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SafeLog

Safe human-robot interaction in logistic applications for highly flexible warehouses

Title: System Integration Test Plan

Deliverable: D6.4

Prepared by:

Name	Benjamin Andres
Organisation	SLA
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Approved by:

First Reviewer	David Puljiz
Second Reviewer	Jonas Stenzel

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Contents

1 Summary

This deliverable addresses the preparation of the demonstration cells (s. Demonstrations), as defined in *WPT-1.1 Use-Case and Scenario Definition*. The aim of this task is on the one hand to schedule and define workshops for integration and testing and on the other hand to design and implement test-cases for integration testing in accordance with the requirements. In general, this will involve:

- Configure the existing demonstration environment at SLA and LivingLag at IML
- Design of the additional virtual cells for simulating the interplay of a complete production system
- Integrate SafeLog developments in the demo cell
- Implementation of the integrated demo scenario

This will follow the structure of the tests described in *D6.2 Component Test Plans [M26]*, with the additional challange of running the complete system in a real environment. In cases where a real environment is not applicable due to the size of the test facility, the tests will be run in simulation.

2 Preparation of Equipment

The test cell in Augsburg consists of approx. 175sqm of system. It has access to 2 standard operator windows and contains roughly 20 racks. Access to the system is given via the maintenance area and an additional access door. The system can host up to 6 vehicles. Around the system there is approx. 300sqm of free space.

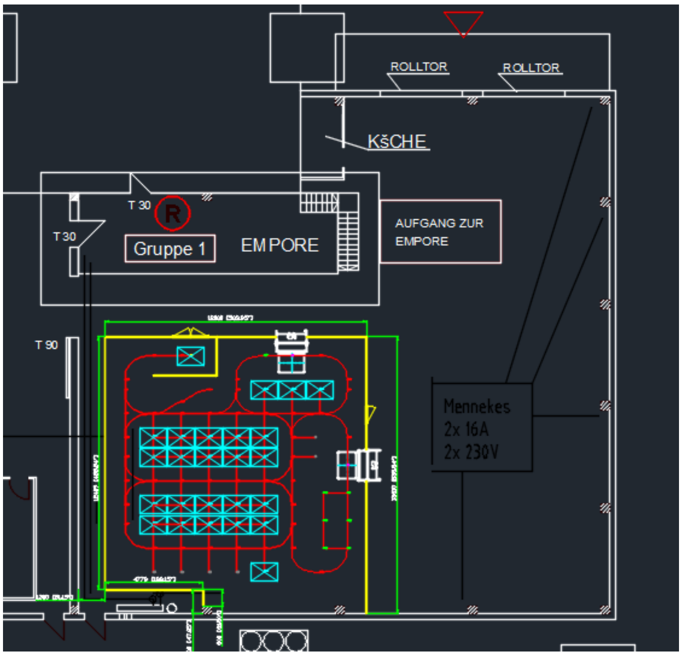

Figure 1: Layout of the test cell in Augsburg.

In principle the system is available and ready for use with the integration test plan the timing needs to be verified to block the resources and system from other tests. The test facility needs to be updated with the newly developed fleet manager.

3 Integrate Safelog components (into test environment)

Integrated safety concept

To fully utilize the safety concept – both the Carries and the stationary equipment needs to be equipped with the additional Hardware. The control cabinet of the system needs to work with two additional signals

- Fails signal via which the SVBS triggers warehouse-wide safe state (stop all AGVs).
- Entry/exit signal via which the SVBS opens the light curtain to enable entry and exit of the warehouse for the person wearing the Vest.

The carry needs to be modified with the UWB receiver to stop the vehicle. For both modifications the parts for integration need to be sent roughly 4 weeks prior to testing to allow time for integration and testing.

Heterogeneous Fleet Management

For elaborate tests of the hetrogeneous fleet management features the test facility is too small since only a few possibilities for alternative routes exist. In addition, the system is not yet rated safe for human - robot collaboration.

However, we have prepared layouts in different sizes as off – 200 racks, 2000 racks and 9600 racks for simulation. Those layouts cover the whole spectrum of system sizes.

Although limited, some tests may be executed live with a human standing outside of the storage influencing the routes of carries within.

4 Virtual Test Environment

Currently we also have an implemented virtual reality warehouse where several components can be tested. In particular the interaction between the *CO005: Fleet Management System*, *CO009: Fleet Manager Terminal*, *CO011: Location Server* with the virtual AR device. The VR environment also acts like a mobile robot simulator. Modalities of AR interaction can likewise be tested. At the end of the project it can also be reused as a training framework for warehouse workers

5 Consortium

Role of KIT

KIT has two roles:

1. KIT will be coordinator of SafeLog. Coordinating person will be Björn Hein. The department FORScience of KIT will handle all management issues (s. previous paragraph, section *Management structure and procedures* and *WP8 Project Management* in document Part 1).

2. Regarding research and innovation KIT will mainly focus on the human-system interaction and assistive technologies in the envisioned flexible and collaborative warehouse *WP4 Assisting technologies for a collaborative and flexible warehouse system* with the corresponding relations to the other work packages.

Role of SLA

Swisslog provides expertise in automation and logistics ranging from industrial robot applications, electrical overhead monorails, transport AGVs and goods-to-man systems. Swisslog will handle the demonstrator based on a fleet of mobile goods-to-man robots. For this system prior work exists comprised of fleet-manager, standard safety infrastructure and also a 2D emulation environment. Swisslog will take the lead of WP1 and WP6.

Role of CVUT

CVUT will lead *WP3 Planning and scheduling for a heterogeneous fleet manager*. The target of the workpackage is to realize a planning module that will provide coordinated plans for robots and humans in the warehouse CVUT will also significantly contribute localization activities in *WP2 Integrated safety concept for detecting and localizing of humans* as well as specification and requirement analyzis *WP1 Requirements and Specifications* and integration *WP6 Integration and Demonstration*.

Role of UNIZG-FER

UNIZG-FER will lead *WP2 Integrated safety concept for detecting and localizing of humans*. The target of the workpackage is development of a holistic safety concept that will allow safe collaboration of humans and robots in the warehouse. UNIZG-FER will also contribute in human aware planning in *WP3 Planning and scheduling for a heterogeneous fleet manager*, localization and human intention recognition in *WP4 Assisting technologies for a collaborative and flexible warehouse system*, specification and requirement analyzis in *WP1 Requirements and Specifications* and integration in *WP6 Integration and Demonstration*.

Role of IML

IML has a comprehensive knowledge about a multitude of interlogistic applications as well as a deep knowledge about development of embedded eletronic components and robotic solution.

In this position IML will contribute to the overal integration of the different concepts by leading the *WP6 Integration and Demonstration*. Furthermore IML will bring in the expert knowledge in embedded systems and communication technologies to contribute majorly to the safety concept and hardware development of the vest as part of *WP4 Assisting technologies for a collaborative and flexible warehouse system*.

Role of KEEI

KEEI will lead *WP5 Development of a Safety Vest*. The goal of this work package is to develop a Safety Vest which enables humans to safely enter and work in a flexible warehouse system with AGVs. Special attention shall be given to safety certification of the safety west and the Safety Concept developed in *WP2 Integrated safety concept for detecting and localizing of humans*. KEEI will contribute to the Project with its experience in embedded systems design and in development and certification of safety critical control systems for railway applications.

6 Glossary

AGV

Automated Guided Vehicle: An Automated Guided Vehicle is a mobile robot that follows markers or wires in the floor, or uses vision, magnets, or lasers for navigation. They are most often used in industrial applications to move materials around a manufacturing facility or warehouse. Application of the automatic guided vehicle has broadened during the late 20th century.. 5, 7, 8

AR

Augmented Reality: Augmented reality is a visualization technique where a direct (e.g through glasses) or indirect (through a camera and screen) view of the real world is supplemented by sensory input and data to achieve a better and more informative understanding of the scene.. 6

SV

Safety Vest: A vest which enables, together with other systems, persons to work safely in automated warehouses alongside AGVs.. 5

UWB

Ultra-Wide-Band: UWB is a radio technology pioneered by Robert A. Scholtz and others that can use a very low energy level for short-range, high-bandwidth communications over a large portion of the radio spectrum. UWB has traditional applications in non-cooperative radar imaging. Most recent applications target sensor data collection, precision locating and tracking applications. Unlike spread spectrum, UWB transmits in a manner that does not interfere with conventional narrowband and carrier wave transmission in the same frequency band.. 5