An Update from the Exploration of Next Generation Technology Application to Modeling and Simulation Standing Study Group

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ABSTRACT

We live in a world of rapidly advancing computing technologies that are evolving independently from military Modeling & Simulation (M&S), which arguably lags the state-of-the-art in computing. In order to take advantage of these advances to benefit military M&S stakeholders, we must be smart in our own evolution bearing in mind how to best adopt new technologies while considering interoperability with existing systems and standardization.

To that end, the Simulation Interoperability Standards Organization (SISO) established the Exploration of Next Generation Technology Applications to Modeling and Simulation (ENGTAM) Standing Study Group (SSG), which includes members from many NATO nations, to research emerging technologies with the goal of understanding how they can be adopted and adapted to support military M&S. The ENGTAM SSG focuses on technology adoption, interoperability, and technical areas, such as big data, cloud computing, artificial intelligence, machine learning and mixed reality.

This paper will discuss relevant findings from the ENGTAM SSG and what they mean to the military simulation community.

1.0 OVERVIEW

In today's environment there is no shortage of emerging and evolving technologies that could be useful to the Modeling & Simulation (M&S) Community of Practice (CoP). Development is not limited to any one technology, M&S use case, vendor, or nation; thus, technologies can be developed anywhere in the world by any size organization or company for many different purposes. Having an array of globally developed options, rather than making the choices easier, can in fact be its own barrier to adoption. The issue for the consumer is not the quantity to select from but how to make an informed decision towards identifying and selecting the correct technology for the requirement. A literature search was conducted in the digital libraries of the: International Organization for Standardization (ISO); Institute of Electrical and Electronics Engineers (IEEE); North Atlantic Treaty Organization (NATO) Science and Technology (S&T) Organization; Interservice/Industry Training Simulation and Education Conference (I/ITSEC); ITEC; and, Simulation Interoperability Standards Organization (SISO). An examination of these noted international organizations and fora focused on the advancement of technology and standards development did not reveal any internationally accepted processes for technology identification, selection, and adoption collectively.

To assist in identifying new technologies, the SISO Exploration of Next Generation Technology Applications to Modeling and Simulation (ENGTAM) Study Group (SG) was created in December 2015 [1]. The concept for the original SG was inspired by the United States (US) Army's Research and Development (R&D) goal of thinking forward with respect to Science and Technology (S&T). The rapid progress in commercial technology solutions and new data transmittal and sharing paradigms led to the need for the M&S CoP to examine what paradigms are becoming more ubiquitous in commercial solutions and can be used in the next generation of M&S technologies. Acknowledging there is no single body, source, or person that knows all of what is required throughout the M&S industry, a venue to support a diverse membership was sought. In order to facilitate maximum participation, a SISO SG was selected for this exchange of ideas and information; a SISO SG permits participation by all interested parties and does not require membership or affiliation in any organization. For this reason, the group has grown to over 100 members from government, academia, and industry world-wide, representing the full spectrum of issues related to technology adoption.

The ENGTAM SG began with a heavy focus on discovering new technologies and discussing how they could be applicable to the M&S CoP. While considering technologies' usefulness, we found that we did not have a basis for making this analysis due to a lack of specific, broadly applicable (and shareable) use cases and no formal way to trace new technology capabilities to existing or future requirements for the M&S CoP. The inability to identify or create such use cases made assessing the utility of the latest and greatest technologies ambiguous due simply to the lack of context of how they would be applied. In searching for use cases and best practices for applying the latest technology to the M&S communities, or to organizations and projects, the SG could not find a structured set of best practices or standards for discovering and adopting new technology for the M&S communities. The lack of best practices and standards for discovering and adopting technology into organizations led the SG to attempt to make a positive impact in that area by addressing this void.

After two years, the SG decided they would like to continue as a SISO Standing Study Group (SSG) with an expanded focus on technology adoption as well as examining the technologies themselves. The SSG's Terms of Reference (TOR) includes six main tasks that help focus the group's activities, discussions and path forward:

- Capture and decompose common M&S program goals
- Explore the latest industry technology trends and available solutions
- Account for security requirements

- Consider other architecture quality requirements and management requirements
- Assist the M&S CoP in staying informed
- Produce a final report and deliver to the SISO committee with oversight

The SSG continued their literature search and concluded that there are limited materials on technology adoption within industry inside and outside of the M&S community of practice. Each organization, and how they adopt and utilize new technology, can have very different goals and objectives, which makes it difficult to create a standard that fits everyone's needs. The SSG believes that although a standard would be difficult, best practices could be developed that could assist M&S organizations and projects in discovering the latest advancements, staying current on technologies, and determining the applicability to their needs.

2.0 SSG VALUE TO INTERNATIONAL M&S COP

Government M&S practitioners are living in a world where technology advances are continuously occurring outside of their purview without control of how or when these technologies will be developed or implemented. Historically, new technologies relevant to the M&S CoP primarily were explored and developed by the government. Today, the majority of these developments are being driven by commercial industries for non-military and non-M&S requirements. While we in the M&S CoP do not set the requirements, we do have the ability to adapt these technologies for our use. All M&S-enabled communities can benefit from the work of the ENGTAM SSG. The SSG focus has been enlightening, educational and entertaining in the exploration of the new technologies to apply to existing needs. The basic challenges of technology exploration and adoption has many facets, and, as discussed previously, the SSG has begun to design a process to assist the user in making informed decisions. By applying the phases outlined in the Technology Adoption Activity Model (Figure 5-1), we may avoid dependencies on technologies that may not be well-suited for an organization, have technical integration issues with current technologies, or do not have lasting power in the market. Application of these phases facilitate further consideration of the ways in which we adapt these technologies to M&S-enabled communities.

By functioning as a diverse body of knowledge for the M&S CoP, the SSG can address issues pertaining to adoption of technologies. For instance, while a specific technology may have an Application Programming Interface (API), without coordination as a community on how to interface with that technology, every application interfacing with it will be custom. In other words, each user will be inventing case-specific methods to address their individual requirement, thus limiting the ability for reuse across other M&S. In some cases, API's may be developed with a dependency on a specific technology as opposed to being systems engineered to be technology agnostic. In turn, it behooves the M&S CoP to work together in an SSG that is all inclusive in membership as we consider how these new technologies will be applied in order to help determine the best methods to advance the art of M&S. A diverse group of participants will also be able to share unforeseen consequences of adopting some technology. For example, in August 2018, the United States Department of Defense began to restrict the use of fitness trackers, a common app on wearable technology, due to security concerns over location tracking [2]. Through collaboration among the many diverse stakeholders in the M&S CoP to address common issues and solutions, an integrated, synergetic effect will result as the ENTGAM SSG explores the adoption of new technologies.

3.0 TECHNOLOGY AREAS

The SSG meets telephonically on a monthly basis to discuss technologies, technology adoption, use cases and the best direction forward regarding how the M&S CoPs can remain knowledgeable with the fast pace of technology advancements. There is a large participant base with lively discussion about the topics at hand.

During these monthly meetings, the SSG has hosted briefings and conversations that included both general concepts and specific project or technology briefings. Some of the concepts covered include technology adoption, applying cognitive solutions to M&S, M&S use cases, simulation in a more autonomous future and wearable technology. The specific projects and technologies presented include those shown below.

3.1 Big Data by the United States Training and Doctrine Command (TRADOC)

The SSG was presented a concept of a data-centric organization using big data tools, methods, and artifacts to improve organization performance. The big data tools for data ingestion, integration, search, visualization and many more methods are being used by TRADOC to improve critical thinking, harnessing the power of data-based insights to frame future threats, provide insights on current threats, and to build US Army readiness. Some specific tools presented included multiple visualization techniques and formats, geo-mapped events, unstructured data analysis, a directed search engine, network generator, document annotator, and a faceted search among others. [3]

3.2 Cloud Computing Use Cases and Resources by Google

Google staff presented to the SSG technologies relevant to the CoP based on geographically distributed computing. The discussion varied across Google's massive global infrastructure as well as the Google Cloud Platform [4], covering dozens of tools and capabilities, including orchestration, raw data management, information extraction, trend analysis, and visualization. The tools within the Google Cloud Platform are enterprise level solutions but using any commercial cloud solution can be challenging within the defense industry due to security concerns. Much of the discussion with Google and the SSG members centered on how Google's solutions could be used within the rules and regulations dictated by various governments by their respective Information Technology (IT) departments.

3.3 Commercial Off-The-Shelf Technology (COTS) Emerging Technology Evaluation & Exploitation (CETEE) Project by the Defence Science and Technology Laboratory (Dstl) in the United Kingdom (UK)

The UK Dstl briefed the SSG about a research program in the UK that informs and enables the UK government to exploit COTS and emerging technology known as CETEE [5]. This program researches emerging technologies within industry, constructs practical demonstrations per UK defense requirements, and provides detailed assessments of technologies ultimately for technology adoption. CETEE has several successful case studies where detailed analyses were conducted to determine if and how new technologies identified by their constituency could be exploited to the benefit of UK programs.

3.4 Applied Machine Learning for Cyber Security by IBM

IBM staff presented outcomes from a project that used machine learning and IBM Watson [6] technology to support a cyber security use case. Machine Learning [7] was used to detect specific behavioral patterns within datasets to train systems for threats to the network. The mathematical analysis, and big data strategies, such as aggregation, anomaly detection, and filtering, were useful for the SSG to learn about as those methods apply to many M&S use cases.

3.5 Enabling M&S in the Internet of Things (IOT) Landscape by ANSYS, Inc.

The SSG received a brief about M&S using IOT technologies [8] across wearable technology and sensors [9] within system development use cases. The complexities of sensors, protocols, and the mix of mechanical, electronic, and software systems being orchestrated for M&S use cases were described and discussed. Multiple use cases were discussed to determine applicability to the M&S community. The general lessons learned from implementing and managing complex systems of systems is applicable to many M&S programs, but more broadly, applicable to many defense programs as well.

3.6 Operationalizing Big Data by the US Army Tank Automotive Research, Development and Engineering Center (TARDEC)

This presentation included fascinating examples of how big data is currently being used by professional sports teams, broadcasting companies, and game developers to optimize their respective performances [10]. An emphasis was placed on the importance of data to national defense and how big data techniques could be applied within M&S use cases. Specific examples were provided of existing programs using big data strategies for their mission for many reasons including improvement of behaviors, better understanding of phenomena, and machine understanding for better automated performance.

These technology areas are still rapidly growing and possible uses of the technology are not fully known. It is important for the M&S community to remain vigilant in discovering new technologies, and understanding how those technologies can assist in their respective missions.

4.0 TECHNOLOGY ADOPTION

The initial research conducted by the SSG found many models for aspects of technology adoption; however, most only focused on a portion of the issues, such as how technology is adopted, how it is accepted, and defining the technology lifecycle as a whole. The overall difficult process of adoption from identification of the need to implementation did not seem to have a canonical definition; our literature search did not find references that provided sufficient detail about the specific steps to take but did identify an attempt at keeping the applications generic, which is reasonable.

Due to the varying types of organizations with respect to size, types of technologies, how ubiquitous the technology is employed within the organization and the varied audience within an organizational structure, discussing adoption in a meaningful way can be challenging as are attempts at standardizing technology adoption. To be specific enough to be useful, the discussion has to be focused toward a specific type of organization, type of technology, and application. But, narrowing the scope in this way shrinks the audience that would benefit. Thus, in order to address technology adoption as a whole, the SSG decide to create a generic Technology Adoption Activity Model.

During the literature search, we attempted to find sources that characterize categories of technology adopters. Dr. Everett Rogers, in his work the “Diffusion of Innovations” [11], graphed a curve of new technology market share across classifications of people (innovators, early adopters, early majority, late majority, and laggards). Another attempt at visualizing technology adoption is the Gartner Hype Cycle [12], which depicts that expectations of technology grow quickly over time with the “innovation trigger” until, at the “peak of inflated expectations,” there is a drastic drop into the “trough of disillusionment” where users better understand what the technology can really provide.

The SSG further conducted research to identify indicators that could assist in forecasting what technologies will be prevalent for consideration by the M&S CoP in the near future. Among those found, the SSG considered the Varian Rule[13], which states that, "a simple way to forecast the future is to look at what rich people have today; middle-income people will have something equivalent in 10 years, and poor people will have it in an additional decade." For example, in the M&S CoP, the "rich" could be a number of groups including: large government M&S programs; large commercial M&S vendors; new start technology companies with large amounts of venture capital, etc. How users accept the technology to do their mission is important to how technology is adopted. The Technology Acceptance Model [14], shown in Figure 4-1, illustrates the acceptance of technology being based on its perceived usefulness and ease of use.

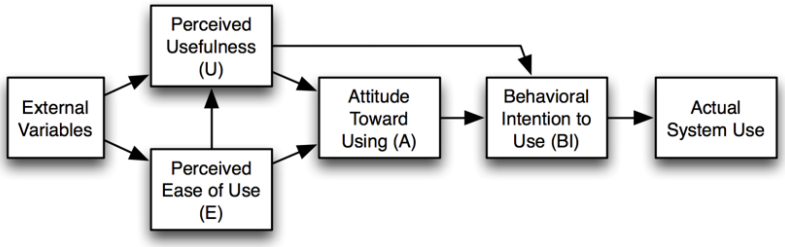

Figure 4-1. Technology Acceptance Model

These theories and models provide a solid foundation for the SSG to begin building a best practice guide for technology adoption. Examining technology adoption case studies [15] [16] [17] and issues [18] led the predecessor SG to the phases and considerations for technology adoption within the M&S CoP in the following section.

5.0 BEST PRACTICES

The best practices that the SG, and then the SSG, have identified are targeted to a wide breadth of potential use cases, including government research and development projects, government programs of record, large companies and small companies. The best practices consider the use of technology by internal and external users, where internal users are defined as people within the organization that employ technology to accomplish internal tasks, and external users are defined as people outside the organization, like customers, that employ technology as they interact with the organization.

The SSG has broken the technology adoption model into five phases, as shown in Figure 5-1. These five phases are meant to encompass the spectrum of understanding the organizational goals, discovering new technology that is applicable to the mission, adopting that technology, and maintaining it over the relevant lifecycle. They are:

- Understanding the Current State – knowing the organization goals is the first step to understanding how any new technology may be of benefit.
- Technology Exploration – a concerted effort of finding new technology, new products, and what is coming in the near future.
- Technology Evaluation – a process for learning more about technology, including capabilities, integration points, pricing, maintenance, etc.

- Technology Adoption – bringing a new technology into an organization, whether replacing an existing technology or not, thereby bringing a new capability to an organization.
- Technology Management – maintaining, adjusting, or removing technologies.

Step	Current State	Exploration	Evaluation	Adoption	Management
Activities	• Organization goals • Organization strategy • Organization capabilities • Organization needs / weakness • Use Cases • Systems Views	• Identify capability areas • Identify technical areas • Plan, staff and schedule exploration activities • On-going monitoring	• Systems engineering for how technology will integrate (technical and process) • Testing (component and system) • Pricing (full life cycle) • Scheduling	• Backup Existing Solutions / Data • Partial / Full Replacement Strategy • Training • Installation • Integration • Data Migration • Process Adjustments	• Maintenance • Upgrades • Process Refinement • Integration Adjustments

Figure 5-1. Technology Adoption Activity Model

5.1 Understanding the Current State

This step was influenced by the SSG's struggle with broadly applying the technologies we were discovering to M&S projects and/or organizations. The SSG found numerous emerging technologies with seemingly useful capabilities, but it was difficult to identify who (organizations and projects) within the M&S CoP would benefit from that technology without having knowledge of what methodology and/or technology the projects and organizations were using to address the task and if there was a technology void to be filled.

Discovering, understanding, acquiring, and applying new technologies would be greatly enriched if one knew what the functional objectives were and how those functions are currently being accomplished. This understanding should be based on the organization's strategy going forward, both for the business model as well as the technology, and how technology fits within the organizational strategy. The organizational goals (its mission), strategy (how it will achieve that mission), current capabilities, and needs are all critical to understand before knowing how any technology can be of use to that organization. These can be recorded in any format the organization chooses (e.g., use cases, systems views, etc.) and agreed on by those leading the organization, those executing the current mission, and those pursuing new technology on behalf of that organization. The use cases and/or systems views should include how users interact with the technology, the organizational processes, how the technology is integrated or connected, and how the technology is maintained, upgraded, and eventually replaced.

The current state of the organization should not drive the technology exploration; it is important to approach the discovery process with an open mind. The current state will, however, provide a foundation to determine the value of further exploration by the organization, and can be viewed as a baseline to focus the technology discovery and evaluation. As new technologies and capabilities are identified, they can be assessed based on the organization's goals for applicability and how they might be used.

5.2 Technology Exploration and Discovery

Once the current state and the future goals of the organization or project are known, the next step is to find out what technology exists, or will exist soon, that can help the organization meet its goals. This starts with learning and staying abreast of the relevant industries that can satisfy the target capabilities. Knowledge about what technology exists in the marketplace is the underpinning for discovering new technologies and how to discern their advantages over existing and competitive/similar technologies. Without broad market research, a technology maybe chosen that is not optimal for the organization's needs. While this may sound obvious, too often what is chosen is the first technology that seems relevant, rather than what would truly have the most benefit. Technology exploration is best suited for somebody already familiar with the technology domain, the current implementation, and the state of the marketplace relevant to the technologies useful for the organization.

Furthermore, technology exploration and discovery should be an on-going and iterative effort. True exploration of the marketplace is more than reading magazines and going to conferences. Technology explorations and discovery should be treated as a research project with on-going tracking. Based on the organizational capabilities defined in the current state assessment, this step should concentrate on identifying both specific areas of capabilities upon which to focus and technical areas that relate to the organizational capabilities. The technology exploration effort should be planned, staffed, and scheduled. This is not a trivial task, but rather a time-consuming, detail-oriented task, which should be treated as an important, comprehensive, and documented process. The iterative nature of this effort will allow for monitoring of progress within the commercial industries of interest as well as within the organization, and how it progresses over time with consideration to changing goals and capabilities. Regular evaluation and feedback, and maintaining up-to-date documentation, is key to success in this phase.

5.3 Technology Evaluation

Once a technology has been identified as potentially being useful to an organization, the next phase in the process is to assess the technology in detail including: how the technology would be used; how it would integrate with other systems; and the robustness of the system, technology, pricing, and availability.

Systems engineering, including an assessment of processes, should be conducted to understand how technology would fit in to an organization's process and workflow, and how it would integrate with its other technology. This phase should be treated as if it were a new development effort with appropriate systems engineering artifacts, processes, and reviews to ensure that all the systems within the organization operate appropriately for the organization's goals.

Before adopting the new technology into the organization, it should be tested at both a component level and System of Systems (SoS) [19] level. Testing of the new technology can be done with or without a vendor. In some cases, the vendor may not allow for trials, tests, and usage before purchase, but if that it is an option, the technology should be placed in an appropriate environment within the organization for internal, unbiased testing.

Pricing should be considered across the entire expected lifecycle of the technology including licenses, training, maintenance, staffing, and eventual removal. The price of any technology is more than the purchase/license cost,

but also includes how much it will cost the organization to incorporate the technology. Such costs include training staff, technical administration and maintenance, on-going license or support, integration, and additional consideration throughout lifecycle of the technology (including removal) from the organization. Organizations should also consider the cost of not adopting the new technology; that is, both the current and opportunity cost of maintaining the status quo.

Scheduling also needs to consider systems engineering, procurement, installation, testing, training, the learning curve of the users, and maintenance. This planning and scheduling, especially for large organizations, can be a big concern, but it should be planned with risk in mind. New technologies, and their adoption within organizations, can be fraught with risk due to the uncertainty of how the new technology really works, the potential immature nature of emerging technologies, and the perception of how it works due to marketing material instead of actual experience with the technology. Risk factors of bringing in new technology can be reduced with a strict and thorough evaluation process.

5.4 Technology Adoption

Adopting a new technology can have varying levels of disruption within an organization depending on its use. How users interact with the new technology is important to understand within the organizational processes, outreach, and management. Considerations for users should be for both users outside the organization (paying customers) as well as users within the organization (employees). Bringing in new technology will require proper scheduling (i.e., system down time, training), will come with expense, and could have some unforeseen consequences that need to be handled.

From an execution perspective, engineers should plan for and implement backups, schedule down time with users, install the new technology, and migrate any appropriate data from old formats to match what is required by the new technology. Process adjustments may need to be made, which should be driven by the systems engineering in the technology evaluation. It may make sense to execute a partial adoption when organizations have critical real-time systems or a large number of users. Partial implementation split across users could help mitigate risks when problems occur.

Training and the resultant learning curve, potentially creating a decrease in productivity, should be considered, scheduled, and anticipated. In some cases, the new technology involves a modification of processes, new user interfaces, new data, or other items that users need to adjust to. Careful consideration should be made to determine if the new technology has easy to use interfaces, user guides, and training. In some cases, the old system should be maintained for a limited amount of time in case there are issues or critical needs.

5.5 Technology Management

Technology management includes maintaining, upgrading, and improving the technology, how it is used, and how it is integrated within the organization. On-going maintenance is different for each technology; how the new technology differs from the old technology could mean that the maintenance requirements differ in terms of time, money, effort, and cost. Most technology providers disseminate upgrades as they become available. How and when an organization upgrades from one version to the next depends on what new capabilities are provided with the upgrades. Upgrading also has a transition period where the system may be unavailable for a period during the upgrade. These periods' length and complexity issues (e.g. data migration, integration points, etc.) are specific to the technology, data, and organizational usage.

Organizations should also consider improvements and adjustments to how the technology is used and integrated with other technologies within the organization. In order to determine the return on investment, data should be collected (as possible) in order to quantify cost avoidance (both time and money) or any other improvements that the new technology brings to the organization. As the technology improves or how it is used changes, the systems engineering artifacts from the first phase (understanding the current state of the organization) should be constantly updated. This entire process should be iterative and continual. Technology will never stop improving. There should be plans for periodic reviews to assess the technology for future lessons learned.

6.0 CONCLUSION

The Modeling and Simulation CoP appears to be a natural place to benefit from new technologies; however, organizations cannot evaluate them in the abstract. Well-formed use cases are critical as a framework for measuring the potential value of adopting a particular technology. The ENGTAM SSG has found that frequently well-defined usage needs have had an immediacy that could not wait to follow a lengthy process for the evaluation and adoption of new technologies. Conversely, persistent use cases were described at too high a level to inform technology decisions. Introducing a well-defined process, like the five-step process developed by the SSG, can help focus an organization's activities and introduce a methodical technology evaluation and adoption process. Periodic discussions on successes and failures in adopting new technologies will be extremely beneficial, since new technologies appear on the market with a breadth and speed that make it impossible for any single program to maintain cognizance of all of them. As this problem space continues to expand and morph, the SSG can remain agile enough to respond to the CoP's emerging needs. Wide participation allows all SSG members to introduce the latest trends and to advise each other on some of the unintended consequences of technology adoption that we may experience. To help with this, the SSG is actively soliciting input to formalize this process and its implementation from the larger M&S communities of practice. The authors encourage participation in the ENGTAM SSG activities by anyone who is interested.

7.0 REFERENCES

[1] McGroarty, C., Metevier, C., Gallant, S., McDonnell, J., & McGlynn, L.. (2016) Are We Progressing?: Exploration of Next Generation Technology Applications to Modeling and Simulation Study Group Update. Simulation Interoperability Standards Organization (SISO). Simulation Innovation Workshop (SIW).

[2] Garamone, J. (2018) New Policy Prohibits GPS Tracking in Deployed Settings. U.S Department of Defense News. https://www.defense.gov/News/Article/Article/1594486/new-dod-policy-prohibits-gps-enabled-devices-in-deployed-settings/

[3] Darone, K. (2018) TRADOC G2 Operational Environment Enterprise Big Data Presentation to ENGTAM. SISO. https://discussions.sisostds.org/index.htm?A3=ind1805&L=SIW-SSG-ENGTAM&E=base64&P=1634&B=--part-Ae5ZMF1ME1aA1Kcpd225AQc5gjF3yA7E7DAA1Z7pSK0PB&T=APPLICATION%2FPDF;%20name=%22201805001%20ENGTAM%20Kaye%20Darone.pdf%22&N=201805001%20ENGTAM%20Kaye%20Darone.pdf

[4] Google (2018) Google Cloud Platform. https://cloud.google.com/products/

[5] Defence Science and Technology Laboratory (DSTL). Commercial Off The Shelf (COTS) & Emerging Technology Evaluation & Exploitation. http://www.cetee.org/Documents/CETEE%20Info%20Sheet.pdf. 2016

[6] IBM Watson Product Information. (2018) https://www.ibm.com/watson/

[7] Nilsson, N. (1998) Introduction to Machine Learning. Robotics Laboratory, Department of Computer Science, Stanford University. http://ai.stanford.edu/people/nilsson/MLBOOK.pdf

[8] Vermesan, O. & Friess, P. (2013) Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems. Aalborg, Denmark. River Publishers.

[9] Ryan, S. (2014) Garments of Paradise: Wearable Discourse in the Digital Age. MIT Press.

[10] Smith, R. (2017) Operationalizing Big Data. TARDEC Brief to the TRADOC G-2 Mad Scientist Series. https://www.youtube.com/watch?v=fLtDLLtSkA0

[11] Rogers, E. (1983) Diffusion of Innovations (3rd ed). New York: Free Press of Glencoe.

[12] Fenn, J., Raskino, M. (2008) Mastering the Hype Cycle. How to Choose the Right Innovation at the Right Time. Harvard Business School Press.

[13] Varian, H. (2011) Micromultinationals Will Run the World. Foreign Policy. https://foreignpolicy.com/2011/08/15/micromultinationals-will-run-the-world/

[14] Davis, F., Bagozzi, R., Warshaw, P. (1989) User Acceptance of Computer Technology: A comparison of Two Theoretical Models. Management Science, 35: 982-1003.

[15] Kyratsis, Y, Ahmad, R., & Holmes, A. (2012) Technology Adoption and Implementation in Organisations: Comparative Case Studies of 12 English NHS Trusts. BMJ Open 2012; 2(2): https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3329608/

[16] Ammenwerth, E., Iller, C., & Mahler, C. (2006) IT-Adoption and the Interaction of Task, Technology and Individuals: a Fit Framework and a Case Study. BMC Medical Informatics and Decision Making 2006 6:3. https://bmcmedinformdecismak.biomedcentral.com/articles/10.1186/1472-6947-6-3?report=reader

[17] Groves, M. & Zemel, P. (2000) Instructional Technology Adoption in Higher Education: An Action Research Case Study. International Journal of Instructional Media, New York 27.1.

[18] Choudrie, J. & Dwivedi, K. (2005) Investigating the Research Approaches for Examining Technology Adoption Issues. Journal of Research Practice. Volume 1, Issue 1, 2005. http://jrp.icaap.org/index.php/jrp/article/view/4/8

[19] Maier, M. (1998). "Architecting Principles for System of Systems". Systems Engineering. Vol 1, Issue 4, Pages 267–284. International Council on Systems Engineering (INCOSE).