European Cooperation
in Science and Technology
- COST -

Secretariat

Brussels, 16 December 2010

COST 4203/10

MEMORANDUM OF UNDERSTANDING

Subject :	Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action TD1006: European Network on Robotics for NeuroRehabilitation

Delegations will find attached the Memorandum of Understanding for COST Action TD1006 as approved by the COST Committee of Senior Officials (CSO) at its 180th meeting on 1 December 2010.

MEMORANDUM OF UNDERSTANDING
For the implementation of a European Concerted Research Action designated as

COST Action TD1006
EUROPEAN NETWORK ON ROBOTICS FOR NEUROREHABILITATION

The Parties to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 4159/10 “Rules and Procedures for Implementing COST Actions”, or in any new document amending or replacing it, the contents of which the Parties are fully aware of.

2. The main objective of the Action is to enable the development of innovative, efficient, and patient-tailored robot-assisted therapies for neuromotor recovery, incorporating the latest findings from clinical neurorehabilitation, rehabilitation robotics, computational neuroscience, and motor neuroscience.

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 48 million in 2010 prices.

4. The Memorandum of Understanding will take effect on being accepted by at least five Parties.

5. The Memorandum of Understanding will remain in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Chapter V of the document referred to in Point 1 above.

A. ABSTRACT AND KEYWORDS

The aging of the European population will inevitably accelerate the demand for effective rehabilitative therapies to ameliorate the motor deficits caused by major age-associated neurological syndromes such as stroke. Robots for neurorehabilitation offer a significant advantage in addressing this need. They can extend substantially the capacities of therapists who work with patients suffering from motor impairments. Typical robotic devices can convey instructions to patients on how to perform specific movements, can assist and guide the execution of motor actions, and can objectively assess movement capabilities. The growing variety of robotic devices used in primary research and clinical practice offers a rich framework for expanding their use in an expanding number of different patient groups. The main objectives of this Action are firstly to develop new, efficient and patient-tailored robot-assisted therapies by coordinating basic and applied research perspectives. Secondly, the Action will provide a clear structured overview about existing and emerging robot-assisted therapies to clinicians and therapists, so they can increase the availability of effective, standardised clinical practice across Europe. The Action will be carried out by an interdisciplinary team of leading researchers from robot engineering, clinical motor neurorehabilitation, computational neuroscience and motor neuroimaging.

Keywords: Robotics for Neurorehabilitation, Neuroplasticity, Neuromotor Recovery, Stroke, Aging Populations

B. BACKGROUND

B.1 General background

It is estimated that in the EU the proportion of the population aged over 65 will rise from 17.1% in 2008 to 30% in 2060 and that the proportion of persons aged over 80 will rise from 4.4% to 12.1% over the same period (EUROSTAT population projections).

Neurological conditions, especially stroke, are a major cause of disability among older people. Incidence of a first stroke in Europe is about 1.1 million and prevalence about 6 million. Currently, about 75% of stroke sufferers survive one year after. This proportion will increase in the coming years due to steadily increasing quality in hyper-acute life saving practice, follow-up acute and subacute care, and life-long management of these conditions. Despite these positive developments in stroke care, approximately 80% of stroke patients experience long-term reduced manual dexterity and half of all patients with neurological conditions are unable to perform everyday tasks. Thus the consequences of neurological diseases such as stroke will have a growing impact on the health and economic prosperity of the European community.

One implication of this scenario is that there will be an increasing demand for treatments that help to restore motor function after events like stroke. However, physiotherapists and occupational therapists are already now a scarce resource and economic pressure forces therapy centres to treat patients in short periods of time. Therefore it is imperative to find solutions that ensure therapy for everyone and optimize the type and timing of treatments that patients can receive in a limited time window. A research area holding the promise to deliver such solutions is robotics for neurorehabilitation.

One example of a rehabilitation robot is the MIT-Manus (developed at MIT, Massachusetts Institute of Technology). This device engages patients to train one-, two-, and three-dimensional wrist, elbow, or shoulder movements by using a manipulandum to move to targets and can provide visual, tactile, and auditory feedback during movement. The robot can be operated in passive mode (stabilizing the limb), in active mode (moving the limb with actuators), or interactive mode (e.g. movement triggered actuation of the limb). Randomized, controlled clinical trials have shown that intensive training with assistive-robotics in the acute/subacute phases of stroke leads to significant reductions in motor impairment, gains in motor coordination and muscle strength. Similar but more modest results exist for the chronic phase of stroke.

In practical terms, robots may assist in patient exercises that the therapist can perform but may have no time to do, thereby directly addressing the growing need for therapies highlighted earlier. A further advantage of rehabilitation robots is the possibility to assess motor impairments in an objective, accurate, and quantitative way. Furthermore, the embedded sensors of many robot devices could work not only as an assessment tool in rehabilitation, but also as an interface between the patient and a friendly user interface (videogame). This may allow a more motivating and enjoyable therapy avoiding tiredness and boredom.

Despite the advantages offered by robots for neurorehabilitation, the acceptance of such devices among clinicians is still low. One reason for this may be that there is no unique and well structured description of the manifold designs and characteristics of rehabilitation robots available to clinicians, therapists, and health fund managers. A second reason is that the processes underlying recovery after stroke and the factors influencing this recovery are still only poorly understood. Current evidence shows that intensive, task specific, repeated exercise has the most beneficial effects. However, there is only limited knowledge about other factors (e.g. drugs to speed up recovery) influencing the outcome of robot-aided therapies and physiotherapy. Therefore, it is very likely that the effectiveness of robot-aided therapies as well as conventional physiotherapy could be significantly improved.

This COST Action will directly address the stated issues by coordinating and stimulating European research in the areas of rehabilitation robot engineering, clinical neurorehabilitation, computational modelling of recovery, and motor neuroimaging.

The objectives of the Action are:

- To provide clear, evidence-based guidelines for patient selection and application of robot-aided therapy.
- To coordinate research necessary for understanding factors influencing recovery processes after stroke.
- To recommend desirable features of new and efficient robot-based therapies, taking into account future application scenarios (e.g. neurological conditions other than stroke, decentralized domestic tele-rehabilitation).

Among the currently available European funding schemes COST is the best match to achieve these objectives. In fact, this Action focuses on the consolidation and extension of results from national research programmes and on interdisciplinary networking activities. The Action is designed to have long-lasting positive effects on European uptake in rehabilitation robotics and to build strong links to non-academic partners.

B.2 Current state of knowledge

Traditionally, research in robotics for neurorehabilitation is driven by technological developments and many prototypes of rehabilitation robots have originated from engineering labs. Therefore, a lot of research has concentrated on the mechanical design of robots with different degrees of freedom, the haptic properties of robots, and the development of visual and auditory feedback mechanisms. A relevant amount of research in Europe still continues in this tradition, for example there are research programmes focusing on the development of novel actuation technologies (variable impedance actuation) which embody part of the intelligence necessary for control in the physical design of the robot (Seventh Framework Programme (FP7) projects EVRYON "Evolving Morphologies for Human-Robot Symbiotic Interaction" and VIACTORS "Variable Impedance ACTuation systems embodying advanced interaction behaviORS"). It is expected that these technologies will enable the development of lightweight wearable robots for neurorehabilitation, providing improved physical interaction with humans. Feedback mechanisms currently being developed in European projects use virtual reality techniques to provide feedback driven by behavioural and physiological data acquired from the patient (FP7 project MIMICS "Multi-modal immersive motion rehabilitation with interactive cognitive systems"). The hypothesis underlying this research is that maximal patient motivation and improved therapy outcomes can be achieved through immersive and multimodal sensory feedback provided by the robotic system.

To validate the technological developments from engineering labs it is of great importance to test the developed devices in clinical trials. To some extent this work has already taken place (in Europe and other parts of the world) and it has been shown that robot-aided training after stroke can lead to equal or better results than regular physiotherapy. For lower limb training with devices such as the Lokomat (Hocoma AG, Switzerland) randomized controlled clinical trials have shown that stroke patients receiving regular physiotherapy and robot-aided gait training exhibit greater gains in their ability to walk independently than patients receiving an equivalent amount of only regular physiotherapy. For robot-aided upper limb training, several different devices have been developed. Randomized clinical trials with this kind of devices have shown that intensive robot-aided training involving the shoulder and elbow leads to significantly better outcomes in terms of ameliorating motor impairment. For training the wrist and hand such differences were not found. Independently of the trained part of the upper limb, no significant differences between physiotherapy and robot-aided therapy were found for improvements in activities of daily living such as eating or grooming. Given these rather general findings, future work in the clinical application and testing of rehabilitation robots should concentrate on refining these results, on exploring which haptic and sensory feedback features positively influence rehabilitation outcome, and on defining clear guidelines for the application of specific types of robots to individual patients. Strongly related to the clinical testing of rehabilitation robots is robot-aided assessment of patient impairments. Here, it has been shown convincingly that robots can objectively assess parameters of patient impairment (e.g. spasticity measurements). However, to make robot-aided assessment useful in clinical practice further research is necessary to clarify the relation between robot-aided assessment scales and clinical scales (e.g. the Ashworth scale).

Besides being applied for robot-aided therapy and patient assessment, robots are also increasingly used to study the mechanisms underlying motor learning and motor recovery. Advancing the understanding of these processes is crucial for improving the efficacy of robot-aided and traditional neurorehabilitation. From experimental studies (independent of robots for rehabilitation) it is known that motor learning is likely mediated by modifications in function (synaptic strength) and structure of neural circuits in different brain regions. Studies using methods such as electroencephalography, functional imaging and brain stimulation have demonstrated – in analogy to results obtained with more invasive methods in animal models – that sensorimotor and associated cortices, the basal ganglia and the cerebellum are undergoing functional modifications that are associated with the learning of novel movements. Recovery after brain lesion shares many of the modifications happening during motor learning. Studies employing rehabilitation robots have shown that neural circuits not affected by injury learn to compensate for lost cells and connections thereby re-enabling effective movements. Current research in Europe in this area focuses on determining the efficacy of specific robotic training protocols (e.g. assistance vs. perturbation of movements) and the modifications in function and structure of neural circuits involved in potential treatment effects. Robots are also used in conjunction with brain-computer interfaces (e.g. FP7 project BETTER “BNCI (Brain-Neural Computer Interaction)-driven robotic physical therapies in stroke rehabilitation of Gait disorders”); this means the patient’s brain activity controls a robot that moves, for example the patient’s arm or leg. A further issue being studied is the application of robot-aided therapy in combination with supportive rehabilitative treatments (drugs, brain stimulation) in patients with various clinical conditions while characterizing the neurophysiological consequences of their use.

Experimental studies of motor learning and motor recovery should go hand in hand with theoretical modelling of these processes. However, theoretical modelling of recovery during robot-aided neurorehabilitation is a relatively new research area and little knowledge exists. Like in experimental studies it is highly probable that parallels can be drawn with research results about motor learning and motor adaptation in healthy subjects. Explicit models of motor adaptation have been used to understand key properties of adaptation, like the gradual development of an internal model of the disturbance, the concurrent action of multiple adaptive processes with different time scales and the sensory and motor components of adaptation. Only initial attempts have been made to extend this modelling framework to the case of robot-assisted motor recovery. Ongoing research (e.g. FP7 project HUMOUR “Human behavioral modelling for enhancing learning by optimizing human-robot interaction”) is focused on improving such models and applying them to robot-aided rehabilitation. Other existing models in this area deal with higher levels of abstraction and describe the time course of recovery in robot-assisted rehabilitation.

The main impact of this COST Action will be produced through the coordination of interdisciplinary research activities resulting in innovative outcomes such as effective patient-tailored robot-aided therapies, new therapeutic concepts supporting scenarios such as decentralized home-rehabilitation, and recommendations for future research directions. This will increase the impact of rehabilitation robots in clinical practice and help to direct basic research results towards applications and practical clinical problems. Discussion of research problems in rehabilitation robotics from multiple viewpoints will allow working towards solutions in a synergistic way, to prepare research agendas addressing future application scenarios, and to reach a consensus about future research directions.

B.3 Reasons for the Action

Robots for neurorehabilitation hold a large promise to support clinicians and therapists in the provision of effective, time-efficient and cost-efficient therapy to a large number of patients. However, to allow society to fully profit from this promise, several research questions should be urgently answered. Examples for such questions are: How to match parameters of robot-aided therapy to individual patients in an optimal, evidence-based way? How can robots be used to assess motor impairments in a systematic way? Which kind of new opportunities is offered by recent technological developments, what are possible future application scenarios for robots, and how should these opportunities drive the development of new rehabilitation robots? What are the physiological mechanisms in the central nervous system underlying recovery and how can these mechanisms be influenced by adjunct treatments (e.g. drugs, brain stimulation)?

Research activities aiming to answer the above questions are ongoing across Europe. However, these activities are scattered throughout different research disciplines, different labs, and different clinics. The best way to coordinate, bundle, and streamline the ongoing research is a multidisciplinary COST Action. This Action will immediately improve exchange of information and will accelerate the solution of scientific problems. This will ultimately result in a better quality of life of patients and a reduced burden on the European society. Therefore, this COST Action will address both the economical/societal as well as scientific/technical needs of the European society.

B.4 Complementarity with other research programmes

Nowadays, in many European countries there are research groups working directly on topics of robotics for neurorehabilitation or on related topics. However, the networking among these groups is very limited and there is no consensus on which directions the field should take. European research consortia funded under the FP7 programme (e.g. the HUMOUR, BETTER, MIMICS, VIACTORS, and EVRYON projects) focus on thematically different aspects of robotics for neurorehabilitation. Therefore the amount of cooperation is too low to avoid duplication of work and to accelerate progress. Furthermore these projects dedicate only a small amount of work to questions related to the practical clinical application of rehabilitation robots.

This COST Action will improve cooperation between research initiatives on the European and national level by providing a unique way to interact and exchange information. Compared to other EU programmes the advantages of this COST Action are its multidisciplinary character and its flexible structure, allowing new research groups to join the running Action and new emerging research directions to be explored.

C. OBJECTIVES AND BENEFITS

C.1 Main/primary objectives

The main objective of the Action is to enable the development of innovative, efficient, and patient-tailored robot-assisted therapies for neuromotor recovery, incorporating the latest findings from clinical neurorehabilitation, rehabilitation robotics, computational neuroscience, and motor neuroscience.

C.2 Secondary objectives

The secondary objectives of this Action are structured into three groups:

1. Promote the use of rehabilitation robots in clinics and therapy centres

- Summarize and catalogue established research results on robot-aided therapies. Formulate evidence-based guidelines for the application of robot-aided therapies in clinical practice.
- Summarize and catalogue established research results on robot-aided assessment of patient capabilities. Clarify how robot-aided assessment procedures are related to existing clinical scales.
- Identify disabilities and diseases for which robot-aided therapies represent potentially beneficial treatments.
- Organize an information day for clinicians and therapists, representatives of governmental bodies, and representatives of end-user associations.

2. Advance research concerning mechanisms and models of motor recovery

- Identify patient and therapy parameters which are important for theoretical modelling of motor recovery.
- Discuss the relation between models of sensorimotor learning and models of motor recovery.
- Discuss results of ongoing clinical trials and experiments about the neurophysiological mechanisms of motor recovery.
- Plan and coordinate future experiments and clinical trials.
- Share datasets recorded in experiments studying the neurophysiological mechanisms of motor recovery.
- Organize a workshop on theoretical modelling of motor recovery.
- Compile a repository of software tools for modelling motor learning and motor recovery.

3. Coordinate the development of future rehabilitation robots

- Identify key features of future rehabilitation robots from an analysis of established research results, experience with clinical use of robots, and ongoing research programmes.
- Identify emerging technologies which could be of use in future rehabilitation robots.
- Discuss future application scenarios such as for example tele-rehabilitation.
- Recommend future research directions for the technological development and clinical application of rehabilitation robots.

In quantitative terms, the achievements of the objectives of this Action can be evaluated by the following numbers:

- Number of active participants in the Action
- Number of presentations and publications authored by participants of the Action
- Number of Short-Term Scientific Missions (STSM) supported by the Action
- Number of participants in Training Schools and workshops organized by the Action
- Number of accesses (hits) on the Action website
- Number of citations referring to publications generated during the Action
- Number of datasets shared on the Action website
- Number of modelling tools described on the Action website

C.3 How will the objectives be achieved?

The objectives will be achieved through discussion, coordination, and organization of ongoing research programmes related to robotics for neurorehabilitation. The participants of this Action are leading European experts in their fields and are partners or leaders of relevant research projects at the European and national level. Expertise from several disciplines will be combined and will be crucial to achieve the objectives of the Action. Instruments to achieve the objectives include:

- A website showcasing recent research in rehabilitation robotics and related fields. The website will serve to announce meetings, workshops, and conferences. Additionally the website will contain a repository of publications, a repository of modelling tools, and datasets recorded from patients.
- A mailing list for discussions, announcement of conferences, and announcements of new publications
- Training of researchers in Training Schools organized by the Action
- Exchange of researchers in the framework of Short-Term Scientific Missions
- Dissemination and discussion of new findings at the meetings of the Action
- Organization of workshops at scientific conferences
- Organization of an information day for key stakeholders
- Interaction with representatives of companies active in the area of rehabilitation robotics

C.4 Benefits of the Action

By accelerating progress in basic science, promoting the use of rehabilitation robots in clinics and therapy centres, and steering the future development of rehabilitation robots, the Action will be of benefit to society, science, and economy.

Societal Benefits

- Advanced, intensive and efficient forms of therapy become available at comparatively lower cost than present.
- Improved quality of life of patients with motor impairments after stroke
- Patients depend less on caregivers for performing activities of daily living

Scientific Benefits

- Evidence-based agreed protocols and outcome measures will provide scientific evidence for effectiveness; including matching protocol to patient characteristics across diseases.
- Informed development of rehabilitation robots, ensuring that design is driven by clinical need and scientific evidence
- The Action will advance the theoretical modelling of motor recovery. This will eventually allow developing new efficient forms of robot-aided therapy.
- The summarization of already established results will clearly identify gaps in knowledge and enable formulation of new, innovative research programs.
- Knowledge about training factors influencing recovery of neuromotor control after stroke is brought together from different scientific research areas, companies, and clinics.
- Clinical trials and experiments taking place in different research programmes are coordinated and duplication of work is avoided.

Economic Benefits

- Increased clinical use of robot devices will benefit manufacturers, enabling Europe to be world-leading in this industry.
- Strengthened position of European companies in the emerging market for rehabilitation robotics and assistive technologies.

C.5 Target groups/end users

- Researchers / Engineers
- Clinicians
- Therapists
- Caregivers
- Manufactures and developers of rehabilitation robots
- Patients

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

The primary objective of this Action is to enable the development of a new generation of innovative, efficient, and patient-tailored robot-aided therapies for neuromotor recovery. To achieve this objective, the Action focuses on the coordination of work across four different aspects of research concerning robotics for neurorehabilitation (clinical, engineering, theoretical modelling, and motor neuroscience).

To foster the clinical application of rehabilitation robots it is necessary to summarize the existing evidence about the efficacy of different types of robot-aided therapies in different types of patients. The development of guidelines for the clinical application of existing robots will lead to increased acceptance of these devices among clinicians and therapists. Research efforts focusing on robot-aided assessment of patient capabilities have to be coordinated to clarify the relation between robot-aided assessment scales and clinical scales and to ultimately achieve clinical acceptance of robot-aided assessment methods.

For the future development of rehabilitation robots a European consensus about important research directions has to be found. The consensus should be formed taking into account the functionalities that can be implemented with different technologies, knowledge about recovery processes after brain injury, and the importance of different robot functionalities from a clinical point of view.

To better understand the processes underlying motor recovery after stroke (or other brain injury) research on theoretical models of motor recovery and experimental studies of neurophysiological mechanisms underlying recovery have to be coordinated. Research tasks to be coordinated in this area are the extension of existing models to include individual patient parameters, and parameters of the therapy setting. Furthermore, experimental studies concerning the efficacy of different robot-aided therapies, with different supportive therapies, and in different patient populations have to be coordinated.

The research tasks and research disciplines mentioned above should be seen as a minimum that is necessary to make significant progress. However, this Action is structured to allow for the inclusion of new perspectives on robot-aided neurorehabilitation, which might arise during the course of the Action.

D.2 Scientific work plan - methods and means

The objectives of the Action will be achieved through the joint efforts of four Working Groups. The objectives of each Working Group and the interaction between Working Groups are described in the following:

WG1 Clinical application of rehabilitation robots
The main objective of the Working Group is to formulate clear, evidence-based guidelines for the clinical application of rehabilitation robots. Commercially available approaches to robot-aided therapy will be categorized using a matrix of: activity performed (e.g. walking, standing, reaching, and hand function) by technology (e.g. degrees of freedom, active / passive devices, see WG2). The matrix will be used to evaluate the efficacy of different types of therapies for different types of patients taking into account data from clinical trials, systematic reviews, meta-analyses, and expert opinions. The evaluation will be used to formulate evidence-based guidelines for the clinical application of robot-aided therapy. Specifically, the guidelines will describe how robotic devices and training protocols can be matched to individual patients based on level and type of disability and stage of recovery.

A second objective of the Working Group is to describe how robot-aided assessment can be used to generate clinically accepted performance measures. To work towards this objective, robot-aided measurement methods have to be compared to established clinical scales (e.g. the Ashworth scale) in terms of what is measured, and in terms of sensitivity and repeatability.

The third objective of the Working Group is to give recommendations for the development of future rehabilitation robots from a clinical point of view. It is anticipated that during the evaluation of currently available approaches to robot-aided therapy directions for further research and promising clinical applications will be identified. This will allow specifying desirable functions new robots should support to fulfil the requirements of patients and clinicians.

WG2 Technology development for new rehabilitation robots

The main objective of this Working Group is to recommend directions for future efforts in the technological development of rehabilitation robots. Relevant emerging technologies (e.g. virtual reality, multimodal feedback, exoskeletons with structural intelligence) will be categorized according to the functionalities that can be implemented with these technologies (e.g. maximizing patient motivation, wearable robots). The practical importance of different functionalities will be determined from results obtained through the other Working Groups of this Action (WG1, WG2, WG3). Future application scenarios (e.g. application of robots in neurological conditions other than stroke and home-based tele-rehabilitation) will be discussed between all Working Groups. Based on this work, recommendations will be made in the following areas:

1. Desirable mechanical and haptic features of a new generation of rehabilitation robots, with particular emphasis on multijoint and wearable robots.
2. Desirable data processing and artificial intelligence features of a new generation of rehabilitation robots. This will mainly concern issues related to online adaptation of assistive/perturbation forces and automatic goal setting and therapy scheduling.
3. Desirable sensory feedback mechanisms future robots should support. Emphasis will be on techniques that help to maximize patient motivation.
4. Requirements and necessary developments for new robot-aided assessment methods (movement kinematics and dynamic parameters, limb impedance, muscle tone, muscle synergies etc.).

A second objective of this Working Group is to catalogue robots for neurorehabilitation according to activity performed (e.g. walking, reaching, standing, and hand function) and key technological parameters (e.g. degrees of freedom, active / passive devices). This work will be done in collaboration with WG1 to support the formulation of guidelines for the clinical application of rehabilitation robots.

WG3 Theoretical models of motor recovery

The main objective of this Working Group is to advance the theoretical understanding and modelling of motor recovery. This will be achieved by coordinating research necessary for the definition of a modelling framework for motor recovery. The goal is to characterize patient function at different levels of description and to transfer this description into personalized models and therapies. To enable the modelling of patient-specific impairments, parameters known from clinical practice (e.g. the degree of spontaneous recovery shortly after stroke) that potentially allow predicting outcomes of robot-based therapies will be identified in interdisciplinary discussions (with WG1). Following a similar principle, robot-aided assessment methods and the time-course of changes of parameters measured with such methods will be discussed (with WG1 and WG2). Close interaction with WG4 will allow to communicate hypotheses derived from models to experimentalists and to test models on datasets acquired from patients receiving robot-aided therapy.

A second objective of this Working Group is to promote basic research on theoretical modelling of motor recovery and motor learning. This will be achieved by compiling an open access repository containing descriptions of software tools for modelling. Furthermore, a training school on theoretical modelling of motor recovery and motor learning will be organized.

WG4 Neurophysiological mechanisms of motor recovery

The main objective of this Working Group is to advance the understanding of motor recovery from an experimental point of view. To achieve this goal, the Working Group will plan, coordinate, share and discuss in context the results obtained from single-centre studies using robotics with or without supportive treatments in different patient populations. Designing and performing these studies will require interdisciplinary input from neuroscientists, clinicians (WG1), engineers (WG2) and theoreticians (WG3). The joint interpretation of the results will lead to an optimal use, design and development of robots in the rehabilitation of patients with stroke or other diseases. The following scientific problems are of special interest for the Working Group:

1. Which parameters of robot therapy are important to optimize therapy outcome? Examples of topics that are of interest here are: Robots using multimodal biofeedback (visual, proprioceptive, haptic, and auditory); Robots that perturb locomotor sequences to improve gait stability and balance; Arm and leg robots controlled by brain computer interfaces.
2. Studies examining the effect of supportive therapies in conjunction with robot-aided neurorehabilitation. Examples of supportive therapies are: Drugs, such as levodopa and dopamine agonists to enhance cortical plasticity and learning; Transcranial electrical and magnetic stimulation to render the cortex more apt to plastic modification; Functional electrical stimulation to enable movement in the absence of central nervous system (CNS) control.
3. Examples of typical imaging tools are: Transcranial magnetic stimulation to probe efferent motor pathways and interhemispheric connectivity; Morphological imaging, including structural magnetic resonance imaging (MRI) and diffusion tensor imaging (DTI), to determine the influence of lesion characteristics, brain and fibre tract atrophy on therapy efficacy.

A second objective of this Working Group is to make a small number of datasets recorded from patients available on the Action website. The datasets will include precise descriptions of the experiments performed and of the methods used to measure the data. This will allow early-stage researchers interested in modelling motor recovery to start working without generating their own datasets. Furthermore, it is expected that the descriptions of experiments will allow working towards a standardization and consolidation of experimental methods.

E. ORGANISATION

E.1 Coordination and organisation

The Action will be coordinated and organized by the Management Committee (MC). The MC will operate according to the rules specified in the document “Rules and Procedures for implementing COST Actions” (COST 4159/10) or any new document amending or replacing it. An Action Chair, and Vice-Chair, four Working Group Leaders and four Working Group Co-Leaders will be elected from the members of the MC at the kick-off meeting of the Action. The Action Chair, Vice-Chair, together with the Working Group Leaders and Co-Leaders will form a Scientific Steering Group.

Further persons in charge who will be elected at the kick-off meeting are: a Coordinator for Early-Stage Researchers and Gender Balance, a Website and Electronic Mailing List Coordinator, and a Dissemination Coordinator. The responsibilities and tasks for each of the organization elements of the Action are described in the following.

The Management Committee (MC) will be responsible for the general planning and coordination of the Action. More specifically, the yearly work programme, budget, and dissemination plan will be discussed and agreed on by the MC. Furthermore, the MC will coordinate and plan its own meetings, meetings of the Working Groups, Short-Term Scientific Missions, and other events taking place during the course of the Action.

The Scientific Steering Group will be responsible for scientifically guiding the Action. The tasks of the Scientific Steering Group will include organization of the communication between the Working Groups, harmonization of the research topics used in the different Working Groups, designing and overseeing the technical programmes of workshops and training schools organized by the Action, and other related tasks.

The Working Group Leaders and Co-Leaders will be responsible for organizing and chairing working group meetings, preparing the agenda of working group meetings, establishing minutes of working group meetings, and communicating to other Working Groups and the Management Committee.

The Coordinator for Early-Stage Researchers and Gender Balance Issues will be responsible for promoting the participation of early-stage researchers and women researchers in the Action. Specifically, the responsible person will have the task of identifying early-stage and women researchers having profiles suitable for participation in the Action and to take steps towards the participation of these researchers in the Action.

The Dissemination Coordinator will be responsible to produce information materials about the Action and to distribute this information to different target audiences. This will include the collection and dissemination of scientific publications produced by the members of the Action (through the Action website), the announcement and promotion of workshops and conferences organized by the Action, and the communication with key industrial partners, clinicians and therapists, and governmental bodies.

The Website and Mailing List Coordinator will be responsible for setting up and managing a website and an electronic mailing list for the Action. The mailing list will serve as a discussion forum and for general information exchange, e.g. to announce meeting dates and meeting locations of the Action. The website will be organized such that all members of the Action will be able to post content to the website, for example in the form of announcements of conferences, publications, videos, or datasets. It will be the responsibility of the website coordinator to ask Action members for content and to approve content before it is made public.

Four milestones serve to guide the work and monitor the progress of the Action.

M1 (Month 6 in Year 1):

- Website online and populated with initial contents, mailing list active
- Action structure (Action Chair, Working Groups, etc.) established
- Work-, budget-, and dissemination plan established

M2 (Month 6 in Year 2):

- Public repositories (modelling tools, patient datasets) online and populated
- Outline of guidelines for application of rehabilitation robots after stroke
- Outline of recommendations for future research directions

M3 (Month 6 in Year 3):

- Joint publications on motor-recovery processes
- Draft of guidelines for application of rehabilitation robots after stroke
- Draft of recommendations for future research directions

M4 (Month 10 in Year 4):

- Guidelines for application of rehabilitation robots after stroke ready for publication
- Recommendations for future research directions in rehabilitation robotics finalized
- Sustainable interdisciplinary research network of clinicians, engineers, researchers, and companies formed

E.2 Working Groups

Four Working Groups will be formed at the beginning of the Action. The Working Groups have the following titles:

1. Clinical application of rehabilitation robots
2. Technology development for new rehabilitation robots
3. Theoretical models of motor recovery
4. Neurophysiological mechanisms of motor recovery

The Working Groups are organized to cover applied research aspects (WG1 and WG2) as well as basic research aspects (WG3 and WG4) of robotics for neurorehabilitation. Joint working group meetings will be organized such that intensive communication between basic and applied research is ensured. This will allow the Working Groups to actively cooperate and exchange ideas while working towards the objectives of the Action. More specifically, work will be organized as follows:

- WG1 will lead the work on guidelines for clinical application of rehabilitation robots. The technical description of robot features necessary for formulating the guidelines will be delivered by WG2. Gaps in clinical knowledge and gaps in functionalities of available robots will be communicated to WG3 and WG4.

- WG2 will lead the work on recommendations for future research directions in rehabilitation robotics. WG1 will contribute to these recommendations by communicating desirable functions of robots from a clinical point of view. WG3 and WG4 will contribute by communicating open scientific problems.
- WG3 and WG4 will work jointly on advancing the understanding of motor recovery after brain injury and will support WG1 and WG2. The work of WG3 and WG4 will be strongly influenced by clinical requirements and technical possibilities communicated by WG1 and WG2.

E.3 Liaison and interaction with other research programmes

Several projects funded under the Seventh Framework Programme of the European Union are related to the themes of this Action (project acronyms: BETTER, EVRYON, HUMOUR, MIMICS, and VIACTORS). At least one partner of each of these projects participated actively in the preparation of this Action or is interested in joining the Action. This fact will strongly simplify the exchange of information between the Action and ongoing FP7 projects. Furthermore, the presentation of results from ongoing FP7 projects in the framework of this COST Action will allow to discuss these results from different points of view, and to foster coordination between the different projects.

Regarding projects at the national level, a similar principle applies. Researchers who actively participated in the preparation of this Action or who are interested in joining the Action are partners of the following national research projects: “Hybrid Brain” project, Germany; National Center of Competence in Research “Neural Plasticity and Repair”, Switzerland, “Brahma” project, France; “iPAM (intelligent Pneumatic Arm Movement)” project, UK, “Tracking and altering the time course of spontaneous biological recovery after stroke”, Switzerland and USA; “Messa a punto di nuove tecnologie per la teleriabilitazione neuromotoria”, Italy; "Hybrid Neuroprosthetic and Neurorobotic Devices for Functional Compensation and Rehabilitation of Motor Disorders", Spain. The partners from these projects will present their latest results in the framework of this Action and will coordinate their ongoing research.

E.4 Gender balance and involvement of early-stage researchers

This COST Action will respect an appropriate gender balance in all its activities and the Management Committee will place this as a standard item on all its MC agendas. The Action will also be committed to considerably involve early-stage researchers. This item will also be placed as a standard item on all MC agendas.

A number of early-stage researchers have been involved in the preparation of the Action and these researchers are working together with established national experts. Further steps for involving women and early-stage researchers will be taken by the Coordinator for Early-Stage Researchers and Gender Balance. More specifically, the Coordinator for Early-Stage Researchers and Gender Balance will encourage women and early-stage researchers to participate in workshops and Training Schools organized by the Action, and to profit from budget allocated to Short-Term Scientific Missions by the Action.

F. TIMETABLE

The duration of the Action is four years. The Action starts with a kick-off meeting at which the Action Chair, the Working Group Leaders, and other persons in charge (see section E.1) are elected. After the kick-off meeting, the Management Committee and the Working Groups meet twice yearly. The first yearly meeting will be devoted mostly to scientific discussions and to work on outputs of the Action. An exception is the first year in which the first yearly meeting will help to set up the Action structure and the work plan. In the second, third, and fourth year the date of the first yearly meeting is held flexible to allow collocation with important scientific meetings. The second yearly meeting will serve to agree on the budget, work, and dissemination plan for the forthcoming year, and to give updates about the work which took place in the past year.

The Action will organize two workshops, one workshop will be organized in the first year, and one workshop in the last year. In the second year, a Training School will be organized. In the third year, an information day featuring a small conference and exhibition of rehabilitation robot devices will be organized. Scientific experts, representatives of governmental/regulatory bodies and end-user associations (e.g. the Stroke Alliance for Europe (SAFE)) will be invited.

Timetable for the Action: Events which are flexibly scheduled are marked in gray; other events are marked in black.

	Year 1				Year 2				Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Meetings MC																
Meetings WG1																
Meetings WG2																
Meetings WG3																
Meetings WG4																
Information Day																
Training School																
Workshop																
STSM																
Website																
Milestones		M1				M2				M3					M4	

G. ECONOMIC DIMENSION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: BE, CH, DE, ES, FR, IL, IT, NL, RS, SE, SI, UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 48 Million € for the total duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

H. DISSEMINATION PLAN

H.1 Who?

Several target audiences for the dissemination of the results of the Action have been identified:

- Clinicians, therapists, and caregivers
- Healthcare institutions and medical associations
- Patient associations

- The participants of the Action
- Research institutes working in rehabilitation robotics and related areas
- Early-stage and women researchers in rehabilitation robotics and related areas
- Companies selling and developing rehabilitation robots
- Government policy makers (at European, national and regional level)
- The general public

H.2 What?

Website (all types of audience)

A website platform will be the key tool for the dissemination of outcomes of this Action. The website will address all types of audience and will have specific areas for researchers, therapists and clinicians, and patients:

- The area for researchers and Action participants will contain scientific publications related to robotics for neurorehabilitation, a collection of datasets recorded from patients, and a repository with tools for theoretical modelling of motor learning and recovery. Parts of the area for researchers will contain confidential information and access to these parts will be restricted to Action participants.
- The area for therapists and clinicians will contain links to selected publications about the clinical application of robots. Furthermore this area will contain descriptions of available robots, robot-aided therapies, and robot-aided assessment methods.
- The area for patients will contain information describing robot-aided therapies from a patient-perspective. Examples of content for this part of the webpage are links to patient associations and descriptions of the practical experiences patients made with robots.

Guidelines (clinicians, therapists, patients, companies)

One major outcome of this Action will be guidelines for the clinical application of rehabilitation robots. The guidelines will be posted on the Action website in electronic format and will also be available in the format of a brochure. Clinicians and therapists, patient associations, and companies producing or selling rehabilitation robots will be informed about the availability of the guidelines.

Recommendations (Researchers and clinicians)

Recommendations for future research directions will be published in the format of a journal special issue. The special issue will contain articles describing recent work of the Action partners as well as articles edited jointly by Action partners and containing ideas and recommendations for future research directions.

Publications (Researchers, clinicians and therapists)

High quality scientific publications (e.g. in journals such as IEEE Transactions on Neural Systems and Rehabilitation Engineering, Stroke, or Brain) generated in the research programmes of the participants of this Action, and generated as a result of networking within the Action will be collected on the Action website. Whenever it is legally possible the full text of publications will be made available.

Mailing List (Action participants and other scientific audience)

A mailing list will be created which will serve to announce Action meetings, conferences, and new publications and research findings.

Meetings (mainly Action participants)

Meetings of the Working Groups and the Management Committee will be a key tool for exchanging information between the participants of the Action. Where indicated, meetings will be open to students and scientists from the organizing institution.

Workshops (scientific audience)

Workshops and special sessions at scientific conferences will be organized and expert speakers will be invited. Examples of relevant conferences taking place in the coming years in Europe are the International Conference on Rehabilitation Robotics and the European Neurorehabilitation Congress. When indicated, proceedings from these workshops will be published.

Information day (policy makers, scientists, companies, clinicians and therapists, patient associations)

An information day showcasing the latest developments in rehabilitation robotics, and featuring an exhibition of robots for hands-on experience will be organized.

H.3 How?

Dissemination of the outcomes of the Action is a task which is decisive for the impact achieved by the Action. To ensure effective dissemination a Website Coordinator and a Dissemination Coordinator will be elected at the kick-off meeting of the Action. Dissemination and website updates will be placed as a standard item on the agenda of the meetings of the management committee.

The Website Coordinator will be responsible for the technical setup and maintenance of the website platform and will help in uploading and approving new content for the website. The Dissemination Coordinator is responsible for requesting content from all members of the Action and for identifying possible sources of content. Additionally the Dissemination Coordinator supports the website by serving as contact person for the external scientific environment, new Action members, related research programmes, companies, clinicians, policy makers, and the press.