STESSA IT Solutions, LLC

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Simulations in Highly Interactive Virtual Environments (HIVEs) White Paper

STESSA's Advanced Simulation Framework (ASF) for prototyping: A model of a highly automated maritime container terminal in Second Life(TM)

Lissa M. Mangini, M.Ed., CEO
Stefan Stöhr, CIO

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STESSA IT Solutions, LLC

PO Box 662, Zephyrhills, Fl 33539
Phone: (813) 788-2629 or (813) 298-9043
Email: info@stessa-solution.com

www.stessa-solutions.com

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1 STESSA's Advanced Simulation Framework (ASF) for prototyping: A model of a highly automated maritime container terminal in Second Life

Highly interactive virtual environments (HIVEs) for industrial or enterprise endeavors is advantageous from the operational to the educational aspects of an organization. The following document describes the simulation of a automated maritime container terminal with STESSA's Advanced Simulation Framework (ASF) in the virtual world environment “Second Life”.

1.1. The real world, Container Terminal Altenwerder, Hamburg, Germany

The HHLA Container Terminal Altenwerder (CTA) in Hamburg, Germany currently is one of the most modern container terminals in the world, located in the Altenwerder quarter.

The terminal, opened in year 2001, spreads on a surface of 983,500 square meters (10,586,306 sq ft) and has the capacity of approx. 3 Mill. TEU (Twenty-foot equivalent unit) annually. Right now, 2.4 Millions TEU capacity is used.

The centric container area with a capacity of 30.000 TEU takes the largest part of the surface with connections for cooltainers. The area is served by 22 pairs of cranes and 53 vehicles. The characteristic of the terminal is the nearly fully automated operational sequence. [2]

A complex, continually upgraded IT system controls all the different elements, from the container gantry crane to storage management. The basis of CTA’s efficiency is optimized interplay.

Container handling is split into two stages. On the waterside, double trolley gantry cranes load and discharge from/to the vessel. The gantry crane’s main trolley is operated by a driver; the human element instinctively perceives a ship’s inevitable movement. Computers are unable to do this and moreover do not attain the productivity an experienced crane driver provides. Safe handling at this stage of the cargo unloading cycle is best performed by an experienced crane operator. The container is lowered on to working portal, where a group of employees remove/affix twist locks. In addition, a further manifest check is made to identify the containers. The second trolley, known as a “gantry trolley” then accepts the container automatically and lowers it on to an Automated Guided Vehicle (AGV). Seventy-four of these

vehicles provide transport between the gantry cranes and container storage. They find their way completely independently without direct human involvement. The AGV searches for the fastest route with the aid of more than 10,000 transponders set on the ground. Signals from these are transmitted to specially developed software that calculates and controls the shortest route to the destination while allowing for other moving vehicles.

The container storage consists of 26 blocks, each served by two rail-mounted gantry cranes (RMGs). These are of different height and can therefore operate in parallel. This allows for containers to be delivered even if one crane is not operational. Storage of the boxes is computer controlled, with slots being optimized during slack periods to ensure that release is as fast as possible. Port-side release is the responsibility of the staff at the control center using a joystick and camera to lower the container on the semi-trailer chassis. Three-hundred semi-trailers and 14 tractors are used to move containers between the storage blocks and rail terminal. [1]

Illustration 1: ©Frank Grunwald, Picture from the top of one of the container bridges of the HHLA Container Terminal Altenwerder (CTA) in Hamburg. You can see the Blocklager and the AGVs.

1.2. Advantages of realizing Simulations with STESSA's ASF

In addition to the advantages in marketing and branding, corporate training, and virtual collaboration of HIVEs explained in our document “Benefits of 3-D Simulations.” The technical and/or industrial processes with STESSA's Advanced Simulating Framework (ASF) provide the following advantages:

1.2.1. Cost Efficiency

Implementing simulations utilizing propitiatory software is costly as well as time and work intensive. STESSA's ASF provides the structure and the methods to simulate all the logic, communication and behavior of real-world (RW) equipment, like cranes or vehicles. Using ASF reduces dramatically the costs and time of developing.

1.2.2. Return of Investment and Investment Security

Through the modular software concept and our implementation methods, customized adjustments and expansions are continuously possible and available long term, which guarantees a ROI. The implemented ASF Modules used for the Container Terminal Simulation for example are not limited to run inside Second Life, they can also run on other virtual worlds such as the open source OpenSim. Implementation in other virtual worlds is seamless and continues to provide the same ROI.

1.2.3. Visualization of technical or industrial processes

Simulations can be used for visualization of operations planning, implementation of new operational processes and marketing. Safe training of personnel can be implemented in a cost-effective manner.

Our prototype CTS demonstrates in a visual and understandable manner the complex interaction between the different automated components like the automated AGVs, the RMGs and the different controlling components like the resource planning or the terminal operating systems (TOS).

1.2.4. Evaluation, testing of software components and algorithms

With the ASF its easy to test and “visualizing” new software components; for example, exchanging the “shortest path finding” of an AGV or alternative AGV/Yard trailer routing plans. Doing this type of testing in a simulation like our CTS cuts on use of real world AGV, thus, curtailing loss of productivity, wear-and- tear on equipment, and eliminating fuel consumption for trial-runs.

2 Technical realization of the Container Terminal Simulation (CTS)

2.1. Modeling the real world in the Virtual World of Second Life

Like in real world in the virtual world there are objects and resources. The properties and behaviors are build in modules and the interaction between are covered by a communication module. The same data processing for planning, controlling and execution are used inside the simulation.

Used software components at CTA	*Software component inside simulation*
Common (Application Server: BEA WebLogic, JMS: SwiftMQ)	Communication Module
CBS (ContainerBasisSystem, Java) CBS (ContainerBasisSystem, InterSystems Caché, VMS Alpha)	Container Database Module
ATLS (Automatik Terminal Logistik System)	CTS Main Module
PS (Planungssystem, Schnittstellen zu NAVIS SPARCS)	Planning Module
AGV-Managementsystem (Fa. TBA (ex Gottwald Port Technology), Suse Linux 10)	Collision Avoidance Module Pathfinding Module Traffic Control Module
HTLS (Hinterland Terminal Logistik System, INFORM tess, Sun Solaris)	Planning Module Data Module
FMDS (FehlerMeldeDiagnoseSystem (GluIT), Microsoft Windows 2000)	CTS Main Module
SPARCS (NAVIS)	CTS Main Module Planning Module

Table 1: Used software components at CTA, Hamburg

2.2. ASF Objects

Objects are a representation of real world physicals objects like vehicle, ships, cranes, etc. They have physical attributes like mass and dimensions. “Movement” of these Objects is achieved by the controlling modules running inside these objects. These controlling modules define the operations the objects are to fulfill. Also, additional modules can be implemented for more complex real world tasks. For example, the AGVs are running a Pathfinding Module and a Collision Avoidance Module that gives them the capability to find its own way to a target.

Implemented Objects in the CTS are:

- Container Bridges and Rail Mounted Gantry (RMG)
- Automated Guided Vehicle (AGV)
- Vessel
- Container Storage Block
- Container

Illustration 2: ©Stessa IT Solutions, Container Terminal Simulation. You can see the Container Block Storage and the AGVs.

2.3. ASF Modules

Modules are the representation of real world “intelligence”. They provide the behaviors and capabilities of physical objects or controlling tasks.

2.3.1. CTS Main Module

The Main Module controls the simulation. It provides all methods for starting and running a scenario.

2.3.2. Data Module

The data module delivers methods for import and export real-world or realtime data in and out of simulation. This gives the capability of setting up the simulation to represent a real-world situation, comparing the simulated state to a real-world state or controlling the simulation from outside the virtual environment.

2.3.3. Communication

The Communication Module provides all Methods for communication between the objects, modules and user interaction.

2.3.4. Planning

The Planning Module provides methods for generating orders for the different objects to execute a command like “unloading container x from ship y and store it in block z”.

2.3.5. Collision Avoidance

The Collision Avoidance Module runs inside of the AGV's and provides the capability to avoid collisions with other objects or vehicles.

2.3.6. Container Database

The Container Database Module is tracking the movements of the containers and provides the coordinates of a container.

2.3.7. Path-Finding

The path finding Module runs inside of the AGV's and provides the capability to find its way to a target like a parking slot, a special crane slot, etc.

2.3.8. Traffic Control

The Traffic Control Module controls higher tasks like sending AGV's to a waiting position when there is no free resource, for example in case all crane parking slots are busy.

2.3.9. Scenario Control

The Scenario Control Module is setting up the simulation for specific scenarios like for example ship unloading, ship loading or failure simulation.

2.4. Technical remarks on Implementation ASF Components inside Second Life

- SL uses the physical engine HAVOK 4 for all in-world dynamics
- SL allows 64kb memory per script, modules have to be split to match this limitation
- Sim-Size of 256m x 256m, bigger simulations needs more than one Sim to keep a 1:1 representation
- Usage of the Event-Queue System. SL Scripts communicate through events

3 Glossary

ASF: STESSA's IT Solutions Advanced Simulation Framework

AGV: Automated Guided Vehicle

CTS: Container Terminal Simulation

HIVE: Highly Interactive Virtual Environment

RMG: Rail Mounted Gantry

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Assistant Professor, Department of Systems and Operations Management, College of Business and Economics, California State University, Northridge
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