



SPRINT

SMART MOBILITY DEVICES
WITH IMPROVED PATIENT
PROSTHESIS INTERACTION

Plan for a Centre of Research Excellence

Content

SPRINT-CoRE Information	5
Executive Summary	8
1 Introduction and Background	10
1.1 Founding of SPRINT	11
2 Vision and Mission	15
2.1 Vision	15
2.2 Mission SPRINT	17
3 Added value, relevance and urgency	19
3.1 Added Value	19
3.2 Relevance	21
3.3 Urgency	23
4 Landscape	24
4.1 International context	24
4.2 Need assessments	25
5 Organization	28
5.1 Structure in headlines	28
5.2 Description of the pillars	28
5.3 Internal functioning	29
6 Management and Governance	30
6.1 Management	30
6.2 Governance	32
7 Finances	34
7.1 Partners input	34
7.2 IMDI impulse	35
7.3 Structural growth	35

Colophon

Commissioned by:	ZonMw, Den Haag
Publication date:	November 2010
Author:	SPRINT
Editors:	Evers + Manders Subsidieadviseurs, Hoevelaken Maarten Evenblij, Amsterdam
Design:	BGMW, Haarlem
Printer:	A-D Druk B.V., Zeist

*This publication has been compiled with the greatest possible care.
The authors are not responsible for any errors or inaccuracies and no rights may be derived from this publication.
Text may be reproduced for own use, providing the source is acknowledged.*

8	Operational Plan 2011-2013	36
8.1	Current projects	36
8.2	New projects	38
8.3	Funding	43
8.4	Results to be expected after 5 years	43
9	Indicative Research Agenda 2014-2020	44
9.1	Deliverables	44
10	Leadership competences	46
10.1	Prof. Bart G.J.Verkerke PhD ir	46
10.2	Prof. Klaas Postema PhD	46
10.3	Prof. Luc H.V. van der Woude, PhD	47
10.4	Prof Bert Otten, PhD	47
10.5	Prof. Bart H.F.J.M. Koopman, PhD Ir	47
10.6	Che H. Falkenström PhD Biomedical Engineer	47

SPRINT- CoRE Information

SMART MOBILITY DEVICES WITH IMPROVED PATIENT PROSTHESIS INTERACTION

Clinical/care scientific leader: Prof.dr. K. Postema (UMCG)
Technical scientific leader: Prof.dr.ir. G.J. Verkerke (UMCG/UT)
Managerial leader: Vacancy
Contact: g.j.verkerke@med.umcg.nl

Management team

Prof. dr. E. Otten (UMCG), Prof. dr. G.J. ter Horst (UMCG),
 Prof. dr. ir. H.F.J.M. Koopman (UT), Prof. dr. J. C. Wortmann (RuG),
 Prof. dr. J.S. Rietman (Roessingh Research & Development),
 Dr. ir. C.H. Falkenström (Orthopedische Instrumentmakerij - Orthopedie)

Founding Partners

This centre was founded by the following parties:



Public research groups:

- University Medical Center Groningen (UMCG)
- Rijksuniversiteit Groningen (RUG)
- Universiteit Twente

Healthcare institutions:

- Center for Rehabilitation UMCG
- Roessingh Rehabilitation, Enschede
- Rehabilitation Friesland, Beetsterzwaag
- Military Rehabilitation Center, Doorn
- St. Maartenskliniek, Nijmegen

Private research groups:

- St Maartenskliniek Research
- Roessingh RRD, Enschede
- Healthcare Innovation Forum
- INCAS3, Assen

Collaborating large industries:

- Otto Bock, Son en Breugel
- Össur, Son en Breugel
- OIM, Assen
- Philips Healthcare

Collaborating SME's:

- Waag Society Amsterdam
- Ambroise, Enschede
- Motek Medical, Amsterdam
- Demcon, Oldenzaal
- Xsens, Enschede
- McRoberts, Den Haag
- Baat Engineering, Hengelo
- BrainCenter Group Drachten
- Gameship, Leeuwarden

Executive Summary

Focus

The SPRINT center endeavors to increase mobility of elderly by prevention, by training and rehabilitation at home and by developing the next generation of intelligent mobility devices for the individual patient. This will contribute to the necessary shift from intra- to extramural care that can decrease health care costs and workers.

Background

Future healthcare will be characterized by an increasing number of patients due to ageing and a decreasing amount of manpower. An ageing population demands for a high level of independent functioning and full participation in society. Restoring and maintaining mobility is crucial for this and will require high-quality interactive training devices and programs, prostheses and orthoses. However, most contemporary mobility devices are not patient-driven, but technology-driven. This results in high-tech devices, difficult to control with many options, but not the appropriate ones. Moreover, they are made for the 'average' patient. As a consequence, the individual patient with a specific motor function, muscle force, well-balanced sensory-motor system, motivation, drive, and practical ability must adapt to the device instead of the other way around. This results in an inefficient training or rehabilitation and an early abandonment of the device.

Need for research and development

Intelligent mobility devices, in combination with home-based training programs and telecare (coaching and feedback from the professional) create the possibility of keeping elderly longer mobile and independent. It also makes it possible to finish rehabilitation at home instead of in the rehabilitation center. In research areas like biomechanics, neuro-muscular science and learning behavior, important new insights have been developed. Other areas like serious gaming and telemonitoring offer many possibilities. However, these hardly reach the developers of devices for the recovery of mobility. SPRINT will narrow this gap and will develop medical devices that allow patients to stay mobile for a longer period of time or become mobile more quickly. Moreover, medical devices and programs that allow patients to follow rehabilitation programs at home will be developed.

Aims and objectives

SPRINT will increase knowledge on balance and rehabilitation processes to prevent people from falling through a loss of balance and create better suited training devices and extramural rehabilitation. Furthermore, SPRINT will increase knowledge on the interactions between patients and mobility devices to develop second generation individualized, intelligent mobility devices. Combining various disciplines will create many new possibilities and will realize a breakthrough in mobility prevention and restoration. SPRINT will transfer all developed devices to industry - through start-up or existing companies - and will evaluate their use in daily practice. SPRINT's effort will result in a new generation of intelligent mobility devices like training devices and programs, prostheses, orthoses and wheeled devices to strengthen elderly and to keep them mobile and independent for as long as possible.

Economic impact

SPRINT's efforts will decrease the direct and indirect costs of Dutch rehabilitation care. For example, a 30 percent reduction in falls will generate an expected yield of € 180 million per year and intelligent prosthesis, in combination with telecare consultation, can annually keep 1,000 elderly at home instead of in a nursing home, which saves an annual € 50 million. Furthermore, many medical devices are currently being imported, while health care research in the Netherlands is one of the best in the world. By focusing on valorization, SPRINT uses research results to make products that will benefit our society and economy.

Ambition

In five years from now, SPRINT expects to have created a well-organised center that integrates many traditional disciplines, like biomechanics, rehabilitation, movement sciences and neuro-sciences and new disciplines like serious gaming and telemonitoring. This center will complete at least fourteen PhD theses, 100 publications and expects to have developed eight new mobility devices. SPRINT will apply for patents to support industrial transfer and to support start-ups and SMEs. Focus on fundamental research will create new knowledge on the adaptation of mobility devices and on the learning processes of patients. Increased knowledge of learning and adaptation processes in the human brain in response to mobility devices will provide key parameters to monitor and predict the effectiveness of those devices used by individual patients. And thus, will create second-generation devices, focused on passive or even active feedback, including a new set-up of the organization of health care, based on health care on a distance. Projects will result in new and improved devices and strategies which contribute to the prevention of mobility impairment and a conversion from clinical procedures to home therapies.

1 Introduction and Background

Future healthcare will have to deal with large groups of elderly people who want and / or need to contribute to the employment process, despite their inevitable impairments and resultant function loss. In addition, an increasing demand for a high quality of life is expected. This will put pressure on the demand for high-quality interactive prostheses and orthoses, as IEEE Spectrum 2009 states: 'The revolution will be prosthetized'. However, the design and fitting of prostheses is a craft that has only recently been reinforced by knowledge from the fields of biomechanics, motor learning and adaptability of the human motor system.

To date, most development of rehabilitation devices has been technology driven. Devices (for instance prostheses) are developed to enhance or restore a function as such. They often are highly sophisticated from a technological point of view. However, the user aspects are often neglected. So the use of a technical device can be very challenging and difficult for elderly people. The devices are often used for only a limited period of time and then abandoned.

This is strengthened by the fact that during the rehabilitation period there is optimal interaction with the professionals that advise the patient about how to get the best out of using the device. However, contact comes to an end after the rehabilitation period, if there is a problem, the patient has to visit a doctor or other professionals for advice. It is then often difficult to get all the necessary information and advice, so treatment is far from satisfactory.

Moreover, most devices are made for the 'average' patient who does not exist. As a consequence, an individual patient with a specific rest function, muscle force, well-balanced sensory-motor system, motivation, drive, and practical ability must adapt and become an 'average' patient, instead of adapting the device to the patient. The result is that the rehabilitation process is unnecessarily lengthy, and function restoration is far from optimal.

In addition, healthcare costs and the number of healthcare professionals need to be reduced to create a healthcare system capable of treating the increasing number of elderly people and improving the quality of treatment (healthy ageing) in the future. Instead of devices that are non-optimal and require a lot of guidance by the professional we need interactive, intelligent devices that adapt to the changing needs of the patients and that need less capacity of healthcare. We think that this will become a major deliverable of SPRINT.

1.1 Founding of SPRINT

1.1.1 Development in Groningen

In various departments of the UMCG, RuG and UT research is performed on Biomedical Engineering. Some research is performed in cooperation with industry or external healthcare institutions. Most research projects are small and very fragmented. That is why the UMCG decided to focus research in a research programme Healthy Ageing, part of the Healthy Ageing Network Northern Netherlands (HANNN) (www.hannn.eu).

The aim of HANNN is to achieve innovations and fundamental breakthroughs that will entail structural improvements in the conditions for healthy ageing, and so stimulate economic research phases in the region. HANNN functions as an umbrella organization. It offers an overall perspective to individual initiatives places them into a Northern Netherlands strategy and provides a supra-regional platform. The mission of HANNN is that in 2020 the Northern Netherlands belongs to the top of the European regions regarding the expertise in the field of healthy ageing, and will be the (inter)national testbed for development of research, education and training, and business research phases related to healthy ageing.

1.1.2 Development in Overijssel

At the same time the 'High-tech Health Farm (www.fieldlab.eu/nl/projecten/high-tech-health-farm/) was founded in Overijssel to support future healthcare provision that will take place more frequently outside of the hospital environment, preferably in the patient's own surroundings. The aim of the 'high-tech health farm' is to create a test environment for this kind of care and to improve access to high-quality healthcare. New technology will be able to ensure this strongly personalized form of healthcare. This technology has already been developed to a highly advanced level within the UT and will become available to the 'High-tech Health Farm.

1.1.3 Synergy

In this North-East Netherlands landscape of High-tech Health care the initiative was born to combine these two centers of knowledge with mobility of elderly as focal area. It is well known that maintaining or restoring mobility of elderly not only contributes to an independently life and employability, but also to a sound health that contribute to the prevention of many accidents. An inventory made clear that mobility was already present in many research projects. Disadvantage was that the research was very fragmented.

To combine and focus research on mobility the CoRE SPRINT was created by a group of researchers and healthcare professionals from UMCG, RuG and UT. SPRINT will stimulate mobility of elderly and restore mobility of patients. Hence, SPRINT will contribute to the fundamental goals of Healthy Ageing

SPRINT will contribute to the plans of the high-tech health farm by developing new rehabilitation techniques and devices that restore patient mobility and shift intramural rehabilitation to extramural care.

SPRINT includes a unique multi-disciplinary combination of fundamental researchers, applied researchers, health care institutes and industries. This makes it possible to cover the entire chain of innovation, from fundamental research on mobility to market introduction of products.

1.1.4 They cover a wide spectrum of multidisciplinary knowledge:

- UMCG/Bio Medical Engineering (BME) has a long-lasting reputation in creating innovative medical devices to measure and restore human functions; several of them are created in close scientific cooperation with the UT.
- UMCG/Neuro Imaging Center (NIC) plays a leading role in in-vivo neuroscience.
- UMCG/Human movement sciences, Orthopedics, Rehabilitation and Geriatrics cooperate on research to monitor human functions.
- The UMCG includes the Center for Rehabilitation, Beatrixoord in Haren. This centre works on research on virtual reality, locomotion, and is studying the functioning of elderly. Numerous relevant patient groups, incl. amputees, are treated at all included healthcare institutes, and they are willing to participate in research. The Umbrella project includes a database of 226 people with a spinal cord injury. LifeLines is a cohort study in a large representative sample of the population of the northern provinces of the Netherlands, covering three generations. The main objective is to unravel the interaction between genetic and environmental factors in the development of multifactorial diseases and their concurrent development in individuals.
- RUG/ Research Institute for Mathematics and Computing Science (IWI) has expertise on image-analysis. New algorithms are developed for improving image quality and for automatic feature extraction.
- RUG/ Discrete Technology and Production Automation (DTPA) has expertise on mechatronics and robotics systems.
- UT/Biomedical Engineering (BW) covers the complete area of human motion control (from a systems point of view). In the extensive collaboration with clinical and corporate partners they developed supporting devices that are optimally interfaced with the users.
- UMCG Neurologic, Orthopedic and Rehabilitation Departments have a lot of experience in clinical research on mobility and in rehabilitation treatment.

- The participating health care institutes and medical departments of the UMCG have ample experience in cure and care of patients that have mobility limitations. They often participate in research projects, partly to express patient needs, partly to explore limitations and capabilities of patients and partly to test innovative devices.
- The participating industries are selected on their experience to validate research results into products that have been introduced into the market. This requires knowledge on the market, overview of competitors and of future trends. The participating industries offer a wide range of experience in this field, from start-up companies that found niches in the market to multinationals that are world-wide leaders in their field. Also specialized companies like the OIM (Orthopedic Instrument Maker) that serve patients on an individual basis are incorporated.
- Several institutes are included that have networking as their core business. They are experienced in linking industries, health care institutes, research departments and other stakeholders like health insurance companies to start new research projects and the development of new devices.

1.1.5 Education

Research at SPRINT is performed by PhD-students and post-docs that work in project teams, led by scientific staff members. SPRINT has direct access to graduate schools, where the best students are selected to be trained as researchers.

SPRINT has access to and intensive contacts with the Graduate School of Medical Sciences (GSMS), the Graduate School of Sciences (GSS) and the Graduate School for Health Research (SHARE). All three include top Master's and International Research Master's. At the UT a graduate school is under construction.

To have sufficient high-quality students for these graduate schools the UMCG and RuG train them in Master's programmes in Human Movement Sciences and Biomedical Engineering. Recently a European Erasmus Mundus Master's in Biomedical Engineering is added to these Master's. At the UT a Master's in Biomedical Engineering and Technical Medicine exists.

To facilitate the shift from intramural to extramural care, we will prepare medical students by changing their curriculum. More focus will be on new technologies like telemedicine and the inevitable changed role of the medical specialist from regular consultation to monitoring and advising by telemedicine. This has been started already in the academic year 2010-2011.

1.1.6 equipment

Within the UMCG several well-equipped labs exist, like a lab for virtual reality and different gait analysis laboratories.

Within the RuG an ICT-center is available that offers computer power for simulations and complex calculations. It also facilitates a Reality Cube virtual environment.

The Neuro-Imaging Center offers extensive equipment for neural imaging and analyses.

Within the UT also several labs are available on gait analysis, tribology, human performance and robotics.

Gameship offers a fully digital video studio with virtual reality possibilities.

The various Rehabilitation Centers also have different gait laboratories and a virtual reality lab.

SPRINT combines a very broad range of multidisciplinary expertise with a long tradition of research on mobility and an excellent spectrum of facilities that enables fundamental breakthroughs in mobility research that will entail structural improvements in the conditions for healthy ageing.

2 Vision and Mission

2.1 Vision

To maintain the high standards and the accessibility of rehabilitation in the Netherlands in the future, health care costs need to be reduced and the labor productivity of health care workers needs to be increased.

In our vision, this will be accomplished by:

- Focus on prevention of falls and increase of physical condition of elderly and chronic patients (with affected balance performance).
- Focus on increasing autonomy of the elderly and chronic patients.
- Shift of Intramural rehabilitation to extramural rehabilitation care (home-based rehabilitation).
- Increase efficiency of professional care.

Increasing the mobility of patients and the elderly in order to make or keep them mobile will improve their health, prevent falls, enhance their quality of life and enable them to be independent for longer than was the case in the past. It will also diminish the need for help from healthcare professionals, and thereby contribute towards reducing the number of healthcare professionals and concomitant costs.

In case they still need medical care, intramural care should be shifted to extramural care as much as possible, because that is an effective and efficient way of reducing the number of healthcare professionals, and costs.

In our view, our research must be patient-driven instead of technology-driven: the needs of the individual patient are essential, not the latest technologies that must be applied. In a patient-driven developed device the device will adapt to the patient, while in a technology-driven developed device the patient has to adapt to the device. Individual, patient-driven research will ensure that solutions are usable for the individual patient.

ICT will impact the (near) future of mobility preservation and restoration. Distant monitoring will enable regional centers of expertise to obtain a comprehensive picture of the patient and provide the patient and the physician with better and timely report. This will reduce the number of face-to-face meetings of the patient with his physician and will reduce the time between exacerbation and treatment.

Training and rehabilitation of patients with mobility disorders will be performed to a greater extent in the home environment using sophisticated training devices and tele-care facilities. This will shorten the stay in an intramural environment and will reduce travel time and costs. It will also facilitate a prolonged training period to enable optimal behavior and optimal use of prostheses and orthoses.

Special attention will be given to fall prevention as the quality of balance control can be monitored and training programs can be adapted accordingly. This will, especially for the elderly, preserve their mobility for several years.

Data obtained from studying the introduction of these new technologies will enable us to develop business cases on the level of the individual patient (improved quality of life, reduced travel cost and time), on the level of the physician and his organization (improved effectiveness of treatment and reduction of time) and on the national level (reduced intramural stay and involvement of healthcare professionals).

Based on hypothetical but realistic cases and occurrence of such cases in the different Dutch regions business cases with respect to the levels mentioned above will be developed for different care arrangements for these cases.

Serious gaming will offer new possibilities for rehabilitation programmes. Tools like the Nintendo Wii create a new world that can be explored for application in rehabilitation and prevention. Projection of a virtual environment (like is done in computer games) can be used to study the behaviour of patients when subjected to changing or conflicting impressions.

Another possibility is the creation of a virtual rehabilitation environment that will stimulate patients to rehabilitate or elderly to stay fit.

Human beings are able to overcome their cognitive processing limitations, resulting in mobility impairments, by utilizing knowledge embedded in the environment of their activity. This embedded knowledge will be used in the virtual environment.

In our vision research should be transferred into the society via the development of products that will contribute to a shift to extramural care, to prevention and to more efficient intramural care.

This will increase the position of the Dutch Medical Device Industry and will stimulate further research by increased cooperation between industries, universities and health care institutes.

2.2 Mission SPRINT

The overall mission is to increase mobility of elderly people. More specific;

- Increasing mobility by realizing training devices and orthoses to improve balance and physical condition and thus prevent elderly people from falling.
- Restoring mobility by realizing training devices or processes that enable rehabilitation at home.
- Restoring mobility by realizing second-generation individualized, intelligent mobility devices that are adapted to and interact with the individual patient.

To achieve this scientific mission we defined seven well-balanced goals.

2.2.1 First goal: Increase knowledge on interaction between patient and mobility device.

This includes motor skills of individual patients and the variation of it among patients and determining the main parameters that define individual differences in device control. When we understand this interaction, not only in general but for the individual patient, we are able to create better mobility devices.

2.2.2 Second goal: Increase knowledge on the learning process of patients

By using non-invasive techniques like MRI, EMG, EEG, TMS, mobility monitoring, force measurement and their combinations.

2.2.3 Third goal: Create intelligent, interactive, preventive devices and training programs

To strengthen elderly and keep them mobile and independent for as long as possible.

2.2.4 Fourth goal: Create a new, patient driven, generation of intelligent mobility devices

These devices will provide individual solutions for patients. Motivation for this is that up to now, mobility solutions are designed for the 'average' patient (technology driven). However, this 'average' patient does not exist. Patients differ in rest function, balance control, muscle force, sensory functions, motivation, drive, practicality, etc. So patients are forced to adapt to solutions for the 'average' patient. This will result in a difficult, time-consuming rehabilitation process and a non-optimal function restoration. So in contrast the next generation of, patient driven, mobility devices will adapt to the needs of the individual patient. These devices will help people to become independent again.

2.2.5 Fifth goal: Create monitoring systems for mobility devices.

These systems should collect data of mobility devices when the patient is at home or en route, analyze the data, inform the physician with statistical data providing insight in the behavior and condition of the patient, about misuse and functional errors of mobility devices over time and when the patient requires urgent care for instance when he cannot recover from a fall.

2.2.6 Sixth goal: Move health care from intramural to extramural.

This will allow more efficient, cheaper and for the patient more comfortable health care with less appear on health care workers.

2.2.7 Seventh goal: Stimulate valorization of the results

Create several start-up companies and expand existing companies that produce intelligent mobility devices.

3 Added value, relevance and urgency

3.1 Added Value

SPRINT will initiate research into Biomedical Engineering that is much more patient-oriented, i.e. driven by the needs of the user.

This is in contrast with most present research, which is very much technology-driven, and often leads to excellent innovations that are not practical for the patient. Secondly, instead of focusing on a specific function loss, SPRINT concentrates on the entire chain, from individual learning processes, capabilities and limitations to feedback on medical device use.

Research will also include valorization to assure that research results become available for society in terms of products for patients and elderly people. Thanks to the many participating industries and their commitment to each project from the start we can realize a high degree of valorization.

Research at the SPRINT Centre will benefit from the high number of scientific and clinical parties that are involved. Most of the clinicians already have strong cooperation with the researchers.

Thanks to the many participants and their diverse expertise we will focus on the entire chain, from fundamental research to market introduction. By combining research groups with a long history on mobility research they will learn from each other's experiences and will apply this knowledge on creating superior mobility devices. Combining the research forces of the universities, industry and healthcare institutes releases considerable potential.

Science will benefit by increased knowledge on the learning and adaptation process of humans that will benefit improved control of prostheses, orthoses and other mobility devices. Science will also benefit by increased knowledge on balance and its impact on the prevention of accidents that impair mobility.

3.1.1 Socio-economic impact

The centre will increase diligence by developing innovative mobility devices with a great market potential. Mobility devices range from exercise equipment, based on the Wii to intelligent, autonomous leg prostheses. The many participating industries will profit, because they will be able to increase their market position.

New innovative spin-off companies will be launched for marketing new products that do not fit in the portfolio of the participating companies. This economic activity will contribute to a better relation between expenditures in health care and economic profit in the Netherlands.

Since we will focus on improving mobility of elderly and since mobility impairments will occur in every elderly, the market potential is huge.

The centre will contribute significantly in reducing healthcare costs and the number of healthcare professionals and will thereby be instrumental in achieving affordable healthcare.

3.1.2 Prevention will bring major savings

In the Netherlands per year 140.000 elderly are medically treated after a fall accident. 32.000 are admitted to the hospital. Yearly 15.000 elderly are admitted with a broken hip after a fall accident. The direct medical costs and the chance on permanent disability are also high. The direct medical costs of a hip fracture (including rehabilitation) are on average €15.000. The costs of permanent disability and dependency are a multiple depending on the level of independency. 25% of the elderly (3750) become permanent disabled and dependent after a hip fracture. The costs of admitting to a nursery home are about € 66.000 yearly. An estimate of the costs of the disability and dependency is €10.000 for each person, each year. After a fall, 17.000 elderly, not having a fracture, are admitted to the hospital. The costs are, on average, € 2.700 for each person. By fall training devices and programs, balance improving orthoses and good fitting shoes we strive for a 30%-reduction in the number of falls. Savings as a result of this decrease are $4500 \times (\text{€}15.000 + \text{€} 10.000) + 5000 \times \text{€} 2.700 = \text{€} 120$ million per year. In the UK direct and indirect costs after a fall are rated at € 8,9 million per day, so € 3,25 billion per year. For the Dutch situation this would be about € 0,8 billion per year. A decrease by 30% would result in a cost reduction of about € 240 million. When we average both estimations, savings of about € 180 million per year are expected.

3.1.3 Cure

In the Netherlands there are about 20.000 people with a major amputation with a yearly incidence of 3.000. The costs for prosthetic care are about € 140 million each year (without medical and house-hold care).

With the intelligent prosthesis, in combination with tele-care consultation, it will be possible to keep yearly 1000 elderly at home instead of in a nursery home. This will lead to a yearly saving of € 50 million.

Amputees are in the need of telecare consultation in order to be able to solve the problems they encounter at home without looking for medical care and household help. When amputees get a short period of rehabilitation training at home, after the rehabilitation in the rehab center and have the possibility of telecare consultation, they can be discharged at least two weeks earlier. In this way we can save € 10 million each year. After five to ten years SPRINT will develop also mobility devices, orthoses and balance improving devices, for patients with other diagnoses, like stroke, neuromuscular diseases, multiple sclerosis, spinal cord lesions, etc. The goal is to shorten the rehabilitation treatment with 10% and to reduce the regular visits to the medical specialist with 25%.

The total costs for the rehabilitation of the adults in the Netherlands are approximately € 265 million each year. We can save on this € 26 million each year. Due to ageing the number of elderly will increase strongly. The number of 65plus elderly will increase from 2.5 million in 2009 to 3.9 million in 2030. The number of 85plus elderly will increase from 281.000 in 2009 till 401.000 in 2030. With this, the costs of treatment of mobility disorders will almost double. So savings will double as well. In the coming years the number of amputated patients will increase even more, due to an increased number of diabetic patients.

Overall, we estimate that total savings of € 250 million annually for the Dutch health care system can be realized in the areas of accident prevention, prosthetic cure and rehabilitation. Compared to the average expenditure of the SPRINT center of € 11 million annually these savings are more than a factor of 20 higher than the investments.

3.2 Relevance

The SPRINT Centre has a wide range of unique expertise that varies from fundamental research via applied and clinical research to the market introduction of new products. It is truly multi-disciplinary. Its scientific participants are selected for their excellent track record. They are all recognized leaders in their field, have an excellent reputation, have an extensive international network, and will be able to attract research funds: UMCG/BME includes many studies that are funded with national and European grants; BME also participates in national consortia like BMM.

- UMCG/NIC's high-quality staff includes a number of VIDI (PIONIER) laureates. Prestigious EU grants (EURYI, Marie Curie Excellence Award) have been awarded. NIC participates in national consortia such as TI Pharma and TI Food and Nutrition.
- UMCG/Human movement sciences, Orthopaedics, Rehabilitation and Geriatrics were awarded grants for research into virtual reality, locomotion, and studying the functioning of elderly people.
- RUG/IWI was awarded several large NWO grants for developing new visualization techniques.

- RUG/DTPA participates in the MicroNed consortium in the Netherlands.
- UT/BW realised major funding from national and European programmes.

UMCG and RuG have already a very close relation. To reinforce this, formalization of this cooperation on institution level is being prepared. As part of this cooperation, the number of dual appointments will be increased in the future. Currently Prof. Verkerke and Prof. Grijpma hold positions at both the UT and UMCG. Prof. Rietman holds positions at both Roessingh RRD and UT.

3.2.1 Valorization

Both UMCG and UT foster product innovation and stimulate valorization. In the past many research results created by the participants have been transferred to the industry. Also several spin-off companies were established. Several of them participate in this SPRINT-Centre.

The same strategy will be followed for the research that will be performed within the SPRINT center. At both universities Prof. Verkerke is appointed as professor in Bio-medical Product development. His methodical design process to overcome the difficulties in designing medical products will be applied to all projects within SPRINT:

- Teamwork aspects are highlighted: how to build effective teams that use each other's qualities and recognize and accept each other's differences.
- Valorization is presented, including the difficulties that are encountered, like extensive test period, EC-regulations and bridging the gap from a prototype to a series product.
- Technology assessment is included to force early screening of concepts and prototypes to the specifications to prevent late rejection, thus saving time and costs.
- Technology assessment also forces the involvement and commitment of all stakeholders (including health care professionals, industries and patient) in this process that results in better decisions, better acceptance of the realized product, better awareness of each other's needs and expectations and thus better (more efficient and effective) design teams. So in all projects the teams are composed of researchers, health care professionals, representatives from companies and patients.
- Only this approach enables the development of many products that will be commercialized in co-operation with the various participating companies. Valorization of research results is very much facilitated by the many companies that participate in SPRINT. They have experience in transferring scientific results into commercialization.

3.3 Urgency

3.3.1 Economy

Many medical devices are imported into the Netherlands. So there is a high flow of money out of the Netherlands. On the other hand health care research in the Netherlands is one of the best in the world. Somehow we are not able to transfer research results into products that benefit our society and economy. The CoRE SPRINT will change this situation substantially by focusing on valorization. An instrument that proved to work well is the start of spin-offs from universities. UT and UMCG are very successful in launching these companies. We expect to create several start-up companies that will develop the prototypes resulting from this project and turn them into commercial products that will be introduced in the market.

3.3.2 Society

In a rapidly ageing society such as in the Netherlands, much more effort needs to be put into helping elderly people continue to function independently and to participate fully in society (healthy ageing). This will require more input from the healthcare sector, and will be accompanied by an increase in costs and manpower levels, both of which our society can no longer afford.

So society needs medical devices that will contribute towards cheaper healthcare and less manpower. The CoRE SPRINT will contribute by realizing medical devices that allow patients to stay mobile for more years or become mobile faster and that allow patients to follow a rehabilitation programme in their own home.

4 Landscape

4.1 International context

The mission of SPRINT fits perfectly within the latest plans of both the WHO and the EU:

- In the latest WHO report about Priority Medical Devices (Medical devices: managing the mismatch: an outcome of the priority medical devices project, WHO-press, 2010, ISBN 978 92 4 156404 5) telemedicine and labor-saving technologies is mentioned as one of the future research areas.
- One of the future research areas of EU Health is “Innovation on health products and health technology needs of older people”. Diagnosis and treatment through ICT is foreseen, as well as innovations to help older people manage their disease and remain active and independent at home and in the community.
- The EU ‘Ambient Assisted Living’ program (resulting from the 2007 plan on ‘Healthy Ageing in the information society (IP/07/831)’ aims to give socially isolated, weak, disabled or chronically ill elderly an independent living using ICT-technology. It is focused on the development of methods to prevent falls. These applications increase their quality of life, decrease the costs of health care and open new market opportunities for companies.

Biomedical Engineering in the Netherlands is a strong field of research. The Netherlands is internationally regarded as one of the leaders in the field of rehabilitation technology. Almost all participating groups are active on a European level and receive funding for their European research projects. For more details, see chapter 10.

Several participants of the CoRE SPRINT are active in international societies like ESEM, the European Society for Engineering and Medicine and like the ISPO, the International Society for Prosthetics and Orthotics. These societies facilitate the start of new research on an European level.

The research from several participants in the field of prosthetics and orthotics is directed to motor learning process, serious gaming and development of new treatment programs. It is of very high international level and fits seamless in the activities of the CoRE SPRINT.

Some of the participating Dutch companies are part of an industry that operates worldwide: Philips, Össur, Otto Bock, Atos Medical.

4.2 Need assessments

4.2.1 Patients

For elderly maintaining independent from health care workers for as long as possible is also very important. Patients demand more and more high-quality health care to maintain or restore a high quality of life. In case of an accident, a short hospital stay is important and, of course, full recovery.

When human perception and action, like mobility, are impaired, there is a need for these functions to be restored by mobility devices such as prostheses, orthoses and wheel-chairs. Patients differ in rest function, balance control, muscle force, sensory functions, motivation, drive, practicality, et cetera. So they expect devices that are custom-made instead are designed for the ‘average patient’, so patients are forced to adapt to solutions for ‘the average patient’. The CoRE SPRINT contributes to this by focusing on the individual patient with its specific needs and potentials. In addition, devices will improve human functioning by augmenting sensory information (e.g. bio-feedback), or by providing information that assists the person, and caregivers, in restoring function (e.g. monitoring devices).

These devices help attain a shift from intramural care to extramural care, so patients will be involved in part of their rehabilitation programme in their own home. Moreover, frequent hospital check-ups are no longer necessary because these devices incorporate intelligence which means they adapt to the patients and they can communicate with the specialist for feedback when necessary. This results in an effective, time-efficient rehabilitation process and optimal function restoration.

Restoring mobility will not only bring back a very important function, but it will also mean that patients are less dependent on others, so there will be less demand for home care. It also will contribute to a better health status of the patients, and therefore obviate the need for medical care.

In case that a product at the end does not fit into the need of the patients (due to unforeseen circumstances), we will consider to find other applications or other patient groups that will benefit.

We will focus upon the following groups:

Prevention – Elderly

- The intelligent balance training devices developed by SPRINT decrease the risk of falling of elderly. It increases and keeps the physical condition on optimal level.
- Cure – Amputees and other mobility impairing diseases.

Amputees follow a training program in the rehabilitation center in order to learn independency with their prosthesis. After the program they go home and often meet a lot of problems there concerning the stump and prosthesis. Also most amputees show a fall back in the first year after discharge. The intelligent prosthesis is adaptable to the needs of each individual patient. It will collect important information, and send this by telemedicine to the professional. Via telemedicine there will be also feedback about the use of the training program. Arm amputees will also get an intelligent prosthesis and they also will be coached and monitored by the professional via telemedicine.

All kind of diseases can result in wheelchair designation. Riding a wheelchair is very energy demanding and sitting in a wheelchair for many hours causes too high and long pressures on the ischial bones, resulting in decubitus. The propelling mechanism of the intelligent wheelchairs will be suited optimally for each individual patient. The sitting will deal with the high and long pressures.

After some years SPRINT will focus also on other diseases that cause impairments in mobility, as stroke, neuromuscular diseases, multi trauma, spinal cord lesions, etc. Intelligent orthoses and training devices will be developed with the same concept: patient driven development and intelligent in combination with interactive training programs and telemedicine.

Industry in the Netherlands requires a steady growth. Knowledge on rehabilitation, biomechanics, neurology in the Netherlands is high, valorization of research results is limited. SPRINT will combine existing knowledge to make it possible to create second generation intelligent mobility devices for individual patients. With fundamental knowledge that will be developed in this centre it is possible to create third generation mobility devices, capable of autonomous functioning by intelligent adaptation to the patient and his or her circumstances. Research will result in prototypes that have been tested successfully in healthcare institutions. They will be further developed by the companies that are included in this centre to products that can be marketed worldwide.

A shift from intramural to extramural care will also offer tremendous possibilities for industry. Telemonitoring and the organization of it will require a completely new infrastructure. By joining together different types of industry (serious gaming, sensors, prostheses, etc.) new opportunities become possible for each of them.

Science in the Netherlands requires fundamental knowledge on how people learn to use artificial devices, like prostheses and orthoses. This will make them much more efficient. Science on mobility issues is very scattered. It will benefit from clustering it. This will allow studying more aspects and will result in a higher level of knowledge on mobility. Science requires a mind shift from technology-driven to patient-driven (market pull). One should not focus on new technologies and try to find application for it. It is better to focus on the problems patients have and to concentrate on the development of solutions for these problems. New technologies can be used for that.

SPRINT uses a strong patient driven concept, resulting in adaptable devices completely tuned to the individual patient:

- Learning process: studies to the learning process and motor control and the connection of the motor capabilities of the patients to the needed properties of the mobility devices.
- Discovery Learning: this means using the movement solutions which are automatically generated by the patient and not given by the therapist. Serious gaming and embedded cognition of the prosthesis / orthosis can be used in the development of discovery learning. This results in an effective training.
- Patient driven development: Devices will be developed that can be adapted to the patient.
- Training programs, based on the knowledge of the learning process and the discovery learning results: interactive training programs will be developed so the patients can train at home instead of in the Rehabilitation Center and can continue training after the Rehabilitation period (prevention of fall back).
- Tele Medicine: The devices will be provided with different kind of sensors that inform the physician and other healthcare professionals with information about use, misuse, problems and the data about the training activities. This enables the professionals to monitor the patients and to provide them with advises, while the patient can stay at home and regular visits to the Rehabilitation Center for training or consulting become superfluous.
- Evaluation, improvement and valorization of the devices.

5 Organization

5.1 Structure in headlines

- The Management team (MT) is the central organization that together with the board of directors will control the CoRE SPRINT.
- The MT defines the mission of SPRINT and derives research programmes to realize its mission. These research projects are the fundament of SPRINT. They will create innovative devices that will realize an increased mobility of patients and elderly.
- The projects within these research programmes are monitored and steered by the management team, external advisory board and the scientific leaders.
- The management structure of SPRINT (figure 2) is aimed at optimal performance of these projects.

5.2 Description of the pillars

The CoRe SPRINT is based upon four research pillars:

1. **Development of balance improving orthoses and training devices for the elderly, for extramural use.** With these device elderly can improve their balance and prevent accidents caused by decreased balance. Using them in an extramural setting will limit the costs.
2. **Development of intelligent, patient-specific prostheses and orthoses, based on Discovery learning & Embodied Cognition, with distant feedback to the physician.** These devices will restore mobility of patient much faster, perform better due to a personalized design, can be trained faster due to optimal adaption to the learning process and can be trained at home.
3. **Development of innovative wheeled mobility, with distant feedback to the physician.** These devices are designed from a patient point of view instead of a technological point of view. This will increase efficiency and decrease the learning phase.
4. **Development of extramural rehabilitation programmes and training devices in combination with serious gaming.** This will allow a shift from intramural rehabilitation to extramural rehabilitation, which will be much cheaper, requires less medical manpower and is much more comfortable for the patient.

5.3 Internal functioning

The internal functioning of the CoRE reflects the research driven approach of the CoRE. Each program will wrap the following research phases:

1. Analysis of patients' specific needs, resulting in patient driven development of devices;
2. Fundamental research into Discovery Learning & Embodied Cognition of prostheses;
3. Studying human motor functioning, and mechanisms of motor recovery for the adaptation of mobility devices to the motor skills of individual patients in a methodological way;
4. Design of a new generation of mobility, training or rehabilitation devices;
5. Distance-control of a device to allow early discharge of patients and increase safety in use; this includes studying the technical and organizational aspects of telemonitoring;
6. Clinical test to evaluate the newly developed equipment and devices in daily healthcare;
7. Valorization. Transfer to industry for further development of prototypes in series products and for market introduction.

The links between these research phases in each program are presented in figure 1.

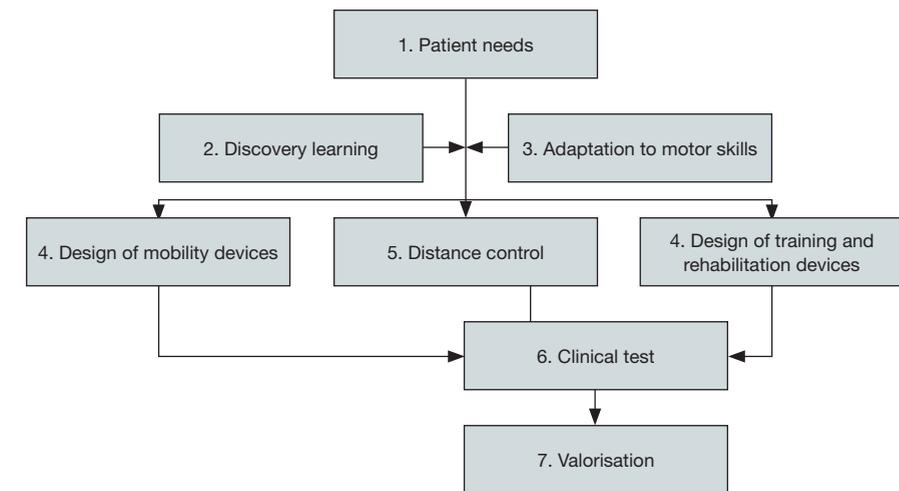


Figure 1: Relation between essential research aspects in research projects.

6 Management and Governance

6.1 Management

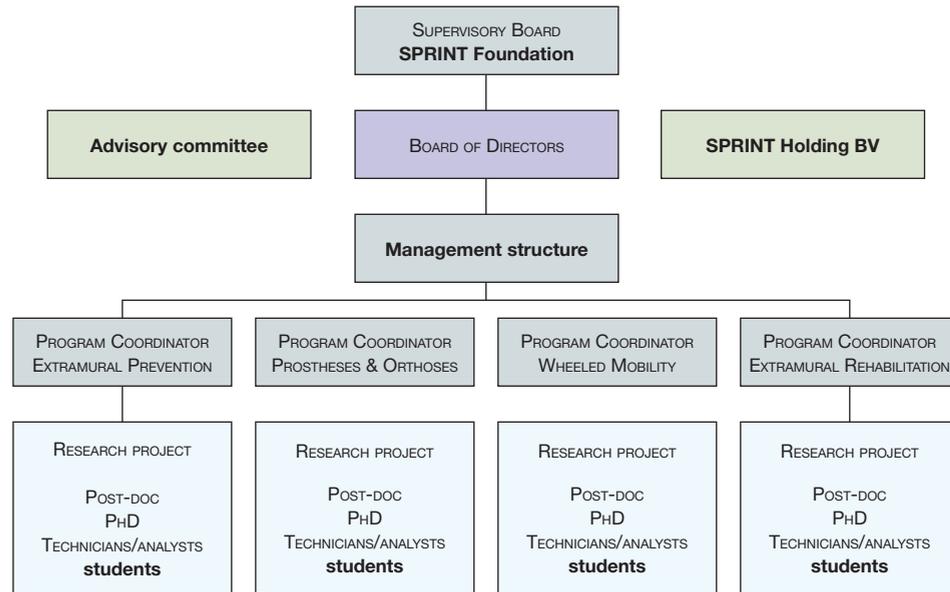


Figure 3: Management structure of the CoRE SPRINT.

6.1.1 The Supervisory Board (SB):

The board of director of

1. RUG;
2. UMCG;
3. UT;

will establish the “stichting SPRINT”.

The main responsibilities of the SB are:

1. Supervise, monitor and control the Board of Directors;
2. Control finances;
3. Appoint major positions;
4. Monitor CoRE quality and performance;
5. Judgment of yearly report.

6.1.2 Advisory committee (AC)

The Supervisory board will install an advisory Committee. Members of this AC are:

1. Representatives of various companies;
2. Patient organizations;
3. Participating research groups;
4. Societal organizations;
5. Health insurance companies;
6. Healthy ageing’-initiative;
7. ‘Health valley’-initiative.

The main tasks of the AC are:

- To strengthen the regional position of the CoRE.
- To provide advice about new research strategies.
- To provoke economic activities and entrepreneurship.

6.1.3 Board of directors

The supervisory board will install the board of directors. This board will consist of

- The technical scientific leader (Prof. Verkerke);
- The clinical scientific leader (Prof Postema);
- The managing director (to be appointed).

The board of directors is supported by an administrative secretariat.

Financial management is provided by the three participating universities, experienced in managing multi-participant projects.

The tasks of the board of directors:

- To determine the CoRE-strategy, defined by mission, vision, goals and defining long term plans.
- To ensure good connections with regional, national and international research structures.
- To organize MT-meetings every three months and yearly scientific meetings for all partners.
- To initiate additional funding.
- To prepare the yearly reports (2010-2020).

6.1.4 The management team (MT)

The members of the MT are the 6 members which represent the various expertise fields.

The tasks of the MT are:

- To define research programmes in which projects will be performed.
- To initiate project calls.
- To assess and evaluate the project proposals.
- To support projects by offering facilities and expertise.

6.1.5 SPRINT holding

The supervisory board will install a SPRINT holding. The main task of this holding is to stimulate valorization and the development of spin-off companies.

6.1.6 Meetings

For optimal performance of the running research projects and to initiate new research projects, several meetings are scheduled.

- The two coordinators responsible for day-to-day management meet at least once a month to discuss practical issues.
- The management team meets every three months.
- Project teams (comprising members from different institutes) meet every month to discuss and decide upon progress, quality, planning and budget.
- Once a year a scientific meeting is to be organized for all participants to discuss how the different projects are progressing and which new project could be initiated.

6.2 Governance

6.2.1 Selection of new projects and the ending of failing projects

The management team decides about the selection of the new research project.

The 8 main assessment criteria are:

1. Evident fit in the theme 'Extramural care';
2. Substantial contribution with respect to the decrease of health care cost;
3. Evident fit in one of the research programmes;
4. High scientific quality with clear innovative aspects;
5. Adequate utilization plan (valorization);
6. Presence of a clinical and industrial representative to safeguard clinical and industrial aspects;
7. Realistic goals and planning;
8. Realistic budget.

Monitor running projects: Every year an evaluation report has to be written. With this report progress will be judged. If necessary the project will be stopped, if progress and quality are insufficient. Stop criteria are: the project is running behind planning for more than 25%, budget is exceeded by more than 25% and in comparison to the most competitive product the performance is inferior by 25% or more according to the stakeholders.

6.2.2 Principles guiding intellectual property policies

In general, the intellectual properties policy of SPRINT and its implementation in contracts and guidelines will follow the previously developed concepts and widely accepted guidelines developed in the European framework programs and in national technology programs like STW. This means that already in the development stage of each project proposal, the valorization path will be clarified and stakeholders identified. Publication of the results of research will be tuned with the stakeholders to avoid endangerment of patents and commercial exploitation. All project proposals will involve a patent search beforehand and a clear policy on how to deal with it (ownership, participation). SPRINT will develop an IP strategic plan for developing and exploiting a coherent IP portfolio.

Start-ups will be promoted by using the expertise and experience of the UT, UMCG and RUG.

6.2.3 Principles guiding the legal structure

The legal structure will either be a separate legal entity (foundation) or will be governed by way of a consortium agreement, which all partners have to agree and sign. This will be determined when and if financial support is available. UMCG could be the coordinating partner. The legal structure should be in line with the overall goal to create long lasting to permanent structure. In either structure goals, governance, management, funding audit and periodic reporting will be accounted for according good practice.

7 Finances

Figure 4 shows SPRINT's own contributions, IMDI budget and growth.

SPRINT budget

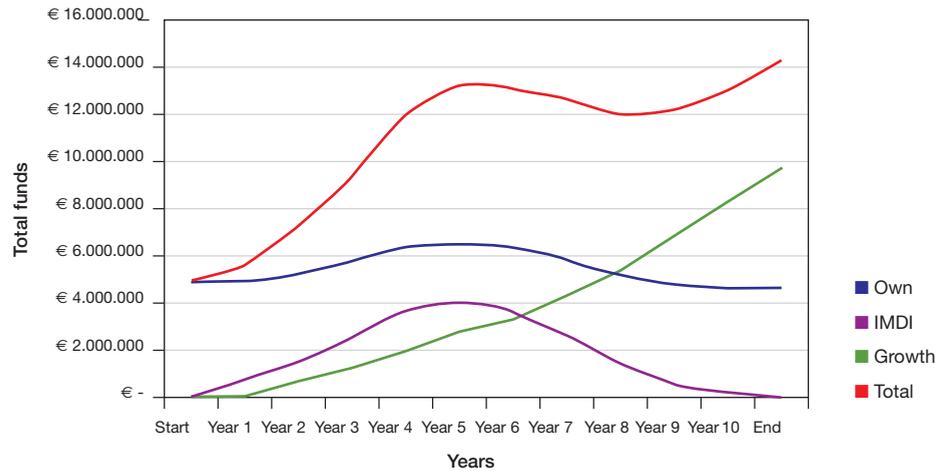


Figure 4: SPRINT budget

7.1 Partners input

At the start of the Centre, fixed and temporary staff is financed by the participating institutes and by way of external grants (2nd and 3rd research funds) or contract research. The consortium staffing level is almost 130 fte. The corresponding budget including materials, equipment and overhead is 14,5 million €. Of this capacity 63 fte with a relating budget of 4.6 million € will be used to develop and perform research in the field of the CoRE SPRINT. Over a 10 year period an increasing proportion of the thus allocated staff, materials and equipment will provide the necessary in kind matching for the IMDI funding as well as the matching needed in the externally acquired research funds and contract research. In Figure 4 this is represented by a constant level of the basic funding of "own" budget of 4.6 million € annually.

7.2 IMDI impulse

The IMDI funding will work as a flywheel. In Figure 4 this is represented by "IMDI". The funding contribution increases because of the increasing research effort and number of projects to be started, and reaches a maximum level in the years 4, 5 and 6. Then, SPRINT will become better and better known and will be a popular partner for the industry of new mobility devices. Due to the strength of the CoRE SPRINT it will become easier to attract external funds and the IMDI funding decreases as shown in Figure 4. The annual turnover of the Center will grow from €5,5 million in the first year to almost € 13 million in year 10. The own contribution of the public research groups will be at least 25%. The total matching by research groups and industry is estimated to be 50%. After 10 years the institutes are prepared to maintain this level of turnover, which is estimated at € 14 million annually.

The IMDI impulse will lead to a growth of the fixed staff. These staff members will be funded later by new external grants.

7.3 Structural growth

SPRINT will show a substantial growth, see Figure 4. In the first year five new projects will start. Every project will take four years. The number of new projects will grow to 84 in the last year. In the last year there will be 29 running projects. The total number of projects that will start during the complete period is 84. Since all projects are built up in a PhD structure, this means that 55 PhD students will have passed their PhD examination in year ten, and 84 PhD students will have passed their PhD examination in four years later.

We expect the structural growth in 2nd, 3rd and 4th funding to increase steadily to reach € 8.3 million in year 10.

The overall budget of SPRINT, shown as "Total" in Figure 4, steadily increases during the first 5 years. After year 5 the decreasing IMDI funds are matched by increasing growth resulting in a more or less constant total budget.

8 Operational Research Plan 2011-2013

All partners have agreed to start up this Centre of Research Excellence by appointing various staff members and PhD-students. In total more than 130 FTE are available.

This staff will perform research in line with the research plans of this Centre. The partners will also make their infrastructure available to support this research.

In 2010 a call for projects will be launched. Project proposals will be selected and contracts with industries prepared. We strive to cover the entire range of research programmes. When financial support becomes available, projects will be funded according to their ranking.

8.1 Current projects

1) *Regarding the development of balance improving orthoses and training devices for the elderly, for extramural use:*

- Evaluation of home-based interventions for supporting mobility in older people with an increased risk of falling;
- Balance and gait variability and stability in patients with neurological and orthopaedic impairment;
- Knee orthosis that will restore knee cartilage and thereby avoid the need for knee implants;
- Scoliosis brace that will adapt to its correction process;
- Insole devices that will improve balance in the elderly.

2) *Regarding the development of intelligent, patient-specific prostheses and orthoses, based on Discovery learning & Embodied Cognition, with distant feedback to the physician:*

- Learning to use an arm prosthesis;
- Trans Femoral (Upper leg) prosthesis adapted to the needs of the individual patient;
- Interaction of prosthetic foot properties and individual motor-capacity;
- Automated analysis of fine motor control;
- Visualization of brain connectivity data;
- Cueing and freezing: aiding the brain in the organization of movement;
- Learning processes and mechanical properties of voluntary closing body-powered prosthesis;
- Corticospinal excitability during observation and imagery of simple/complex hand tasks;
- Learning process optimization for controlling humanoid robotic arm;

- Development of a prosthesis with intelligent and energy-efficient actuation and natural bidirectional control interface for transfemoral prostheses;
- Improve the control of a myoelectric arm prosthesis by increasing the number of degrees of freedom using multichannel surface electromyography.

3) *Regarding the development of innovative wheeled mobility, with distant feedback to the physician:*

- Low-intensity hand-rim wheelchair training and motor learning.

4) *Regarding the development of extramural rehabilitation programmes and training devices in combination with serious gaming:*

- Development of a robot training device with functional electro stimulation for stroke patients;
- Koala: acquire insight into the business problems that arise when telecare is implemented;
- Sasleg: research into the variants and dynamics of processes to deliver care services to citizens by local municipalities;
- Cost-benefit analyses of three largest telecare projects in the Netherlands for the 2008 financial year.

The first challenge is to integrate these projects in the proposed research programmes. The running projects will be judged on the requirements, set for the new projects. In this way a comprehensive set of projects are left over.

Then new projects will be formulated to realize the long-term goals, defined in this report. This will stimulate the creation of the centre and the development of joint research projects within the framework of SPRINT. So even before funding from the national NMD programme a common research programme becomes available. Should this funding not become available, then SPRINT will be continued, but the growth will be substantially slower.

8.2 New projects

New projects will start in every research programme:

8.2.1 Regarding the development of balance improving orthoses and training devices for the elderly, for extramural use:

- Ongoing research about insight in learning of balance;
- Use of serious gaming and discovery learning in balance training;
- Development of intelligent information for balance training monitoring and feedback;
- Development of interactive training program for balance training at home;
- Development of training devices;
- Development and implementation of telemedicine (including infrastructure and courses for training the trainers);
- Evaluation and adaptation;
- Valorization.

8.2.1.1 Milestones

- 2012: Report with possibilities for intelligent information needed for monitoring and feedback of balance training.
- 2013: First prototype of 'home balance training device'.
- 2013: Report with balance training program for at home.
- 2013: Prototype telemonitoring devices and web applications for the balance training device, suitable for elderly.
- 2013: Report with infrastructure and agreements with healthcare institutes for telemonitoring.
- 2014: Report with training program for involved healthcare professionals for telemonitoring and coaching.
- 2014: Patent for 'home balance training device'.
- 2017: Evaluation report of daily use and effects of the 'home balance training device', including an economic effect study.

8.2.1.2 Deliverables

- 2014: Telemonitoring devices and web applications for the balance training device, suitable for elderly.
- 2014: Ten publications and two PhD Theses about learning of balance and use of serious gaming.
- 2015: Five publications and one PhD Thesis about the development of an intelligent balance training program.
- 2015: Company producing home balance training devices for elderly.
- 2017: Five publications and one PhD Thesis about the evaluation of daily use and effects of the 'home balance training device', including an economic effect study.

8.2.2 Regarding the development of intelligent, patient-specific prostheses and orthoses, based on Discovery learning & Embodied Cognition, with distant feedback to the physician:

- Ongoing insight in adaptation mechanisms;
- Match on motor capacity of the patient and biomechanical properties of the prosthesis;
- Use of serious gaming and discovery learning for daily activities with a prosthesis;
- Development of intelligent information for monitoring daily activities with a prosthesis;
- Development of intelligent prostheses;
- Development of interactive training program for daily activities with a prosthesis;
- Development and implementation of telemedicine (including infrastructure and courses for training the trainers);
- Evaluation and adaptation;
- Valorization.

8.2.2.1 Milestones

- 2012: Report with possibilities for intelligent information needed for monitoring and feedback of daily activities and training with prosthesis at home.
- 2013: First prototype of 'intelligent prosthesis'.
- 2013: Report about the possibilities of use of serious gaming and discovery learning for training daily activities and physical condition at home with a prosthesis.
- 2013: Prototype telemonitoring devices and web applications for monitoring and coaching patients with a leg prosthesis for their daily activities and training with the prosthesis.
- 2013: Report with infrastructure and agreements with healthcare institutes for telemonitoring.
- 2014: Report with prosthesis training program for at home.
- 2014: Report with training program for involved healthcare professionals for telemonitoring and coaching.
- 2014: Patent for 'intelligent prosthesis'.
- 2017: Evaluation report of daily use and effects of the 'intelligent prosthesis', including an economic effect study.

8.2.2.2 Deliverables

- 2014: Intelligent prosthesis.
- 2014: Telemonitoring devices and web applications for the intelligent prosthesis.
- 2014: Five publications and one PhD Theses about the match on motor capacity of the patient and biomechanical properties of the prosthesis.
- 2014: Five publications and one PhD Theses about the use of serious gaming and discovery learning for daily activities with a prosthesis.
- 2015: Five publications and one PhD Thesis about the development of a program for training with the intelligent prosthesis at home.
- 2015: Company producing the intelligent prosthesis.
- 2017: Five publications and one PhD Thesis about the evaluation of daily use and effects of the 'intelligent prosthesis', including an economic effect study.

8.2.3 Regarding the development of innovative wheeled mobility, with distant feedback to the physician:

- Low-intensity hand-rim wheelchair training and motor learning;
- Anti decubitus information and automated control;
- Optimal position at different riding speeds.

8.2.3.1 Milestones

- 2012: Report with possibilities for intelligent information needed for monitoring of and feedback about low intensity training of wheelchair users.
- 2012: Analysis of possible and needed information for a decubitus control system.
- 2013: Report with a structural analysis of implementation process of telecare related to wheelchair training.
- 2013: Report with a structural analysis of implementation process of telecare related to decubitus control.
- 2013: First prototype of 'intelligent wheelchair with integrated information systems' about wheelchair training and decubitus control.
- 2014: Report with infrastructure and agreements with healthcare institutes for telemonitoring.
- 2014: Home based low intensity wheelchair training.
- 2014: Report with training program for involved healthcare professionals for telemonitoring and coaching.
- 2015: Evaluation report of the use and effects of the low intensity home based wheelchair training.

8.2.3.2 Deliverables

- 2014: Prototype 'intelligent wheelchair with integrated information systems' for wheelchair training and decubitus control.
- 2014: Telemonitoring devices and web applications for the low intensity wheelchair training.
- 2015: Five publications and one PhD Thesis about the development of a program for low intensity wheelchair training.
- 2016: Company producing the integrated information systems for wheelchair training and decubitus control.
- 2017: Five publications and one PhD Thesis about the evaluation of the use and effects of the low intensity wheelchair trainings program and the decubitus control system.

8.2.4 Regarding the development of extramural rehabilitation programmes and training devices in combination with serious gaming

- Development of a robot training device with functional electro stimulation for stroke patients;
- Koala: acquire insight into the business problems that arise when telecare is implemented;
- Sasleg: research into the variants and dynamics of processes to deliver care services to citizens by local municipalities;
- Cost-benefit analyses of three largest telecare projects in the Netherlands for the 2008 financial year.

8.2.4.1 Milestones

- 2012: Analysis of the special needs of stroke patients at home for training.
- 2012: Report with possibilities for intelligent information needed for monitoring and feedback of training with a robot training device.
- 2012: Analysis of the business problems that arise when telecare is implemented.
- 2012: Analysis of variants and dynamics of processes to deliver care services to citizens by local municipalities.
- 2012: Cost-benefit analyses of three largest telecare projects in the Netherlands for the 2008 financial year.
- 2013: Report with a structural analysis of implementation process of telecare related to robot training device for stroke patients at home.
- 2013: First prototype of intelligent robot training device for stroke patients at home.
- 2014: Report with infrastructure and agreements with healthcare institutes for telemonitoring.
- 2014: Home based program for training of stroke patients with a robot training device.
- 2014: Report with training program for involved healthcare professionals for telemonitoring and coaching.

2014: First prototype of the robot training device for stroke patients at home.

2016: Evaluation report of the use and effects of the robot training device for stroke patients at home.

8.2.4.2 Deliverables

2012: Report with possibilities for intelligent information needed for monitoring and feedback of training with a robot training device.

2012: Report with analysis of the business problems that arise when telecare is implemented.

2012: Report with analysis of variants and dynamics of processes to deliver care services to citizens by local municipalities.

2012: Report with cost-benefit analyses of three largest telecare projects in the Netherlands for the 2008 financial year.

2013: First prototype of the robot training device for stroke patients at home.

2014: Telemonitoring devices and web applications for the robot training device for stroke patients at home.

2015: Five publications and one PhD Thesis about the development of a robot training device for stroke patients at home.

2016: Company producing the robot training device for stroke patients at home.

2017: Five publications and one PhD Thesis about the evaluation of the use and effects of the robot training device for stroke patients at home.

8.2.5 Infrastructure

Current infrastructure is, like research, very fragmented. The facilities will be concentrated in conjoined research labs and expanded to come to the following research labs:

Serious gaming; the four labs with a Computer Assisted Rehabilitation Environment (CAREN) system will join their forces leading to a conjoined control and to standardization of measurement systems.

The different Gait laboratories will also join their forces and realize standardization.

So the different labs can work on the same project, because the measurement results will be comparable.

8.3 Funding

- We will initiate an active policy in realizing sufficient funding. In the Netherlands we will focus on STW-grants, Veni-, Vidi- and Vici-grants.
- We also will focus on Europe and the EU-funds. We will benefit from the liaison-officers from the UMCG and UT. These officers have very good contacts in Brussels and are experienced in coping with obtaining grants for large research projects.
- The fact that research on mobility in the Netherlands is concentrated in the CoRE SPRINT and that initial funding has stimulated the growth of it will facilitate the realization of external funding, because we can guarantee a high level of focused research, facilities and expertise.
- Active acquisition will be performed to include more research departments, health care institutes and industries. Our consortium will also be expanded by international partners. Every MT-member and PI will pro-actively recruit new partners that can contribute to the activities of SPRINT.

8.4 Results to be expected after 5 years

- Results will directly follow from new projects, initiated by SPRINT.
- Projects that focus on fundamental research will create new knowledge on the adaptation of mobility devices and on patients' learning processes. The study of learning and adaptation processes in the human brain in response to prosthesis will provide information about the corresponding cortical network by integrating muscle (EMG) and brain (EEG and fMRI) measurements. This will enable us to determine key parameters to monitor and predict the effectiveness of prosthesis use by individual subjects.
- Projects will result in devices that contribute to prevention of mobility impairment.
- Projects will also create new mobility devices based on already existing knowledge within the SPRINT centre. They can be considered to be second-generation devices, focused on passive feedback.
- Projects will result in strategies and devices that contribute to a decrease in the number of outpatient clinic procedures.
- We expect to complete at least fourteen PhD theses, 100 publications and to have developed eight new mobility devices. We will apply for patents to support industrial transfer. Projects will also result in strategies to decrease the number of outpatient clinic procedures.
- To present our results we will organize an annual national symposium.

9 Indicative Research Agenda 2014-2020

- 1) Projects which focus on fundamental research will continue to create new knowledge on the adaptation of mobility devices and on the learning process of patients.
- 2) Projects on applied research will lead to the development of new mobility devices, based on knowledge gained in the first five years of the SPRINT centre.

9.1 Deliverables

- 55 PhD theses;
- 250 publications;
- At least twenty innovative mobility devices (including transfer to the industry) will be developed that will contribute significantly to increased patient mobility and quality of life and a reduction of health care workers and costs.

9.1.1 Mobility devices

- We expect to develop various mobility devices and transfer them to industry for commercialization. These third generation devices will contribute significantly to increased patient mobility because of their intuitive use, better function restoration, leading to a faster rehabilitation process and fewer hospital visits because the devices will adapt themselves. They will also enable more patients to return to work and make them more employable. They will even improve sports participation, overall fitness and help prevent inactivity-related secondary health problems.
- Society will benefit because the devices help reduce healthcare costs because they function better and safer than previous models, so there will be less dependency on healthcare professionals. Elderly people will experience a significant increase in their quality of life, allowing them to enjoy a healthy ageing process.

9.1.2 Scientific deliverables

- Our research will lead to numerous PhD theses and scientific presentations. To present our results we will organize an annual national symposium, which will soon become an international event.
- In the future we will strive for an own building. Then participants can be organized per project instead of per department. The philosophy behind this is that it is easier to go to colleagues from one's own background to get information than to go to colleagues with different background.

9.1.3 Socio-economic evaluation

- With the results of the SPRINT centre the estimated annual savings in the health care sector amount to 250 Meuro.
- In year six, the MT starts a special project with the purpose of initiating evaluation and measuring activities on the savings actually achieved by the new treatment and training programmes and medical devices developed by the project.

9.1.4 Long-term vision

- With existing technology it is possible to create second generation intelligent mobility devices for individual patients.
- Fundamental research is an essential element of SPRINT, because it will provide knowledge that leads to new devices and therapies for prevention and cure of mobility disorders.
- With this knowledge, developed in this centre, it is possible to create a third generation mobility devices, capable of autonomous functioning by intelligent and continuous adaptation to the patient and its circumstances. An interactive feedback by a professional is given via telemedicine (ICT).
- All elderly have the disposal of third generation intelligent balance - and physical condition training devices and access to interactive coaching.
- Intelligent mobility devices and rehabilitation training with a third generation intelligent mobility/training device at home, in combination with tele coaching, is a regular provision in the Rehabilitation Medicine. Therefore, the shift from Intramural care to Extramural care will further increase.
- Low back pain and musculoskeletal pain in general cause tremendous absenteeism of work. Intelligent training / mobility devices are regularly used to keep people at work.
- New devices will further decrease the number of falls of elderly, and therefore play an essential role in keeping elderly mobile and independent, and therefore SPRINT further reduces the demand on medical-, nursing- and homecare.
- The CoRE SPRINT is developed into an international research center on intelligent mobility devices with strategic alliances with Rehabilitation Centers, hospitals and homecare organizations, as well as, national and international.
- A strong integration exists with the CoRE Centre for Care Technology Research.

10 Leadership competences

The technical and clinical scientific leaders, respectively Prof. Verkerke (UT/UMCG) and Prof. Postema (UMCG) are complementary in their expertise fields.

- Prof. Verkerke is an engineer and is very experienced in developing of innovative devices.
- Prof. Postema is medical specialist for Rehabilitation and has much scientific and clinical experience in prosthetics and orthotics in relation to motor control/learning and gait analysis. Prof. Postema was for eight years head of the Center for Rehabilitation of the UMCG.

10.1 Prof. Bart G.J.Verkerke PhD ir (SCIENTIFIC LEADER OF SPRINT)

- Main area of expertise: Medical product design, Biomechanics.
- Position: Full professor in Design of Biomedical Products, UT University and full Professor in Biomedical Product development, UMCG, RuG
- Publications: 133
- Lot of contacts with industry
- Grants: M€ 8,5

10.2 Prof. Klaas Postema PhD (CLINICAL LEADER OF SPRINT)

- Main area of expertise: gait analysis and motor control of amputees and elderly
- Position: professor in Rehabilitation Medicine, UMCG, RuG
- Publications: 74
- Different contacts with industry
- Grants: M€ 1.0

10.3 Prof. Luc H.V. van der Woude, PhD

- Main area of expertise: Human Movement Sciences, human functional recovery and human powered wheeled mobility
- Position: Professor in Movement Sciences, Institute for Movementsciences, UMCG and RuG
- Publications: 136
- Grants: M€ 2.6

10.4 Prof Bert Otten, PhD

- Main area of expertise: NeuroMechanics and Prosthetics
- Position: Professor in Neuromechanics, Institute for Movementsciences, UMCG and RuG
- Publications: 162
- Lot of contacts with industry
- Grants: 891 K€

10.5 Prof. Bart H.F.J.M. Koopman, PhD Ir

- Main area of expertise: Dynamic simulation; models of the muscular skeleton; biomechanics; Biomedical Engineering; Human-machine interaction; Muscle modelling; Mechanical Engineering
- Position: professor in Biomechanical Engineering, Department of Biomedical Engineering, UT
- Publications: 120
- Many contacts with industry
- Grants: M€ 5.1

10.6 Che H. Falkenström PhD Biomedical Engineer

- Main area of expertise: development of new instruments and managing enterprises for medical mobility devices.
- Current position: CEO, OIM Holding B.V., Assen, The Netherlands (since 2004)
- Former positions: Manager and director in different companies for medical devices
- Board memberships: Member of the board of NVOS-Orthobanda, society of the Dutch orthopaedic industries (since 2009)

