MS2G AS PILLAR FOR DEVELOPING STRATEGIC ENGINEERING AS A NEW DISCIPLINE FOR COMPLEX PROBLEM SOLVING

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ABSTRACT

Simulation science is a strategic resource to address most challenging problems; in this paper, it is provided an overview about how new simulation capabilities, such as that ones based on MS2G (Modeling, interoperable Simulation and Serious Games), could enable to address complex systems and to support decision making; in addition, the new Strategic Engineering Discipline is proposed as framework where to combine all these new approaches for Problem Solving and Strategic Planning nowadays; several real examples are proposed as case studies to confirm the validity of these innovative concepts.

Keywords: Modelling & Simulation, Interoperability, Decision Support, Strategic Engineering, Serious Games

1 INTRODUCTION

Today very important changes in geo political situations generate a very dynamic evolution: large humans' migrations, climate change affecting nations economies, religious and ethnical conflicts, new emerging powers and their actions devoted to promote power projection.

These situations are related to many factors and affect many different layers: politics, economies, market, homeland security, etc. Along last decades, technology has changed several aspects in human life due to many factors including: interconnectivity, mobile technologies, computational power, data science and machine learning, micro sensors, biomedical devices, etc. These elements are providing us new challenges as well as opportunities that slightly change the potential in analyzing and addressing the strategic issues.

In facts, the term Strategy comes from Greek, combining *stratos* (army) and *agein* (leading) so it is pretty clear that it deals with leading resources. In facts, it has been said that "Strategy is the art of good direction" ("La Stratégie est l'art de bien diriger", Jomini, Prècis de l'Art de la Guerre, 1838), therefore also the necessity to have dynamic solutions for strategic planning was clearly stated by Von Clausewitz, published by his wife while almost 200 years ago (Vom Kriege, 1832): "we need a *philosophy of strategy* that contains the seeds of its constant *rejuvenation*, a way to chart *strategy in an unstable environment*". So this good directions rely today on new supports, simulators and models integrated with other system and devoted to be successful and competitive. In facts to support strategic planning we need *engineering methodologies* able to deal with current complexity of the world and to use the available enabling technologies; in this sense simulation is a crucial science to support these activities and in fact the MS2G (Modeling, interoperable Simulation and Serious Games) paradigm is one of the most promising approach to be used in this context; this paper proposes an overview on how to use new simulation models with other techniques to support strategic decision making and outline the importance to shape new discipline integrating all these capabilities within a framework such as Strategic Engineering.

2 TODAY vs. YESTERDAY

Today it turns possible to identify how to solve a problem by using the high density information available and smart algorithms; it is also possible to test them on models able to simulate reality; in this way the simulators could predict complex system behaviors, on different time horizons, and could analyze a wide spectrum of alternatives that lead to develop dynamic solutions able to self adapt to changes in boundary conditions and eventually to competitor strategies.

This, obviously, have a great impact on problem solving and decision making related to strategic issues. However, somebody might object that this is not new, that these considerations were in place since computer technology was available and that even in the past this process was applied by using M&S; obviously this is partially true (Longo, 2011). In facts a perfect example, to understand this point and related changes, is proposed by Mission Earth initiative and the GENI (Global Energy Network Institute) global simulation; these activities have been inspired by the first report of *Club of Rome*, established in 1968 at *Accademia dei Lincei* in Italy by an international community of individuals including former head of state, diplomats, scientists, economists, business leaders, etc (Meadows et al., 1972). On the early fifties, the founder of *Society for Computer Simulation International*, John McLeod, established the "Simulation in Service of the Society" and later on with another simulation titan, Ben Clymer, activated Mission Earth initiative (McLeod 1968, 1986; McLeod John & Suzette, 1974; Clymer 1969, 1980, 1994; House & McLeod 1977). Mission Earth initiative focused on the creation of new simulators to address in new way the concepts behind World Simulation Game proposed on 60's as well as to support development of new strategies (Fuller 1969). For instance, in this framework, GENI project was devoted to study how to

distribute power around the globe to promote cooperation, to solve major issues and, even, to support Earth Development and Peace (McLeod 1999; Clymer A. 1993; Clymer M. & Mechoso 1997). These are examples about very innovative global models addressing world problems, developed by major experts of simulation, along three decades, many year ago; so it is clear that the idea to use M&S for Strategies has always been there; so what changed? The answer is in the example itself, by analyzing the problems experienced in relation to these initiatives: most of them were based on few extraordinary volunteers with limited visibility on media; in addition the models were pretty complex and the results difficult to understand for a broader audience with no scientific background considering multidisciplinary elements; last, but not least, setting up these scenarios and acquiring reliable data was a major issue (e.g. just the collection of GDP data of all countries over a decade was not "just one click" in 70's or 80's). These considerations make it clear what changed: today we have possibility to cooperate among a wide community of scientists with web technologies, to discuss and share models; we have technologies to integrate models and to let them interoperate over the web; we can access huge amount of pretty reliable data that could *easily* used in simulators; we have much more computational power and even the possibility to distribute these models on smartphone among people and let them play the "Global Energy Distribution Network Game". These are just few examples, but they make it easy to answer the question "what changed?": the change is that today we have technologies, data, resources and capabilities to turn the dreams of our "simulationist fathers" into reality. This means that visionary new projects could be developed and the old ones could be completed providing a real "Service to the Society" by using Modeling and Simulation (M&S).

3 TODAY AND TOMORROW

It is possible to consider a new question "so why we don't do all this marvelous use of simulation if it is possible?". Also in this case, it is easy to reconsider the characteristics of technological enablers that we used to confirm, in previous paragraph, the great current capabilities. For instance, combining different models is obviously a major necessity if we need to address complex strategic problems (Bruzzone et al. 2014); in the proposed case of power distribution and generation over wide regions: there is necessity to combine models related to economy, quality of life, diplomacy, politics, etc. In this case, even if interoperable simulation standards are consolidated since 20 years, it is evident that we are still far away from being able to easily integrate two different simulators (Kuhl et al.2000; Bruzzone & Massei 2017). This is due to currently available standards and developments: they are mostly addressing technological interoperability while conceptual interoperability is an open issue (Bruzzone et al. 2017a); in additions there are programming aspects that need to be improved in terms of reliability by M&S Research and Developments (R&D) for being able to interconnect such systems (Bruzzone 2017). Human factors represent another crucial element, very hard to be addressed and expected to keep a significant role in future sophisticated models due to its stochastic nature despite the big potential in developing simulators facing these elements (Bruzzone et al. 2015). Another major aspect is related to the quantity of data, including actual ones and collected in quasi real time from the field: it is something pretty new and requires new solutions to be developed for filtering them as well as to extrapolate trends and symptoms that before were impossible to detect due to the low frequency (or not availability) of available samples (McAfee et al.,2012). Similar problems are related to data farming and capability to check and validate output (Sanchez 2014). Another very important factor potential of available algorithms, often based on AI (Artificial Intelligence), that allow to correlated the data and extrapolate behaviors: these need further developments and improvements (Wu et al., 2014;Najafabadi et al., 2015). Some other critical aspects are related to simulators distributed over mobile solutions and smart phones operated by people: also in this case technology is available, but a lot of R&D is required to improve reliability, immersive capability, interactivity, to reinforce and consolidate concepts such as MSaaS (Modeling and Simulation as a Service) or cloud services (Li et al.,2010; Cayirci 2013). So, what is the consequence of this Maieutic analysis? The point is that we have a potential capability, but Simulation Community, as well as other scientists, need to work hard on R&D to turn the potential in reality and to let evolve techniques and methodologies to be reliable and usable. MS2G moves exactly in this direction because it emphasizes not only the technological aspect, but also the necessity to create models that engage and immerse the users, enabling them to understand the simulation framework respect the reality and how to interact with it. In facts, one major future challenge will be also related to the necessity to increase people and decision makers' level of knowledge to properly operate these systems; this requires different kind of cultural developments such as capability to have transdisciplinary teams, to understand big data and complex correlations, to develop skills for interacting with new Simulation Systems (Elfrey 2006; Bruzzone et al.2014b, 2017b). In facts, MS2G deals to develop new features in simulators to facility people, but it is evident that is also fundamental to update Educational Programs and Initiatives to support the evolution of potential users' community.

4 TOMORROW CHALLENGES & THREATS

Tomorrow challenges are always infinite as human imagination; MS2G can be combined (with a great potential) with other sciences & Technologies as very recent researches show in different domains and applications areas, e.g. Data Science (Irani et al., 2018),

AI & Machine Learning (Longo et al. 2017), Internet of Everything (Naranjio et al., 2018) among the others; so it is expected to create a real innovative context where decisions are taken based on deep knowledge, valid models, extensive alternative comparison, multi-criteria analysis and dynamic evaluation of feedbacks.

This sounds as the philosopher's stone, therefore this approach should provide even simple aids; for instance thinking back to the 90's, GPS and driving systems were already there as well as technologies to know traffic density, while Intelligent Transportation Systems were collecting and processing such data; however the available information were much more limited and the driving systems were performing just search on routes, with pretty limited capability to consider traffic situations. (Varaiya 1993; Bart et al. 1996). Today, we have ultra light smart phones with large screens that show us the map including many details (e.g. info on shopping, parking, attractions) while the length of traffic queues estimated with 100m precision (Kim 2017; Wan et al., 2016). This means that in near future MS2G could lead to address not only the "world energy program for United Nations", but also the "recycling process optimization for a town in North Italy", saving few million Euros and improving quality of life of hundred thousand people. In addition MS2G could be used even for more radical changes, such as improving mutual trustiness between Institutions and Populations, by sharing these models and cooperating in developing solutions trough crowd sourcing (Bruzzone et al.2014b). In facts, we might imagine a future where people could run the simulators and analyze proposal from political leaders to check and validate them; at the same time an emerging issue could be addressed by the people that are experiencing it and their proposals could be tested on the model and, if applicable, incorporated in solution to be adopted by authorities. This could lead to have very dynamic decisions and plans, capable to react and adapt to mutating boundary conditions.

In this sense, just in these days, the author is working in using previously developed models to manage the crisis generated by the collapse of "Morandi Bridge" in Genoa (Harding 2018). In this case, a specific model was adapted to study Genoa respect Strategic Urban Planning for preventing and mitigating Flooding as part of "Decision Theater" project framed in Smart City Initiatives, closed just last December (Bruzzone et al.2017b). This means that in August XIV, 2018, when the crisis emerged, the Population and City Models were already available and tuned, so it is currently possible to use them to analyze different solutions.

However, as always, all these capabilities could be sensitive to improper uses and it is recommended to adopt ethical code in developing solutions based on Simulation Science (Oren et al., 2002). It worth to mention some of the major threats: one for all, a misleading Models Validation and Verification (Balci 1997); indeed not validated models or, even worst, simulators deliberately mistuned to provide desired output, could lead to wrong decisions. Therefore there are more sophisticated threats that are hidden in the folds of the future: a major one is in *the eye of the beholder*. In facts, if the simulation users and decision makers don't know what are the questions or what is the proper perspective to address a problem, even new paradigms cannot provide valid solutions. Considering the above mentioned case of the recycling process applied to a small town: if the Authorities would focus on path optimization in garbage collection service, they might miss the point that population consumption modes could be more sensitive factors to reduce waste: e.g. paying back for empty cans or bottles as happens in some countries (Huang et al., 2005; Duma & Nemeslaki 2013). This reveals a need to educate and train people in strategic view and this is one of the major goals of the new initiatives such as STRATEGOS the new MSc in Strategic Engineering recently activated at the Genoa University (*www.itim.unige.it/strategos*).

Indeed STRATEGOS is devoted to promote quantitative modeling to support decisions by developing a new generation of Engineers able to deal with Strategic Thinking and to support Decision Makers by mastering advance modeling, simulation as well as other enabling technological and scientific areas.

There are many other potential shortfalls, but it is important to outline a major threat related to simulation that in future could turn even more hard to face. A famous quote by Mahatma Gandhi states "*freedom is not worth having if it does not include the freedom to make mistakes*". The new generation solutions, combining science along with all new technologies, could provide very efficient models to predict behaviors, with invasive control of communications, biodata, etc. It could turn possible to control each individual or group and to predict their action influence by violating privacy as it happen usually nowadays. Obviously human factors will be present anyway, but by adopting some kind of sci-fi vision, it could be possible to imagine models able to predict society and group evolution, and to develop plan to influence them it as happen with psychohistory (Asimov 1951). It is important to highlight that this could be an issue for the whole mankind considering that it could reduce *free will* based on a "wide computational intelligence supported by science". In such sense we can figure out a variety of possible future scenarios, not necessarily for the good of the humanity: from the *good shepherds* driving the decisions based on a comprehensive view that overpass individual capability, to *conspiracies* using these technologies passing through a super Artificial Intelligence "*equipped*" of friendly or hostile behavior. Scientific literature considers some of these elements and for sure new predictive and reactive capabilities should be addressed in some way without losing a pragmatic point of view (Duderstadt 2005; Blackmore 2006, Barrat 2013). The Solution to these pitfalls is not easy and unknown, yet. Nevertheless human being is able to be responsible, to behave ethically, to be noble, to lead for equality and freedom, to discern good and evil and to be brave enough to make right decisions

despite consequences; these properties of human beings are unique and probably the basis to find prospective answer based on author point of view. In any case, the scientists should identify as early as possible these potential risks and to work together to find viable solutions; it is evident that the future will require to lead these technologies along with people education while obscurantism might be not a solution.

5 NEW SIMULATION PARADIGMS FOR DECISION MAKING

The MS2G (Modeling, interoperable Simulation and Serious Games) is an innovative paradigm devoted to support development of new solutions able to benefit from the different characteristics of these specific methodologies and to enhance fundamental aspects of Simulation Science such as usability, engagement, fidelity and modularity. In facts, the basic concept is to develop an approach that combines Interoperable Simulation with engagement and immersive capabilities provided by Serious Game approach.

In facts, the MS2G is a pillar for new capabilities development in many applications sectors with particular attention to complex problems affected by uncertainty where the users are decision makers with time and resource constraints. In this case there is often a necessity to have different models interoperating while considering stochastic factors and at the same time to maintain control over results fidelity while the time to configure, use and analyze the results is short and need to be intuitive for the user and able to guaranteeing its trustiness.

6 STRATEGIC ENGINEERING AS EMERGING DISCIPLINE

Strategic Engineering is a new Discipline that could be one of the possible solutions to create skilled experts for developing the new generation of simulators. In facts, the main aim is to prepare experts and develop a framework where to amalgamate different domains and strong scientific foundations that could lead to prepare new models highly interoperable and strongly interconnected with other systems and data. It is evident that Strategic Engineering strongly relies of the capabilities of simulation advances such as MS2G paradigm. Therefore the Strategic Engineering is devoted to develop Strategies in Industry, Business, National and International Activities, Defense and Homeland Security. Indeed the Strategic Engineering considers to address the complexity related to these sectors by creating a combined approach based on Modeling & Simulation, Data Science, Artificial Intelligence and Operational Research combined with enabling technologies, such as IoT (Internet of Things), Cloud Services, etc. Obviously MS2G is an ideal paradigm to support this activity that could be effectively used by Decision Makers dealing with Complex Problem Solving. These activities are eligible to be used into development of new Strategies for a wide spectrum of sectors where transdisciplinary elements are fundamentals (e.g. economy, operations, politics, social aspects) to succeed (Elfrey 2006).

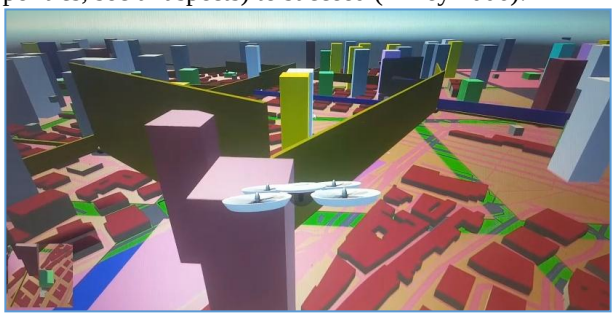

Figure 1 – Flying over Town Dynamics with Big Data

In this sense there is a necessity to develop capabilities and even skills for Strategic Engineering and also the opportunity to create new educational path for engineers and scientists mastering these techniques as well as training programs for Decision Makers and Strategists to learn how to use these innovative approaches. The synergy MS2G and Strategic Engineering could lead to develop new solutions for actual applications.

7 CASE STUDIES AND EXAMPLES

The Strategic Engineering proposes several case for new MS2G Solutions applications; indeed these elements are pretty interesting while addressing problems currently popular, where the number of variables and output data is so large that intuitive and immersive frameworks connected to interoperable simulation are crucial. In this sense, several applications have been developed along last years by authors as summarized by following cases:

ARPIA: MS2G in Urban Strategic Planning

ARPIA (Augmented & virtual Reality for Population modeling based on Intelligent Agents) is a Simulation Environment able to integrates in HLA (High Level Architecture) different Simulation Models and IA-CGF to reproduce City Dynamic Evolution as well as People Consensus and Population Behaviors over Regular conditions as well as during a Crisis or a Disaster.(www.itim.unige.it/projects/arpias.html).

T-REX: MS2G in Homeland Security

T-REX (Threat network simulation for REactive eXperience) is an example of MS2G dedicated to consider different kind of mission environments such as Homeland Security and Hybrid Warfare; indeed T-REX supports HLA Simulation and enable the possibility to be federated federation with other elements to evaluate different aspects and their interactions (e.g. economics, finance, politics) even through interoperability among models (www.liophant.org/projects/t-rex.html).

JESSI: MS2G for Defense & Cyber Warfare

SO2UCI (Simulation for Off-Shore, On-Shore & Underwater Critical Infrastructure) is a Simulation for Vulnerability Reduction in Critical Infrastructures considering direct/indirect impacts & multiple domains (www.itim.unige.it/projects/so2uci.html)

8 STRATEGOS

It worth to mention how critical is promote and develop these concepts, also to activate new initiatives in terms of education and training such as STRATEGOS.

Strategic Thinking and Strategy Development have been always key Competitive Factors, given the Complexity of Reality and Human Goals. Strategy means ability to deal with a variety of variables, taking into account uncertainty, scalability, extensibility, dependability. One statement, among millions, confirms the importance of Strategic Engineering: "If you want to grow, find a good opportunity.

Today, if you want to be a great company, think about what Social Problem you could solve." (Ma Yun, alias Jack Ma, co-founder and executive chairman of Alibaba, in 2018: Personal Net Worth 42.2 GUSD; Alibaba 462th World Raking, 23.8GUSD Revenues, 6.2GUSD Profits, 56% Growth in Net Revenues, Stocks +15% within a single month based on *Fortune Global*). Obviously, Strategy is nowadays strongly related to Complex Systems involving Quantitative Data and Digital Information. However, to the best of our knowledge, there are few Master Programs, worldwide, specifically dedicated to Strategy Development with solid M&S, Engineering Foundations, strong integration in Innovative Enabling Technologies and Information and Communication Technologies (ICT). Indeed, Engineering is not just about designing new Technological Systems and Products, but even to support Identification and Definition of New Strategies devoted to direct Future Developments. These aspects deal with developing New Processes, Solutions and Organizations devoted to achieve the Success respect Strategic Goals. In facts the Operational Lifecycle of Innovative Systems are usually quite long, rich of Uncertainties and strongly affected by many Variables as well as by different potential Scenarios; so a proper approach in Modeling and Analyzing Quantitatively these Elements is fundamental for the Final Success. Up to now, these Strategic Aspects are frequently roughly addressed by traditional approaches and educational practices: often just qualitative approaches or simplified static analysis methodologies are proposed as investigation aid, while, vice versa, today modern M&S, Machine Learning, Big Data, Innovative ICT solutions are potentially more effective in dynamically addressing these Issues. The main goal of this initiative is to set up a new International Engineering Master Program which relies on M&S and ICT education and it is able to address Strategic Modeling and Decision Support, providing the Deep Scientific Knowledge as well as the Technical Engineering Skills needed for developing, tailoring and using methodologies for Strategy Definition, Innovative Solution Development and Capability Assessment. The profile that will result as outcome of this Master Program is expected to operate in a variety of application domains (ranging from Manufacturing to Engineering, from Military Sector to Business, from Politics to Personal and Societal Development), being able not only to apply Strategies using the most appropriate Models, but also to gain Requirements for new Methods and to design new Methodologies, Techniques and Instruments for Strategic Planning and Management.

CONCLUSIONS

This paper proposes a view on emerging innovative concepts and paradigms that could lead simulation to be the strategic resource for future developments; criticalities, opportunities, shortfalls and threats are outlined as well as the requirements to prepare future generations in successfully developing these concepts and mastering these disciplines.

REFERENCES

Asimov (1951) “Foundation”, Gnome Press, NYC

Blackmore, S. (2006). Conversations on consciousness. Oxford University Press, UK

Balci, O. (1997, December). Verification validation and accreditation of simulation models. In Proceedings of the 29th conference on Winter simulation (pp. 135-141). IEEE Computer Society.

Barrat, J. (2013). Our final invention: Artificial intelligence and the end of the human era. Thomas Dunne Book, Macmillam, NYC

Bruzzone A.G., Massei M., Longo F., Maglione G.L., Di Matteo R., Di Bella P., Milano V. (2017) "Verification and Validation Applied To an Interoperable Simulation for Strategic Decision Making Involving Human Factors", Proc.of WAMS, Florence, September

Bruzzone A.G., (2017) "Smart Simulation: Intelligent Agents, Simulation and Serious Games as enablers for Creating New Solutions in Engineering, Industry and Service of the Society. Keynote Speech at International Top-level Forum on Engineering Science and Technology Development Strategy- Artificial intelligence and simulation, Hangzhou, China

Bruzzone A.G., Agresta M., Sinelshchikov K. (2017a) “Simulation as Decision Support System for Disaster Prevention”, Proc. of SESDE, Barcelona

Bruzzone A.G., Massei, M. (2017b) “Simulation-Based Military Training”, in Guide to Simulation-Based Disciplines, Springer, pp. 315-361

Bruzzone A.G., M. Massei, F. Longo, L, Nicoletti, R. Di Matteo, G.L.Maglione, M. Agresta (2015) "Intelligent Agents & Interoperable Simulation for Strategic Decision Making On Multicoalition Joint Operations". Proc. of DHSS, Bergeggi, Italy

Bruzzone A.G., Massei M., Agresta M., Poggi S., Camponeschi F. & M. (2014) "Addressing strategic challenges on mega cities through MS2G", Proc. of MAS2014, Bordeaux, September

Bruzzone A.G., Massei, M., Tremori, A., Poggi, S., Nicoletti, L., & Baisini, C. (2014a) “Simulation as enabling technologies for agile thinking: training and education aids for decision makers”

International Journal of Simulation and Process Modelling 9, 9(1-2), 113-127

Bruzzone A.G., Massei M., Tremori A., Longo F., Nicoletti L., Poggi S., Bartolucci C., Picco E., Poggio G. (2014b) "MS2G: simulation as a service for data mining and crowd sourcing in vulnerability reduction", Proc. of WAMS, Istanbul, September

Cayirci, E. (2013, December). Modeling and simulation as a cloud service: a survey. In Proceedings of the 2013 Winter Simulation Conference: Simulation: Making Decisions in a Complex World (pp. 389-400). IEEE Press.

Barth, M., Johnston, E., & Tadi, R. (1996). Using GPS technology to relate macroscopic and microscopic traffic parameters. Transportation Research Record: Journal of the Transportation Research Board, 1520, 89-96.

Duderstadt, J.J. (2005). A roadmap to Michigan's future: Meeting the challenge of a global knowledge-driven economy, National Academy Press, Washington, D.C.

Clymer, A.B. (1993, December). Applications of discrete and combined modeling to global simulation. In Proceedings of the 25th conference on Winter simulation (pp. 1135-1137). ACM.

Clymer, A.B. & Mcleod, J. (1993) "Mission Earth Symposium", Summer Computer-Simulation Conference, San Diego, July 18-20

Clymer, A.B. (1994). " Mission Earth Symposium: World Simulation for Education", Proc. of the National Educational Computing Conference, Boston, June 13-15

Clymer A.B. (1980). Simulation for training and decision-making in large-scale control systems: Part 1: Types of training simulators. Simulation, 35(2), 39-41.

Clymer, A. Ben (1969, April). The Modeling and Simulation of Big Systems. In Proceedings of the Pittsburgh Simulation and Modeling Conference.

Clymer, M.G., & Mechoso, C. R. (1997) "Mission Earth: Modeling and Simulation for a Sustainable Global System", Proc. of the Western Simulation Multi Conference, SCS, Phoenix, January 12-15

Duma L., Nemeslaki A. (2013) "Of Aluminium, Recycling and the Homeless: A case study of technology driven social inclusion", Proc. of EGPA Annual Conference, Edinburgh, September

Elfrey P. (2006) "Moving out the Planet", Invited Speech at Summer Sim, Calgary, Canada, July

Fuller, R. B. (1969). The World Game. Ekistics, 286-292

Harding J. (2018)"CCTV shows Genoa bridge collapse", BBC News, August 21

House, P. W., McLeod, J (1977). Large-scale models for policy evaluation. John Wiley & Sons, NYC

Huang, G. H., Linton, J. D., Yeomans, J. S., & Yoogalingam, R. (2005). Policy planning under uncertainty: efficient starting populations for simulation-optimization methods applied to municipal solid waste management. Journal of Environmental Management, 77(1), 22-34.

Irani Z., Sharif A.M., Lee H., Aktas E., Topaloğlu Z., van't Wout T., Huda S., 2018. Managing food security through food waste and loss: Small data to big data. Computers and Operations Research, vol. 98, pp. 367-383.

Kim, J. H. (2013) "Universal GPS traffic monitoring system", U.S. Patent No. 8,386,157, U.S. Patent and Trademark Office, Washington, DC:

Kuhl, F., Dahmann, J., & Weatherly, R. (2000). Creating computer simulation systems: an introduction to the high level architecture. Upper Saddle River: Prentice Hall PTR

Li, B. H., Zhang, L., Wang, S. L., Tao, F., Cao, J. W., Jiang, X. D., ... & Chai, X. D. (2010). Cloud manufacturing: a new service-oriented networked manufacturing model. Computer integrated manufacturing systems, 16(1), 1-7.

Longo F., 2011. Advances of modeling and simulation in supply chain and industry. Simulation, vol. 87, no. 8, pp. 651-656.

Longo F., Nicoletti L., Padovano A., 2017. Smart operators in industry 4.0: A human-centered approach to enhance operators' capabilities and competencies within the new smart factory context. Computers and Industrial Engineering, vol. 113, pp. 144-159.

McAfee, A., Brynjolfsson, E., Davenport, T. H., Patil, D. J., & Barton, D. (2012). Big data: the management revolution. Harvard business review, 90(10), 60-68.

McLeod, J. (1999). Simulation as a Possible Tool for Peace. Simulation, 72(5), 348-352.

McLeod, J., & McLeod, S. (1995) "Mission Earth And The Big Bird From The Ashes", Simulation, SCS, vol.64, n.1, June 1

McLeod, J. (1986). Computer modeling and simulation: The changing challenge. Simulation, 46(3), 114-118.

McLeod, J. (1968). Simulation: the dynamic modeling of ideas and systems with computers. McGraw-Hill.

McLeod, John & McLeod Suzette (1974) "Simulation in The Service of Society: World Simulation Organization", Simulation, SCS/SAGE, April 1st, doi.org/10.1177/003754977402200412

Meadows, D. H., Meadows, D. H., Randers, J., & Behrens III, W. W. (1972). The limits to growth: a report to the club of Rome (1972). Google Scholar

Najafabadi, M. M., Villanustre, F., Khoshgoftaar, T. M., Seliya, N., Wald, R., & Muharemagic, E. (2015). Deep learning applications and challenges in big data analytics. Journal of Big Data, 2(1), 1.

Naranjo P.G.V., Pooranian Z., Shojafar M., Conti, M., Buyya R., 2018. FOCAN: A Fog-supported smart city network architecture for management of applications in the Internet of Everything environments. Journal of Parallel and Distributed Computing (in press).

Oren, T. I., Elzas, M. S., Smit, I., & Birta, L. G. (2002, July). Code of professional ethics for simulationists. In Summer Computer Simulation Conference (pp. 434-435). Society for Computer Simulation International; 1998.

Sanchez, S. M. (2014, December). Simulation experiments: better data, not just big data. In Proceedings of the 2014 Winter Simulation Conference (pp. 805-816). IEEE Press.

Varaiya, P. (1993). Smart cars on smart roads: problems of control. IEEE Transactions on automatic control, 38(2), 195-207

Wan, J., Liu, J., Shao, Z., Vasilakos, A. V., Imran, M., & Zhou, K. (2016). Mobile crowd sensing for traffic prediction in internet of vehicles. Sensors, 16(1), 88

Wu, X., Zhu, X., Wu, G. Q., & Ding, W. (2014). Data mining with big data. IEEE transactions on knowledge and data engineering, 26(1), 97-107