While the work of the consortium **in the first year** was focused on expanding clinical protocols to the field of telemedicine and on developing new protocols, with its key activity being the creation of the protocol repository, the key task of the
second year
comprised designing, implementing and testing the core functions of the telemedicine system for implementing the processes, as well as analysing the economic parameters of the processes and services to be implemented with the help of the system via the protocols.

The key task for the **third year** was to further develop the terminal devices supporting the protocols selected for implementation, to link them to the system and to test their operation.
By the end of the project
, the technical system meeting the project goals was created: a functionally tested prototype of the TELeHEALTH service system which is capable of implementing the selected protocols and has flexible expansion capabilities.

Development took place in four major cycles. These cycles were based on the protocols on one hand and on the new technologies and solutions used in the protocols on the other hand. The work involved the clarification and specification of the steps associated with the protocol to be implemented, clarification of the way the required core components (remote examination, assessment, consultations etc.) worked, and then - based on this information - the development and testing of the components of the devices and of the core system. The protocols developed were validated and commented on by the Clinical Work Group. The elements of the theoretical framework created by the other work groups for the formalised representation of the protocols, as well as the design documents describing the system were updated in line with the expectations and the progress of the development process. Basic user and operator documentation was prepared to make it as easy as possible for users and operators to start using the system. Also, a management solution to support operation was added to the central telemedicine system. As a first step of preparation for business use, the Economic Work Group drew up a preliminary business plan for a telemedicine service provider using the system for the telemedicine procedures created.

Clinical Work Group

Following additional consultation with physicians, the descriptive protocols for the protocols selected on the basis of the economic analysis – i.e. the Asthma Diagnostics, Asthma Monitoring and Stroke Tele-Rehabilitation Protocols – were complemented and clarified.

Researchers of the Semmelweis University participated in the work of the Clinical Work Group as well as in the work of the Protocol Representation Framework and Core Component Repository Groups of the Protocol Repository Work Group and in the work of the Economic Work Group.

Economic Work Group

To ensure that maximum benefit is derived from the use of telemedicine in terms of improved efficiency, *cost efficiency and feasibility analyses* were carried out as planned. The main purpose of the analyses was to identify the processes and applications where efficiency could be most improved or costs could be most reduced while the level of health benefits remains the same or increases. This aspect is most relevant for the players providing funding for healthcare services. In the second phase of the work we repeated our calculations and considered a worst case scenario where only funding from private economic players could be relied on. Economic analyses were based on scientifically sound models approved by the industry. We selected the methodologies successfully used in international and domestic healthcare, collected information, and analysed such information to formulate a proposal for selecting the most appropriate protocols.

Our findings are presented in detail in the project documents. During the work we had to realise that the scientific findings based on mathematical economic models need to be reviewed in the light of the lessons from the shock affecting healthcare systems worldwide - including in Hungary, unfortunately. An example we could mention is that (apart from some very large countries) a few years ago the economic benefit offered by telemedicine in saving travel costs for the patient was not of outstanding importance. Now, even in Hungary the situation is different. As experienced and highly skilled doctors leave the country en masse, only a few central institutions can provide services of the required quality. Travelling to these institutions from hundreds of kilometres away results in radically increasing travel costs and significant loss of time spent working. The principles, telemedicine applications and tools developed by the project can offer solutions to both the healthcare administration and the patients in resolving the issues arising from the diminishing quality and quantity of healthcare resources.

Protocol Repository Work Group

The task of the work group for the third year included the maintenance of the *framework* for the formal description of the protocols, the transfer of the changes to the protocol packages

resulting from (this and) the clarifications, followed by their publication in the protocol repository.
The protocol packages
selected for implementation were made to comply with the newest version of the protocol representation framework. Also, for testing purposes, the points of measurement allowing the analysis of the execution data were included. In the course of maintaining the framework, we made an effort to preserve the distinction set up in the second work phase at the level of business and technical core components. In defining the core components we followed the principle laid down in the original concept for the protocol repository, i.e. that protocol packages - together with the descriptive framework - shall define and clarify the process to a level which is unambiguous for the community of human users. They may not, however, contain requirements (recommendations at most) referencing the BPMN process-based IT devices used (or usable) for implementation.

System Engineering and Core System Work Group

Development took place in four major cycles, which were based on the protocols on one hand and on the new technologies and solutions used in the protocols on the other hand. The work involved the clarification and specification of the steps associated with the protocol to be implemented, clarification of the way the required core components (remote examination, assessment, consultations etc.) worked, and then - based on this information - the development and testing of the components of the devices and of the core system. The telemedicine protocols developed were validated and commented on by the Clinical Work Group. Basic user and operator documentation was prepared to make it as easy as possible for users and operators to start using the system. Also, a management solution to support operation was added to the central telemedicine system. Following the implementation of the technical systems, the relevant system documentation was finalised.

Terminal Devices Work Group

The Terminal Devices Work Group was active in all three work phases of the project. Its members, the Logistics and Production Technology Institute of the Bay Zoltán Foundation for Applied Research (later: Bay-Logi) and Thormed Ltd. helped the work of the consortium in this work group by presenting technical solutions related to patient-side measurement methods, procedures and tools, followed by the technological assessment of the protocols developed, and, finally, by developing the concept and breadboard models. The design and production of terminal devices aligned with the protocols was based on the clarified ideas which were found economically favourable.

The *devices* born from the project are part of a versatile and scalable set of tools which can offer several solutions of various cost and service level to meet the needs of the financing entity (the healthcare insurance body). When designing the devices, the distribution of the relevant illness among the age groups was taken into consideration and the basic functions of the devices were designed to fit the needs and habits of the dominant age group. Mobile phones and home PCs play an important role in the life of young people (in the case of the asthma, diagnosis and therapy protocols) and they are adept at operating these devices. Therefore it was made possible for them to connect to our system via their own, familiar devices. Older people (COPD, stroke rehabilitation), on the other hand, are not necessarily fond of computers and smart phones and were therefore provided other ways to use the system which better fit their needs.

One of the features of the system which is outstanding by international standards is that the main units in the set of devices developed in the project are able to transmit the measurements to the telemedicine centre in more than one way: directly, via the GSM network or indirectly, via the *Home Hub*. The Home Hub also comes in several variations: as a virtual, simple or as a multi-functional, integrated unit. The device communicates in accordance with the recommendations of the Continua Health Alliance, in which the Bay Zoltán Foundation for Applied Research has been a member for a year.

Several novel solutions have been developed, such as functional breathing tests usable at home (international patent pending), home monitoring and supervision of patients with balance issues (patients participating in stroke rehabilitation, Parkinson's patients) (Hungarian patent pending).

Another novelty is that the Home Hub can not only support devices developed by the members of the Terminal Devices Work Group but also works with other devices designed based on the Continua Health Alliance guidelines. This open system can prevent the funder of the telemedicine system from being dependant on a single manufacturer (it can switch to another manufacturer, which is impossible in a closed system).

Devices capable of performing tests - measurements of environmental and patient parameters - required by the asthma care protocol and the stroke patient care protocol, respectively:

- a remote stethoscope for remote medical examinations, easy to use by the patient or a family member, primarily for checking breathing and heart sound;
- a balance sensor suitable for monitoring the improvement of the patient's condition and to

support physiotherapy;
sensors attached to the body, suitable for measuring the amount of exercise, to detect posture and falling, to analyse walking parameters and to support physiotherapy;
- environmental sensors for monitoring the living conditions of the patient;
- testing and therapeutic applications running on the Home Hub (e.g. memory training and test, speech therapy support).

Possibly the most important output product of the project is the protocol-based telemedicine system (using a process-oriented approach), as well as the associated terminal device prototype. Their application can generate to the social and economic benefits considered in the economic analysis.

By the end of the project (Sept. 2011)

We also accomplished joint tests of the central system and all endpoint devices developed to serve the three implemented telemedicine guideline in test environment. The guidelines were chosen on the base of economical evaluation, giving the highest potential benefit from a joint viewpoint of healthcare providers, patient and community.

Possibly the most important output product of the project is the protocol-based telemedicine system (using a process-oriented approach), as well as the associated terminal device prototype. Their application can generate to the social and economic benefits considered in the economic analysis.