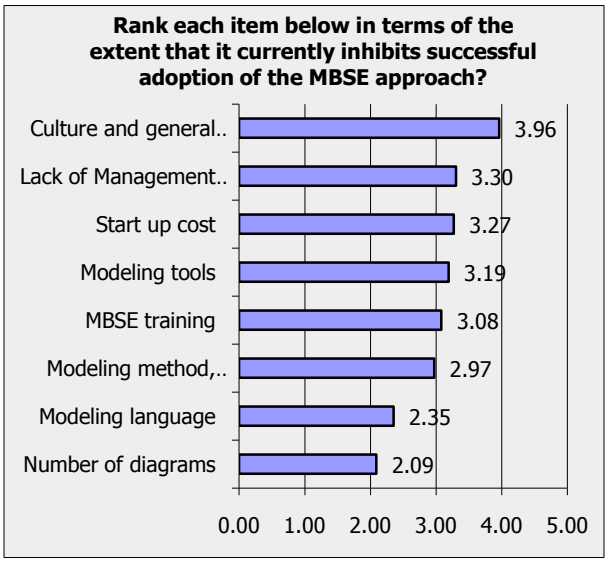

Figure 7 Inhibitors to Adoption of MBSE

An effort to collect consistent and well defined (with purpose) metrics regarding MBSE should be initiated. This survey showed that metrics are being collected but that they are not consistent and are not collected in significant enough quantity to be able to justify the benefit of using an MBSE approach. There was not one responder that gave hard proof of the benefit of MBSE. This does not mean that proof did not exist. Although only 22.6% of all responders stated that their program collected metrics.

The last recommendation is that a series of shorter, targeted surveys be conducted to establish a better understanding of the findings from this initial survey. Some of the topics that should be investigated further include but should not be limited to: 1) what is the root cause(s) of the perception of a steep learning curve of MBSE, 2) how much does the tools affect adoption of MBSE and SysML, and 3) better understand how diagrams are being used and why. It may be useful for these surveys to be conducted by academia rather than the OMG.

Conclusions

The OMG SysML RFI 2009 Survey has provided a wealth of insight into the current state of MBSE and SysML. The output of this survey has in the most part shown that more data needs to be obtained to make specific conclusions on the large issues addressed in this survey. This survey should be seen as a stepping stone into other research and possible surveys to flush out root causes to the insights found from this survey. Though, many high level conclusions can be drawn from the survey in regards to SysML and MBSE.

References

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Biography

Dr. Robert Cloutier is an Associate Professor of systems engineering in the School of Systems and Enterprises at Stevens Institute of Technology. He has over 20 years experience in systems engineering & architecting, software engineering, and project management in both commercial and defense industries. Industry roles included lead avionics engineer, chief enterprise architect, lead software engineer, and system architect on a number of efforts and proposals. His research interests include model based systems engineering and systems architecting using UML/SysML, reference architectures, systems engineering patterns, and architecture management. Rob received a BS from the US Naval Academy, an MBA from Eastern College, and his Ph.D. in Systems Engineering from Stevens Institute of Technology. Currently Rob also holds an appointment as an Associate Professor II at Buskerud University College in Kongsberg, Norway.

Mary Alice Bone has worked as a Systems Engineer for GE Transportation, BAE Systems, and Rockwell Collins. She holds a B.S. in Aerospace Engineering from the University of Missouri – Rolla and a M. Eng. in Systems Engineering from Iowa State University. She is currently a Research Assistant under Dr. Robert Cloutier at Stevens Institute of Technology where she is pursuing her PhD in Systems Engineering.