

TNO report**TNO 2013 R11434****ePartners: quick scan of future application
domains****Behavioural and Societal
Sciences**

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Samenvatting

De eerste fase van het 'ePartner that cares' project heeft laten zien dat het mogelijk is om ePartners in het domein van de gezondheidszorg te ontwerpen, voor verschillende gebruikers, gezondheidsproblemen en -gebieden. Maar de toekomst van het ePartner raamwerk blijft niet beperkt tot de gezondheidszorg. Actoren in andere domeinen kunnen ook hun voordeel doen met de ondersteuning op maat, om daar optredende problemen op te lossen. Om deze mogelijkheden te verkennen zijn de volgende onderzoeksvragen geformuleerd:

- 1 Wat zijn de generieke en domeinspecifieke aspecten van ePartner functies en ontwikkelmethoden die tot nu toe zijn vastgelegd, en
- 2 hoe kunnen we domeinafhankelijkheid minimaliseren om ePartners flexibel in te zetten in verschillende domeinen, binnen en buiten de gezondheidszorg (zoals mobiliteit en educatie)?

Om deze vragen te beantwoorden zijn generieke en domeinspecifieke aspecten van de modellen en methoden die tot nu toe gebruikt zijn beschreven, met name het ePartner concept (kernfuncties), de ePartner ontwikkelmethoden (situated Cognitive Engineering en Intervention Mapping) en de resultaten die tot nu toe behaald zijn in het project. Situated Cognitive Engineering maakt het mogelijk om systematisch use cases, user requirements, claims en design patterns voor ePartners te documenteren. De verwachte directe impact van 'ePartners that care' (gedragsverandering (naar een gezondere levensstijl), gezonder leven, (langer) zelfstandig leven) is domeinafhankelijk en moet geherformuleerd worden voor andere domeinen. De indirecte impact (bijvoorbeeld vertrouwen (in eigen kunnen), toenemende motivatie, kennis en inzicht, in controle zijn), is domeinonafhankelijk.

Daarnaast is een overzicht (quick scan) gemaakt van veelbelovende gebieden voor ePartners binnen en buiten het gezondheidszorgdomein, door middel van interviews met TNO experts en co-financiers (Yulius, Inmote and Cofely). De gebieden zijn georganiseerd rond de maatschappelijke thema's van TNO: Defensie en Veiligheid, Gezond leven, Energie, Informatiemaatschappij en Mobiliteit. Voor alle thema's zijn algemene maatschappelijke en marktontwikkelingen beschreven, maar ook de ePartner ontwikkelingsstatus, kennispositie, kennishiaten en drempels voor implementatie. Om valorisatie van ePartners te versnellen, moeten zaken als privacy en ethiek, hardware, software, implementatie en een solide business case worden beschouwd. Ten slotte wordt een overzicht gegeven van huidige en veelbelovende ePartner projecten, gecategoriseerd rond de toepassingsgebieden Gezondheid, Leven en Reizen, Veilig, Werken en Leren, en Informatie.

Alle informatie in dit rapport kan dienen als inspiratie voor de ontwikkeling van ePartners in nieuwe domeinen of voor nieuwe doelgroepen, die voldoen aan de geïdentificeerde kernfuncties, om nieuwe ePartner use cases, requirements, claims en design patterns te creëren.

Summary

The first phase of the 'ePartner that cares' project has shown that it is possible to design ePartners in the health care domain, for various users, health problems and health areas. However, the future of the ePartner framework is not limited to health care only. Actors in other domains could also benefit from tailored support, to contribute to solving problems occurring there. To address these possibilities, the following research questions were formulated:

- 1 What are the generic and domain-specific aspects in ePartner functions and development methods documented so far, and
- 2 how can we minimize domain-dependency to be able to deploy ePartners flexibly in various domains, within and outside of health care (such as mobility and education)?

To answer these questions, the generic and domain-specific aspects of the models, and methods developed so far were described, in particular the ePartner concept (core functions), ePartner development methods (situated Cognitive Engineering and Intervention Mapping) and results obtained so far in the project.

Situated Cognitive Engineering offers a method for systematically documenting use cases, user requirements, claims and design patterns for ePartners. The expected direct impact of 'ePartners that care' (behaviour change (towards a healthier lifestyle), healthier living, living (longer) independently) is domain-dependent and should be reformulated for other domains. However, the indirect impact (e.g. trust (in own achievements), increasing motivation, knowledge and insight, control skills), is domain-independent.

Further, an investigation (quick scan) was made of promising areas for ePartners inside and outside of the health care domain, through interviews with TNO experts and co-financers (Yulius, Inmote and Cofely). The areas are organized according to the TNO societal themes Defense, Safety and Security, Healthy Living, Energy, Information Society and Mobility. For all themes, general societal and market developments were described, as well as ePartner development status, knowledge position, knowledge gaps and barriers for implementation. In order to accelerate valorisation of ePartners, issues such as privacy and ethics, hardware, software, implementation and a solid business case should be taken into account. Finally, an overview is provided of current and promising ePartner projects, categorized according to the application areas Health, Live & Travel, Safe, Work & Learn and Information.

All information in this report may serve as inspiration for the development of ePartners in new domains or for new target groups, which adhere to the identified core functions, thereby creating new ePartner uses cases, requirements, claims and design patterns.

Contents

	Samenvatting	2
	Summary	3
1	Introduction.....	5
2	ePartners characteristics and development methods.....	6
2.1	Introduction	6
2.2	ePartners: characteristics and context	6
2.3	Methods for developing ePartners.....	8
2.4	Scenarios, use cases, requirements and design pattern	10
2.5	Generalizability of ePartners and development methods.....	12
3	Societal themes	13
3.1	Introduction	13
3.2	Defense, Safety & Security.....	13
3.3	Healthy Living	15
3.4	Energy	16
3.5	Information society.....	17
3.6	Mobility.....	21
3.7	Recommendations for accelerated valorisation	23
4	Future domains.....	25
5	Conclusions	26
6	References	27

1 Introduction

The project “ePartners that care” contributes to problems in health care by offering technological support to both the care provider and the care recipient. An ePartner is an interactive personal computer application which is available through various platforms (e.g. website, smartphone) and which you can communicate with. An ePartner (that cares) supports care recipients and providers by offering tailored coaching and advice. The ePartner accomplishes this by gathering and combining information in a smart manner, tailored to the person and situation, through an accessible and intuitive interaction. The project aims at realizing a coherent framework with a set of building blocks to develop ePartners. To accomplish this, extensive use is made of existing scientific knowledge in the domain of health goals, (influencing) behaviour, information exchange, and behaviour and interaction models.

In the first phase of the project, the initial ePartner that is being developed is targeted at the health care domain (an ePartner that cares). Involved co-financers interested in this domain are Inmote B.V., Yulius Academy B.V and Cofely. However, the future of the ePartner framework is not limited to health care only. Actors in other domains (which may include the current co-financers) could also benefit from tailored support, to contribute to solving problems occurring there. To address these possibilities, the following research questions have been formulated:

- 1 What are the generic and domain-specific aspects in ePartner functions and development methods documented so far, and
- 2 how can we minimize domain-dependency to be able to deploy ePartners flexibly in various domains, within and outside of health care (such as mobility and education)?

To answer these questions, the generic and domain-specific aspects of the models, and methods developed so far were described, in particular the ePartner concept, ePartner development methods (situated Cognitive Engineering and Intervention Mapping) and results obtained so far in the project. Also, a description is made of how the domain-specific aspects can be described in terms of generic, domain-independent concepts, for the purpose of tailored support in other domains (Chapter 2). Further, an investigation (quick scan) was made of promising areas for ePartners inside and outside of the health care domain, through interviews with TNO experts and with co-financers. The areas are organized according to the TNO societal themes Defense, Safety and Security, Healthy Living, Energy, Information Society and Mobility (Chapter 3). Also, an overview is provided of current and promising ePartner projects, categorized according to the application areas Health, Live & Travel, Safe, Work & Learn and Information (Chapter 4). Finally, conclusions from this work are drawn in Chapter 5.

2 ePartners characteristics and development methods

2.1 Introduction

This Chapter first provides an overview of the characteristics of ePartners (Section 2.2). Then two methods for developing ePartners are presented. The first method is situated Cognitive Engineering (sCE), a human-centred, iterative process of deriving, refining, shaping and validating user requirements (Section 2.3.1). The second method is Intervention Mapping (IM), a method to design (technological) interventions for behaviour change (section 2.3.2), including the choice of appropriate behaviour change techniques. The combination of both methods is considered suited for developing 'ePartners that care'. To illustrate the application of the methods, three scenarios in the health domain are briefly described (Section 2.4), with associated use cases, user requirements, claims and a design pattern. The chapter concludes with an overview of the generic aspects of ePartners, sCE and IM, to stress possible generalizability to other types of users and domains (Section 2.5).

2.2 ePartners: characteristics and context

In the project "ePartners that Care", TNO researches smart support systems, which are, in principle, always available to the user through various connected platforms, like a smartphone, a tablet, a website or a TV set. An ePartner is a personal computer application that helps its user to achieve personal goals such as managing his or her health related behaviours concerning nutrition, exercise and medication (Neerincx, 2004; Blanson Henkemans, 2009; Neerincx & Grant, 2010; De Greef, 2012; Kayal et al., 2013). Persons from the social environment who may contribute to such personal health management (e.g., parents, teachers or home aid nurses) can have an ePartner too (see Figure 1). These networked ePartners collaborate to achieve the personal health goals, for example by delivering relevant information (e.g. nutritional data), by providing recommendations or advice (e.g. to refrain from physical exercise given recent food consumption and glucose level), by planning of meetings (e.g. consults with the caregiver or sessions with a peer community), and by giving or mediating encouragement (e.g. rewarding, praising). The users make agreements with their ePartners on the concerning information and support processes (e.g. on the conditions for sending a health-risk warning and the persons who will receive this warning), to establish transparent and situated human-technology partnership (e.g., the obligations and authorities of human and technology actors to process warning information).

The support that an ePartner provides may have indirect or direct impact on its users. An *indirect* impact affects certain characteristics and skills of the user (such as a higher knowledge level, more trust); *direct* impact affects specific behaviours, depending on the specific domain of use (such as a healthier lifestyle), possibly through the indirect changes.

<i>Indirect</i>	<i>Direct (for health care domain)</i>
• trust (in own achievements) • increasing motivation • knowledge and insight • control skills	• behaviour change (towards a healthier lifestyle) • healthier living • living (longer) independently

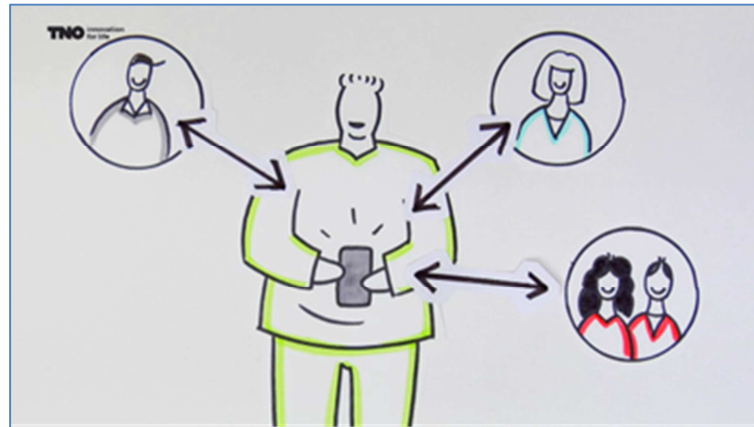


Figure 1 The ePartner user connected to other persons from his social environment (with their own ePartners) through the device.

In summary, the core functions of an ePartner are:

- supports (the interest of) the user (both short-term and long-term);
- supports achievement of personal goals;
- acts based on explicit agreements with the user;
- is connected to the user's social network;
- is dynamic and 'intelligent', which increases through interaction and learning;
- may take the following roles: informant, planner, motivator, inspirer, intermediary, advisor, mentor, coach, leader by example, team worker, winner, visionary (see Figure 2);
- may have indirect (e.g. motivation) and/or direct impact on its users (e.g. behaviour changes).

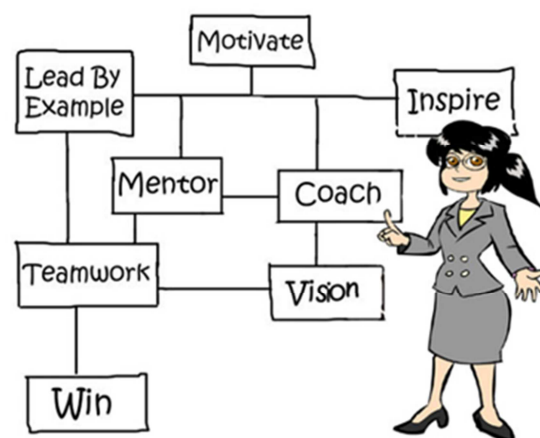


Figure 2 Examples of roles the ePartner may take.

2.3 Methods for developing ePartner

2.3.1 sCE

'situated Cognitive Engineering' (sCE) has been developed to channel a human-centred, iterative process of deriving, refining, shaping and validating user requirements (Neerincx & Lindenberg, 2008). Values, standards and guidelines explicitly feed into the requirements, combined with the identification of specific user characteristics or technological preconditions (Neerincx, 2011). Use case analyses drive this specification and refinement process, integrated with claims analyses that provide the justification (i.e. the expected outcome of the interaction). The use cases and user requirements with an appropriate justification are shaped into interaction design patterns (see Figure). However, if appropriate design patterns are already available, these practices can be selected and re-used. The set of patterns can be implemented in a prototype for evaluation. The sCE Tool (sCET) is used to establish coherent and concise design specifications with their, theoretically and empirically founded, design rationale (see www.scetool.nl).

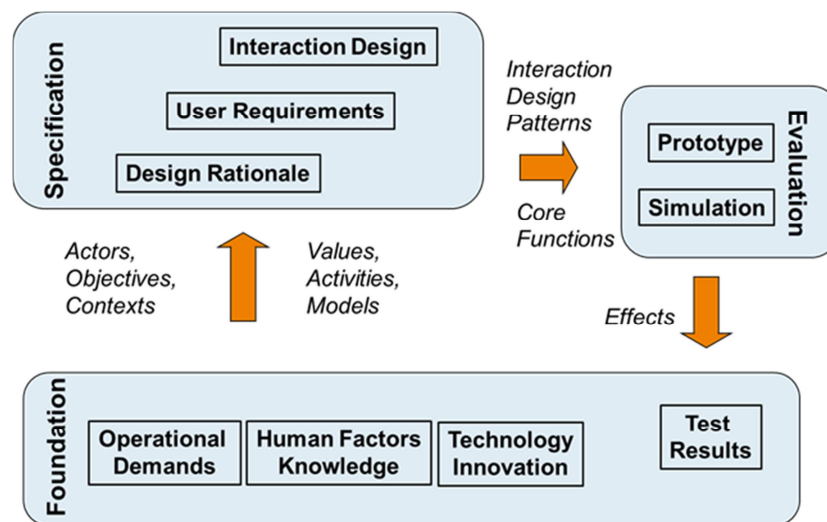


Figure 3 Situated Cognitive Engineering: from Foundation to Specification and Evaluation. Boxes in bold indicate results in various phases, orange arrows with italic texts indicate inputs to next phases.

In summary, sCE is a development and evaluation method, with an associated instrument (sCET), with the following overall characteristics:

- Generic, domain-independent approach;
- supports integration of a broad spectrum of expertise's (multi-disciplinary);
- practice-oriented (iterative, incremental), but based on a scientifically sound design rationale;
- documents and defines (ontology);
- offers hierarchies of generic requirements, with associated refined concrete requirements.

2.3.2 Intervention Mapping

Intervention Mapping (IM) is a method to design (technological) interventions for behaviour change (Bartholomew et al. 2011). Otten et al. (2013) state that there are many theories and determinants that explain behaviour, but they do not describe how to change behaviour. This distinction between explaining behaviour and changing behaviour is essential for methods that design interventions, like Intervention Mapping. Otten et al., (2013) have adapted Dusseldorp's et al. (2013) grouping of 26 different Behaviour Change Techniques (BCTs) (taxonomy by Abraham and Michie, 2008) into three phases of behaviour change: motivation phase (5), planning phase (10), and action/continuation phase (11).

Intervention Mapping (Bartholomew et al., 2011) describes six steps to ensure that (health promotion) interventions are systematically developed and grounded in theory and evidence, and to maximize the likelihood for effects. Step 1 represents the behaviour, step 2 the determinants, and step 3 selection of the BCTs. These 3 steps will result in the design of an application in step 4. In designing this specific application the sCE-method is especially useful. Steps 5 and 6 represent the adoption, implementation, sustainability and evaluation.

- 1 Conduct a needs assessment:
 - a Determine the (health) issue (e.g., being overweight);
 - b determine the risk factors, related to behaviour (e.g., overeating) and environment, (e.g., availability of food in the house);
 - c describe the at risk population to which these risk factors apply (e.g., young women);
 - d illustrate how risk factors lead to health issue (e.g., adolescent is alone, sitting depressed at home and falls back to eating);
 - e choose theories and models which *explain* behaviour (of both the at risk population and actors of influence in the environment) and which indicate how to *affect* it (e.g., Reflective impulsive model);
- 2 Develop matrices of change objectives:
 - a Determine performance objectives for the at risk population and their environment to mitigate the health issue (e.g., develop alternative response to feeling depressed besides eating);
 - b Assess, from theories and models, which determinants explain behaviour to realize performance objectives (e.g., attention);
 - c Describe change objective, i.e., activity that displays that a determinant has changed and contributes to realizing performance objectives (e.g., girl focuses less on food);
- 3 Map BCTs to determinants:
 - a Assess, from theories and models, which BCTs have been proven effective in influencing determinants to realize performance objectives (e.g., attention bias modification treatment);
 - b determine which boundary conditions apply to BCTs (e.g., effects have been found with regard to snacking attitudes and behaviour);
 - c describe how BCT is applied for specific actor and determinants (e.g., girl plays cognitive bias modification game).
- 4 Integrating these methods and strategies into an organized program.
- 5 Planning for the adoption, implementation and sustainability of the program.
- 6 Generating an evaluation plan.

2.4 Scenarios, use cases, requirements, claims and design pattern

2.4.1 Scenarios

Three scenarios were chosen to represent the variety in the health and health care domain (adapted from Otten et al., 2013). These scenarios differ regarding (a) age of the actor, (b) mental and/or physical health problems, and (c) prevention, cure or care.

- Stephan, a child with ADHD who needs to adhere to his medication and to structure his daily activities, and
- Rashid, an overweight adolescent who needs to improve his lifestyle, that is, exercise more and eat more healthy food, and
- Mr King, an elderly man with three conditions (osteoarthritis of his hips and knees, heart rhythm disorders, and the loss of his wife made him gloomy) living alone independently needs to maintain social contacts and to exercise regularly.

2.4.2 Use cases

Within these scenarios, behaviour was chosen that needed to change to obtain a desired goal, determinants of that behaviour were formulated, and BCTs to influence those determinants. Next, use cases were described that illustrated what the ePartner required in order to apply a BCT. In this section we describe one use case (of 40) of each scenario as an example of requirements necessary to support behaviour change by an ePartner following the framework described above.

2.4.2.1 Example use case Stephan child with ADHD

Behaviour: taking medication on specific moments.

Determinant: barriers.

BCT: prompt review of behaviour goals.

Use case Action sequence:

- ePartner notifies the user at an appropriate moment (private, quiet) to reflect on progress on goals;
- ePartner indicates that user does not perform activities that contribute to goal behaviour (and shows several moments);
- ePartner indicates that this was a goal they both agreed upon;
- user indicates that he did not notice the reminders;
- ePartner shows the moments of these reminders;
- user sees that he is not wearing the smart watch during these times;
- ePartner suggests to shift the reminders earlier on the daily schedule;
- user agrees.

Requirement: ePartner shall give performance feedback.

2.4.2.2 Example Scenario Rashid overweight adolescent

Behaviour: buy healthy food.

Determinant: attitude, knowledge.

BCT: Provide information on consequences.

Use case Action sequence:

- The ePartner invites the user to play a nutritional product game in supermarket;
- the user accepts the invitation;
- the ePartners asks the user which product he/she intended to buy;
- the user answers to intend to buy unhealthy food and drinks (e.g. a bag of chips and a soda);

- the ePartner challenges the user to find three more and three less healthy products within the intended product range;
- the user fulfils the challenge by looking at number of carbs of various products in range;
- the ePartner challenges the user to find three more and three less healthy products outside the intended product range (e.g., vegetables, water);
- the user fulfils the challenge by looking at the number of carbs of various products outside the range;
- the ePartner provides rewards for fulfilling the challenges;
- the ePartner asks the user what he/she assesses from the challenges (i.e., comparison of products);
- the user reflects on the game outcomes (e.g., intended products are very unhealthy and there are healthy and enjoyable alternatives);
- the ePartner thanks the user for his/her time.

Requirement: The ePartner shall initiate and accommodate playing known games, harmonized to the user goals and momentary context.

2.4.2.3 *Example use case Mr King elderly person with comorbidity*

Behaviour: train as proposed by physiotherapist.

Determinant: (implementation) intention.

BCT: prompt Specific goal setting.

Use case Action sequence:

- ePartner reminds the user of the training;
- ePartner asks whether the user is motivated to perform the behaviour
- user answers he is not;
- ePartner suggests exercises that match the personal interests of the user;
- ePartner suggests that the user sets a goal for training regarding these exercises;
- user agrees;
- ePartners suggests that the goal should be specific regarding time and context
- user sets a goal;
- ePartner checks whether the goal is specific regarding time and context;
- ePartner qualifies the goal on specificity, proximity and whether it matches with personal values;
- ePartner provides feedback on whether the goal is specific, proximal and personal enough;
- user adjusts the set goal according to the feedback of the ePartner;
- ePartner saves the goal for later review;
- ePartner thanks the user and ends.

Requirement: ePartner shall adapt to user's characteristics.

2.4.3 *Requirements and claims*

As part of 40 use cases for the 3 scenarios that were developed, a total of around 175 requirements were formulated. User requirements are included in sCET, organized hierarchically, resulting in the following seven top level requirements.

- The ePartner shall interact with other persons, ePartners and systems (R002);
- the ePartner shall adapt its behaviour and interface based on knowledge about user and environment (R004);
- the ePartner shall monitor the user and his/her context (R025);

- the ePartner shall provide the user with necessary information (R057);
- the ePartner shall facilitate behaviour modification (R093);
- the ePartner shall respect the privacy of its users and adequately secure the personal information of these users (R094);
- the ePartner shall motivate the user (R168).

In addition, 46 claims have been formulated, all linked to one or more user requirements.

2.4.4 *Design pattern*

As part of the project an initial design pattern for 'Parental praise' is developed for the scenario of Stephan, the child with ADHD (Paulissen et al, 2013). The design pattern contains information on the design problem (What) ("Give the child a feeling of appraisal by his/her parent when desired behaviour is carried out."), the context of use (When), the design solution (How) (modality, content and dialogue style, messenger, timing and repetition) and the design rationale (Why). Design patterns provide very specific guidelines for design, but still leave room for own contributions of designers.

2.5 **Generalizability of ePartners and development methods**

The 'ePartners that care' project has shown so far that it is possible to design ePartners in the health care domain, for various users (ages), health problems (mental and/or physical), and health areas (prevention, cure or care). Three scenarios have led to 40 use cases and 175 user requirements and 46 claims, documented in sCET. Although all use cases describe specific behaviour goals, they are also linked to generic behaviour determinants and behaviour change techniques (Intervention Mapping). ePartner roles are also specified as part of the use cases (e.g. game master, motivator, educator, goal planner, guide, assessor, and rewarder). Since the user requirements and claims are ordered hierarchically, they offer, as needed, both more generic and more specific ones. Generic requirements as formulated so far already reflect a part of the ePartner core functions as listed in Section 2.2. Design patterns are relatively specific for a certain use case and a certain functionality. However, future 'family trees' of design patterns may offer more generic to more specific design patterns. In any case, specific design patterns may offer inspiration for designing for other users, problems and domains.

Finally, the indirect impact of ePartners is domain-independent (e.g. trust (in own achievements), increasing motivation, knowledge and insight, control skills), but the direct impact should be reformulated for other domains.

3 Societal themes

3.1 Introduction

TNO focuses over-all on seven societal themes. Projects related to ePartners derive from five of these themes. We therefore focus on these five themes in this quick scan. Of all selected themes, the director, a business line manager or a business developer was interviewed. Furthermore, all co-financing parties in ePartners that care were contacted to arrange a conversation on their perspectives. The goal of the interview was to identify the most important societal and market developments that are relevant for ePartner development and the current status of ePartner research in the theme. Besides, in order to develop an ePartner, the relevant domain knowledge in the area of application needs to be available. This, however, is not always the case. Therefore, the gaps in domain knowledge that as yet exist in the themes are also described. Lastly, barriers for implementation in each domain were identified and are summarized for each domain. Potential implementation areas for ePartners that were suggested by interviewees are listed in Appendix D. The potential implementation areas that were put forward by the co-financing parties are listed in a separate paragraph. The number(s) after each societal and/or market development correspond with the numbers of the specific ideas for implementation per theme. The names and functions of the people that were interviewed are shown in Appendix A.

In the following four sections of this chapter, the results of the interviews are described per TNO theme. The results of the interviews with co-financing parties are merged in this overview. In the final Section 3.7 general recommendations for accelerated valorisation of ePartners are given. Furthermore, the theme's projects related to ePartners are listed in Appendix B. In addition an overview is given of potentially suitable organizations for joined future ePartner research and development in Appendix C.

3.2 Defense, Safety & Security

This theme focuses on a safe society by creating innovations for Defense, police, emergency services and business. These organizations are supported with both technical innovations and innovations that increase the effectiveness of employees.

3.2.1 *Societal and market developments*

The interviewees from the TNO theme Defense, Safety and Security stated the current developments that are most relevant for ePartners within their domain. These are mostly developments within Defense and civil security organizations, the main clients of this theme.

- *Support for families:* the navy has developed a new 'care concept', which consists of four layers: the home front, the crew of a ship, the Defense organization (e.g. support services) and the medical organization. The aim is to keep care and support in the lower layers as much as possible. As part of this concept a home-front-organization to support families has been established. This organization should provide families with practical, social and psychological support, when the soldier is on a mission or during reintegration (D1).

- *Support for reintegrating soldiers:* where most of the military used to live at or nearby the base, now most of them live with their families at a more distant location, and thus 'live in two worlds'. A result of this is that soldiers returning from a mission, lose the intensive contact with their platoon. Therefore, within the new 'care concept', also a 'collegial network' for support from colleagues has been established. One of the aims of this new concept is to reduce the number of psychological complaints among soldiers after missions (D2).
- *Ad-hoc teams:* due to the changing operational environment the military works more with ad-hoc teams. For a good team-composition it is important to know which persons have which skills and competences (D3).
- *Support for soldiers in the field:* the changing operational environment of the military demands more flexibility and adaptability from soldiers (D4).
- *Support for operators:* command and control centres are getting more complex due to increasing automation. Intelligent support for operators, like adaptive interfaces, is desirable (D5).
- *Learning on the job* gets more important for civil security, due to the changing environment and type of work (D6, D7).
- *IT-support:* there are a lot of developments on IT-support in the civil security domain, especially with respect to big data, smart cities and use of sensors (e.g. for camera surveillance) (D8, C4).

3.2.2 *Current status in ePartner development*

Interviewees think that the Dutch Defense organization would be willing to host studies into the development and use of ePartners, but emphasize that the concept of ePartner under study should be implementable and that its utility for Defense should be made clear. Within the safety and security domain there are as yet no projects running on ePartners or comparable support systems.

3.2.3 *Knowledge position relevant for ePartners*

Within former and running programs, research has been done on the applicability of smart tools for dismounted soldiers. These projects have resulted in demonstrators. Another program addressed the development of methods and tools for physiological and mental measurements of military performance. Such measurement devices, like biosensors, can be integrated into ePartners.

The army has a care system in place for the detection of PTSS, which consists of different layers of stakeholders ranging from the home front up to psychologists. The current approach is however not efficient. A support system that can deliver the right support easier and sooner is desirable. This could, for instance, be achieved via coordination between the layers, providing information and personal support.

3.2.4 *Knowledge gaps considering ePartners*

To ensure that new applications are being used, it has to be known which incentives can promote the use of ICT-support systems like ePartners.

There is currently no research being done by TNO on nutrition for soldiers, while understanding the opportunities to promote cognitive and physical performance through nutrition would be valuable. More research is also required for early signalling of PTSS. Knowledge on how people at risk can be identified is essential for the implementation of ICT solutions for early detection.

3.2.5 *Barriers for implementation of ePartners*

The diversity of the Defence organization makes it likely that ePartner-applications will be developed in separation (e.g. measuring impact of ammunition, communication, control of unmanned systems). An overarching system for ePartner development and documentation would be very eligible.

With respect to cure and care within the Defence organization: The military does not have a central patient care record, so there is no insight in the use of medical care, number of disorders and medical status of soldiers. Since this information is essential in research on the medical status of soldiers and the effectiveness of interventions, this is a barrier for the development of ePartner applications.

3.3 **Healthy Living**

This theme initiates technological and social innovations that contribute to a healthy life style and a healthy society. The focus on these innovations is on (the intersection between) the following domains: employment, living environment, nutrition, medicine, healthcare and recreation. The interview insights of Yulius Academy, one of the co-financers, are merged in this Section. Yulius Academy is the scientific knowledge centre for mental health of the overarching expertise organization Yulius. Yulius Academy aims to optimize the range of care options in the mental health area and professionalize employees.

3.3.1 *Societal and market developments*

Adherence to human factor principles and user satisfaction has become increasingly important in healthcare innovations. This has led to several new developments in the health care domain, some of which are listed below.

- *Integration of human factors in innovations:* adherence to human factor principles and user satisfaction become increasingly important in (health care) innovations (C1, C11).
- *Self-management and empowerment:* in the care domain there is an increasing focus on self-management and empowerment of people. Introducing the concept of self-management in care has important implications: it not only requires the development of self-management skills of care users, but it also requires a different role of the care giver (H1, H2, H3, C3, C7, and C8).
- *Monitor workload and stress:* due the growing burn-out rates related to pressure at work, employers are interested in measures for workload and stress. Such measures provide the starting point for remediation and prevention (H4, H5).
- *Technological applications in health care* are being explored. Rabobank and BeBright for instance initiated Diagnose 2025, a collective exploration of innovation and technology in the health care sector. The resulting book can be used to gain insight in economic, societal, political and technological developments as well as chances and risks of business opportunities (H6, C3).
- *Increase in (mental) care demand:* the request for professional guidance and treatment in the healthcare sector increases steadily. The number of care givers and the costs involved, urge for technological breakthroughs to slow down this trend or increase efficiency (C1, C2, C6).
- *Insight in revenues of health care innovations:* the changes in the health care sector not only give rise to the question what the financial revenues of innovations are, but also what the revenues are in terms of happiness and health of care users (C2, I8).

3.3.2 *Current status in ePartner development*

TNO is already involved in quite a number of projects aimed at the development of ePartners in the health domain. The project ePartners that Care has been used to accumulate the knowledge position, which is described in Chapter 1.

3.3.3 *Knowledge position relevant for ePartners*

The results of these projects also give insight in determinants of effective intervention strategies. For instance within the Stress coach project knowledge on the determinants of stress and how this can be measured has been built up. Within another project this has been brought one step further, by researching how arousal, an indication for stress, can be measured with sensors.

Also, more general knowledge has been built up, like knowledge on behavioural change techniques (BCT's), recognition of behavioural patterns in data, personalization of feedback and a method for developing ePartners. The current knowledge base is a good starting point for further development of the proof of concepts of ePartners.

3.3.4 *Knowledge gaps considering ePartners*

More research is required with respect to effective feedback mechanisms for behaviour change and which behavioural components need to be monitored for reflection on learning behaviour.

3.3.5 *Barriers for implementation of ePartners*

According to project leaders of the various current or former projects related to ePartners, TNO especially has experience in using knowledge, but not in implementing this knowledge. Large-scale implementation of ePartners is necessary to gain insight in the effectiveness of ePartners, the main effective factors and user-experiences, and for gaining market position.

3.4 **Energy**

The Energy theme wants to contribute to long-term availability of energy via technological innovations for efficient energy usage, energy storage and sustainable energy sources. The latter includes both profitability and feasibility of these alternative sources for the Netherlands.

3.4.1 *Societal and market developments*

In this Paragraph the most relevant developments for ePartners in the energy domain are listed. The numbers correspond with potential applications for ePartners in the next paragraph.

- *Interdisciplinary cooperation* is increasingly important in the energy domain (e.g. co-creation, crowdsourcing, integration between stakeholders, and early involvement of end users). Organizational innovations should improve cooperation between organizations by taking factors like varying interests, costs/benefits, ways of working and trust into account and result in win-win situations and effective communication (E1).
- *Supply of sustainable energy*: there is a shift towards sustainable energy. However, supply of sustainable energy is difficult to control since it depends on the weather conditions. This demands for smart solutions, like smart-grids, that can match demand and supply (E2).

- *Awareness of energy-usage*: due to the shift from top-down to bottom-up in the energy supply chain, it is increasingly important for consumers to be aware of their own energy-use and to be able to anticipate on that (E2).
- *Behaviour change techniques*: energy-supply is no longer a top-down process. The role of the consumer in the supply chain has to be taken into account. This requires transmission system operators and retailers to get involved in behaviour change techniques (E3).

3.4.2 *Current status in ePartner development*

A Smart Meter has been developed, which gives consumers insight in their energy use. Besides, an Energy Intervention Framework has been developed and implemented in practice. This gives energy suppliers and transmission system operators the opportunity to get acquainted with behavioural change techniques in an accessible way. Both the Smart Meter and the Energy Intervention Framework do however not have personalized features or ePartner functionalities.

3.4.3 *Knowledge position relevant for ePartners*

The Energy Intervention Framework is based on the steps from Intervention Mapping. It can be used to introduce behaviour change interventions to industry and to help them identify the desired behaviour change, determinants of this behaviour, and the social environment. Since the framework gives insight in how consumers can be made aware of the problem and be activated to change their behaviour, it is a good starting point for developing ePartners.

3.4.4 *Knowledge gaps considering ePartners*

In general, bringing about sustained behaviour change takes at least half a year. However, sustainability of behaviour change and the long-term effect of feedback on energy use are not known. Research has to show to which extent the effects on short-term will also endure on long-term and whether or not feedback mechanisms need to be endured to avoid roll back of behaviour change.

3.4.5 *Barriers for implementation of ePartners*

Industry (retailers, transmission system operators, etc.) are not familiar with behaviour change interventions and the importance of tailoring such interventions to increase effectiveness.

The current interventions for changing energy behaviour are not effective in reaching people with low SES, while this group is responsible for about 30% of the total energy use. More information is required on how the low SES group can be reached or how automation can be used to alter energy use among low SES people.

3.5 **Information society**

This theme does research on the consequences of the information society for civilians, companies and government. Also, this theme stimulates the introduction of new services, applications and policies based on the newest ICT, media and space technology. The interview insights of Inmote B.V. and Cofely Zuid Nederland B.V. are merged in this section. Inmote is a software company that focusses on mobile technology for the professional market.

Projects range from software implementations to close combinations with hardware solutions. Cofely provides technical services in multiple domains.

The healthcare department of Cofely mainly focuses on buildings, but wants to increase its focus on the primary process and position itself as the number one ICT-service provider in health care.

3.5.1 *Societal and market developments*

- *Empowerment of people* is a trend in multiple domains; IT-solutions can support this. ePartners for empowerment can be implemented in various domains for multiple goals and target groups (I3, I4, I5, I6, I7, I9, and C5).
- *Accessing and using information in various domains*: the shift towards the information society has led to availability of a lot of information. Accessing this information requires specific skills and knowledge about the availability and use of information and media. For all domains the added value of access to information has to be identified, to effectively utilize the available information (I11, I12, C6, C9, and C12).
- *Mobile & wearable technology*: technology becomes location independent, small applications run on smartphones. The trend in affective computing goes along with the rise of 'wearable tech' (wearable sensors). Sensors are being increasingly used for all kinds of applications, like measuring physical activity of humans. Mobile and wearable technology can be used for all kinds of ePartner applications (I1, I2, I8, and I9).
- *Identification & Privacy*: identification of persons and privacy of personal data are important issues in the emergence of information society and should be taken into account in implementation of all ICT-solutions and thus also all ePartner applications. In the related examples especially access to the preferences of the user is of importance (I10, I11, and C2).

3.5.2 *Current status in ePartner development*

Within the theme Information Society a team of 2 persons works full-time on IT-solutions and the translation of innovative knowledge to marketable products and tools. Up to know, most ePartner related projects have at most resulted in scripted demonstrators; no fully operational ePartners have been developed yet.

3.5.3 *Knowledge position relevant for ePartners*

Sensor data

ePartners should be able to collect data and to make observations. Sensors can do these observations and map the context in which an ePartner is used. Sensors can broadly do two types of observations. Firstly, sensors can make the same observations as humans, whether these are conscious or unconscious observations. The latter is however more complex, since the mechanisms behind unconscious observations by human are not always known. Secondly, sensors can do observations that human cannot do, like computer vision techniques for visual images.

In the run-up to a spin-off 'Meta-data-extraction services' research is done on how specific information can be sought in video-material. This knowledge can be coupled to a recommendation engine which can give tailored advice to consumers with respect to media consumption.

Measuring arousal to prevent stress; arousal can be determined by sweat secretion for instance and can determine stress levels. This application can be used in multiple domains, like in the army for signalling acute stress during missions or for the prevention of PTSS and in health care for monitoring stress of people before surgery or among their doctors.

Modelling & integration

Within TNO also algorithms and models are being developed that can translate sensor output to useful information for the ePartner, just as the required software to support this.

AI

On the internet already multiple tools that make use of artificial intelligence can be found, such as WEKA that develops software for machine learning. One method for the design of machine learning, cognitive task analysis, is researched by TNO. Cognitive task analysis (Schraagen et al., 2000) is a method for analysing how someone performs a task and uses this as input to teach a machine how it can take over this task. This method can be used for optimization of processes by automation. An expert system uses cognitive task analyses to analyse human experts and that translates this knowledge to the system. One specific form of an expert system is a recommendation system. In such a system a user can enter personal data and preferences with respect to information supply. The system can anticipate on that by automatically providing the user with the desired information. Such systems are already in use by search engine companies like Google.

Behavioural models

Learning cannot take place without feedback. The content, form and timing of feedback are of critical importance. Preliminary research has shown that feedback on learning behaviour increases learning performance by 30%. Research is now being done to identify which behavioural components need to be monitored to be able to reflect on learning behaviour and which feedback mechanisms are most promising. This knowledge can be used to tailor advice to the learning methods and preferences of the student.

In an EZ-co TNO is working on gamification of financial behaviour, with the aim to increase insight in spending patterns of both consumers and companies and to identify high-potential interventions in preventing financial problems.

3.5.4 *Knowledge gaps considering ePartners*

Sensor data

With the current knowledge position on sensor technology, almost everything can be measured. the biggest bottlenecks lie in the interpretation of the sensor data, ethical and privacy aspects and security of data. Interpretation of sensor data has two dimensions, namely psychological knowledge (which sensor has priority with contradictory signals, what are inter- and intra-individual differences) and context (framing).

The validation of psychological, sociological and biological constructs is still difficult. Arousal can for instance be used as a measure for emotions, but the direction of these emotions (valence) is difficult to measure.

In some cases, the technology to make sense of data is still too immature to be of practical use in ePartner applications. Speech recognition is an example.

There are very good microphones to record human speech. However, to interpret what is being said is another matter. It very much depends on the domain and context of use whether or not speech recognition is feasible in ePartner systems. The applicability of sensor data is dependent on the context. At this moment, it is still difficult to use sensors in a dynamic environment.

Modelling & integration

Another bottleneck in developing ePartners is the integration of the various aspects of an intelligent system, like logic, representation, pattern recognition, data input, output and connecting data. Another difficulty is that it is impossible to model the entire context including all factors, therefore choices have to be made on which data is essential.

AI

AI may be considered to reflect different perspectives, namely an agent's perspective (logic & reasoning), pattern recognition (machine-learning) and knowledge representation (semantic web ontology). In most projects only one or two of those perspectives are included; better integration of perspectives is required.

An ePartner should not only learn from feedback from the user, but also from feedback from third parties or even by feedback generated by the environment. For the latter, sensors can be used as input.

3.5.5 Barriers for implementation of ePartners

Knowledge on psychological models is mainly based on theories and thus qualitative. Research mainly uses GLM- and regression techniques, which calculate averages over large cohorts. These averages are not necessarily representative for individuals and do not take inter and intra-individual differences into account.

A lot of research is done in lab-settings instead of real-life. Especially with the use of sensors, in real-life there is always 'noise' in the data due to the context.

This makes implementation in real-life difficult. Real-life pilots are required to gain insight in the effectiveness of ePartners.

A pilot in real-life requires a working (prototype of) an ePartner. The development of such a prototype requires incorporation of (AI driven) intelligence in products and thus knowledge on how intelligence can formally be incorporated in ePartner-products.

To reduce time-to-market for ePartners, applications should be based on simple principles, to be expanded in due time. Initial applications can also result in good-case-practices that give shape to the generic platform.

3.6 Mobility

The Mobility theme aims to integrate technological innovations, influencing human behaviour and smarter organization of mobility to reach structural improvement of mobility in the Netherlands as well as clean, quiet and safe transport.

3.6.1 Societal and market developments

- *Economical driving*: there is an increasing interest in 'green driving'. Various companies are developing apps that promote green driving, by giving insight in the fuel consumption of a car and providing tips for economical driving. These apps however do not give insight in own driving behaviour (M1, C10).
- *Driver safety*: according to legislation, the number of traffic fatalities should be reduced, just as injuries from accidents. Therefore, road safety should be increased. Up to present, interventions in this area do not focus on influencing driver behaviour, while awareness of own behaviour of drivers is an important determinant of safe driving behaviour (M2).
- *Warning signals*: various car manufacturers work on warning signals to improve driving safety and comfort (e.g. trigger to hit the brakes, alarm to take a break). These warning signals do not take the drivers' preferences and state into account, while it is known that three false-positives (warning signals when this is not necessary) can already lead to rejection of a system (M3).
- *Real-time information*: from the government as well as the industry there is interest in connecting real-time travel information to traffic information and the personal agenda of drivers, such that travel advice can take potential traffic problems into account (M4).
- *Reduce vehicle idle time*: from the market there is a demand for innovations that help reduce vehicle idle time, i.e. prevent people from ending up in traffic jams at cost of effective working hours and thereby reducing costs associated with file drive and being late at appointments (M5).
- *Smart energy grids*: matching energy supply and demand is getting more important due to alternative energy sources. Therefore, research is done on smart energy grids that should match supply and demand in the street. Electrical mobility should be integrated in such a smart energy grid (M6).

3.6.2 Current status in ePartner development

Several car manufacturers are already working on new functionalities to support drivers. An ePartner in the mobility theme is a 'nice-to-have'. Thus, there is not a demand from the market, but merely interest. This interest can probably be triggered best by focusing on the possibilities of an ePartner in increasing user acceptance of new functionalities.

3.6.3 Knowledge position relevant for ePartners

TNO is looking into possibilities for connecting various sources of real-time information to provide accurate travel advice. This can be used as starting point for developing an ePartner.

Also, research is done on the mood of drivers in relation to the estimated workload. Based on this knowledge, personalized recommendations can be given on whether or not to increase the workload while driving, for instance not to make a phone call due to an imminent traffic jam.

Outside TNO, several car manufacturers are already working on intelligent in-car systems. Several cars for instance have Autonomous Emergency Breaking systems, which gives warning signals as trigger to hit the brakes and that starts braking autonomously if the car gets too close. Warning systems are also already used to warn drivers when it's time to take a break (after a 2 hour drive). These systems are based on time and traffic information and not on the driver's alertness state.

Mercedes developed a car that can autonomously drive in traffic jams (up to 50 km/h). Renault works on a prototype car in which an avatar is implemented in the board computer. This avatar gives all kinds of advice and feedback on driving behaviour, problems in traffic (e.g. upcoming traffic jams, diversions), battery (how long can you still drive), but can also take over chauffeur's tasks, like turning on the lights. The avatar bases its actions on real-time information (traffic, weather, etc.) and information about the driver. Besides, this avatar has learning capacity (pattern recognition in software) and should become a real buddy to the driver (via personalized communication).

3.6.4 *Knowledge gaps considering ePartners*

Incentives can be used to achieve behaviour change among road users.

Financial incentives are for instance effective in stimulating drivers to travel outside peak hours. However, when this financial incentive stops, drivers stop traveling outside peak hours. Therefore, research has to be done to identify incentives for sustainable behaviour change in the mobility sector.

Also, more insight is needed in what information drivers require while driving, but also what information is required in autonomously driving cars (for example, how do drivers want to be informed that they should take over the wheel due to an imminent traffic jam?).

3.6.5 *Barriers for implementation of ePartners*

To develop an ePartner for the mobility domain, multiple information sources need to be connected in-car. Not only real-time information, but also information about the driver (personal preferences, current state, driving behaviour). This information can be collected based on voice recognition, sensors (pressure on the wheel for instance), Heart Rate Monitor, etc. Such in-car measures still have to be developed.

User acceptance is a key in the implementation of in-car systems. It is however not known how this can be achieved, partly due to large differences in personal preferences. Especially for warning systems, users' acceptance is importance. If systems give warnings when this is not necessary, drivers perceive this as annoying and will most likely refrain from using the system. Therefore, research is necessary to identify optimal thresholds for warning systems.

3.7 Recommendations for accelerated valorisation

During the interviews, also some recommendations were given by the interviewees that could contribute to the development of ePartner and decrease time-to-market for ePartner applications. These recommendations are described in this paragraph.

3.7.1 *Privacy / ethical considerations*

Two of the biggest challenges in developing an ePartner are privacy and ethical aspects. For each functionality of the ePartner, it should be considered which data should be collected, where these data should be stored and whom it should be shared with. Especially if it concerns personal and medical data. The data has to be stored in a safe location that cannot be accessed by thirds. The user of the ePartner should be able to influence who has access to the collected data at any time. However, aggregation of data can have scientific value, since it can be used to learn more about the effectiveness of interventions. Therefore, (medical) data should be uncoupled from individual data, such that the data cannot be traced back to a specific person.

3.7.2 *Hardware*

An ePartner is a supportive entity with an appearance of its own, that operates independently of hardware platforms. The ePartner can thus be accessed on demand on any chosen platform of by the user. However, not all platforms are broadly available yet. Also, interlinking of platforms is still a challenge. In developing ePartners, the availability of these platforms thus has to be taken into consideration. Integration of the ePartner in currently used software or hardware can also increase the chance of implementation.

3.7.3 *Software*

With respect to the software the artificial intelligence is the biggest challenge, but also has the biggest potential. Implementing a relevance-feedback-loop in the ePartner, gives the user the possibility to explicitly or implicitly indicate which data/tips/information are relevant. The ePartner should use this information to deduce which information should be supplied again.

If an ePartner makes use of warning signals, take into account that false positives lead to rejection. Thorough analysis of good thresholds for warning signals is necessary to avoid rejection of the ePartner.

For validation of the software, triangulation can be used, by using sensor measures and checking if these data are correct by administration of questionnaires or using simple Likert-scales.

3.7.4 *Implementation*

Several interviewees gave the advice to start small. Developing an 'all-in' ePartner will cost at least a few decennia. Accelerated valorisation of the ePartner concept can be achieved by using simple principles for the first applications. For the first version of an ePartner it will suffice if it only has a few functions, which can be expanded in due time. This way, the public can get used to the ePartner concept and TNO can get useful feedback and start getting revenues for their investments. The use of an ePartner should also be simple. Companies want a robust product that works immediately after purchase (or after filling in some personal data). Demonstrators as end-result of projects will not suffice if TNO wants to profile itself as expert in the field.

3.7.5 *Business case*

Developing an ePartner is costly, so make sure that there is a solid business case and that the ePartner has high profitability. YES, a concept from TU Delft, can be used as good case practice in how revenues (money and/or work) can be generated from spin-outs. The product can already be marketed when the first application is developed. An additional advantage of this is that the benefits can be reinvested in the further development of ePartners.

4 Future domains

In order to create an overview of possible future domains for ePartners, all information from previous chapters was used as input. Possible ePartner applications and target groups based on issues suggested by interviewees, partly building on current projects, were identified. In a common session with the work package team, all possible applications and target groups were organized around five domains: health, living and travelling, information, learning and working, and safety. Possible applications were also loosely ordered according to technology readiness level (see Figure 4). Brief descriptions of the possible applications are provided in Appendix D.



Figure 4 Overview of ePartner future domains (slices of pie), with target user groups at the outer circle in blue, and possible applications in green. Possible applications are placed according to technology readiness level. Premature ideas are ordered close to the centre, mature ideas are placed on the outer parts of the diagram.

5 Conclusions

The 'ePartners that care' project has shown so far that it is possible to design ePartners in the health care domain, for various users, health problems and health areas. All use cases developed so far describe specific behaviour goals, but they are also linked to generic behaviour determinants and behaviour change techniques (Intervention Mapping). User requirements and claims are ordered hierarchically, offering both more generic and more specific ones. Design patterns are relatively specific for a certain use case, but future 'family trees' may offer more generic patterns. sCE offers a method for systematically documenting use cases, user requirements, claims and design patterns.

The expected direct impact of 'ePartners that care' (behaviour change (towards a healthier lifestyle), healthier living, living (longer) independently) is domain-dependent and should be reformulated for other domains. However, the indirect impact (e.g. trust (in own achievements), increasing motivation, knowledge and insight, control skills), is domain-independent.

Chances for deployment of ePartners in other domains, within and outside of health care, have been collected through interviews with representatives of various TNO societal themes (Defense, Safety and Security, Healthy Living, Energy, Information Society, and Mobility) and co-financers. For all themes, general societal and market developments are described, as well as ePartner development status, knowledge position, knowledge gaps and barriers for implementation. In order to accelerate valorisation of ePartners issues such as privacy and ethics, hardware, software, implementation and a solid business case should be taken into account.

Possible ePartner applications and target groups based on issues suggested by interviewees, partly building on current projects, were identified and organized around five domains: health, living and travelling, information, learning and working, and safety.

All information in this report may serve as inspiration for the development of ePartners in new domains or for new target groups, which adhere to the identified core functions, thereby creating new ePartner uses cases, requirements, claims and design patterns.

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