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## Publishable Executive Summary

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### **IROME C - Interactive RObotic social MEdiators as Companions**

State of the art research emphasises the important role of play in child development as a crucial vehicle for learning about the physical and social environment, the self, and for developing social relationships. Project IROME C targets children who are prevented from playing, either due to cognitive, developmental or physical impairments which affect their playing skills, leading to general impairments in their learning potential and more specifically resulting in isolation from the social environment. IROME C will investigate how robotic toys can provide opportunities for learning and enjoyment. The developed robotic system will be tailored towards becoming a social mediator, empowering children with disabilities to discover the range of play styles from solitary to social and cooperative play. Robustness, dependability as well as “plug&play” operation of the robot system are specially addressed.

#### **Project Objectives:**

IROME C aims to empower children with disabilities to prevent dependency and isolation, develop their potential and learn new skills by development of a robot-supported play environment which meets the users' expectations for a safe and reliable, versatile and tailorable, ready to use and affordable system. The main objectives of the project are:

- Addressing the three main aspects of playing (enhancement of “Quality of Life”, enhancement of “Social Inclusion”, enhancement of “Learning and Therapy”) through delivering a social robot system acting as a social mediator in a play environment that can be configured depending on the specific needs of cognitive and multiple disabled children.
- Providing a concrete solution
- Pursuing an active dissemination and exploitation strategy by which primary and secondary users, therapists and educational institutions are early and continuously informed about the product under development.

This leads to the two following technical project objectives:

- Development of a “Framework for robotic social mediators”
  - Developing and testing a set of scenarios in which mediating robots can be used
  - Analysis of different styles of interaction
  - Developing different evaluation techniques regarding the performance of the robot as well as potential therapeutic effects
  - Developing a set of general guidelines for appropriate robot behaviour and interfaces
- Development of a prototype robotic toy
  - Prototyping a robot system with special focus on safety and reliability
  - Prototyping of intuitive and multi-modal user interfaces for the particular target group
  - System evaluation in a multi-center trial series

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**Work Progress:**

The project started with an in-depth assessment of particular user needs. Two rounds of user panels in five different countries – Austria, UK, the Netherlands, Italy, and Spain – were performed in order to support this task. The first user panel round was used for a more general exploration of the topic – the second user panel round was based on a structured analysis of user needs. The outcome of the two rounds of user panels gave a good indication about the play activities for which robot toys could be of added value, as well as of wishes considering robot toys, connected to the target groups.

Based on the outcomes of the user panels, a first set of specifications and concepts has been elaborated in order to guide through the realisation phase performed in years 2 and 3. A collection of user-centered play scenarios has been worked out – based also on experimental work, literature review as well as on previous experience from the IROMECE partners. Furthermore, a description of the general robot concept with special emphasis on interaction and interfaces as well as of the core robot system and its functionalities has been worked out. Finally, a study dealing with “Critical Factors” involved in robot mediated playing activities of children with disabilities has been performed and documented. Major aim of this research was the analysis of use and effects of IROMECE as a tool for therapy and education of children with disabilities.

Based on the work from the first project year, main outcome of project year 2 was the finalisation of the IROMECE play scenarios. The elaborated play scenarios have been confirmed in another user panel round (UP3) – findings from UP3 also led to a prioritisation of the play scenarios into a “Top-10” list. For completion of the IROMECE scenarios the addressed therapeutic and educational objectives have been described by using the ICF classification. Hand in hand with the scenario descriptions, the design of both the core robot system as well as of the application module(s) has been completed. Two operational modes for the robot system have been defined – in the “horizontal configuration” the application module is being attached to the mobile platform, in the “vertical configuration” the application module is being used “stand-alone”. All scenarios using robot movement are in “horizontal configuration”; “vertical configuration” is being used for play scenarios like “Imitation Game”. A detailed design guideline for user interaction (module) has been worked out and first prototypes have been developed and used for evaluation. Functionality for the mobile (core) platform has been refined based on the scenario description and a first prototype of the robot has been developed. A detailed HAZOP analysis has been performed as part of the RAMSS activities in order to ensure safety and reliability. For the “IROMECE Framework” a first draft for “Guidelines for using robots to support the play of children with disabilities” has been worked out. It is based on the prior research on “Critical Factors” and represents a concrete use of the “Critical Factors” checklist and concept map. A dedicated form has been created as a particular application of the general framework in order to be compiled by clinicians and teachers involved in the experimental trials with the help of instructions. For evaluation a basic framework has been developed and concepts have been worked out in order to fill this frame. Evaluation will take place in three phases: technical evaluation and toy safety, evaluation of scenario soundness, usability and playfulness, and evaluation of educational/therapeutic impact. Another round of User Panels (UP4) has been performed in order to investigate evaluation methods used in current praxis in order to setup a dedicated evaluation methodology for IROMECE.

Main activity of the third project year was the finalization of the final prototype of the IROMECE robot system as well as realisation of a first small series of 7 robots for multi-center evaluation. Based on the first evaluation results in project year 2 a complete redesign of the interaction module has started in year 3. Different from the original concept the basic idea behind the new design is to have a very limited set of typical GUI elements – like an animated “hair” for output and an animated “fur knot” which serves as a input element in different configurations – and use this for all implemented play scenarios. Hand in hand with the re-design of the main interaction element – the graphical user interface on the application module (APM) – there was also a redesign of the APM hardware (in order to save weight, cost and power consumption) as well as of the mobile robot base (also in order to save power consumption and decrease complexity). Following the planned

concept of modularity a set of optional “add-ons” have been designed and realized. For example exchangeable side-panels (also called “lateral add-ons”) can be attached in order to add special light effects, a semi-transparent fur with touch sensors can be used to cover the main monitor and as additional input device and dedicated hardware masks can cover the animated face (if desired). In addition to the development of the robot prototypes, another result of project year 3 is the finalisation of the “framework”. The guidelines for setting up educational and therapy session - which already were drafted in the second project year – have been completed with methods for play assessment. Finally a second report is giving an in depth description about the use of robotic technologies in the area of play for children with disability. Questions like objective selection, play setting, the role of adults and peers in play, suitable features of robots etc are discussed in the report. Another significant part of the “framework” – and result of the research in the third project year - finally is dealing with IROME C evaluation tools and an accompanied software (“EVA Software”) which should allow teachers, therapists or carers to evaluate improvements in different developmental areas that children playing over time with the IROME C robot (or any similar robot) may achieve.



Figure 1 – First prototype of the IROME C robot system during user trials

	Sub-area	Objective	ISO1			ISO2			ISO3			ISO4			ISO5		
			AUT	SMI	MMR												
Sensory Development	Perceptual functions	VISUAL PERCEPTION	+			+	+	+									
		TACTILE PERCEPTION															
		VISUOSPATIAL PERCEP. (spatial awareness)										+	+	+	+	+	+
		PROPRIOCEPTION (body awareness)										+	+				

	Sub-area	Objective	ISO6			ISO7			ISO8			ISO9			ISO10		
			AUT	SMI	MMR	AUT	SMI	MMR									
Sensory Development	Perceptual functions	VISUAL PERCEPTION										+	+	+			
		TACTILE PERCEPTION															
		VISUOSPATIAL PERCEP. (spatial awareness)				+		+	+								
		PROPRIOCEPTION (body awareness)															

Figure 2 – Mapping of objectives (for example sensory development objectives) to IROME C play scenarios as one important part of the developed “framework”

## The IROME C Results:

The final IROME C prototype opens up new perspectives in the area of robot-assisted play in education and therapy. Project results cover a wide range of topics – starting with guidelines for development of appropriate robot and interaction systems, up to the definition of exemplary play scenarios and the mapping to particular objectives (with respect to the ICF-CY definitions) and finally guidelines for the appropriate set-up play sessions, for the use in education and therapy as well as for the suitable evaluation of playability and therapeutic effects. A further result of the project is the development of a small series of dedicated IROME C robots for a prototypic evaluation of the aforementioned guidelines. The robot and the implemented play scenarios can be seen as a first exemplary implementation with a range of innovative features that easily allow building a new generation of robot systems for play and education of disabled children.

- Guidelines for robot and interaction design

The research in IROME C results in an extended analysis of hardware and software requirements for a robot system in the given area of play in education and therapy. Based on different input sources – like experience from previous projects, literature research and especially feedback from the User Panels installed during the project – a set of design guidelines for an interactive and mediating setup has been developed.

- Modularity and Safety

Due to the big variation of requirements in the three selected user groups (and even within each user group) the requirements for the robot system also varies very much. Modularity has turned out to be a key approach in order to tackle this problem. The IROME C robot system thus is designed in a modular way – speaking in terms of both software and hardware design. The IROME C robot system – for example – consists of two separate main modules, a mobile robot platform and a exchangeable application module (APM) for multi-modal interaction. Defined hardware and software interface between APM and robot allows to combine with other modules. The APM can be used in connection with the robot but also “stand-alone”. Additional “add-ons” for the APM – like side-panels with/without additional visual effect, semi-transparent fur cover for touch-sensitive input, face masks, manipulator arms (in progress) – allows further individualisation of the robot. Graphical elements for the main GUI as well as used sounds for acoustic feedback can be individualized easily. A dedicated “Scenario Configurator” (in progress) allows variation of existing as well as development of own play scenarios.

Beside of the aforementioned aspect of modularity, safety was a second main design criteria in IROME C. In the given application area there always is the realistic use scenario that a child is coming very close to a mobile robot, which certainly is a safety issue. An in-depth analysis of safety and reliability thus was accompanying the entire design process. Results from this safety analysis can be transferred and used for similar setups as well.

- Play scenarios and mapping to objectives

Hand in hand with the development of robot guidelines and based on the feedback from the IROME C User Panels the project could accomplish a set of Play Scenarios. Beside of a detailed description of the setup and all activities for each of these games (including variations) the scenario description also includes an analysis of the particular educational and therapeutic objectives (with reference to the ICF-CY<sup>1</sup>) related to each play scenario. These objectives cover five different developmental areas that are: sensory development, communicational and interaction, cognitive development, social and emotional development and motor development. The resulting outline of play scenario has been used as design guideline for IROME C but can be also used for similar setups.

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<sup>1</sup> International Classification of Functioning – version for Children and Youth

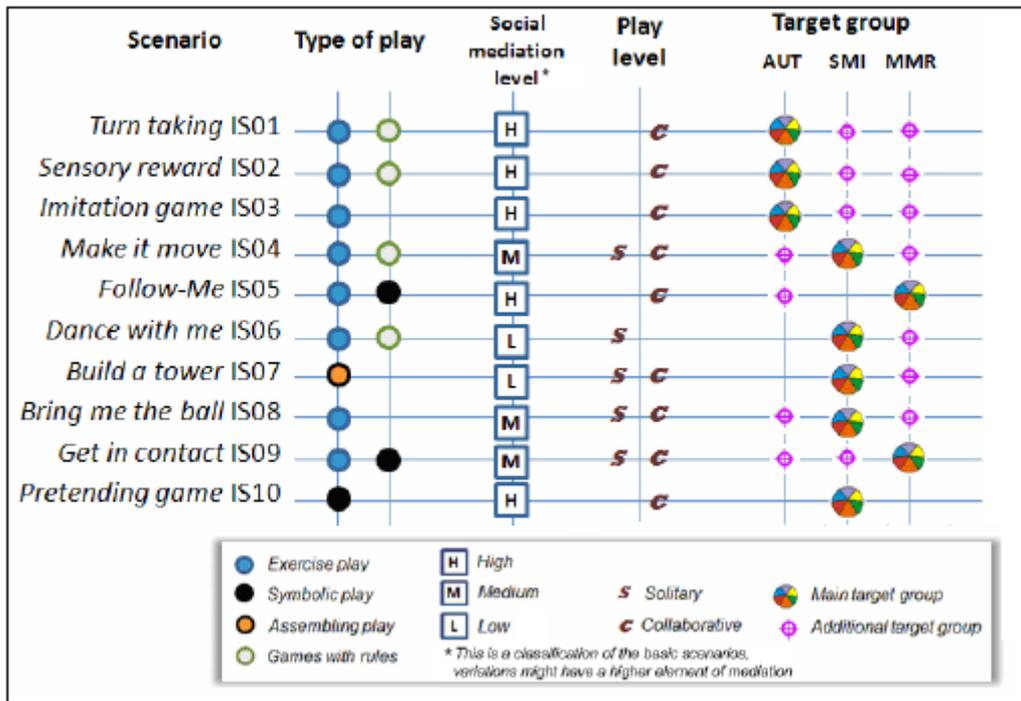


Figure 3 – IROME C ‘Top Ten’ Play Scenarios and mapping to IROME C target groups

- Guidelines for setup and use

Another important result of IROME C is the accomplished framework for using robot technology for playful activities in education and therapy. The guidelines which were worked out in the project are discussing all aspects of using this new technology, like suitable setup, role of participating persons (peers, teachers, etc), advantages/possibilities of a robot system as well as advice for evaluation. Similar to other IROME C results these guidelines are focusing on the IROME C robot setup, but can be used for other similar setups as well.

- Guidelines for evaluation

The ‘Guidelines for Evaluation’ resulting from the IROME C project allow teachers, therapists or carers to evaluate improvements in different developmental areas that children playing over time with the IROME C robot may achieve. The IROME C evaluation tools (‘EVA Tools’) of therapeutic and educational objectives combine quantitative and qualitative methods. The ‘EVA Questionnaire’ consists of a list of questions (items) that are presented to the teacher or therapist who are familiar with the child. It contains all the questions related to objectives that were identified as relevant to that specific user group. An additional optional tool (‘EVA software’) was developed to further facilitate the teacher/therapist during the intervention period and help the evaluation process. This software can assist the teacher/therapist to set the objectives for each child, plan the intervention process, choose the relevant play scenarios to be played in each session (according to the selected objectives), monitor the child progress and assist the evaluation. It tailors the evaluation questionnaire to the specific child according to the child’s selected objectives and the planned play scenario.

- IROME C Robot Prototype

Supplementing the aforementioned results which forms the ‘IROME C Framework’ the project finally has generated a small series of seven robots systems in order to support the planned multi-center evaluation. Each of the setups consists of the IROME C robot with the mobile base and the application module APM and the auxiliary components, like mounting frame for use of the APM in

vertical configuration, a set of APM “add-ons”, Teacher Panel and wireless buttons for remote control.



Figure 4: IROMECE Robot System in “horizontal configuration” (left image) and “vertical configuration” (right image)

### The IROMECE Future:

The multi-center long-term evaluation which has started in the framework of the EC-FP6 project IROMECE will be continued until summer 2010. In parallel to this evaluation acquisition of additional test sites is taking place in order to increase the number of children working with the robot. Continuation of the dissemination activities by publications in scientific and non-scientific journals as well as presentations and demonstrations will support these acquisition activities. Realisation of further robot setups for new institutions also will be used for incremental optimisation of the setup. Additional modules like robot arms, Scenario Configurator and new application modules are already in progress and will further extend the use of the robot system.

Finally, and subject to a positive evaluation of the educational/therapeutic impact of the IROMECE system in the long term evaluation, a more significant redesign will be executed in order to reduce the system costs and complexity.

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