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Abbreviations

Abbrev.	Description
AAL	Ambient Assisted Living
AAL JP	Ambient Assisted Living Joint Programme
PWL	Physical Wellbeing Layer
CT	Cognitive Training module
KPI	Key Performance Indicator
CBA	Cost-benefit-analysis
SER	Socio-economic return
FTE	Full-time equivalent

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1 About this Document

1.1 Role of the deliverable

This evaluation report presents the results of the socio-economic evaluation, taking into account the perspectives of all relevant stakeholders. Using cost-benefit analysis, supportive evidence for the future creation of a sustainable business model is produced.

1.2 Relationship to other PEARL deliverables

The deliverable is related to the following PEARL deliverables:

Deliv:	*Relation*
D2.1	Report on User and Stakeholder Requirements: this deliverable reflects the elicitation, consolidation and documentation of stakeholders' requirements (including older workers requirements) for the PEARL platform. The initial requirements from the end-users for the PEARL platform (as described in D2.1) are used to develop the first prototype of PEARL, which was evaluated during the first lab trials. The list of user requirements is adapted based on the outcomes of the first lab trials. A new prototype was build based on the adapted user requirements list, which was evaluated during the second lab trials with prospective end-users.
D2.2	Use cases, Scenarios and Integrated Functionalities: this document describes scenarios and use cases which are based on the user requirements, resulting from T2.1 (reported in D2.1). These scenarios and use cases form the basis for the PEARL prototype, which is evaluated during the second lab trials. Based on recommendations resulting from the second lab trials, a new prototype was developed which was evaluated during the PEARL field trials.
D2.3.2	First PEARL User Interfaces: in this deliverable the first user interface of the PEARL platform and the module specific user interfaces are illustrated and described, which were evaluated during the second lab trials.
D2.4.1	Evaluation Plan and Sites Preparation: this report includes a general description of the protocol to be executed during the first- and second lab trials and field trials of PEARL.
D2.5.1	Report on First Lab Trials: this document presents a summary of the findings and conclusions resulting from the first lab trials, in which the PEARL platform was tested at mock-up level. The findings resulting from these trials were used for the further refinement of the PEARL platform, which resulted in a second prototype of a higher technological maturity level. This prototype was evaluated during the second lab trials. Based on recommendations resulting from the second lab trials, a new prototype was developed which was evaluated during the PEARL field trials.
D2.5.2	Report on Second Lab Trials: this deliverable entails a detailed protocol description of the second lab trials (based on the general guidelines report in D2.4.1) and its forthcoming results. Based on recommendations resulting from the second lab trials, a new prototype was developed which was evaluated during the PEARL field trials.
D2.6	Report on Field Trials: This deliverable summarizes the methodology used, the findings

Deliv:	*Relation*
	and conclusions resulting from the field trials conducted in NL, CH, RO/GR.
D5.3	Market Analysis Survey: A report with a thorough analysis of ICT markets relevant to PEARL.
D5.4.2	Business and Sustainability Plans: Business and sustainability plans for the later exploitation of the PEARL platform and services.

2 Socio-economic evaluation

2.1 Objectives

Putting into place ICT systems supporting older employees in their working life means that a multitude of stakeholders are affected by changes to their individual and organisational working processes and often to their economic performance, at least in principle.

The objective of the socio-economic evaluation within PEARL is to conceptualise, measure and analyse the positive and negative effects of PEARL on all stakeholders with a particular view to understanding the economic workings of the proposed prototype solution.

2.2 Method

2.2.1 Background

The assessment framework applied in PEARL is based on a method and approach called *ASSIST - Assessment and evaluation tools for e-service deployment in health, care and ageing*[1]. The core aim of ASSIST is to facilitate the transposition of a product or service concept into routine deployment and to support service providers and IT industry in achieving a sustainable economic model where service benefits are higher than service costs.

In summary, the ASSIST framework consists of a methodological approach, a service assessment model and a software toolkit. The methodological approach covers the basic characteristics of the framework as well as descriptions of the empirical and economic methods used. The service assessment model consists of a generic set of stakeholders that can be involved in a service (divided into service users, service provider organizations and their staff, and IT industry), and of a set of cost and benefit indicators for each of these stakeholders. As a first step of an assessment, the service assessment model is adapted to the actual conditions set by the service. The software toolkit supports the adaptation of the service assessment model, the collection of data, the analysis and the presentation of results. Depending on its configuration it can be used as a self-assessment tool without expert support or as part of a moderated assessment process. The latter is the way in which ASSIST is being applied in PEARL.

ASSIST was originally developed for use in the context of telemedicine and telehealth services in a project funded by the European Space Agency which ran from 2010 to 2012. The project contained a systematic review and valuation of existing approaches, development of an own assessment framework making use of the most valuable approaches, a software toolkit implementing the assessment framework and a

[1] See http://assist.empirica.biz.

validation phase. During the validation phase ASSIST was successfully applied by five telemedicine projects. It is now available under open source licences from http://assist-telemedicine.net/.

In the course of three EU-funded projects addressing the use of ICT in the wider health and social care domain (CommonWell[2], INDEPENDENT[3] and SmartCare[4]), the original ASSIST framework was expanded. Basic assumptions on service models and market structures were adapted to cover a much wider area than the original domain of telemedicine. As part of the work carried out in PEARL, ASSIST is further expanded to also cover ICT solutions supporting older people in working life.

2.2.2 Methodological requirements

Ammenwerth and de Keizer (Ammenwerth and de Keizer 2004) note that evaluation of health information systems and services has to deal with a multitude of heterogeneous variables, including actors (the people), artefacts (the technology), the environment in which it is implemented as well as their interactions - plus, most importantly, the outputs and outcomes. This can be considered to be applicable also to the thematic domain addressed in PEARL that includes technical, psycho-social, organizational, business and societal aspects. Assessing the socio-economic aspects of PEARL means to incorporate all these aspects into the analysis. The research of Ammenwerth (Ammenwerth and de Keizer 2004) on the evaluation methods of 1,035 studies in health information systems shows that there is a huge bandwidth of evaluation methods, but many of them seem to be not fully suitable to deal with a comprehensive, holistic evaluation of a complex intervention due to several methodological shortcomings.

In order to define a suitable assessment framework, ASSIST defined a set of general requirements for telemedicine assessments. For the expansions to the wider domains of eHealth and eCare and of ICT tools for older employees, these requirements were again reviewed. These requirements were used to benchmark 16 frequently cited methods with the aim of identifying the most suitable starting point. These 16 methods were identified from literature published in peer reviewed journals and from presentations on events such as the eHealth High level conferences by the European Commission. While it seems not possible to claim comprehensiveness it can be assumed that all key methods available at the time of the review in 2010 were included.

As said before, the multi-dimensional character of complex service provisions where many stakeholder groups are affected requires an assessment framework which is able to put together several sub-methods into a consistent whole. This whole must be able to

[2] See http://www.commonwell.eu.
[3] See http://www.independent-project.eu.
[4] See http://www.pilotsmartcare.eu.

deliver a limited set of outcome indicators across its different dimensions to support decisions to be made by stakeholder on different levels.

The following criteria were defined and are further described in the following:

- *Benefits and costs estimation:* The assessment framework must be able to identify and account for a change of “utility” or benefits for the stakeholders in a positive as well as a negative direction. Neglecting costs is especially problematic if the stakeholder receiving the benefit is not identical to the one bearing the costs. In addition, several assessment frameworks, especially financial ones, do not account for intangible costs and benefits, either because they are difficult to measure or because they are considered to be of marginal importance compared to more immediate monetary effects. Examples for such intangible effects include employee satisfaction, impacts on perceived safety or anxiety, but also impacts on colleague satisfaction or on company image. Numerous further examples can be found. They raise concerns whether their exclusion from an assessment would not seriously hamper its outcomes due to the fact that what are potentially critical success factors would not be considered for decision making. Furthermore there exist a number of empirical methods to measure intangible effects, such as the analysis of willingness-to-pay or the use of suitable proxy indicators.
- *Testing rigour:* In social sciences there are four commonly applied quality tests a method should pass (Yin 2003): construct validity, internal validity, external validity and reliability. Validity cannot be understood to be state but rather an aim. Thus applying these principles leads to a degree of validity. A degree of uncertainty and failure will always remain. Therefore an assessment framework needs to provide a way to test the rigour of its results, e.g. by means of sensitivity analysis.
- *Sustainability of the service to be assessed*: Sustainability is a major aspect of product and service development. Christopher Gordon describes sustainability as referring to “the ability to continue any given activity into the future within the likely existing resources of an organisation, as part of its ongoing budgetary and management processes” (Gordon 2009). In the context of PEARL, a business model can be considered sustainable when it provides organisations with this above described ability to continue provision (of business) activities. With a view to the assessment methodology, this would seem to imply the following:
    - The method must be able to project the future of a service and not only assess its history.
    - A projection requires a service or business model on which assumptions can be based. This also implies a corporate strategy and the development of a plan for the future.

- An appraisal must assess the affordability of an undertaking, which means that the needed amount of cash is available and net returns also take into account the cost of financing (e.g. the interest rate of a bank loan).
- The method should provide means to assess risks, e.g. those of market development assumptions, changes in governance frameworks etc.

- *Multiple stakeholders to be considered*: Many published evaluation studies seem to focus on assessing the impact of a product or service on a single or few stakeholders. At the same time, assessments can differ widely dependent on the point of view from which it is performed and the assessment of ICT service supporting older employees makes no exception. In a direct consumer market setting the main beneficiaries tend to pay for the value they receive. In the domain of PEARL this is not necessarily the same stakeholder which as a consequence can easily lead to a mismatch of demand and supply. Private benefits (to the investor) do not provide a sufficient incentive for investment, but social benefits (to all stakeholders) do. This has to be reflected in the assessment method by ensuring that all stakeholders' perspectives are being analysed. The assessment process is thus to be from the perspective of what the economic literature has (maybe somewhat mis-)labelled 'the social planner's perspective', i.e. accounting for the individual and summative positive and negative impact on all possible stakeholders in a society.
- *Time dimensions (from planning to routine services)*: Most products or services undergo a specific life cycle from the first idea to routine use, and finally they are supplanted by another more appropriate or new service (The Lewin Group 2000). Important stages in the early phase of development are pilots which are often funded by research agencies or industry. This market validation phase is preceded by an initial assessment of the anticipated benefits enabled by a specific piece of technology. The pilot phase ends with an assessment whether the service has potential for routine implementation. However, such pilots have a strongly varying character. Some are similar to a proof of concept; others are full implementations on a small scale. Nearly all shades can be found in between. For the purposes of a socio-economic impact assessment it is important to be clear about when the assessment is to be conducted. The answer to this question depends on the intended use of the measurement results. BraIN names three of the main reasons for measuring benefits (Benefits Realisation & Achievement International Network 2009):
    - Measurement for management: To obtain evidence of value that justifies the investment
    - Measurement for improvement: To inform course correcting and change management activities throughout the implementation and usage of a service

- Measurement for new knowledge: To establish quantitative evidence that can inform the planning activities of other initiatives both within the organisation and in wider contexts.

In relation to the implementation of PEARL it would seem that both measurement for management to achieve well-informed decisions as well as measurement for improvement to adjust a piloted product are valid reasons for an assessment. This has important methodological implications. An assessment looking only backwards, based on data from a pilot implementation and conducted as the final step in a development project, is not necessarily able to give recommendations on how to take course corrections. A complementary appraisal also needs to look forward and show options how to strategically further develop and perhaps modify a service during the initial commercial implementation phase. It strongly relies on projections and therewith on assumptions. Assumptions can be based on past data from piloting and testing, but need to be extrapolated into the future.

- *Comparability of measures and options*: Decision making requires the discussion of options that might not be comparable at first sight like comparing a task done by a nurse to that transferred to an IT system. An assessment method therefore needs to provide ways to take options into account and make them comparable to each other.

2.2.3 The ASSIST framework

The ASSIST framework was developed to address the requirements elaborated above to the greatest possible extent while at the same being sufficiently lean to be applicable in the practical context of product and service development. The framework can be said to have two key features: One is an objective, impartial assessment of the impact and potential of a solution. The other is a meaningful estimation of future potential, taking into account different options. These two features give evidence-based support *if* and, more importantly, *how* to proceed with post-pilot implementation and how to modify the planned solution to render it (more) successful.

The theoretical foundation of the ASSIST methodology is *value theory*, and in particular, the concept of value added. Value added in economics is the additional value resulting from transformations of factors of production into a ready product. At its simplest, it is the difference between the value of a product and the aggregate value of its individual components provided by other participants in the value system. Over the last decade, value added has been a widely used approach supporting investment decision making. In the context of an ASSIST assessment, the effects and outcomes of a product or service is understood as value-added to society, either in part or as a whole, on the one hand and value-added to the individual stakeholders involved on the other, by implementing and using the solution. This combines an overall, societal perspective with an organizational and individual perspective. The societal perspective includes all

stakeholders and aggregates their respective gains and losses, or benefits and costs. Positive effects, or benefits, create value, negative effects, or costs, occur when value is reduced. The total value added is the sum of positive and negative 'value added', which is also referred to as net benefit. This societal perspective is aggregated from the benefits and costs of each stakeholder group. Furthermore, what may be a benefit to one group may be a cost to another group, and in the aggregate some of them may cancel out. The analysis must expose these shifts in value in order to provide a reasonable account of the impact of the new service on individual stakeholders as well as society as a whole.

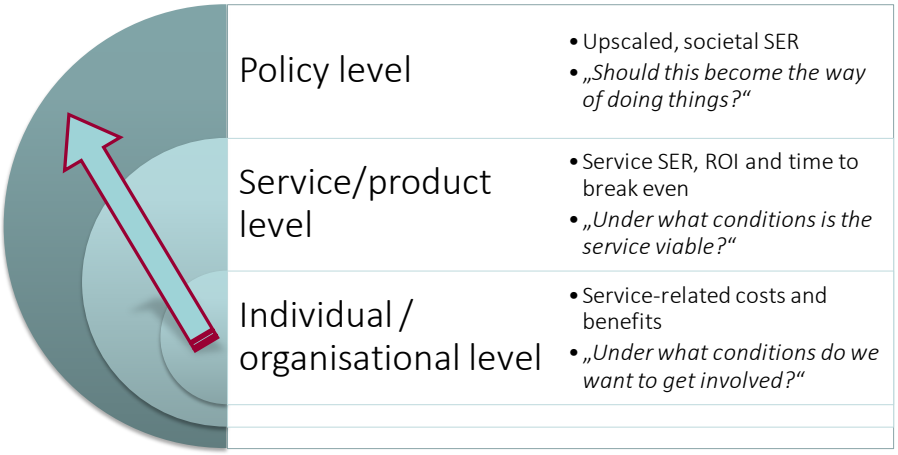

Figure 1: CBA assessment levels

ASSIST uses the methodological approach of cost benefit analysis (CBA) to turn these theoretical foundations into a pragmatic evaluation tool (EHR IMPACT 2008). Among others the UK Treasury's Green Book (UK HM Treasury 2003), Germany's WiBe (Röthig 2009) and the White House Office of Management and Budget (White House Office for Management and Budget 1992) specify the CBA methodology as an appropriate tool for analysing the impact of investments and activities in domains of public interest, including social and healthcare. CBA enables the impacts on all stakeholders to be included in a socio-economic evaluation, over the selected timescales, and the identification of the narrower financial components within the costs and benefits, also for individual stakeholder groups. These subsets can include the data used for Cost Analysis (CA), Cost Effectiveness Analysis (CEA) and Cost Utility Analysis (CUA). CBA is in general the more comprehensive concept with the key challenge, however, of monetarising intangible impacts (Drummond 2005).

ASSIST uses cost benefit analysis (CBA) to analyse on the one hand the value-added (in this case) of the PEARL system and service to society, either in part or as a whole, and, on the other hand, value-added to the individual stakeholders involved in implementing and using the solution. This combines an overall, societal perspective with an organisational and individual perspective. The societal perspective includes all

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2.2.4 Assessment process

An ASSIST assessment is a comparison between a given status to which the evaluator wants to compare a new service or intervention. In the case of ASSIST in PEARL, the intervention is neither a single agent nor a single point in time but a process of changing working processes from one status to another, thereby covering multiple agents including different stakeholders as well as IT systems.

The ASSIST assessment therefore covers a time span usually split up into three phases:

- the development of the new product or service
- the testing during a pilot phase and
- the deployment on a mainstreamed or full scale.

Usually, data will only be collected during the first two phases, whereas the third phase is covered in terms of data modelling and scenario building. As PEARL was not intended to end in a mainstream product or service, the last phase could not be assessed, but data were used to model future scenarios and identify improvement potentials.

The assessment is done in four steps:

2.2.4.1 Step 1 – Stakeholder identification

Work starts with consolidating the initial assumptions made by the project team on what stakeholders will play a role in the provision and use of PEARL. A first set of these assumptions was developed during a project meeting in the first year. These will, however, require further elaboration and fine-tuning and may be different for the three pilot companies.

As a general rule, the value case should cover all stakeholders that are

a. involved in the provision and use of PEARL, i.e. playing an active role; or
b. affected by the provision and use of PEARL, i.e. in a passive manner.

Both cases, active and passive, are characterised by a stakeholder experiencing any kind of impact, negative or positive, due to PEARL.

Initial assumptions made about the stakeholders in a service show a tendency to neglect particular affected stakeholders. A possible reason for this can be seen in the fact that the initial stakeholder model, being an instrument to plan the development and implementation of the solution, is primarily concerned with stakeholders that have an active role. Individuals and organisations that will neither deliver nor receive the product or service therefore do not play an essential role in these considerations. With a view to sustainability and scalability however, they may be of importance, in so far as they could support the service (if it is beneficial for them) or act as veto players (if it causes them more costs than benefits).

Initial stakeholder models can also neglect individuals or organisations with a potential active role. This can for example concern colleagues of the older employees. Reasons for this can be simple oversight, or an unawareness of the capacities and competencies of these stakeholders, as well as factual concerns, e.g. about split of responsibility, skill levels, data security, etc. Similar to the case of the affected stakeholders, inclusion of additional active stakeholders will usually have an impact on the entire service, and can cause fundamental changes to the value model.

As the first step in the process, the stakeholder identification is conceived as a pragmatic exercise which usually requires to be informed by the stakeholders in the pilot companies and other project partners. Usually, it takes several iterations until all stakeholders are identified and included in the assessment tool. The process is supported by the task leader, who brings in supporting evidence from earlier projects or literature to help the formulation of ideas, or to check existing ideas against proven practice. In that sense, the work is largely reciprocal, combining local context and pre-existing information.

2.2.4.2 Step 2 - Impact identification

The second step is to identify all relevant positive and negative impacts for each stakeholder, as well as to define suitable indicators to measure each impact. Again, the final shape of the impact model and indicator set depends largely on the local context. On the one hand, the indicators need to make sense in relation to the locally implementable configuration, and any given framework conditions that cannot be changed. At the same time, populating the indicator set with data needs to be practically feasible under the given circumstances. Picking up the results of Step 1, work now is more systematic, with a view to ensuring a full coverage of all relevant impacts and a correct identification of indicators for each. This is achieved by employing a causal chain linking the outputs and outcomes of the service to its impacts.

For example (see figure below), the implementation of automatic workspace adaptation based on RFID tags (output) allows older employees to start working at any workplace

in the company quickly and flexibly (outcome). This in turn may then lead to increased satisfaction and productivity on the part of the older employee, as well as to a more effective use of office space (impact). These impacts then create the value of the outputs and outcomes for each stakeholder. Whereas the outputs and outcomes are neutral, impacts are positive or negative. Indicators are then defined that allow the measuring of each impact. For the example just given, indicators for productivity gains could for example measure the time spent by an older employee on predefined tasks before and after the introduction of PEARL. The efficiency gain would be commensurate to the time saved.

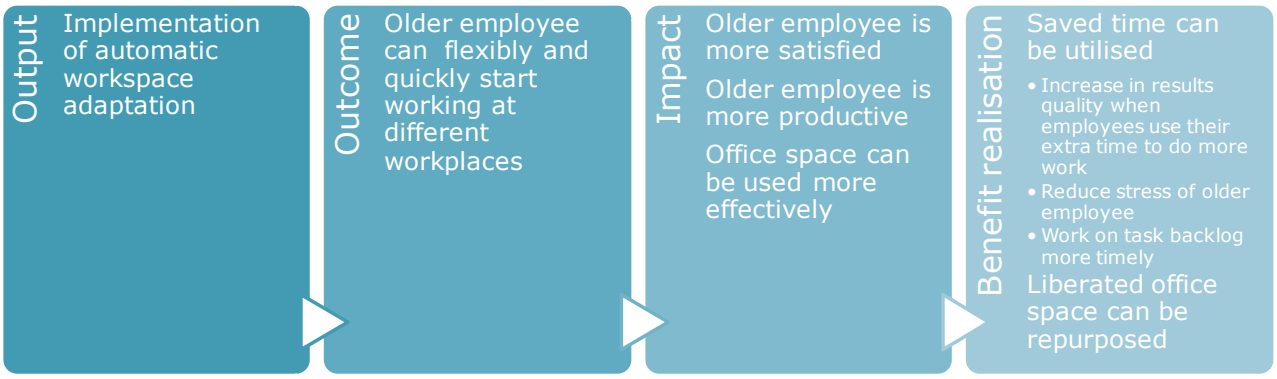


Figure 2: Causal chain: From output to impacts

Sometimes non-monetary impacts need to be realised to be of utility for a stakeholder. Turning time savings into cost savings for example may necessitate a reduction in staff. Alternatively, in a growing service, efficiency gains can lead to a slower growth of staff base compared to client base. Usually, there are different ways to realise a given benefit, each with its own knock-on effects (e.g. public protest against staff lay-offs). Because of the high number of alternative ways of benefit realisation, as well as their sensitivity to financial and political framework conditions, they are not a regular part of the value model in a calculatory sense. Instead, options for benefit realisation are discussed in the textual analysis of the value model (see Step 4).

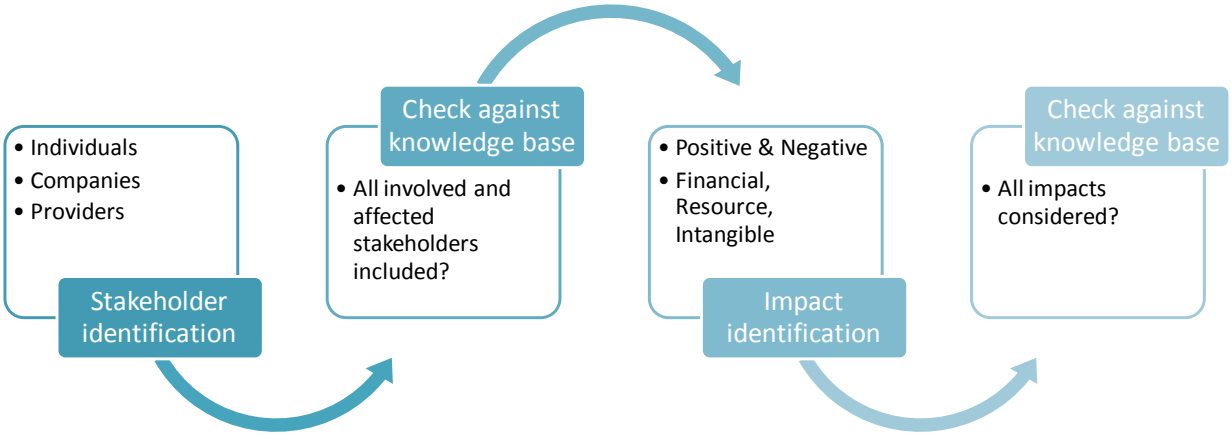


Figure 3: Summary of Step 1 Stakeholder identification & Step 2 Impact identification

As with Step 1, impacts and indicators are checked against the knowledge gained from previous implementations or other sources.

2.2.4.3 Step 3 – Data collection

Data to populate the indicators defined in Step 2 usually comes from different sources. Primary sources include all data collected directly in the course of the testing phase, such as log data stored in ICT systems, administrative data, and time sheet data specifically gathered for the purpose of the project. Also, end-user data is usually gathered by means of a dedicated questionnaire applied towards the end of the pilot duration. However, as the testing phase in PEARL was very short, expert estimates had to be used in many cases that limit data reliability to some extent.

2.2.4.4 Step 4 – The value case: strengths and weaknesses of the service

On the basis of the input data, different performance measures or return indicators are calculated, as shown below. The performance measures are expressed as ratios of different kinds of costs and benefits. The main outcome measure is based upon the ratio of total costs to total benefits, i.e. including financial costs and benefits, resource costs and benefits, and intangible costs and benefits. This overall ratio is referred to as socio-economic return (SER). At the overall product or service level, it can be seen as reflecting the perspective of a higher-level decision maker (e.g. a national policy maker); the SER can support the assessment and evaluation of options and decisions for improved service delivery. Ratios of the financial costs and benefits indicate cash flows and the affordability of the service, sometimes called the cash flow return on investment (CFROI). Ratios using the totals of financial and resource costs and benefits are tangible and a measure of an economic ROI because they measure the potential net income for the service.

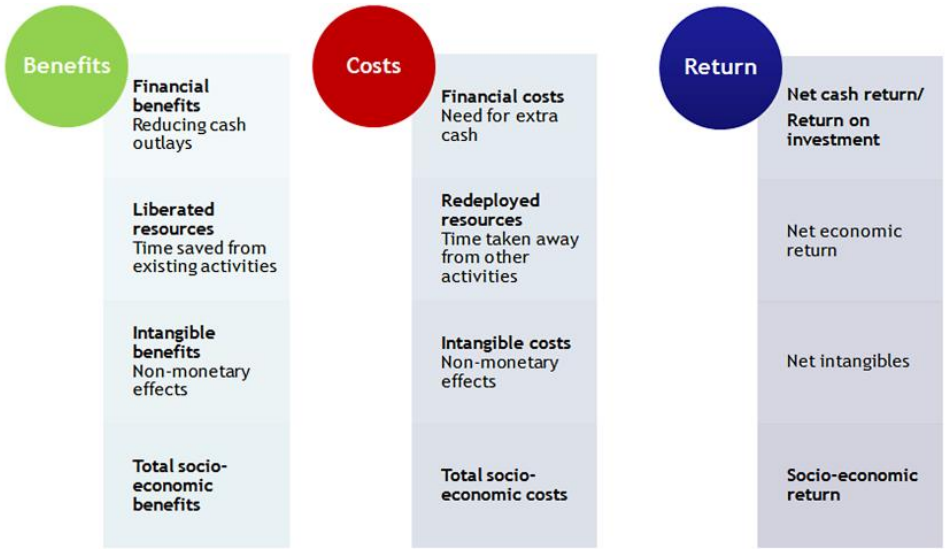


Figure 4 Key performance measures

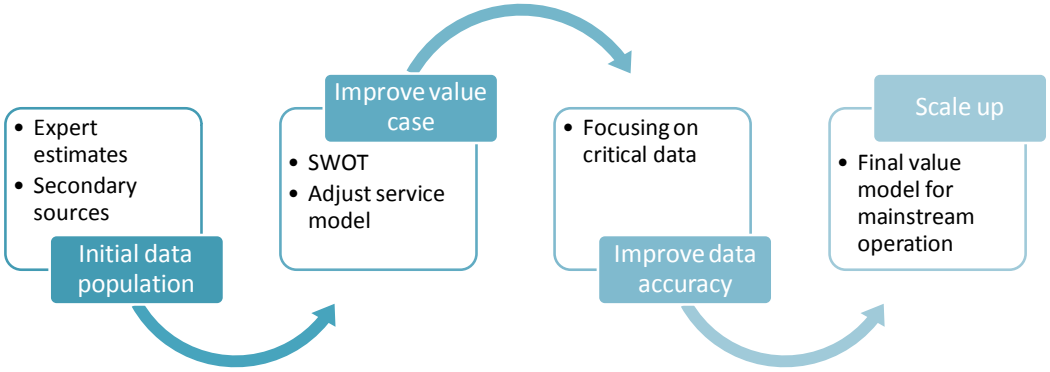


Figure 5: Summary of Step 3 Data collection & Step 4 The value case

2.2.5 Discounting

As part of the calculation process, all monetarised data is discounted. Discounting here reflects an individual's or organisation's preference to have money or resources now to employ them and gain value from them as opposed to later. Whether some intangible benefits should be discounted is a matter of debate, as the utility of constructs such as satisfaction is perceived different from those of money or products. Until further clarity is reached we follow the advice by Drummond to do so, which means that all indicator are discounted in the same way (Drummond 2005). The ASSIST assessment framework discounts positive and negative impacts to net present values. The base year is the first year of analysis. The default discount rate can be set at 3.5%, reflecting an average

factor of current official rates found across Europe (Sorenson, Drummond et al. 2008). The software toolkit allows the evaluator to adjust this rate. The default discount rate is a social time preference rate. For investment decisions one would expect a higher rate similar to corporate bonds. ASSIST differentiates between for-profit and not-for-profit stakeholders. Not-for-profit stakeholders are calculated with the social time preference rate.

2.2.6 Mathematics of the performance measures

As was shown in the section on data collection, the analysis is founded on individual indicators for benefits, b_i^k and costs, c_j^k that can be of three categories: cash, resources, and intangible impacts. In the following, the mark $k = \{cash, reap, int\}$ indicates the respective category of the benefit or cost indicator.

The sets of permanent values, $p = (p^1, p^2, p^3, ...)$, and of time series values $s_t = (s_t^1, s_t^2, s_t^3, ...)$, provide the basis for calculating the monetary value of each benefit indicator b_i^k and each cost indicator c_j^k. The monetary values are functions of the variables p and s for the relevant month of calculation (*t*):

$$b_i^k(t) = f_i(s_t, p) \qquad (2)$$

$$c_j^k(t) = f_j(s_t, p) \qquad (3)$$

Based on this general model, specific functions are created for each individual indicator. From them, the value of Annual Benefit (AB) in month t of each category k can be calculated, defined as the sum of the individual benefit b^k indicators, as shown by equation 4. The value of Annual Costs (AC) of each category k is derived correspondingly, depicted by equation 5. For *n* benefit indicators and *m* cost indicators, the annual benefit and cost for category k are:

$$AB^k = \sum_{i=1}^{n} b_i^k(t) \qquad (4)$$

$$AC^k = \sum_{j=1}^{m} c_j^k(t) \qquad (5)$$

The Present Value (PV) of the Annual Benefit for category k in year *t* of the initiative is the sum of the individual benefit indicators for category k discounted by the discount rate *r*:

PV of AB^k = $$(1+r)^{-(t-\alpha)} \sum_{i=1}^{n} b_i^k(t) = (1+r)^{(\alpha-t)} \sum_{i=1}^{n} b_i^k(t) \qquad (6)$$

Because the base year for discounting is the start year of evaluation, an additional variable (α) denotes the time to this year. α becomes negative when estimating future performance. The cost discounting works in the same way. Equation 7 shows the present value of the annual Net Benefit (NB) of category k in year t, which is the discounted difference between the annual benefit and annual cost:

PV of annual NB^k = $$(1+r)^{(\alpha-t)}\left(\sum_{i=1}^{n} b_i^k\ (t) - \sum_{j=1}^{m} c_j^k(t)\right) \qquad (7)$$

The PV of the cumulative net benefit, or the Net Present Value (NPV) of category k of the initiative, is the sum of discounted annual net benefits of each year, up to month T, the end of the horizon. The mathematical function is shown by equation 8:

NPV^k = $$\sum_{t=0}^{T}\left[(1+r)^{(\alpha-t)}\left(\sum_{i=1}^{n} b_i^k(t) - \sum_{j=1}^{m} c_j^k(t)\right)\right] \qquad (8)$$

Written out, the NPV of the three categories *cash*, *redeployable* and *intangible* are illustrated by equations 9 to 11:

Cash NPV = $$\sum_{t=0}^{T}\left[(1+r)^{(\alpha-t)}\left(\sum_{i=1}^{n} b_i^{cash}(t) - \sum_{j=1}^{m} c_j^{cash}(t)\right)\right] \qquad (9)$$

Redeployable NPV= $$\sum_{t=0}^{T}\left[(1+r)^{(\alpha-t)}\left(\sum_{i=1}^{n} b_i^{redp}(t) - \sum_{j=1}^{m} c_j^{redp}(t)\right)\right] \qquad (10)$$

Intangible NPV = $$\sum_{t=0}^{T}\left[(1+r)^{(\alpha-t)}\left(\sum_{i=1}^{n} b_i^{soc}(t) - \sum_{j=1}^{m} c_j^{soc}(t)\right)\right] \qquad (11)$$

The economic net benefit is defined as the sum of financial and redeployable economic resources. Using the discounted values, this effectively means adding equations 9 and 10:

Economic NPV = Cash NPV + Redeployable NPV

$$= \sum_{t=0}^{T}\left[(1+r)^{(\alpha-t)}\left(\sum_{i=1}^{n} b_i^{cash}(t) + \sum_{i=1}^{n} b_i^{redp}(t) - \sum_{j=1}^{m} c_j^{cash}(t) - \sum_{j=1}^{m} c_j^{redp}(t)\right)\right] \qquad (12)$$

The socio-economic impact consists of all three categories, adding the social dimension to the economic one. In a discounted form, this means adding equations 11 and 12:

Socio-Economic NPV = Economic NPV + Social NPV

$$= \left[(1+r)^{(\alpha-t)} \left(\sum_{i=1}^{n} b_i^{cash}(t) + \sum_{i=1}^{n} b_i^{redp}(t) + \sum_{i=1}^{n} b_i^{soc}(t) - \sum_{j=1}^{m} c_j^{cash}(t) - \sum_{j=1}^{m} c_j^{redp}(t) - \sum_{j=1}^{m} c_j^{soc}(t) \right) \right] \quad (13)$$

Equations 14 and 15 deal with calculations of return rates. First, the proxy economic Return on Investment (ROI) is defined in equation 14. It involves both economic indicator categories, $k = cash$ and $k = redp$. The economic ROI is comparable to a traditional return from an investment, say in the stock market, yet does not require the step of converting redeployable resources into cash. It is calculated as follows:

$$\text{Proxy economic ROI} = \frac{\sum_{t=0}^{T} \left[(1+r)^{(\alpha-t)} \left(\sum_{i=1}^{n} b_i^{cash}(t) + \sum_{i=1}^{n} b_i^{redp}(t) - \sum_{j=1}^{m} c_j^{cash}(t) - \sum_{j=1}^{m} c_j^{redp}(t) \right) \right]}{\sum_{t=0}^{T} \left[(1+r)^{(\alpha-t)} \left(\sum_{j=1}^{m} c_j^{cash}(t) + \sum_{j=1}^{m} c_j^{redp}(t) \right) \right]} \quad (14)$$

In the final step, equation 15 calculates the Socio-Economic Return (SER) of the investment, which is the ratio of discounted cumulative net benefits and cumulative costs:

$$\text{SER} = \frac{\left[(1+r)^{(\alpha-t)} \left(\sum_{i=1}^{n} b_i^{cash}(t) + \sum_{i=1}^{n} b_i^{redp}(t) + \sum_{i=1}^{n} b_i^{soc}(t) - \sum_{j=1}^{m} c_j^{cash}(t) - \sum_{j=1}^{m} c_j^{redp}(t) - \sum_{j=1}^{m} c_j^{soc}(t) \right) \right]}{\sum_{t=0}^{T} \left[(1+r)^{(\alpha-t)} \left(\sum_{j=1}^{m} c_j^{cash}(t) + \sum_{j=1}^{m} c_j^{redp}(t) + \sum_{j=1}^{m} c_j^{soc}(t) \right) \right]} \quad (15)$$

The SER is the primary performance parameter used for assessment and evaluation of service viability. It provides a comprehensive measure of value for money, accounting for all social and economic impacts in relation to the costs associated with those impacts. On the overall service level it can be seen as reflecting the perspective of a higher-level decision maker (e.g. a national policy maker), and the SER can support the assessment and evaluation of options and decisions for improved service delivery.

Overall, the analysis of these performance measures will allow the PEARL partners to:

- Justify investment: The analysis of the overall performance of the service will allow responsible product managers and other decision makers to prove that the investment (both in terms of money and time) is worthwhile.
- Calculate break-even: When communicating the costs and benefits to involved persons it is important to understand when the benefits surpass the costs.

- Understand service impacts: The understanding of all impacts (including secondary and long-term effects) may offer a new perspective on PEARL that is led by an economic and strategic view. This is a value in its own right, because it complements a technical and organisational point of view and explains and predicts why stakeholders behave as they do.

2.3 PEARL stakeholder and indicator model

The stakeholder and indicator model for PEARL is depicted in the figure below. It shows the two main stakeholder groups involved in PEARL in orange boxes:

- PEARL developers/deployers
- client companies.

Each group contains further organisational or individual entities, shown as green boxes. The PEARL developers consist of the technical partners of the PEARL project and possible further (in the future involved) companies. The PEARL deployers are currently the same as the developers. Within the client companies, PEARL involves or affects different groups and individuals, commencing with the older employees as primary end-users, their colleagues or co-workers, decision makers and line managers, as well as Human Resource Managers.

For each group, the main cost and benefits assumed are depicted as white boxes. A plus sign (+) depicts a positive impact or benefit, a minus sign (-) depicts a negative impact or cost. As was described above (see figure on key performance measures), both cost and benefits can be of a financial, resource or intangible nature.

The stakeholder and impact model is an outcome of Steps 1 & 2 of the assessment process, as described above.

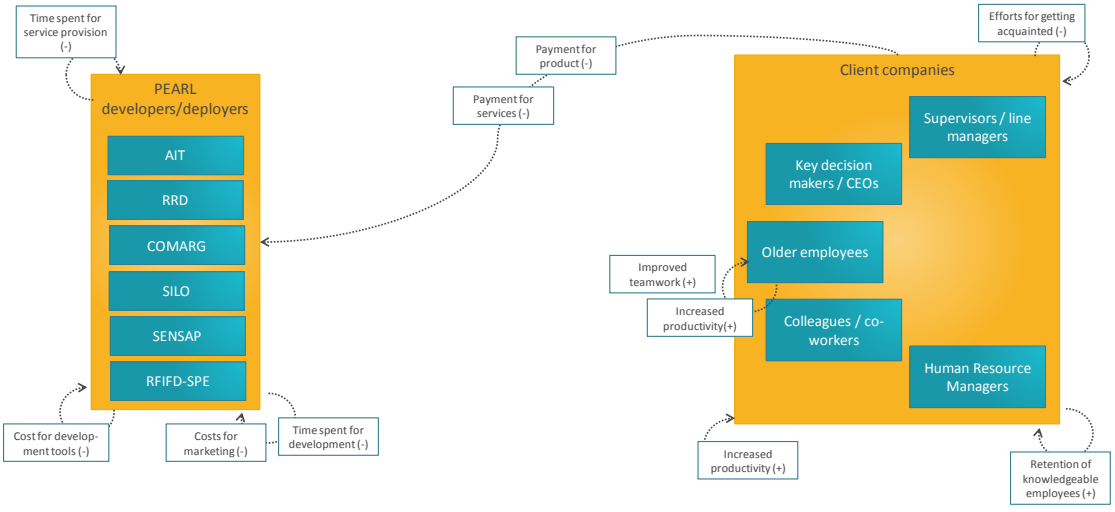


Figure 6 Stakeholder and indicator model

Based on the vision of the PEARL systems and applications it was decided that colleagues and supervisors of the older employees (as primary target group) will be affected by changes introduced through PEARL, as well as key decision makers including line managers and CEOs. Decision makers were specifically included in order to gain requirements ensuring a) a smooth integration of the PEARL services into overall work processes and b) alignment with key strategic company / department objectives

The following target groups are included into different phases of PEARL project:

- **Human-Resource-Managers***:* This is normally an individual within an organization responsible for hiring new employees, supervising employee evaluations, mediation between employees and bosses as necessary, and general overseeing of the personnel department.
- **Colleagues / co-workers**
- **Supervisors / line managers***:* Normally a manager/team leader who leads a revenue-generating department.
- **Key decision makers / CEO** responsible for a firm's overall operations and performance.

However, as there direct involvement during the testing phase of the PEARL system and services was very limited, these stakeholders were not included in the ASSIST calculation. Their views were however gathered through a dedicated questionnaire and reported in D2.6.

3 Overview of the benefits and costs involved

The data available for the purposes of the assessment was used to estimate the costs and benefits accruing to the individual stakeholder groups involved in PEARL during an assessment period of seven years, including the development and testing period of the system in the framework of the PEARL project.

Due to the relatively short testing period calculations had to be based on validated estimations by experts involved in the development and testing of the PEARL system. Further to this, 39 older employees were included in the testing phase of PEARL; 20 additional employees entering the service per year were estimated as being a realistic assumption for the assessment timeframe of seven years, at least under the current conditions. In total, 179 older employees are served with the PEARL system and services after a period of seven years.

It has to be stressed that the PEARL modules were never intended to reach a pre-commercial level within the framework of the project and thus the results presented here are based on expert estimates on costs and benefits, calculated at small scale.

Assuming an unchanged service model and unchanged framework conditions for service delivery, the monetarised total benefits occurring during the assessment period outweigh the costs slightly, as it becomes clear by a positive overall socio-economic return rate of 3%. This means that the sum of all service-related benefits are 3% higher than the sum of all service-related costs, including monetary, resource and intangible costs and benefits. This rather low SER after seven years of assessment is however not surprising as the PEARL modules are still in their prototype version and development and maintenance efforts included in the analysis are rather high.

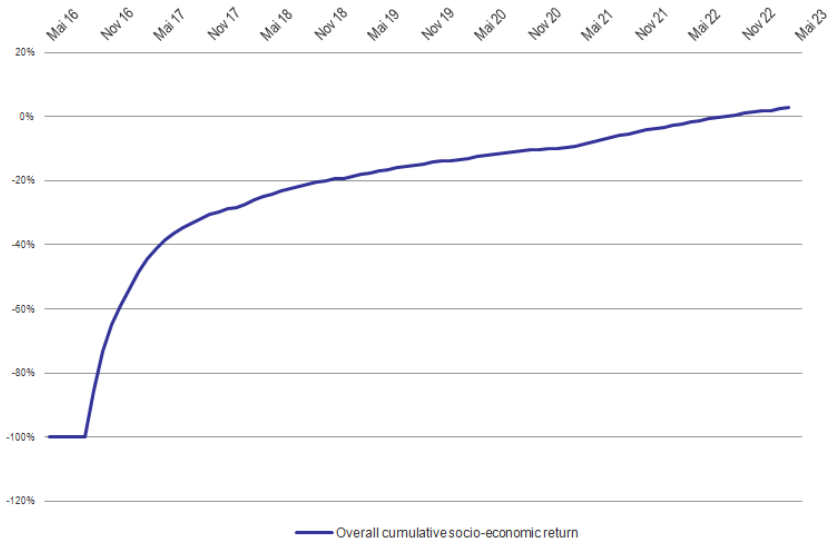


Figure 7- Overall Socio-economic return rate

Further to this, costs and benefits are not equally distributed across the individual stakeholder groups involved, as can be seen in the table below. Most importantly, PEARL is expected to result in a positive cumulative socio-economic return (sum of financial, resource and intangible costs and benefits) for older employees over seven years. However, all other stakeholder groups currently do not achieve a positive socio-economic return.

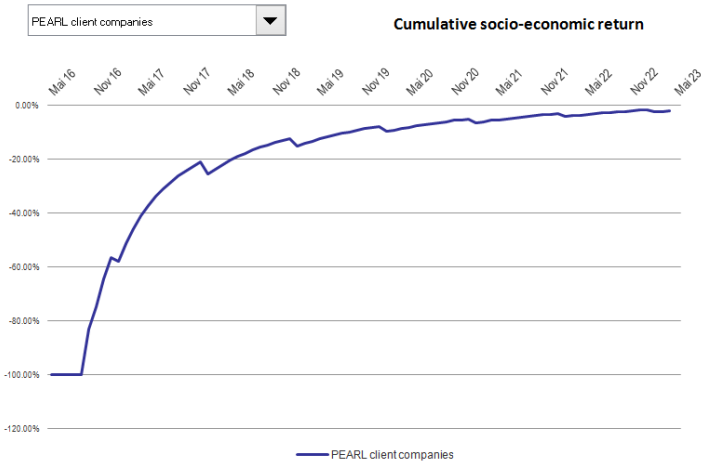
Overall socio economic return	⇨	3%
Individuals		
Older employees	⇧	23%
PEARL suppliers and customers & staff		
RRD	⇩	-90%
PEARL client companies	⇩	-2%
AIT/AAU	⇩	-87%
SILO	⇩	-99%
COMARG	⇩	-97%
SENSAP/RFID-SPE	⇩	-60%

Table 1 – Overview of the cost/benefit relationship for PEARL

PEARL client companies

The PEARL platform (and its components) aims at facilitating the development of age-friendly workplaces. Such workplaces are usually built and deployed by private enterprises, as part of their age friendly and corporate social responsibility policies and plans. Private enterprises, notably within the creative industries are primary customers for the PEARL solutions.

Client companies (i.e. those companies employing older employees who use the system) can expect to in the long run (7 years modelling period) nearly reach breakeven with a socio-economic return rate of -2% after seven years, under unchanged conditions. Benefits accrue mainly due to an expected increased productivity of employees. Expert estimations from the client companies involved in the test phase revealed savings of one sick day per year per older employee and around 20 minutes per year saved time due to improved communication processes between older employees and their co-workers and team leaders. This under current circumstances seems to be the largest benefit for the client companies (70% of all benefits).



On the cost site, the client companies will have to pay for the PEARL solutions and possible services (such licensing costs, or costs for the lamps to adjust lighting at the desk or maintenance). It is also to be expected that all affected groups within the company will have to invest efforts in getting acquainted with PEARL.

Key service costs	Share of stakeholder's total cost
Extra time for service provision Includes all extra time spent by older employees and as an effect of the new service. Time is counted for different types of activities, the time spent on them, and their frequency of occurrence. Other than for provider organisations, extra time reflects inconvenience caused by using the service, rather than a tangible cost item.	69%
Training and adaptation time	8%
Key service benefits	**Share of total benefits**
Resource liberation older employees Includes all extra time saved by older employees as an effect of the new service. Time is counted for different types of activities, the time spent on them, and their frequency of occurrence.	70%
Revenue from older employees Service fee paid by older employees to the client companies	9%

Table 2- Key service impacts for client companies

Given an increasing number of employees using PEARL, the overall socio-economic return rate for the whole assessment period of seven years is -2%, meaning that not all cost can be recovered throughout this period. Over time, the return rate is expected to steadily increase, even though with a flattening increase rate and yearly repeating periods of slight decrease due to training and adaptation efforts for new employees entering the service.

Older employees

Overall, older employees seem to benefit from the PEARL system. The socio-economic return rate is 23%, meaning that the sum of all service-related benefits are 23% higher than the sum of all service-related costs.

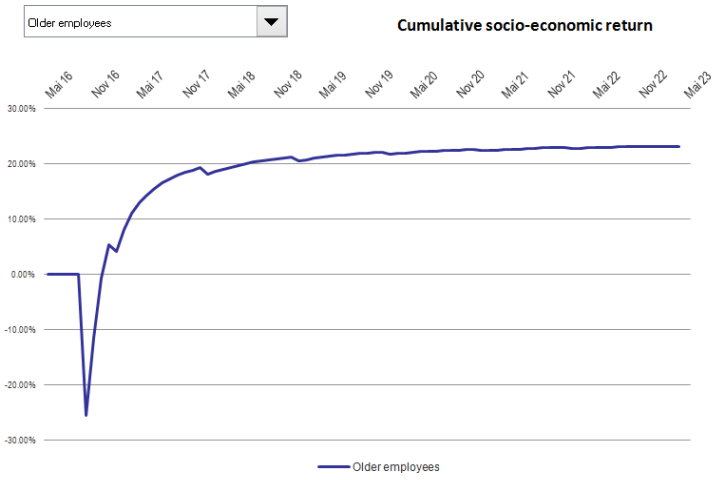


Figure 8- Overall socio-economic return rate "Older employees"

The main benefits for older employees are expected time savings due to better communication with colleagues and other staff and the ability to manage overall workload. Although most of older employees do not see an influence of PEARL on their ability to work with colleagues (72,4%), almost one third (27,6%) judged the system to increase their ability to work with colleagues a little.

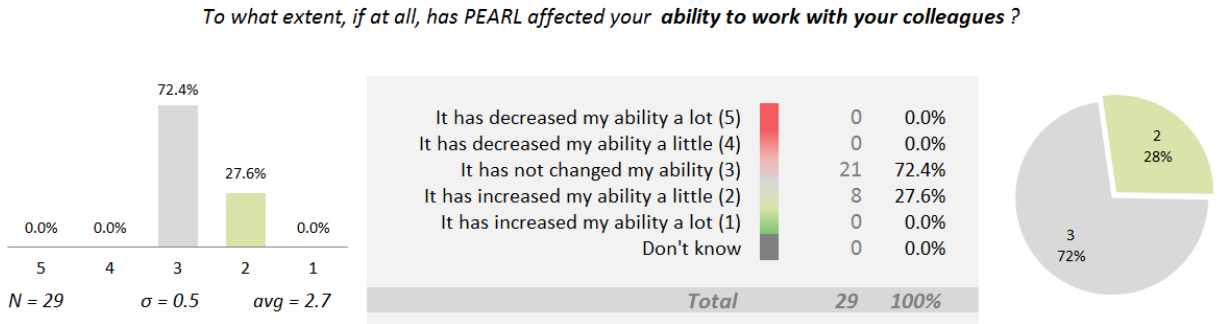


Figure 9- Ability of older employees to work with colleagues (self-assessment)

A somewhat similar picture emerges when looking at self-assessed ability to manage the overall workload of older employees, with however almost 40% of older employees assessing their ability to manage overall workload as increasing a little since they use the PEARL system.

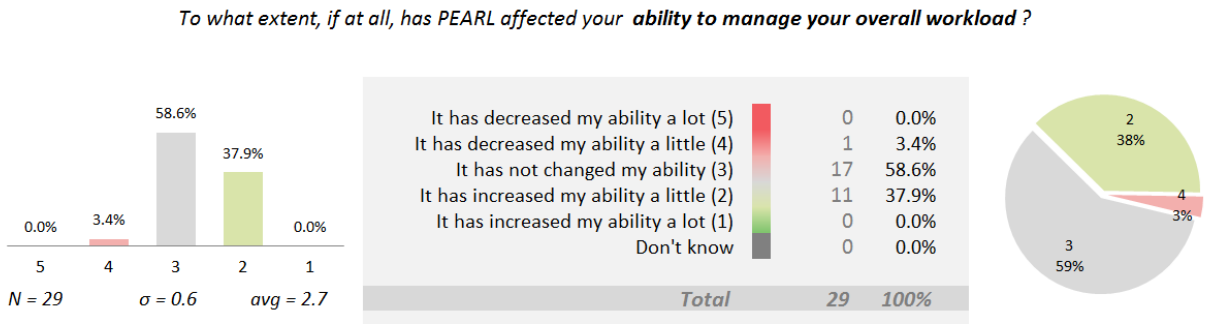


Figure 10- Ability of older employees to manage overall workload (self-assessment)

Further to this, involved experts estimated that one sick day will be saved per older employee due to increased motivation of older employees (Figure 11) as well as an increase level of activity (Figure 12) that was assessed as supporting older employees in retaining their health.

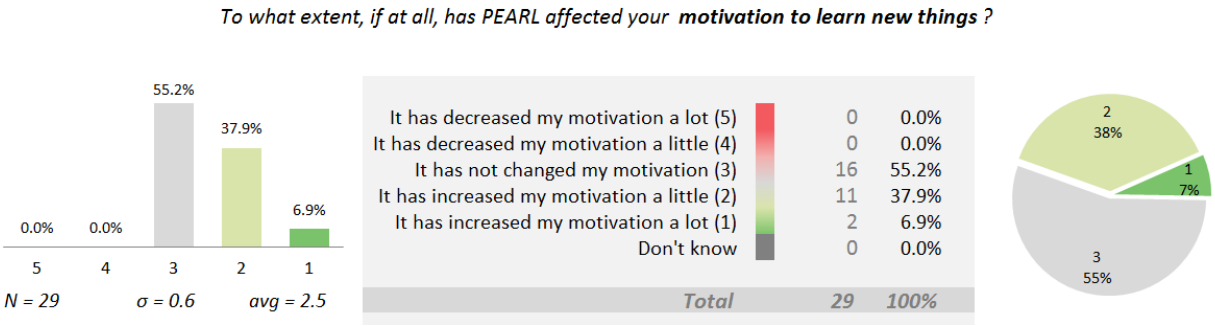


Figure 11- Motivation to learn new things (self-assessment)

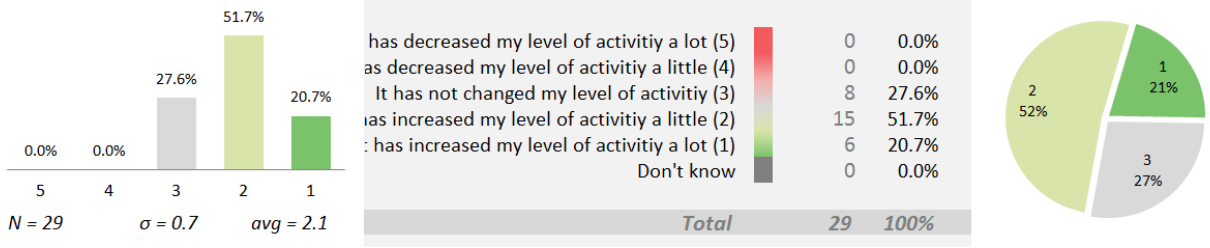


Figure 12- Level of physical activity (self-assessment)

On the other hand, older employees are also expected to spent additional time due to the introduction of PEARL. This was assessed by experts to take up 10 minutes per working week per employee, e.g. through the use of the training or physical well-being module.

As can be seen in the table below, additional time spent for using the PEARL modules on the one hand and expected time savings on the other are the main impact factors for

older employees. Adaptation time was estimated by experts being 8 minutes per day for a period of 0,5 months and older employees are expected to need a one-off training of 2,5 hours.

Key service costs	Share of stakeholder's total cost
Inconvenience: Extra time for service use Includes all extra time spent by older employees and as an effect of the new service. Time is counted for different types of activities, the time spent on them, and their frequency of occurrence. Other than for provider organisations, extra time reflects inconvenience caused by using the service, rather than a tangible cost item.	98%
Training and adaptation time	2%
Key service benefits	**Share of total benefits**
Convenience: Time saved due to service used Includes all extra time saved by older employees as an effect of the new service. Time is counted for different types of activities, the time spent on them, and their frequency of occurrence.	100%

Table 3- Key service impacts for older employees

PEARL developers and providers

As the PEARL system and its modules are still in a prototype status, the business case developers and providers of the different modules of PEARL at this stage shows a need for improvement over the next years in order to reach a sustainable modus.

At the current stage, a somewhat similar cost-benefit structure accrues for the different provider organisations with costs for the development of the service and time spent for provision and maintenance being the main cost items for now and service fees expected to be able to take from customers in the future being the main benefit item.

AIT & AAU

For AIT and AAU as developers of the Calendula and task switching modules the monetarised benefits achievable are unlikely to outweigh the costs involved, resulting in a negative overall socio-economic return of -87%.

Although the SER is increasing over time the cost-benefit-structure for AIT/AAU needs considerable improvements before becoming viable for the providers (cf. figure below). The increase from May 2021 is due to an expected service fee from the older employees. However, at the moment the service fee calculated through the willingness-to-pay analysis is not high enough to outweigh the cost accruing during the development phase, at least not within the analysis timeframe of 7 years.

Figure 13- Overall socio-economic return rate for AIT/AAU

Rather high development cost for the prototypes at this stage (PEARL modules were never intended to result in mainstream products at the end of the project) accrue to AIT/AAU in the beginning. It is also clear that cost saving potentials deserving attention concern possibilities for lowering staff time costs (e.g. for maintenance).

Key service costs	Share of stakeholder's total cost
Staff time spent on service development Includes all extra time spent by staff for the development of the modules.	75%
Extra staff time for service provision	3%
Key service benefits	**Share of total benefits**
Revenue from clients Service fee older employees are expected to pay (at the current stage of development)	100%

Table 4- Key service impacts for AIT & AAU

Further to this, there may be room for increasing the service fee from older employees currently calculated with 2 Euro per months once the prototypes have been further developed and finalised to a mainstream product. This however would only be reasonable once a final product has been developed and tested.

RRD

Based on the available data estimates, the additional overall costs for the developer of the physical wellbeing module RRD over an assessment period of 84 months are estimated to outweigh the additional benefits by 90%.

The overall cost-benefit structure is similar to the one of AIT & AAU: Main cost items are staff time spent on service/prototype development whereas main future benefits flow to RRD from the monthly service fee from older employees (estimated with 1€) and estimated future incomes through the sale of a physical wellbeing app (0,99€ per sale).

Key service costs	Share of stakeholder's total cost
Staff time spent on service development Includes all extra time spent by staff for the development of the modules.	74%
Extra staff time for service provision	2%
Key service benefits	**Share of total benefits**
Revenue from clients Service fee older employees are expected to pay (at the current stage of development)	100%

Table 5- Key service impacts for RRD

As the physical wellbeing module was significantly improved within the framework of PEARL, considerable efforts had to be put into the development of the prototypes. This was estimated by experts from RRD as 20 hours per month over a period of 18 months for a RRD manager and 30 hours per month over a period of 18 months for a RRD manager developer. Further to this, it was estimated that 60 minutes per year/older employee would need to be dedicated to service provision as the module at the moment needs explanation and guidance. These efforts clearly explain the negative SER for RRD for the current assessment period.

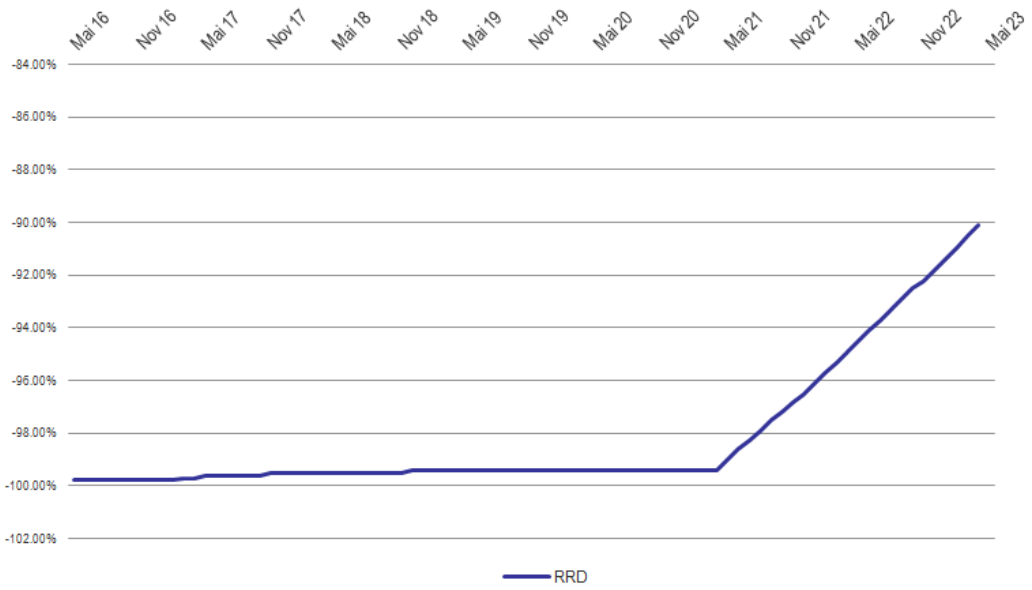


Figure 14- Overall socio-economic return rate for RRD

The SER for RRD increases over time and with increasing numbers of older employees using the service, albeit with a very (too) slow growth rate (cf. figure 14 above). The increase from May 2021 is due to an expected service fee from the older employees. Cost saving potentials that deserve attention concern possibilities for decreasing time spent by staff for service provision (e.g. for maintenance and service delivery). Further to this, there may be room for increasing the service fee from older employees currently calculated with solely 1 Euro per month once the prototypes have been further developed and finalised to a mainstream product.

SILO

The overall socio-economic return rate for SILO over an assessment period of 84 months is -99%, meaning that overall additional costs for SILO outweigh the benefits that also accrue (in the future at least) by 99%.

Main cost items are staff time spent on prototype development and maintenance which was estimated to be 10 minutes per day per developer involved at SILO. Further to this, licence cost (one-off) had to be paid (330€) that however do not influence that overall cost-benefit structure substantially.

On the benefit side, future fees from older employees are currently the only benefit flowing to SILO. The underlying estimation based on the WTP analysis is a fee of 0,25€ per month per employee.

Key service costs	Share of stakeholder's total cost
Staff time spent on service development Includes all extra time spent by staff for the development of the modules.	70%
Extra staff time for service provision	6%
Key service benefits	**Share of total benefits**
Revenue from clients Service fee older employees are expected to pay (at the current stage of development)	100%

Table 6- Key service impacts for SILO

COMARG

Similar to the other developers, COMARG does not reach a positive socio-economic return (the SER is -97%), with the main cost item being extra staff time needed for development as well as service provision and maintenance. The training module has to be regularly fed with new or updated content and is, at the current stage, estimated to need 3 minutes per day for maintenance.

Key service costs	Share of stakeholder's total cost
Staff time spent on service development Includes all extra time spent by staff for the development of the modules.	75%
Extra staff time for service provision	2%
Key service benefits	**Share of total benefits**
Revenue from clients Service fee older employees are expected to pay (at the current stage of development)	100%

Table 7- Key service impacts for COMARG

On the benefit side again, the only item at the current stage of assessment is a future service fee flowing from the older employees to COMARG. This was estimated with a monthly fee of 1€ per employee.

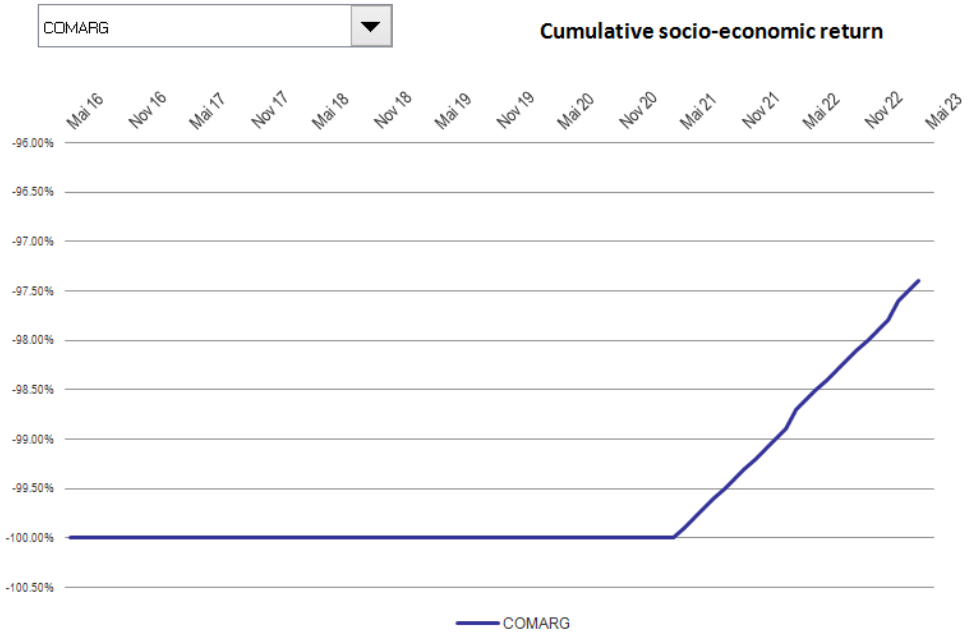


Figure 15- Overall socio-economic return rate for COMARG

SENSAP/RFID-SPE

SENSAP/RFID-SPE reaches within the assessment period of 84 months an overall socio-economic return of -60%, so that also for these developers benefits do not outweigh costs, making a sustainable business model difficult at this stage.

Main cost items accruing for SENSAP/RFID-SPE are in the first instance extra staff time for service provision, estimated being 180 minutes per year per developer. Further to this, SENSAP/RFID-SPE had to spent costs on hardware (lamps and RFID cards) which make 34% out of the total cost accruing for SENSAP/RFID-SPE.

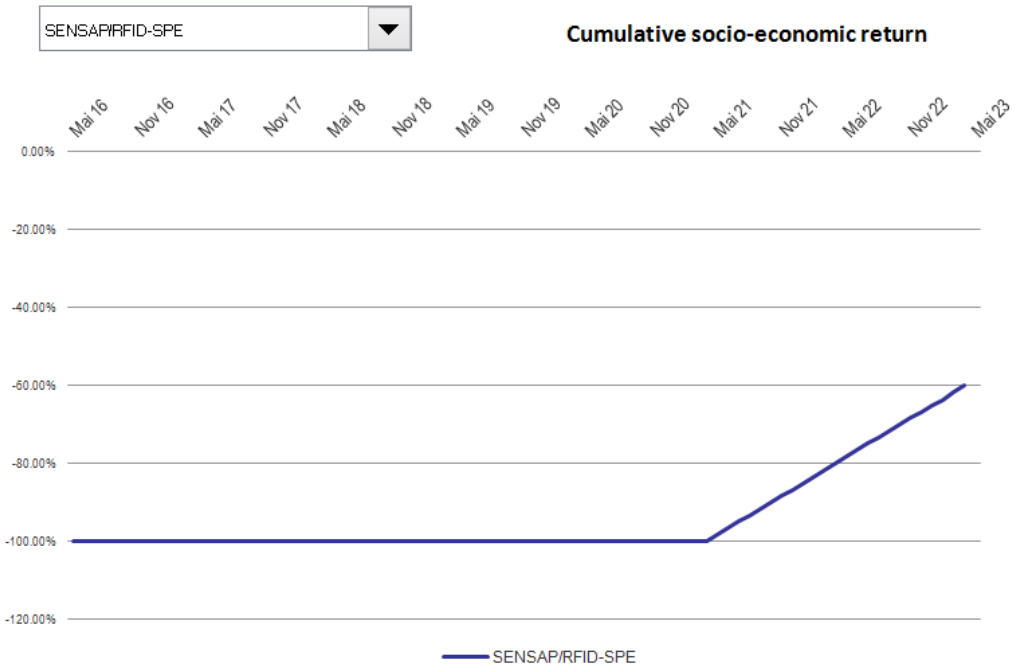


Figure 16- Overall socio-economic return rate for SENSAP/RFID-SPE

On the benefit side, revenues flowing to SENSAP/RFID-SPE come from an estimated service fee from older employees of 1€ per month and a potential revenue from reselling equipment to the clients.

Key service costs	Share of stakeholder's total cost
Staff time spent on service development Includes all extra time spent by staff for the development of the modules.	50%
General hardware	34%
Key service benefits	**Share of total benefits**
Revenue from clients and resell of hardware sets Service fee older employees are expected to pay (at the current stage of development)	100%

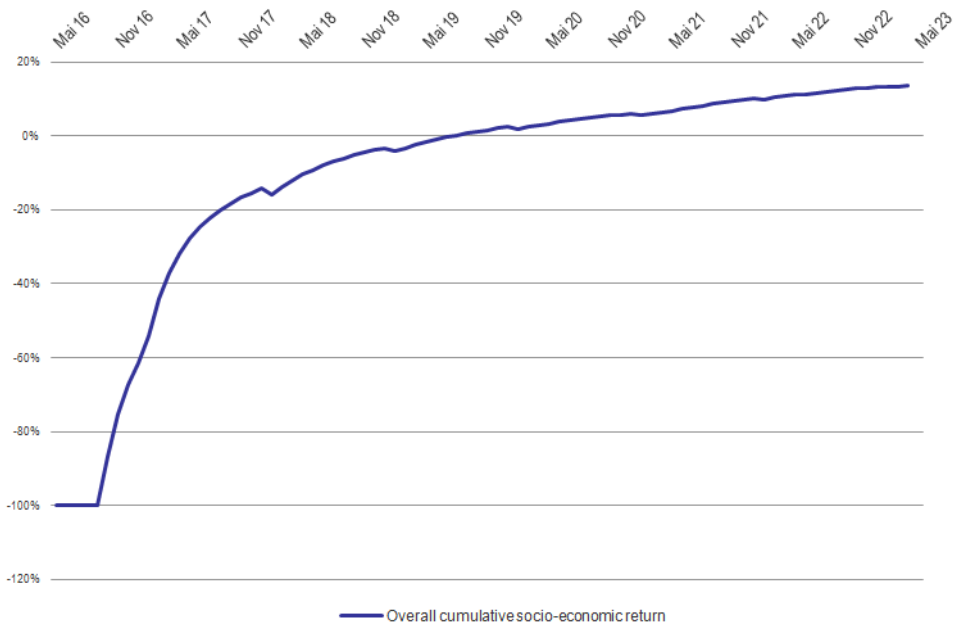
Table 8- Key service impacts for SENSAP/RFID-SPE

4 Outlook

The data available for the current cost benefit assessment suggest that a positive socio-economic return can be achieved over a duration of seven years, under specific assumptions:

- Module prototypes are finalised after 60 months of the assessment period and no further costs for development accrue after that point in time.
- The number of older employees using PEARL is increasing more (e.g. 100 additional customers per year).
- A service fee can be taken from older employees after finalising of the modules.

The overall socio-economic return would rise up to 15%, meaning that overall benefits across all stakeholders are 15% higher than overall costs (see Figure 17).



Overall socio economic return	↑	15%
Individuals		
Older employees	↑	23%
PEARL suppliers and customers & staff		
RRD	↓	-63%
PEARL client companies	↓	-3%
AIT/AAU	↓	-31%
SILO	↓	-95%
COMARG	↓	-90%
SENSAP/RFID-SPE	↓	-22%

Figure 17- Overall SER with increased number of older employees in the service

However, development costs are high for the developers of the different PEARL modules as they are at the current state still prototypes requiring high development as well as maintenance efforts. This leads to the fact that the SERs for the different developer and deployer organisations do even under improved assumptions not yet reach a positive level. The benefit side of deployers still needs improvements in order for the business model to become viable.

Improved modules could for example be expected to reach a higher willingness to pay at the side of the older employees, improving the benefit side for the developers of PEARL. Further to this. serving higher numbers of older employees would also increase the SER for the different developers and deployers.

Issues for further consideration

- *For the developer and provider organisations involved in the current service model the estimated benefits do not outweigh the estimated additional costs*
- *Efforts for prototype/product development accruing for the developers of the various PEARL modules would need to and are expected to decrease in order to optimise the overall cost-benefit structure.*
- *There may be merit in taking a dedicated effort to collate further evidence on monetarisable benefits achievable by the stakeholders involved.*

Annex 1: Indicator set

Older employees		
Cross-cutting variables	**Unit**	**Time period**
Average gross annual income of older employees	€	per year
Number of older employees in service	no	per month
Negative impacts	**Unit**	**Time period**
Fee for services		
Service fee paid by older employees to developers	€	per month
Inconvenience: training time		
Time spent by older employees receiving training	hours	per new employee
Inconvenience: adaptation time		
Inconvenience period for older employees	months	
Time spent by older employees with the service during adaptation	minutes	per day
Inconvenience: extra time for service use spent by older employees		
Average (extra) time spent by older employees using PEARL, per year.	min	per session
Positive impacts	**Unit**	**Time period**
Convenience: time saved for service use by older employees		
Average time saved by older employees receiving PEARL services, per year.	min	per session

Client companies		
Cross-cutting variables	**Unit**	**Time period**
Average gross annual income of colleagues	€	per year
Number of colleagues in service	no	per month
Average gross annual income of client older employees	€	per year
Number of client older employees in service	no	per month
Overhead rate	%	
Negative impacts	**Unit**	**Time period**
Staff time spent on training provision		
Colleagues receiving training	hours	per new colleague
Client older employees receiving training	hours	per new client older employee
Adaptation time		
Time spent by colleagues with the system during adaptation	minutes	per day
Time spent by client older employees with the system during adaptation	minutes	per day
Inconvenience period for colleagues		months
Inconvenience period for client older employees		months
License cost		
General license cost	€	per month

Hardware cost		
General hardware cost	€	per month/per older employee
Devices for older employees		
Cost per set of devices for older employees	€	per unit
Extra staff time spent by older employees - actual time		
Extra time spent by older employees	minutes	per month
Extra time spent by colleagues	minutes	per month
Positive impacts	**Unit**	**Time period**
Resource liberation due to slightly assumed increased productivity		
Time saved by client older employees	minutes	per one older employee per year

PEARL developers and providers		
Cross-cutting variables	**Unit**	**Time period**
Average gross annual income of manager	€	per year
Number of managers in service	no	per month
Average gross annual income of developer	€	per year
Number of developer in service	no	per month
Overhead rate	%	
Negative impacts	**Unit**	**Time period**
Staff time spent on service development		
All extra time spent by managers for the development of the module(s)	hours	per month
All extra time spent by developers for the development of the module(s)	hours	per month
Duration of development period	no	months
Staff time spent on training		
Manager receiving training	hours	per year
Developer receiving training	hours	per year
Manager providing training	hours	per new older employee
Developer providing training	hours	per new older employee
License cost		
General license cost	€	per month
Hardware cost		

General hardware cost	€	per month/per older employee
Extra staff time for service provision & maintenance- actual time		
Extra time spent by manager	minutes	per month
Extra time spent by developer	minutes	per month
Positive impacts	**Unit**	**Time period**
Service fee	€	per month per older employee
Reselling of equipment	€	per set