Utilization of Simulation for Training Enhancement

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Abstract

Engineering system design, operation and maintenance has been handled for a long time through mathematical and real time models. The advent of computers, multimedia age and improvement in visualization has further proved the reality of fact that picture speaks more than words; also research in education and training has proven that visualization has great effect in improving learning. The complexity of real world situation of engineering education has obvious limitation of instructional presentation and training. Simulation gives result from theoretical representation of complex phenomena when hardware for the task is lacking, or in situations when enough time is not available for explanation. This paper will discuss, opportunities brought about by simulator as a tool in the training and certification of Malaysian Maritime Academy cadets training program. The usefulness of simulators in continuous education program to amplify and enhance competency based education and instructional training to meet goals of safety, cleaner ocean and protection of marine environment will be highlighted.. The paper will also present the potential of simulators as training tool in other field of knowledge for enhanced outcome and competency based education.

Keywords: Simulation; Engineering; competency, complexity, enhancement; safety; education; training

1.0 Introduction

The world of man and the quest for knowledge to facilitate human activities including developing things that surround us has gone through various phases of development. The early man, used memorization as a tool, and wrote information on leaves, trees and mountains to store knowledge which was to be passed to the next generation. The main tools for everything related to learning has likewise gone through various phases of change and the most significant of these changes has been the emergence of ICT in the last one decade. Today, the developments in ICT have greatly accelerated the pace of knowledge delivery and the Simulation-Based studies and training is one typical example of such an evolution. Simulation refers to the application of computational models for the study and prediction of physical events or the behavior of engineered systems. The development of computer simulation has drawn resources from a deep pool of scientific, mathematical, computational, engineering knowledge and methodologies. From the depth of its intellectual development and wide range of applications, computer simulation has emerged as a powerful tool, one that promises to revolutionize the way research in engineering and science are conducted in the twenty-first century.

Simulation has long been identifies in several areas of knowledge and it is playing a remarkable role in promoting developments vital to the health, security, and technological competitiveness of the nation. Engineering and scientific communities have become increasingly aware that computer simulation is an indispensable tool for resolving a multitude of technological problems. Basically, computer simulation represents an extension of theoretical science in that it is based on mathematical models. Such models attempt to characterize the physical predictions or consequences of scientific theories. With simulation engineers are better able to predict and optimize systems affecting almost all aspects of our lives and work, including our environment, our security and safety, and the products we use and export. The use of computer simulations in engineering science began over half a century ago, but only in the past decade or so has simulation theory and technology made a dramatic impact across the whole engineering fields. That remarkable change has come about mainly because of developments in the computational and computer sciences and the rapid advances in computing equipment and systems.

Clearly, the use of simulation is quickly becoming indispensable for goal based engineering education. Simulation is an important feature in engineering systems or any system that involves many processes. Most engineering simulations entail mathematical modeling and computer assisted investigation. Mathematical model used to dominate simulation world however mathematical modeling is not reliable and the incorporation of physical model often helpe to improve today complex system simulation. The development and use of such frameworks require the support of inter-disciplinary teams of researchers, including scientists, engineers, applied mathematicians, and computer scientists. Maritime industry due to its nature and need for safety to maintain Cleaner Ocean has institutionalized and incorporated opportunity offered by simulation to training of marine personnel to fulfill objective of having competent personnel to man the ships that sail the ocean of the world.

Encouraged by belief that knowledge, understanding, application and integration which are requirement for outcome and competency based education could enhance traditional instruction delivery method, through incorporating audio visual and multimedia tools, led the IMO to adopt resolution to use simulation as part of STCW requirement. Simulation is thus becoming central to advancement in maritime competency based training and education as well as educational training in biomedicine, nanomanufacturing, microelectronics, energy and environmental sciences, advanced materials, and product development. And there is ample evidence that developments in these new disciplines could significantly impact virtually every aspect of human experience [1, 2]. This paper explores potentials and prospects of incorporating simulation in engineering and science education structure. Good practice and experience enjoined by maritime industry including ALAM will be discussed. The authors will also discuss the core issues of simulation, the major obstacles to its development and the impact of simulation on training, educational and research.

2. Maritime simulation and simulators

Marine simulators bears similarity to flight simulators, which are used to train pilots on the ground in extreme hazard situations such as landing with no engine, pilot to crash aircraft without being hurt or complete electrical or hydraulic failures. The most advanced simulators have high-fidelity visual systems and hydraulic motion systems. However, marine simulators train ships' personnel, Simulators like these are mostly used to simulate large vessels. They consist of a replication of a ships' bridge, with operating desk, and a number of screens on which the virtual surroundings are projected. The complexity of shipping activities from design to operations training and maintenance remain one of the factors that have made IMO to enact strong regulations to ensure safety at all times[3].

Due to new issues of imbalance in human activities and environmental behaviors, ship and its operating areas in closest proximity to ocean that cover two third of the world has further put maritime work a target by public and land based environmental agencies whose pressure has given IMO further challenges of protection of environment that has called for new way of doing things based on risk and proactive manner. Simulator is obviously one of the tools that fit in such proactive measures to prevent accidents as its consequence leads to serious environmental problems [4,5]. While International laws are best implemented and enforced through local authorities law, the performance and control are best achieved through third eyes. DNV is one such third eye under classification society in maritime industry which has laid down some guidelines marine simulators. Certification of the simulators by DNV ensures that simulator systems have qualified personnel giving realistic and high quality simulator training conforming to SCTW requirement. Table and 1 and 2 show approved STCW courses and DNV certified simulation institutions [6,7].

Table 1 - STCW Courses

COURSE PROVIDER	CERTIFICATE NO.	COURSE TITLE	EXPIRY DATE	COUNTRY
Seagull AS	04/014	Assessor Training CBT	03.12.2007	NORWAY
	091/061214	ECDIS Training CBT	14.12.2009	
Nordic Crisis Management AS	005/050304	STCW Crowd Management Course	02.03.2008	
Furuno INS Training Center	047/051122	ECDIS Training Course	22.11.2008	DENMARK
Malaysian Maritime Academy Sdn Bhd (ALAM)	055/060306	Nautical Studies and Marine Engineering Courses	06.03.2011	MALAYSIA
NYK Ship Management PTE-LTD	102/070320	BRM Course	20.05.2010	SINGAPORE

Table 2 Approved simulators (manufacturers) – Source DNV classification

MANUFACTURER	CERTIFICATE NO	EXPIRY DATE	SIMULATOR TYPE	CLASS	COUNTRY
Kongsberg Maritime AS	011/060606	2007.12.06	Machinery Operation	A	NORWAY
	012/060606	2007.12.06	Cargo Handling	A	
	A-9616	2010.05.25	Bridge Operation	A	
Transas Ltd.	A-9641	2010.06.20	Bridge Operation	A	IRELAND
	A-9642	2010.06.23	Machinery Operation	A	
L-3 Communications MPRI	A-9335	2009.12.30	Machinery Operation	A	USA

However the use and the corresponding training program has been developed on ad hoc basis of individual training center working with many shipping companies where simulation is often inserted into existing program rather incorporating simulation as part of the objectives. Neither has there been any standardization for simulation. The fact is that simulation itself does not train but its benefit to training comes from the way it is used, it become imperative to make part of training aim and objective that comes with education requirement. STCW was built on conventional approach that focus on knowledge to determine competency with oblivion to job task and performance in training that arise from reality of mismatch between training course and corresponding needs. The ability of simulation fidelity, producing real life task in a safe environment and provide mitigation option to this where simulation come in as fundamental tool to bridge gap between theory and application [7, 8].

3. Marine simulation curriculum and training process

In maritime industry, IMO classified simulation under STCW amendment into the following groups:

Category 1 - Full mission capable of simulating full visual navigation including maneuvering.
Category 2 -Multitask - full mission capable of simulating full visual navigation excluding maneuvering ie radar simulator.
Category 3 -Limited task- capable of simulating environmental for limited extreme conditions.
Category 4 - Special task- capable of simulating maneuvering with operator outside the environment.

Simulation in STCW code is made of two parts, where:

Part A is mandatory and includes the minimum standards of competency for seagoing personnel, simulator used in both training and assessment. And the requirement for ARPA (Automatic Radar Plotting Aid - thus simulator equipment being used prior February 1, 2002 may be exempted at the discretion of parties involved).
Part B deal with guidance to those involved in education, training or assessing the competence under STCW provision concerning application of various safety and environmental regulation and conformity.

Maritime training is divided into two groups:

i. License – This include experience trainee that undergo additional training designed toward improving their existing skill, performance and awareness. Such training includes: Watch keeping, ARPA, Control, Ship resources management, Ship team management, Emergency procedure, Ship handling, Vessel traffic management, Search and rescue, Area familiarization

ii. Unlicensed- this involved cadets working towards first certificate of competency under standard structure program. Simulation application for this training includes: Watch keeping, knowledge of international regulation, Communication, Radar, electronic navigation, main and auxiliary machineries.

Most of these courses are not actually mandatory, how good it will have been if they shipping company could incorporate them in their program. Thus recent amendment of STCW recommendation for use of simulation is a significant stepping stone in this direction. The training should be designed by considering the following:

i. Training need through identification of gaps between training, required knowledge, skills abilities and actual knowledge, skills and ability.
ii. Specific training objectives which should include performance measurement
iii. Training method including assessment weather simulation is required to achieve the objective
iv. Total training program
v. Experience of trainee
vi. Level and type of simulation
vii. Instructor qualification and experience
viii. Effectiveness and benefit of the training

Once this is determined a scheme of work which includes: Aim and general objective, trainees and numbers, structure and schedule.

i. Individual simulation exercise that include specific objective, planning, debriefing session and instruction to staff on methods of debriefing
ii. Method of assessment

The instructional process itself required the following consideration: Instructional process, Scenario design, Use of control and monitoring station, and Debriefing technique. Rational for simulation can be stressed out from the fact that traditional class room method of teaching that use tool like chalk, overhead projector, occasional use of video material to amplify training objective give unbalanced advantage to instructor to have direct control that may not entertain training participation. Adding simulation to curriculum and allow the instructor to fill gap between theory and practical could change this equation. Simulation is expected to have programmed where and when it will be effective and useful in operation. Apart from concentration on fidelity of simulation - the degree of realism of simulators and simulation learning process includes the following factors [9,10]:

i. The progression from easy to more complex and difficult task and operation
ii. The involvement of more than one sense
iii. The need to concentrate interest on single problems
iv. The trainees control of his own activities and possible mistakes

Effectiveness of simulation based depends on the following attributes of simulation that add up to the advantage simulation has for the future of man and knowledge.

i. Exceptional Bandwidth: The conceptual basis of materials modeling and simulation encompasses all of the physical sciences.
ii. Elimination of Empiricism: A virtue of multiscale modeling is that the results from both modeling and simulation are conceptually and operationally quantifiable.
iii. Visualization of Phenomena: The numerical outputs from a simulation are generally data on the degrees of freedom characterizing the model.
iv. Prediction of the consequences of threats and Countermeasure responses -Extreme engineering processes such as structural responses, fluid transport of contaminants, power distribution, and transportation systems, as well as the response of the human population.

4. ALAM`s simulation and simulator experience

ALAM training towards a world class one stop maritime institution aims to deal with challenges of today and future through “ beyond competency “ partnership with DnV seaskill in order to add value of soft and hard skill required of marine personal and industry to conform with international local statutory requirements and often multi-national operations.

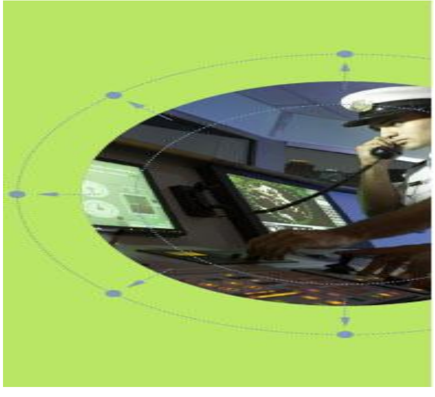

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Figure 1- ALAM`s simulator

ALAM simulation adds value to competence for ships staffs to be able to plan, define, develop and improve the competence of employees according to external requirements and established business goals to meet targets of safer, efficient operations, cleaner ocean and protection of marine environment DNV SeaSkill Standard for Competence under STCW focus on providing necessary tools and expertise to evaluate the competence of individuals, through test questions and practical assignments, in relation to specific jobs or positions wwith competence standards developed with the industry and outlining competence requirements for given positions; individuals may both be assessed and certified. The program also helps ALAM to recruit suitable mariners at suitable position good degree of reliability.

ALAM has undertaken a major effort in cooperation with DnV to improve the professional competency importance of maritime vocational and qualification by basing them on standard of proficiency required in employment. Towards this end, ALAM simulation is used as required as part of competency assessment on the ability of trainee to perform on board ship according to standards. Thus it is very important to incorporate cost comparison for necessary differentiation. ALAM invest on what to be achieved through simulation training involve task analysis and performance criteria developed to meet trainee and employers needs, IMO and classification society requirements whose aim concentrate on competency training. However ALAM invest on what to be achieve

ALAM simulator was built by Transas Marine USA, a simulator manufacturer known for building of state of the art simulators consisting of Transas Navi-Trainer Professional 3000 full mission ship simulator system with integrated GMDSS communications simulation capabilities, as well as ARPA/Radar simulator. Transas Marine's unique combination of simulation software, dedicated hardware (real ship controls) and commercial-off-the-shelf components, the simulator is an ideal tool in the training and certification of Maritime education programs. The ship simulator, IMO STCW training standards and the latest Det Norske Veritas 'Standards for Certification of Maritime Simulator Systems' to Class A as well as meet USCG. DnV has certification for simulators that meet the need of the marine industry quality training solutions.

Transas simulators are based on mathematical model that allows processes to be accelerated without detriment to physical realism at considerable reduced time. The simulations can be form under the following areas:

i. Full mission Ship - Handling simulation
ii. Engine room simulation
iii. Cargo operations simulation

The simulator has diverse cargo types databases that facilitate selection and on almost all types of cargo for operation training. Cargo operation simulations include:

i. Large Crude Oil Carrier (LCC);
ii. Liquefied Petroleum Gas (LPG) Carrier;
iii. Chemical tanker (CHT);
iv. Liquefied Natural Gas (LNG) Carrier.

4.1 Full Mission Ship-handling Simulator

The Full Mission Ship-handling Simulator (FMSHS) with capacity to simulate extensive exercise scenarios is certified by DNV as Class A Standard. Consisting of a single main bridge with nine high resolution projectors, 270° field of view visual scene (with a panning and tilting facilities to provide rear and over-the-side view), an extensive bridge mockup complete with a full complement of bridge equipment, environmental effects (consisting of wind, water current, depth, and bank forces), and high-fidelity own ship and passing ship hydrodynamic effects, the system realistically presents the total marine scene.

Figure 1- ALAM``S Full Mission Simulator

Three additional cubicle bridges with 120° field of view are similarly equipped to provide interconnected operation and total ship-handling interaction between the simulators. In addition, one of the cubicle bridges is equipped with a dynamic positioning system. With a library of more than a hundred geographic databases, 79 ship models and a facility to generate a new geographic database

4.2 Engine room simulator

Built to DNV Class A specification, the Engine Room Simulator (ERS) consist of the machinery space, engine control room and a computer workstation laboratory. The machinery space is equipped with local operation stations to provide appropriate indicators and controls for local power plant control. Four 42" plasma screens provide an innovative 3D virtual reality of the engine room compartments, the machinery layout, and the physical realism of the ship environment. The engine control room is equipped with main engine control console, diesel generator control console and main switchboard console to allow trainees to operate valves and machinery throughout the engine room. Realistic engine room sounds and alarms are also simulated in the engine control room to provide aural cues. Equipped with twelve (12) student workstations, the computer workstation laboratory provides trainees access to a wide variety of equipment and controls associated with the various power plant and auxiliary system and may be used for both individual and team instruction. Five engine models provide trainees with comprehensive knowledge of major engine makers like MAN B&W, SEMT Pielstick, Wartsila Sulzer and Kawasaki Heavy Industry. . When interconnected, the FMSHS will response in accordance with the ERS models, which have been accurately modeled and validated.

4.3 Liquid Cargo Operation Simulator

These are designed to conform to latest liquid cargo operation system found on modern ship, the Liquid Cargo Operation Simulator (LICOS) is equipped with twelve (12) student workstations that provide access to a wide variety of examples of liquid cargo operation functions and may be used for both individual and team training. Eight (8) of the workstations have two LCD monitors and the other four (4) workstations are fitted with four LCD monitors which may be configured as an oil terminal when integrated with the VLCC model for team training.

ALAM`s Liquid Cargo Operation Simulator

The calculations of tanks, hull strength and ship loading in the simulator are carried out by the Load Calculator System, which is a real on-board Load Calculator. The Graphics User Interface (GUI) is optimized for familiarization with the entire system operating principles and for acquiring practical skills in equipment handling. The main tanker units are implemented as 3D objects, showing cross sections of individual assemblies. Computer animation is used to display the current processes. Since operations by the bridge team on the main FMSHS will impact team operations of the ERS, and vice versa, the main Full Mission Ship-handling Simulator will be fully integrated with the Engine Room Simulator (ERS) to provide team training. When interconnected, the FMSHS response is in accordance with the ERS models, which have been accurately modeled and validated - making the ALAM Simulation Center a world-class simulator-based learning environment [10,11].

5. Benefits of simulation

Benefit offer by incorporating simulation in education are further amplified by the following:

i. Simulation allows us to explore natural events and engineered systems that have long defied analysis, measurement, and experimental methodologies. In effect, empirical assumptions will be replaced by science-based computational models.
ii. Simulation also has applications across technologies—from microprocessors to the infrastructure of cities.
iii. Simulation methods will lay the groundwork for entire technologies that are only now emerging as possibilities.
iv. Simulation will enable us to design and manufacture materials and products on a more scientific basis with less trial and error and Shorter design cycles.
v. Simulation improves our ability to predict outcomes and optimize solutions before committing resources to specific designs and decisions.
vi. Simulation will expand our ability to cope with problems that have been too complex for traditional methods. Such problems, for example, are those involving multiple scales of length and time, multiple physical processes, and unknown levels of uncertainties.
vii. Simulation will introduce tools and methods that apply across all engineering disciplines—electrical, computer, mechanical, civil, chemical, aerospace, nuclear, biomedical, and materials science. For instance, all engineering disciplines stand to benefit from advances in optimization, control, uncertainty quantification, verification and validation, design decision-making, and real-time response.
viii. Simulator certification benefits training institutions seeking assurance on heavy investments result in optimal training conditions and marketing of simulator training centers services

In addition to this simulation also offer advantage of:

- Protection against Air Contaminants:
- Optimization of Infrastructures:
- Prediction of Long-Term Environmental Impacts
- Optimization of Emergency Responses
- Optimization of Security Infrastructures for Urban Environments
- Planning of countermeasures
- Prediction of treat and countermeasure responses

5.1 Educational strategies of the future for Engineers and Scientists

Our time has seen significant dramatic expansion of the knowledge base required to advance modern simulation. The expansion ignores the traditional boundaries between academic disciplines, which have long been compartmentalized in the rigid organizational structures of today's universities. The old silo structure of educational institutions has become an antiquated liability. It discourages innovation, limits the critically important exchange of knowledge between core disciplines, and discourages the interdisciplinary research, study, and interaction critical to advances in simulation.

Today's demands nonetheless call for:

i. Citadel of learning to change their organizational structures to promote and reward collaborative research that invigorates and advances multidisciplinary science. It has also become a matter of need for universities to implement new multidisciplinary programs and organizations that provide rigorous, multifaceted education for the growing ranks of simulation trainers and researchers.
ii. Simulation need to be incorporated in our educational discipline as a engineering tool and proponent life-long learning opportunity
iii. Simulation requires a broad range of interdisciplinary knowledge that tomorrow's engineers and scientists with substantial depth of knowledge in computational and applied mathematics, as well as in their specific engineering or scientific disciplines. Participation in multidisciplinary research teams and industrial internships will give students the broad scientific and technical perspective, as well as the communication skills that are necessary for the effective development and deployment of simulation education.
iv. Integrating simulation into the educational system will broaden the curriculum for undergraduate students. Undergraduates, moreover, will have access to educational materials that demonstrate theories and practices that complement the traditional experimental and theoretical approaches to knowledge acquisition.
v. Simulation will also provide a rich new environment for undergraduate research, in which students from engineering and science can work together on interdisciplinary teams.

vi. As in any entrenched culture, change is hard to come by. To change the culture of separate disciplines in our universities will require well directed, persistent, and innovative government initiatives.
vii. The necessary changes in educational structure will come without strong directives from leaders from academia, industry, and government laboratories.
viii. And provide funding for multidisciplinary graduate education programs that offer students simulation integrated approach of team research and career development.

5.2 Challenges

There are challenges, that need to be faced regaining multiscale and multi-physics modeling, real-time integration of simulation methods with measurement systems, model validation and verification, handling large data, and visualization for discipline that want to incorporate it for the first time. It is only by these challenges involved in resolving open problems associated with simulation. Significantly, one of those challenges is education of the next generation of engineers and scientists in the theory and practices of simulation in every subject. There is no doubt that a lot of money will be involved, and research will be required for specific feed where simulations need to be plugged into the program, But the risk worth taken research to exploit the considerable promise of Simulation in education. Therefore it also necessary to provide new cyber -infrastructure that will allow teacher and scientists to pursue Competency and Objective Based Education and research in new ways and with new efficiency" by utilizing [12,13]:

i. high-performance, global-scale networking,
ii. middleware,
iii. high-performance computing services,
iv. observation and measurement devices, and
v. improved of interfaces and visualization services.

Building simulation center require serious consideration of feasibility of developing a parallel programs in simulation that interfaces to multiple divisions of engineering education in concert with cyber infrastructure. Progress in simulation will also require the creation of interdisciplinary education teams that work together on leading-edge simulation problems. A sweeping overhaul of our educational system towards simulation and initiative for change will not likely come from academia alone; it must be encouraged by the engineering and scientific leadership and throughout the organizational structure of our universities as well as simulation institution in industry. The payoffs for meeting these challenges are profound. We can expect dramatic advances on a broad frontier of knowledge and practice.

The following list is a summary of its current limitations:

i. The development of models is very time consuming, particularly for geometries of complex engineering systems such as ships, automobiles, and aircraft. Moreover, the determination of material properties often requires extensive small-scale testing before simulation can be started, especially if statistical properties are needed. This testing also lengthens the time to obtain a simulation and hence the design cycle.
ii. Methods are needed for linking models at various scales and simulating multi-physics phenomena.
iii. Simulation is often separate from the design optimization process and cannot
iv. Simultaneously deal with factors such as manufacturability, cost, and environmental impact.

5.2 Overcoming the challenges of now

As design processes increasingly rely on computer simulation, validation and verification procedures will become increasingly important. Although some efforts have been made at providing validation benchmark problems for linear analysis, nonlinear simulation software has not been subjected to extensive validation procedures. Clearly, a basic understanding of verification and validation procedures is urgently needed. After all, to be useful, the simulation tools used by industry and defense agencies must provide reliable results. Furthermore, since many real-world phenomena are not deterministic, statistical methods that can quantify uncertainty will be needed. Design optimization is also in its infancy, and it too has many obstacles to overcome. The constraints on the optimization of a product design relate to manufacturability, robustness, and a variety of other factors. In order to be effective for engineering design, optimization methods must be closely coupled with simulation techniques[13,14]. Overcoming the barriers behind simulation will require challenges and progress in our basic understanding and in the development of powerful new methods. Among these challenges are the following:

i. Multiscale methods that can deal with large ranges of time and spatial scales and link various types of physics.

ii. Methods for computing macroscopic phenomena, such as material properties and manufacturing processes, in terms of subscale behavior.
iii. Effective optimization methods that can deal with complex integrated systems, account for uncertainties, and provide robust designs.
iv. Frameworks for validation, verification, and uncertainty qualification.
v. Methods for rapidly generating models of complex geometries and material properties.
vi. Multiscale methods will provide extensive benefits.

The following are a few of the areas requiring development:

i. • Quantitative models of the processes to be simulated must be developed. For many of those processes, models of some level of fidelity already exist, or they are being developed for narrower engineering purposes.
ii. • A comprehensive simulation system is required that integrates detailed models of a wide range of scales. The comprehensiveness of the simulation system is a requirement if simulation in education applications is to simulate multiscale complex systems. Some of the issues are generic, but others are problem specific.
iii. • New models of exceptional fidelity are required. The development and validation of such models entail the acquisition of data of extraordinary detail.
iv. • A better understanding of the role of uncertainty is required. Some degree of uncertainty is inevitable in the ability of a model to reflect reality and in the data the model uses. We need to find ways to interpret uncertainty and to characterize its effects on assessments of the probable outcomes.

Generally, however, we still lack a fundamental understanding of what constitutes an optimal design and how to find it in a complex multi-criteria design environment. Once optimization methods are developed that can deal with these complexities, we can expect to see chemical plants, automobiles, laptop. Simulation has the potential to deliver, within a short design period, designs that are optimized for cost performance and total impact on the environment.The rewards of meeting those challenges are great: enhanced efficiency, security, safety, and convenience of life in the digital, infrastructure, city and ecosystem, a social infrastructure of unparalleled efficiency, rational responses to natural events and optimal interactions with natural environments.

6. Conclusion

The need for Simulation based education is at a crossroads in our global technological development. For almost half a century, developments in mathematical modeling, computational algorithms, and the technology of data intensive computing have led to remarkable improvements in the health, security, productivity, quality of life, and competitiveness of nations. We have now arrived at an historic moment where simulation is the key elements for achieving progress in engineering and science. The challenges of making progress, however, are as substantial as the benefits. We must, for example, find methods for linking phenomena in systems that span large ranges of time and spatial scales. We must be able to describe macroscopic events in terms of subscale behaviors. We need better optimization procedures for simulating complex systems, procedures that can account for uncertainties. We need to build frameworks for validation, verification, and uncertainty quantification.

In today's competitive world, in order to b at the frontier of knowledge it has become important to explore the possibility of incorporating in our engineering educational system to reflect the multidisciplinary nature of modern engineering and to help students acquire the necessary modeling and simulation skills. Thus simulation required good computer speed, funding and efficiency. However, this barrier can be solved by promoting interaction between multiple disciplines that fit naturally and strategically in parallel with or within the Cyber infrastructure framework. Simulation definitely has the potential to deliver designs that are optimized for cost performance and their total impact on the environment (from production to disposal or recycling), all within a short design cycle. This achievement is not possible, however, simply by extending current research methods and taking small, incremental steps in simulation based education development. The barriers to the realization of simulation in education relate to our entire way of conducting research development and educating engineers. Other field of engineering can surely use experience of the shipping industry as a guide to incorporate simulation in education work.

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Appendix

Table 3 - Simulation Product Types

SIMULATOR CENTRE	CERTIFICATE NO	EXPIRY DATE	SIMULATOR TYPE	CLASS	COUNTRY
Maritiem Instituut 'Willem Barnentsz'	002/060222	2010.05.31	Bridge Operation	A	
	003/060220	2010.05.31	Bridge Operation	A	
	004/060220	2010.05.31	Machinery Operation	A	
	005/060220	2010.05.31	Cargo Handling	A	NETHERLANDS
STC B.V	006/060223	2010.05.10	Bridge Operation	A	
	007/060223	2010.05.10	Bridge Operation	A	
	008/060223	2010.05.10	Bridge Operation	A	
	009/060223	2010.05.10	Bridge Operation	A	
Malaysian Maritime Academy (ALAM)	001/060217	2011.02.17	Bridge Operation	A	MALAYSIA
Sperry Marine Training Centre	010/060523	2011.05.23	Bridge Operation	C	GERMANY
Evergreen Seafarer Training Center	SSP-103	2006.06.30	Bridge Operation	A	
	SSP-104	2006.06.30	Bridge Operation	C	
	SSP-105	2006.06.30	Bridge Operation	C	
	SSP-106	2006.06.30	Bridge Operation	C	
	SSP-202	2006.06.30	Machinery Operation	A	
	SSP-203	2006.06.30	Machinery Operation	X	
	SSP-301	2006.06.30	Radio Communication	B	
National Kaoshiung Institute of Marine Technology	SSP-204	2008.05.23	Machinery Operation	A	
	SSP-109	2006.07.25	Bridge Operation	X	TAIWAN
	SSP-115	2008.05.23	Bridge Operation	A	
	SSP-118	2008.05.23	Bridge Operation	C	
	SSP-303	2007.10.11	Radio Communication	A	
National Kaoshiung Marine University	A-9467	2010.02.14	Cargo Handling	A	
National Taiwan Ocean University	SSP-205	2008.05.23	Machinery Operation	A	
	A-9368	2009.12.06	Cargo Handling	A	
	013/060825	2011.07.21	Bridge Operation	C	
	SSP-113	2007.10.10	Bridge Operation	A	
	SSP-116	2008.05.23	Bridge Operation	C	

Split Ship Management Ltd.	SSP-110	2006.10.31	Bridge Operation	A	CROATIA
MPA Integrated Simulation Centre of Singapore	SSP-111	2007.06.28	Bridge Operation	A	SINGAPORE
	SSP-112	2007.06.28	Bridge Operation	A	
Haeyong Maritime Services Co. Ltd.	014/061026	2011.09.11	Bridge Operation	B	KOREA
NYK Shipmanagement Pte. Ltd. Training Centre	015/061120	2011.11.20	Bridge Operation	A	SINGAPORE
	018/070323	2012.3.23	Cargo Handling	A	
Maersk Training Centre AS	016/061212	2011.11.15	Cargo Handling	A	DENMARK
Changi Naval Training Base FMSS Centre	016/061205	2011.12.05	Bridge Operation	A	SINGAPORE
Warsash Maritime Academy	017/070228	2012.03.01	Cargo Handling	A	UNITED KINGDOM