Grant agreement no: FP7-600877

SPENCER:

Social situation-aware perception and action for cognitive robots

Project start: April 1, 2013

Duration: 3 years

DELIVERABLE 7.3

Final dissemination material and exploitation plan

Due date: month 36 (May 2013)

Lead contractor organization: BLUE

Dissemination Level: PUBLIC

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Contents

1 Introduction

This deliverable describes the activities in dissemination and exploitation of SPENCER results and proposes a plan whose goal is to maximize the project's impact during and beyond its life-time.

Summarizing, the SPENCER consortium has generated excellent impact scientifically, in terms of media coverage and regarding exploitation. In total, the consortium published 61 scientific papers, submitted 35 project deliverables, and organized an IROS workshop on social norms in robotics. We created the SPENCER web page, Wiki, brochure, YouTube channel, common code repositories, and for the final demonstration, prepared a comprehensive press kit with factsheet, Q&As, professional pictures and video footage and published several press releases. The project got worldwide press coverage with more than 150 articles in online and printed press including appearances in TV and radio interviews. Notable exploitation outcomes are that SPENCER has helped partner BLUE to expand its business in the aviation industry and the transfer of people and know-how to Bosch Research.

2 Public dissemination

In addition to the previously reported creation of the usual dissemination channels such as SPENCER web page, YouTube channel or project leaflet, we focussed in the final project phase on the preparation of the final deployment and demonstration of the SPENCER robot at Schiphol Airport. To this end, we took several measures, including:

- Dedicated press page on the SPENCER web site,
- Press kit with SPENCER fact sheet and Questions & Answers document,
- Professional video footage and photos, and
- Several coordinated press releases.

After the surprisingly successful press release on the first deployement at Schiphol Airport during Integration Week IVb in Dec 2015 (over 100 articles mainly in the online press, see below), we anticipated an even large press echo for the final deployment. Thus, the consortium prepared a very detailed communication and demonstration plan with the purpose to ensure a smooth ride through the intensive final deployment phase which consists of the final integration week V, the final SPENCER Steering Board meeting, the final review meeting with demonstrations and a press event. The document is structured as follows:

- Transportation of the robot to Schiphol airport: details on arrival, security check, transport to deployment site
- Preparatory work: behavior guidelines for the team when deploying the robot in the terminal building in terms of passenger behavior and safety and Schiphol Airport security
- Film/photo session: plan, timing and instructions for film crew and photographer
- Review meeting: procedures, demonstration details, timing
- Media day and press event: procedures, timing, communication contents, guidelines for all project partners for the sake of a consistent communication towards the press
- Contacts and participants: invited press, KLM and consortium contacts

- Permits: for reviewers, PO and press.
- Working and storage space: details on the place where the robot is stored and charged during the night.

2.1 Press Page on SPENCER Web site

In conjunction with the final demonstration, a dedicated press page was created to provide an overview of the SPENCER project and offer professional dissemination and press material. The objective of the press page is to provide easy and quick access to essential project information for the general public. The press page went online in a concerted fashion together with all press releases on the afternoon of March 29, 2016.

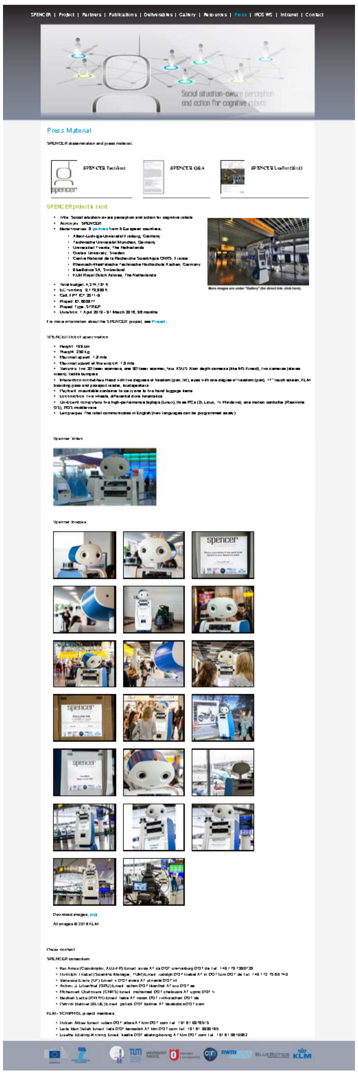

Figure 1: The Press page on the SPENCER web site

The press page offered a comprehensive press kit which includes: factsheet, Q&As, SPENCER leaflet, short description of the project and the robot, professional high-resolution video and photo material and the press contacts of the consortium (see Fig 1):

SPENCER Factsheet contains information about the project in a form that is accessible by the general public, which include basic data, abstract, summary of the planned demonstration at Schiphol, a brief description of the robot, partners, the work plan, and contacts. The SPENCER fact-sheet is shown in Fig 2.

SPENCER Questions & Answers gives answers to the most frequent questions about SPENCER. The Q&A sheet is also intended for the general public and provides more detailed information about the project than the fact sheet. It includes a brief description of the scientific achievements, safety considerations and a list of remaining challenges. The Q&A is seen in Fig 3.

SPENCER leaflet contains a brief, popular summary of the project, the list of the partners and contact information with a link to the SPENCER web site. The leaflet has been available since M12 and was intended as a first step for someone interested in SPENCER. A more detailed description of the leaflet is given in Deliverable 7.2.

SPENCER video and images are professionally produced. They show the SPENCER robot and how it interacts with passengers at Schiphol Airport and guides passengers to the right gate with information obtained from reading the boarding pass. The robots' social situation awareness in the complex environment of an airport is also demonstrated, *e.g.* where the robot recognizes a group of people and avoids cutting through the group or where the robot adapts its speed to suit the group it guides. The video and images can be seen and downloaded from the press page (http://www.spencer.eu/press.html). The video is also on YouTube where it got already over 19,000 views and 115 likes (https://www.youtube.com/watch?v=ir_Ku4rCOO8).

2.2 Press Appearances

2.2.1 Final Press Releases on March 29, 2016

The publication of the press releases was made in a concerted action among all partners to avoid information leaks and provide a consistent face of the project toward the press. They were all released at the same time in the afternoon on March 29, 2016. We give an excerpt from the English version:

> *"We are excited to have realized and present SPENCER which is the first socially-aware robot that has ever been deployed at an airport. What makes SPENCER unique is that it can deal with social situations between people. It can 'see' and analyze people nearby with its sensors. It reasons about possible social relations between people like whether they are a family or group. It also learns about and then complies to social rules and act in a human-friendly way. These abilities are important for many intelligent service robots to be used by people such as future household robots, collaborative factory assistants, or self-driving cars. Guiding people at an airport is a good example of a challenging everyday problem. It is a very busy environment with*

Project SPENCER: Factsheet

SPENCER project in short

Title: Social situation-aware perception and action for cognitive robots
Acronym: SPENCER
Beneficiaries: 8 partners: 6 university and 2 industrial partners from 5 European countries
Total budget: 4,274,181 €
EC funding: 3,179,933 €
Project ID: 600877
Project Type: STREP
Call: FP7 ICT 2011-9
Duration: 1 April 2013 – 31 March 2016, 36 months
Project Website: http://www.spencer.eu
Press Material: http://www.spencer.eu/press.html

Abstract

SPENCER is an EU-funded research project that is motivated by the increasing number of robots that share a space with people, for example, in our homes, work places, care facilities, factories or city streets. Such robots face a variety of new and fundamental research questions like: how should machines perceive and analyze humans with their sensors? How can they learn, understand and reproduce human social behavior? How should robots reason about actions, plan movements and communicate with humans in a way that users find them pleasant and productive?
By addressing these questions jointly and in an international multi-disciplinary team, the SPENCER consortium breaks new ground for understanding human-robot relationships in populated environments and for designing effective cognitive systems that operate robustly and safely among humans.

Demonstration at Schiphol Airport

KLM, the end-user in the consortium, believes that robotics will have a growing impact on air transport in the coming years. One example for which the technologies developed in SPENCER are highly relevant is the area of ground passenger services. At their home base Schiphol Airport, up to 80% of passenger traffic is due to transfer passengers whose efficient handling is a significant operational challenge. Every day, there are passengers that miss their connecting flight due to short disembark-embark times, wayfinding problems, or language and alphabet barriers. To help these people, SPENCER's tasks include guidance of short-transfer passengers to their destination e.g. from/to the Schengen barrier or from/to their gate of arrival or departure. The deployment is an excellent benchmark of the research developed in SPENCER given the demanding nature of airports as highly populated environments and has a large exploitation potential within and beyond the aviation industry.

SPENCER Robot

The SPENCER robot was designed, built and integrated during the project.

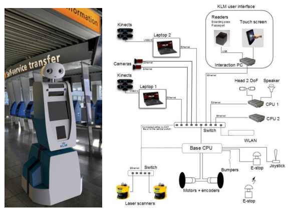

Figure 1: Design and Hardware Architecture

- **Height:** 193 cm
- **Weight:** 250 kg
- **Maximal speed:** 1.8 m/s
- **Speed at the airport:** around 1.0 m/s
- **Sensors:** two 2D laser scanners, one 3D laser scanner, four ASUS Xtion depth cameras (like MS Kinect), two cameras (stereo vision), tactile bumpers
- **Interaction modalities:** Head with two degrees of freedom (pan, tilt), eyes with one degree of freedom (pan), 17" touch screen, KLM boarding pass and passport reader, loudspeakers
- **Payload:** mountable container to carry one to two hand luggage items
- **Locomotion:** two wheels, differential drive kinematics
- **On-board computers:** two gaming laptops (Linux), three PCs (2x Linux, 1x Windows), one motion controller (Real-time OS), ROS middleware.
- **Languages:** The robot speaks English (new languages can be programmed easily)

Description of project partners and their role

1. Albert-Ludwigs-Universität Freiburg, Germany (Coordinator, ALU-FR)
The Social Robotics Laboratory (SRL) within the Computer Science Department of the University of Freiburg is headed by Prof. Dr. Kai Arras. The lab is concerned with technologies for perception, learning, estimation, and planning in the context of socially enabled cognitive systems. Within SPENCER, SRL develops technologies for detecting, tracking and analyzing people and groups of people as well as learning human behavior models for socially-aware motion and interaction planning. Prof. Arras is the project coordinator of SPENCER.
Competences Related to SPENCER: Range-based people and group detection and tracking (WP4, WP3), Perception and learning (WP2, WP4), Human activity modeling (WP5), System specification and integration (WP1), Management (WP8)

2. Technische Universität München, Germany (TUM)
The TUM Computer Vision Group, headed by Prof. Dr. Daniel Cremers, is focused on a range of topics in computer vision, image analysis and pattern recognition. Over the years, the group has developed novel convex optimization methods to solve a number of problems including image segmentation, image denoising, image-based 3D reconstruction, shape matching and optical flow estimation.
Competences Related to SPENCER: Unsupervised object detection (WP2), Online estimation of dynamic objects (WP2), 3D mapping and SLAM (WP2).

3. Universiteit Twente, The Netherlands (UT)
The Human Media Interaction group, headed by Prof. Dr. Vanessa Evers, is part of Computer Science Department. The focus of the group is on intelligent multimodal human computer interaction.
Competences Related to SPENCER: Social signal processing (WP2), Human-robot interaction (WP4 and WP6), User experience evaluation (WP4 and WP6), Cross-cultural human robot interaction (WP4 and WP6).

4. Örebro University, Sweden (ORU)
The AASS Mobile Robotics and Olfation Lab, headed by Prof. Achim J. Lilienthal, has a focus on perception systems for mobile robots that operate in an unconstrained, dynamic environments. The developed approaches typically address real-world needs and are characterized by fusion of different sensory modalities. In addition to the scientific activities, the group is interested in transferring research results into industrial demonstrators.
Competences Related to SPENCER: SLAM and navigation in dynamic environments (WP2), Semantic mapping (WP2), Navigation (WP5), 3D perception (WP2).

5. Centre National de la Recherche Scientifique CNRS, France (CNRS)
The Laboratoire d'Analyse et d'Architecture des Systemes (LAAS) is a laboratory of CNRS, the French National Organisation for Scientific Research. Research at CNRS-LAAS covers automatic control, computer science and engineering, and microelectronics. The Robotics and Artificial Intelligence Department, the largest in France, is active in research on intelligent and autonomous robotic systems. The team is composed of members from the Robotics and Interactions group.
Competences Related to SPENCER: Human-aware motion planning (WP5), Decisional issues in human-robot interaction (WP5), Architectures for cognitive and interactive robots (WP1 and WP5), Software system specification and integration (WP6).

6. Rheinisch-Westfälische Technische Hochschule Aachen, Germany (RWTH)
RWTH is represented by the Computer Vision group headed by Prof. Dr. Bastian Leibe, which is part of the chair of Computer Science 8, Computer Graphics and Multimedia. The group is focusing on computer vision applications for mobile devices and robotics platforms and has gained substantial experience in visual object categorization, tracking, and in the interface between recognition and 3D reconstruction. Particular emphasis is placed on real-world applicability of the developed algorithms, which is an important prerequisite for robotics applications.
Competences Related to SPENCER: Computer vision (WP2 and WP3), Object recognition (WP2), Visual tracking (WP2), Figure-ground segmentation (WP3), Body pose estimation and articulated tracking (WP3).

7. BlueBotics SA, Switzerland (BLUE)
BlueBotics SA is a spin-off company of the Autonomous Systems Lab, EPFL. Founded in 2001 with the mission to market innovative and promising mobile robotics technologies, the company is now active in two segments based on autonomous navigation solutions: Automation and service robotics. With its portfolio, BlueBotics SA belongs to the most experienced companies in Europe when it comes to the specification, design and deployment of complex interactive robots in real-world environments.
Competences Related to SPENCER: Robot design (WP1), System integration (WP1), Exploitation and technology transfer (WP7), Robot navigation (WP5).

8. KLM Royal Dutch Airlines, The Netherlands (KLM)
KLM Royal Dutch Airlines is a worldwide airline company based in the Netherlands. KLM operates worldwide scheduled passenger and cargo services to more than 90 destinations. It is the oldest airline in the world still operating under its original name and has around 33,000 employees. It comprises the core of the KLM Group, which further includes KLM Cityhopper, transavia.com and Martinair. KLM works very closely with Air France within the AIR FRANCE KLM Group, which exists since the two companies merged in 2004. The AIR FRANCE KLM Group is Europe's leading Group in the Airline business.
Competences Related to SPENCER: Aviation industry end-user (WP1), Exploitation, public relations and dissemination (WP7).

Work Plan Structure

The project's work plan is divided into eight work packages:
(see www.spencer.eu/project.html for more details)

	Description	Respons.
WP1	Requirement Analysis, Platform Specification and Design	BLUE
WP2	Far-Range Perception: People and Object Analysis	TUM
WP3	Close-Range Perception: Human Attribute Analysis	RWTH
WP4	Group-Level Analysis and User Studies	UT
WP5	Behavior Learning and Planning	ALU-FR
WP6	System Integration, Deployment, and Evaluation	CNRS
WP7	Dissemination and Exploitation	ORU
WP8	Management	ALU-FR

Contact

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Figure 2: The SPENCER factsheet.

SPENCER Questions & Answers

What is project SPENCER about?

SPENCER is a European Union-funded research project that advances technologies for intelligent robots that operate in human environments. Such robots come in different sizes and shapes: guidance platforms at airports, domestic household assistance, care-takers for the elderly, collaborative production assistants in factories, or self-driving cars. Common to all of them is the need for new technologies that address questions such as: how should machines perceive and analyze humans with their sensors in order to act more naturally and unobtrusively? How can they learn and reproduce human social behavior? How should robots reason about actions among humans and communicate with users in ways that are socially-aware, safe, and efficient at the same time? By addressing these questions jointly and in an international multi-disciplinary team, the SPENCER consortium breaks new ground for understanding human-robot relationships and for designing effective cognitive systems in human-populated spaces. In short, SPENCER is about social robots "in the wild" – namely the extremely challenging environment of an airport.

Who is involved?

The project consortium consists of eight partners, six university partners and two businesses from five European countries:

1. Albert-Ludwigs-Universität Freiburg, Germany (coordinator)
2. Technische Universität München, Germany
3. Universiteit Twente, The Netherlands
4. Örebro University, Sweden
5. Centre National de la Recherche Scientifique CNRS, France
6. Rheinisch-Westfälische Technische Hochschule Aachen, Germany
7. BlueBotics SA, Switzerland
8. KLM Royal Dutch Airlines, The Netherlands

The project has been initiated by the university partners.

What will the robot do during the final demonstration?

SPENCER is a robot designed to help passengers find their way around the airport. KLM believes that robotics will have a growing impact on air transport in the coming years, for example for ground passenger services. At their home base Schiphol Airport, up to 70% of KLM's passenger traffic is due to transfer passengers whose efficient handling is a significant operational challenge. Every day, travelers miss their connecting flights for all sorts of reasons including delays, short transfer times, losing their way, and language barriers. To help these people, SPENCER guides transfer passengers along the shortest route to their departure gate. During the final deployment in March 2016, we will make tests with real passengers. This is a unique service, which we believe will lead to a new appreciation of the experience provided by KLM and possibly to a reduction of the number of passengers who miss their connection at Schiphol.

What's new in SPENCER?

Scientifically, SPENCER breaks new ground for cognitive systems in human environments. The scientific novelties are:

- **Social scene understanding for robots** by the abilities to perceive and analyze individuals and groups of people from on-board sensors and to recognize social relations, hierarchies and activities. These abilities enable the robot, for example, to detect people in its surrounding, estimate if they form a group and if yes, what the group is doing and who would be the best individual for addressing the group.
- **Learning socially normative behaviors for robots** by the abilities to acquire models of normative behaviors from demonstrated human behaviors and to use such models to plan its motions in human-friendly ways. These abilities enable the robot to be polite in the way it navigates among pedestrians. Couples or other groups of people, for instance, are not to be split up even if this was the shortest path for the robot to take. The robot also respects people's personal spaces. It can further decide to ignore social norms, for example, when it is guiding a group of transfer passengers in a rush.
- Other contributions include new ways to **learn maps of highly dynamic environments** that change over several time scales, to self-localize robots in such environments as well as **empirical experiments to assess the actual effects** of normative robot behaviors perceived by users.

SPENCER is the first socially-aware robot that has ever been deployed at an airport.

Where does the name SPENCER come from?

SPENCER is an acronym derived from the project's title **S**ocial situation-aware **PE**rceptio**N** and action for **C**ognitiv**E** **R**obots. SPENCER is the name of the project and the robot.

Are there other applications of SPENCER technologies, not at airports?

Yes, there are many of them. As is typical for EU-funded projects, SPENCER addresses fundamental research questions beyond a specific use-case. As there is a larger trend towards robots that share a space with people in domestic, professional, or urban environments, the technologies developed in SPENCER can be applied to a variety of cognitive systems in human environments. Examples include: domestic household robots, self-driving cars, robots in care facilities, collaborative production assistants in factories, transportation platforms in intralogistics, etc. All these robots need to perceive, analyze and model people in their surrounding, make predictions about their future actions, reason on their own actions and learn their probable effect on humans -- key challenges addressed in SPENCER.

Why is KLM part of this project and with its role?

KLM is the end-user in the project and provides a use-case which is both business-relevant and challenging for the technology developments of the university partners.

KLM's motivation to be part of SPENCER is a strategic one: the advent of robotics is an important development, for which the company has to be prepared. KLM is of the opinion that robotics will have a growing impact on air transport in the coming years. KLM is testing technologies in several areas to assess if and how robotics would enhance their services.

These developments are wholly in line with KLM's objectives with regard to innovation as one of the cornerstones of strategy. At KLM, the chief purpose of robotics will be to offer staff and customers even better support using innovative technologies.

Is it safe to operate a robot in such a crowded area?

Yes. For the consortium safety is the most important element of all. We have conducted many tests on robot safety using standard practices and protocols and improved the robot's hardware and software. All tests were successfully passed – a prerequisite for us to deploy the robot in a human-populated environment such as Schiphol Airport. In addition to the measures taken to make the robot safe, during the tests in March 2016, there is always a human operator near the robot with a remote emergency button to shut down the robot instantly.

What can you say about its trial run at Schiphol Airport in December 2015?

After a series of tests at the partner locations in Toulouse (F) and Freiburg (D), SPENCER was deployed at Schiphol Airport for the first time in end of November/December 2015. The airport is a particular complex and challenging environment for robots: changing light conditions and difficult surfaces in glass are problematic for its sensors, dense and highly dynamic crowds of people are a challenge for its perception, cognition and planning algorithms, and gate areas and walk-in shops that change their look several times per day pose challenges to its mapping and localization components. SPENCER was first overwhelmed by these difficulties and only many night shifts later, we had a fully working platform. The insights gained in these tests have enabled the consortium to further improve the robot and prepare for the final demonstration in March 2016.

Why a robot and not a navigation systems such as the ones in mobile phones?

Navigation systems in mobile phones do not work indoors, and only a robot could transport luggage, for example, and provide a unique user experience.

Also, a mobile robot is much more convenient than a navigation system on a phone: you only have to follow it, and you can use your phone for other things. Guidance is intuitive. Interpreting the instructions of a navigation system requires more attention than just following a robot. An autonomous robotic platform can address and guide groups simultaneously. Furthermore, a mobile robot gives the provider the opportunity to keep all services on his side, e.g. no app must be downloaded and installed, software maintenance and versioning is easier, etc.

What happens after the project ends?

The outcome of a research project like SPENCER is typically not a market-ready product but a prototype suited to conduct scientific experimentation and first proof-of-concept tests. The consortium, and in particular end-user KLM, will evaluate the robot thoroughly during and after the final demonstration. Depending on the outcome, KLM will determine with the project partners how to proceed.

What challenges remain?

At the end of SPENCER we have gained unique insights into the research questions we initially sought to answer. At the same time we are seeing plenty of even more intriguing questions for future research. They include soft mobile robots which are a class of robots made of soft materials. The robot would imitate a key feature of the human body, namely cushioning and compliance which would render it safer and would allow for even higher operational speeds among humans. Another line of work is an even more powerful perception of the robot's social context towards a deep understanding of what could be called social scene understanding. The difficulty with robots versus, for instance, networks of stationary overhead cameras like in visual surveillance, is that the robot senses the world from a shaky first-person perspective with limited sensing and limited onboard computing but loads of objects and people that occlude each other. Understanding context is key for reproducing socially compliant robot behavior: in very dense crowds, for instance, physical contact may be tolerated to some degree whereas in spaces with few people it is considered awkward. Speaking of context, cross-cultural aspects play a very important role in the design of socially normative robots which we have not systematically addressed in SPENCER. Of course, we see new research challenges also along the lines of more cognition, learning, interaction and navigation.

What needs to be done to make SPENCER a product?

Another great challenge is a commercialization of the SPENCER robot in case of a positive evaluation at and after the final demonstration at Schiphol. This would require to make the robot cheaper, safer, more light-weight, and smaller. We would have to make our algorithms more robust with fewer sensors and less computing power while interaction with the robot would have to be even more appealing. We have learned many lessons in SPENCER on how to do that. The gained insights enable us today to specify and prioritize many of the remaining open points.

How interactive is the SPENCER robot?

The robot carries a boarding pass reader which provides names and travel destinations of the passengers that interact with the robot. A touch screen shows additional information, such as time and distance to their gate. Then, during movements, the robot uses its head and eyes to communicate motion intent -- which was particularly appreciated by the participants in our studies. SPENCER communicates in English and can beep but currently uses those modalities only to excuse itself when it is blocked or if surrounding people cause the robot to take a large detour.

Engaging more sophisticated verbal interaction with the robot was not the focus of the project and would also be hard in a multicultural, noisy environment like an airport. Finally, the robot's task is guidance of transfer passengers who have to catch a connecting flight under time pressure. We believe that designing a chatty companion in this case would be the wrong interaction design approach.

Will SPENCER replace people?

No. SPENCER is a result of a research project and it is not near commercial use. We still need to do some more research and testing, before we can consider how to go further.

Figure 3: The SPENCER Questions & Answers document.

many people and there is a lot of time pressure while the robot has to operate safely and in a socially acceptable way."

The list of individual press releases by the SPENCER partners, including their links, is as follows:

- **ALU-FR:** news.tf.uni-freiburg.de,
- **UT:** www.utwente.nl/en/news,
- **ORU:** www.mynewsdesk.com/se/orebrouniversitet/,
- **CNRS:** news.cnrs.fr/articles,
- **KLM:** news.klm.com.

The press releases generated substantial media interest and a large number of articles in printed and online press. We give a very small selection. For a more comprehensive list, in particular of online press articles about the project, we invite the reader to search the web for "spencer robot schiphol".

Print Media

- Freiburger Wochenbericht, Hier kommt SPENCER, April 6, 2016,
- Hamburger Abendblatt, Roboter begleitet Passagiere durch den Flughafen, April 6, 2016,
- Staatsanzeiger Baden-Württemberg, April 22, 2016,
- Saarbrücker Zeitung, Roboter Spencer weist den Weg, April 13, 2016 [URL],
- TechnologyReview, KI: Roboter bringt Passagiere zum Gate, May 2016,
- iX Magazin, Roboter mit sozialer Kompetenz, April, 28 2016,
- Badische Zeitung, Echte Macher - Roboter nehmen Menschen viel Arbeit ab und werden ihnen auch immer ähnlicher, April 30 2016, [URL],
- Alb Bote Münsingen, Roboter zum Abheben, April 04 2016 [URL],
- de volkskrant, Een robot als vliegveld-gids, vogelvoer en efficiënt stapelen, April 2, 2016,
- De Ingenieur, Sociale robot op Schiphol, March 30, 2016,
- Metrotime, A laéroport dAmsterdam, Spencer le robot guide ses premiers passagers, April 3, 2016,
- Svt, Roboten Spencer testad på flygplats, March 30, 2016.

TV

- TV appearance in German 3sat show nano, April 29, 2016, "Roboter unter Menschen - Spencer weist den Weg", [URL] (between minute 2:00 to 7:00, see Fig. 4),
- TV appearance in German SWR Landesschau Baden-Württemberg, April 22, 2016, "Ein Roboter mit Sozialkompetenz", [URL] (see Fig. 4),
- SPENCER will be shown by German science TV show Galileo, ProSieben (shooting done, air date pending),

Radio

- German Radio Regenbogen on March 30, 2016, "Hilfe und Begleitung an Flughäfen".
- Radio live interview with coordinator by KölnCampus Radio on April 4, 2016,

Figure 4: Example frames from the German science TV show nano and the SWR Landesschau.

2.2.2 Press Release in November/December 2015

In conjunction with the first robot deployment during Integration Week IVb at Schiphol airport from November 30, 2015 to December 3, 2015, a short press release generated a significant interest from public media. As a result more than 100 newspaper articles were published in several European countries, mainly in the online press. Articles appeared in counties all over the planet, e.g. in Europe, the US, Pakistan, India, Mexico, China, or Japan.

A collection of the articles from *both* press releases can be found at the internal web page http://www.spencer.eu/internal/index.html under “SPENCER Newspaper articles”.

3 Scientific Dissemination

3.1 Publications

In total 61 publications were accepted: 11 in 2013 (1 journal, 8 conference and 2 workshop papers), 20 in 2014 (2 journal, 16 conference and 2 workshop papers), 21 in 2015 (18 conference papers, 2 workshop papers and 1 technical report) and 9 in 2016 (8 conference papers and 1 book chapter). The papers are listed below. A continuously updated list of SPENCER publications is also available under http://www.spencer.eu/publications.html.

The publications accepted over the whole project are:

2016

1. O. Islas, G. Varni, M. Andries, M. Chetouani, R. Chatila Modeling the dynamics of individual behaviors for group detection in crowds using low-level features. Proc. IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN) 2016, to appear.
2. O. Islas, H. Khambhaita, R. Chatila, M. Chetouani, R. Alami Robots Learning How and Where to Approach People. Proc. IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN) 2016, to appear.
3. A. Narr and R. Triebel and D. Cremers. Stream-based Active Learning for Efficient and Adaptive Classification of 3D Objects. Proc. IEEE Int. Conference on Robotics and Automation (ICRA), 2016, to appear.
4. Linder and K.O. Arras. People Detection, Tracking and Visualization using ROS on a Mobile Service Robot. Robot Operating System (ROS): The Complete Reference. Springer Studies in Systems, Decision and Control, 2016.
5. Lu Zhang and Hayley Hung. Beyond F-formations: Determining Social Involvement in Free Standing Conversing Groups from Static Images. Proc. IEEE conference on computer vision and pattern recognition (CVPR), Las Vegas, 2016, to appear.
6. S. Breuers, S. Yang, M. Mathias and B. Leibe. Exploring Bounding Box Context for Multi-Object Tracker Fusion. IEEE Winter Conference on Applications of Computer Vision (WACV), 2016.
7. Palmieri L., Koenig S. and Arras K. O. RRT-Based Nonholonomic Motion Planning Using Any-Angle Path Biasing. Proc. IEEE Int. Conference on Robotics and Automation (ICRA), 2016.
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3.2 Data Sets

Finally, at the resources page of the SPENCER web site, http://www.spencer.eu/resources.html, we have made available two new data sets, “RGB-D Human Attributes” and “Idiap Poster Data”. In addition, software was included related to the paper “Biternion Nets: Continuous Head Pose Regression from Discrete Training Labels” in addition to the open-source github repository of SPENCER at .

Due to privacy reasons, we cannot publish any of the data sets collected at Schiphol Airport. Screen shots with blurred faces are used in our scientific papers but video footage or sensory data contain passenger data (mainly images) for which we have no given consent for any form of dissemination.

4 Exploitation

This section describes the activities of the SPENCER consortium under lead of partner BLUE regarding the exploitation of SPENCER results. We systematically identify exploitable results from the consortium partners using a questionnaire approach and propose an exploitation plan based on the results of many interactions with potential end-users of SPENCER technologies.

Highlights of the exploitation activities are that SPENCER helped BLUE to expand their business in the aviation industry by partnering with SITA, a major player in this market, for a new project and a novel service robot and that several key personnel of SPENCER have been hired by Bosch Research. Negotiations on the acquisition of the SPENCER platform and the transfer of foreground is ongoing.

4.1 Discussions with End-Users

BLUE organized several multi-lateral discussions potential end-users of SPENCER technologies mainly including KLM, Geneva Airport and SITA.

4.1.1 KLM

KLM, being a SPENCER partner and a major European airline would be an ideal partner for exploitation of SPENCER results. Clearly, BLUE alone will have difficulties to sell robotic products

Figure 5: BLUE's "Robbi" robot in the luggage claim area of Geneva Airport.

and services without partnership with a big player that has the necessary brand name, domain knowledge and market experience.

After the good collaboration within SPENCER, discussions between KLM and BLUE are ongoing and hopefully lead to the start of a collaboration. However, decisions have not been taken at this point.

4.1.2 Geneva Airport

BLUE was already in contact with Geneva Airport prior to the SPENCER project. This collaboration resulted in the development of a service robot called Robbi developed by BLUE for Geneva Airport which was first deployed in the luggage claim area of the airport in 2013. The task of Robbi was to guide passengers to dedicated places such as currency exchange offices, train ticket machines, special luggage desks, or toilets. Later, the robot was also used in the transit zone to entertain and guide passengers. Refer to https://www.youtube.com/watch?v=_L5BdMtbQMA for a video of Robbi.

A meeting was held in February 2016 at Geneva Airport with representatives from the airport and SITA, a major aviation industry player and supplier of airport technology. The representatives from Geneva Airport were very enthusiastic, and very happy to see the results of SPENCER. They suggested different scenarios at Geneva airport with the SPENCER robot which are given below in this document. They are open to share ideas and concepts with SPENCER researchers in case of any follow-up activities. SITA was also very interested in the developed technologies both on a component-level and on the level of the entire system. With their worldwide position in the aviation industry, SITA is an ideal partner to industrialize SPENCER technolgies.

4.1.3 SITA

Indeed, a collaboration with SITA led to new business for BLUE. Since the deployment of Robbi at Geneva Airport, BLUE had several discussions with SITA. SITA also helped SPENCER by supplying the boarding pass readers for free mounted on the SPENCER platform. In 2016, SITA mandated BlueBotics for the development and production of a new baggage transportation robot "Leo".

Figure 6: Leo in Terminal 1 at GVA.

LEO's mission is to take the luggage check-in and drop process out of the airport terminal to reduce the flow of passengers with luggage within the airport. The robot waits for a passenger outside in front of the terminal building. It is equipped with a so-called "Scan and Fly" device, a device allowing the passenger to perform the bag-drop procedure by him or herself. When the luggage container door opens, the passenger loads the luggage and Leo print his luggage tag. The platform then moves autonomously to the unload station in the secured area of the airport and the passenger is free to walk through security control to go airside.

The platform was presented at Geneva airport on 10th May 2016 as a World premiere. It was then presented on 24th-26th May at the SITA IT summit in Barcelona.

The below links are the official page on the SITA website and the official SITA video:

- http://www.sita.aero/baggagerobot
- https://www.youtube.com/watch?v=W3WaNHzE9SU
- http://releasd.com/c19b: This link summarize all the articles related to Leo

Clearly, SPENCER itself and the buzz created by the integration weeks in Schiphol helped convincing SITA to team up with BLUE in this new project.

4.2 Exploitation Plan of SPENCER Technologies

The SPENCER demonstrator worked excellently at the end of the final deployment and was a great success in terms of passengers appreciation and visibility of SPENCER partners and the EU. However, as expected after a three-year STREP project, the current system is only a prototype and cannot be commercialized "as is". Several steps are needed to make the SPENCER robot a dependable market-ready product.

To this end, a good option is the creation of a dedicated company, either a start-up or a joint venture between some or all partners. But even when pursuing another model, exploitation of SPENCER results towards this goal should follow several steps:

- Technology transfer

- Industrialization of the system
- Development of the business model
- Prospection and sales
- Field experience

We will now go through these steps in more detail:

4.2.1 Technology transfer

Today the developed foreground knowledge within SPENCER is spread between the different partners. In order to have a fully operational system, several persons with different competencies must be involved. 20 days were needed in order to set-up the final demo with the presence of all partners, and it is likely that any follow-up deployment would also need 10-20 days. Thus, the first step on the road to success is the technology transfer to the created entity (a dedicated start-up company, a technology provider like BLUE).

Technology transfer should be multilateral with all the partners of the consortium, ideally suppored by the transfer of people. Intellectual property questions as well as licensing questions will appear and have to be solved to insure that all needed components and competences are available.

4.2.2 Industrialization of the system

The following step would be the optimization of the system. During SPENCER, all partners developed their own subsystems, which were integrated into the architecure. The system is not optimized because margins were taken at different places to ensure that every sub-system had enough resources (e.g. in terms of computational power) to work properly. One example is the amount of PCs on the platform (5) which is too high for a dependable and cost-effective commercial platform: 2 high-end industrial PCs, 1 interaction PC, 2 high-performance gaming laptops).

Hardware optimization: This industrialization process should optimize the system in term of hardware. Every hardware component should be checked, and if needed, resized or even removed if useless, For example, the amount of battery power could be reduced which would result in a smaller form factor, weight and size, and thereby improved safety. The sensors, typically the most expensive components of a robot system, should be analyzed, and only the necessary ones should be used. The same applies to most hardware components which should be replaced by cheaper ones. The amount of on-board computers should be reduced, ideally to 1.

The mechanical design should be optimized to reduce and ease assembly and maintenance. Finally the aesthetical design should also be reconsidered to make the robot robust against vandalism. Experience shows that if something can happen, it will happen.

Software optimization: In term of software, the amount of applications and processes running in parallel must be reduced and ideally, only 1 piece of software should run on 1 PC. The user interface should be improved and made more flexible in a way that it can be easily adapted to different use-cases and customers.

Tools: The development of tools to setup, deploy and monitor the system is part of the industrialization process. With simple and user-friendly tools, technicians with less skills/experience would be able to setup the system. This will save money and resources.

All these actions must lead to a significant simplication of the system at a minimal reduction of its functionality to increase reliability and reduce costs for production and maintenance.

4.2.3 Development of the business model

In parallel of the industrialization of the system, a viable business model must be developed which defines how to commercialize the system and creat lucrative business. The questions are if the system should be *sold or rented* and if the system is inflexible and allows only a single application or usage or should it be customizable based on the customer needs.

Based on experience of partner BLUE and several discussions with end users, we are convinced that the system must be made flexible and adaptable to the specific needs of the customers. Taking into account KLM and two other potential end users, we already have five different application scenarios (see below). Each customer will come with its own specification and use-case. This is a daily business for BLUE: proposing a rigid and final solution will not suit the needs of most customers.

With a customizable system, the question of renting it should be analyzed. This would decrease the price for the customer (e.g. airlines/airports) and allow the created entity to make business with the system also for short periods of time, e.g. for an event.

4.2.4 Prospection and sales

Prospection would be the first concrete step to success. Once the business model is developed, the target customers will be defined. During prospection, the needs of the customers should be matched and the profitability of the product should be analyzed.

4.2.5 Field experience

Getting experience is key for success. BLUE and its ANT® navigation technology is a good example. The ANT® technology was industrialized quickly after the creation of BLUE. The big problems were solved in short times. The first deployments showed to BLUE, however, that every installation is unique and each customer has his own specification in term of hardware and software. Deployment after deployment, new issues were discovered and solved which took years to solve many small problems after the big issues were already solved.

One example small issues that takes ages to be solved is the Wifi network. Wifi technology is mature today, but we still have problem with poor Wifi communication and strategies to optimize data transfer should be developed.

4.3 Potential Use-Cases for Exploitation

In SPENCER, two relevant scenarios were found and specified in WP1 to showcase the developed technologies. They were found in collaboration with end-user KLM as potential business cases:

- *Schengen barrier use-case*: This use-case should optimize passenger flow in particular for transfer passengers that enter the Schengen area. KLM staff assigns passengers to the robot at the arrival gate which then guides them to the Schengen barrier. At the final destination, the robot instructs passengers to use the priority lane and provides further services to passengers in case they missed their connecting flight.
- *Information provision use-case*: The robot drives around and looks for people in need for assistance. It is able to approach people and offer services with its built-in KLM kiosk.

While the second scenario can be used in many airports around the world as it is quite generic, the first one is specific to European hubs. In the frame of our exploitation activities, BLUE had several discussions and exchanges with other potential end-users from the aviation industry towards alternative use-cases. They include:

- *Guide robot*: The robot drives around in the airport and is ready to guide passengers to predefined place on demand, e.g. ATM machines, passengers lounge, toilets, shops, restaurants. This scenario can also be adapted at the check-in level to guide passengers to the right desk and avoid congestion at the airport entry hall.
- *Mobile information and mediation desk*: The robot drives around in the airport and answers passengers questions. It can be linked to a call center, where real operators, displayed on the robot's display, can talk to the passengers and assist them. The robot can also be equipped with a device to indicate the direction to follow.
- *Mobile information display*: The robot is used as a generic information display. It is operated by the airport staff and there is no specific interaction with the passengers. For example: the robot goes to gate 32 and displays the next flights for connecting passengers. Then, the robot goes to gate 45 to display other information. During the transfer, advertisement can be displayed. The robot moves autonomously between locations.
- *Guide passengers to shops*: The robot displays the list of available shops and guides the passengers where they want to go. This is similar to the guide robot, but with a more commercial objective: the airport can deal with the shops their appearance on the robot's display and provide them with statistics.
- *Crowd management*: In crowded airports, mobile robots could be used to manage the crowd and dynamically optimize the people traffic within the airport.

Several aspects apply to all use-cases: the discussions clearly showed that every customer has his own application and dedicated scenario or would like to customize an existing one. Another aspect concerns travel speed of the robot, particularly for guidance. This was confirmed by people with prior experience with mobile platform: when the travel speed is too low compared to human walking speed, the robot should not guide the passenger all the way to the destination but only for few meters to indicate the direction to follow and maybe the duration of the journey. If the mission of the robot is too long, passenger get easily bored and leave the robot. However, this problem has been successfully solved in SPENCER with the platform that operated at a high speed of 1.3 m/s at the airport – brisk walking speed for adult humans.

These potential scenarios show that there is no single winner application but many possible usages of mobile platforms at airports which should be carefully evaluated accounting for the airport's needs and constraints such as profitability, transit optimization, entertainment value but also floors, steps, stairs, and architectural configuration.

These considerations lead to the key concept of **system flexibility** in term of

- Navigation, possibility to navigate in different environments
- Passenger interaction and display customization
- Capabilities, head movement and additional devices for interaction with passengers

A flexible hard- and software framework should support these multiple options to allow quick and easy adaption of the platform to the customer's needs.

In addition to the aviation industry, there are more potential application domains of SPENCER technologies. Clearly, the developed technologies could easily be applied in other environments such as railway stations, supermarkets, concert halls, sport stadiums, exhibitions and fairs etc. All these application require the basic technolgies developed in SPENCER such as free navigation in populated environment, efficient and effective interaction with humans, and safety for robots and humans.

With the emphasis on flexibility throughout the system and business approach (hardware, software, business model), we propose an exploitation plan that we consider best to quickly combine the developed technologies to new use-cases and application domains given that there is no silver bullet use-case in the relevant application domains.

4.4 Identification of Exploitable Results

To systematically identify exploitable results, all SPENCER partners were asked to answer a set of questions. There are two groups of questions, a summary of the answers is given hereafter.

Exploitable results status

- What is your sub-system and what is its status in the end of SPENCER?
- What are the exploitable results out of SPENCER?
- Is there a business plan?
- Who are the competitors?

Partners exploitation vision

- What did you gain by being part of the SPENCER project and consortium?
- How do you see the industrial exploitation of the sub-system you develop in the SPENCER project?
- What are the steps needed before industrial exploitation?
- To which field and which application could the system be adapted?
- Is the launch of new spin-offs considered?

4.4.1 Summary of answers

The SPENCER consortium consists of eight partners, six academic institutions, one industrial partner and one end user. All academic partners have exploitable results in addition to their dissemination, mainly for their scientific purposes. They all developed sub-systems and will reuse them in future activities and projects. SPENCER enabled them to collaborate, advance their research and work in a challenging and motivating environment.

The industrial partner developped new hardware that is ready to be reused in industrial projects and software that has already been reused. They gained contacts in the aviation industry and SPENCER helped them to start a collaboration with major player SITA in a project on a new service robot for self-service luggage drop-off. Further, Bosch Research has hired key personnel of SPENCER with the goal to transfer knowledge and possible one of the two SPENCER platforms. The goal of Bosch is to push their research in robotics with SPENCER technologies.

The end user KLM gained valuable contacts with people outside of their usual business, and experience with robotic systems. No directly exploitable outcomes have been identified by KLM which is also as expected with a prototype after a three-year STREP project.

We now give the individual answers by all partners:

4.4.2 ALU-FR

4.4.2.1 Exploitable results status

What is the status of your sub-system?

- Subsystem for human detection and tracking using 2D laser and RGB-D in highly crowded environments. Status: Pre-mature for industrial use, additional person re-identification functionality needed to reach even higher level of occlusion robustness.
- Subsystem for fast motion planning in highly dynamic environments. Status: Mature, only minor improvements necessary.
- Subsystem for learning socially normative motion behaviors. Status: Pre-mature for industrial use, needs systematic experimentation to assess benefit.

What are the exploitable results?

- Bosch has hired the entire ALU-FR team for its corporate research department. The coordinator is now head of robotics research at Bosch, Luigi Palmieri, Timm Linder will start in May and June 2016, respectively, as Bosch researchers.
- Bosch has plans to purchase the SPENCER robot as research platform to push internal research activities in service robotics and HRI. Negotiations about the the platform acquisition and foreground licensing are on-going.
- All SPENCER software components are open-sourced on a githup repo. The community can use them.

Is there a business plan?
No.

Who are the competitors
Everyone that can download a ROS component and tries to earn money with robotics.

4.4.2.2 Partners exploitation vision

What did you gain by being part of the SPENCER project and consortium?
Keep and further push ALU-FR research to state-of-the-art level, gain visibility in community and among industrial stakeholders.

How do you see the industrial exploitation of the sub-system you develop in the SPENCER project?
Negotiations between Bosch and ALU-FR (or more SPENCER partners if needed) about licensing or acquiring rights on specific software components and IP may start after a positive evaluation of the platform in autumn 2016.

What are the steps needed before industrial exploitation?

- Increase the TRL from now 6 or 7-ish (”System prototype demonstration in an opera-tional environment”) to 8 (”Actual system completed and qualified through test and demonstration). It is well known that increasing a TRL may take several years of R&D.
- Main market barriers towards an economically feasible system are price and robustness of hardware components as well as safety:
  - Using a Velodyne or two SICK sensors is way too expensive for this kind of service robots.
  - MS Kinect sensors are too unreliable under real-world conditions (e.g. in sunlight).
  - Required computing power is still too much in the current platform.
  - Safety needs to be addressed properly so as to operate the robot in a fully unsupervised fashion Overall, while the main functionalities are essentially there, the platform needs to be downscaled in terms of weight, size, and costs. These measures will also facilitate safety certification (with a lighter-weight and smaller robot).
  - To address these issues, The SPENCER consortium has concrete plans to submit an IA-proposal to the next H2020 Robotics Call.

To which field and which application could the system be adapted?
All autonomous and interactive systems that share a space with humans.

Is the launch of new spin-offs considered?
No.

4.4.3 UT

4.4.3.1 Exploitable results status

What is the status of your sub-system?
Knowledge, insights, guidelines

What are the exploitable results?
Possibility to carry out validation studies leading to more knowledge on acceptance of robotic services in public places. The SPENCER platform should be up and running for that.

Is there a business plan?
No.

Who are the competitors
No industrial competitors, but other research groups working in HRI.

4.4.3.2 Partners exploitation vision

What did you gain by being part of the SPENCER project and consortium?
We got the opportunity to conduct tests in a challenging environment with an autonomous robot; expertise we dont have ourselves.

How do you see the industrial exploitation of the sub-system you develop in the SPENCER project?
Our study can be used by technical partners and industry in order to make their systems with a higher degree of awareness, with a better effectiveness when being put on the market.

What are the steps needed before industrial exploitation?
The industrial partners need to integrate the results of the research into their system and test them intensively

To which field and which application could the system be adapted?
Everywhere a HRI can be found.

Is the launch of new spin-offs considered?
No.

4.4.4 ORU

4.4.4.1 Exploitable results status

What is the status of your sub-system?
We were working on the localization sub-system and it will be at best at TRL6/7 at the end of the project

What are the exploitable results?
The localization sub-system.

Is there a business plan?
No.

Who are the competitors
We did not make a comprehensive search, but all the navigation providers are potential competi-tors.

4.4.4.2 Partners exploitation vision

What did you gain by being part of the SPENCER project and consortium?
We could further develop our approaches to localization and socially annotated mapping and got deeper insights into a great application.

How do you see the industrial exploitation of the sub-system you develop in the SPENCER project?
The developed technology will be exploited by our industrial partners, either the partners in SPENCER or our industrial partners in Sweden.

What are the steps needed before industrial exploitation?
The industrial partners need to bring the localization sub-system to TRL9, which mainly requires testing.

To which field and which application could the system be adapted?
To all fields that need very accurate and reliable localization, particularly in dynamic environments.

Is the launch of new spin-offs considered?
Not at ORU.

4.4.5 CNRS

CNRS will exploit the results and experience it acquired and/or extended in SPENCER along several directions. The first aspect concerns the fact that CNRS is planning to develop further its contributions in sev-eral French and European projects. For instance, a first exploitation that already started is the application of the CNRS algorithms and learning techniques to build interactive motion primitives for the H2020 Mummer project.

Other ideas coming from Spencer have been developed and proposed in recent (2016) calls (ANR and H2020).

CNRS has also been contacted by two French airports and a company interested in developing robot oriented services in public spaces. Names cannot be given now since we are still in a confidential negotiation phase.

4.4.6 BLUE

4.4.6.1 Exploitable results status

What is the status of your sub-system?
BLUE developed the SPENCER platform after specification by the consortium. The platform was improved during the project with input of the partners. It is today fully functional in term of hardware, mobility and safety. The platform can be navigated either by the ANT® navigation system from BLUE or by the software developed by the consortium.

The SPENCER platform can be deployed for demonstrations or in the frame of the BLUE activities. The mobile base is ready to be reused for new projects. The upper part of the platform can be adapted to the application.

What are the exploitable results?
SPENCERs platform kinematic The kinematic designed by BLUE for the SPENCER platform turns out to be suitable for many applications, both indoor and outdoor. Several existing customers have given positive feed-back about this approach. BLUE will exploit this technology for the design of future robots.

ANT® CAN interface The CAN interface designed by BLUE to interface ANT® lite to the Maxon motor controllers has already been re-used for industrial projects where similar motor controllers have been chosen. The developed framework eases the development of future CAN interfaces to different motion controllers. It is already in use in many projects

Is there a business plan?
No specific business plan, it is included in BLUE global strategy.

Who are the competitors
Competitors related to the ANT® navigation: Kollmorgen NDC suite, SICK NAV200, Gtting, Guid-

ance Limited, Siemens ANS, Frog, Balyo, ...

4.4.6.2 Partners exploitation vision

What did you gain by being part of the SPENCER project and consortium?

- BLUE gained the opportunity to create new contact in the aeronautic field and to strengthen already existing contact. There are potential new applications and new projects for the BLUE ANT® navigation system in this field.
- Visibility to the aviation industry during the demonstrations in Schipol and the press releases.
- A project with a key player in the aviation industry, SITA has been signed during SPENCER. See above for more information ("Leo robot").
- A new robotic base, to be reused in future projects.
- Improvement in the interfacing of ANT® navigation system to motion control systems via CAN.

How do you see the industrial exploitation of the sub-system you develop in the SPENCER project?

- The hardware base developed in SPENCER is ready to be reused or adapted for new projects in many different application indoor and outdoor.
- The CAN interface can be directly used for industrial projects.

What are the steps needed before industrial exploitation?

- The base is ready to be used.
- The CAN interface is already being used in industrial applications.

To which field and which application could the system be adapted?

- Any field in which BLUE is active today, mainly industry.
- The system can also be used for different service robot, based on the requested needs.

Is the launch of new spin-offs considered?
No, this is included in the BLUE global strategy

4.4.7 KLM

4.4.7.1 Exploitable results status

What is the status of your sub-system?
KLM has not developed sub-systems. Our task was mainly to provide functional specifications (based

on use-cases) and design input for SPENCER's "look & feel" and facilitate and partici-pate in the final demonstration.

What are the exploitable results?
KLM has not any directly exploitable results from this project.

Is there a business plan?
KLM as end user has no business plan to deploy SPENCER. However the project provided sufficient valuable insights and results to support future decisions on new robotics projects.

Who are the competitors
As an end user, we do not see any competitor.

4.4.7.2 Partners exploitation vision

What did you gain by being part of the SPENCER project and consortium?
KLM gain a lot of knowledge in an area which are not part of our core competences. For example, we learned that:

- Deploying autonomous operating robot systems in very dynamic environments is much more challenging than anticipated.
- While deploying SPENCER in the airport, it became clear that the airport environment undergoes minor changes on a daily basis. Shops and their displays vary per day, but also some semi-static elements move around. The impact this has on the robots performance was underestimated by KLM.
- We obtained many valuable contacts with the other consortium partners, who are outside our normal business circle.

How do you see the industrial exploitation of the sub-system you develop in the SPENCER project?
This question is not applicable for KLM.

What are the steps needed before industrial exploitation?
Although KLM has no exploitation plans/possibilities, we believe that some additional functionalities should be added to maximize the added value of the system. Due to the findings during the deployment at Schiphol Airport, much more testing needs to be done to improve SPENCER's functioning in densely crowded airport areas to become a market-ready product.

To which field and which application could the system be adapted?
Once the system works in a location like Schiphol airport, many other densely crowded areas such as train stations, large event and exhibitions.

Is the launch of new spin-offs considered?
No this is not foreseen form KLM's point of view.

4.5 Exploitation-Related Contacts After the Project

After the final deployment and the following press coverage, the SPENCER consortium has been contacted by several potential users and companies interested in the SPENCER system:

4.5.1 Honda

Honda contacted partners ALU-FR, RWTH and ORU for their tracking and SLAM systems. Several emails of increasing technical nature even with code-level questions took place.

4.5.2 Parabit Systems

The coordinator has been contacted by Parabit Systems, a US-based company that installs and manufactures welcome centers and self-service kiosks for the aviation industry. Quote: "We would like to know if this robot is or will be manufactured, one of our [airport] clients [that would use the robot the same way the demo in Amsterdam works] would like to order 10 of them."

4.5.3 Swiss railway SBB/CFF/FFS

The coordinator has been contacted by the head of innovation of Swiss railway SBB/CFF/FFS. They are interested to have a SPENCER-like robot with the same or similar functionality at railway stations. They might be interested to raise money for a pilot project.

4.5.4 Media Markt Spain

The coordinator has been contacted by the Social Media Manger of Media Markt Spain. They are interested to have a SPENCER-like robot in Media Markt stores. Quote: "I think the experience of our clients in our stores with Spencer could be amazing."