THE 8TH INTERNATIONAL WORKSHOP ON APPLIED MODELING & SIMULATION

SEPTEMBER 21-23 2015
BERGEGGI, ITALY

EDITED BY
AGOSTINO G. BRUZZONE
PAOLO FADDA
GIANFRANCO FANCELLO
MIQUEL ANGEL PIERA

PRINTED IN RENDE (CS), ITALY, SEPTEMBER 2015

Volume ISBN 978-88-97999-17-1 (paperback)
Volume ISBN 978-88-97999-18-8 (PDF)

Proceedings of WAMS, ISBN 978-88-97999-56-0 (paperback)
Proceedings of WAMS, ISBN 978-88-97999-65-2 (PDF)

Volume ISBN 978-88-97999-17-1 (paperback)
Volume ISBN 978-88-97999-18-8 (PDF)

Proceedings of WAMS, ISBN 978-88-97999-56-0 (paperback)
Proceedings of WAMS, ISBN 978-88-97999-65-2 (PDF)

THE 8TH INTERNATIONAL WORKSHOP ON APPLIED MODELLING AND SIMULATION

SEPTEMBER 21-23 2015, BERGEGGI, ITALY

ORGANIZED BY

DIME - UNIVERSITY OF GENOA

LIOPHANT SIMULATION

SIMULATION TEAM

IMCS - INTERNATIONAL MEDITERRANEAN & LATIN AMERICAN COUNCIL OF SIMULATION

DIMEG, UNIVERSITY OF CALABRIA

MSC-LES, MODELING & SIMULATION CENTER, LABORATORY OF ENTERPRISE SOLUTIONS

UNIVERSITY OF CAGLIARI

MODELING AND SIMULATION CENTER OF EXCELLENCE (MSCOE)

LATVIAN SIMULATION CENTER - RIGA TECHNICAL UNIVERSITY

LOGISIM

LSIS - LABORATOIRE DES SCIENCES DE L'INFORMATION ET DES SYSTEMES

MIMOS - MOVIMENTO ITALIANO MODELLAZIONE E SIMULAZIONE

MITIM PERUGIA CENTER - UNIVERSITY OF PERUGIA

BRASILIAN SIMULATION CENTER, LAMCE-COPPE-UFRJ

MITIM - MCLEOD INSTITUTE OF TECHNOLOGY AND INTEROPERABLE MODELING AND SIMULATION - GENOA CENTER

M&SNET - MCLEOD MODELING AND SIMULATION NETWORK

LATVIAN SIMULATION SOCIETY

ECOLE SUPERIEURE D'INGENIERIE EN SCIENCES APPLIQUEES

FACULTAD DE CIENCIAS EXACTAS. INGEGNERIA Y AGRIMENSURA

UNIVERSITY OF LA LAGUNA

CIFASIS: CONICET-UNR-UPCAM

INSTICC - INSTITUTE FOR SYSTEMS AND TECHNOLOGIES OF INFORMATION, CONTROL AND COMMUNICATION

NATIONAL RUSSIAN SIMULATION SOCIETY

CEA - IFAC

UNIVERSITY OF BORDEAUX

UNIVERSITY OF CYPRUS

I3M 2015 INDUSTRIAL SPONSORS

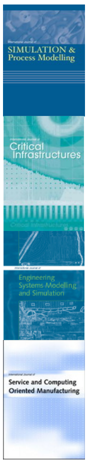
CAL-TEK SRL

LIOTECH LTD

MAST SRL

SIM-4-FUTURE

I3M 2015 MEDIA PARTNERS



Inderscience Publishers – International Journal of Simulation and Process Modeling

Inderscience Publishers – International Journal of Critical Infrastructures

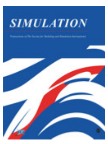
Inderscience Publishers – International Journal of Engineering Systems Modelling and Simulation

Inderscience Publishers – International Journal of Service and Computing Oriented Manufacturing

IGI GLOBAL – International Journal of Privacy and Health Information Management

Halldale Media Group: Military Simulation and Training Magazine

Halldale Media Group: The Journal for Healthcare Education, Simulation and Training



SAGE
Simulation Transaction of SCS

Euromerci

De Gruyter
International Journal of Food Engineering

EDITORS

AGOSTINO BRUZZONE
MITIM-DIME UNIVERSITY OF GENOA, ITALY
agostino@itim.unige.it

PAOLO FADDA
CENTRAL LABS, ITALY
fadda@unica.it

GIANFRANCO FANCELLO
UNIVERSITY OF CAGLIARI, ITALY
fancello@unica.it

MIQUEL ANGEL PIERA
AUTONOMOUS UNIVERSITY OF BARCELONA
miquelangel.piera@uab.es

THE INTERNATIONAL MULTIDISCIPLINARY MODELING AND SIMULATION MULTICONFERENCE, I3M 2015

GENERAL CO-CHAIRS

AGOSTINO BRUZZONE, *MITIM DIME, UNIVERSITY OF GENOA, ITALY*
YURI MERKURYEV, *RIGA TECHNICAL UNIVERSITY, LATVIA*

PROGRAM CHAIR

FRANCESCO LONGO, *DIMEG, UNIVERSITY OF CALABRIA, ITALY*
EMILIO JIMÉNEZ, *UNIVERSITY OF LA RIOJA, SPAIN*

THE 8TH INTERNATIONAL WORKSHOP ON APPLIED MODELLING AND SIMULATION, WAMS 2015

GENERAL CO-CHAIRS

AGOSTINO BRUZZONE, *MITIM DIME, UNIVERSITY OF GENOA, ITALY*
PAOLO FADDA, *CENTRAL LABS, ITALY*

PROGRAM CO-CHAIRS

GIANFRANCO FANCELLO, *UNIVERSITY OF CAGLIARI, ITALY*
MIQUEL ANGEL PIERA, *AUTONOMOUS UNIVERSITY OF BARCELONA, SPAIN*

WAMS 2015 International Program Committee

Tracks and Workshop Chairs

Modeling and Simulation for System Reliability Analysis
Chair: Alfredo Garro, University of Calabria, Italy

Simulation Techniques and Methodologies
Chairs: Simonluca Poggi, MAST, Italy

Simulation Applications
Chair: Alberto Tremori, NATO STO CMRE, Italy

GENERAL CO-CHAIRS' MESSAGE

WELCOME TO WAMS 2015!

The International Workshop on Applied Modeling & Simulation concentrates on Applications of Simulation and Computer Technologies and it is organized in the wonderful framework of Bergeggi, Italy. WAMS is a small workshop but it can be regarded as a good opportunity for the International Simulation Community to meet together during September. This is particularly this year, because WAMS is co-located with the International Multidisciplinary Modeling & Simulation Multiconference (I3M 2015) that includes additional 8 International Conferences (EMSS, HMS, MAS, IMAACA, DHSS, IWISH, SESDE and FOODOPS).

In fact WAMS is a workshop very effective in networking and very useful to set up new proposals and projects. Within the framework of I3M, this year worldwide specialists have the opportunity to participate and to interact on similar topics related to Applied Modeling & Simulation. The audience will include scientists and researchers operating in applying advanced techniques to main application areas and sectors including Industry, Business, Logistics Environment, Services & Defense.

Historically, WAMS started as a series of international workshops organized in Latin America, AMS2004 (Rio de Janeiro) and AMS2006 (Buzios); these events were focusing on Application and Theory of Modeling & Simulation. In the following years, WAMS was organized on both sides of the Atlantic Ocean (i.e. Rio de Janeiro, Italian Riviera), while in 2011, WAMS was co-located with the International Marine Defense Show in St. Petersburg, Russia, organized in Joint Cooperation with SPIIRAS Russian Academy of Science. In 2012, WAMS was held in Rome in connection with the NATO CAX Forum and in 2013 the workshop was back in Latin America, Buenos Aires. In 2014 WAMS moved in Bosphorous between Asia and Europe in the beautiful town of Istanbul and this year is back in Italy to provide the attendees with the opportunity to enjoy the famous Italian Riviera.

As usual, the WAMS contributions have been selected through a peer review carried out by international experts in order to guarantee high quality standards. This year WAMS includes few papers but this is mostly due to high percentage of rejected papers as well as to the economic crisis that in some countries is still ongoing preventing authors from traveling. However, also this year a best paper award will be delivered as well as there will be opportunities to publish extended versions of WAMS papers within International Journals.

AGOSTINO BRUZZONE
DIME, University of
Genoa, Italy

PAOLO FADDA
Central Labs, Italy

ACKNOWLEDGEMENTS

The WAMS 2015 International Program Committee (IPC) has selected the papers for the Conference among many submissions; therefore, based on this effort, a very successful event is expected. The WAMS 2015 IPC would like to thank all the authors as well as the reviewers for their invaluable work.
A special thank goes to all the organizations, institutions and societies that have supported and technically sponsored the event.

I3M 2015 INTERNAL STAFF

AGOSTINO G. BRUZZONE, *DIME, UNIVERSITY OF GENOA, ITALY*
MATTEO AGRESTA, *SIMULATION T EAM, ITALY*
TERESA BARBIERI, *CAL-TEK SRL, ITALY*
CHRISTIAN BARTOLUCCI, *SIMULATION TEAM, ITALY*
LUIGI BRUNO, *DIMEG, UNIVERSITY OF CALABRIA*
ALESSANDRO CHIURCO, *DIMEG, UNIVERSITY OF CALABRIA, ITALY*
MARIO COSENTINI, *CAL-TEK SRL, ITALY*
RICCARDO DI MATTEO, *SIMULATION TEAM, ITALY*
CATERINA FUSTO, *DIMEG, UNIVERSITY OF CALABRIA, ITALY*
FRANCESCO LONGO, *DIMEG, UNIVERSITY OF CALABRIA, ITALY*
GIANLUCA MAGLIONE, *CAL-TEK SRL*, ITALY
MARINA MASSEI, *LIOPHANT SIMULATION, ITALY*
LETIZIA NICOLETTI, *CAL-TEK SRL*
ANTONIO PADOVANO, *DIMEG, UNIVERSITY OF CALABRIA, ITALY*
ALBERTO TREMORI, *SIMULATION TEAM, ITALY*
MARCO VETRANO, *CAL-TEK SRL, ITALY*

This International Workshop is part of the I3M Multiconference: the Congress leading **Simulation around the World and Along the Years**

Index

ADAPTIVE SIMULATION-BASED TRAINING FOR A COMPLEX WORLD

Ms. Latika Eifert[(a)], Dr. Jonathan Stevens[(b)], Mr. Dean Reed[(c)], Mr. Oleg Umanskiy[(d)], Dr. Boris Stilman[(e)(f)]

[(a)] United State Army Research Laboratory (ARL), Orlando, FL
[(b),(c)] University of Central Florida, Institute for Simulation and Training, Orlando, FL
[(d), (e)] Stilman Strategies LLC, Denver, CO, [(f)] University of Colorado Denver, Denver, CO

[(a)]latika.eifert@us.army.mil, [(b)]jonathan.stevens@knights.ucf.edu, [(c)]dreed@ist.ucf.edu , [(d)]oleg@stilman-strategies.com,
[(e)]boris@stilman-strategies.com

ABSTRACT
The U.S. Army must operate in a highly complex world and dynamic operational environment (OE). In order to maintain pace with a rapidly evolving OE, the Army must distribute training and education to its soldiers and leaders at the point of need. The Linguistic Geometry Real-time Adversarial Intelligence & Decision-making (LG-RAID) simulation supports this goal and is being developed for the Army to train leaders to rapidly develop tactically sound plans. The LG-RAID simulation is a planning tool for Army leaders that semi-automatically generates enemy estimates in a semi-immersive setting. The tool accurately anticipates the enemy's actions, reactions and counter-actions, resulting in the development of a qualitatively better tactical plan. In this paper, we discuss the development and design of the simulation to meet the Army's objective of training leaders to meet the challenges of a complex OE. We also discourse on development and design challenges faced and the future employment of the simulation to meet the Army's objective.

Keywords: simulation, training, predictive analysis, course of action

1. INTRODUCTION

The United States Army operates in a highly complex and dynamic operational environment that requires leadership that is both agile and capable of critical analysis (Graves & Stanley, 2013). As the Army exits a prolonged period of counterinsurgency warfare, more emphasis is being placed on training for major combat operations (MCO) as its focus broadens (Odierno, 2012). In fact, recent Army doctrinal changes stress the importance of lethality, even referring to this capability as the foundation for land operations (Benson, 2012). The Army's challenging transition back to MCO training is occurring in the midst of a resource-constrained environment and subsequent manpower drawdown (Snider, 2012).

In light of this environment, new approaches to training as well as new technology are required in order for the Army to most effectively and efficiently prepare its leaders for an uncertain world. Simulation-based training (SBT) is an evolving domain and represents one of many potential new approaches to solving this dilemma. Recent literature highlights effective changing approaches to employing SBT in both the medical profession (Hamstra, Brydges, Hatala, Zendejas, & Cook, 2014) (Arora, et al., 2014) as well as military (Stevens & Eifert, 2014) (Sotomayor, Mazzeo, M., Hill, & Hackett, 2013) (Blow, 2012).

The U.S. Army continues to discover novel ways to use SBT (Lele, 2013) since it has been empirically demonstrated to successfully provide transfer of training from the simulated environment to the live environment (Harrington, 2011; Blow, 2012; Seymour, et al., 2002; Hays, Jacobs, Carolyn, & Eduardo, 1992; Salas, Rosen, Held, & Weissmuller, 2009). Game-based training, defined as the employment of interactive software for training that is generally characterized by its low overhead and cost (Bergeron, 2006) is a new variant of SBT that offers tremendous promise. In this paper, we discourse on a new game-based trainer that the U.S. Army is developing in order to meet the training needs of Soldiers operating in a complex environment.

Software tools based on advanced Artificial Intelligence represent a potential breakthrough that may facilitate the Army's objective of effectively and efficiently preparing its leaders for a complex OE. In this paper, we discuss both the development and design of the Linguistic Geometry Real-time Adversarial Intelligence & Decision-making (LG-RAID) simulation tool to meet the Army's goal of training leaders to operate successfully in a complex OE. We also discourse on development and design challenges faced and the future employment of the simulation to meet the Army's objective.

2. BACKGROUND

2.1. LG-RAID

LG-RAID is a new Army Research Laboratory (ARL) development effort and technology that may assist the Army in its pursuit to train leaders to meet the challenges of a complex OE. Linguistic Geometry (LG) is a game theory that has demonstrated an ability to solve large-scale problems in near real-time (Stilman B.

, 2014) (Stilman, Yakhnis, & Umanskiy, 2010). It is particularly useful in solving strategy-like problems, such as mission planning, by representing them as a class of opposing games, the so-called Abstract Board Games (ABG). LG provides highly efficient decomposition of the game state space by projecting it on the Abstract Board, generating strategies, and elevating them back to the state space (Stilman B. , 2014) (Stilman, Yakhnis, & Umanskiy, 2007) (Stilman B. , 2000).

As the name implies, the LG-RAID tool makes use of the LG algorithms to solve a class of real-world ABGs. In this case, the ABG is a tactical planning mission being conducted by an Army leader. Thus, LG-RAID is a light-weight simulation that employs novel game theory to generate intelligent, predictive and tactically-correct courses of action (COAs) for mission planning exercises (Stilman & Yakhnis, 2003).

2.2. Technology Enabled Capability Demonstration 7

Senior U.S. Army leadership identified and prioritized the Army's top ten science and technology challenges in 2011 in response to a rapidly changing operational environment (Buschmann & Pellicano, 2014). In order to demonstrate that these challenges were being adequately addressed and progress subsequently measured, the U.S. Army Science and Technology (S&T) Advisory Group created the Technology Enabled Capability Demonstration (TECD) concept. For each of the top ten challenges, a TECD was established to demonstrate and rapidly deliver high-impact, innovative technological solutions to complex problem sets. One of the top ten challenges designated by Army leadership was the improvement of training techniques and technologies for small unit and leader training. In order to address this particular designated challenge, the TECD 7 effort was created.

The purpose of TECD 7 was to conduct research and develop training technology and methodologies to achieve a more effective training capability to enhance small unit, squad, and leader performance across the full range of military operations (Martinez, 2012). One of the emerging technologies selected to participate in the TECD 7 effort was the LG-RAID simulation due to its potential high-payoff in improving leader training. In the following section we discuss the development and design of the simulation to meet the Army's objective of training leaders as a part of the TECD 7 effort. We also discourse on development and design challenges encountered and the future employment of the simulation to meet the Army's objective

3. METHOD

3.1. Capability Development and Design

The overarching objective of the TECD 7 effort was to provide "an immersive, full-spectrum, training experience for Small Units at home station and/or while deployed that approaches the complexity and realism of fixed-site combat training centers but requires a minimum of infrastructure and pre-event preparation" (Freeman, 2011). We identified the following design goals in order to achieve this objective:

- Ease of deployment and access
- Streamlined user interface
- Game-like interactive use
- Simplified terrain import

3.1.1. Ease of Deployment and Access

In order to allow trainees ubiquitous access to the LG-RAID simulation, a cloud-based service was chosen as the primary deployment approach. The tool was designed to be installed on a server (or multiple servers) and then accessed by end-users over the network using a common browser requiring no configuration for the end-users. Standard installation package and custom configuration tool (LGConfigTool) wizards were employed to deploy and configure the entire software stack on any Windows-based operating system. The LG-RAID installation was fully self-contained and included any required components, such as web server, databases, and 3rd party modules. This provided both simplified and more secure deployment by removing the need for and risk of installing and misconfiguring other software packages. All client-server communications are performed using well defined and documented REST API (Representational State Transfer Application Programming Interface) over HTTPS (Hypertext Transfer Protocol Secure) using JavaScript Object Notation (JSON) and Extensible Markup Language (XML). This approach provided serveral benefits: security due to encrypted communications, compatibility with government and corporate firewalls, and ease of integration. This communication can take place over the local area network (LAN), virtual private network (VPN), or over the Internet, NIPRNET, or SIPRNET (Figure 1).

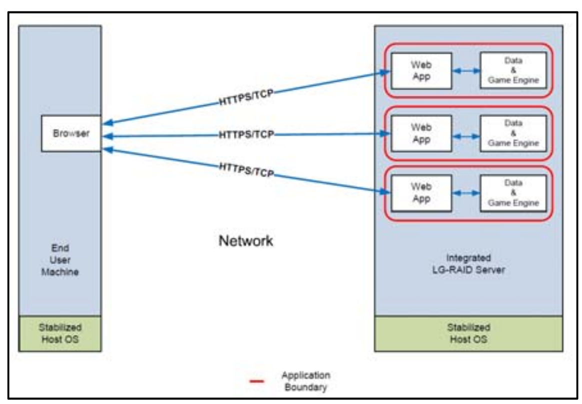


Figure 1: LG-RAID Network Communication

If desired, standalone installation can be accomplished by installing the server components on the end-user's Windows computer. As described above, the installation and configuration process is similar in difficulty to any commercial off-the-shelf (COTS) software and can be performed by the end-user. All the

LG-RAID processes are executed as Windows Services, running in the background, and do not interfere with normal computer operations. Server and local deployment support allow us to address needs of various training organizations. Cloud-based option provides ubiquitous access without need for infrastructure maintenance; however, it requires a stable Internet connection that may not always be available in training facilities. Alternatively, local server installation provides a small and secure cloud instance within individual classrooms without external network connectivity. Finally, the standalone LG-RAID option, loaded on each student's laptop, provides a fully disconnected option.
The other benefit of local or Internet-based cloud deployment is an opportunity for collaboration between multiple users of the same server. The Requests and Updates Manager (RUM) component of LG-RAID implements support for multiple simultaneous users. Each user can save and load scenario files, perform Simulation Based Training execution, as well as collaborate with other users by exchanging files or participating in *Joint Editing* sessions for concurrent editing on the same scenario. As a classroom training tool, these functionalities can also be leveraged for instructor-student communications such as exchange of assignments.

3.1.2. Streamlined User Interface

For consistent experience for both standalone and cloud-based employment, the end-users are able to access the tool using the web app either locally from the same machine where the server components are installed or from any COTS laptop or desktop computer, with any modern operating system using a common Internet browser such as Chrome, Firefox, or Internet Explorer. Using the web browser provides additional benefit of familiarity to the users. It was assumed that students would have previous exposure to the profusion of consumer web applications, such as maps, email, and social networks. Thus we leveraged this experience and reduced training requirements by providing a user interface that employed familiar elements (Figure 2).

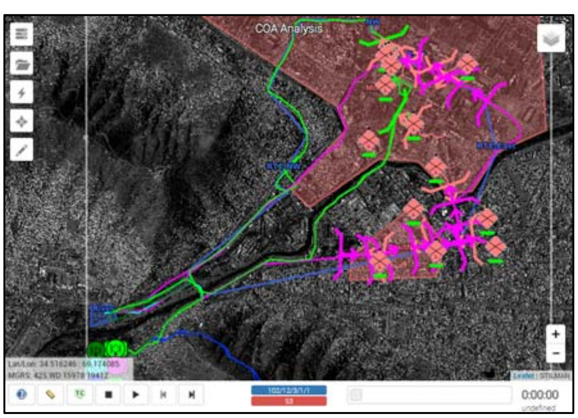


Figure 2: Streamlined Interface

To achieve this, the LG-RAID interface was built using the same open source technologies that drive some of the popular commercial websites, including HTML5, CSS, Bootstrap, AngularJS and Leaflet map engine. As a result, the look and the feel of the UI match user's expectations from other familiar applications and leads to intuitive use (with little training required). For example, the LG-RAID user interface (UI) employs the same control to move a map with a mouse as all common Internet mapping applications. Additionally, visual on-screen queues are used to guide the user through the functionality, e.g., drawing a polygon on the map (Figure 3).

Figure 3: Polygon Depiction in LG-RAID UI

It is important to consider that the target user of this software is a military student. Therefore, the UI should leverage both common web application elements and military concepts. This includes such features as use of the Military Grid Reference System (MGRS) in the bottom left corner and doctrinal Army terminology in mission specifications.

3.1.3. Game-Like Interactive Use

LG-RAID had been previously employed in a COA analysis role, where the entire mission is automatically evaluated using the Artificial Intelligence (AI) engine based on the initial BLUFOR mission plan and OPFOR information provided by the user. This method is applicable for training for providing comparison between alternative COAs. This comparison includes qualitative analysis based on visual animated playback of the mission as well as quantitative evaluation based on numerical mission statistics. Both types of analyses could be employed by the students and the instructor. To further enhance this functionality, mission statistics have been expanded to include expected casualties and fuel and ammunition expenditure for both friendly and enemy forces (Figure 4).

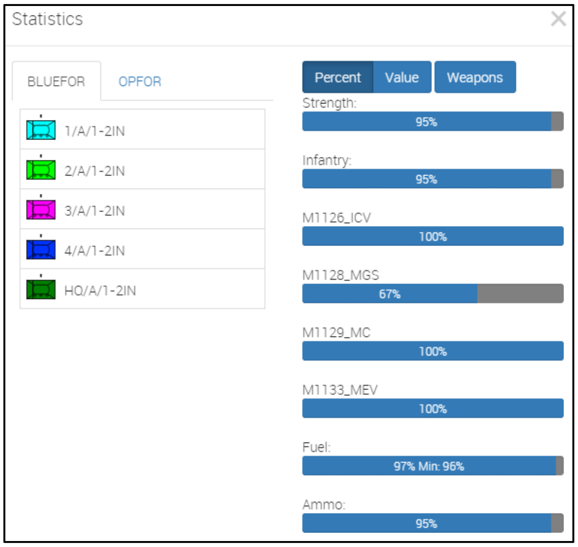


Figure 4: Expanded Mission Statistics

Additionally, more immersive simulation based training was achieved by introducing a new game-like interactive mode. The student begins by entering the BLUFOR mission plan. However, the enemy information, prepared by the instructor, is hidden from view. During mission execution, the student can watch the plan unfolding as friendly forces move across the map, enemy forces are discovered, and engagements take place. At any point, the user can pause the simulation and alter their mission plan by changing taskings for any of their units. As the simulation is resumed, the LG-RAID engine automatically adjusts the enemy's actions in reaction to this change to provide the student with a challenging enemy. In addition to dynamic control of the OPFOR, the engine removes the need to micromanage the BLUFOR. For example, the Company Commander in training can simply assign tasks to the platoons, and LG-RAID will fill in intelligent actions for the subordinate units, removing the need for human players to act as platoon leaders or squad leaders. This approach was used to provide ubiquitous access so that students can perform training exercises on their own without any pre-event preparation or additional support personnel, which was a key requirement of the TECD 7 program.

3.1.4. Simplified Terrain Import

A common challenge for simulation based training has been availability and quality of terrain data. Often times, simulation terrain databases have to be augmented with additional information such as stair cases, doors and window locations, as well as photorealistic textures for 3D visualization. In order to keep this simulation light weight, only Digital Terrain Elevation Data (DTED) and shapefile feature data are required for LG-RAID. Additional information such as windows, doors and floors is inferred. Such *source* data is typically easier to procure, however, it typically requires some processing to correct any errors, inconsistencies, or non-standard formats. The Terrain Data Manager (TDM) was added to the LG-RAID toolset to simplify this process. TDM (Figure 5) can be used to produce *geospecific* regions, i.e., representing a real-world area, or *geotypical* regions, i.e., non-specific representations of terrain typical for a given area. The latter is especially useful for training as it challenges the student with operations on several, different versions of the same terrain.

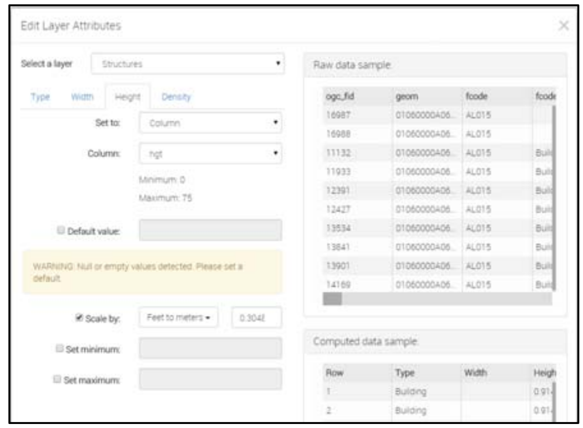


Figure 5: Terrain Data Manager (TDM)

Any set of shapefiles and DTED files can be uploaded through the TDM web app. The user can then use a wizard interface to classify the data, choose key data fields, such as heights, and perform conversions between measurement units. In addition to such bulk format corrections, the user can also view terrain features overlaid on top of the satellite pictures and manually correct the shape or parameters of any specific feature, such as a road or a building (Figure 6).

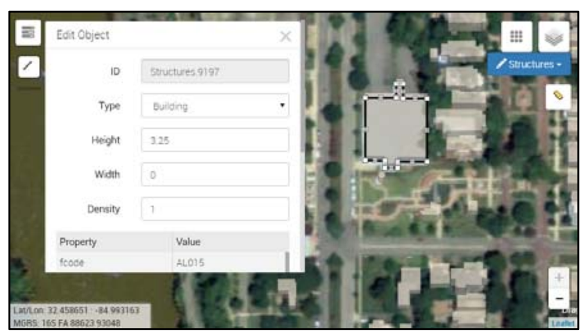


Figure 6: TDM Wizard Interface

Once the data has been classified and corrected, the Deploy Region Wizard is used to automatically process the terrain area into a format required for the LG-RAID simulation engine. This unattended cycle can take several hours, and, once done, the user can perform Simulation Based Training on this new area.

In addition to producing underlying data required for the simulation, TDM can also be used by instructors to prepare raster images that will serve as a map background for the student. These can be produced from any common formats, e.g., GeoTIFF (Georeferenced Tagged Image Format) or RPF (Raster

Product Format). The instructor can choose to provide only the maps appropriate for the exercise, while removing access to other. For instance, the student could be allowed to use topographic maps but not high resolution satellite imagery. This capability was added to support doctrinal training such as the student's ability to perform tactical analysis using specific geographic products.

3.2. Challenges

One of the challenges with producing a training product for the Army is adhering to strict Security Technical Implementation Guides (STIGs) required to obtain a Certificate of Networthiness (CoN). These guidelines were used by the development team to provide security of the overall system. To follow these guidelines requires additional work for the final product release for installation on Army computers. Additionally, as any web-based application, this system must be resilient to network latencies and outages. Our team chose to address this challenge by reducing the need for a constant server connection. The web-based GUI is responsible for all scenario creation and visualization of results without relying on server-side processing (with the exception of actual simulation computations). This was achieved by leveraging the power of modern web browser technologies mentioned previously. For universal accessibility, the web GUI has to support common browsers including Chrome, Firefox, and Internet Explorer. However, due to the novelty of some of the HTML5 standards, additional testing and workarounds are needed to address numerous inconsistencies across these platforms. This can be even more difficult in light of the additional security configurations that affect Internet Explorer operation on some of the government laptops that employ the Army Gold Master Windows Operating System.

Another common challenge has been to ensure that the user interface remains easy and intuitive to use. We have kept the usability at the forefront of development through rapid prototyping, usability testing, and feedback from target user groups, retired military subject matter experts (SMEs), instructors, and students from military learning institutions. These efforts endured through the entire lifecycle of this project to ensure the final version remained easy to use as the capabilities of the software and the complexity of the UI grew.

The training provided by the system must be consistent with the US Army doctrine to be effective. Capturing the doctrinal taxonomy, specific equipment, tactics, techniques and procedures presented a significant challenge. These military concepts must be translated into the specific LG models in order to support analysis by the LG-RAID engine. Close collaboration between the military SMEs and the software development team was necessary to continuously refine and improve fidelity.

Terrain data availability is a common challenge to any simulation system. While TDM can now be used to help address some of the terrain-related problems, producing new or correcting very poor terrain data remains manually intensive. We adopted the strategy of requesting areas of interest from target user groups as early as possible in order to mitigate the time required to procure and prepare the data. Additionally, we proactively prepared terrain data, as requested by TECD 7 stakeholders, in order to provide them with common training locales such as the National Training Center (NTC).

3.3. Future Employment of the Simulation

Preliminary demonstrations have already been conducted with the Maneuver Captains Career Course (MCCC) and Cavalry Leaders Course (CLC) at the Maneuver Center of Excellence (MCoE), Ft Benning in order to gather direct user feedback on current functionality and identify key directions for future development. The next step in this project is to employ the LG-RAID software for Simulation Based Training within the scope of a particular Army schoolhouse course, such as MCCC and CLC, for more direct assessment of applicability and required enhancements. Such testing is currently slated to begin during the summer of 2015 using two Company level training scenarios at MCCC.

Once the project's Certificate of Networthiness has been received, all three methods of deploying the software can be supported. Cloud-based deployment on the Army Games for Training servers would provide easy access. However, some classrooms prefer installation on individual laptops. Based on previous feedback, yet another deployment option is the use of a laptop-based server with a WiFi hotspot to support instructors that travel to numerous training locations, such as National Guard Training Centers. Most of these courses last only a few weeks, and an easy, low overhead system with little-to-no training requirement is essential.

While standalone, low overhead, SBT is the primary goal, integration with other simulations and mission command systems may be of interest to training courses. For example, using LG-RAID to stimulate Mission Command systems could allow the students to train using the same exact software systems that they will later use in the field.

A key area for future improvement is breadth and depth of the military scenario modeling provided by the tool. Past focus of LG-RAID has been on maneuver force-on-force Company level operations. However, the key simulation capability can be extended to both lower (i.e., Platoon) and higher (i.e., Battalion and Brigade) echelons. Larger scale operations in particular, would require a significantly larger set of units and mission types. Supported mission types can be expanded to include more detailed representation of reconnaissance, engineering, and logistics operations. This development will proceed in tight cooperation with the SMEs from specific Army courses to ensure a high degree of relevance to particular learning objectives. Additional features can also be introduced to the User Interface to support these learning objectives, such as Line of Sight, Surface Danger Zones, and others. Interactive and collaborative features of the tool can also be expanded to allow for teams of students to play against each other in a real-time multiplayer team environment, including support for instructor interventions.

There are many other directions for the future employment of LG-based simulation tools. One of them is simulation based acquisition. For this purpose, the LG technology permits modeling and evaluation of new conceptual military hardware in terms of its functionalities before actually building it. Using LG tools, the analysts will create a gaming environment populated with the Blue forces armed with the new conceptual hardware as well as with appropriate existing weapons and equipment. This environment will also contain the intelligent enemy with appropriate weaponry and, if desired, with conceptual counters to the new Blue weapons. Within such a LG gaming environment, the analyst will run various what-ifs with the LG tools providing the simulated combatants with strategies and tactics solving their goals with minimal resources spent. If the new hardware functionality has hidden flaws, the simulated enemy guided by the LG strategies would be able to exploit them providing the hardware evaluators with hands-on proofs of failure. Contrariwise, if the new hardware functionality has spectacular advantages, the Blue forces guided by the LG strategies would be able to convincingly demonstrate how these advantages could be translated into victory for the Blue forces. This not only helps the evaluators to assess the hardware's advantages, it will help to convince the funding agencies to fund the prototype construction. In similar fashion, several alternative functionalities could be compared using the ultimate criteria – how well the conceptual weapons and/or equipment will do against an intelligent adversary fully simulated by the LG tools. Experimentation within the LG simulated environment may provide an inexpensive alternative to the live exercises typically conducted for the same purpose.

4. CONCLUSION

In this paper, we described how simulation is enabling the U.S. Army to adapt to a complex and dynamic operational environment (OE). The TECD 7 effort was the Army's collective training response to a rapidly changing operational environment. The LG-RAID simulation was chosen as a TECD 7 participant due to its potential high-payoff capability, in alignment with the TECD 7's charter to develop training technology and methodologies to achieve a more effective training capability to enhance both small unit as well as Army leader performance across the full range of military operations.

We discoursed on the development and design of new LG-RAID capabilities that will support the achievement of the TECD 7 mission. Ease of deployment, a more streamlined interface, higher interactivity and rapid terrain importation are a few of the critical capabilities currently being developed with this goal in mind. We also covered challenges encountered during our design and development cycles as well as future methods of the simulation's employment.

The LG-RAID simulation will provide the Army with a low-overhead capability to train its leaders on tactical planning in response to a changing OE. The ability to maintain pace with a complex and dynamic OE, through the use of adaptive simulation, is a strategic goal for the Army's leadership and training communities of interest. The LG-RAID simulation, through its design, development and testing cycles, is on pace to meet this goal.

5. REFERENCES

Arora, S., Cox, C., Davies, S., Kassab, E., Mahoney, P., Sharma, E., & Sevdalis, N. (2014). Towards the next frontier for simulation-based training: full-hospital simulation across the entire patient pathway. *Annals of surgery*, 260(2), 252-258.

Benson, B. (2012). Unified Land Operations: the evolution of Army doctrine for success in the 21st Century. *Military Review*, 47-57.

Bergeron, B. (2006). *Developing Serious Games (Game Development Series).* Charles River Media.

Blow, C. (2012). *Flight School in the Virtual Environment.* Fort Leavenworth, Kansas: United States Army Command and General Staff College.

Buschmann, D., & Pellicano, M. (2014). *Actionable Intelligence & Mission Command Technology Enabled Capability Demonstration Network Platoon Increment FY14 Test Report – E14.* Aberdeen Proving Grounds, MD: U.S. Army Research, Development and Engineering Command.

Freeman, M. (2011). *Army S&T Challenges for POM 14 The Way-Ahead.* Retrieved from https://acc.dau.mil/adl/en-US/506470/file/63383/07142011_Freeman_Tech%20Directors_Final.pdf

Graves, T., & Stanley, B. E. (2013). Design and Operational Art: A Practical Approach to Teaching the Army Design Methodology. *Military Review*, 93(4), 53.

Hamstra, S. J., Brydges, R., Hatala, R., Zendejas, B., & Cook, D. A. (2014). Reconsidering fidelity in simulation-based training. *Academic Medicine*, 89(3), 387-392.

Lele, A. (2013). Virtual Reality and its Military Utility. *Journal of Ambient Intelligence and Humanized Computing*, 17-26.

Martinez, I. (2012, April 2). Collective Training for Tactical Operations. *TECD 7 Project Briefing*. Orlando, FL, U.S.: U.S. Army Research, Development and Engineering Command.

Odierno, R. (2012). The US Army in a Time of Transition: Building a Flexible Force. *Foreign Affairs*, 91, 7.

Snider, D. (2012). Once Again, the Challenge to the US Army During a Defense Reduction: To Remain a Military Profession. *ARMY WAR COLLEGE STRATEGIC STUDIES INST CARLISLE BARRACKS PA*.

Sotomayor, T., Mazzeo, M., Hill, A., & Hackett, M. (2013). Severe Trauma Stress Inoculation Training for Combat Medics using High Fidelity Simulation. *lnterservice/lndustry Training, Simulation, and Education Conference (1/JTSEC)* . Orlando, FL: NTSA.

Stevens, J., & Eifert, L. (2014). Augmented reality technology in US army training (WIP). *Proceedings of the 2014 Summer Simulation Multiconference* . Society for Computer Simulation International.

Stilman, B. (2000). Linguistic Geometry: From Search to Construction. Kluwer (now Springer).

Stilman, B. (2014). What Is the Primary Language. In *Artificial Intelligence and Soft Computing* (pp. 558-569). Springer International Publishing.

Stilman, B., & Yakhnis, V. (2003). Linquistic geometry: new technology for decision support. *AeroSense 2003.* International Society for Optics and Photonics.

Stilman, B., Yakhnis, V., & Umanskiy, O. (2007). Strategies in Large Scale Problems. In Ed. by A. Kott (DARPA) and W. McEneaney (UC-San Diego), *Adversarial Reasoning: Computational Approaches to Reading the Opponent's Mind,* (pp. Chapter 3.3, pp. 251-285). Chapman & Hall/CRC.

Stilman, B., Yakhnis, V., & Umanskiy, O. (2010). Linguistic Geometry: The Age of Maturity. *Journal of Advanced Computer Intelligence and Intelligent Informatics*, Vol. 14, No. 6, pp. 684-699.

Thompson, M. (2013, November 4). Reshaping the Army: A Force Built to Fight the Cold War is now Battling Changes to its Size, Shape and Mission. *Time*, pp. 34-40.

AUTHORS BIOGRAPHY

Latika (Bonnie) Eifert is a Science and Technology Manager at the U.S. Army Research Laboratory-Human Research and Engineering Directorate, Simulation and Training Technology Center (ARL-HRED STTC) located in Orlando, Florida. Ms. Eifert manages several projects associated with simulation and training and also supports the Defense Advanced Research Project Agency (DARPA) by managing various research program efforts. She received her M.S. in Computer Engineering from UCF in 2003.

Dr. Jonathan Stevens is a Research Scientist with the Institute for Simulation and Training (IST) at the University of Central Florida (UCF), specializing in training effectiveness research. Dr. Stevens is a retired Lieutenant Colonel of the United States Army with over 22 years of military experience as both an Infantry and Acquisition Corps officer. He received his Ph.D. in Modeling and Simulation from UCF.

Dean Reed (B.S. in Computer Science, UCF 2000) is a Senior Associate for Simulation with the Institute for Simulation and Training (IST) of the University of Central Florida. Mr. Reed is a veteran of the U.S. Army, leads a team of developers at IST and has over 15 years of simulation development experience.

Oleg Umanskiy is the Chief Software Architect at STILMAN Advanced Strategies (STILMAN) and leads the software development effort of the LG-RAID simulation. Oleg has over 18 years of software design, development and research experience, and has been the architect and the leading developer of the LG-RAID simulation for STILMAN. He received special recognition for his work from the Defense Advanced Research Projects Agency (DARPA). Oleg is a Ph.D. student at the University of Colorado Denver.

Dr. Boris Stilman is the Chairman & CEO at STILMAN Advanced Strategies (STILMAN) and Professor of Computer Science at the University of Colorado Denver. Dr. Stilman leads STILMAN since its foundation in 1999. All the software applications including LG-RAID developed at STILMAN are based on Linguistic Geometry, a new type of game theory in Artificial Intelligence, which has been originated and further developed by Dr. Stilman since 1972. He has published over 200 research papers.

INTERNET OF THINGS (IoT) APPLICATIONS STUDY USING BIG DATA AND VIRTUALIZATION PROCESS TECHNOLOGY.

Albino Ribeiro Neto[(a)], Gerson Gomes Cunha[(b)], Luiz Landau[(c)], Sergio Poliano Villarreal[(d)], Cristina Jasbinscheck Haguenauer[(e)]

[(a),(b),(c), (e)] Computational Methods in Engineering Laboratory
LAMCE/COPPE/UFRJ
[(a),(d)] National Service for Industrial Training - SENAI/FIRJAN

[(a)] sansao@lamce.coppe.ufrj.br, [(b)]gerson@lamce.coppe.ufrj.br, [(c)] landau@lamce.coppe.ufrj.br,
[(e)]crisjh@lamce.coppe.ufrj.br
[(a)] arneto@firjan.org.br, [(d)] svillarreal@firjan.org.br

ABSTRACT

This paper is about the study about the Internet of things (IoT) applications using Big Data (or "data analytics ") and the virtualization process. The Internet of things is at the beginning, but is expected that in the near future will transform the world, creating a giant network of devices and machines globally connected, aggressively increasing communication and data exchange, the IoT is still seen as fiction, but in reality this world already exists through numerous devices present in our daily lives: the "wearables" (term meaning technologies to wear) like tablets, smartphones, smart watches and bracelets. With the use of IoT comes the solution of various problems, but through this intense communication another problem is created, the huge volume of collected data. This problem is being solved by Big Data, that handles structured and unstructured data.

Keywords: Automation, Security & Intelligence, Industrial Engineering, Internet Of Things

1. INTRODUCTION

The Internet of Things covers several technologies that have been developed in recent years, according to Ayres and Sales (2010), this is an expression used from the 90s relating the network connections between objects to the Internet, Figure 01. Technologies that guarantee much of its development are RFID[1] (Radio Frequency Identification) sensors, ubiquitous[2] wireless networks and the Internet Protocol change for IPv6 version.

Nowadays, the IPv4 protocol is the most used, and capable of generating up to 4 billion IP (Internet Protocol) addresses. In this case, different addresses can only be given to a limited number of computers, mobile phones and devices connected to the network. With Internet of Things, each object must have its own address. The solution to this obstacle is on IPv6. Through Ipv6 an almost unlimited amount of codes can be generated to a lot of objects, more precisely 340 undecillion objects.

[1] RFID technology (radio frequency identification) is nothing more than a generic term for technologies that use radio frequency for data capture. Therefore there are several methods of identification, but the most common is to store a serial number that identifies a person or object, or other information, in a microchip. Such technology allows automatic data capture, to identify objects using electronic devices, known as electronic labels, tags, RF tags or transponders that emit radio frequency signals to readers that capture this information. It exists since the 40s and came to complement bar code technology, widespread in the world.

[2] The term "Ubiquotous Computing" was originally stated by Mark Weiser in 1991, on his article "The Computer for XXI Century", to refer to devices conetcted everywhere so transparently to the human being, we will end up not realizing they are there.

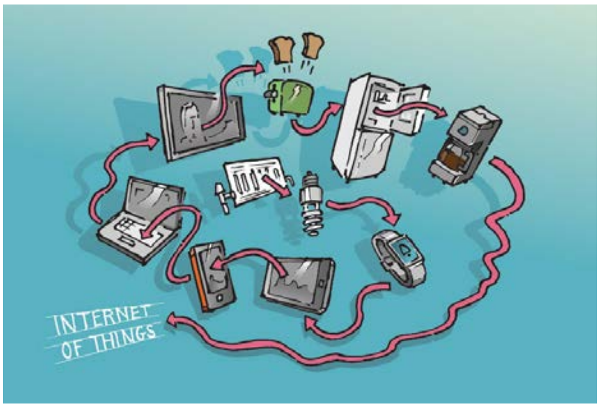


Figure 01 – Internet of Things (IoT)

In general, the Internet of Things (IoT) is an extension of the internet to the real world (physical) where a great interaction with objects and their independent communication between them become possible, however, according to Singer (2012), define what actually is the Internet of Things (IoT) is complicated in the face of several studies and publications on the subject. A lot of information stored on computers around the world is used on the Internet. This is a totally virtual world where people browse and interact with pages accessed via hyperlinks. On the Internet of things, objects have their own identification and this can be read in an automated manner. Physical objects are now represented in a virtual environment.

2. IoT CONCEPTS:

- Internet access;

- AIDC[3] (Automatic Identification and Data Capture);

- Context perception.

These three concepts allow the development of a fairly complete model of technologies needed for the creation and deployment of IoT (Internet of Things) services. Interest in this area is very large due to the potential this concept has to be applied for idealizing new business models. IoT is a very representative technological revolution regarding the future of computing and communications, its development depends mainly on technological innovation of nanotechnology and new wireless sensors. Advances in miniaturization processes and nanotechnology enable small objects to connect and interact.

[3] Automatic identification and data capture (AIDC) refers to the methods of automatically identifying objects, collecting data about them, and entering data directly into computer systems (i.e. without human involvement). Technologies typically considered the part of AIDC include bar codes, Radio Frequency Identification (RFID), biometrics, magnetic stripes, Optical Character Recognition (OCR), smart cards, and voice recognition. AIDC is also commonly referred to as "Automatic Identification", "Auto-ID" and "Automatic Data Capture".

The advantage of this vast amount of information integrated between various industrial products and everyday items only become possible through sensors that are able to identify environmental physical changes. These modifications allow static objects to be transformed into dynamic, adapting intelligence and stimulating the development of several innovative products and new applications. RFID (Radio Frequency IDentification) is the most promising technology in this regard, Figure 02.

According to the analysis of Kranenburg, 2008, p.62, which states:

> "Cities across the world are about to enter the next phase of their development. A near invisible network of radio frequency identification tags (RFID) is being deployed on almost every type of consumer item. These tiny, traceable chips, which can be scanned wirelessly, are being produced in their billions and are capable of being connected to the internet in an instant."

Figure 02 - Basic scheme of RFID use.

Most of these devices are already used in several countries including Brazil. Some of the benefits of the internet of things are:

- Identify and track assets and people;

- Check and improve process efficiency;

- Improve inventory control efficiency;

- Improve perishable products control;

- Reduce losses;

- Facilitate supply chain synchronization;

- Increase supply chain visibility;

- Reduce operational risks;

- Increase customer satisfaction and loyalty;

- Reduce theft and forgery;

- Get greater reliability in data management;

- Get accurate information for decision making;

- Meet the requirements for Retailers and Distributors;

- Check after-sales and warranty.

Through advanced nanotechnology development and internet penetration, the natural way is the connectivity of these RFID tags to the computer network and the information switching between them. IoT is an increasingly present reality.

Some applications that can be developed: subcutaneous health monitor warning your doctor or the nearest hospital of a heart attack risk; a product informing your health monitor of gluten, lactose or phenylalanine presence; smart refrigerators able to report the lack of food, find recipes on specialized sites and add products to the supermarket shopping list, and the user is able to approve and confirm it over the internet with a click. Objects themselves would be responsible for this interaction: a chip in the milk box, for example, warns the device of the proximity of expiration date; when the last beer is consumed, the device informs electronically it is necessary to buy more.

3. WEARABLES

There are devices called "Wearables"[4] (a term that refers to technologies to wear). This technology is being used mainly in “smart” watches and devices for sports practice, but there is much more about this technology. Manufacturers like Samsung, Intel, LG, Sony, Qualcomm and others, developed several wearable equipment, figure 03. The list of large companies that have developed innovations in this segment is quite representative. Also, a large portion of small industries have participated, desirous of finding even more specific purposes for developed microchips.

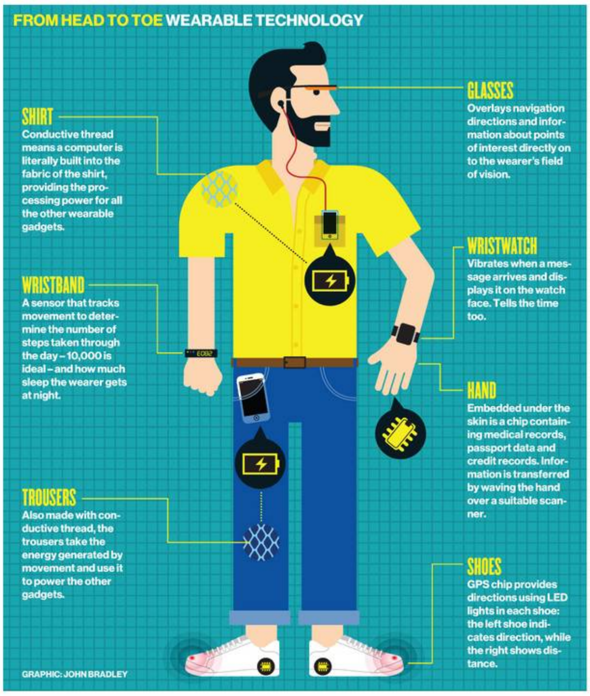


Figure 03 - Examples of Wearable devices.

Sony and Samsung went ahead placing on the market the “smart” watches SmartWatch 2, figure 4, and the Galaxy Gear, figure 5. Even though there is still a small share of users, these devices are increasing their use of technology possibilities, and more and more applications are developed for such equipment. Receive e-mail notifications, access Twitter[5] or even Facebook posts, remotely control the smartphone and start a car in the distance, figure 6, are just some of the possibilities.

The "smart" bracelets that have been released prior to the clocks found another way to help consumers monitoring their health. An example is the LG Life Band Touch, figure 7, which in addition to controlling smartphones can also monitor your heart rate. All collected data is transferred to the phone via Bluetooth, and through a specific application, it is possible to measure distances and even count steps, average speed and calories expended during use. This type of technology is increasingly diverse and present in our daily lives.

[4] Wearable computers, also known as body-borne computers or wearables are miniature electronic devices that are worn by the bearer under, with or on top of clothing. This class of wearable technology has been developed for general or special purpose information technologies and media development. Wearable computers are especially useful for applications that require more complex computational support than just hardware coded logics.

[5] Twitter is a social network and server for microblogging, which allows users to send and receive personal updates from other contacts (texts up to 140 characters, known as "tweets") via the service website, via SMS and specific software management.

Figure 04 – Sony SmartWatch 2.

Figure 05 – Samsung SmartWatch Galaxy Gear.

Figure 06 – Starting the car with the SmartWatch.

Figura 07 - LG Life Band Touch.

4. FORECASTS FOR IoT

Cisco[6] made a preview about the growing number of devices per person, based on a study in China which came to the conclusion that in 5.36 years (2001-2006) the number of devices doubled. Thus it is estimated that in 2020 we will have a world population of about 7.6 billion people and 50 billion devices connected to the Internet, figure 08, this generates an average of about 6.58 devices per person. (Evans, 2011).

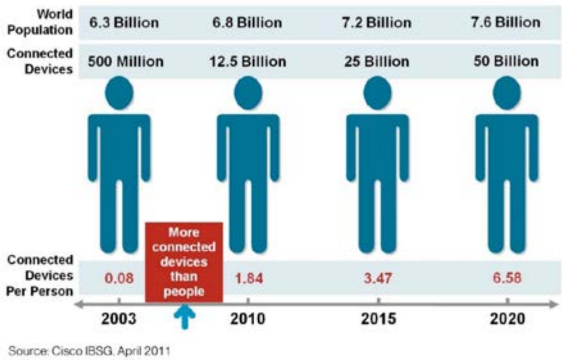


Figura 08 - The Internet of things was "born" between 2008 and 2009.

The greatest effect of all this is a large increase in variety of devices, various possibilities that are unknown even to the industry. The most obvious items, not coincidentally, are the ones that are first delivered to the public: "smart" bracelets, watches and glasses now have their own processors and have the ability to integrate and interact easily to tablets and smartphones.

[6] Cisco Systems, Inc. is an American multinational technology company headquartered in San Jose, California, that designs, manufactures, and sells networking equipment. The stock was added to the Dow Jones Industrial Average on June 8, 2009, and is also included in the S&P 500 Index, the Russell 1000 Index, NASDAQ-100 Index and the Russell 1000 Growth Stock Index.

The industry estimated sales projection is 171 million units by June 2016. Devices probably will enter the market in extremely different ways, reaching in several ways our personal lives, from health services to fitness, from well-being care to medicine, including sectors of entertainment and information.

Technological dimension is highly insufficient for understanding the world of IoT and to build roadmaps representing realistically and adequately how to forward efforts and investments in research and development to enable everyone, as soon as possible, to use the benefits IoT can provide.

Brazilian industry uses this system in several projects, mainly through application with the RFID technology. The most common segments in the market with troubleshooting focus are:

- Consumer Goods have more traditional solutions with technology use in supply chain;

- Logistics with focus on traceability solutions and urban mobility;

- Industry focused on productivity solutions;

- Services focused on quality solutions for providing services to clients;

- Entertainment focused on innovative solutions and integrated experiences for consumers;

- There are several initiatives which stand out in the areas of education, health, and safety, and the combination of safety with other technologies consists of high value-added projects.

5. USE OF BIG DATA IN IoT

The term Big Data[7] is fairly new, emerging around 2005 with Google and increased greatly in 2008 with Yahoo, who changed the Hadoop platform and to turn it into Open Source.

When someone hears the term Big Data, immediately comes to mind a literary translation of the text "Big data" related to the huge amount of data to be analyzed.

[7] Big data is a broad term for data sets so large or complex that traditional data processing applications are inadequate. Challenges include analysis, capture, data curation, search, sharing, storage, transfer, visualization, and information privacy. The term often refers simply to the use of predictive analytics or other certain advanced methods to extract value from data, and seldom to a particular size of data set. Accuracy in big data may lead to more confident decision making. And better decisions can mean greater operational efficiency, cost reductions and reduced risk.

But the term is much broader, Carlos Barbieri (2013) states that Big Data is commonly classified by 5V's, that identify its five premises:

- **Volume**, relates the large amount of data inside and outside the company;

- **Velocity**, every second a lot of new data is created on the Internet, and some of this data may be of interest to one´s company;

- **Variety**, the data may be a blog post sharing, a text in a social network, an e-commerce review, etc.

- **Veracity**, collected and mined data should have authenticity;

- **Value**, as it is important to have return on investment.

With the evolution of IoT applications and the increasing need for information, more and more applications are being developed, continually increasing the amount of information. The growth of data in enterprise applications annually is of approximately 60%. It is estimated that a company with a thousand employees can generate annually about 1,000 terabytes, and this number tends to increase fifty times by 2020. With this significant increase in applications, information is generated exponentially, thereby manageability of these information becomes essential for these applications.

5.1 BIG DATA CHALLENGES

The biggest challenge of Big Data is to manage a large volume of data and mine this information in a shorter request. An excellent strategy is to make the application grow as it is required, using thus a vertical scale (the power of the hardware is increased by increasing memory and processing of a single machine) or horizontally (where the number of machines is increased). Although it is more complex, the horizontal scalability ends up being very cheap, and it is easier to grow or shrink resources according to demand.

An aspect rarely discussed in Big Data, is related to the speed in the software development and the speed of modeling. One example is Twitter where many users use the hashtag[8] ('#' added together with a word) and when searching for that hashtag will then present each message that has been tagged with it.

In conclusion, the concept of Big Data is extremely easy, even diverging from various sources, which is to carry out the management of a huge amount of memory extremely quickly.

6. FINAL CONSIDERATIONS

The Big Data technology is a modern tool of Predictive Management and Analysis, bringing great gains and benefits to different areas, whether private or public. The future will be much more challenging and productive by utilizing the Internet of Things, since this technology makes the Internet connection to everyday objects possible: household appliances, televisions, automobiles, etc. To provide smart environments, IoT will revolutionize our lives as consumers.

Big Data allows integrating high volume of data in IoT with data from companies' owners. This will allow a deep insight into customer behavior, especially regarding usage of a product. In the automobile industry, automakers will be able to learn about the real mileage of the vehicles, the driver´s driving style, if the drive more on the road or in urban areas heavy traffic. Thus, the returns will be much greater enabling a relationship that will attract the customer to do maintenance and reviews more effectively. The possibilities of joint action creation will be almost limitless among auto parts manufacturers and dealers, offering at the right time, replacement of the product with the right solution to the problem, helping the customer he is close to replace his vehicle and through the information obtained, offer a more appropriate model to his needs, and a bank loan plan according to the customer's financial conditions and thus increasing customer loyalty.

The conclusion is that without Big Data it will not be feasible to have the Internet of Things, as one depends intrinsically on the other. For Ayres and Sales (2010) the concept of the Internet of Things (IoT) had its beginning at MIT (Massachusetts Institute of Technology) at the 1999 AutoID Center program. Today the world's leading Internet of things research and development centers are the Massachusetts Institute of Technology (MIT), the precursor in the United States, and the University of Manchester in England, where the annual conference "The Future of Things " is hosted.

ACKNOWLEDGMENTS

This paper was supported by my PhD advisor Luiz Landau through guidelines and advice throughout the project, and he provided all the necessary research to build the prototype object of this work.

Also, the Innovation Director of the state of Rio de Janeiro Federation of Industries, Bruno Souza Gomes, the Strategic Innovation Manager, Carlos de Mello Rodrigues Coelho and the Executive Manager of the CTS Automation and Simulation, Sergio Villarreal Poliano, who provided all the infrastructure and research necessary to build the prototype object of this work, essential to the completion of this research phase.

REFERENCES

AYRES, Marcel; SALES, Heber. Internet of Things and Mobile Marketing: limits and possibilities. 2010. Available from: <http://marcelayres.com.br/blog/artigo-internet-das-coisas-e-mobile-marketing/>. Accessed April 25, 2015.

Bringing it Altogether - EIM, B2B and IoT. Available from Objects and Flash Animations in Teaching <http://www.gxsblogs.com/morleym/2014/01/bringing-it-altogether-eim-b2b-and-iot.html>. Accessed May 10, 2015.

EVANS, Dave. The Internet of Things - How the Next Evolution of the Internet Is Changing Everything. 2011. Available from <http://www.cisco.com/web/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf>. Accessed March 18, 2015.

Hyundai wants you to start and lock the car using the clock. Available from: Objects and Flash <http://www.makeupautos.com.br/noticias/detalhe/id/381>. Accessed March 5, 2015.

Internet of things. Available from: <http://www.rfidsystems.com.br/internet.html> Accessed April 15, 2015.

Internet of things, the concept. Available from: <http://hypescience.com/internet-das-coisas-o-conceito/> Access February 27, 2015.

IoT will handle 17 trillion by 2010. Available from: <http://www.baguete.com.br/noticias/03/06/2015/iot-movimentara-us-17-trilhao-ate-2020>. Accessed June 5, 2015.

KRANENBURG, Rob Van. The Internet of Things. The critique of ambient technology and the all-seeing network of RFID. 2008. Available from: <http://www.networkcultures.org/_uploads/notebook2_theinternetofthings.pdf>. Accessed May 19, 2015.

SINGER, Talyta. All Connected: concepts and representations of the Internet of Things. 2012. Available from: <http://www.simsocial2012.ufba.br/modulos/submissao/Upload/44965.pdf>. Accessed May 21, 2015.

Have reliable and consolidated information to support the decision making of your business with our solutions (BI). Available from: <http://stefanini.com/br/smart-solutions/inteligencia-de-negócios/>. Accessed June 3, 2015.

The Internet of Things Made Simple. Available from: <http://now.avg.com/the-internet-of-things-made-simple/>. Accessed May 3, 2015.

AUTHORS BIOGRAPHY

Albino Ribeiro Neto

Holds a Bachelor´s Degree with academic honors - Magna Cum Laude in Scenography from the Federal University of Rio de Janeiro (2010), a Master´s Degree in Civil Engineering (2014) from the Federal University of Rio de Janeiro, ongoing Ph.D. in Civil Engineering PEC / COPPE / UFRJ (2014) Capes 7, Ph.D. discontinued in Naval and Ocean Engineering PENO / COPPE / UFRJ (2014) Capes 6, he is a member of the SBC (Brazilian Computer Society) and ABED (Brazilian Association of Distance Education). He is currently a Senior Researcher and Consultant in technological services at SENAI Automation and Simulation at FIRJAN system, also a researcher (not affiliated) in the Applied Virtual Reality Group GRVA projects, this group is linked to LAMCE / COPPE / UFRJ. He has experience in the areas of programming, embedded electronics and simulators for virtual reality - Civil Engineering, acting on the following topics: virtual reality, virtual sets, virtual environments, learning objects, virtual learning environments, conservation and restoration.

Gerson Gomes Cunha

Holds a Bachelor´s Degree in Civil Engineering from the Federal University of Rio Grande (1985), a Master's Degree in Civil Engineering - Civil Engineering Program (1991) and Ph.D. in civil engineering from the Federal University of Rio de Janeiro (2004). He is currently a collaborator researcher at COPPETEC Foundation and partner at Simset Simulation Technology Ltd. He has experience in computer science, with emphasis on virtual reality, acting on the following topics: offshore exploitation of oil, virtual reality and simulation.

Luiz Landau

Holds a Bachelor´s Degree in Civil Engineering from the Pontifical Catholic University of Rio de Janeiro-PUC / RJ (1973), Master's Degree in Civil Engineering from the Federal University of Rio de Janeiro-COPPE / UFRJ- (1976) and Ph.D. in Civil Engineering from the Federal University of Rio de Janeiro (1983). He is currently a professor of the Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering at the Federal University of Rio de Janeiro (COPPE / UFRJ), Coordinator of the Computational Methods Laboratory of Civil Engineering of the Engineering Program (LAMCE / PEC / COPPE / UFRJ), Consultant of the Project Coordination, Research and Technology Foundation –COPPETEC, IA Researcher IA at CNPq and Coordinator of PRH-02 ANP.

Sergio Poliano Villarreal

PMP, MCSE + I, TOEFL, Business Management - Cambridge - UK, Post graduating in project management, Design and 3D Modeling (American University System) Degree at Universidade Veiga de Almeida (UVA), Concept Design Specialist, Web Master and Web Design from INFNET, extension in Augmented Reality - METAIO - Germany, Innovation Institutes Management - Fraunhoufer, Germany, Specialist in the development platforms 3DStudio Max and Photoshop, Certified by Autodesk and Adobe. He has experience as Designer, Simulation Specialist, Technology Services Coordinator, Simulation Technology Sector Coordinator and is currently Executive Manager at SENAI Technology Center Automation and Simulation and Vice-director of SENAI College.

Cristina Jasbinschek Haguenauer

Holds a Bachelor´s Degree in Civil Engineering from UERJ (1985), Master´s Degree in Engineering from PUC-RJ (1988) and Ph.D. in Science and Engineering at UFRJ (1997). Associate Professor at the UFRJ School of Communication; active in teaching, research and consultancy in the field of Information Technologies and Communication, focusing on Distance Education, Professional Development, Continuing Education, Hypermedia, Educational Games, Virtual Learning Environments, Information and Virtual Reality Portals. Coordinator of the Research Laboratory of Information Technologies and Communication - LATEC / UFRJ.

LOW COST LAPAROSCOPIC TRAINING PLATFORM: PRIMARY VALIDATION PROCESS

E.Perino[a], M. Sguanci[b], F. Mandolfino[c] , M. Minuto[d] G. Vercelli[e] M. Gaudina[f] , S. Marcutti[g], V. Rumolo[h], G. Marcocci[i], M. Frascio[l]

[a]DISC - Department of general surgery
[b]DISC - Department of general surgery
[c]DISC - Department of general surgery
[d]DISC - Department of general surgery
[e]DIBRIS – Department of Informatics, Bioengineering, Robotics and Systems Engineering
[f]DIBRIS – Department of Informatics, Bioengineering, Robotics and Systems Engineering
[g]DIBRIS – Department of Informatics, Bioengineering, Robotics and Systems Engineering
[h]DISC - Department of general surgery
[i]DISC - Department of general surgery
[l]DISC - Department of general surgery

[a]enrico.perino@yahoo.it [b]marcosguanci@yahoo.it, [c]fcmandolfino@gmail.com [d] micheleminuto@hotmail.com
[e] gianni.vercelli@unige.it [f]marco.gaudina@gmail.com [g]simar88@hotmail.it [h]valerio.rumolo@gmail.com
[i]dinasv@hotmail.it [l]mfrascio@unige.it

ABSTRACT

The use of simulation in laparoscopic surgery training appears to be qualitatively effective if supported by a suitable evaluation system.
The increasing demand of more complex laparoscopic simulators has inspired the creation of a 4d simulator which is a physical low-cost laparoscopic training platform that reproduces the tactile feedback (eLaparo4d) integrated with a software for virtual anatomical realistic scenarios (Unity3D V 4.1).
The aim of the present project is to show the validation process results of this system using two instruments: the face validity and the construct validity.
The face validity was used for an ergonomic analysis of the simulator, the construct to test the system's ability to differentiate expert users (experienced surgeons in laparoscopy) from non-experts (student without experience in laparoscopic surgery).
A sample of 20 students was selected, divided into 2 homogeneous groups with respect to the level of confidence with the use of video games, consolles, smartphones (this has been possible thanks to the use of a questionnaire, administered before the practical phase of training).
The groups participated in a training program based on 5 basic laparoscopic skills (laparoscopic focusing and navigation, hand – eye – coordination and grasp coordination). So, a second and third study sample was chosen, consisting of 20 post graduate students (intermediate group) and 20 experienced surgeons in laparoscopy; for theese groups was provided a training program identical to the previous group as well as their subdivision into 2 group.
We analyzed the results of the three samples obtained by comparing variables such as:

score
% of fullfillment
panality
time

At the same time, the students improvements has been monitorized, developing a customized learning curve for each user.
To evaluate the structural characteristics of the simulator a specific questionnaire has been used.
The results encouraged us. The simulator is ergonomically satisfactory and its structural features are adapted to the training. The system was able to differentiate the level of experience and also has therefore met the requirements of "construct validity".

Keywords: low cost simulation, face validity, construct validity, training, laerning curve

1. BACKGROUND

The use of simulation in laparoscopic surgery training appears to be qualitatively effective if supported by a suitable evaluation system.
The continually increasing demand of more complex

laparoscopic simulators has inspired the creation of a 4d simulator which is a physical low-cost laparoscopic training platform that reproduces the tactile feedback: eLaparo4d) integrated with a software for virtual anatomical realistic scenarios (Unity3D V 4.1).
The School of Medicine of Genoa and the Biomedical Engineering and robotic department (DIBRIS) have cooperated to create a low-cost model based on existing and brand new software.
Aim of this work is to describe the the platform validation results using two instruments: the face validity and the construct validity.

2. MATERIALS AND METHODS

This study validates eLaparo4D simulator: face and construct validity.

2.1 The simulator system

The system is based on a nodejs (htpp://www.nodjes.org) application server that manages the visualisation system, the communication with hardware interfaces and the database where users' data are stored.
The server technology is indeed a sort of data gateway between the several different elements, regardless they are hardware or software. The following figure (figure 1) shows how communication data are exchanged from the very low part of the system (Hardware Interfaces, bottom) to the user interface (HTML Client,top).

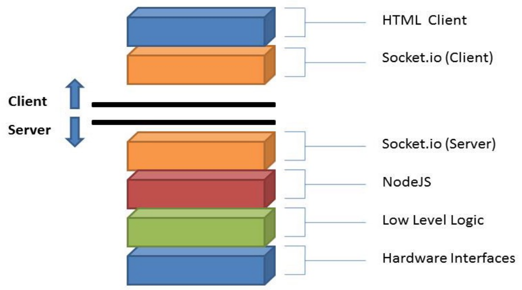


Figure 1: part of the system simulation

The user interface is a simple HTML5 web page running a Unity3D engine (htpp://unity3d.com) plugin. We run several performance tests to compare Unity3D and native WebGL, getting same results. We finally decided to adopt
Unity3D engine due to its rapid development time. WebGL is a great technology but still too young to allow us working on a powerful and robust framework. The use of web pages as the main user interface allows us to be more versatile and in the future will give us the possibility, thanks to HTML5 powerful characteristics, to easily share contents in a live way with other systems. An interesting feature is, for example, having the possibility to be guided by an external supervisor, who is monitoring the training phase, while data are quickly exchanged via internet.
As previously introduced, visual modelling is a very important aspect of the entire project.
A videolaparoscopic surgery simulator needs a detailed representation of the organs and the tissues inside of the human abdomen. The meshes included in eLaparo4D are developed in Blender 3D Modelling software (htpp://blender.org), and then imported in Unity3D, including textures and UV maps. Eventually, in Unity3D render shader materials are added to the raw meshes, to simulate the specific surface of each of the modelled tissues. In Figure 2, a screenshot of the current virtual environment is shown.

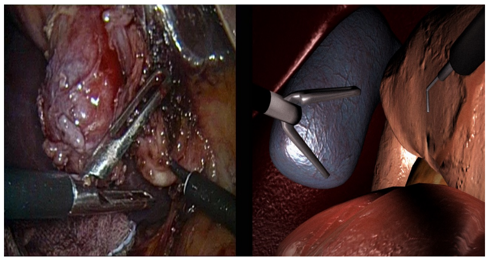


Figure 2: a screenshot from the current aspect of the virtual environment compared to a screenshot of the camera view of a real surgical operation.

As remarked by our colleagues of the Videolaparoscopy Unit of the Department of Clinical Surgery, highly specific training sessions are required to help the operator achieving a proper skill set. In an ideal scenario, medical students should have access to a complete simulator composed of several training scenes, as part of a modular and step-based training process. While the main components and controls of the simulator should be in common, each scene should focus on a very specific surgery operation, differentiating in: the zone and the organs physically manipulated (the target), the particular surgical maneuvers performed (the task), and the type of manipuli used (the means).Considering these remarks, we developed a dynamic parametric physical simulation approach, arbitrary applicable to the rendered meshes in every scene and able to avoid system overloads. Such an approach permits the creation of different scenes starting from the same set of models and interaction algorithms, easily supporting a step-based training. In detail, each 3D object in the scene carries a selectable 3 layer collider component, driving a vertex deformation script.

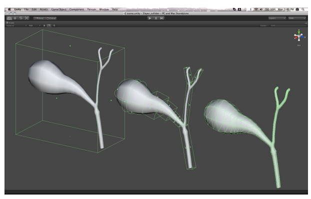


Figure 3: I.e of a collider layer for a gallbladder model

second one is a combination of simple shape colliders which cover, with good approximation, nearly all the volume of the object; the third is a precise mesh collider which exactly coincides with the vertex disposition of the object's mesh. In the foollowing figure (figure 3) is possible to see the 3 different collider layer for a gallbladder model.

2.2 Haptic Feedback

Haptic feedback is implemented thanks to the use of three Phantom Omni devices from Sensable (htpp://sensable.com).
The first two are used as manipuli (grasper, hook or scissors) and the third one is used to move the camera within the virtual abdomen, as it happens in a real scenario. The system generates a resultant force when the user puts a manipulus in contact with a mesh, according to the executed task. Phantom devices have been chosen because reasonably low cost although precise enough for the needed level of realism. Furthermore, their stylus-like shape will permit a complete merging of the devices with the physical environment reconstruction; in particular, each stylus will be easily connected to real manipuli. Thanks to an Arduino board connected to a vibrating motor we have also included a vibration feedback. Vibration is used to enhance the realism of operations like tissue shearing (hook) and cutting (scissors).

2.3 The primary validation process

A valid simulator measures what it is intended to measure.
There are a variety of aspects to validite; subjective approaches are the simplest.
In this sense, we have chosen 2 different kind of validation:

1. The Face Validity
2. The Construct Validity

Face validity usually is assessed informally by no experts and relates to the realism of the simulator; that is, does the simulator represent what it is supposed to represent.
This kind of validity relates to the realism of the simulator.
A questionnaire validation was created.
In this document 12 closed-ended questions were selected about the following topics:

ergonomics
structure
realism
tactile feedback
quality

For each question must be given a score according to the rating scale "Likert" (Highly inadequate, Insufficient, Sufficient, Good, very good).

Concurrent validity: is the extent to which the simulator, as an assessment tool, correlates with the "gold standard."
This testing can be achieved by evaluating two groups of subjects, with a different professional experience, with the simulator, comparing the performance scores. This necessitates establishing an objective structured assessment of technical skills (OSATS) evaluation by which the model or "gold standard" performance can be assessed reliably for comparison.(Max V. Wohlauer et al. , 2013)
About this, the simulator must be able to distinguish the experienced from inexperienced surgeons. This is best determined by testing a large number of surgeons with various degrees of training, experience, and frequency of performance of a specific surgical skill or procedure.
For competency assessment, the performance of an individual on a simulator should ideally predict, or at least correlate with, that individual's performance in the real environment of the operating room. As such, a valid and reliable measure of operating-room performance must be established. This allows differentiation between surgeons assumed to be clinically competent (experienced or expert clinicians) and noncompetent (junior or inexperienced residents). These evaluations are much simpler to perform when a specific task like Hand-eye coordination and laparoscopic navigation and focusing.

2.4 Construct validity program

We have involved a total of 60 subjects to the validation program. This entire group is divided into 3 categories: cluster A is composed by 20 students of Medical and Pharmaceutic Sciences of the University of Genoa without any experience in laparoscopic surgery, cluster B by 20 general surgery residents with moderate laparoscopic experience and cluster C by 20 surgeons with high experience in laparoscopic surgery.

2.5 Selection criteria

Selection criteria and inclusion of " Intermediate " and " Expert " pattern: we have chosen the number of laparoscopic surgical procedure as first operator as parameter.

Group A: novices (NO experience in laparoscopic surgery)

Group B: 20 intermediate (at least 20 total laparoscopic operations in the last year)

Group C: 20 experts (at least 50 laparoscopic operations as first surgeon in the last year and at least 100 laparoscopic operations in the last 3 years)

Validation process currency:

The validation process has been organized in three rotations of 5 workdays (from Monday to Friday). We have chosen this method to avoid the possible bias due to a excessive and unnatural number of participants.

2.6 Methodology

For the platform validation, 5 tasks have been selected. These tasks are focused to enhance the most basic skills.

Acquisition of basic skills: exercises related to the acquisition of tasks which allow students to reach basic gestures competences. They could practice using probes that simulate the haptic feedback according to the kind of action.

The 5 selected tasks are:

1. *laparoscopic - focusing - navigation*: This task aims to evaluate the ability to navigate a laparoscopic camera with a 30º optic. This is done by measuring the ability to identify 14 different targets placed at different sites
   Two different exercises were chosen:

   Exercise 1: the student, working with a 30° ptic, have to focus different solid targets in a static scenario. This task evaluates the macro – focusing.

   Exercise 2: the student working with a 30° ptic, have to focus a lot of hidden micro- targets, placed in different areas of the scenario.

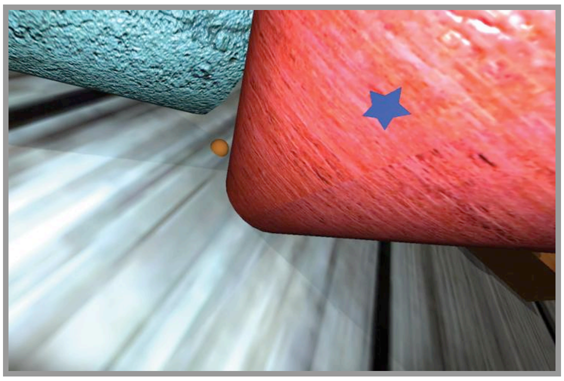


Figure 4: a screenshot of task 2

2. *hand – eye – coordination (HEC):* This task aims to evaluate the ability to work with the non-dominant and dominat hand.
   The camera is static.
   Two different exercise were chosen:

   Exercise 3: the student have to touch a defined point in an "circular target" with the left and right instrument simultaneously

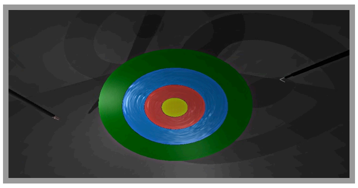


Figure 5: a screenshot of task 3

Exercise 4: the student have to touch a lot of spheres that appear sequentially and in random positions. There is a time limit to center and touch each sphere with the right and left hand. In this task, the camera is static.

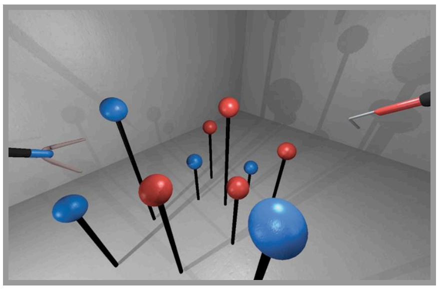


Figure 6: a screenshot of task 4

Exercise 5: the student have to grasp 3 objects and to put these in a selected form.

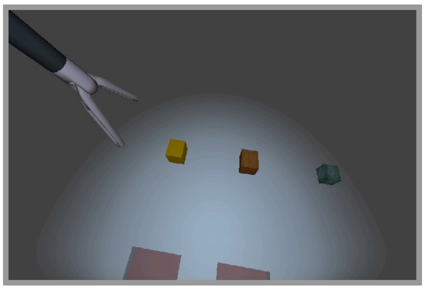


Figure 7: a screenshot of task 5

For each of these tasks, a certain number of metrics have been automatically recorded.
Metrics are defined as follows:

- *Total time.* Time that the user needs to accomplish the task
- *Fulfillment.* Percentage of partial tasks done within the established time.
- *Penality:* number of penality about each task.
- *Score: task's* score
- *Coordination*
- *Accurancy*

Which metrics are recorded for each task is shown in Table 1.

Task	Description	Metrics
Navigation	ability to navigate a laparoscopic camera with a 30º optic	Fulfillment (%) Total time (s) Score penality
Navigation and focusing	the student have to focus different solid targets in a static scenario	Fulfillment (%) Total time (s) Score penality
Coordination (HEC) **1st exercise**	the student have to touch a defined point in an "circular target"	Fulfillment (%) Total time (s) Score Penality Coordination Accurancy
Coordination (HEC) **2nd exercise and 3rd exercise**	the student have to touch a lot of spheres that appear sequentially and in random positions. The student have to grasp 3 objects	Fulfillment (%) Total time (s) Score penality

Table 1 "Metrics and Tasks" in the Construct Validity

In particular we have guaranteed assistance to all participants divided in morning/afternoon turnations: 5 days (one week) for each group to permit the best compliance as possible to every subject involved.
Each group has been divided into two smaller homogeneous groups based on the questionnaire about the personal level of confidence in the use of videogames, virtual platforms, etc:

- Subgroup A1, B1, C1: little/absolutely not confident
- Subgroup A2, B2, C2: confident/very confident

The questionnaire has been administered to each subject before the beginning the test.
To guarantee a correct statistic analysis, we have adopted a closed testing system where the subjects had a limited number of attempts (an open testing system might show bias like weakness, time delays or methodological limits).
When finished the test, the expert group has been completed the "Face validity" questionnaire to explore the ergonomic adequacy of the system.
Each subject had max two attempts for every examination (2 attempts for exercise 1 level easy, 2 attempts for exercise 1 level intermediate, 2 attempts for exercise 1 level difficult).
Each participant have finalized 6 examinations for a total of 30 at the end of the process.

2.7 Setting

The setting has been the same during all the parts of the process. To increase the subject 's perception of the scenario in which it will operate, every subject had to dress surgical gloves, coat, mask and headdress.
Similarly, the platform has been prepared with the virtual utilities present on the surgical field to make the handpieces movements more adherent to reality.

2.8 Data analysis

We have collected for each group several variables about the level of confidence with virtual platforms, and data about execution time, score, penalty where applicable, motion accuracy where applicable, motion coordination where applicable.

2.9 Face validity questionnaire

All Expert and intermediate subjects were requested to fill a Face validity Questionnaire, referred to characteristics of the eLaparo4D simulator (11 questions).
The questions had to be answered in a 5-point Likert Scale:

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

2.10 Statistical analysis

Statistical analysis was performed using Excel software and SPSS.
Data are expressed in terms of mean $\pm$ standard deviation. The data from the Novice, intermediate and expert group are compared with the Mann-Whitney U test; about this, differences were considered significant at $P \leq 0.05$.
In this first validation program, we decided to use also the Cronbach's Alpha Test to measure the "Reliability" of the internal consistency of the simulator.

3. RESULTS AND DISCUSSION

3.1 Results

Face Validity

The questionnaire analysis has showen the following data:

Experts opinion:

- A real confidence in the ability of this device to allow an accurate performance measurement (4 $\pm$ 0,81)
- A great degree of realism in the management of the optic in the virtual scenario (3,9 $\pm$ 0,87)
- An excellent realism of targets (4,1 $\pm$ 0,56)
- An excellent degree of realism of the positioning of the instruments (3,9 $\pm$ 0,56)
- An high quality of the images (4 $\pm$ 0,81)
- A great Haptic feedback (sensation) (3,3 $\pm$ 0,67) Excellent degree of usefulness of simulation in reference to 'acquisition of skills, "basic" hand-eye coordination (4,4 $\pm$ 0,69)

Intermediate opinion:

- An excellent degree of realism in the management of the 30° optic
- A great quality of scenario
- A very good capability of the simulator to teach gestures and action
- The devices position show a good degree of realism

Characteristics	Experts (n=12)
Realism	3,6 $\pm$ 0,84
Degree of realism of the positioning of the instruments	3,9 $\pm$ 0,56
quality of the images	4 $\pm$ 0,81
Realism of targets	4,1 $\pm$ 0,56
Degree of "realism" movement	3,4 $\pm$ 0,96
Haptic feedback (sensation)	3,3 $\pm$ 0,67
Degree of realism in the management of the optic	3,9 $\pm$ 0,87
Degree of utility of the haptic feedback	3,5 $\pm$ 0,70
Degree of usefulness of the simulator about acquisition of "basic" skill (hand-eye coordination)	4,4 $\pm$ 0,69
Degree of usefulness of the simulation about acquisition of skills with non-dominant hand	3,9 $\pm$ 0,63
Degree of overall usefulness of the simulator about acquisition of basic laparoscopic techniques	3,8 $\pm$ 1,03
Confidence in the ability of this device to allow an accurate performance measurement	4 $\pm$ 0,81

Table 2 Face Validity (expert) Questionnaire resultsConstruct validity
Construct validity

About construct validity, there were significant differences between the experienced group (Expert), intermediate group and non-experienced group (Novice) in several tasks.
At least one of the metrics of each task presents significant differences.
The tasks 3, 4 and 5 (about coordination) discriminates between experts and novices in all the evaluated parameters.
There were significant differences between the experienced group and non-experienced group in the task 3, in terms of "total time", "score", "coordination" and "accurancy"; this task shows a better executions accomplished by experts than the ones accomplished by novices.
The task 2, about navigation, shows a better percentage of fulfilment in favour of expert group (90/100% fulfillment).
Total time, shows significant differences in task 2,3,4,5.
There weren't significant differences between the experienced group and non-experienced group in the task 1.
As previously described in the methodology, metrics that are evaluated in all tasks are total time, fulfillment, score and penality.

3.2 Discussion

Surgery simulators are important in the training process of surgeons in laparoscopic surgery.
A validation of simulators is always necessary in order to determine their capacity for surgeons training although as far as we know, there is not any mandatory validation strategy (6).
The Face validity and the Construct validity are two important steps of this process.
The Construct validity determines the capacity of the simulator to punctuate the execution according to the level of experience of the subject who is accomplishing the task.
So, a construct validated simulator will be able to distinguish between surgeons with different levels of experience in laparoscopic surgery.
The Face Validity is just based on the opinion and experience of surgeons and cannot be used in every case to define the validity of a new simulator.
As the face validity is very subjective, it is usually used at the first stages of validation. (Gallagher AG et al., 2003)
The aim of this work is to validate "eLaparo4D" simulator accomplishing a face and construct validity in order to determine whether it is adequate for basic skills training.
Expert group and intermediate group agree with usefulness of the simulator in reference to 'acquisition of skills, "basic" hand-eye coordination and confidence in the ability of this device to allow an accurate performance measurement.
The realism of the targets and the scenario is a great characteristic, like the position of the instruments.
The haptic feedback is considered by expert as acceptable, most important elements in this kind of virtual simulators.
The results of the study show that there are significant differences between the execution of tasks by novices and by experts and intermediates for the evaluated metrics.
Among all, navigation and coordination tasks show the clearer results.
The task 1 about navigation not present any difference

between the different levels of experience: this result can be due to the fact that novices have experience virtual games and in video camera use.
In task 3,4 and 5 the difference between novices and experts is evident; total time, score and penalty are in favour of experts.
In task 3, the expert group showed a better coordination and accurancy than novices.
The "total time" are evaluated in all tasks because is an important variable; novices need more time than experts to finish the tasks in all cases and experts fulfil the majority of the tasks and more efficiently than novices.
To evaluate the reliability, we decided to performe the correlation index to the metrics: total time and score.
The results of this test show an high value of correlation for the total time and a lower value for the score.
From these values, the Split half Methodology was applied, to calculate the coefficient of Reliability; we applied the Spearman-Brown correction and the final result was: 0.91
This conclusion leads us to the point that eLaparod4D could be used in training programs as an assessment tool.

ACKNOWLEDGMENTS

We would like to thank G. Vercelli, L. Lagomarsino, E. Bellanti and S. Marcutti of Dept. of Informatics, Bioengineering, Robotics and Systems Engineering for their precious collaboration.
Thanks to all of our collaborators.

REFERENCES

1. htpp://www.nodjes.org
2. htpp://unity3d.com
3. htpp://sensable.com
4. htpp://blender.org
5. Max V. Wohlauer, Brian George, Peter F. Lawrence, Carla M. Pugh, Erik G. Van Eaton, Debra DaRosa. 2013. Review of Influential Articles in Surgical Education: 2002–2012. Journal of Graduate Medical Education 5:2, 219-226.
6. Gallagher AG, Ritter Em, Satava RM (2003) Fundamental principles of validation, and realiability: rigorous science for the assessment of surgical education and training. Surg Endosc 17:1525– 1529
7. Molina CR, de Win G, Ritter O, Keckstein J, Miserez M, Campo R (2008) Feasibility and construct validity of a novel laparoscopic skills testing and training model. Gynecol Surg 5(4): 281–290

MODELLING AND SIMULATING THE ASSEMBLY LINE SUPPLY BY TUGGER TRAINS

T. Staab[(a)], M. Röschinger[(b)], M. Dewitz[(c)], W. A. Günthner[(d)]

Institute for Materials Handling, Material Flow, Logistics – Technische Universität München

[(a)]staab@fml.mw.tum.de, [(b)]roeschinger@fml.mw.tum.de, [(c)]dewitz@fml.mw.tum.de, [(d)]kontakt@fml.mw.tum.de

ABSTRACT

Tugger trains are an efficient and flexible material supply concept especially for mixed-model assembly lines. However, the performance and efficiency of a tugger train system are influenced by many external factors (e.g. material throughput) and internal interdependencies (e.g. cycle times, overtaking or stopping) making a discrete-event simulation necessary to prove the feasibility of the planned systems. We present the results of a simulation study carried out on behalf of the BMW Group. For this, we used a generic simulation model which was adapted to the unique requirements and elements of the planned system. We determined the security of supply and level of service and validated tugger train routes and schedules. The congestion on roads and intersections, space for overtaking and the number of trains passing and supplying a point of need were found to be the main influencing factors.

Keywords: tugger train, in-plant milk-run, mixed-model assembly line, interdependencies of vehicles

1. INTRODUCTION

In practice, tugger trains (TT) are a very common concept for the in-plant transport of materials. As the trend towards individual customer products continues, a greater number of different products have to be produced in the same production facilities, thus it follows that more different materials have to be supplied to the different points of need. Especially, but not exclusively, manufacturing companies with a mixed-model assembly line concept find themselves confronted with the situation that this greater number of different materials cannot be supplied within the restricted space of the production facilities with the current safety stock levels and lead times (Emde and Boysen 2012). Therefore, stock levels must be reduced, and this hand-in-hand with smaller lot sizes and containers and a high-frequency provision of materials.

Tugger trains (sometimes in-plant milk-run concepts are used synonymously) are an approach to fulfil those needs. So-called TT, usually consisting of a manually-operated industrial truck and several trailers, circle on predefined routes through the production area and are loaded with whatever material is needed at the points of need assigned to this route. Often these TT are operated according to a fixed timetable similar to public transportation (Brungs 2012; Günthner et al. 2012; Kilic, Durmusoglu and Baskak 2012). The points of need are passed on each TT tour, so the recurrence period is much shorter than with typical direct transport concepts using a forklift truck, for example. As different materials are transported on the same tour, even small batches and containers can be supplied efficiently (Baudin 2004). Those are just some of the reasons why the BMW Group has decided to introduce standardised TT systems in all of its vehicle plants (Arlt 2012). Furthermore, central logistic areas for storing and sequencing the material as well as loading the TT were built close to the production areas.

While in an early planning phase, analytical models were sufficient to estimate, for example, the required number of employees and TTs, a more detailed investigation was necessary to prove the feasibility of the new logistic processes prior to their "going live". External factors such as the material requirements or the location of the points of need as well as internal interdependencies between IT processes (e.g. call-off processing), TTs and other vehicles were seen as important factors influencing the performance and efficiency of the TT system. For this reason, a discrete-event simulation study was carried out on behalf of the BMW Group. The study's main aspects and results are to be presented in this paper.

2. SCOPE AND STRUCTURE OF THE PAPER

This chapter provides basic information concerning the design and control strategies for TT systems, as well as a brief literature review on available methods for the planning and dimensioning of TT systems. Section 2.3. describes the procedure during the simulation study and the structure of this paper.

2.1. TT systems for material delivery

In practice, various concepts for TT systems exists which differ considerably with respect to size, process design and material equipment. However, some basic elements most TT systems have in common are shown in Figure 1. Furthermore, referring to (Günthner et al.

2012) and (Martini, Stache and Trenker 2014), typical design variants for each element are displayed.

Starting from a material source close to the production site, material is either stored or buffered. A so-called material call-off represents a demand for a specific material at a specific point of need at a specific time. To satisfy this demand, the tour on which the material call-off will be transported must be determined. While in flexible TT systems, every tour serves different points of need and tour start-times are dynamically planned, most industrial applications are operated according to fixed transportation routes and timetables. All material call-offs assigned to a tour are then taken from the material source and loaded onto the TT. This can be done either directly (e.g. by taking the TT through the warehouse), or the load is buffered within a separate station and is loaded onto the TT there. Afterwards, the delivery itself starts. For this, the driver must pass at a minimum all the points of need of the assigned material call-offs using a shortest path navigation. However, additional tasks, such as empties handling or replenishment control tasks (e.g. collecting kanban cards), could require a static routing strategy.

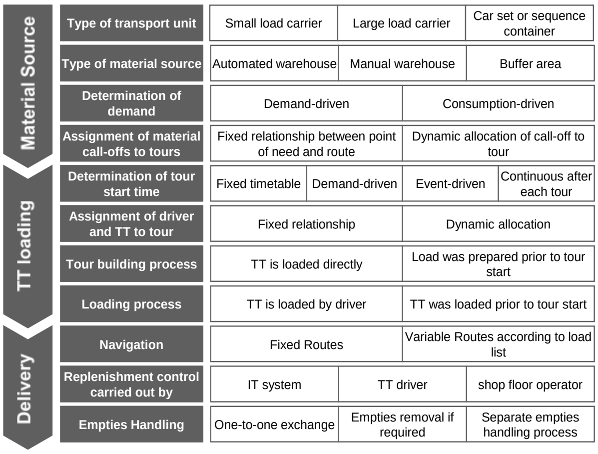


Figure 1: Basic Elements And Design Variants Of TT Systems

These design leeways, combined with many interdependencies, result in a highly complex TT system and a difficult planning task. In addition, TTs share various resources (e.g. roads, intersections, loading areas) which leads to an even greater complexity (Staab, Galka and Klenk 2013a) that cannot be analysed using analytical models, making a discrete-event simulation necessary.

2.2. Brief literature review

Most available literature on TT systems, such as (Gyulai et al 2013), (Vaidyanathan et al. 1999) and (Emde and Boysen 2011), focus on finding an optimal route using adapted vehicle-routing problems (VRP). (Dewitz, Günthner and Arlt 2014) describe a model for calculating cycle and departure times in order to generate smoothed TT schedules. Stochastic influences, such as demand fluctuations or road blockages, as well as interdependencies between different system elements, are not taken into account.

Therefore, companies, especially in the automotive industry, use discrete-event simulation to support the planning of intralogistics processes in general, and TT systems in particular (Günthner et al. 2012). (Costa et al. 2008) and (Wiegel et al. 2013) present models and results of case studies for specific TT systems. Generic modelling approaches are presented in (Mayer and Pöge 2010), (Dreher, Nürnberger and Kulus 2009), (Roth 2012) and (Staab, Klenk and Günthner-2013b). (Mayer and Pöge 2010) introduces the so-called *VDA Automotive Library* for *Plant Simulation*, a modelling kit of currently 14 libraries with standardised modules for production systems in the automotive industry, including TT systems.

Alternatively, with the *MALAGA* commercial software product (see Dreher, Nürnberger and Kulus 2009; Roth 2012), planning and optimising TT systems is possible, but these are subject to the same restrictions of the analytical models mentioned before. An interface to Plant Simulation called *ZIP Massimo* exists to validate the results.

(Staab, Klenk and Günthner 2013b) describe an alternative approach. The generic simulation model focuses on modelling TT systems and traffic situations, rather than production systems in general. The simulation model thereby requires less standard components from the framework and can be adjusted to the unique requirements and aims of the simulation study.

2.3. Methodology and structure of the paper

In this paper, the main modelling aspects and results of a simulation study on a TT system will be presented for which the same generic modelling kit described in (Staab, Klenk and Günthner 2013b) was used.

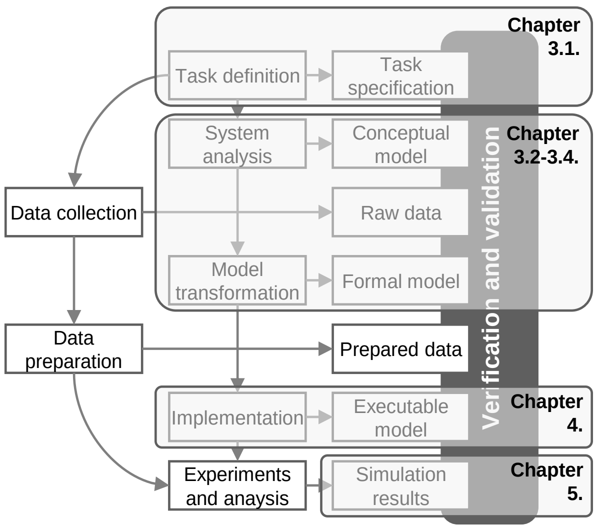


Figure 2: Procedure During The Simulation Study And Structure Of The Paper According To (VDI-Richtlinie 3633 Blatt 1 2014)

Taking into account the complexity and size of the modelled system, a structured procedure during the simulation study was essential. For this, the procedure model for a simulation according to (VDI-Richtlinie 3633 Blatt 1 2014) was used which also formed the basis for the structure of this paper (see Figure 2). The tasks and aims of the simulation study are pointed out in chapter 3.1. As part of the systems analysis, chapter 3.2.-3.4. focuses on the key information and description of the modelled system. Chapter 4 describes the executable simulation model and the implementation of specific elements which were unique to this simulation study. Further information can also be found in (Staab, Klenk and Günthner 2013b). The main results of the simulation study are presented in Chapter 5.

3. MAIN ASPECTS OF THE CONSIDERED SYSTEM

This chapter contains the description of the TT system which is investigated in the research project. The deep understanding of the system and its processes is essential, as it serves as the basis for the subsequent modelling process which is also presented in this chapter in respect of its main aspects and challenges.

3.1. Key figures for characterising the system

Due to the great complexity of the system, the discrete-event simulation was executed in order to support the current planning stage. Different key figures, which characterise the system, were defined and determined in simulation runs. The key figures can be assigned to the following categories and questions:

- Security of supply: Can the material be provided at the assembly line at the scheduled time?
- Level of service: Can all the material be provided with the planned TT routes and scheduled tours?
- Employee requirements: How many employees are necessary to handle the scheduled TT tours?
- Space requirements: How much space is necessary for departing and returning the TT in the train station area?
- Volume of traffic: How do interdependencies with other system elements influence the TT tours?

In order to understand the choice and relevance of the key indicators, the system is described closer in the next sections. Initially, a short overview of the overall process, which is visualised in Figure 3, is given. On this basis, the procedures of the IT control systems are described. Finally, the driving behaviour of TT and the corresponding restrictions are explained.

3.2. Overview and key information

Based on material requirements along the assembly lines, material call-offs are generated and sent to the central IT control system. Here, the material call-offs are collected and, according to a static timetable, assigned to a specific TT tour. At a pre-determined point in time, which refers to a tour's scheduled departure time, the loading process begins. All the material thereby assigned to the tour is loaded onto a train, with each trailer carrying a maximum of four frames each.

In this context, basically two processes have to be distinguished. On the one hand, components can be loaded manually onto the frames in a picking warehouse, whereby the material on one frame is of the same type and intended for one specific delivery point along the assembly line. On the other hand, there is an automatic process, in which the train's frames are loaded with containers for different delivery points. The containers are stored in an automatic small parts warehouse and automatically brought onto the frames by using different conveyor systems.

Manually-loaded TTs are provided on defined departure tracks in the train station area punctually before the scheduled departure time. As soon as this time is reached, a driver takes the train and leaves the train station area. Automatically-loaded TTs, however, need to pick up the loaded frames before leaving the train station area. The train which, at this moment, consists of four trailers with each one carrying an empty frame, drives into an automatic frame-converter device. Therein, empty frames are removed from the trailers and full frames, which are provided by a conveyor system, are moved onto the trailers. Afterwards, the TT leaves the device and finally, at the scheduled departure time, the train station area.

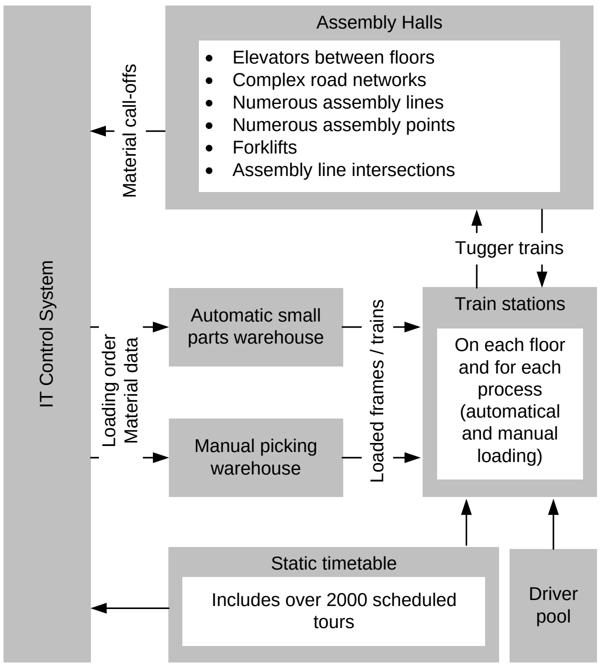


Figure 3: Overview Of The Considered TT System

All the TTs run on several determined routes through the assembly halls where they stop at the delivery points for which they are transporting materials. In the case of manually-loaded trains, full frames are exchanged with empty frames at the delivery point, whereas in the case of automatically-loaded trains, containers are exchanged. After delivering all the contained materials, the TTs return to the train station, where they stand by for the next tour. So, in the course of one day, over 2000 tours supply about 1000 assembly points.

3.3. Call-off processing in the IT control system

The main task of the IT control system is the processing of material call-offs. These are generated in different ways along the assembly line, which is why the three types of call-offs represented in the following sections have to be differentiated.

3.3.1. Call-offs for sequenced components

At each individual assembly point, a defined component, which belongs to a certain material type but exists in several variants, is added to the product. Therefore, all the variants of a component, which are to be assembled within the next assembly cycles, must be available at each assembly point, namely in the sequence they are installed. In order to achieve this, corresponding material call-offs are generated at specific call-off points along the assembly lines. These points are located at a pre-determined distance from the points where the material is needed for installation. When defining the distance between assigned call-off and assembly points, sufficient time for delivering the material in time is considered and ensured.

For a pre-determined period of time, the IT control system collects all the call-offs for one individual assembly point. It then looks for a TT route which passes this point. As there are several tours within one route, the next step is to select an appropriate tour from the timetable. The scheduled time of each tour, at which the TT returns to the train station, is considered in this. Only if this time is before the time at which the material is needed at the assembly line, and the tour's planned loading and departure time have not yet elapsed, is the tour viable. The component needed earliest is thereby decisive. Finally, the last but one tour, which fulfils the described requirements, is chosen. This is because, in the next step, it might be that the capacity needed for delivering all the requested material exceeds the capacity provided by one TT. In this case, the material is assigned to the latest possible tour. This is, in other words, the last tour which returns to the train station before the point in time at which the material is needed. In this context, it has to be taken into account that the materials for other assembly points also passed by the route might already be attached to the selected tour. Furthermore, a TT contains a maximum of four frames, whereby each one is loaded with material for one specific assembly point. So, if it is not possible to assign the material to a scheduled tour, the IT control system initialises an additional special tour.

After a tour is planned, the data is forwarded to the picking warehouse where the frames are loaded with the required variants of the components. Due to pre-determined time management, it can be ensured that the loaded TT is ready in the train station at the scheduled departure time of the tour at the latest.

3.3.2. Demand-driven automated call-offs for containers

As mentioned above, in addition to the manual loading process, there is also an automatic loading process in which containers stored in an automatic small-parts warehouse are automatically conveyed onto the frames. The corresponding material call-offs for the containers are generated at specific points along the assembly line. Each of these points is located at a defined distance from the material's assembly point as already described above. If the product which passes the call-off point requires the material at the assigned assembly point, the stock of the respective material is proactively reduced by the required number of components. When, as a result, the defined minimum stock falls below a pre-determined value, a container call-off is generated.

The further planning corresponds largely to the already-specified methodology (see 3.3.1.). Thus, the container is booked onto the tour passing the assembly point and is the second to last tour which guarantees a punctual delivery. At a pre-determined time, referring to a tour's scheduled departure time, the tour is closed. Thus, no more material can be assigned onto the tour and the removal of the already attached containers from the automatic small parts warehouse is initiated. Whilst loading the frames, the sequence of unloading the containers is considered. This means that the storage shelves of the frames are filled, beginning with the containers which are removed first at a delivery point. Thus, the frames are loaded and unloaded on different sides.

3.3.3. Consumption-driven Kanban call-offs for containers

Not all containers are called off automatically as described in the last section, there is a kanban-based method, too. Nevertheless, the processing of the call-offs does not differ significantly, other than that the kanban call-off is generated directly at the assembly point. A sign there indicates that a container has run empty. Afterwards, the call-off is generated by a passing TT's driver. The IT control system then looks for when the next tour is leaving, which is not already closed for loading, and assigns the required container onto this tour.

3.4. Vehicle's driving behaviour and restrictions

After a TT leaves the train station area, it goes into the assembly halls. The TTs can move between the floors using a vehicle elevator. Coming from a train station, a TT always follows the pre-determined route, to which the tour is assigned, across the assembly hall.

On its way along the assembly lines, a TT stops at the assembly points where material has been loaded onto the frames. An unloading TT standing at an assembly point can be overtaken by another TT whose next destination is not the same assembly point. However, in the case of one-way roads along the assembly lines, this is only possible if the road is wide enough. As this is not always given, corresponding restrictions referring ranges of road widths are stated in a traffic concept. Furthermore, the admissibility of overtaking depends on the type of the TT, above all in terms of its trailer´s width. For example, a TT transporting containers must overtake all other TT on medium and wide roads whereas a TT transporting sequenced components must only overtake on wide roads. In case of roads with oncoming traffic the same restrictions are valid. Additionally, a TT´s driver must assure that no oncoming train is hindered before overtaking.

Besides TT other vehicles also move around in the assembly halls. These vehicles, e.g. forklifts, deliver large components and containers, and present obstacles for the TT as they move more slowly and cannot be overtaken.

According to the arrangement of the assembly lines, the road networks include a few dead ends where TTs have to turn around. This represents one particularity of the road networks. Another one is the existence of numerous intersections due to the roads having been designed along mainly parallel assembly lines flowing into orthogonally-arranged main roads. Hence, there are intersections with up to four adjoining roads and therefore the definition of the rights of way becomes inevitable. These definitions are shown in Figure 4 and state that a TT coming from a road along an assembly line has priority when turning onto the main road. This is because at the end of a few of the roads along the assembly lines, there are crossing gates which close according to the assembly cycles. Thus, it can be ensured that no TTs block assembly line crossings and the material flow of the products which are conveyed on a parallel running line. For the same reason, TTs intending to turn from the main road onto a road along an assembly line have secondary priority, providing there is enough space behind a crossing gate. The last priority is assigned to TTs moving straight on the main road. Apart from the priority rules, there is the regulation that, if the intended turning directions allow turning without collision, more than one TT may turn at the same moment.

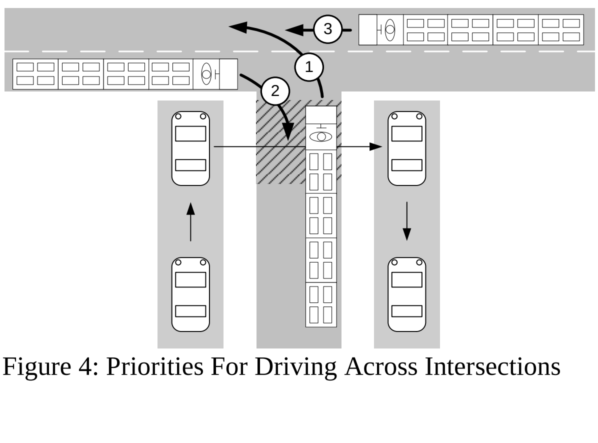


Figure 4: Priorities For Driving Across Intersections

The restrictions described for overtaking and turning in intersections, in combination with further interdependencies between TTs and other vehicles, result in a dynamic, complex and unpredictable system status (i.e. traffic jams) and affect the scheduled duration of a tour. Amongst other things, these aspects are examined by a dynamic simulation of the presented TT system. For this purpose, the system was reproduced and implemented in a simulation model which is described in the next chapter.

4. IMPLEMENTATION OF THE SIMULATION MODEL

The simulation model was implemented using the discrete-event simulation software, *Plant Simulation*, whose use is widespread within the area of production and logistics. The software offers various customisable modules, i.e. roads, warehouses, working stations and vehicles. The control of information and material flows is realised by procedures programmed by the user and assigned to a specific event (i.e. reaching a defined time or a vehicle passing a pre-determined point).

The subsequent sections deal with a closer description of the simulation model, focussing on the model's level of detail, as well as its basic structure. Moreover, main challenges and adequate solution proposals are presented, in order to inform readers dealing with related issues.

4.1. Basic structure and processes of the simulation model

The simulation model consists of different networks which are arranged in two hierarchy levels. At the top level, the IT control system is modelled in order to generate and process material call-offs which is why various input data is integrated into this network. Two examples for the required input data are a timetable including all the tours and their corresponding scheduled times, as well as a quantity structure of parts containing data for each material, such as container capacities, route assignment, parts per product, assembly point and the likelihood of installation into a product. On the basis of the latter, a procedure monitors and adjusts the material stock and demand for each material and assembly point and, if necessary, generates a material call-off. As the material flow of products along the assembly lines is not modelled, the procedure is executed at intervals of the assembly cycles when material is used. The further processing of material call-offs is implemented according to the described IT control system (see 3.4.) and realised by several procedures accessing various tables and variables.

After the planning of a tour is completed, a procedure initialises the provision of a TT in one of the train station networks depending upon which floor the route runs. The generated object thereby receives all the necessary information, such as contained material, delivery points, scheduled times and route. The loading of the TT is not simulated, but respected in the form of time restrictions. At the scheduled departure time, the

TT leaves the train station network and moves along its route into one of the assembly halls.

In order to facilitate the implementation process, as well as the understanding of the simulation model, real layouts are deposited in the background of each network. The essential processes in the assembly hall networks are surveyed in the following explanations.

4.2. Main challenges and solution proposals

In conclusion of the chapters 2 and 3 the high degree of complexity of TT systems can be stated. In order to address this fact, a main challenge consisted in implementing a transparent and comprehensible simulation model which serves as a basis for future projects. Therefore, typical elements of TT systems are implemented as stand-alone and general components which can easily be parametrised. However, there are a few elements of a TT system which must be implemented according to specific requirements of a particular use case. The provided simulation model gives a clue how these elements can efficiently be implemented and combined with the general components.

In this context, apart from the detailed implementation of the IT control, the greatest challenges consisted in the modelling of the vehicles' driving behaviour as there are various interdependencies to be considered. The following sections therefore highlight the realisation of navigation and overtaking processes, as well as the consideration of interdependencies between TTs and forklifts in the simulation model.

4.2.1. Navigation to delivery points along routes

The navigation of TTs along their routes within the modelled road networks is based upon the sequential arrangement of intersections whereby each intersection, which represents an instance of the according network class, automatically determines its direct successive intersections when starting a simulation run. Additionally, the sequence of intersections, which must be passed through, is made available in a table for each route. Hence, any road networks can be modelled using the provided intersection element.

As soon as a TT arrives at one of an intersection's maximum of four accesses, a procedure designates the intersection - by checking the above-mentioned table - which the TT must pass through next on its way along its route. For this purpose, each TT carries the information on which intersection is just now being passed through. As it is possible to pass through the same intersection back-to-back (i.e. in case of dead ends), the TT does not carry the explicit identification of the intersection, but a pointer to the corresponding row in the table. Hence, the procedure checks the entry in the next row and routes the TT to the equivalent exit of the intersection, whereby the above mentioned priority rules are considered (see 3.5.). Furthermore, the pointer is updated so that the described process reruns over and over in the coming intersections until the TT finally returns to the train station.

The navigation of TTs not only involves driving along determined routes, but also stopping at delivery points for which material is transported. This is why the sequence of delivery points is documented in a table for each route. After generating a TT in the train station, a procedure identifies the first delivery point to be approached along the corresponding route. This is done by comparing the list of delivery points contained in the TT object with the content of the above-mentioned table. The name of the first delivery point is then written into a corresponding attribute of the TT object.

Pursuant to the real assembly layout, each delivery point's position is considered in the simulation model. Hence, at such positions, a so-called sensor can be found on the respective object of the modelled road networks. When a TT passes a sensor, a procedure compares the name of the delivery point assigned to the sensor with the TT's delivery point attribute. If both match, the TT is stopped for a pre-determined time in line with the real duration for stopping, dismounting, unloading, as well as boarding and starting again. Afterwards, the next delivery point is detected and the attribute updated. Finally, the process just described is repeated until all the material is supplied.

Eventually it can be stated that the algorithms controlling a TT´s navigation to delivery points along defined routes operate independent of certain road networks and are therefore easily transferable on other simulation models.

4.2.2. Overtaking delivering TT

As already mentioned, a delivering TT may be overtaken taking into account a few restrictions. The applied simulation tool, however, does not allow overtaking actions on a road object. For this reason, a TT is transferred onto an object next to the road object as if supplying material at the just-reached delivery point as shown in Figure 5. Thereupon, a sensor is generated on the road object at a position which meets the TT's rear position. The front position of the TT correlates to the above-mentioned sensor at which the need for stopping at the assigned delivery point is examined.

As soon as another TT arrives at the sensor representing the rear position of a delivering TT, a procedure which verifies the possibility of overtaking is activated. The various restrictions described in section 3.4 are thereby checked. If overtaking is not allowed, i.e. because of a too narrow road section, the TT must wait until the delivering one continues running on its route. In this case, the waiting TT's explicit ID is written into a table where it is assigned to the corresponding delivery point. Once a TT completes the delivery process, it is transferred back onto the road object and the sensor representing its rear position is deleted. At the same time, the table is scanned for a waiting TT and its starting at the appropriate time initiated.

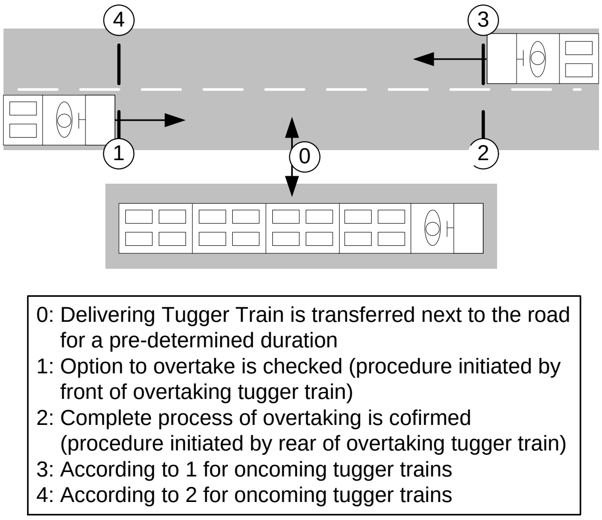


Figure 5: Sensor Positions For Delivering And Overtaking Processes

If, however, overtaking is possible, the TT does not stop but drives on and passes the delivering TT. In doing so, an entry stating that, at the moment, there is an overtaking in process along the delivery point, is made into the table. The entry is deleted as soon as the overtaking TT's rear has passed the sensor which represents the delivering TT's front positions. Consequently, before a delivering TT is transferred back onto the road object, a procedure, which uses the table, checks if the TT is being overtaken at that moment. Where necessary, it has to wait until the overtaking TT has completely passed by, or if the corresponding table entry has been deleted.

In the event of roads with oncoming traffic, the implemented overtaking process is analogically organised. Although, before overtaking, a procedure checks if there is oncoming traffic between the front and rear position of the delivering TT, it is not until this has been ascertained as not being the case, that the overtaking process can start, and the lane for oncoming traffic is locked at the front position of the delivering TT until the process is concluded. This is done by using sensors as shown on Figure 5, and tables as described above for one-way roads.

As described in this section, the process of overtaking delivering TT is implemented according to specific restrictions and configurations of the investigated system. Nevertheless, the basic idea and structure of the algorithms can be used for other simulation projects.

4.2.3. Consideration of forklifts and crossing gates

Forklifts move on defined road sections at various times at which no other vehicle can be on these sections, as forklifts need the complete road width in order to shunt. As there is no such thing as a timetable allowing the modelling of the forklift-runs in accordance with the real system, these are modelled in a simplified way. This means that at defined intervals, which are calculated on the basis of the forklift's appearance in the real system, the road sections concerned are locked. After an analogously calculated duration, the road sections are released and potentially waiting TTs moved on. Forklifts themselves are not modelled by means of a moving object, but visualised on the road sections.

In comparison with forklifts, the gates at the assembly line crossing are modelled more accurately as they close according to the assembly cycles. So, an object is inserted into the road networks corresponding to the real position of intersection gates. The status of the object (open or closed), as well as the colour (green or red), is set according to the assembly cycles. Arriving TTs trigger a procedure which checks the current status of the gate object and either allows the TT to move on, or stops it until the status changes.

As the elements for forklifts and crossing gates are implemented separately and parametrisable, they can easily be integrated in other simulation models. Moreover, the forklift element can also be applied for considering any periodically moving element interdepending with TTs.

5. RESULTS

The implemented simulation model offers various functionalities to record and calculate key figures which are shown above (see 3.1.). The key figures are summarised in several tables and variables. These are filled with procedures which are initiated by the respective events in the TT's process. For example, the actual delivery time at the assembly points is measured and compared with the planned delivery time.

The implemented functionalities do not only serve the model validation and verification, but also as a basis for evaluating the real system and deriving optimising measurements which are presented in the following chapter. In addition, they provide valuable information for a potentially needed economic evaluation of the system. For example, savings by reducing the number of employees and TTs could be compared with costs for additional unplanned transports to maintain the security of supply.

As the planning of the system presented in the paper at hand is still in progress, the numbers given in this section are anonymised simulation results.

5.1. Security of supply and level of service

Security of supply is defined as the share of material call-offs provided in time at the point of need. To guarantee a sufficient supply of the assembly line and stable production, call-offs have to be provided in time. As the time between the creation of a call-off and the provision thereof depends on dynamic effects, it is useful to plan additional buffer time.

In the simulation model described above, each call-off is given a target time. Once the TT has finished its tour, the time of supply of each call-off is compared to the target time.

To prove a security of supply of 100 percent is a central requirement for the simulation study. If any missing parts are detected, further analysis is necessary on how to optimise it to 100 percent. Even then, the real system might not reach that security of supply as there are additional hardly calculable influencing factors, e.g. mistakes, such as supply at the wrong point of need or the wrong picking in the warehouse. With a 100 percent security of supply, the buffer times planned in advance between call-off generation and the estimated time of supply are sufficient to compensate for any queues and disturbances occurring during the whole process, whereas each late call-off bears the risk of stopping the assembly line or causing a rework, as the missing part has to be assembled once the product has left the assembly line. In both cases, additional high costs would be incurred.

The level of service is another important performance figure for measuring the supply quality: it is defined as the share of call-offs provided by default processes (see 3.2 and 3.3). Typically, a default process is designed to cope with the estimated number of material call-offs. Due to system dynamics like call-off peaks or queues, this process design can sometimes be insufficient. To cover such cases, a back-up routine is defined using a substitute TT to deliver this material. Along with the supply time measurement, each activation of a back-up process is logged and evaluated in the simulation.

In the case of fluctuating material demands and low default process reserves, a level of service of less than 100 percent is likely to be seen. As each activation of the back-up process leads to an additional vehicle driving through the road networks, the next question would be whether the overall traffic is increased to such an extent that it affects the material supply. Again, the security of supply can be considered for that: if it reaches 100 percent for the default and back-up process, the back-up process itself has been reliably designed, too.

5.2. Employee requirements

Once the supply of the assembly line is ensured, the next aim is to use as few employees as possible. Thus, the employee requirement is defined as the number of drivers needed to cover all the tours. In the analysed system, drivers are organised into pools, whereby one pool corresponds to one train station and every driver in a pool is trained for each route starting at that station. If too few regular drivers are planned for a pool, the schedule may be delayed. On the other hand, too many drivers in a pool lower the average workload per driver and cost more.

To get the data needed for an evaluation of the employee requirements, the number of drivers available in each pool is logged and converted into a distribution graph (see Figure 6). If the pool size is not limited, each tour starts in time and the maximum value in the graph shows the number of active drivers needed at once. Each driver who is not available at the station, but currently on the way on a certain tour, is defined as active.

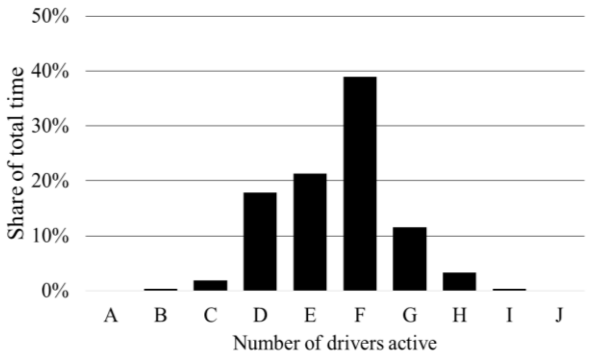


Figure 6: Distribution Of Employee Requirements Over Time

The frequency distribution serves as a useful basis for further optimisation. If the distribution is even quite near the upper boundary, the average workload per driver is low most of the time. In the visualised example, a maximum of J drivers are needed, but only for a very short time. In this case, the distribution shows how much time is covered by reducing the number of employees available: if H drivers are used, only a little time is “lost” in which the number of drivers is insufficiently low. When only using G drivers, a significantly higher amount of about 5% of all the time is not covered. The results on the schedule, as well as material supply, must then be additionally analysed.

If the employee requirement is not estimated using the simulation results as in Figure 6, but is adapted from the schedule only, the number of drivers needed would be underestimated. Although the schedule contains all the information on the start and planned return for each tour, and therefore allows the derivation of the time efficiency of each driver, this static calculation is based on the assumption that all the tours are executed exactly in time with any dynamic effects being factored out. By using simulation, these dynamic effects (e.g. queues and disturbances) are taken into account and increase the time needed per tour. In such cases, the driver’s availability at the station is decreased and more drivers are needed to compensate for possible delays in subsequent tours. As an alternative, the dynamic effects on the time needed per tour, e.g. traffic jams, could be reduced in different ways to increase the drivers’ availability.

5.3. Space requirements

Besides the employee requirements, train station design contains the calculation of space required for the handover between the picking warehouse and the road networks. Similar to the employees, the space requirement is defined as the number of handover places needed to cover a certain percentage of all tours. As the system described above is installed in an already existing plant, space is scarce. Too few handover places cause queues in the train station and can delay the departure of subsequent tours.

In the case of the space requirement, the number of handover places available is logged and converted into a frequency distribution graph, too.

As with the employee requirement, the maximum number of handover places should be installed if possible. On the other hand, if there is not enough space, a distribution, such as in Figure **6** 6, shows the effect when the available space is reduced.

5.4. Volume of traffic

Dynamic effects like queues and disturbances were identified as reasons for increased employee and space requirements. For a further analysis, the volume of traffic is evaluated to derive possible approaches to lower their influence.

The first performance figure needed is the number of vehicles per hour passing each road section. The higher this congestion measure, the higher the risk that disturbances will develop. Secondly, the waiting time per hour is calculated for each road section. This figure reveals the reasons for delays as shown in an analysis of the time needed per tour. In total, the time between departure and the arrival back at the station consists of three parts: driving, supply, and waiting due to disturbances. The driving time is constant as is the route and thus the distance per tour is fixed. Secondly, the time needed to supply the TT's load depends on the capacity efficiency and thus varies slightly. However, compared to driving and waiting, this time period is short. The duration of waiting caused by disturbances fluctuates and is therefore uncertain. When creating a schedule, this time is calculated using an overhead. If this overhead is insufficient on a certain tour, the planned time is exceeded and the schedule delayed.

In the simulation, each road section is able to detect passing trains. This information is collected after each experiment for further analysis. In addition, as soon as waiting is caused, each vehicle affected is logged, including its position, as well as the duration of waiting. For this, procedures initiated by all the sources are used for the waiting in the modelled system, e.g. intersections, supply processes and vehicle elevators.

For a visualisation and parallel evaluation of the volume of traffic, road sections can be coloured. The darker the grey, the higher the value of the represented performance figure. Figure **7** shows a section of the road networks where a high number of vehicles pass and sources of waiting occur.The right vertical road is the main transit section, which explains the high number of passing vehicles. Regarding waiting, the number of waiting vehicles is only one part of the analysis. Some sections in Figure **7** show a high number of stops, but the duration of each stop is important, too, because less, but longer, waiting processes could have more effect on the road networks and other vehicles. In the example at hand, the waiting time per stop is long, when many vehicles have to wait. Thus, the section shown in the figure shows a high volume of traffic and should be considered for optimisation.

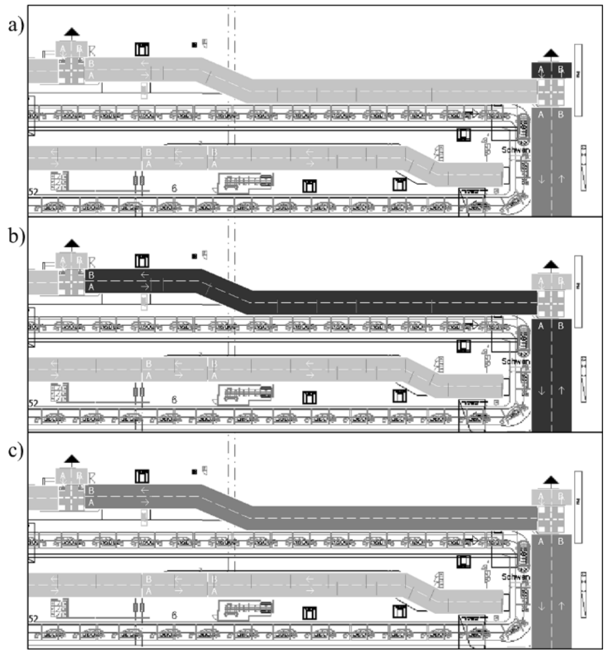


Figure 7: Visualisation Of Passing Vehicles (a), Waiting Vehicles (b) And Waiting Time (c)

As in the example in Figure 7, the whole road network should be checked for such sections. Beginning with the sections with the highest congestion, the road networks should be optimised. Based on the number of passing vehicles, roads can be merged to sectors with a high risk of disturbances. In the current planning status, such sectors exist, but are used for transit only, which means that no points of need are arranged alongside. For the future planning of routes and supply, sectors should be considered which neither increase the congestion, nor create new reasons for delays, especially if obstacles of any kind are added. In addition, this volume of traffic could be critical for safety at work, for example, in case workers have to cross between their workplace and any other points of interest.

To derive recommendations for sections with a high waiting risk, an individual analysis of the reasons is necessary. In front of obstacles, like elevators between the first and second floors, queues also affect passing trains if there is only one lane for all vehicles. By adding a second lane exclusively for waiting vehicles, transit traffic remains unaffected. In some areas, roads are too narrow for vehicles to overtake, if a precursor stops to supply material. By widening the roads in sections that were found to have potential, waiting can be reduced. A way to avoid waiting, especially in dead ends, would be to split the applicable routes there: assuming a route A supplies material inside a dead-end section, as well as outside (see Figure 8), it could be split into a route A1 supplying only the points of need outside, and a route A2 which would only supply inside the dead-end: the capacity efficiency of A1 and A2 would be reduced, as the amount of material to be supplied is defined by the quantity structure of the parts, and their sum equals the capacity efficiency of A. This would allow for the trains to go less frequently, but to be loaded with more material. Thus, the number of vehicles inside the dead-end is reduced while material supply is unaffected.

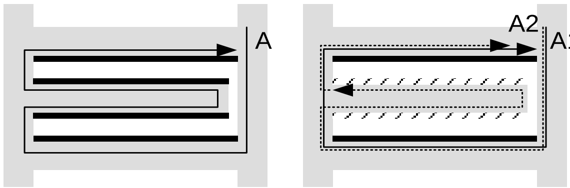


Figure 8: Route-splitting For Efficiency Optimisation

6. SUMMARY

The paper on hand describes the modelling and implementation of a TT system supplying several automotive assembly lines with more than 2000 tours on various routes. The focus of the simulation model lies on the IT system with three types of call-off processing, as well as on reproducing the vehicles' driving behaviour. Specific elements, like restrictions on overtaking and turning, were taken into account to facilitate meaningful results. For this, five important performance figures were derived from the main aims of the research: security of supply, level of service, employee and space requirements, as well as the volume of traffic. Firstly, the required security of supply of 100 percent has to be proved. For further analysis, the level of service helps to check the default process design. Employee and space requirements can be analysed using a histogram to find the requested balance between high security and a low need of resources. Due to the complex road networks with specific restrictions and a large variety of vehicles, the volume of traffic reveals highly-congested sections which need to be considered in further optimisations.

In summary, the requirements of creating a simulation model with a reusable framework were met. Universal objects like vehicles or roads were combined with specifically adaptable elements like overtaking behaviour or IT-processes. Thus, the model can easily be adjusted if further questions arise during future planning or if different TT systems with deviating properties are to be analysed in the future.

REFERENCES

Arlt, T., 2012. Neue Wege in der Automobillogistik bei BMW, *21. Deutscher Materialfluss-Kongress*. 29.03.2012, Garching bei München.

Baudin, M., 2004. *Lean logistics - The nuts and bolts of delivering materials and goods*. New York, Productivity Press.

Brungs, F., 2012. *Der Milkrun in der Produktionslogistik*. Aachen: Shaker.

Costa, B.; Dias, L. S.; Oliveira, J. A.; Pereira, G., 2008. Simulation as a tool for planning a material delivery system to manufacturing lines. *2008 IEEE International Engineering Management Conference*, pp. 1–5, 28-30.06.2008, Estorial.

Dewitz, M., Günthner, W. A., Arlt, T., 2014. Fahrplanoptimierung für innerbetriebliche Routenverkehre. *Logistics Journal* Vol. 2014, 2014, pp. 1-14.

Dreher, S., Nürnberger, A. and Kulus, D., 2009. *Routenzugoptimierung in der Produktionslogistik*. *ZWF*. 3-2009, pp. 131–135.

Emde, S., Boysen, N., 2012. Optimally locating in-house logistics areas to facilitate JIT-supply of mixed-model assembly lines. *International Journal of Production Economics* 135: pp. 393–402.

Emde, S., Boysen, N., 2011. Optimally routing and scheduling tow trains for JIT-supply of mixed-model assembly lines. *European Journal of Operational Research* 217: pp. 287-299.

Günthner, W. A.; Klenk, E.; Galka, S., 2012. *Stand und Entwicklung von Routenzugsystemen für den innerbetrieblichen Materialtransport - Ergebnisse einer Studie*. München: fml Lehrstuhl für Fördertechnik Materialfluss Logistik.

Kilic, H. S.; Durmusoglu, M. B.; Baskak, M., 2012. Classification and modeling for in-plant milk-run distribution systems. *The International Journal of Advanced Manufacturing Technology* 62: pp. 1135–1146.

Martini, A.; Stache, U.; Trenker, F., 2014. *Planung von Routenzugsystemen - Übersicht möglicher Gestaltungsalternativen und Vergleich von Planungsmethoden*. *ZWF* 109, pp. 50–55.

Mayer, G.; Pöge, C., 2010. Auf dem Weg zum Standard - Von der Idee zur Umsetzung des VDA Automotive Bausteinkastens. *Integrationsaspekte der Simulation: Technik, Organisation und Personal*. pp. 31–36, 07-08.10.2010, Karlsruhe.

Roth, S., 2012. Virtuelle Logistik- und Materialflussplanung - Beispielhafte Anwendungen. Integrationsaspekte der Simulation. *Zusammenarbeit im Umfeld der Digitalen Fabrik*, 21.09.2012, Hannover.

Staab, T.; Galka, S.; Klenk, E., 2013a. Effizienzsteigerung für Routenzüge. *15. ASIM Fachtagung Simulation in Produktion und Logistik*, pp. 167–176, 09-11.10.2013, Paderborn.

Staab, T.; Klenk, E.; Günthner, W. A., 2013b. Simulating Dynamic Dependencies And Blockages In In-plant Milk-run Traffic Systems. *27th European Conference on Modelling and Simulation*, pp. 622–628, 27-30.05.2013, Aalesund.

Vaidyanathan, B., Matson, J.O., Miller, D., Matson J.E., 1999. A capacitated vehicle routing problem for just-in-time delivery. *IIE Transactions* 31: pp. 1083–1092.

Wiegel, F.; Immler, S.; Knobloch, D.; Abele, E., 2013. Simulationsgestützte Optimierung innerbetrieblicher Milkruns. *PRODUCTIVITY Management* 18: pp. 51–54.

VDI-Richtlinie 3633 Blatt 1, 2014. *Simulation of systems in materials handling, logistics and production*. Berlin: Beuth.

AUTONOMOUS SYSTEM SIMULATION TO IMPROVE SCENARIO AWARENESS AND CAPABILITIES TO PROTECT MARINE, OFF-SHORE AND COASTAL CRITICAL INFRASTRUCTURE

Agostino G. Bruzzone[1], Marina Massei[1], Alberto Tremori[2], Diego Crespo Pereira[3], Giulio Franzinetti[3], Manlio Oddone[2], Arnau Carrera[4], Fabio Camponeschi[3], Luciano Dato[3]

[1] **DIME University of Genoa**
Via all'Opera Pia 15, 16145 Genoa, Italy
Email: {Agostino, massei}@itim.unige.it
URL: www.itim.unige.it

[2] **NATO STO CMRE**
Via San Bartolomeo 400, 19126 La Spezia, Italy
Email: {alberto.tremori, manlio.oddone}@cmre.nato.int
URL: www.cmre.nato.int

[3] **Simulation Team**
Via Molinero 1, 17100 Savona Italy
Email: {diego.crespo, giulio.franzinetti, fabio.camponeschi, luciano.dato}@simulationteam.com
URL: www.simulationteam.com

[4] **Universitat de Girona**
Plaça de Sant Domènec, 3, 17004 Girona, Spain
Email: arnau.carrera@udg.edu
URL: www.udg.edu

ABSTRACT

This paper proposes and integrated approach to address maritime security respect the use of innovative autonomous systems operating within the extended maritime framework. Indeed the paper addresses the vulnerability of ports as well of off-shore and coastal critical infrastructures. The paper outline the advantage to use interoperable simulation to address this context by a global approach combining industrial, homeland security and defense point of view. The authors propose the scenario definition and the main objects and variable to be considered. The paper proposes the process to develop a simulation framework able to be reused and to serve as reference point of the different stakeholders

Keywords: *Autonomous Systems, Interoperability, Modelling and Simulation, Joint Naval Training, Tactical Decision Ai*d

INTRODUCTION

Maritime Security is a major issue that represent a strategic context for National and International interests. Indeed these aspects are even overstressed by the evolution of the socio economic scenario; the constant trend in world merchandise traffic is a very consolidated phenomena continuously growing along 2010-2013 ranging from +12.9% to +2.2% yearly for world traffic; the western developed economies are characterized by lower values that in any case confirm positive trends for USA (Import +15.9% down to +2.6%, Export +14.8% down to +0,9%) while some recession effect is present in Europe (Export from +11.6% to +1.4%, Export from 9.4% down to a minimum 2.5% that is recovering to 1.2% in 2013), these figures are cumulative and reprent a very significant overall increase as proposed in figure 1 (Rogers 2014). Indeed the logistics of the raw material flows and goods is mostly based on shipping lines, so ports represent the strategic entry gate for being able to maintain industrial activities and sustainability of the large majority of existing economies; figure 2 provide an interesting overview of world sea traffic increase just between 2013 and 2013. In addition to these aspects, 44% of world population is located on coastal area and this rate is increasing year by year (Choen et al. 1997); a large quantity of critical infrastructures are located within coastal areas (e.g. power plants, fuel storages, refineries, water treatment, waste treatments, etc) due to the population density and/or the need to logistics and technological benefits arising from facing the sea. In addition to these aspects the off-shore resources for power (e.g. oil rigs, gas rigs, wind farms) are normally located not so far from the coast up to 200 NM (Matrangelo 2005). It is important finally to outline that very strategic world assets are concentrating near the coast representing critical infrastructures such as Underwater Pipelines and Communication Cables.

Based on all these elements it is evident the necessity to study how to improve the security of the assets located in this context and due to the complexity of this framework it is evident the necessity to use M&S as investigation tool.

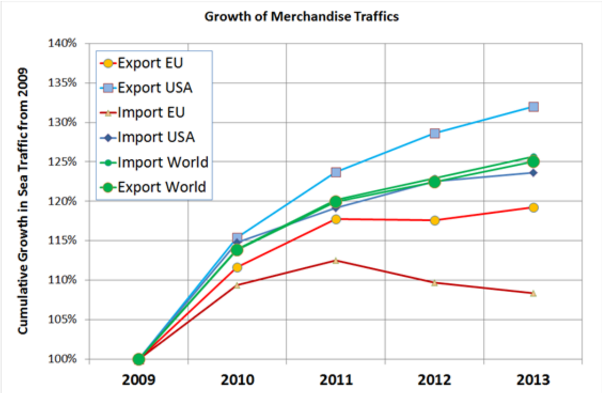


Figure 1 –World Traffic Cumulative Increases

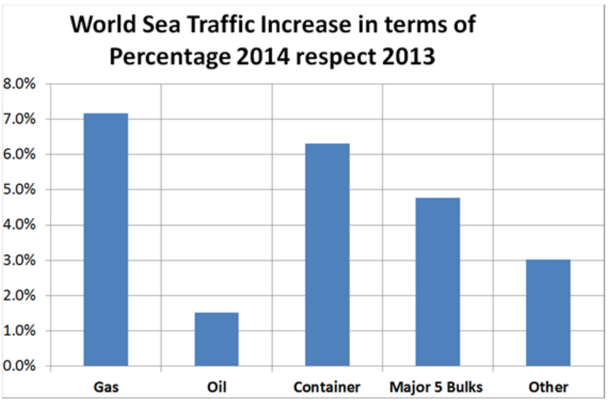


Figure 2 –World Sea Traffic 2013-2014 Trends

2. MODELING AND SIMULATION FOR MARITIME SECURITY

In many of these context the defense policies need to be reviewed considering the very dynamic nature of emerging threats as well as the necessity to protect wide infrastructures with very high vulnerabilities; from this point of view the use of autonomous systems and heterogeneous sensor network could allow to develop new sustainable solutions for improving security and reducing vulnerability, but it is still necessary to define the architecture of these new solutions, the technological requirements, the utilization policies and procedures as well as their reliability and efficiency (Been et al. 2008); for all these purpose the simulation represent a promising approach able also to support the development of innovative training equipment for promoting the diffusion and service (Waite 2001).
So considering all these elements it is fundamental to develop simulators able to consider marine infrastructures and address these issues and to dynamically adapt themselves to the evolution of these scenarios (Longo, 2010; Bruzzone et al. 2013c; Bruzzone et al. 2013e). Indeed, historically Modeling & Simulation (M&S) has been already extensively used in the maritime domain, mostly to support decision making, education and training (e.g. Longo et al. 2013; Longo et al. 2014). Therefore the potentials of M&S in this area has been widely proved and this fosters the use of M&S to support cutting-edge research to protect marine, off-shore and coastal critical infrastructures.
Due to these reasons the authors are considering interoperable simulation based on state of art technology as the best approach and are working to establish initiative in this fields through excellence networks and international organizations and institutions.
This initiative is currently addressing the development of an interoperable simulation environment to study the combined use of Autonomous Systems and Traditional Assets within the Extended Maritime Framework (i.e. Sea Surface, Underwater, Coast, Air, Space, Cyber) to protect related critical infrastructures (Bruzzone 2015).
Indeed the concept of Extended Maritime Framework (EMF) was developed to consider the strong correlation among the different domains and the necessity address them within a common simulation framework (Bruzzone et al. 2013b); EMF represents a very critical mission environments where the interoperability importance is over stressed by the nature of this battlespace and the complexity of the specific heterogeneous networks among the related assets.
In addition to these elements, as anticipated, very critical infrastructures are present in this context including among the others strategic resources, such as cables, underwater pipelines, ports, as well as off-shore and on-shore plants, LNG, terminals, etc.
The use of autonomous systems to protect these critical infrastructure results very promising for reducing their vulnerability in this multi domain environment; therefore it is evident the importance to investigate these solutions by quantitative models, extensive experimentation; it is also critical to be able to study the interoperability of the autonomous systems with traditional assets (e.g. helicopters, boats, ships, MPA etc) in this framework.
Probably simulation is the only methodology able to develop this investigation capability and to evaluate a priori the most effective strategic solutions to face these challenges.
Currently the authors are developing an initiative in joint cooperation among Simulation Team, CMRE, M&S COE, NATO MSG for promoting the development of this research within leading institution in M&S: this initiative is defined as SA3C4 and should investigate the most effective approaches, as well as their capability, to augment the scenario awareness and the capabilities to protect marine, littoral and Coastal Critical Infrastructure by using a mix of autonomous systems and traditional assets
This idea is strongly relying on the solid experience and background in the sector of interoperable simulation, marine M&S and operational simulation acquired by Simulation Team, CMRE and the other NATO Entities supporting this initiative (e.g. NMSG, NATO M&S COE) in strong liaison with excellence centers (e.g. M&S Net, McLeod Institute, VMASC, Genoa University, etc.) in worldwide leading Institution (Bruzzone et al 2011c).

It is important to outline that this research is addressing also the need to extend NATO capabilities in Joint Naval Scenario Simulation and should benefit of existing activities such as Exploratory Team MSG-ET-036 "modelling and Simulation of Autonomous ASW capable vehicles to Augment surface and maritime air Capabilities"; this previous research was devoted to identify the available simulation resources to develop an interoperable simulation able to reproduce the combined use of autonomous and traditional assets for operational naval scenario (e.g. Anti Submarine Warfare); the preliminary results achieved by this Exploratory Team by interacting with different centers are currently confirming the potential of this approach by interactive demonstration on an HLA federation of simulators (High Level Architecture) that provide guidelines and references for further developments in this context (NATO 1998, 2012; Bruzzone 2014c).
In addition to HLA the idea to use this simulation to support education and training as well as table top exercise suggest to adopt the SaaS (Simulation as a Service) paradigm experienced already with DVx2 simulator (Bruzzone et al. 2014b).

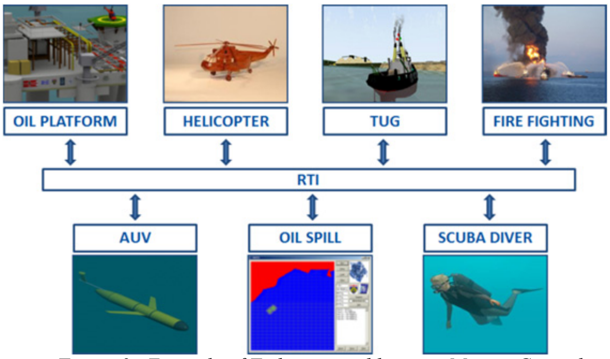


Figure 3 –Example of Federation addressing Marine Critical Infrastructure Protection

3. OBJECTIVE IDENTIFICATION

The goals of this Interoperable Security Simulation for extended Maritime framework (ISSEM) is to establish a M&S reference on combined used on Autonomous Systems and Traditional Assets able to combine behavioral models and resource simulation (both platforms and networks) with the simulation of the critical infrastructures to assess the effectiveness of solutions devoted to protect of Strategic Assets within the Extended Maritime Framework (i.e. Sea Surface, Underwater, Coast, Air, Space, Cyber).
Obviously several of these models will need to be created ad hoc to reproduce new elements (e.g. autonomous systems swarms) and many legacy systems will require major revision to be usable within this context; therefore the creation of this ISSEM federation, represents the opportunity to develop a strategic capability in modelling and analyzing the Extended Maritime Framework for protection of littoral, coast and related infrastructure. A major step forward supported by ISSM is the possibility to couple the critical infrastructure simulation dealing with the effects resulting from compromising their security with the simulation of new autonomous systems as well as that one of traditional solutions.
ISSEM concept is based on multi layer simulation already applied for industrial and natural disaster (Girbone et al.1994; Bruzzone & Massei 2006; Bruzzone et al. 2014d); indeed this context requires to be able to estimate not only the vulnerability reduction, but also to evaluate the damage resulting from the attacks respect different target functions including the strategic role of the assets, its costs, its implication within society; so it means that if a power plant fails this correspond to an heavy impact on urban activities, while attacks to oil and gas process plants could lead toward the generation of direct and indirect on population and environment (Bruzzone et al. 2014a). An example of ISSEM federation addressing these issues is proposed in figure 3.
An important aspect to focus is the identification of interoperable simulation requirements for the creation of distributed collaborative simulation amongst potential users; indeed by this approach it becomes possible to assess the benefits provided by unmanned systems when integrated within existing surface and maritime air capabilities in protecting marine, coastal and littoral critical infrastructures (e.g. cables, underwater pipelines, ports).
ISSEM final goal is the creation of an HLA Federation of simulators and related guidelines to further extend it in respect of standards for interoperability; the decision on using the reference interoperability standards for M&S is also motivated by the availability of multiple simulation framework and experiences for marine environment based on HLA (Massei et al. 2010; Longo 2012; Bruzzone et al. 2013a; Bruzzone et al. 2013b; Bruzzone et al. 2013d).
In order to achieve valuable results and create an effective demonstration with limited resources it is crucial to define the boundary of the scenario to be simulated by ISSEM federation; this means that the demonstration should focus on a specific scenario to be defined as common agreements among the different partners and by analyzing specific case studies strategically relevant for maritime Security; in this context the threat modeling as well as the simulation of resource coordination results critical dealing with maritime asymmetric scenarios (Mevassvik et al.2001; Bruzzone et al. 2011a); in order to succeed in this case it is fundamental to federate elements introducing intelligence within the scenario; in this case the idea is to use the IA-CGF (Intelligent Agent Computer Generated Forces) already used in marine security over other scenarios (Bruzzone, Tremori, Massei 2011b).
It is important to define this scenario in a way that allow ISSEM to demonstrate its general purpose capabilities in relation to dual use (defense and civil application); from this point of view it is suggested to combined the identification of the kind of critical infrastructures to study (e.g. oil rigs, commercial ports) with the expectations from business the sectors related to crucial industries and plants (e.g. oil & gas, shipping, terminal operations) in this context.

The development plan should be based on a synergy among leading entities in simulation community; currently the authors have already developed some example of these concepts and are in contact with Simulation Team, CMRE, NMSG, NATO M&S COE for activating an joint initiative using ISSEM as basic for further developments.

4. ISSEM FEDERATION

A preliminary configuration ISSEM federation was create to investigate the concepts proposed and to validate them (Bruzzone 2002); the case was finalized in relation to scenario dealing with an off-shore platform and the use of some autonomous vehicles (e.g.AUV and Gliders) devoted to patrol the area versus opposite autonomous systems and cooperating with a surface vessel as proposed in figure 4 ().
The architecture proposed is based on HLA and several different marine simulators have been evaluated for the interaction as Habitat, ST_VM, Jeans, MCWS, COLA2, DVx2 and MSTPA; an example of execution of current ISSEM is proposed in figure 5; ISSEM Federation uses time management and is able to operate fast time and real time and was tested also including SIL (Software in the Loop) related to AUV Navigation in a basic MCM patrol scenario (Mine Countermeasures); the virtual representation
The simulation mission is to guarantee a patrolling by three AUV (Autonomous underwater Vehicles) while an UAV (Unmanned Aerial Vehicle provide air coverage; a frigate in the area is in charge of recovery and deploy the AUVs taking care of recharging the batteries, full data download; the procedure for bordering the ship is based on approaching the stern gate usually devoted to handle a large RHIB (Rigid Hull Inflatable Boat); this mission was activated as example for testing interoperability within JEANS Simulator (Join Environment for Advanced Naval Simulation) using discrete event stochastic simulation for the events and threats; Jeans allows to visualize green capsules and orange pyramids, on demand, over the AUV to simplify the awareness on the situation and immediate identification of underwater assets even from surface virtual representation (see figure 5).

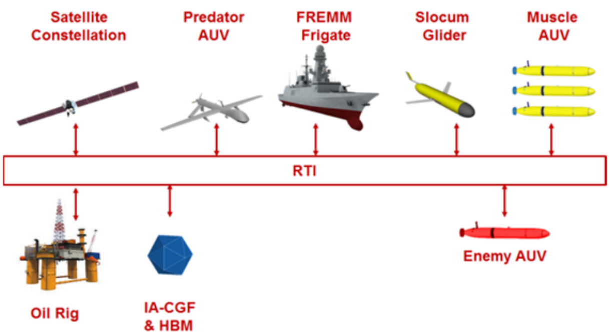


Figure 4 –Example of ISSEM Federation configured for Patrolling the Oil Rig

Obviously this case is just an example that could be further extended to other cases, indeed the modeling standard and guidelines for this Interoperable Simulation are a good reference for further developments within marine environment; in particular the authors are working in order to couple ISSEM federation with models reproducing the impact of actions versus the marine critical infrastructures.

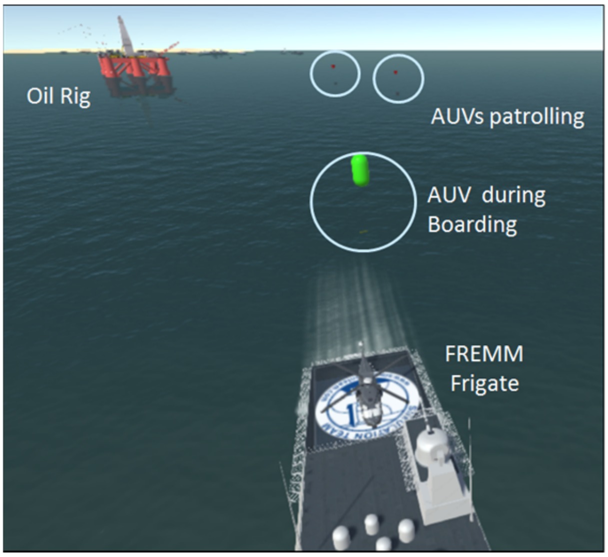


Figure 5 –Virtual Simulation federate presenting dynamic evolving situation within ISSEM Federation

ISSEM could be used for education and training in these new kind of operation (Bruzzone et al.2009); therefore it could be also applied for supporting decision making on maritime security dealing with strategic assets.

5. DEVELOPMENT PLAN

As anticipated ISSEM represents a first step also in relation to the activation of a Maritime Security initiative within NATO; in this case the general objectives are dealing with industrial application and homeland security, therefore it could be necessary to address more specifically the defense; in this case it should be tailored a special version of ISSEM federation addressing the related detailed scenario. This defense scenario should require a development plan to guarantee the involvement of stakeholders and the exploitation of the results; this could be achieved by activating different activities including among the others:

- Survey on Available interoperable models and simulators available for being integrated in the Federation
- Detailed Definition of Federation Objectives, Mission Environment & Scenario, Architecture
- Definition of Federation Configuration for the 1st Experimentation devoted to test, present, and exploit interactively the Augmented Capabilities provided by the interoperable simulation

In addition it will be necessary to plan proper the ISSEM Demonstration & Networking. The Federation

Demonstration is devoted to finalize on a specific defense scenario relevant for protection of littoral, coast and related critical infrastructures; this demonstration could become an important support to diffuse the use of the related FOM and federates as reference for interoperability in maritime security within the extended maritime framework.
Currently the author plan to demonstrate the ISSEM Federation on a specific workshop organized ad hoc to interact with Stakeholders and Subject Matter Experts and to exploit the result of the project; in addition, ISSEM could be presented within major Technical/scientific Conference such as I/ITSEC, ITEC and/or UDT, NATO CAX Forum and I3M/DHSS.
In general, the Prospective Stakeholders of ISSEM are the National and Alliance Decision Makers, the National Navies, the Extended Maritime Framework Stakeholders, the Autonomous System Community, the Simulation Community, the Coast Guards, the Homeland Security Agencies, elements from industry (e.g. Defense Industry, Oil & Gas Industry, Commercial Ports, Shipping). This activity should be devoted to exploitation and engagement of different entities, Nations and SME. Indeed the proposed Federation of Simulators could be demonstrated during in several communities representing the interested subjects. In addition it could be possible based on available resource and support to exploit the ISSEM results by interacting with scientific community in major conference and exhibitions (i.e. NMSG, I/ITSEC, ITEC and/or UDT, NATO CAX Forum I3M/DHSS).
The tailored ISSEM Federation and/or a specific release for defence could be finalized in synergy among existing projects and in cooperation with partners; this could be made available as a new tool for improving marine investigation capabilities for the Alliance and Nations. Different examples of ISSEM federation are currently operational within different simulation Labs (i.e. CMRE SimLab, Simulation Team Labs in Savona Campus); these examples could be further developed to be made available for evaluating solutions as well as to be used for table top exercises and further analyses.

CONCLUSIONS

This paper combines previous researches carried out in maritime security with the innovative concepts such as interoperable simulation and Saas. The preliminary runs carried out on the oil rig patrolling platform confirmed the potential for combining existing models and for completing experimental tests; currently the authors have completed technological integration and they are working forward for integrating also other simulators.
Future developments involve the engagement of SME in using ISSEM for analyzing maritime security scenarios and identifying specific additional models that should be added.

REFERENCES

– Been, R., Hughes, D. T., & Vermeij, A. (2008). Heterogeneous underwater networks for ASW: technology and techniques. Proc. UDT-Europe.
– Bruzzone, A.G., (2002) “Simulation based VV&A methodology for HLA federations: an example from the Aerospace Industry” Proc. of Annual Simulation Symposium. pp. 80–85.
– Bruzzone A.G., Massei M. (2006) “Modelling for Estimating Impact on Road Transportation of Regional Emergencies & Disasters”, Proc.of HMS, Barcelona, Spain
– Bruzzone, A., Cunha, G., Elfrey, P., & Tremori, A. (2009). Simulation for education in resource management in homeland security. In Proceedings of the Summer Computer Simulation Conference (pp. 231-238), Istanbul, Turkey, July
– Bruzzone, A. G., Massei, M., Madeo, F., Tarone, F., & Gunal, M. (2011a). Simulating marine asymmetric scenarios for testing different C2 maturity levels. Proceedings of ICCRTS2011, Quebec, Canada, June.
– Bruzzone, A.G., Tremori, A., Massei, M., (2011b), “Adding Smart to the Mix,” Modeling, Simulation & Training: the International Defence Training Journal, 3, 25-27.
– Bruzzone, A.G., Massei, M., Tremori, A., Longo, F., Madeo, F., Tarone, F. (2011c) “Maritime security: emerging technologies for Asymmetric Threats”, Proceedings of the European Modeling and Simulation Symposium, EMSS2011 (Rome, Italy, September 12-14, pp.775-781
– Bruzzone, A., Longo, F., Nicoletti, L., & Diaz, R. (2012, March). Traffic controllers and ships pilots training in marine ports environments. In Proceedings of the 2012 Symposium on Emerging Applications of M&S in Industry and Academia Symposium (p. 16). Society for Computer Simulation International.
– Bruzzone A.G. (2013a) “New Challenges for Modelling & Simulation in Maritime Domain”, Keynote Speech at SpringSim2013, San Diego, CA, April
– Bruzzone A.G., Fontaine J., Berni A., Brizzolara, S., Longo F., Dato L., Poggi S., Dallorto M. (2013b) "Simulating the marine domain as an extended framework for joint collaboration and competion among autonomous systems", Proc. of DHSS, Athens, Greece, September
– Bruzzone, A., Longo, F., & Tremori, A. (2013c). An interoperable simulation framework for protecting port as critical infrastructures. International Journal of System of Systems Engineering, 4(3-4), 243-260.
– Bruzzone, A. G., & Longo, F. (2013d). 3D simulation as training tool in container terminals: The TRAINPORTS simulator. Journal of Manufacturing Systems, 32(1), 85-98.
– Bruzzone A, Longo F, Tremori A (2013). An interoperable simulation framework for protecting port as critical infrastructures. International Journal of System of Systems Engineering, vol. 4, p. 243-260, ISSN: 1748-0671, doi: 10.1504/IJSSE.2013.057661
– Bruzzone A.G., Massei M., Agresta M., Poggi, S., Camponeschi F., Camponeschi M. (2014a) “Addressing

Strategic Challenges on Mega Cities through MS2G", Proc.of I3M2014, Bordeaux, France, September

– 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, Turkey, Sept.

– Bruzzone A.G. (2014c) "Modeling and Simulation of Autonomous ASW capable vehicles to Augment surface and maritime air Capabilities", CMRE ET Proposal, SP

– Bruzzone A.G., Frascio M., Longo F., Chiurco A., Zanoni L., Zavanella L., Fadda P., Fancello G., Falcone D., De Felice F., Carotenuto P. (2014d) "Disaster And Emergency Management Simulation In Industrial Plants" Proc. of EMSS, Bordeaux, France, September

– Bruzzone A.G. (2015) "Simulation of Autonomous Systems to Augment scenario Awareness and Capabilities in joint Cooperation within traditional assets to protect Marine, Littoral & Coastal Critical Infrastructure", Maritime Security Initiative Project Proposal, CMRE, La Spezia, Italy

– Cohen, J. E., Small, C., Mellinger, A., Gallup, J., Sachs, J., Vitousek, P. M., & Mooney, H. A. (1997). Estimates of coastal populations. Science, 278, 1209.

– Giribone, P., & Bruzzone, A. G. (1994, April). Man-made disasters- Chemical plant accidents. In SCS Simulation Multiconference, San Diego, CA(USA), 10-15 Apr 1994 (Vol. 1994, pp. 30-35).

– Longo F. (2010). Design And Integration Of The Containers Inspection Activities In The Container Terminal Operations. International Journal of Production Economics, vol. 125(2); p. 272-283, ISSN: 0925-5273, doi: 10.1016/j.ijpe.2010.01.026.

– Longo F (2012). Supply chain security: an integrated framework for container terminal facilities. International Journal of Simulation & Process Modelling, vol. 7, p. 159-167, ISSN: 1740-2123, doi: 10.1504/IJSPM.2012.049154.

– Longo F, Huerta A, Nicoletti L (2013). Perfomance Analysis of A Southern Mediterranean Seaport via Discrete Event Simulation. STROJNISKI VESTNIK / Journal of Mechanical Engineering, vol. 59, p. 517-525, ISSN: 0039-2480, doi: 10.5545/sv-jme.2013.963.

– Longo, F., Chiurco, A., Musmanno, R., Nicoletti, L. (2014). Operative and procedural cooperative training in marine ports, Journal of Computational Science, (in press), DOI: 10.1016/j.jocs.2014.10.002

– Massei, M., Tremori, A. (2010) "Mobile training solutions based on ST_VP: an HLA virtual simulation for training and virtual prototyping within ports", Proc. of International Workshop on Applied Modeling and Simulation, St.Petersburg, Russia, May

– Massei, M., Tremori, A., Poggi, S., Nicoletti, L. (2013) "HLA-based real time distributed simulation of a marine port for training purposes", Int. Journal Simul. Process Model. 8, 42. doi:10.1504/IJSPM.2013.055206

– Mastrangelo, Erin. (2005) "Overview of US Legislation and Regulations Affecting Offshore Natural Gas and Oil Activity." Energy Information Administration, Office of Oil &Gas, /www.eia.gov/pub/oil_gas/natural_gas/feature_articles/2005/offshore/offshore.pdf, September

– Mevassvik, O. M., Bråthen, K., & Hansen, B. J. (2001). A Simulation Tool to Assess Recognized Maritime Picture Production in C2 Systems. In Proc. of the 6th International Command and Control Research and Technology Symposium, Annapolis, USA.

– NATO (1998) "NATO Modelling and Simulation Master Plan: Version 1.0", Technical Report, Document AC/323/(SGMS)D/2

– NATO (2012) "NATO Modelling and Simulation Master Plan: Version 2.0", Technical Report NMSG, Document AC/323/NMSG(2012)-015

– Rogers J. (2014) "Review of Maritime Transport 2014", Technical Report UNCTAD RMT 2014, Geneve, CH

– Waite, Bill (2001) "M&S Professional Body-of Knowledge", Proc. of SCSC, Orlando Fl, July

Author's Index