DRIVERS AND PARKERS TRAINING IN CAR TERMINALS

Francesco Longo[(a)], Letizia Nicoletti[(b)], Alessandro Chiurco[(c)], Adriano Solis[(d)]
Francisco Spadafora[(e)]

[(a)(b)(c)(e)] DIMEG, University of Calabria, Italy
[(d)] York University, Canada

[(a)]f.longo@unical.it, [(b)]letizia.nicoletti@unical.it, [(c)]a.chiurco@unical.it,
[(d)]asolis@yorku.ca, [(e)]f.spadafora@msc-les.org,

ABSTRACT
The paper presents a simulation based training framework for drivers and parkers in car terminals along with some preliminary results achieved during the development phase. The proposed framework relies on a modular simulation architecture devoted to reproduce the main processes and activities taking place in a car terminal. To reproduce the car terminal operational processes with accuracy and provide the users with a cooperative training scenario, the simulation architecture includes three interoperable simulation modules; namely the Operator Simulator (the Marshalls), the Ship Simulator and a Vehicle Simulator. In particular, the paper focus is on the Vehicle Simulator, whose development and implementation is discussed in detail. As for the other modules, a general overview is provided.

Keywords: car terminals, drivers training, parkers training, simulation

1. INTRODUCTION

A car terminal is a complex system whose complexity relies on two main elements: the nature of inner daily processes and the great number of operators and vehicles (of different types) involved. Therefore, operators' training is critical to preserve operators', vehicles and equipment safety and security, ensure operational efficiency and avoid economic losses. Each operator has his own role and therefore specific training needs. However, within the whole scenario the most critical roles are taken by drivers (both vehicle and taxi drivers) and marshalls (operators assisting drivers during parking operations) whose errors may cause severe human and economic damage. In fact, drivers have to deal with a variety of working conditions including different levels of risk. The main risk factors depend on the configuration of the ship involved in loading/unloading operations; i.e. steep ramps, sharp bends, narrow aisles, slippery floors, etc. Moreover, for optimization purposes, vehicles loading and unloading are concurrent operations therefore it is likely that opposite flows cross each other increasing even more the risk of accidents.

Needless to say that only well-trained (both in theory and practice) and highly qualified staff can cope with the complexity of such a working environment and carry out its tasks effectively and safely. As mentioned before, improper behaviors, lack of coordination, incorrect procedures may result in losses of human lives and, from an economic point of view, in increased direct and indirect costs (Bruzzone and Longo, 2013).

Traditionally, training activities include frontal classes aimed at illustrating and discussing best practices and operational procedures that should be adopted in standard, unusual and dangerous conditions. Usually, training is not limited to frontal classes but includes also practical training where inexperienced operators are involved in coaching sessions driving in the real system with real vehicles. In particular, drivers and Marshalls courses last between 20 and 40 hours whereas coaching sessions last between 40 and 80 hours. In addition, training does not involve inexperienced operators only; further training is needed to illustrate lessons-learned, successful experiences or even new procedures. Furthermore, training for after-action review may be required in case of accidents and vehicles damage. In this case, training activities aim at understanding why the accident occurred identifying which measures and operational modes can prevent the same situations from happening in the future.

Hence, operators' training is a crucial and critical activity in car terminals; as a consequence there is a continuous search for tools that allow reducing training costs and maximizing training effectiveness.

To this end, Modeling & Simulation (M&S) has proved to be a powerful methodology for dealing with complex systems design, management and even training. As a matter of facts, development and testing real prototypes, even prototype solutions based on simulation, is a relevant training opportunity for its users (i.e. operational testing of weapon systems in the military industry is a clear example).

Simulation allows reproducing a real system and its behavior through an artificial system (the simulation model) therefore, operators involved in simulation-based training activities, while interacting with the simulated environment (that in most of the cases is a 3D virtual environment) can learn how to interact with the real system and the real equipment. As a result this approach can be advantageous especially when using real equipment in the real system is costly and dangerous as it may be in a car terminal. Indeed, simulation provides a safe training environment (the operator interacts with a virtual word reproducing the real system) where human errors have not economic impacts. In other words, operators can even apply wrong procedures to see the consequences of his actions and learn how to handle vehicles and equipment safely to perform their tasks effectively and efficiently.

The main benefits of M&S can be summarized as follows (Cimino et al., 2010):

- practice theoretical concepts and gain awareness of the main consequences related to the undertaken course of action in a very immediate and visual manner;
- provide instructors with a controlled environment where a large amount of data can be recorded and analyzed to evaluate the trainee's evolution and performances;
- avoid hazardous situations that usually occur when inexperienced users manipulate real machines;
- reduce costs associated to training operations;
- provide trainees with the possibility of working in any desired condition (i.e. arbitrary weather conditions).

Figure 1: Cars accident during loading/unloading operations in a car terminal

2. RELATED WORKS

Over the years Modeling & Simulation (M&S) has proved to be a very effective problem solving methodology in different areas including Industry, Logistics and Supply Chains (Piera et al. 2004). As far as the marine ports domain is concerned, many are the cases in which M&S has been used for supporting decision making at strategic, tactical and operative level (Longo 2007, Bruzzone et al., 2000; Bruzzone et al. 2012) also including (above after September 11th 2001) security enhancement (Longo, 2010). However, in the same domain, M&S has been also widely applied for supporting operators training (i.e. container terminals) especially for high-risk and costly activities. There are many examples of works and research projects where simulation is profitably used as a training tool. In the following a general survey on past related works is proposed. In particular, the state of the art allows pointing out that simulation has been used extensively for the training of the operators involved in containers handling processes and loading/unloading operations. As follows a brief description of different types of applications is reported. Many are the examples of simulation systems devoted to train quay cranes operators: Wilson et al. (1998) propose a 3D virtual system devoted to simulate crane operations; such system allows reproducing also the feelings and sensations that can be experienced in a crane cockpit. Huang (2003) presented a method to design an interactive visual simulation mobile crane training. Daqaq (2003) developed a virtual simulation for training of ship-mounted cranes operators. Rouvinen et al. (2005) developed a gantry crane simulator intended for container handling operations between yard and ships. Fernandez et al. (2009) present a training simulator for different kinds of operators, namely quay crane, gantry, rubber tired gantry and reach-stacker operators. The simulator includes an automated system devoted to track and monitor operators' skills. In Elazony et al. (2010), attention is focused on the design and implementation of reusable and interactive simulation-based training systems. Similarly, Lau et al. (2007) present a distributed real-time simulation model for container terminal processes. Furthermore specific research works have been developed to support operators' training and procedures design within container terminals. Moreover, several examples of distributed simulation for operators training in container terminals can be found in Merkuriev et al. (1998), Bruzzone et al. 2010, Bruzzone et al. (2011).

In addition it is worth mentioning that a complete survey on the major projects focusing on simulation systems for training of marine operators is one of the main deliverables of the OPTIMUS (Operational Port Training Models Using Simulators, that is financed by the European Union) project.

A careful analysis of the state of the art shows that the most common simulators for training in the port area include:

- ships bridge simulators:
- engine room simulators;
- handling loads simulators

In these simulators, usually the particular attention is paid on the visualization system that consists of a series of screens where the virtual environment (which recreates the real system) is projected. In addition, these simulators are designed for the training of the following kinds of operators:

- ships pilots;
- forklift operators;
- Reach Stacker operators;
- Straddle Carrier operators;
- Gantry Crane operators (STS, RTG, RMG);
- Offshore Crane operators;
- Tower Crane operators;

Some of the most important commercial simulators include:

- Drilling Systems (http://www.drillingsystems.com) whose simulator KraneSim is an advanced tool for simulating a wide range of quay cranes and vehicles.
- Oryx Simulations AB (http://www.oryx.se/), crane simulators that provide the users with different scenarios and different options in terms of cockpit, motion-based system, real-time graphics, background sounds, etc.
- ARI (http://www.ariworld.com/simulation/default.asp) and Total Soft Bank Ltd. (http://www.tsb.co.kr/) simulators for training on different types of cranes QC (Quay cranes), RTG (Rubber Tyre Gantry), RMG (Rail Mounted Gantry), SG (Ship Gantry), PC (Pedestal cranes), SC (Straddle Carriers)
- MPRI Ship Analytics (http://www.mpri.com/esite/), develops crane simulators for training that can play faithfully the operational characteristics of 12 types of cranes.
- STC Group http://www.stc-group.nl has developed simulators for various types of cranes such as containers cranes, bulk cranes and off-shore cranes.
- Simulation Team http://www.simulationteam.com has developed HLA interoperable simulators of different logistical means including gantry cranes, transtrainers, stackers, trucks, etc. These simulators are used for training, performance analysis and biomedical operators, as well as for virtual prototyping. Such simulators are available also in a full motion, immersive cave and containerized solution that can be easily transported where it is needed.

The studies on the effectiveness of M&S applications have pointed out their usefulness for training applications. In fact, simulators are widely used both for the first contact with machines and equipment and for the skill upgrading experienced operators. The effectiveness of simulation-based training is evaluated according to the transfer of the learned concepts to the real world during scheduled sessions where the operator acts in the real world under the supervision of an experienced instructor (Morrison et al 2000).

The literature review allows pointing out that there are many simulation-based applications for the port operators and especially for container terminal operators and for operators handling different types of vehicles (cars, trucks, buses, etc.). However, as far as we know, no research projects about training issues and M&S solutions applied to car terminals exist.

In fact, further analysis of the state of the art show that existing research works on car terminals are focused on transshipment operations using multi-agent systems (Fischer et al 2004), on operations management (Mattfeld et al 2002) and on business processes definition. In addition, the role of such logistic nodes in the supply chain of the automotive sector has been analyzed be Dias et al. 2007. However, the issues related to training and exercise of various professionals using advanced approaches based on M&S and 3D immersive virtual environments, are unexplored yet.

2.1. Contribution of the research work

Even if this paper shows only some preliminary results, the authors are carrying out a research project (called CTSIM) that will provide the following contribution to the current state of the state of the art:

- a training system for drivers of small, medium and large cars operating in car terminals;
- a training system for bus drivers operating in car terminals;
- a training system able to offer multiple scenarios (only the yard, only the ship, ship-yard, etc.), with at least two types of ships (a big ro-ro ship and a feeder ship);
- a training system for carrying out cooperative training of drivers of different vehicles (i.e. cars and buses);
- definition of appropriate performance metrics for evaluating trainees;
- a virtual advanced environment that can be used for performance evaluation also in case of structural lay-out changes in the terminal area;
- development of a business model easily exportable between different car terminals.

3. MAIN PROCESSES AND ACTIVITIES IN A CAR TERMINAL

In this section the main processes and activities that usually take place in a car terminal are described. One of these processes includes vehicles unloading and their placement into the yard. This process occurs after each ship entering the port is towed and moored. However, before unloading operations can start, some preliminary validation activities and macroscopic controls are carried out; in particular during these activities the staff verifies the compliance of each group of vehicles with the information reported in the informative systems and checks whether there are damaged vehicles. In addition, after that, the optimal unloading sequence of vehicles is defined and the yard position assigned to each vehicle is established. At this stage, unloading operations can start.

In the next step, each vehicle is placed in the previously assigned location; after arriving to its assigned location the vehicle is checked for damages (caused during the movement to the interiors or to the bodies). In case of damage a damage report is drawn up.

Another typical process that is carried out in a car terminal includes vehicles transfer from the yard area to a service area devoted to pre-delivery inspection (PDI) activities and a subsequent transfer to the loading area.

As far as the loading process is concerned, it should be noted that some of the vehicles are loaded on trains or trucks while other vehicles are loaded again on ships. Before the loading operation, further controls are carried out and if damaged vehicles are found these vehicles have to return to the PDI buffer area (to be repaired before leaving the terminal area). The vehicles that have to be loaded on ships are driven from the yard to the boarding ramps and, after an integrity check, are driven to the assigned spot on board.

Even in this case, it is possible that after inspections a damage report is drawn up and is attached to the involved vehicle. The main actors responsible for the aforementioned processes are:

- Drivers: they are in charge of vehicles handling (from the ship to the yard and vice versa) during loading/unloading operations and in the yard during shifting operations. Moreover, drivers have to cooperate with quality checkers and marshalls (parkers) in order to avoid incidents and errors while executing particular manoeuvres.
- Taxi Drivers: they pick drivers up from the yard and move them onto the ship (or vice-versa) during loading/unloading processes. In addition, they work in cooperation with quality checkers and marshalls, to ensure the correct loading/unloading sequence.
- Quality checkers: they verify that operators' behaviours are compliant with the instructions and procedures they must adhere (in particular they execute severe controls at dangerous points and during the vehicles inspections). On the other hand, coordination functions include those activities that are carried out in collaboration with taxi drivers and parkers to choose and communicate the assigned position (on the yard or on board the ship) and to ensure that the established loading/unloading sequence is respected.
- Service persons. The service persons are responsible for the viability on board and on the ramps; moreover, they assign bar codes and they are the first responders in case of accidents.
- Tally Men. The tally men are in charge of bar codes scanning (to get Vehicle Identification Numbers, VINs), of assigning a destination to the vehicles of each row/parking area; particular attention has to be paid in order to avoid scanning (wrongly placed) of vehicles with a destination different from the one assigned to the same row.
- Marshall (Parker). The marhsalls or parkers have to ensure that vehicles are parked according to the required instructions (such as distances between adjacent vehicles, parking on the line, checking handbrake / first gear, etc).

4. THE CTSIM GENERAL ARCHITECTURE

As already mentioned in section 2.1, the authors are carrying out a research project (CTSIM, Car Terminals Simulator) with the aim of developing a simulation framework devoted to car terminals operators training. On overview on the CTSIM architecture is given in figure 2. Basically, the main components of the architecture are three different interoperable simulators: the vehicle simulator, the ship simulator and the operator simulator. The vehicle simulator has been already developed while the development of the other simulators is still on-going. In this section the main characteristics of the ship and operator simulators are briefly described, while in section 5 the vehicle simulator is presented.

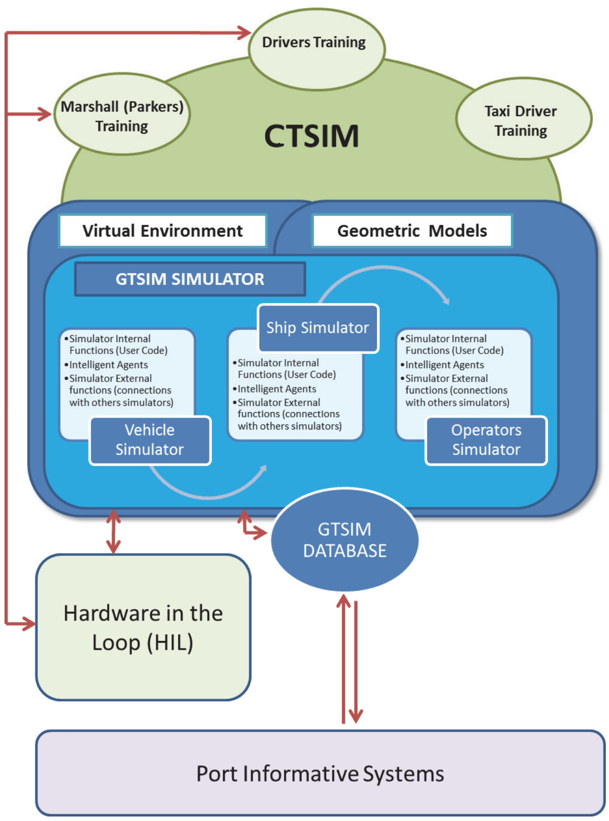

Figure 2: The CTSIM general architecture

The Ship Simulator allows simulating two types of vessels devoted to transport cars and buses: ro-ro car/truck carrier for long transport routes (international and/or intercontinental) and ro-ro feeder. In addition this simulator will provide the users with the opportunity to select climatic conditions such as wind, visibility, rain and sea state so as to offer the possibility to train over a wide variety of operating scenarios. The two types of ships will include side ramps and a stern ramp. Moreover, for each kind of ship, it will be possible to choose among different configurations in terms of bridges layout, lanes, ramps, etc. Therefore it will be possible to set-up different training scenarios for the operations that occur on board of ships. Since the Ship Simulator will be part of an interoperable architecture that will allow the cooperative training of different operators (i.e. parkers and drivers), the visualizations system will allow changing the viewpoint and therefore different operators can see the ship interiors from different perspectives as it happens during operations on board a ship in a real car terminal. Furthermore user interfaces will be based on Man in the Loop (MIL) solutions that will be integrated within the simulator; for instance basic parameters such as operators' viewpoints, type of display etc will be controlled by a computerized console and some hardware devices. Figure 3 shows the cars parked inside a ro-ro ship as they appears within the Ship Simulator.

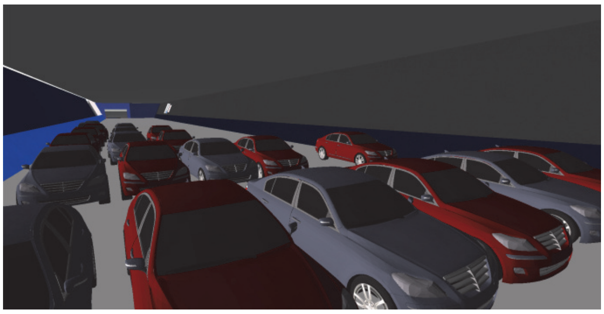

Figure 3: Cars parked inside a Ro-Ro ship

The Operator Simulator will recreate the main tasks of marshalls, tally men and quality checkers. The scope of this simulator is twofold: it can be used to train operators different from drivers and it can also be used to train drivers in being acquainted with the meaning of parkers' gestures (or in general to interact correctly with the other operators). As in the ship simulator, operators will have the possibility to change their point of view based on the needs that arise from the contingent situation they are dealing with. In this way they can act as it happens in the real system and can provide the drivers with accurate instructions. Moreover, even in this case, user interfaces will be based on advanced hardware and MIL solutions (i.e. the avatar of the operator in the virtual environment can be controlled through motion controllers, the virtual environment can be seen through head mounted display). The figure 4 shows the view of an avatar while interacting with a car that is approaching the ship, while figure 5 depicts the real operator controlling the avatar through a motion controller and seeing the virtual environment through a mounted head display.

Figure 4: an avatar interacting with a car approaching the ship

Figure 5: the real operator controlling the avatar through a motion controller and experiencing the virtual environment through a mounted head display

4.1. Performance Measure description

The main objective of any training simulator is to raise the level of personnel qualification as a function of time that elapses from the moment the training is started. One of the main problems in car terminals is related to the time required for an operator to be considered an "expert operator". The main recommendation coming from the navigation lines in ro-ro sector and from the automobile manufacturers suggest 1 year of work as estimated average time to reach an acceptable level of qualification. Indeed the estimated time for an operator to experience at least two times all the possible driving scenarios in a car terminal is 2 years. As already highlighted complex driving situations are characterized by:

- Concurrent operations involving multiple ships and simultaneous loading/unloading operations;
- Simultaneity of operations on ships, trains and yard;

- Simultaneity of operations on the same ship (concurrent vehicles embarkation and disembarkation);
- Operations during the night or during adverse weather conditions.

Therefore, a higher level of qualification obtained in a shorter time would have a direct impact on the following performance measures

- increase of the operators productivity in terms of number of handled vehicles per day;
- reduction of the risk of accident
- reduction of the number of collisions;
- reduction of total number of major damage (total loss) and micro damage with consequent reduction of all direct costs;
- reduction of insurance costs;
- optimization of human resources in terms of operators flexibility in carrying out different types of operations.

5. THE VEHICLE SIMULATOR

As part of the CTSIM general architecture, the vehicle simulator has been already developed (even if additional research activities are still on-going trying to improve some aspects of the simulator). Figure 6 shows a panoramic view of the car terminal area.

The Vehicle Simulator allows recreating the standard operations carried out by drivers while moving vehicles within a car terminal. In particular, the Vehicle Simulator includes three different types of cars (small, medium and large) and a generic model of bus. Figure 7 shows developing and testing activities MSC-LES lab, University of Calabria.

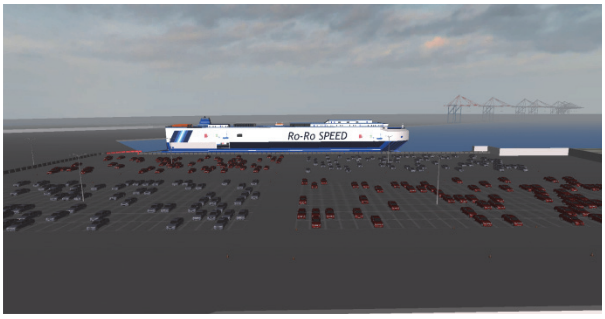

Figure 6: Panoramic view of the car terminal

The Vehicle Simulator can be controlled by specific hardware interfaces (i.e. Steering wheel, pedals, dashboard, etc..) and could be equipped with a 6 Degree of Freedom motion platform. The Vehicle Simulator includes a user interface for the operator based on computerized console. These interfaces (MIL and HIL) allow the handling of the vehicle in accordance to the inputs provided by the driver, creating at the same time, the dynamic behaviour of the real vehicle.

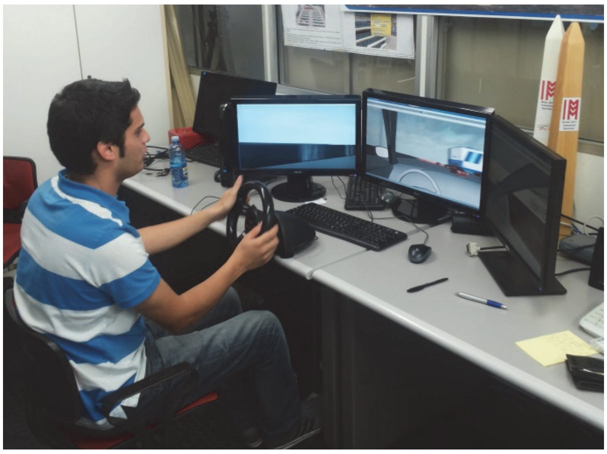

Figure 7: developing and testing the vehicle simulator at MSC-LES, University of Calabria

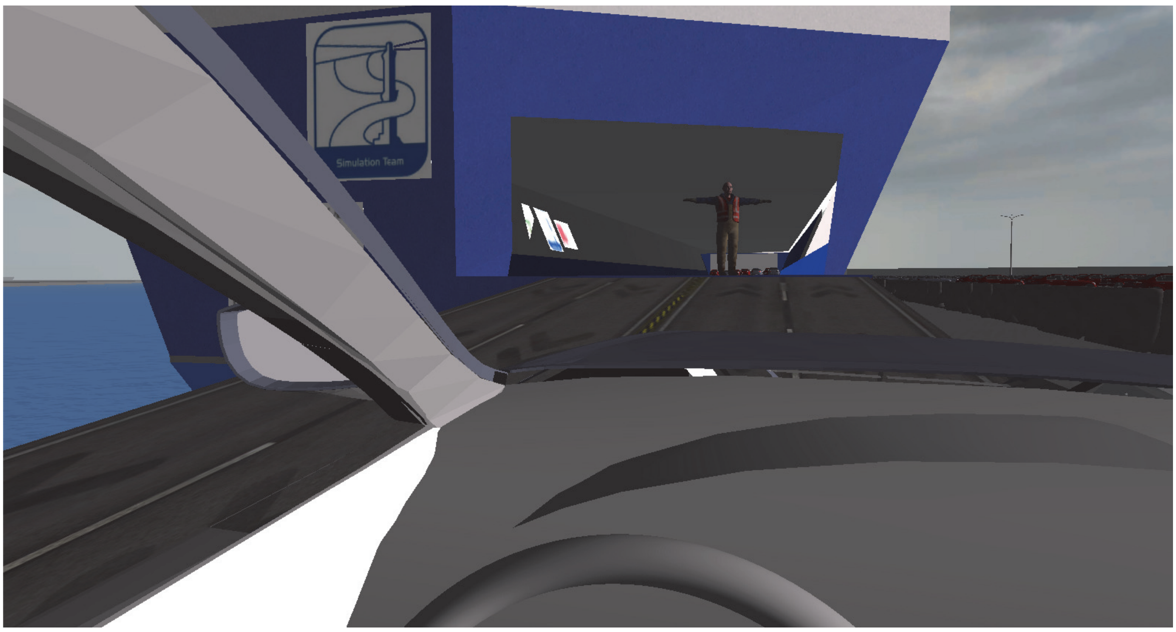

Figure 8: internal view from the car while approaching the ramp for entering the ship

The simulator can run on an immersive visualization system based on multiple screens and an integrated sound system in order to guarantee the view of the external port environment and the feeling of being in the real port. The Vehicle Simulator is also equipped with multiple views that allow the visualization of the vehicle in the virtual car terminal. The figure 8 shows an internal view from the car while approaching the ramp for entering the ship (note the presence of the avatar controlled by the real operator through the Operator Simulator).

Through parameters setting, it is possible to change the yard scenario (i.e. number and types of vehicles parked in the yard). Indeed the Simulator engine includes a method that, once selected the vehicles types, the number of each vehicle type and the parking requirements, it fills the yard with the appropriate number of vehicles arranging them in a casual order (therefore a huge number of possible scenarios are possible) or according to a specific sequence provided by the user. The method loads only one geometric model for each vehicle and it replicates this model to render all the cars. This approach allows the trainer to set the parking conditions just modifying very few parameters and, at the same time, permits the minimization of the GPU workload.

Figure 9 shows one of the possible results of the automated procedure for filling the yard area

Figure 9: Results of the automated procedure for filling the yard area

6. CONCLUSIONS

The paper presents the general architecture of the CTSIM simulation framework devoted to cooperative training of car terminal operators. In the first part, the paper presents a survey of the current state of the art highlighting that there are many works in the area of container terminal operators training by using simulation while a lot can be done for car terminal operators training.

After having identified and described the main operators usually working in a car terminal and the training needs, the general architecture of the CTSIM framework is presented. CTSIM is a modular simulators system composed by three interoperable simulators: an Operator Simulator, a Ship Simulator and a Vehicle Simulator. A description of the three simulator is provided.

There are research activities still ongoing mainly related to the development of the Ship and Operators simulators, while the Vehicle simulator is currently under testing.

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