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

Title: DMP - Data Management Plan

Deliverable: D7.2

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Contents

1 Summary

The Data Management Plan (DMP) will provide a structure to cope with all data generated, collected and to be disseminated during SafeLog and after its completion. The DMP will describe the type and origin of data to be generated or collected, IPR policies, who will own and have access to the data, how the data will be handled, what facilities and equipment will be required, and who will be responsible for each of these activities. This task will ensure the necessary IPR protection, and that SafeLog background and foreground will be clearly communicated both within the consortium and to external stakeholders.

As the DMP is a living document, part of the task will also be its maintenance.

2 Policies for access and sharing

Table 2.1 shows the kind of data that will be collected during SafeLog. It indicates the sort of data, its format, the planned access to the data and the it's type (XML, MP4, etc.).

Table 2.1: Summary of digital output and planned access

No	Data	Format/Duration/size	Planned Access	Type
1	Position and orientation of a person's body obtained from Visual Odometry and IMU device(s)	*currently n/a*	Confidential but open access for dedicated data after anonymisation in the context of benchmarks for tracking.	XML
2	Velocity of the person based on the position differential	*currently n/a*	Confidential but open access for dedicated data after anonymisation in the context of benchmarks for tracking.	XML
3	Position and orientation of the person's head	*currently n/a*	Confidential but open access for dedicated data after anonymisation in the context of benchmarks for tracking.	XML
4	Gaze direction	*currently n/a*	Confidential but open access for dedicated data after anonymisation in the context of benchmarks for tracking.	XML
5	Video capturing using cameras attached to Safety Vest.	ROS bag file/30min/20GB	Confidential	e.g. MP4, ROS bag file
6	Video capturing using cameras attached to HMD.	MP4/30min/1GB	Confidential	e.g. MP4
7	Audio recording of voice	MP3/30min/60MB	Confidential	e.g. MP3
8	Safety Vest's self-test and diagnostics log.	*currently n/a*	Confidential	e.g. XML
9	Safety Vest's log of communication transactions with AGVs.	*currently n/a*	Confidential	e.g. XML
10	ESM's self-test and diagnostics log.	*currently n/a*	Confidential	e.g. XML
11	ESM's log of communication transactions with Safety Vest(s).	*currently n/a*	Confidential	e.g. XML
12	Node Position (Sticker with 9 DataMatrix on the ground)	Either on initialization or on demand with read ID	Confidential but open access for dedicated or made-up data in the context of benchmarks for path planning.	e.g. XML
13	Position or Pose of AGVs	*currently n/a*	Confidential but open access for dedicated or made-up data in the context of benchmarks for schedule planning.	e.g. XML
14	Position of racks	*currently n/a*	Confidential but open access for dedicated or made-up data in the context of benchmarks for schedule planning.	e.g. XML
15	Picker utilization (Time spend on searching, picking, scanning, waiting, walking)	*currently n/a*	Confidential, sensitive, private	db record

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Table 2.1: Summary of digital output and planned access (... continued)

No	Data	Format/Duration/size	Planned Access	Type
16	Robot utilization (Time spend on driving empty, driving loaded, waiting, idle, error, charging)	*currently n/a*	Confidential, private	db record
17	AGV history (Driven distance empty, driven distance loaded, number of pickup and drop operations, charging cycles, battery state)	*currently n/a*	Confidential, private	db record
18	Login information (Who is working at the pick station; Who is wearing the safety vest)	*currently n/a*	Confidential, sensitive, private	db record
19	Maintenance history (Who repaired when the robot? What was the issue?)	*currently n/a*	Confidential, sensitive, private	db record
20	Maintenance utilization (Time spent on arriving to the location, resolving the incident and leaving the location of the incident)	*currently n/a*	sensitive, private	db record
21	Traffic density as a function of time and space (robots and humans)	*currently n/a*	Confidential, private	db record
22	Alarm history (How long was an alarm active? What was the reason? Reported failures of AGVs, Safety Vests, pick stations, ...)	*currently n/a*	Confidential, private	db record
23	Rack history (Number of pickup and drop operations, travel distance, number of rotations during rack lifetime)	*currently n/a*	Confidential, private	db record

Note

The SafeLog consortium is considering to publish benchmark descriptions regarding typical application scenarios which do incorporate typical layouts of warehouse systems (place of pick stations, entry points, etc.), number of robots, number humans, orders, etc. which will be made public with corresponding results via the SafeLog site. With this it is intended to provide the possibility to compare planning algorithms and their results in the research community.

3 Policies for re-use, distribution

According to the informed consent all participants agreed that their data will be used only and exclusively for the implementation of the project SafeLog. Therefore the members of the consortium are well aware that a reuse of the data for implementing other projects or supporting the implementation of other projects is not permitted. Also it is not permitted to distribute the data to third parties for implementing other projects or supporting the implementation of other projects. The data will only be distributed within the members of the consortium and only if this is absolutely necessary to guarantee the implementation of the project. The participants gave their informed consent to this procedure.

As mentioned in Policies for access and sharing (see 2) the SafeLog intends to provide data in form of benchmarks and results. Data based on real human-robot interaction will be made public only if anonymisation can be guaranteed. If this can't be guaranteed made up data close to reality is planned to be provided.

4 Plans for data storage, archiving and preservation

After processing the data will be archived only to ensure a **Good Scientific Practice** and sustainable project results only in regard to the project SafeLog. Only when receiving justified inquiries concerning the project results the archived data will be used to validate the project results. In such a situation all data protection law relevant aspects will be considered and in the case of doubts the responsible data protection officers will be consulted. The data will be stored by the partner who collected the data in the first place and by those partners that can justify a need to process the data in order to achieve the results proposed in the Description of Action (DOA). Data will be archived only in internal and self-contained systems and not on external servers, and it will not be distributed to third parties offering storage services. The data will only be stored and will not be reused or distributed. As during the collection of the data particular caution will be taken to only store and archive data that was absolutely necessary for the project implementation. By giving informed consent all participants agreed to the procedures mentioned. The data will be stored for the same period of time records have to be kept according to the Grant Agreement, Art. 18.

The consortium is fully aware of the provisions set out by EU Directive 95/46/EC and will undertake any measures to fulfill the guidelines set out there. As soon as the new General Data Protection Regulation No. 2016/679 will be adopted (expected in May 2018) the Data Management Plan for "Safelog" will be reviewed and adjusted if necessary.

5 Consortium

5.1 Karlsruhe Institute of Technology

The Karlsruhe Institute of Technology (KIT) is a higher education and research organisation with about 10.000 employees, 25.000 students, and a total annual budget of about 750 million Euros. It bundles the missions of both precursory institutions: a university of the state of Baden-Württemberg with teaching and research tasks and a large-scale research institution of the Helmholtz Association conducting program-oriented provident research on behalf of the Federal Republic of Germany. Within these missions, KIT is operating along the three strategic fields of action of research, teaching, and innovation.

In establishing innovative research structures, KIT is pursuing joint strategies and visions. KIT is devoted to top research and excellent academic education as well as to being a prominent location of academic life, life-long learning, comprehensive advanced training, exchange of know-how, and sustainable innovation culture. KIT's research profile is characterised by a strong focus on information and communication technology, energy technology and mobility. It has significant competencies in the fields of optics and photonics, climate and environment, and the inter-relations of humans and technology. It hosts a significant number of infrastructures of federal or European importance.

KIT builds on the extensive experience its predecessors have gained in EC-funded research from more than 1000 projects up to now.

The **Intelligent Process Control and Robotics Lab (IPR)** is part of the Institute for Anthropomatics and Robotics (IAR) and covers a vast variety of robotic and automation areas. Research in the field of industrial automation comprises conception and realisation of sensor based autonomous robots for typical tasks in production. Another area is safe human robot co-operation integrating multiple sensors and novel interaction techniques. Further activities consist of designing modular control and diagnosis systems for robots, robot cells and plants based on multi-agent architectures.

FORscience is the central Proposal and Project Management Service at KIT. Established in 2009, it pools KIT's many years of experience in project management. The Project Management Office thus offers professional expertise in all aspects of project management. Its members have substantial experience in supporting EU and other projects from proposal phase to execution, including for example the FP7-CP DACCIWA and the Horizon2020-FoF ProRegio, for both of which FORscience serves as the PMO.

Role

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** 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** with the corresponding relations to the other work packages.

5.2 Swisslog Automation GmbH

Swisslog is one of the leading companies for automation and logistics solutions. For many years Swisslog has been a technological leader in many industrial sectors and has been exploiting innovative solutions for its customers. The portfolio of Swisslog comprises

- Intelligent material handling, production, and automation technologies
- Conveyor systems for light goods and pallets
- Shuttle systems and cranes
- Storage and Robot systems for automated case picking
- Automated Guided Vehicles
- Production lines and equipment for building materials
- Modular Warehouse Management and Control Systems

Swisslog is eager in participating in this project as Swisslog sees a big chance in exploiting the fast growing logistics automation market by state-of-the-art goods-to-man systems. Swisslog however wants to support European research to give this research an industrial platform.

Role

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.

5.3 Czech Technical University in Prague

The CZECH TECHNICAL UNIVERSITY IN PRAGUE (CVUT), founded in 1707, is one of the oldest technical universities and currently the leading technical university in the Czech Republic with approx. 23000 students enrolled in engineering courses. With over 1700 members of academic staff is also one of the largest research institutions in the Czech Republic. The Czech Institute of Informatics, Robotics, and Cybernetics (CIIRC) that will participate in the project is a new institute of CVUT founded in 2013 with the aim to concentrate an excellent research in the fields robotics, intelligent, distributed and complex systems, automatic control, computer-aided manufacturing, bioinformatics, biomedicine and assistive technologies. The key researchers of CIIRC have come from the Department of Cybernetics, Faculty of Electrical Engineering of CVUT this year, which is recognized as an outstanding research centre at the CVUT. In 2000 the department received the "EU Centre of Excellence"' award and in 2006 the prestigious European IST Prize by the European Commission. The Department includes over 80 academic staff and researchers, and over 30 Ph.D. students. The research focus covers the areas of intelligent mobile robotics, computer vision, artificial intelligence, biomedical engineering, and multi-agent systems. The department has been actively involved in scientific collaboration with international partners via various types of research programmes namely FP7/FP6/FP5 programmes. The Department has a strong industrial experience in providing research and development, training services and customized solutions to international industrial partners (e.g. Robert Bosch GmbH, Rockwell Automation, SKODA AUTO/Gedas CR, CADENCE, DENSO Automotive, BAE Systems). Additionally the department extensively collaborates with the defense industry (European Office for Aerospace Research and Development, US Air Force Research Laboratory, US Office for Naval Research and Army Research Laboratory).

Intelligent Mobile Robotics divison (IMR) (http://imr.felk.cvut.cz) will be involved in the project. This unique laboratory founded in 1993 and headed by Dr. Libor Preucil since, steadily builds

excellence in mobile and intelligent systems and robots and stand for major stakeholders in the field in the Czech Republic. Recently, he co-founded **Center for Advanced Field Robotics (CAFR)** (http://lynx1.felk.cvut.cz/cafr) bringing together main robotics research labs and industry in the Czech Republic. Dr. Libor Přeučil is going to supervise herein suggested project and will assure the top level quality research within.

Role

CVUT will lead **WP3**. 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** as well as specification and requirement analyzis **WP1** and integration **WP6**.

5.4 University of Zagreb, Faculty of Electrical Engineering and Computing

The **UNIZG-FER** (http://www.fer.unizg.hr/en) is the highest-quality member of the University of Zagreb, with a large and modern infrastructure devoted to research-based education. Currently UNIZG-FER participates in more than 20 projects financed by EU through various grant schemes (HORIZON 2020, FP7, IPA, COST, etc.). With 170 professors, 220 graduate teaching and research assistants, 4.000 students enrolled in various programs, and operating in facilities of more than 40.000 m2, UNIZG-FER is the largest and leading educational technical and R&D institution in the fields of electrical and computer engineering and computer science in Croatia. UNIZG-FER is organised in 12 Departments which represent the focal points of education and R&D. Research related to this project will be carried out at the Department of Control and Computer Engineering (DCCE) by the Autonomous Mobile Robotics group (AMOR group, http://act.rasip.fer.hr/groups_amor.php).

The AMOR group has a long tradition in research of advanced control strategies and estimation techniques and their application in autonomous navigation of ground and aerial robots in unknown and dynamic environments. The major research activities of the group include: Simultaneous Localization and Mapping (SLAM), Detection and Tracking of Moving Objects (DATMO) and Motion Planning and Control (MPAC). The Group currently consists of 3 Postdocs and 5 PhD students directed by Prof. Ivan Petrović. Laboratory of the AMOR group is equipped with state of the art ground mobile platforms, aerial vehicle, sets of advanced perception sensors, flying arena, etc. The group coordinated the major national robotic research program "Intelligent robotic systems and autonomous vehicles" (2007-2014), which involved 5 major robotic research groups in Croatia. The group has also a long tradition of collaboration with research centres in the EU and worldwide. Currently, Professor Petrović, the head of the AMOR group, is coordinating the EU project "ACROSS - Centre of Research Excellence for Cooperative Robotic Systems" (http://across.fer.unizg.hr), which involves 14 research groups from the University of Zagreb and 16 research institutions from 10 European countries. AMOR group recently successfully organised two robotic conferences: (1) the 4th European Conference on Mobile Robots - ECMR'09 (www.ecmr09.fer.hr) and (2) the 10th IFAC Symposium on Robot Control - SYOROCO 2012 (http://www.syroco2012.org).

Role

UNIZG-FER will lead **WP2**. 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**, localization and human intention recognition in **WP4**, specification and requirement analyzis in **WP1** and integration in **WP6**.

5.5 Fraunhofer IML

The Fraunhofer Institute for Material Flow and Logistics (IML) has been tackling logistic tasks, mainly the process, hardware and software development for internal and external logistics. The IML turnover consists of more than 50% of industrial contracts for software development in different logistical applications, supply chain consulting and R&D of novel logistical solutions. Knowledge acquired from funded projects is directly transferred in industrial contracts. So made-to-measure arranged teams create cross-industry and customer-specific solutions in the area of materials handling, warehouse management, supply chain management, simulation supported business and system planning and also traffic systems, closed loop economy, resources logistics, building logistics and e-business. IML is said to be first address for all questions with respect to holistic logistics, the employees work on all fields of internal and external logistics. At the Institute, founded in 1981, there are at the moment 200 employees as well as 250 post-graduates, supported by colleagues in workshops, laboratories and service areas.

Role

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**. 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**.

5.6 KONCAR - Electrical Engineering Institute Inc.

KONČAR – Electrical Engineering Institute (www.koncar-institut.com) is a leading Croatian industrial institute involved in R&D of equipment and technologies for efficient and reliable energy conversion and power transmission. As a result of a 50-year-tradition in applied R&D, KEEI has developed proprietary solutions for monitoring systems (transformers, electrical rotating machines, bay/switchyard, wind turbines), off-grid power supplies as well as platforms for design of demanding embedded HW/SW systems (including safety related SIL4 platforms). KEEI has been involved in several European and national R&D grant schemes (EUREKA, Proof of Concept (PoC), IPA, ERDF etc.) and has a lot of experience in implementation of various R&D projects. Currently there are 164 employees at KEEI, it is organized in 6 departments and its premises occupy 13.000 m2. In the frame of 6 departments there are specialised R&D sub-departments and 9 well-equipped laboratories which are used for R&D support, testing and diagnostics. In July 2014 KEEI became a Notified Body of the European Commission for several important EC directives (low voltage equipment, machinery, EMC, radio and telecommunications terminal equipment, appliances burning gaseous fuels, pressure equipment and personal protective equipment). Research related to the proposed project will be carried out by Control, Renewables & Power Electronics Department. This Department employs 30 experts and offers extensive knowledge in design, development and testing of industrial embedded control systems (HW and SW components), renewable energy solutions and power converters used in traction and energy applications.

Control, Renewables & Power Electronics Department: The Department is specialized in design, development and testing of industrial embedded control systems, renewable energy systems and power converters. It develops HW and SW components for industrial embedded control systems and complete systems for highly demanding applications such as rail vehicles and power engineering. Based on initial

technical and functional requirements, the Department prepares complete production documentation, performs various tests (type/serial) and eventually provides product life-cycle management. The Department has successfully developed railway crossing safety platform SIL 4 which was positively assessed by TÜV according to EN50126, EN 50128 and EN50129.

Role

KEEI will lead **WP5**. 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**. 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

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, 6, 9, 12

EMC

Electromagnetic compatibility: Electromagnetic compatibility is the branch of electrical sciences which studies the unintentional generation, propagation and reception of electromagnetic energy with reference to the unwanted effects (Electromagnetic interference, or EMI) that such energy may induce. The goal of EMC is the correct operation, in the same electromagnetic environment, of different equipment which use electromagnetic phenomena, and the avoidance of any interference effects - Wikipedia.. 11

HMD

Head-mounted display: A head-mounted display (or helmet-mounted display, for aviation applications), both abbreviated HMD, is a display device, worn on the head or as part of a helmet, that has a small display optic in front of one (monocular HMD) or each eye (binocular HMD).. 5

IMU

Inertial Measurement Unit: Sensor with 3 gyroscopes, 3 accelerometers and often magnetometers capable of measuring velocity, angular velocity and acceleration on all three axes (X, Y, Z) together with orientation from magnetometers.. 5

PMO

The Project Management Office: The project Management Office consists of personnel from KIT FORScience (cf. description of KIT). 8

ROS

Robot Operating System: Robot Operating System (ROS) is a collection of software frameworks for robot software development, (see also Robotics middleware) providing operating system-like functionality on a heterogeneous computer cluster. ROS provides standard operating system services such as hardware abstraction, low-level device control, implementation of commonly used functionality, message-passing between processes, and package management.. 5

SIL

Safety Integrity Level: Safety integrity level is a relative level of risk-reduction provided by a safety function, or a targeted level of risk reduction. In other words, SIL is a measurement of performance required for a safety instrumented function.. 11, 12