MOBILE TRAINING SOLUTIONS BASED ON ST_VP: A HLA VIRTUAL SIMULATION FOR TRANING AND VIRTUAL PROTOTYPING WITHIN PORTS

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1. INTRODUCTION

Training is a critical issue in many different framework; in fact currently new concept such as mobile training are evolving thanks to the support of new enabling technologies; therefore it is important to identify the aspects and requirements for these applications, from this point of view it is critical to proceed on the definition.

Vavoula and Sharples say that there are "three ways that learning can be considered mobile: in term of space, in different areas of life and with respect of time". Today there is a growing importance in developing new methodologies for delivering training services: mobile training laboratories, mobile training programs, ad hoc equipment and trainers. In general sense, it is considered an efficient means of providing education and training even if affected by limitations (i.e. devices, design)

Fig.1 Mobile Training Solution based on 40' Hi-cube Container

In fact, some difficulties rise designing models for specific training scenario, such as: formalization level of highly specialized expertise, competencies based on concrete know-how or on theoretical knowledge, etc. Usually, trainees need a mix of practical competencies, experience, know-how and theoretical competencies. According to Pieri and Diamantini a possible solution could be a blended learning model, which is a combination of different approaches and strategies to make teaching/learning process effective and "customized". By using mobile training and lectures it is possible to get the most from advances in technology and traditional well known face to face training

Based on this possibility, training programs should be designed taking into account the integration of different educational methods, from traditional classes to distance learning, with special attention on lifelong learning.

2. MOBILE TRAINING DESIGN

In order to develop an effective model, useful for the development of training materials and the design of procedures for mobile training, it is fundamental to have a clear understanding of the mobile training as a mix of technology, human capacities and social interaction [Marguerite L. Koole].

To design effective mobile training modules it is important to assess the utilization of the following aspects within a mobile training system:

- Device: is important to assess these characteristics because mobile training device, such as a simulator, provide the trainee and the training task with an interface
- Trainee: take into account trainee's abilities, knowledge, motivations
- Social aspect: takes into account the processes of social interaction and cooperation. The rules of cooperation are fundamental in order to exchange information and acquire knowledge.

In fact only the interaction among the cited aspects provides the trainees with the proper feedback, which is the only way to acquire and maintain knowledge, experiences etc.

Therefore, a simulator for training purposes should:

- Be "user friendly" in order to increase success rates, because the trainee could concentrate on the tasks rather than the tool
- Make possible information exchange and collaboration among people with different goals and purposes
- Take into account the needs of trainees as people with different backgrounds, cultures and environments
- Be effective enabling trainees to interact with trainers, courses and virtual environments

Summarizing, an effective mobile training results from the integration of simulator, trainee and social aspects.

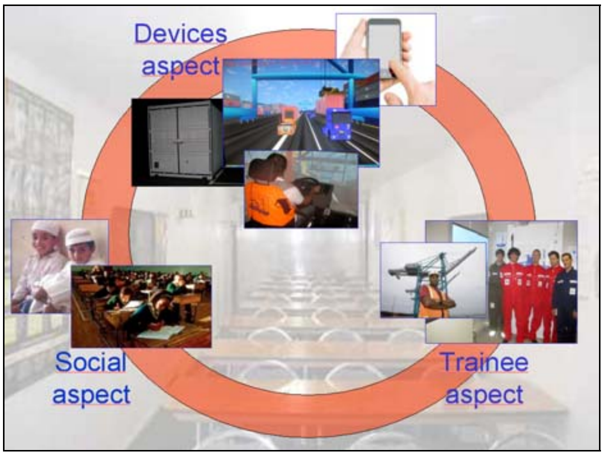

Fig. 2 Aspects to be considered for an effective Mobile Training

3. A MOBILE TRAINING EXAMPLE: VIRTUAL PORT FOR REAL OPERATORS

The authors experienced an innovative mobile training solution by developing a new training equipment for ports titled ST_VP (Virtual Port developed by Simulation Team); ST_VP is an HLA-based Real Time Distributed Simulation application for Training purposes, taking into account operators training and education, handling safety, operative efficiency.

Based on these conditions, an entire virtual world has been designed including surrounding areas, roads, container yard, different type of yard cranes, ship cranes, ships etc. In addition, ST_VP is based on modular approach that guarantee extensibility and interoperability for the dissemination of simulation techniques as Mobile Training Tool.

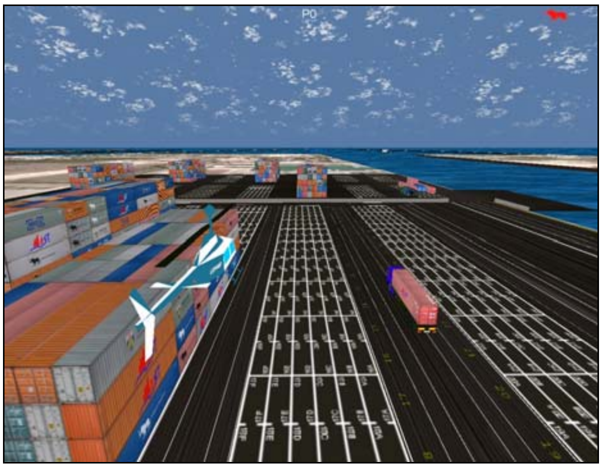

Fig.3 - Virtual Yard with Virtual Trucks and Virtual Copter

Fig. 4 - Virtual Portainer operating on Virtual Ship

The ST_VP structure is based on High Level Architecture and allows to connect multiple models representing different systems where to conduct the training, by this approach it becomes possible to generate scenarios with multiple objects intereacting. This aspect represents a real important concept in training simulation, moving from training on a single system to an environment for cooperative and competitive training. In fact ST_VP deals mostly with Ports, Terminals, Cranes and vehicles with different purposes: training single operators, training the operative squad in procedures, etc.

For these reason a wide range of configurations and operative applications are available, from operating stand alone on a single workstation to creating a federation of cranes interacting in a networks.

Therefore through simple MMI (man-machine interface) it is possible to configure a large set of position that can quickly changed from cranes to truck for creating complex cooperative scenarios; the ST_VP is designed to integrate scalable solutions (i.e. video games interfaces, laptops, workstations, 6 degrees of freedom mobile platforms,etc); by this approach it becomes possible to define cooperative operations where different teams are working concurrently in order to improve efficiency.

In order to support the mobile training several features have been introduced in ST_VP:

- Scalable Hardware Platforms and MMI: this allows to create different configurations able to be relocated quickly based on the current training needs; it is possible to create sessions with extended number of players very quickly.
- Mobile Training Framework: ST_VP is encapsulated in a real Container (40' high cube) that has been transformed in a mobile lab including all the ST_VP elements (computers, mobile platforms, MMIs, biomedical devices, interactive whiteboard, network infrastructure, cameras etc.); the ST_VP Container is designed to operate in extreme weather conditions and it is powered by flexible solution enabling it to operate in Europe, America or Africa; in addition the ST_VP Container have security solutions for protecting him against threats (i.e. firewalls, cameras, alarms, gps).
- Integration with blended education solutions: by this approach it is possible to remotely access the ST_VP Container, wherever in the world, seeing internal activities, communicating with the trainer/trainees and even downloading actions and exercise for remote analysis and evaluation; the trainees are enabled to access a e-learning platform based on Moodle for reviewing exercises and notes from the instructor.
- Tailoring Capabilities: the modular nature of ST_VP, the library of entities and the easy capability in changing the scenario allows to readapt the training to different ports and terminals with different cranes/vehicles, different procedures and different layouts.

In fact in the case of ST_VP it was decided to identify different type of elements supporting mobile training from two different point of view: Direct Supports devoted to help directly the mobility of the training infrastructure and framework service supporting mostly the adaptability of the simulator for being used in different place, so providing him opportunities and capabilities for being relocated; in this sense it is possible to classify in these two categories the following elements:

Direct Support

- Mobile Lab in a Standard 40' Container for easy Shipping
- HVAC ("Heating, Ventilating, and Air Conditioning") designed for facing extreme conditions for operating in any location
- Flexible Power able to support the different standards that are available in the different countries and continents
- Compact CAVE: cave 270 horizontal degrees and 135 vertical degrees operating within 2.2 x 2 meters
- Easy Packaging for shipping of the components in compact solutions inside (tailored configurations for specific users) or outside (lean configurations for basic use) of container

Framework Services

- HLA and Modular Approach for easy reconfiguration of scenarios and players
- Scenario Tailoring and Library supporting easy configuration on the specific training scenarios
- Integration with several user interfaces allowing to access both game engine and professional platforms for extending the number of players
- Blended Education Platform possibility to remote access to the services by trainers (remote instructor) and trainees (reviewing their activities and educational material)

- ➢ Biomedical Device Integration supporting direct measure of the trainee physical conditions and stress level during sessions provide support to complete quick comparison among different training sessions in different frameworks

The ST_VP federation includes several federates:

- Portainer: allows the operator to practice a gantry crane in different scenarios. The operator can virtually load and unload container from a ship, in a virtual dock where different portainers work simultaneously.
- Control & Debriefing: the trainer is provided with capability to navigate the virtual environment and to control the scenario configuration (i.e. set number of containers and operative straddle carriers, number and type of ships in port and number of trains) and to set weather conditions (i.e. time, weather condition, wind and sea condition). In addition the trainer is enabled to activate on-line with the on-going simulation simultaneous debriefing sessions for immediate review of results.
- Truck, reach stacker, straddle carrier, wheel transtainer, rail transtainer, bridge crane, heavy crane federates: they dramatically improve the quality of the training session enabling each trainee to practice different vehicles/cranes in multipurpose operation.

The simulator automatically generates the missions: the user can define for every single operator which container has to be moved and the new position/destination to be reached.

The mission can be “multiple destinations”, in other words the trainee could be asked for moving the container from a yard allocation or a truck trailer and back again. Also, different levels of complexity can be selected, extra-move included, based on the necessities.

The adopted solution for the federation architecture enable the interaction among several vehicles.

Furthermore, the authors use extensively a network of experts in Simulation for Port Logistics as well as DIPTEM laboratories in order to guarantee a successful VV&A.

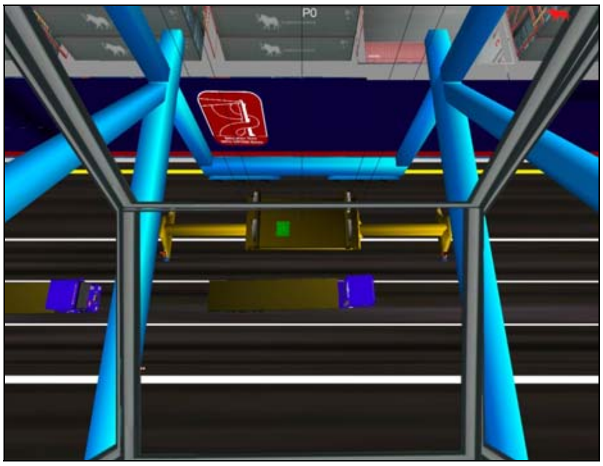

Fig. 5 Virtual Operation involving Virtual Ship and Virtual Truck

4. SIMULATION: AN AFFORDABLE MEANS OF PROVIDING TRAINING

The present study represents an interesting example in the field of Simulation for Mobile Training, the final users take advantage from low cost interactive distributed HLA-based environment which runs on PC equipped with simple devices (basic configuration) or becomes a mobile classroom once containerized with mobile platform and cave (full configuration).

In fact Ports represent a wide set of scenarios where different configurations are present: very different processes using often similar devices; in addition Ports are characterized by different size and needs, so it is very important to tailor the training; for instance ST_VP is currently in use in two Mobile Labs and at the same time are operating in light configuration for specific purposes in several continents.

In general sense, the "mobile" approach makes possible to extend the application of simulation as training support system in new areas, effectively facing interaction, cooperation, competition in a wide range of scenarios, with significant cost saving as well.

Fig. 6 Effective Mobile Training Solution: ST_VP

In the proposed case, ST_VP represents an innovative mobile training based on simulation; therefore with reference to port crane training, it is presented the benefit related to the use of a mobile training respect traditional solutions; the cases are represented by:

- Innovative Mobile training based on Simulation
- Traditional Mobile Pack with Crane Simulator
- Traditional Containerized Crane Simulator
- Fixed Solution for Crane Simulator
- Traditional Training on a Real Crane

The target functions to be evaluated are the number of ports to be tested and the number of people to be trained, in addition another important factor it is the time of direct training (operator interacting with the equipment) vs. the frontal lectures and observation of other people operating; another important factor is related to training costs. It is important to measure even the capability to reproduce a specific scenario; so these factors are estimated as following just considering the crane operation exercises:

$$T_{tot} = \begin{cases} \alpha < 1 & n_s \left[T_{tr} + n_p \left(T_{tvi} + T_{tri}\right)\right] + T_{st} + T_{ta} + T_{sh} \\ \alpha = 1 & n_s \left[T_{tr} + n_p T_{tri}\right] \end{cases}$$

$$N_{ports} = \frac{uc \cdot P}{T_{tot}}$$

$$Ex = T_{tr} \cdot \left(\frac{\alpha \cdot rcr + (1-\alpha) \cdot vcr \cdot pu}{n_p} \right)$$

$$C_{tot} = \begin{cases} \alpha < 1 & T_{tot} \left(Is + (\alpha \cdot Arcr + lc) + (1-\alpha) \cdot Avcr\right) + C_{st} + C_{ta} + C_{sh} \\ \alpha = 1 & T_{tot} \left(Is + Arcr + lc\right) \end{cases}$$

T_{tot} Total Training Time for a Site
n_s Number of sessions on a Site
α Percentage of time on real crane respect Simulation
T_{tr} training time

uc use of the time frame for training (i.e. 8 hours per days, 5 days/week)
p_u number of users concurrently training on the simulator
lc production losses due to unavailability of the realcrane
rcr number of real cranes
vcr number of virtual simulators
T_{tvi} student transition time on simulator
T_{tri} student transition time on real crane
T_{st} setup time for the mobile solution
T_{ta} time for tailoring scenario for the mobile solution
T_{sh} time of shipping for the mobile solution
P Period available for training
N_{ports} Number of serviced Ports over P timeframe
Ex Trainee time operating directly
n_p number of people in a training session
C_{tot} Total Costs on a Site including all sessions
Is Instructor Cost
Arcr Time Cost for using real crane
Avcr Time Cost for using virtual crane
C_{st} setup cost for the mobile solution
C_{ta} cost for tailoring scenario for the mobile solution
C_{sh} cost of shipping for the mobile solution

Table I - Comparison Scenario with Tailoring

		Mobile Training	Containerized Simulato	Pack Simulator	Fixed Simulation	Real Crane	
ns	Number of sessions on a Site	3	3	3	3	3	[sessions]
alfa	percentuage on real crane	0.5	0.5	0.5	0.5	1	
Pu	parallel trainees on simulator	4	1	1	1	1	[people]
Ttr	training time	40	40	40	40	40	[hours]
Ttvi	student transition time on simulator	2	2	2	2	0	[minutes]
Ttri	student transition time on real crane	0	0	0	0	2	[minutes]
Tst	setup time for the mobile solution	0.5	1	0.2	0	0	[days]
Tta	time for tailoring scenario for the mobile solution	1	20	20	20	0	[days]
Tsh	time of shipping for the mobile solution	3	3	3	3	0	[days]
rcr	number of real cranes	0	0	0	0	1	
vcr	number of simulated cranes	4	1	1	1	0	
P	Period available for training	6	6	6	6	6	[months]
np	number of people in a training session	4	4	4	4	4	
Is	Instructor Cost	50	50	50	50	50	[Euro/h]
Arcr	Time Cost for using real crane	171	171	171	171	171	[Euro/h]
Avcr	Time Cost for using virtual crane	175	263	44	219	175	[Euro/h]
Cst	setup cost for the mobile solution	1000	1000	1000	1000	0	[Euro/movement]
Cta	cost for tailoring scenario for the mobile solution	1000	20000	20000	20000	0	[Euro/scenario]
Csh	cost of shipping for the mobile solution	1000	2500	1000	64000	0	[Euro/movement]
lc	loss of productivity	0	0	0	0	2325	[Euro/hour]

Table II - Results on Scenario with Tailoring

		Mobile Training	Containerized Simulato	Pack Simulator	Fixed Simulation	Real Crane	
Ttot	Total Training Time for a Site	228.8	696.8	677.6	672.8	120.4	[hours]
Nports	Number of serviced Ports over P timeframe	4.62	1.52	1.56	1.57	8.77	[ports]
Ex	Trainee time operating directly	25	10	10	10	10	[hours]
Ctot	Total Costs on a Site including all sessions	54,099	209,682	128,753	250,015	306,566	[euro/site]

It is important to note that tailoring represent a critical factor for training effectiveness; therefore this factor is hard to be effective in real crane simulator: if the real crane works off line of the real production it not very realistic (i.e. not operating on a ship, not lanes of trucks) and introduces very high costs, viceversa operating on real procedure (real crane, real ship etc.) it involves high risk in damaging high value equipments as well as creating problems in operations; for instance in a sector where cranes have a cost of 1/10 of the ports the impact of maintenance costs related to training session was estimated in about 40 kEuro/year per crane; for traditional simulators tailoring is very limited too, due to the predefined scenario and the impossibility to create the procedures on-going in each terminal; therefore training is very peculiar and the above scenario is estimated based on mean values by subject matter expert estimations (Bruzzone, Vio, Capasso 2000; Bruzzone, Tremori, Capasso 2009).

Therefore it is interesting to present even the results without considering any requirement for tailoring that are reported in table III and IV.

Table III - Comparison Scenario without any Tailoring

		Mobile Training	Containerized Simulato	Pack Simulator	Fixed Simulation	Real Crane	
ns	Number of sessions on a Site	3	3	3	3	3	[sessions]
alfa	percentuage on real crane	0.5	0.5	0.5	0.5	1	
Pu	parallel trainees on simulator	4	1	1	1	1	[people]
Ttr	training time	40	40	40	40	40	[hours]
Ttvi	student transition time on simulator	2	2	2	2	0	[minutes]
Ttri	student transition time on real crane	0	0	0	0	2	[minutes]
Tst	setup time for the mobile solution	0.5	1	0.2	0	0	[days]
Tta	time for tailoring scenario for the mobile solution	0	0	0	0	0	[days]
Tsh	time of shipping for the mobile solution	3	3	3	3	0	[days]
rcr	number of real cranes	0	0	0	0	1	
vcr	number of simulated cranes	4	1	1	1	0	
P	Period available for training	6	6	6	6	6	[months]
np	number of people in a training session	4	4	4	4	4	
Is	Instructor Cost	50	50	50	50	50	[Euro/h]
Arcr	Time Cost for using real crane	171	171	171	171	171	[Euro/h]
Avcr	Time Cost for using virtual crane	175	263	44	219	175	[Euro/h]
Cst	setup cost for the mobile solution	1000	1000	1000	1000	0	[Euro/movement]
Cta	cost for tailoring scenario for the mobile solution	0	0	0	0	0	[Euro/scenario]
Csh	cost of shipping for the mobile solution	1000	2500	1000	64000	0	[Euro/movement]
lc	loss of productivity	0	0	0	0	2325	[Euro/hour]

Table II - Results on Scenario without any Tailoring

		Mobile Training	Containerized Simulato	Pack Simulator	Fixed Simulation	Real Crane	
Ttot	Total Training Time for a Site	204.8	216.8	197.6	192.8	120.4	[hours]
Nports	Number of serviced Ports over P timeframe	5.16	4.87	5.34	5.48	8.77	[ports]
Ex	Trainee time operating directly	25	10	10	10	10	[hours]
Ctot	Total Costs on a Site including all sessions	47,739	61,428	33,131	112,287	306,566	[euro/site]

It is evident the great benefits of innovative mobile training solution such as that one proposed by ST_VP respect traditional training on real crane and even respect old style simulators as summarized by the following figures.

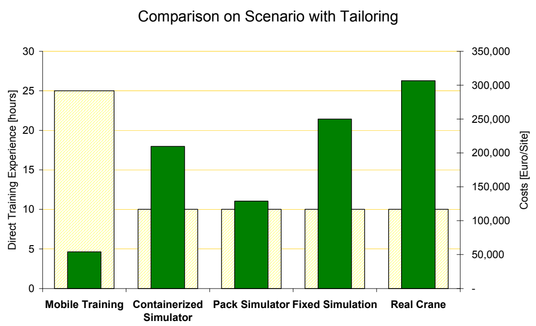

Fig. 7a Benefits of Mobile Training in Effectiveness and Costs with Scenario Tailoring

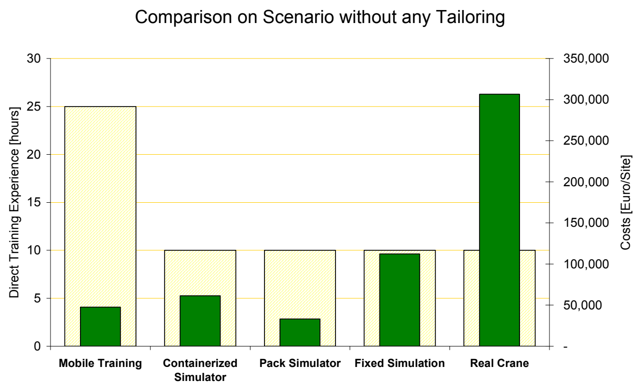

Fig. 7a Benefits of Mobile Training in Effectiveness and Costs without any Scenario Tailoring

CONCLUSION

This papers introduces the concepts of Mobile Training and provides an example of a simulator that is enabling these concepts; from this point of view it is important to identify the features and requirements that support the Mobile Training not only in term of direct support, but even as framework service guaranteeing usability within this paradigm.

In fact the example of ST_VP, developed by the Simulation Team, provides an unique opportunity, due to the high level of flexibility, to improve existing training procedures or to develop new ones, giving the authors the chance to tackle a very serious problem in the related application area. The approach outlined here provides an overview of the elements that supported a Mobile Training solution taking into account the positive follow up of innovative techniques applied to a sector that it is not very familiar with simulation such as maritime environments; the results obtained demonstrated significant benefits in term of training effectiveness; therefore the most interesting benefits obtained are related to the big increase in number of terminals, ports and operators that could benefit from this Mobile Training approach with a cost reduction. Finally the proposed research aims to deliver a training approach that have potential for further implementation in other sectors.

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