POSEiDON

Pers**O**nalized **S**mart **E**nvironments to increase **I**nclusion of people with **DO**wn's syndrome

Report 3

Report on Scientific Progress

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1 Executive Summary

The purpose of this document is to outline the scientific progress achieved within the POSEIDON project. Based on an analysis of the state of the art performed during the proposal phase and later, as well as lessons from experience during the first two periods of the project, this project will outline how the scientific community can benefit from the results of POSEIDON.

The POSEIDON project addresses people with Down syndrome. Most people with Down syndrome experience low integration with society. The main objective of the project is to exploit ICT as an instrument to increase the quality of life and support a more independent life for people with Down syndrome. For this purpose, we explored five potential areas of innovation that are in the scope of POSEIDON. We present an analysis of the state of the art in inclusive technology, context-awareness, adaptive interfaces, virtual reality, and active & assisted living. To emphasize the project's focus on personalization and learning, we have added our ambition in personalization and learning. In addition, we present related European Research projects that are of potential interest to the POSEIDON project.

We outline how POSEIDON planned its initial contributions to the different innovation areas and present the publications so far, including their abstracts. Their contributions to the stated goals are subsequently listed. Finally, we perform a gap analysis and identify aspects that have not yet been covered by our research output. To fill these gaps, we finally give a list of accepted publications in the third period and planned articles, including responsible partners and their contribution.

2 Introduction

This document gives a comprehensive overview of the scientific progress of the European Research project POSEIDON. One of the major goals of any research project is to enrich the body of knowledge in one or more research areas. This document will give an overview of those areas, how we initially planned to contribute, analyze the remaining gaps, and pave the way forward with research to be performed until the end of the project and beyond.

Even before starting this project, we identified some key challenges people with Down syndrome face every day [Fidler 2005, Jarrold 2006, Brigstocke 2008, Tod et al. 2012]:

- Access to education and the support provided is very limited
- Fewer opportunities are given to people with Down syndrome to find employment
- Most people with Down syndrome find it harder to access and maintain social networks
- Sedentarism that can result in health problems for people with Down syndrome
- Public information is often in formats that are not easily accessible for people with Down syndrome (e.g.
- bus timetables)
- Reading and writing can be more difficult for people with Down syndrome

The POSEIDON project wants to give priority to preferences, particular strengths and weaknesses, in order to create technology that is appealing and useful to them. People with Down syndrome, their immediate carers and specialists from all over Europe will co-design our solution along the project.

In order to achieve this goal, we have identified five innovation and research areas, where POSEIDON can and plans to increase the existing body of knowledge. They are inclusive technology, context awareness, adaptive interfaces, virtual reality, active assisted living. Additionally, we look at the market and identify how we can distinguish ourselves from existing products.

On the following pages, we will outline these innovation areas, and identify the specific research questions that POSEIDON plans to answer during the project. We will give an overview of the reports, publications and articles so far and introduce our plans for the remainder of the project and beyond.

3 Analysis of the state-of-the-art

POSEIDON has a very ambitious plan to contribute to the body of work relating to persons with Down syndrome in numerous areas. These contributions relate to a number of innovation areas that will be outlined in the following sections. This analysis of the state of the art in those domains, allows us to clearly outline research questions that can be answered by the POSEIDON consortium. This section is based on the initial description of work, with extensions given in relevant areas.

3.1 Inclusive technology

This category of technology facilitates the integration of citizens with special needs into the fabric of daily life. POSEIDON relies on a mix of existing and proven technology that can be adapted towards persons with Down syndrome and some highly innovative technologies that are experimental but have a high potential on innovation. The utilization of inclusive technologies as a self-management tool for persons with intellectual disabilities has been a busy research area in the past. Literature reviews have showed that the suitable application of these technologies have been an effective tool for providing antecedent prompts that can be self-operated by persons that have been diagnosed as having an intellectual disability [Mechling 2007]. An overview of inclusive technology in education was recently given by Passey [Passey 2014]. He collects and classifies several digital technologies for learners, as well as mediators. A specific focus is on systems that are suitable for specific learner groups, including available systems for persons with Down syndrome.

There is a large variety of inclusive technology systems on the markets. They can be roughly distinguished into software systems, e.g. learning software for special learner groups, and hardware systems, such as special input and output devices. An example for special software is Co:Writer that supports text entry using word prediction[1]. One example for an input device is the Helpikeys keyboard that has an adaptable layout, based on the preference[2]. They can be changed by the user or a carer. The most common forms of inclusive output devices are hearing aids or speech amplifiers, one example being the EchoRA Wireless Speech Amplifier[3].

In recent years, the tablet has become a very popular alternative to many of those systems. Intuitive touch screen control and a large array of integrated sensors have led to numerous apps being released during the last few years. Some examples for special education apps include Language TherAppy[4] for language training or Special Words[5] for word learning.

A comprehensive system for supporting persons with Down syndrome should consider a suitable combination of the existing technologies and evaluate individually and as a whole, which are particularly suited.

3.2 Context awareness

Context awareness describes the use of environmental or status information to understand the state of a system and inform decision-making [Dey 2000, Dey 2001]. Most solutions use a closed loop that registers the context within a certain domain, e.g. home automation systems that react on sensor input. The advent of GPS equipped smartphones has caused a plethora of location-aware applications,

[1] http://donjohnston.com/cowriter/
[2] http://www.helpicare.com/helpikeys/
[3] http://www.hear4you.com/product/echo-ra-voice-amplifier
[4] https://itunes.apple.com/au/app/language-therappy/id525278822?mt=8&uo=4&at=11ldeC
[5] http://itunes.apple.com/au/app/special-words/id451723454?mt=8&uo=4&at=11ldeC

such as augmented reality browsers and navigation solutions [Gellersen et al 2002, Anagnostopoulos et al 2007, Bouzeghoub et al. 2009]. While those systems are becoming more powerful, they typically rely on location as sole context. Recent solutions, such as Google Now combine data from numerous sources to provide personalized higher level services. Some sources include search history, calendar entries, contact information and location. While the resulting service has a high level of personalization, the aspects of privacy and security are only leniently covered. POSEIDON aims at using a certain set of information about the user - a restricted profile and information provided by the system itself to generate higher level services. This solution is less intrusive while still enabling a sophisticated level of personalization and adaptation. Consequently, the system should be more intelligent to learn from previous contexts and to understand when it can be useful, what type of assistance should provide, when help should be offered and in which way to communicate that help to the user. As the system is supposed to serve the primary users (people with Down syndrome) but also other people who interact with them, for example family members, teachers and employers, the system will need different type of awareness for different users. An important part of this awareness is related to safety. The system should be able to receive through the interface an indication from the person with Down syndrome that s/he is feeling in an unsafe situation but equally the system should autonomously be able to sense the perceived level of safety and make this information available to relevant co-users of the system. Research in context-awareness has been prolific [Bettini et al. 2010, Beigl et al. 2011; Ye et al 2012; Bhatt et al. 2012]. However, they require high level of language training to be programmed or specific dedicated functionality implemented in a specific device, for example to achieve geo-fencing through wearable technology, to achieve the type of inclusive services which are a priority in this project. Knowledge representation in this area has been enriched with some ad-hoc contributions, for example Smart Homes ontologies for AAL like the one used in [Muñoz et al 2011] and context ontologies like SOUPA [Chen et al 2004]. Our system will extend these ontologies to create a flexible context ontology, which can be easily integrated to user preferences and be informed by the learning of user's habits in a way that it can automatically create context definitions and guide the provision of contextualized help with safety as a core priority. The context specialized ontology and all other context-awareness related packages will be offered as Open Source software to facilitate the development of these as well as of new services which can be implemented on top of it.

3.3 Adaptive interfaces

Adaptive interfaces change modality, layout and elements according to user preference either manually or automatically, triggered by a changed context [Schneider et al. 1993]. This allows the interface to be conformant to specific user needs. Mostly it is required to change presentation and navigation according to requirements. This research area has been in development for several years. An important topic is the modelling of the user either autonomously or via user input [Langley 1999], allowing to control the interface according to specific context. Considering our tackled scenarios, a combination of both methods is viable using a combination of prior knowledge as ground truth and autonomous adaptation based on the current context. In terms of graphical user interfaces, many frameworks nowadays support a good separation of layout and logic. Particularly active in this regard is the W3C that provides guidelines and languages that attempt to facilitate inclusion and provide support for adaptive interfaces via descriptive languages such as CSS and its officially sanctioned extensions. We can make use of the previous research done in this area [Sullivan 2000] to select best practice and adapt it according to our specific scenarios Adapting user interfaces to specific user groups is an ongoing challenge, e.g. supporting children affected by autism [Magee2010]. Some evaluations have been done on the challenges posed by current computer interfaces to people with Down syndrome [Feng2010, Lazar 2011] with some interesting outcomes on identifying what may be more

useful in terms of communication and safety, there is still much to do, especially with the adaptation of interfaces to contexts, preferences and needs. POSEIDON will select the best practices in those domains, evaluate their adaptability towards persons affected by Down syndrome and provide extensions and refined standards. One fundamental question which has not been researched so far and we will investigate is the type of elements to be used as building blocks of communication. For example, should it be 100% based on icons and modalities (e.g., glowing to call attention) or colours (e.g., red to indicate a task is due)? Or should it also consider words? This element of research and innovation will have an impact on the problem of making the tool valid across different regions of the EU (different languages). Other significant advances will be provided in the way adaptation will be linked to the user preferences and needs and how the interface will change with different contexts to optimize the help offered.

3.4 Virtual Reality

Virtual Reality provides a computer simulated experience of a physical reality [Rheingold 1991] This experience can be more than visual and may include stimuli of other senses. There has been interesting advances in the complexity of environments which can be recreated by adding equipment (e.g. headsets [Hoffman 2004] or haptic interfaces [Colwell 1998]) and also in the complexity and quality of the physical realities being recreated (e.g. flight simulators for training pilots). There has been a recent interest in the exploration of mixed realities (virtual and physical) and how this relates to Smart Environments for work and education [TI-JAISE]. There has been numerous application in the domain of providing learning [Strickland et al. 1996], training [Bryanton et al. 2006] and distraction [Gershon et al. 2004] for different medical conditions. There are various frameworks available aimed at providing virtual reality applications for specific user groups that provide the required level of adaptability [Tramberend et al. 1999; Gibson 2004]. They have been proven useful in training and learning scenarios [Huang2010]. We will consider using such frameworks and investigate their usage in POSEIDON. POSEIDON use Virtual Reality in a novel way by allowing people with Down syndrome to explore, prepare and train to face challenges they are about to face daily life. They can do this in a safe environment (e.g. at home) and extract tips and guidance which the POSEIDON system will then use to guide them in the real experience. This anticipated exploration of scenarios they will face will increase their knowledge and confidence about the task (e.g. reaching a specific place).

3.5 Active Assisted Living

Ambient Assisted Living refers to aware environments and services that support users in need of assistance [handbookAAL]. In the last decade, the challenges of the demographic change have become more apparent and programs such as the European AAL Joint Programme have raised awareness in both scientific community and industry to develop technological solutions. In this scope the research in this area was broadened and the field renamed to Active & Assisted Living. The majority of solutions are aimed at the specific challenges related to elderly users - providing platforms and singular services and solutions. Smart environments that incorporate sensors and actuators that perceive and control their surroundings are used to realize and augment services in this domain, using unobtrusive home automation networks and embedded systems. Again, most applications aim at elderly users. POSEIDON will innovate in this area by combining the context generated in smart environments and external sources to provide a service that is tailored specifically towards persons affected by Down syndrome. This will include the guiding of the development process by overarching concerns on ethics, security, and privacy. These and other important design principles collected from final users first hand through our workshops and pilot studies will provide a valuable source of information to future developments aiming at this segment of the population or similar ones.

POSEIDON aims at using its associated resources efficiently and therefore will innovate in areas that have not been tackled before. Some prerequisites in terms of hardware have to be defined beforehand and we tried to find a balance between state-of-the-art off-the-shelf systems and innovative prototype solutions that can be beneficial for our solution. WP2 has analysed the existing systems on the market and mapped the usable results to an overall architecture that encompasses predefined hardware and best practice solutions found in research and on the market. These have also been mapped into requirements for the novel parts of the POSEIDON system. Inclusive systems and AAL are pillars of both technical work packages and the innovations created in those. WP3 has improved existing context-aware systems and adapted them to our unique user group. WP4 has provide adaptive interfaces, innovative HCI and a support system that is targeted towards our predefined use cases and hardware platform. In the coming last period of the project we will take the findings of the different pilots and publish our analysis of the technologies considered most suitable.

3.6 Personalisation

Personalisation describes the ability of system's to be adapted towards the preferences and capabilities of a single user or groups of users. In this project, we have dedicated a special document for this aspect, called R2 - Personalisation in POSEIDON. Most relevant information on this topic can be found there. In this document, we will focus on the scientific dissemination of these findings.

POSEIDON aims at providing personalisation that is specifically geared towards the user group of people with Down syndrome. Their challenges include visual and hearing impairments and difficulties with fine motor skills, while strengths include mastering of many daily activities and clever use of ICT technologies. A full list can be found in R2 - Personalisation in POSEIDON. Therefore, the solution offers various personalisation options keeping these aspects in mind. We distinguish between content-related personalisation that spans all applications, as well as preferences for single components, e.g. the carer's web, the mobile app, or the interactive table. A full list of the implemented personalisation features can be found in R2 - Personalisation in POSEIDON.

3.7 Learning

A common request during the initial workshops with the families was including additional learning tools and functions. There is vast literature in the domain of learning for persons with Down syndrome. A classic work looks at comparative learning in siblings with one Down syndrome child and a control group [Pueschel et al. 1987]. They found that they performed significantly better with visual-vocal and visual-motor channels of communication, compared to auditory-vocal and auditory-motor channels. Similar findings are reported in newer studies. For example, they try to combine recent research in education-related research with previous findings [Fidler & Nadel 2007]. Finally, other studies take a practical approach and collect experiences from teachers of children with Down syndrome [McFadden 2014].

In POSEIDON we take families and existing popular learning applications used in our involved families as a secondary source of knowledge. In a co-creation process several learning systems will be designed that help with handling of money, or staying healthy. They make use of the personalisation and context-awareness in the project to modify their content.

3.8 Related European research projects

While no previous project directly competes with POSEIDON, there are projects of the past and ongoing initiatives that are interlinked on some themes. In this part, we will shortly present those

projects and indicate if and how we plan to reuse results, adapt developments or create own innovation.

The Serenoa[6] project provides adaptive user interfaces for service front-ends. While the use-cases are work environment centric, the interfaces rely on an abstract language (MariaE) and a descriptive logic. Another FP7 project GUIDE[7] is creating a framework and design tools for integrating accessibility and personalization features into applications. The target group is elderly users and adaptive interfaces a main focus.

The Cloud4all[8] aims at addressing key systemic problems related to accessibility, to lower or remove barriers that currently prevent people with disability from a full inclusion in society, and that prevent them from using device, services, and communities that are increasingly using and relying on digital interfaces. It builds upon the Global Public Inclusive Infrastructure (GPII), a project of the Raising the Floor, a consortium of academic, industry and non-governmental organization and individuals. Cloud4all/GPII is creating an infrastructure to automatically launch, customize and kill (when not needed any more) applications, assistive technologies and settings on GPII-compatible devices.

In the domain of e-Learning various projects have been active in providing solutions for persons that are socially, mentally or physically challenged. They try to facilitate social inclusion (COMEIN[9], INCLUSO[10]), reintegration of marginalized youth (REPLAY[11]) or helping the mental and social development of specific user groups, such as young people diagnosed with autism (HANDS[12]).

In a final domain, various projects aim at gathering context and control the environment based on installed sensors and actuators. These middleware platforms provide interoperability between devices and services. OASIS[13] is a completed project that developed an ontology driven reference architecture and platform for interoperability. universAAL[14] is a currently running project that consolidates numerous previous platform projects into a shared, generalized architecture and middleware. Tellu's middleware for their SmartTracker sensor network might be complemented with OASIS and universAAL to produce a new suitable interoperable infrastructure for POSEIDON.

Table 1 Survey of related research projects.

Name	Relevant Results	POSEIDON Utilization
Serenoa	Interface description language Service front-end use case	Evaluate UI description language for usability Reuse some concepts
GUIDE	Accessibility and Personalization Framework Elderly persons primary use case	Evaluate concepts and tools Adapt for user group

[6] http://www.serenoa-fp7.eu
[7] http://www.guide-project.eu/
[8] http://www.cloud4all.info/
[9] http://www.comein-project.eu/
[10] http://www.incluso.org/
[11] http://www.replayproject.eu/
[12] http://www.hands-project.eu/
[13] http://www.oasis-project.eu/
[14] http://www.universaal.org/

AALuis	Personalized UIs based on user description and associated profiles	Evaluate results and consider usage
INCLUSO	Manual for ICT tools aimed at social inclusion for marginalized youth	Get inspiration by parts of the manual
HANDS	Customized mobile devices for autism-diagnosed devices Backend system for teachers	Reusing some suitable concepts Inquire adaptability of backend for family
OASIS	Ontology-driven interoperability middleware Various exemplary services	Platform candidate Reusing service parts
universAAL	Consolidate AAL middleware platform Service design tools	Platform candidate Evaluating service design tools for service creation
VAALID	Using VR technology to simulate capabilities of cognitively impaired persons	Review of VR and input technologies. Improve on user interaction and interactivity
WayFis	Route pre-planning and real-time guidance using based on user profiles	Optimal routes for elderly users. Review and adapt for persons with Down Syndrome
T&Tnet	Route planning and guidance using emotional social networking	Review solution and adapt concepts of social network route planning.
Cloud4All	Infrastructure for accessibility support on devices that are compatible with GPII.	During the development phase no support for Windows or Android was made available, thus we use SmartTracker for configuration.

As mentioned previously there have been numerous projects active in areas that are similar to the objectives of POSEIDON, albeit not in the unique combinations. We have performed a short analysis of existing projects and how their results may be used in POSEIDON, with a particular emphasis on the progress we will perform in both generating context and facilitating an optimal human-computer interaction for persons with Down syndrome. We have considered to use components from some projects, but in the end used our own solution, based on SmartTracker, as no comprehensive solution for managing the features required for POSEIDON was available.

4 The scientific contributions of POSEIDON

The initial planning of POSEIDON has foreseen contribution to the areas outlined in section 3. We will start this section by giving a recap on our initial analysis on the contributions we wanted to provide. Afterwards, we will describe the scientific publications so far and analyse how they contributed to the goals we set at the beginning of the project.

4.1 Planned contribution to the innovation areas

This section gives a short overview on how POSEIDON planned to contribute to key innovation areas. Therefore, it reflects the state-of-the-art at the beginning of the projects. We will outline in brief, how we contributed so far and will also include new projects in our analysis. The following table 2 gives an overview, before we give some additional details on the specific parts. A detailed outline of our achievements and publications so far will follow in subsequent sections.

Table 2 Overview of planned contributions to the innovation areas

Area	State of the art	POSEIDON contribution
Inclusive Technology	Input support systems Dynamic touch interfaces Haptic feedback	POSEIDON will select and adapt a set of technology specifically aimed towards supporting persons affected by Down Syndrome
Context awareness	Location aware system Big data systems	POSEIDON will extend ontologies and languages to cater the specific requirements of users affected by Down syndrome (user profile including capability modelling)
Adaptive interfaces	Accessibility guidelines Descriptive user interfaces	POSEIDON will provide intelligent, adaptive, and easy to personalize interfaces, specifically adapted for people with Down Syndrome.
Virtual Reality	Can provide reasonably good quality recreations of a real environment It is educational and fun	POSEIDON will adapt the idea to increase knowledge and confidence of people with Down syndrome about the real life situations they will face.
AAL	Primarily aims at elderly users Platforms for smart environments	POSEIDON will make use of platforms and smart environments and provide AAL use cases specific for people affected by Down syndrome (emphasis on ethical uses, security and privacy as a high priority guiding element of the final system produced).
Personalisation	Content adaptation Input/output adaptation	POSEIDON takes best practise from personalisation research, e.g. from accessibility literature. We will adapt this towards people with Down syndrome and verify assumptions during pilots.
Learning	Learning strategies for behavioural phenotypes	POSEIDON makes use of best practise and the co-creation process within the project to create learning applications that help and test their acceptance in the pilots.

To Inclusive Technology, POSEIDON planned to contribute a set of technologies that is specifically aimed towards persons affected by Down syndrome and an increase in the body of knowledge on which technologies are suitable for this group of users. This evaluation extends to the support network

of the Down syndrome users, including carers, family and friends. This can be found in the created prototype and framework, and we will continue to report on it in our publications.

To Context awareness, POSEIDON planned to contribute specifically suited ontologies that consider the daily activities for persons with Down syndrome. This helps us to choose a language and create the tools necessary for modelling a context-aware system that reacts at the appropriate times with the appropriate response. Several publications have shown our efforts in this domain. We have included the findings from the pilots and their effect on system design.

To Adaptive interfaces, POSEIDON planned to contribute intelligent and adaptive input and output interfaces that can be personalized by different user groups. They can be set according to specific needs and preferences that will be evaluated in a requirements gathering phase. The chosen solutions can be found in the POSEIDON prototype. Several publications will show the adaptive features in detail, including contributions on the interactive table.

To Virtual Reality, POSEIDON planned to contribute a system that mimics real-life situations for persons with Down syndrome, to prepare them for upcoming tasks, particularly in navigation. We have reported on the findings in a publication and included the presented solution in our system.

To AAL, POSEIDON planned to contribute to use and contribute to existing platforms instead of creating a new framework. Additionally, a set of use cases is to be prepared, specific for persons with Down syndrome and in particular focusing on aspects of ethics, legal and societal implications. Several publications have reported on the findings of initial questionnaires and the implications on an ethical framework for intelligent environments.

Our ambition in personalisation and learning beyond context awareness and adaptive interfaces was built during the project phases, whereas families requested learning tools to be an integral part of the project outcome. POSEIDON uses state-of-the-art and implements it in the developed infrastructure. We plan to report on the outcome of the piloting of the learning tools.

We will present the publications so far in the coming section, before diving into a gap analysis and an overview of our achieved goals in chapter 5.

4.2 Scientific publications

In this section, we briefly outline the publications that have been accepted for publication so far and how they contribute to the different innovation areas.

Unai Alegre, Juan Carlos Augusto, Tony Clark (2015). *Engineering Context-Aware Systems and Applications: A survey*. To appear in **Journal of Systems and Software**. Elsevier, 2016.

Abstract: Context-awareness is an essential component of systems developed in areas like Intelligent Environments, Pervasive and Ubiquitous Computing and Ambient Intelligence. In these emerging fields, there is a need for computerized systems to have a higher understanding of the situations in which to provide services or functionalities, to adapt accordingly. The literature shows that researchers modify existing engineering methods to better fit the needs of context-aware computing. These efforts are typically disconnected from each other and generally focus on solving specific development issues. We encourage the creation of a more holistic and unified engineering process that is tailored for the demands of these systems. For this purpose, we study the state-of-the-art in the development of context-aware systems, focusing on: A) Methodologies for developing context-aware systems, analysing the reasons behind their lack of adoption and features that the community wish they can

use. B) Context-aware system engineering challenges and techniques applied during the most common development stages; C) Context-aware systems conceptualization.

Dean Kramer, Alexandra Covaci and Juan Carlos Augusto (2015). *Developing navigational services for people with Down's Syndrome*. In: 2015 International Conference on Intelligent Environments, 15-17th July 2015, Prague, Czech Republic.

Abstract. The ability to commute and travel alone is an important skill that enables people to be more independent, and integrated with society. People with Down's Syndrome often experience low social integration, and low degree of independence. As part of the European Commission funded POSEIDON project, we want to explore how context-aware, and assistive technology can enable users with Down's Syndrome be more independent, including the ability to commute alone to a place of interest. In this paper, we report on our current progress in developing navigational services within the context of the POSEIDON project. We carried out a semi-structured qualitative evaluation of an early version of our navigational services with 6 individuals with Down's Syndrome, and report on our findings.

Alexandra Covaci, Dean Kramer, Juan Carlos Augusto, Silvia Rus and Andreas Braun (2015). *Assessing real world imagery in virtual environments for people with cognitive disabilities*. In: Intelligent Environments 2015, 15-17 Jul 2015, Prague, Czech Republic.

Abstract. People with cognitive disabilities are often socially excluded. We propose a system based on Virtual and Augmented Reality that has the potential to act as an educational and support tool in everyday tasks for people with cognitive disabilities. Our solution consists of two components: the first that enables users to train for several essential quotidian activities and the second that is meant to offer real time guidance feedback for immediate support. In order to illustrate the functionality of our proposed system, we chose to train and support navigation skills. Thus, we conducted a preliminary study on people with Down Syndrome based on a navigation task. Our experiment was aimed at evaluating the visual and spatial perception of people with Down syndrome when interacting with different elements of our system. We provide a preliminary evaluation that illustrates how people with Down syndrome perceive different landmarks and types of visual feedback, in static images and videos. Although we focused our study on people with Down syndrome, people with different cognitive disabilities could also benefit from the features of our solution. This analysis is mandatory in the design of a virtual intelligent system with several functionalities that aims at helping disabled people in developing basic knowledge in everyday tasks.

Dean Kramer, Juan Carlos Augusto and Tony Clark (2014). *Context-awareness to increase inclusion of people with Down syndrome in society*. In: Workshop on artificial intelligence applied to assistive technologies and smart environments (ATSE 2015), 14th October 2014, Quebec.

Abstract. Assistive technologies have the potential to enhance the quality of life of citizens. Most especially of interest are those cases where a person is affected by some physical or cognitive impairment. Whilst most work in this area have been focused on assisting people indoors to support their independence, the POSEIDON project is focused on empowering citizens with Down's Syndrome to support their independence outdoors. This paper explains the POSEIDON module which we are in the process of developing to make the system context-aware, reactive and adaptive.

Eva Schulze and Anna Zirk (2014). Personalized Smart Environment to Increase Inclusion of People with Down Syndrome. Results of the Requirement Analysis. In: Miesenberger, K. u.a. (Eds.) Computers Helping People with Special Needs. 14th ICCHP 2014, Springer Vlg., p 144-147. http://link.springer.com/chapter/10.1007/978-3-319-08599-9_22

Abstract: POSEIDON aims at developing a tablet app for people with Down Syndrome to become more independent and integrated. It follows an user-centered approach by involving primary (people with Down syndrome) and secondary users (parents, carers etc.). In order to assess the needs and requirements as well as the usage of technology of people with Down syndrome an online survey was conducted. Results indicate that a majority of them use tablets in their daily life. Most of the carers agree that technical assistants can help to overcome daily challenges and that there is a need for support in the fields of communication, socializing and school/work/learning. Important features and design aspects were mentioned.

Dean Kramer, Juan Carlos Augusto, and Tony Cook (2014). *Context-Awareness to Increase Inclusion of People with Down syndrome in Society.* In AAAI-14 Workshop on artificial intelligence applied to assistive technologies and smart environments (ATSE 2014) http://liara.uqac.ca/aaai14-workshop-atse.htm, Quebec, Canada, 27th of July, 2014.

Abstract: Assistive technologies have the potential to enhance the quality of life of citizens. Most especially of interest are those cases where a person is affected by some physical or cognitive impairment. Whilst most work in this area have been focused on assisting people indoors to support their independence, the POSEIDON project is focused on empowering citizens with Down's Syndrome to support their independence outdoors. This paper explains the POSEIDON module which we are in the process of developing to make the system context-aware, reactive and adaptive.

Carl Evans, Lindsey Brodie, Juan Carlos Augusto (2014). *Requirements Engineering for Intelligent Environments.* In Proceedings The 10th International Conference on Intelligent Environments (IE'14), pp. 154-161. Shanghai, 29th of June to 4th of July, 2014. IEEE Press.

Abstract. The field of Intelligent Environments (IE) is maturing to a level at which a range of sophisticated applications are emerging. Such systems aim to be context-aware, especially being adaptable to possibly unpredictable circumstances. An area of significant potential is that of 'ambient assisted living', with significant advances in fields such as smart spaces, classrooms, and assisted living space for the elderly or people with disabilities. In recent years, however, it has been recognised that numerous IE systems have been developed without adopting best practises from software engineering. The work presented here focuses on the requirements engineering stage and presents a framework for IE systems in which an intrinsic component is context-awareness. Whilst the framework is intended as a general IE model, we are currently applying it to the specific area of ambient assisted living and it is being employed on the POSEIDON project. It is anticipated that such real world application of the model will help endorse its conception and facilitate further refinement of the framework.

Simon Jones, Sukhvinder Hara, Juan Augusto (2014). *eFRIEND: an Ethical Framework for Intelligent Environment Development.* In Proceedings of 7th International Conference on Pervasive Technologies Related to Assistive Environments (PETRA 2014), 27-30 of may, 2014.

Abstract. Intelligent Environments bring technology closer to daily life and aim to provide context-sensitive services to humans in the physical spaces in which they work and live. Some developments have considered the ethical dimension of these systems; however this is an aspect, which requires further analysis. A literature review shows that these approaches are rather disconnected from each other, and that they are not making an impact on real systems being built. This paper summarises the ethical concerns addressed by previous work, highlights other important concerns, which have been overlooked so far, and proposes a more holistic approach. It explains how these concerns can be used

to guide part of the development process in such a way that Intelligent Environments being engineered in the future will consider the ethical dimension in practice, not just in theory.

Juan Carlos Augusto, Terje Grimstad, Reiner Wichert, Eva Schulze, Andreas Braun, Gro Marit Rodevand, Vanda Ridley (2013). *Personalized Smart Environments to Increase Inclusion of People with Down's Syndrome.* Proceedings of 4th International Joint Conference on Ambient Intelligence. pp 223-228. 3-5 of December, 2013. Dublin, Rep. of Ireland. Springer Verlag.

Abstract. Most people with Downs Syndrome experience low integration with society. Recent research and new opportunities for their integration in mainstream education and work provided numerous cases where levels of achievement exceeded the (limiting) expectations. This paper describes a project, POSEIDON, aiming at developing a technological infrastructure which can foster a growing number of services developed to support people with Down syndrome. People with Down syndrome have their own strengths, preferences and needs so POSEIDON will focus on using their strengths to provide support for their needs whilst allowing each individual to personalize the solution based on their preferences. This project is user-centred from its inception and will give all main stakeholders ample opportunities to shape the output of the project, which will ensure a final outcome which is of practical usefulness and interest to the intended users.

Andreas Braun, Stefan Krepp, Arjan Kuijper (2015). *Acoustic Tracking of Hand Activities on Surfaces* - WOAR '15 Proceedings of the 2nd international Workshop on Sensor-based Activity Recognition and Interaction, Article No. 9.

Abstract. Many common forms of activities are tactile in their nature. We touch, grasp, and interact with a plethora of objects every day. Some of those objects are registering our activities, such as the millions of touch screens we are using every day. Adding perception to arbitrary objects is an active area of research, with a variety of technologies in use. Acoustic sensors, such as microphones, react to mechanical waves propagating through a medium. By attaching an acoustic sensor to a surface, we can analyze activities on this medium. In this paper, we present signal analysis and machine learning methods that enable us to detect a variety of interaction events on a surface. We extend from previous work, by combining swipe and touch detection in a single method, for the latter achieving an accuracy between 91% and 99% with a single microphone and 97% to 100% with two microphones.

Andreas Braun, Reiner Wichert, Arjan Kuijper, Dieter W. Fellner (2015). *Capacitive proximity sensing in smart environments.* Journal of Ambient Intelligence and Smart Environments - Volume 7, Issue 4, pp. 483-510.

Abstract. To create applications for smart environments we can select from a huge variety of sensors that measure environmental parameters or detect activities of different actors within the premises. Capacitive proximity sensors use weak electric fields to recognize conductive objects, such as the human body. They can be unobtrusively applied or even provide information when hidden from view. In the past years various research groups have used this sensor category to create singular applications in this domain. On the following pages we discuss the application of capacitive proximity sensors in smart environments, establishing a classification in comparison to other sensor technologies. We give a detailed overview of the background of this sensing technology and identify specific application domains. Based on existing systems from literature and a number of prototypes we have created in the past years we can specify benefits and limitations of this technology and give a set of guidelines to researchers that are considering this technology in their smart environment applications.

Silvia Rus, Meltem Sahbaz, Andreas Braun, Arjan Kuijper (2015). *Design Factors for Flexible Capacitive Sensors in Ambient Intelligence*. Ambient Intelligence - Volume 9425 of the series Lecture Notes in Computer Science pp 77-92

Abstract. Capacitive sensors in both touch and proximity varieties are becoming more common in many industrial and research applications. Each sensor requires one or more electrodes to create an electric field and measure changes thereof. The design and layout of those electrodes is crucial when designing applications and systems. It can influence range, detectable objects, or refresh rate. In the last years, new measurement systems and materials, as well as advances in rapid prototyping technologies have vastly increased the potential range of applications using flexible capacitive sensors. This paper contributes an extensive set of capacitive sensing measurements with different electrode materials and layouts for two measurement modes - self-capacitance and mutual capacitance. The evaluation of the measurement results reveals how well-suited certain materials are for different applications. We evaluate the characteristics of those materials for capacitive sensing and enable application designers to choose the appropriate material for their application.

Andreas Braun, Silvia Rus, Martin Majewski (2016). *Unsichtbare Erkennung menschlicher Aktivitäten in Smart Living Umgebungen mit Kapazitiven Sensoren*. Conference: Zukunft Lebensräume - Kongress. (in German)

Abstract. Smart Living Umgebungen versuchen ihre Bewohner bei der Bewältigung alltäglicher Aufgaben zu unterstützen. Wünsche und Notwendigkeiten werden dynamisch erkannt und eine angemessene Reaktion erzeugt. Dies benötigt mehrere Sensoren, deren Daten intelligente kombiniert werden, um eine Vielzahl von Situation zu erkennen. Häufig greift man hierbei auf Kameras und Bewegungsmelder zurück, die sich nur schwer unsichtbar in der Umgebung anbringen lassen. Kapazitive Sensoren messen Änderungen in elektrischen Feldern und können durch nicht-leitende Materialien hindurch Messungen vornehmen. In den letzten Jahren stieg ihre Popularität in Forschung und am Markt; insbesondere der finger-kontrollierte Touchscreen ist ein populäres Beispiel. In dieser Arbeit führen wir diese Art von Sensorik ein und stellen vor, inwiefern mit diesen menschliche Aktivitäten in Smart Living Umgebungen gemessen werden können. Wir stellen verschiedene Anwendungen in den Bereichen der Aktivitätserkennung und Mensch-Maschine-Interaktion vor, diskutieren Möglichkeiten und Herausforderungen der kapazitiven Sensorik und stellen zukünftige Forschungsrichtungen vor.

Andreas Braun, Michael Alekseew, Arjan Kuijper. *Exploring machine learning object classification for interactive proximity surfaces.* Distributed, Ambient, and Pervasive Interaction 2016.

Abstract. Capacitive proximity sensors are a variety of the sensing technology that drives most finger-controlled touch screens today. However, they work over a larger distance. As they are not disturbed by non-conductive materials, they can be used to track hands above arbitrary surfaces, creating flexible interactive surfaces. Since the resolution is lower compared to many other sensing technologies, it is necessary to use sophisticated data processing methods for object recognition and tracking. In this work we explore machine learning methods for the detection and tracking of hands above an interactive surface created with capacitive proximity sensors. We discuss suitable methods and present our implementation based on Random Decision Forests. The system has been evaluated on a prototype interactive surface - the CapTap. Using a Kinect-based hand tracking system, we collect training data and compare the results of the learning algorithm to actual data.

Andreas Braun, Sebastian Zander-Walz, Stefan Krepp, Silvia Rus, Reiner Wichert, Arjan Kuijper. *CapTap - Combining Capacitive Gesture Recognition and Acoustic Touch Detection.* iWOAR 2016.

Abstract. Capacitive sensing is a common technology for finger-controlled touch screens. The variety of proximity sensors extends the range, thus supporting mid-air gesture interaction and application below any non-conductive materials. However, this comes at the cost of limited resolution for touch detection. In this paper, we present CapTap, which uses capacitive proximity and acoustic sensing to create an interactive surface that combines mid-air and touch gestures, while being invisibly integrated into living room furniture. We introduce capacitive imaging, investigating the use of computer vision methods to track hand and arm positions and present several use cases for CapTap. In a user study we found that the system has average localization errors of 1.5cm at touch distance and 5cm at an elevation of 20cm above the table. The users found the system intuitive and interesting to use.

Eva Schulze, Anne Engler. *POSEIDON – Personalized Smart Environments to Increase Inclusion of People with Down's Syndrome – Results of the first and the extended pilot study.* To Appear in Proceedings WISHWell'16, London.

Abstract**.** The POSEIDON project aims to increase the independence and autonomy of people with Down's syndrome with the help of technical assistants. Therefore, several personalized and smart technology solutions were developed (e.g. a Navigation app, a Home Navigation System, a Money Handling Game, a Calendar app) to help people with Down´s syndrome to become more independent and more included in society. A first pilot study (and in an extended pilot in form of a one-day-event) was conducted in three countries, wherein the prototypes of these technical devises were tested by people with Down´s syndrome and their parents/care givers. Quantitative and qualitative methods were used to collect comprehensive feedback, which is used to develop new technical requirements for revision and further development.

Silvia Rus, Andreas Braun. *Money Handling Training - Applications for Persons with Down Syndrome*. Intelligent Environments 2016 (accepted for publication).

Abstract. Paying for goods and services is a fundamental activity of daily living. Persons with Down Syndrome face these situations as a challenge. Through the usage of assistive technologies, the project Poseidon aims to enable persons with Down Syndrome to be more independent. In this paper we describe a training application for handling money. The novelty is the concept of extending the screen of an application to a palpable table, which serves as novel interaction device. Furthermore, we design the user interface highly personalizable in order to cover a large range of learning profiles of persons with Down Syndrome.

Juan Carlos Augusto, Dean Kramer, Unai Alegre, Alexandra Covaci, Adityarajsingh Santokhee. *Co-creation of smart technology with (and for) people with special needs*. 7th International Conference on "Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion" (2016).

Abstract. We report on the lessons learnt during the application of a methodology to develop Intelligent Environments. This methodology was applied to a project which aimed at helping people with Down's Syndrome and those with similar conditions and needs, to be more included in society. The project is developed by a consortium of commercial, academic, and end user supporting organizations. One important feature of the methodology is that of being strongly user-centred and we report on how that interaction with users took place and how it continuously shaped the project.

Unai Alegre, Juan Carlos Augusto, Tony Clark. *Engineering context-aware systems and applications: A survey*. Journal of Systems and Software, vol. 117, pages 55–83 (2016)

Abstract. Context-awareness is an essential component of systems developed in areas like Intelligent Environments, Pervasive & Ubiquitous Computing and Ambient Intelligence. In these emerging fields, there is a need for computerized systems to have a higher understanding of the situations in which to provide services or functionalities, to adapt accordingly. The literature shows that researchers modify existing engineering methods in order to better fit the needs of context-aware computing. These efforts are typically disconnected from each other and generally focus on solving specific development issues. We encourage the creation of a more holistic and unified engineering process that is tailored for the demands of these systems. For this purpose, we study the state-of-the-art in the development of context-aware systems, focusing on: (A) Methodologies for developing context-aware systems, analyzing the reasons behind their lack of adoption and features that the community wish they can use; (B) Context-aware system engineering challenges and techniques applied during the most common development stages; (C) Context-aware systems conceptualization.

4.3 Overview of publications

This section now analysis how the different publications have contributed to the innovation fields. An additional gap analysis is performed in section 5.1, therefore we will restrict this section to a listing in the following table 3.

Table 3 Overview of scientific publications, their innovation field and specific contributions

No.	Publication	Innovation Field	Contribution
1	Unai Alegre, Juan Carlos Augusto, Tony Clark (2015)	Context-Awareness Inclusive technology	Survey of methodologies for developing context-aware systems, challenges and techniques during developing context-aware systems, and conceptualization of these.
2	Dean Kramer, Alexandra Covaci and Juan Carlos Augusto (2015)	Context-Awareness Inclusive technology AAL	Describes the navigation module of POSEIDON and a semi-structured evaluation of it with six users.
3	Alexandra Covaci, Dean Kramer, Juan Carlos Augusto, Silvia Rus and Andreas Braun (2015)	Virtual Reality Inclusive technology	Introduces the approach for navigation in VR taken in POSEIDON and presents the results of initial evaluations.
4	Dean Kramer, Juan Carlos Augusto and Tony Clark (2014)	Context-Awareness AAL	Introduces the context-awareness module of POSEIDON that supports reactiveness and adaptability.
5	Eva Schulze and Anna Zirk (2014)	AAL	Presents the results of the online survey conducted in the scope of POSEIDON.
6	Carl Evans, Lindsey Brodie, Juan Carlos Augusto (2014)	Context-Awareness AAL	Presents a framework for requirements engineering in intelligent environment scenarios that has been used in POSEIDON.
7	Simon Jones, Sukhvinder Hara, Juan Augusto (2014)	Context-Awareness AAL	Proposes a more holistic approach for consideration of ethical concerns in research and how this can guide the development process.
8	Juan Carlos Augusto, Terje Grimstad, Reiner Wichert, Eva Schulze, Andreas Braun, Gro Marit Rodevand, Vanda Ridley (2013)	Context-Awareness AAL	Introduces the rationale of the POSEIDON system and the approach taken.
9	Andreas Braun, Stefan Krepp, Arjan Kuijper (2015)	Adaptive interfaces Inclusive technology	Presents the technology and method used for the detection of touch and knock events on the CapTap.
10	Andreas Braun, Reiner Wichert, Arjan Kuijper, Dieter W. Fellner (2015)	Inclusive technology Context-awareness Adaptive interfaces AAL	Presents applications of the capacitive technology in the CapTap for smart environments.

11	Silvia Rus, Meltem Sahbaz, Andreas Braun, Arjan Kuijper (2015)	Context-awareness Inclusive technology	Evaluates various materials for suitability with capacitive proximity sensors. Evaluating materials that are suitable for more haptic input devices
12	Andreas Braun, Silvia Rus, Martin Majewski (2016)	Context-awareness AAL	Outlines applications of the technology used in the interactive table for Smart Living environments
13	Andreas Braun, Michael Alekseew, Arjan Kuijper (2016)	Adaptive interfaces Inclusive technology	Presents methods that improve the object tracking for one or more hands using interaction devices, such as CapTap.
14	Andreas Braun, Sebastian Zander-Walz, Stefan Krepp, Silvia Rus, Reiner Wichert, Arjan Kuijper (2016)	Adaptive interfaces Inclusive technology	Description of hardware and algorithms used for creating the CapTap interaction system.
15	Silvia Rus, Andreas Braun (2016)	Inclusive technology Adaptive interfaces	The paper describes a training application for handling money. The novelty is the concept of extending the screen of an application to a palpable table, which serves as novel interaction device.
16	Juan Carlos Augusto, Dean Kramer, Unai Alegre, Alexandra Covaci, Adityarajsingh Santokhee (2016)	Context-Awareness AAL	It explains how a methodology for co-creation was applied to POSEIDON.
17	Eva Schulze, Anne Engler	Inclusive technology AAL	Reports on results of the first pilots.

5 The final steps forward

In this section, we outline how the POSEIDON project provided scientific contributions in the last period and how we are planning to continue scientific dissemination after the project has ended. We will present how the results of the pilots and work performed in the technical work packages will continue on contributing to the different innovation areas. For this, we first outline the remaining gaps in our planned research and how these are filled by the remaining work. In the following section, this is transferred to planned publications that are in review, in progress, or planned.

5.1 Research goals of the last period

Even though the POSEIDON team has made significant progress in the intended innovation areas, there are several areas, in which we plan to provide additional contributions after the project has ended, considering the findings of the last period. In addition, there are several new research questions that became apparent during the runtime of the project. In this regard we have updated our previous gap analysis that tells us, where there are open questions after the project has concluded.

In Inclusive Technology, we have contributed to the body of knowledge, by assessing the suitability of different hardware and software technologies for users with Down syndrome. By performing comprehensive questionnaire studies, different workshops with primary and secondary users, and review of existing literature, we were able to gather insights on how to design inclusive technologies for persons with Down syndrome. This has been driving the design of the systems of POSEIDON during an iterative process. We still have to verify how well the chosen approach fares during longer-term piloting of the developed systems and if the results are transferable to other user groups or even domains.

The contributions and innovation in context-awareness is manifested in several levels. A methodology with supportive tools have been created to design and reason about the most relevant contexts and how to implement them. This starts from requirements gathering (a specific methodology and tool developed and being refined continuously). Then it continues into with the modelling of context-aware rules and all their possible aggregations in a newly designed graphical notation (also with tool support). The outcome of this process can be transformed into C-SPARQL rules at the push of a button. All the above was not available and is scientific innovation created during the POSEIDON project. Under development is a tool to analyse the logical correctness of the initial model automatically through automatic translation of designed context-rules and aggregations into available model-checkers.

In Adaptive interfaces, we have contributed a set of output devices that can be adapted according to personal preference and even configurable input devices that support a larger range of input modalities. Based on a co-creation process with secondary users, appropriate items for personalization have been established and integrated into the final prototypes that were piloted during the last year. During those pilots we established, how well the chosen approach is suited, how we can include those findings in future system design, and how well those approaches can be transferred, even going so far as to change the shape of interaction devices for other groups of users. The findings of those pilots are partially reported after the project has concluded.

In Virtual Reality, we have contributed in multiple ways. Our initial assumptions with regards to the user groups based on literature reviews, showed that there is a gap between theory and practice. We therefore had to adapt to a more usable approach, based on a Mixed Reality approach that overlays information on a virtual model of the actual world. This approach has fared well with primary and secondary users and was thus followed for the final prototype system. In the final year this system was

filled with more content and refined. We have yet to report on the final system and how well it was received by the users.

Regarding AAL, we have built our system based on the existing SmartTracker platform and linked to the universAAL platform as an associated project. This enables potential interoperability with a vast array of different projects and products in the AAL domain. The developed system combines the context-awareness and inclusion focus into a novel solution that is suitable for transfer into other areas of AAL. After the project has concluded, we will report on the usefulness of the system and how the development can contribute to different aspects of the AAL research area.

In personalisation, we have selected appropriate means in types of personalisation in a co-creation process with primary, secondary and tertiary users. The results are outlined in much higher detail in R2 - Personalisation in POSEIDON. Similarly, in learning we have chosen appropriate solutions in accordance with the literature presented and the primary and secondary users participating in the workshops and pilots. Our remaining contributions will be related to report on the evaluation of the acceptance and usability of the chosen solutions during the piloting phase.

Table 4 Overview of remaining research goals in the different innovation areas

Area	Contributions	Remaining Gap
Inclusive Technology	Assessment of how suitable ICT technologies are for users with Down syndrome. Design of appropriate technologies.	Analysis of findings from second pilot and development and refinement of created guidelines.
Context awareness	Methodology and supportive tools on designing and reasoning. New graphical notation for rules. Automated processing into C-SPARQL rules.	Tools for the automated analysis of the logical correctness. Evaluation of appropriateness of created context-awareness after piloting.
Adaptive interfaces	Input and output systems that can be personalized in appropriate ways to users with Down syndrome.	Refining guidelines and personalisation modes according to findings from piloting and finding additional suitable input modalities.
Virtual Reality	Virtual Reality is only partially suitable for persons with Down syndrome. Mixed Reality approaches have been preferred.	Further refinement of chosen approach and testing with larger numbers of users.
AAL	Using existing platforms and linking to other projects in the AAL domain.	Explore further options for interoperable solutions, by linking platforms.
Personalisation	Personalisation options suited for persons with Down syndrome using the POSEIDON system	Evaluate the acceptance of chosen personalisation options and report on findings.
Learning	Using state-of-the-art strategies and a co-creation process in multiple applications.	Evaluate the acceptance of chosen learning strategies and the developed tools and report on findings.

5.2 Planned scientific dissemination

This section build upon the previous gap analysis and shows how the consortium plans to fill these gaps with future publications.

Andreas Braun, Silvia Rus, Martin Majewski. *Invisible Human Sensing in Smart Living Environments using Capacitive Sensors*. Ambient Assisted Living 2016 (accepted for publication).

Contribution. Outlines opportunities for sensing electric field sensing technologies in ambient intelligence, including interaction systems similar to CapTap.

Anna Zirk, Eva Schulze, *POSEIDON – Technology for People with Down's syndrome. Results of the first Pilot*. 15th International Conference on Computers Helping People with Special Needs (under review)

Contribution. In-depth analysis of the results of the first piloting phase.

Andreas Braun, Sebastian Zander-Walz, Martin Majewski, Steeven Zeiss, Arjan Kuijper. *Curved - free-form interaction using capacitive proximity sensors.* (Working paper)

Contribution. CapTap in a different shape that is particularly suited for interaction using VR goggles.

Anna Zirk, Detlef Oesterreich, Eva Schulze. *Competencies of people with Down's syndrome and how to support them to increase their independence and autonomy.* Working Paper.

Contribution. Results and discussion of the questionnaire study performed during the first and second year of POSEIDON.

Silvia Rus, Tobias Grosse-Puppendahl, Arjan Kuijper. *Recognition of Bed Postures using Mutual Capacitance Sensing*. Journal of Ambient Intelligence and Smart Environments (under review).

Contribution. Evaluates other use cases in health for capacitive sensing technology.

Alexandra Covaci et al. *Study on how technology can make people with Down syndrome more independent (working title)*. Working paper.

Contribution. Provides a summary of the achievements on the Assistive Technology side, especially Navigation.

Dean Kramer et al. *Context-Awareness using Stream Reasoning*. Working Paper.

Contribution. Discusses the context-awareness reasoning system and its implementation in C-SPARQL.

J. Augusto, D. Kramer, U. Alegre, A. Covaci and A. Santokhee. *The User-centred Intelligent Environments Development Process as a Guide to Co-create Smart Technology for People with Special Needs* (Submitted to a journal).

Contribution: the article describes how a methodology for developing smart technology has been applied to guide the development of POSEIDON exemplifying with the different stages and deliverables.

Eva Schulze et al. *Results of the pilot studies of POSEIDON (working title).* Working Paper.

Contribution. Results and discussion of the findings of both pilot studies performed in the scope of POSEIDON.

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