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The Value of Modeling and Simulation Standards

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Abstract

In the current economic climate, there is a requirement to justify all government spending by demonstrating the added-value that the expenditure gives. Modeling and Simulation (M&S) community is not exempted from this rule. This paper focuses on attempts to value standards and demonstrates that even though a myriad of different standards exist in the United States today, no one has “cracked the nut” on determining their value. This does not mean that standards are without value. The paper highlights their importance to our society and human development as a whole. Thus if we cannot give a value to M&S standards, we can at least minimize their cost. The paper concludes with some discussions on cost-savings in the development of standards though a study of organizational misbehavior.

1. INTRODUCTION

Due to the recent global recession, there has been an increased concern by the public on the high level of government spending; in response, governments are focusing on placing a “dollar value” on outputs from the expenditures, especially with relation to defense spending. As the Department of Defense is currently the largest customer of Modeling and Simulation (M&S) products, M&S has come under this scrutiny, especially with regards to M&S standards.

This paper discusses the value of standards, with a focus on their application in M&S. A definition of standards is given followed by discussion on Return of Investment (ROI) approaches and examples. A more general discussion is given about the impact of standards on our society and why, ultimately, we cannot live without standards. Finally, organizational misbehavior is discussed with a focus on its impact on the cost of developing M&S standards.

The majority of the material presented in this paper was drawn from a series of workshops conducted by the Virginia Modeling, Analysis and Simulation Center (VMASC) on various aspects of Modeling and Simulation (M&S) and its future [Collins et al., 2010a-b, 2011a-c; Tolk et al., 2011]. The purpose of the workshops was to investigate the future of M&S standards with a focus on requirements and governance. The workshops had over a hundred participants from heterogeneous backgrounds, though most were from the USA’s east coast.

1.1. Definition of standards

A key outpoint from the workshops (Collins et al., 2010a) was that there was not much standardization of many M&S terms and definitions, including “standards.” Thus, this paper uses a formal definition of a standard which is given by the US Federal Office of Management and Budget circular A-119 [Office of Management and Budget 1998]:

“a. The term ‘standard,’ or ‘technical standard’ as cited in the Act, includes all of the following:

(1) Common and repeated use of rules, conditions, guidelines or characteristics for products or related processes and production methods, and related management systems practices.

(2) The definition of terms; classification of components; delineation of procedures; specification of dimensions, materials, performance, designs, or operations; measurement of quality and quantity in describing materials, processes, products, systems, services, or practices; test methods and sampling procedures; or descriptions of fit and measurements of size or strength.

b. The term “standard” does not include the following:

(1) Professional standards of personal conduct.

(2) Institutional codes of ethics.”

This definition is in no way final as there is dissatisfaction from some who use it [Finkleman 2007] and it does not expand upon some of the subtleties of standards, such as implementation (e.g, de facto, de jure, or voluntary).

2. BACKGROUND

Petty et al., identified 23 different M&S standards in a recent study into the attributes of a successful M&S standard [Petty et al., 2012]. These M&S standards relate to many different simulation aspects like interoperability, e.g., High level Architecture (HLA) and Distributed Interactive Simulation (DIS), to conceptual modeling, e.g., Unified Modeling Language (UML). A good summary of these M&S standards can be found in NATO Handbook AMSP-01 [NATO 2009]. The justification of M&S standards is usually given as something that allows for reuse of data and simulations, simplifies interoperability and cost savings. If a simulation is built to a particular standard, then you know what you are getting, making it easier to determine whether the simulation can be used for another purpose. If the simulation is built to use a particular interoperability standard, then you only need to consider the interoperability standard and you do not need to consider all possible other simulations that your simulation will be interacting with. The cost saving comes from the time that would have been spent developing the simulation if the standard had not been available. Giving a cash figure to this cost saving is a hard problem which has not yet been resolved by the M&S community.

The world of M&S standards is mainly dominated by HLA and DIS, though others do exist. Both HLA and DIS are maintained and developed by the Simulation Interoperability Standards Organization (SISO). SISO is a standards development organization for M&S, and have two IEEE-accredited standards (HLA is IEEE Standard 1516 and DIS is IEEE Standard 1278). SISO is a Voluntary Consensus Standards Organization (VCSO) as defined by the American National Standards Institute (ANSI). Voluntary, consensus-based standards development is ANSI’s approved method by which a Standards Development Organization (SDO) should be run.

Given there is a benefit for having M&S standards (e.g. cost-savings) and an existing mechanism to make / develop standards (e.g. through SISO) it would be reasonable to assume that there should not be any problems with the development and implementation of M&S standards. Though standards are believed to save time and money they also cost time and money to produce. Even if the time and money is available, it still takes a period of time to produce a standard,

creating a lag between the latest technology and its related standards. This would be fine in a relatively stable industry, but M&S is a new subject and in a constant state of flux; even the underlying paradigms of M&S are changing [Sieber et al., 2010]. Does this mean that we should not have standards in the first place? No. Standards enable us, as M&S practitioners, to do things otherwise unattainable; it has been argued that every simulation in DoD has been influenced by standards [Morse et al., 2010].; however, this does mean that any M&S standard is likely to have a limited shelf-life of usefulness. This means a standard’s life cycle and/or generational updates needs to be considered in its development [Collins et al., 2010a], which will also cost time and money.

It has been argued that M&S is its own subject area as opposed to a subset of another academic subject, like systems engineering, because it has its own unresolved problems, e.g., M&S interoperability [Tolk et al., 2011b] and composability [King 2009]. In regards to M&S standards, beyond dealing with the unique discipline of M&S, is their development and governance really any different from the thousands of other standards development organization? The generally-accepted view from the above mentioned workshops was “probably not.” M&S standards are comparable to software standards, hardware standards or business process standards. The advantage of this conclusion is that the relevant research and lessons learnt from other standards fields can be applied to M&S standards and there are a lot of other standards to choose from. The problems faced by non-M&S standards development organizations are similar to those faced by the M&S community.

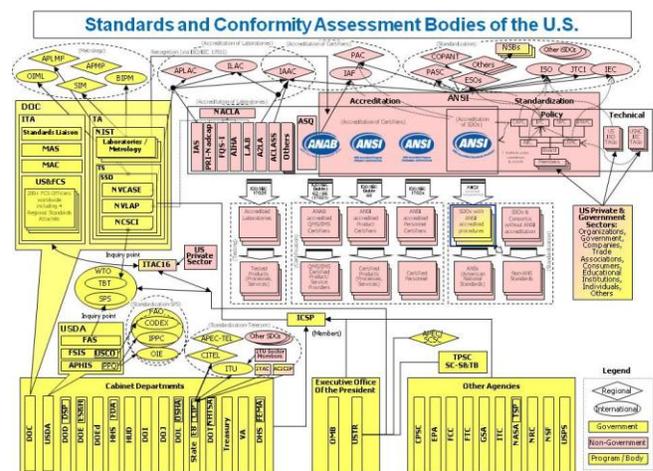


Figure 1: Standards and Conformity Assessment Bodies – USA [ANSI 2006]

Standards are a controversial topic with some people; they claim that they stifle innovation while others claim that they enable it, e.g., USB interface being commonly quoted [Collins et al., 2010a, 2011c]. One truth about standards is that you cannot get away from them: the water pouring out of the tap in the morning to brush your teeth is produced to certain standards and the cup-holder in your car where you place your coffee is made to a standard size. You may not notice the standards around you as one of the qualities of good standard is that the consumer does not need to think about it. You probably do not worry about the health risks of using contaminated water when brushing your teeth, nor do you worry about whether the cup of coffee will fit in your car's cup holder when you purchase from a drive-thru. Since standards must be developed and maintained, a plethora of Standards Bodies and Standard Development Organizations (SDO), exist for this purpose as shown in Figure 1.

3. DISCUSSION

Finding the value of standards is a multifaceted endeavor, with multiple disciplines having their own take on what constitutes the proper measure. Economists track the impact of standardization as a national process affecting socio-economic health, while business analysts struggle to define or predict the impact of standard adoption on a company's bottom line. Social scientists look at the diffusion of knowledge and technology as driven by standards, while legal scholars struggle to find the balance between anti-competition and pro-innovation.

3.1. Measuring the value of standards

Case studies using the ISO Standard Valuation Methodology assign improvements from 1% to 33% on various businesses' "bottom line" – but notably fail to capture empirical improvements in some cases despite "obviously improved operations." Secondly, the real financial impacts of standards' use reach well beyond the balance sheets of individual firms or projects. In January of 2010, the International Standards Organization (ISO) reported the development of a methodology for the economic assessment and quantification of benefits from the application of standards [ISO 2010]. Since then, a number of analyses have been conducted, with several posted on the ISO website. A sampling:

- PTT Chemical (March 2011).. Impact of standards employment on revenues estimated to be approximately \$9.4 million, or 3% [TISI 2011].
- Siemens Switch Technology (March 2011). Assessment indicated an impact on profits of 1.1-

2.8% for the affected divisions. Siemens AG posted after-tax profits of 4,068 million Euros in 2010 - 1.1% of that figure is over 45 million Euros [TU Berlin 2011].

- Nanotron Technologies GmbH (June 2011). Estimated impact of standards on revenues is 33% - 14% in cost savings and 19% in increased revenue [Langer 2011].
- Pretoria Cement (March 2011). Overall impact of standards judged to be 2.5% of revenues (R 5.9 billion) [SABS 2011].
- Festo Brasil (March 2011). Assessment revealed an economic impact of standards of 1.9% of revenues [ABNT 2011].

An observant reader will note that all the examples above are "conventional" manufacturers; i.e., they use traditional manufacturing techniques to produce real, physical products. The ISO Assessment Methodology is relatively new, and, with time, we should probably see these same detailed assessments for R&D-intensive, service-oriented ventures with less routine product lines, such as modeling and simulation.

3.2. Macro Level

At the macro-economic level, it is abundantly clear that the globalization of trade we have witnessed over the past few decades is intrinsically linked to international standards. Numerous studies by the ISO and national standards bodies have detailed both the economic and the social impacts of standards on the international stage. For example, a study conducted for the British Standards Institute (BSI) demonstrates that the effects of standards account for approximately £2.5 billion a year to the UK economy [BSI 2005]. Research reported in an economic report by the Department of Technology and Industry attributed 13% of post-war UK productivity growth to standards-mediated dissemination of technology, management practices and other knowledge as part of the innovation system [DTI 2005]. Though these reported figures are quite impressive, there are several questionable assumptions that are made in the analysis, e.g., the high growth of some industries is attributed to the number of standards it has, as opposed to a high number of standards being an outcome of high-growth industries.

What is clear from the reported studies above is that even though there are thousands, if not millions, of standards out there touching a plethora of different industries, no one has "cracked the nut" on determining a standard's individual value.

3.3. Standards and Human History

Given that no one has been able to determine a universal metric of the value of standards, it is reasonable to ask “Do standards have a value?” We hope to demonstrate that the answer to this question is not only “yes,” but without standards civilization as we know it would not exist. Toffler identified three major waves of human development: Agrarian, Industrial and Information [Toffler 1980]. Krechmer, one of the authors of the “International Electrotechnical” Commission’s report on standardization as a strategic tool, expands that short list to include the Hunter-gatherer and post-information [Krechmer 2000]. Each historic age has certain standards that impact society’s development through that age; these are known as successions of standards, which are shown in Table 1. Thus, a hunter-gather society was only able to develop though the use of communication, which was enabled though the standards of language. Agricultural societies developed through the use of standards of measurement which allowed equivalents to be formed, i.e., a bushel of corn is worth one iron axe, and trade to be enabled. Later, manufacturers began to build products using standard sized items; e.g., two-by-fours, nuts and bolts; this allowed these items to be built on an industrial scale. In our recent time, we have seen standards of compatibility enable the information age and standards of adaptability are forming the post-information age.

Standards are not only useful, but essential for the survival of our modern day society. Thus, standards do have a value even if we are unable to provide a metric for them.

4. ORGANIZATIONAL MISBEHAVIOR

Even if we are unable to put a value of M&S standards, this does not mean that we cannot try to reduce the cost of developing and implementing them. Reducing the cost of something will increase its ROI even if we do not have precise metrics to assess its ROI in the first place. There is no evidence in the literature that the development of standards is a 100% efficient process, thus there is an opportunity to make some cost savings. One area for improvement is mitigating the organizational misbehavior that plagues the development of M&S standards. We define Organizational Misbehavior as behavior by individuals and organizations that slows, de-rails, or otherwise negatively affects the standards development process, whether this is purposely or unintentionally done. Since standards cost time and money to develop, slowing the process of development will increase the overall cost of developing standard.

Table 1: Ages of Human Development and their associated standards [IEC, 2006]

		Age				
		Hunter-gatherer (before 3000 BC)	Agrarian (3000 BC – 1750 AD)	Industrial (1750 – 1950)	Information (1950 – 2000)	Post- Information (after 2000)
Standards Succession		Symbols	Measurement	Similarity	Compatibility	Adaptability
Economic self- reinforcing		Communications	Coordination effects	Scaling and learning effects	Network effects	Gateway effects

As part of a workshop, a non-attributable discussion was had among a group of roughly 30 M&S professionals on the anecdotal evidence of misbehavior within the development of M&S standards [Collins et al., 2011b]. There were several different misbehaviors provided as anecdotal evidence at the workshop; these misbehaviors were generalized within the report and a sampling is given here:

- Persistent Obstructionism: This behavior occurs when organizations that object to the standards in principle have somehow managed to become involved in the development process. The organization intends to derail the development of the standards through a series of delaying tactics, i.e., raising many specious objections to the ideas under development.
- Malicious compliance: This occurs when an organization says that it will adopt a standard in public, but actually has no intention of doing so. This passive-aggressive behavior can be achieved by claiming a series of internal delays / funding issues which are hard for any outsider of the organization to determine.

- **Sloppy Implementation:** The standard is adopted by organizations but implemented in a haphazard or low-cost way, so that the standard causes more problems than it cures.

The motivation behind such behaviors varies depending on the circumstances of the individual organization. The motivations might not simply be financial; some misbehavior might occur for no malicious reasons. It may just be that the organizations involved in the development of the standard are at cross-purposes.

Hollenbach gives a history of the rise and fall of the High Level Architecture (HLA) standard [Hollenbach 2009]. Hollenbach describes how the initial “good” intention of the Department of Defense (DoD) to adopt a single interoperability standard to use within their training simulations, was weakened over time due to the diminishing leadership for the initiative.

The problems faced by non-M&S standards development organizations are similar to those faced by the M&S community. Proof of this statement is seen throughout the literature. For example, when Frits Tolman discusses building and construction modeling standards [Tolman 1999], he concludes that:

“ISO [International Organization for Standardization] is not the optimum organization to steer the pre-standardization process and there is not even consensus among the researchers that are carrying out the efforts. As there is no strong management commitment and no funding, it is not realistic to expect that STEP [the construction modeling standards organization] will solve the industry’s problems.”

Tolman’s statement could have easily been found in any number of reports on M&S standards by simply substituting out the organization’s names for those relating to the M&S industry.

Despite the fact that organizational misbehavior is everywhere, there is very little literature on organizational misbehavior within an M&S standards context. One reason for the lack of reporting is that the M&S standards community is relatively small, thus there might not be a need to communicate such issues to a wider audience. Another reason is that there is generally accepted silence on discussing any such issues. This silence on openly discussing the issues regarding the current M&S standards might be for political reasons which, ironically, can be considered a form of organizational misbehavior.

4.1. Game Theory

Not only is the problem of organizational misbehavior not discussed, it is also not well researched. There are several problems with researching organizational misbehavior, including

collecting data. Companies are unlikely to divulge information that demonstrates that they partake in organizational misbehavior. They are also unlikely to release information that shows other companies partaking in organizational misbehavior, due to the libelous implications. Thus, an analysis into organizational misbehavior will remain in the theoretical realm. Game Theory is one theoretical tool that can be used to simulate and investigate organizational misbehavior.

Game Theory is the analytical study of situations that involve more than one decision maker. Standards, by their very nature, are also about multiple things and involve multiple decision makers. It thus seems appropriate that Game Theory could and has been applied to understanding the organizational behaviors of standards development and its application. Unsurprisingly, there have already been multiple applications of game theory to standards. Probably the most famous example of Game Theory to a standards situation is found in Hardin’s Tragedy of the Commons [Hardin 1968].

Game theory has also been used to demonstrate behavior that is not immediately obvious. For example, Tim Gardner and Jim Moffat tried to explain why major defense contracts are rarely on time or budget in what they term the conspiracy of optimism [Gardner & Moffat 2008]. Using a simple game it is shown that both the defense contractors and the military desk officers benefit from underestimating the resource requirements for a given project. The desk officers, who usually serve a two to three year post, have little or no accountability for the actual budget of the defense contract. The defense contractors gamble on the DoD supporting the project due to its low proposed cost and that they will make their money through eventual changes that happen to the requirements.

The critical point here is that just because organizational misbehavior is not heavily reported within the literature, does not mean that it does not happen. The authors speculate that organizational misbehavior is more common in our modern business culture than our simple anecdotal evidence would suggest.

Does organizational misbehavior have a substantial impact on the development and benefit of M&S standards? Yes. How much of an impact? We are not sure. By collecting and supporting the more pioneering work like that of Gardner and Moffat [5], there might be a large enough body of literature to form a theory of the financial implications of organizational misbehavior on M&S standards. The first step in this process is to acknowledge that there is a problem in the first place, but sadly, these authors

believe that is likely to remain as “whispers in the night.”

5. CONCLUSION

M&S Standards have had an impact on the field’s development over the last thirty years and are most likely to continue doing so. The standards industry is large and influences virtually every aspect our modern life. However, attempts to quantify this value have been limited, thus it is difficult to determine standard’s Return on Investment. It is arrogant to assume that the M&S industry is able to determine the value of standards where many others have failed.

Even though we are unable to place a value on M&S standards, we could make their development and implementation cheaper. One element that negatively affects the cost of the M&S standards is organizational misbehavior. Organizational misbehavior can be studied using Game Theory to help determine strategies to overcome its affect and thus make M&S standards development cheaper.

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BIOGRAPHY

DR. ANDREW COLLINS is the principle investigator on a federal M&S standards governance project and the principle analyst on an award winning investigation which applies agent-based modeling to the foreclosure crisis. He obtained his Ph.D. from the University of Southampton in 2009 and holds a master's in Operations Research and a bachelor's in Mathematical Sciences. He has spent the last 10 years, while conducting his Ph.D. and as an analyst for the UK's Ministry of Defen[s]e, applying game theory to variety of practical Operations Research problems. Other recent research areas include a philosophical investigation into the use of visualization rhetoric in simulations. He is a Dr. Tolk is member of the Institute of Operations Research & Management Science (INFORMS) and the Society for Modeling and Simulation International (SCS).

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SOLOMON SHERFEY, a VMASC project scientist, was a US Navy submariner and then manager of Simulation Database Services for the Joint War Fighting Center before coming to VMASC in 2008. He is a "mustang", earning his bachelor's degree while on active duty and then being awarded a commission in the Navy. He went on to complete a Master's degree in Computer Science from Naval Post Graduate School and has continued his post-graduate coursework in Modeling & Simulation and Geographic Information Systems.