HCI and User Engagement - Design Guidelines

SAPHE

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Contents

1 Introduction

The purpose of this document is to establish some guidelines for producing usable devices for inclusion in the SAPHE system and identify barriers to acceptance. This document will first discuss design and usability principles and lead on to look at barriers to acceptance. It must be remembered that there are many users of the SAPHE system other than the patient themselves, and the design has to take their needs and constraints into consideration.

2 Design

2.1 Design framework

Don Norman [5] proposed a framework for analysing products to include their attractiveness, their behaviour, and the image they present to the user. These three different aspects of a product were identified with different levels of processing by people:

Visceral design

This is the initial impact to its appearance. This is the first level (immediate) of cognitive processing. This relates to the aspects of design such as looks, feel and smell that we react to before significant interaction has occurred.

Behavioural design

This is about the experience of using a product. It is about function, understandability and usability. This is the middle level of cognitive processing that lets us manage simple, everyday behaviours. Behavioural processing can enhance or inhibit both lower-level visceral reactions and higher-level reflective responses, and conversely, both visceral and reflective processing can enhance or inhibit behavioural processing.

Reflective design

This involves conscious consideration and reflection on past experiences. Most branding takes place at this level. It is about the message of the product. It is about what you feel the product says about you to others. Reflective processing can enhance or inhibit behavioural processing, but has no direct access to visceral reactions. This level of cognitive processing is accessible only via memory, not through direct interaction or perception.

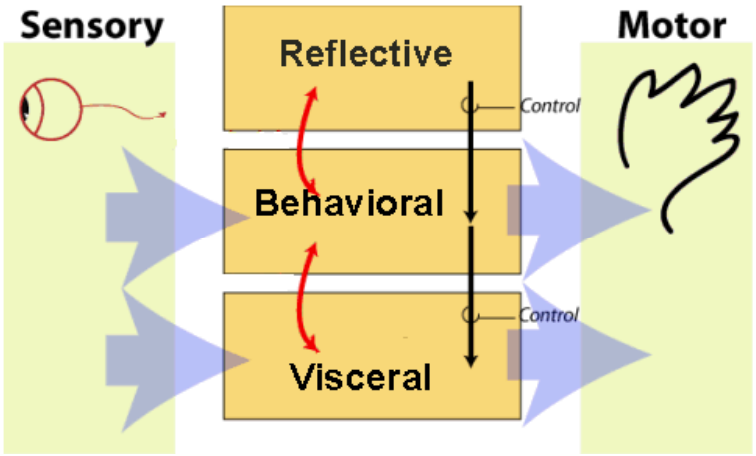

Figure 1 Three levels of processing: Visceral, Behavioural, and Reflective. [2]

2.2 Fit for purpose

Clearly the first consideration of the design is it must fulfill its purpose. How does the device meet the user's needs? What are the tasks they hope to accomplish? How do these tasks fit into the larger system context?

2.3 Design goals

Miller et all [3]suggested some design goals for care systems. These are by no means comprehensive but are good advice for a telecare type system.

2.3.1 Cause no harm

Designing technology to substitute for a human caregiver in the home environment is substantially different than designing other aiding, support or entertainment systems and appliances for the home. The system should maintain or improve the safety of the service user above other quality of life needs. For example, one of the patient's needs a community matron fulfils is the need to avoid isolation. There is a risk that the introduction of a system like SAPHE could reduce the number of visits to the patient. Other services (possibly voluntary services) should be used to fulfil this need.

2.3.2 Accurately convey system capabilities, data, assumptions and limitations

Users should be made aware of the capabilities and limitations of telecare systems. Management of expectations must make sure that the information that provided is taken in to the context of the system. For example stating that the user has taken the medication at a specific time may actually be wrong as all the system knows is that someone took the pill from the pill box.

2.3.3 Avoid depending on the service users for active input of information either at configuration or on an ongoing basis.

Requiring the service users to actively participate in entering information to the system should be avoided, unless there is therapeutic reason. For example entering their own blood pressure readings can be beneficial as the user can get to understand what is normal.

2.3.4 Don't prohibit the service users from providing active input.

While active input from the service users should not be relied upon, especially for safety critical functions, the service users should be capable of adapting and configuring the system to better suit his or her needs. To prohibit this would add to the feeling of being watched and controlled by automation and would, again be a barrier to user acceptance. For example a medication system reminds the patient when to take their pills, but a reminder come right in the middle of Coronation Street, they may want to adjust the timings appropriately.

2.3.5 Design for growth.

Technology moves forever forward and systems should be designed to incorporate them into the telecare environment. New devices will come on to the market and SAPHE should be able to simply add these devices into its system

2.3.6 Design for change

The previous principle emphasized the growth of technology. It is also characteristic of this domain that the user's capabilities will change. These changes will drive the need for modifying, and growing, the capabilities of the system over time. For example being able to read a device display may deteriorate over time and other means of communicating the results may be needed.

2.3.7 Design for variance

People are different, and 'one size fits all' is not a suitable approach. You have to take into account:

- Physical Environment
- Social Environment
- Physical Conditions
- Mental Conditions
- Cultural Factors

2.3.8 Design to enhance quality of life

Users can face several emotionally and mentally stressful losses as they age—the loss of freedom, privacy and convenience associated with impersonal, inept and unhelpful technology need not be one of them. "We should continually seek ways to make the impact of technology as caregiver, be a positive one for the service users that must experience it. After safety and accuracy concerns are addressed, the next question that should be asked about a prospective aiding technology is 'will this make life better for the user?'" To be able to put telecare in the mainstream SAPHE will have to be seen as having benefits beyond caring but giving direct personal benefits.

2.4 Principles of universal design

Principles of universal design were compiled by Connell et all at NC State University: [2] http://www.design.ncsu.edu/cud/about_ud/udprinciples.htm

UNIVERSAL DESIGN:

The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.

2.4.1 PRINCIPLE ONE: Equitable Use

The design is useful and marketable to people with diverse abilities.

Guidelines:

a Provide the same means of use for all users: identical whenever possible; equivalent when not.

b Avoid segregating or stigmatising any users.

c Provisions for privacy, security, and safety should be equally available to all users.

d Make the design appealing to all users.

2.4.2 PRINCIPLE TWO: Flexibility in Use

The design accommodates a wide range of individual preferences and abilities.

Guidelines:

a Provide choice in methods of use.
b Accommodate right- or left-handed access and use.
c Facilitate the user's accuracy and precision.
d Provide adaptability to the user's pace.

2.4.3 PRINCIPLE THREE: Simple and Intuitive Use

Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

Guidelines:

a Eliminate unnecessary complexity.
b Be consistent with user expectations and intuition.
c Accommodate a wide range of literacy and language skills.
d Arrange information consistent with its importance.
e Provide effective prompting and feedback during and after task completion.

2.4.4 PRINCIPLE FOUR: Perceptible Information

The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

Guidelines:

a Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information.
b Provide adequate contrast between essential information and its surroundings.
c Maximize "legibility" of essential information.
d Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions).
e Provide compatibility with a variety of techniques or devices used by people with sensory limitations.

2.4.5 PRINCIPLE FIVE: Tolerance for Error

The design minimizes hazards and the adverse consequences of accidental or unintended actions.

Guidelines:

a Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.
b Provide warnings of hazards and errors.
c Provide fail safe features.
d Discourage unconscious action in tasks that require vigilance.

2.4.6 PRINCIPLE SIX: Low Physical Effort

The design can be used efficiently and comfortably and with a minimum of fatigue.

Guidelines:

a Allow user to maintain a neutral body position.
b Use reasonable operating forces.
c Minimize repetitive actions.
d Minimize sustained physical effort.

2.4.7 PRINCIPLE SEVEN: Size and Space for Approach and Use

Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

Guidelines:

a Provide a clear line of sight to important elements for any seated or standing user.
b Make reach to all components comfortable for any seated or standing user.
c Accommodate variations in hand and grip size.
d Provide adequate space for the use of assistive devices or personal assistance.

3 Usability / accessibility

3.1 Physical limitations

3.1.1 The interface shall be operable by users with limited manual dexterity. Design considerations must include size of interaction components, time-delays of input sequences (i.e. before system prompts for completion of input), tactile feedback. There are a number of factors, which may lead to an individual having limited manual dexterity, the most obvious example being arthritis. However, limited manual dexterity can also be circumstantial, e.g. upon returning home on a cold day, trying to operate interface whilst holding another object in the hand.

3.1.2 The interface shall be operable by users with partial paralysis, e.g. of one side of the body or of lower part of the body. Use of the interface should not require two-handed control (e.g. holding a device with one hand while operating it with the other) where this may be avoided. Design considerations include the impact of using a television-based interface requiring use of a remote control. Users may have suffered a stroke, or a series of strokes, resulting in partial paralysis.

3.1.3 The interface shall not require users to reach too high/low, i.e. to operate wall mounted controls. Unnecessary over-reaching, high or low, could lead to falls. Where possible, wall mounted controls should be placed at an acceptable height for each user.

3.1.4 The design of the interface should be sensitive to the range of mobility likely to be experienced by the target population. Examples include the use of a wheelchair, walking frame or walking stick.

3.2 Sensory limitations

3.2.1 The core features of the interface should be accessible to a blind user, e.g. through an audio interface. Although a blind person may have specific care/telecare needs, there is no reason in principle why this system (designed to 'monitor activity in the home' or to 'detect change in activity trends') could not be used in the home of a person who has been blind for much of their life but has now developed other health problems which threaten their independence and require monitoring. As for use of the interface, it is clear that advanced features such as data visualisation are inherently 'visual', however, summary reports of these features are likely to be preferable for some users anyway, regardless of visual impairment. Thus, these summaries should be made accessible to blind/partially-sighted users.

3.2.2 The interface should be accessible by visually impaired users, including partially sighted and colour-blind users. Within the context of the trial such requirements may be relaxed and instead form part of subsequent productisation. Age-related decline in visual acuity means that small text can be difficult to make out. Poor colour contrast also presents a problem, for colour-blind people of any age, but in particular age-related decline in vision can affect a persons ability to distinguish between different shades of the same colour, e.g. Light blue on dark blue.

3.2.3 The core features of the interface should be accessible to a deaf user, e.g. through visual alternatives to any audio cues or prompts. Like blind users, deaf people may have specific care/telecare needs, but there is no reason in principle why this system could not be used in the home of a deaf person who has grown old (or for that matter, a person who has become deaf in their old age) to monitor activity in order to assist their independence. As for use of the interface, any use of audio, e.g. to act as a reminder to perform a task at a set time, should be complemented by a visual cue such as a flashing bulb.

3.2.4 The interface should be accessible by hearing impaired users. It is highly likely that a significant proportion of the target users of this system will have experienced some age-related decline in hearing. As for those users who are deaf, visual cues should be used to complement any audio used in the interface to the system.

3.3 Cognitive decline

3.3.1 The interface should be accessible by users who have experience a decline in short-term and/or working memory. At the age of 60 years, about 1% of the population is diagnosed with dementia. This then doubles for every subsequent 5 year age band, e.g. 4% at 70, 16% at 80. As such, it is imperative that the design of the interface takes this characteristic into consideration. [4]

- Recognition rather than recall
- Keep options concise
- One task at a time
- Provide cues for input

3.3.2 The interface should be accessible by users who have experienced a decline in speed of cognition. Task performance by older users tends to be adversely affected when time constraints (real or imagined) are imposed. As such, users should be able to complete tasks at their own pace wherever possible. Importantly, a greater proportion of the extra time needed by older people for task completion is due to age related declines in sensory systems, such as hearing and vision, rather than cognitive impairment per se. Therefore, designing the interface to be accessible to users with limited hearing and vision will reduce overall interaction time. Ultimately though, decline in speed of cognition will cause some users to require more time for interaction tasks, so the interface should be designed to allowed for this. Related requirements: Visual Impairment, Hearing Impairment, Recognition rather than recall, keep options concise, one task at a time, provide cues for input.

3.3.3 The interface should be accessible by users who have experienced a decline in selective attention. Selective attention allows us to focus on the important aspect of a given task, while ignoring irrelevant parts. “The efficiency of selective attention is markedly diminished in most forms of cognitive impairment”. Design considerations include making sure that interaction tasks are free of distractions or interface 'clutter'. Also, more critical tasks as well as prompts and reminders must be designed to grab and hold the users attention where they might otherwise become distracted. [4]

3.4 Attitudinal

3.4.1 The system should be designed such that it may be considered successful even if user engagement is low or nil. While it is likely that many users will wish to interact with the system proactively, this should not be critical to the 'success' of the system, i.e. the goal of monitoring activity and reporting issues of concern to a carer ought to be attainable without active user engagement.

3.4.2 The system should be designed such that the user can become proactively involved in the monitoring of their activities and lifestyle. Although it should not be critical to the success of the system, user involvement should be possible when desired by the user. More consideration must be given to the extent of this engagement, i.e. whether the user is able to self-report aspects of their state of health and well-being, or whether user engagement is limited to interactive reporting of data from sensors etc.

4 Interaction design

4.1 General design principles

The following sections present general design rules for use within SAPHE. It should be noted that these rules present ideals that in reality can be mutually exclusive. (based on '*design basics*' from IBM : http://www-03.ibm.com/easy/page/6

4.1.1 Simplicity

Users benefit from functionality that is easily accessible and usable. The interface should support the user's tasks and allows the user to work efficiently.

It should be obvious how to use the device for the novice user, but be still be able to meet the needs of the more advanced user. This is specifically important with in connection of telecare as the assumption that you can do it today does not mean that you will be able to do it tomorrow their tasks.

4.1.2 Support

Technology is there to support the individual. The support needs to be appropriate and timely. It also needs to enable the user be in control rather than be controlled. The system should let you know the context of any action as well as the options available. I.e. where you have come from and what you can do next. The user should not be required to remember the system's state or commands. The system's state and permissible commands should be made clear to the user.

All messages to the user should be constructive and use language and vocabulary with which the user familiar.

4.1.3 Familiarity

It is important to provide a familiar metaphor to enable the user to quickly comprehend the system. The system should maintain a consist approach though out. Real world experiences should be called upon to reinforce the metaphor. By being consistent with something the user already understands, the interface can be made easier to learn, more productive, and even fun to use.

4.1.4 Encouragement & Satisfaction

Firstly every action should be acknowledged in some way (visible or audible) by the system in a way the user expects. Each action should be reversible. Actions which aren't reversible should be confirmed by the user. This encourages the user to explore, knowing that no 'damage' can be done accidentally.

Feedback is an important aspect of encouragement and can give satisfaction as it allows the user to enjoy a sense of accomplishment. Immediate feedback allows users to assess whether the results were what they expected and to take alternative action immediately.

4.1.5 Timely and appropriate interventions

Try not to restrict the user's ability to interact with the system to enforce behaviour. It is important for the user to allow the system to fit in with THEIR behaviour. Intervention should be timely in ain context of their current activity. E.g. there is little point in reminding someone to take their blood pressure when they are out shopping.

4.1.6 Safety

Keep the user out of trouble by constructive error handling. Firstly protect the user from making errors. Any interface should provide visual cues and reminders.

4.1.7 Versatility

Allow users to choose the method of interaction that is most appropriate to their situation, or abilities. Each interaction device should be optimised for use, and will differ from device to device. Ideally users should be able to switch between interaction methods. Providing a range of interaction techniques recognizes that users are individuals with different abilities and situations. The differences include disabilities, preferences, and work environments.

4.1.8 Personalization

Different users have differing requirements. The system needs to accommodation of novice and experienced users. By the nature of telecare users will change their abilities and hence the system may need to be tailored to take this in to account. Remember no two users are exactly alike. Customisation can also help make an interface feel comfortable and familiar.

4.1.9 Aesthetical

The aesthetic or visceral aspect of design can have an impact on the acceptance of product. Telecare systems have problem with the ‘acceptability’ and user have a perceived problem of stigmatisation. The following are visual design principles that promote clarity and visual simplicity in the interface:

- Subtractive design - reduce clutter by eliminating any visual element that doesn't contribute directly to visual communication.
- Visual hierarchy - by understanding the importance of users' tasks, establish a hierarchy of these tasks visually. An important object can be given extra visual prominence. Relative position and contrast in colour and size can be used.
- Affordance - when users can easily determine the action that should be taken with an object, that object displays good affordance. Objects with good affordance usually mimic real world objects.
- Visual scheme - design a visual scheme that maps to the user model and lets the user customize the interface. Do not eliminate extra space in your image just to save space. Use white space to provide visual "breathing room."

4.2 Hardware considerations

In this section we present requirements relating to the characteristics of system hardware which the carers and will interact with. At this early stage, these ought to act as 'guiding principles' of interface design. When we have consulted target users and consequently have a clearer idea of what the system is aiming to achieve, then a more specific set of requirements can be produced.

Many of these suggestions come from IBM's Developer guidelines for hardware accessibility, at: http://www3.ibm.com/able/guidelines/hardware/accesshardware.html

Decisions need to be made on how the will feedback be delivered to the client? Via:

- PC/PDA/TV/custom device,
- (formal/informal) carer (via one of the above),
- printed summary (output),
- questionnaires (input)?

4.2.1 Any screen-based devices shall provide sufficient screen lighting to ensure high contrast between foreground and background colours on the interface.

4.2.2 Any buttons, switches knobs etc should provide tactile feedback upon operation, e.g. a clear click to indicate change of state.

4.2.3 Colour should be used as an enhancement rather than as the only means of conveying information, e.g. Press the 'red' button.

4.2.4 Where we have a say in device selection, consideration should be given to the size of controls, such that they may be operated by those with limited manual dexterity.

4.2.5 Where an interface is accepting input in the form of a sequence of key presses, consideration must be given to the delay for key repeats. e.g. When the key is held down, there ought to be an appropriate delay before it is interpreted as a repeat key press. This supports those with limited manual dexterity who may require longer to press each key. More specific requirements on this will be possible when the functionality of the interface becomes clear.

4.2.6 Avoid combination key presses wherever possible – i.e. a sequence of individual key presses would be preferable to holding down three keys simultaneously.

4.3 Software design considerations

As with the hardware, these requirements relating to the characteristics of the software interface should be treated as 'guiding principles', rather than concrete requirements until we have consulted with target users on what is needed from the system.

4.3.1 The interface should avoid placing time limits on interaction tasks where this can be avoided, instead allow them to complete a task at their own pace.

Exceptions include where a critical task has been left incomplete for a significant length of time, whereupon appropriate prompts and cues could be used.

4.3.2 The user should not be expected to memorise interaction sequences, instead, at every stage, clear options or instructions should be given to enable them to 'recognise' the right path.

4.3.3 Simple steps in an interaction task: make choices as simple as possible, rather than extensive lists of options.

4.3.4 Make it clear to the user where they are in the interface, i.e. if they are midway through a sequence of interaction, where possible, make it clear how they got there.

4.3.5 Provide a means of abandoning current task for users who become lost or confused in the interface, an escape mechanism should be available.

4.3.6 Seek confirmation of choices for important tasks

4.3.7 Adaptive to inferred information - Highly speculative - Could the interface be responsive to the data analysis, e.g. If the data analysis is suggesting a reduction in activity that might hint towards an onset of depression, could the system act more in accordance with design guidelines for people with depression. Similarly for other recognisable trends. Could it? Possibly. Should it? Definitely No. Any attempt to usurp the role of trained professionals in, say, diagnosis, is likely to be very risky for patients and to alienate medical professionals.

4.3.8 Language and terminology - “The use of language in an interactive system should be given careful consideration and the syntax and vocabulary should be kept as straightforward and ‘everyday’ as the context allows. This is particularly pertinent for any form of instruction. If the requirements of a particular stage of an interaction cannot be captured in a few simple concrete statements, then serious consideration should be given to redesigning the interaction itself. Similarly any on-screen display should be kept as uncluttered as practicable and wherever possible should present the user with only a single issue (menu, subject, decision etc.) at any particular point in time. Similarly, but at a larger scale, progression through an interaction should be kept, again wherever practicable, as linear as possible. That is, the user should only need to consider one ‘thing’ at a time. Any requirement to deal with different ‘things’ in parallel will markedly increase the possibility of errors and general user dissatisfaction (Detterman et al., 2000; Salthouse, 1985).” Newell, Carmichael etc. “Among the limitations in verbal ability is the diminution of vocabulary. Particular difficulties have also been found in the comprehension of abstract and metaphorical phrases, with the tendency being to take them literally. Such conditions can develop into more ‘global’ aphasia (e.g. Broca’s aphasia, related to the production of speech and Wernicke’s aphasia, related to comprehension). There is also a likelihood that the general difficulty with recall of proper nouns, found in ‘normal’ aging, can develop into more profound anomia. The depth of such problems may not be apparent to an outside observer as the ability to read

aloud may be well preserved, regardless of the extent to which the content is properly understood and/or subsequently remembered [4]

4.3.9 Error correction - “Even with the best design efforts, however, such problems are likely to make users with cognitive impairment relatively error prone. It is thus very important to ensure the interactive system allows for error correction in an easy to use form. Also, to ensure that the user spots such errors, the system should provide feedback regarding user actions and where appropriate elicit active confirmation from them.” [4]

4.3.10 Transitions / Animations – Animations should be there to reinforce the interaction metaphor. Speed of animation should be such that it does not detract from the interaction performance.

4.3.11 Fonts – Fonts should be clear and legible by target audience. Tiresias Font (see http://www.tiresias.org/fonts/index.htm) has been specifically designed for legibility.

[1] Do not use red text on a green background or yellow text on a blue background.
[2] Avoid patterned backgrounds for text.
[3] It is easier to read text in upper and lower case than all capital letters.
[4] Avoid using underlining since it makes the text harder to read by interfering with decenders.
[5] Italics are more difficult and slower to read so minimise their usage.
[6] Left justified text is easier to read.

5 Generic Barriers to Acceptance

5.1 Psychological Barriers

There are a number of psychological issues to the acceptance. The use of persuasive technologies can be used to overcome some of these (see Literature Study and Prototyping documents).

5.1.1 Benefits

The first point to be considered is “How does this benefit me?” The benefits must be in a tangible form that helps the user attain their objectives. These objectives may not be the primary purpose of the device, but will engage users to want to use it.

5.1.2 Expectations

It is important that the benefits and limitations of any device or system are clearly communicated.

5.1.3 Empowerment

Generally people need feel in control. They do not like having decisions enforced upon them. For example allowing patients to be an active part of the care plan allows them to be empowered to act (or not act) when needed.

5.1.4 Inconvenience

People do not like to have extra tasks placed unless there is a clear benefit to them.

5.1.5 Fear and Anxiety

People sometimes lack confidence in their own abilities/capabilities. The 'newness' of any technology can cause anxiety. They can worry about breaking the technology, the technology going wrong, or the technology not working.

Fear of isolation can be also be a barrier and any device should not aggravate this fear. It may be perceived that the technology is being used to save money or the need for patient contact.

There can also be the fear of 'big brother' is watching you so communicating exactly what is data is being sent for what purpose is important. See 5.5 Privacy and Security.

5.1.6 Habits and living in the past

Habits and routine are important to people as it gives them reassurance and makes them feel more comfortable. Where possible devices should be flexible to fit into the users routine.

5.1.7 Economic

People will weight the cost of a device/service against the perceived benefit.

Time and effort is an issue for all stakeholders and this will have an economic component as well as an inconvenience issue.

5.1.8 Denial

It must be understood that nobody really wants telecare. Acceptance o f telecare can only come after the acceptance of their condition.

5.1.9 Stigmatisation

The use of assistance technology can establish real or perceived stigmatisation of its user.

5.2 Physiological Barriers

The user has to actually use the device. It must require mobility and agility that is with the users ability. See 3.1 Physical limitations and 3.2 Sensory limitations.

5.3 Cognitive Barriers

The user has to be able to use the device / system and understand and remember what they have to do to use it. See 3.3 Cognitive decline. Devices must also take into account the impact of gradual cognitive decline associated with old age.

5.4 Wearable Sensors

Because of the physical presence of 'wearable' sensors on the body, the psychological, cognitive and physiological issues become more apparent. Because of the long term, continual use, the aesthetics and ergonomics of the sensor become critical to long term acceptance. It will be a great deal easier to achieve compliance over a short period with a clear benefit and Goal. For example wearing and SPO2 ear monitor for 48 hrs (say) to establish the need for provision of oxygen in the home.

5.5 Privacy and Security

Fear of who is using the data generated and what decisions are being made may be an issue. There is always the fear that when something is measured the results will be used to remove services.

People may perceive that the data generated is their data and they should have control of who sees it.

Concerns of safety and security are possibly were telecare can help, but it must not be forgotten the 'internet' type technologies have a reputation for fraud and abuse.

5.6 Data in Context

An important part of the interaction will be the timeliness of responses. Clearly medication alerts while your shopping may not be useful, and may lower your opinion of the system. Asking Question need to be asked at the appropriate time. For example asking home you slept is may not be appropriate at Tea time. The use of simple mechanisms for specific questions may be better for compliance. E.g. A simple touch pad asking the question –

5.7 Information

Data needs to be provided as information. For professional carers speed, accuracy, trust and conformance with existing processes and expectations is important to acceptance.

6 User Case Tasks

The section presents the analysis of existing scenarios described in section 3 of Service Usage Scenarios [1]. These are mapped against a number of barriers in the following tables. Each task is then highlighted with XXXX if it is considered that this barrier can be an issue. Please see the Appendix A User Case Tasks for the analysis notes. This should be a useful tool for developers to aid them in their design, by highlighting what barriers they need to consider.

Type		Use	Event	Psychological Barriers 5.1	Physiological Barriers 5.2	Cognitive Barriers 5.3	Wearable Sensors 5.4	Privacy and Security 5.5	Data in Context 5.6
Activities	Activity level	To detect changes in behaviour	3.1	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Activities	Leaving/returning home	Detect wandering	7.1	XXXX	XXXX	XXXX	XXXX	XXXX[1]	XXXX
Activities	Sleep	Identify related problem	1.1	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX[2]
Activities	Sleep, toilet	Detect UTI	2.1	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Activities	Meals	Confirm SU is eating ok	1.3	XXXX					
Falls		Detect falls	5.1	XXXX	XXXX	XXXX	XXXX		XXXX
Clinical	COPD	Condition management	6.1	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Clinical	Weight, BP	General health indicators	1.2	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Clinical	Temperature	Detect hypothermia	4.1	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Medication		Medication compliance and optimisation	1.4	XXXX	XXXX	XXXX			XXXX
Information/ reassurance		Assist SU with understanding own condition/symptoms	9.2	XXXX	XXXX	XXXX		XXXX	XXXX
Alarm/ reassurance		Increase SU confidence in ability to live independently	6.2	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Other	Well-being		11.1	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Other	Earlier discharge		2.3	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Other	Reminders		1.5	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

[1] "Can anyone tell if I left the house?"
[2] Ask questions about sleep when the person gets up.

Type		Use	Event	There may be issues of timeliness of any notification/ alerts going to the carer.	Soliciting feedback at the right time is an important aspect in engaging people.	It may be more difficult to see the benefits if the user has to comply over a long time	Possible confusion over role of device(s)
Activities	Activity level	To detect changes in behaviour	3.1			XXXX	
Activities	Leaving/returning home	Detect wandering	7.1	XXXX			
Activities	Sleep	Identify related problem	1.1		XXXX	XXXX	
Activities	Sleep, toilet	Detect UTI	2.1		XXXX		
Activities	Meals	Confirm SU is eating ok	1.3		XXXX		
Falls		Detect falls	5.1	XXXX			XXXX
Clinical	COPD	Condition management	6.1		XXXX		
Clinical	Weight, BP	General health indicators	1.2				
Clinical	Temperature	Detect hypothermia	4.1	XXXX			
Medication		Medication compliance and optimisation	1.4	XXXX	XXXX		
Information/ reassurance		Assist SU with understanding own condition/symptoms	9.2		XXXX		
Alarm/ reassurance		Increase SU confidence in ability to live independently	6.2				XXXX
Other	Well-being		11.1			XXXX	
Other	Earlier discharge		2.3	XXXX	XXXX		
Other	Reminders		1.5				

Type		Use	Event	Need to input textual information other than simple choices	Understanding that service is not being offered to save cost.	Need to get feedback on progress	
Activities	Activity level	To detect changes in behaviour	3.1				
Activities	Leaving/returning home	Detect wandering	7.1				
Activities	Sleep	Identify related problem	1.1				
Activities	Sleep, toilet	Detect UTI	2.1				
Activities	Meals	Confirm SU is eating ok	1.3	XXXX			
Falls		Detect falls	5.1				
Clinical	COPD	Condition management	6.1			XXXX	
Clinical	Weight, BP	General health indicators	1.2			XXXX	
Clinical	Temperature	Detect hypothermia	4.1				
Medication		Medication compliance and optimisation	1.4				
Information/ reassurance		Assist SU with understanding own condition/symptoms	9.2				
Alarm/ reassurance		Increase SU confidence in ability to live independently	6.2				
Other	Well-being		11.1				
Other	Earlier discharge		2.3		XXXX	XXXX	
Other	Reminders		1.5				

Type		Use	Event	From the professional carers point of view the information has to useful. They have very little time to spend analysing data so it needs to fit with their needs to be quick but thorough.	The informal carers point of view the information needs to be concise and appropriate	Installation / de-installation work.(Time and effort as well as impact on the home. Cables, holes etc.) Inconvenience to the Service User (SU).	Lack of proven record. Trust in the service.	Cost may be incurred by different organisations that are seeing reduced costs.
Activities	Activity level	To detect changes in behaviour	3.1	XXXX	XXXX		XXXX	
Activities	Leaving/returning home	Detect wandering	7.1	XXXX	XXXX		XXXX	
Activities	Sleep, toilet	Detect UTI	2.1	XXXX	XXXX		XXXX	
Activities	Meals	Confirm SU is eating ok	1.3	XXXX	XXXX		XXXX	
Falls		Detect falls	5.1	XXXX	XXXX		XXXX	
Clinical	COPD	Condition management	6.1	XXXX	XXXX		XXXX	
Clinical	Weight, BP	General health indicators	1.2	XXXX	XXXX		XXXX	
Clinical	Temperature	Detect hypothermia	4.1	XXXX	XXXX		XXXX	
Medication		Medication compliance and optimisation	1.4	XXXX	XXXX		XXXX	
Information/ reassurance		Assist SU with understanding own condition/symptoms	9.2	XXXX	XXXX		XXXX	
Alarm/ reassurance		Increase SU confidence in ability to live independently	6.2	XXXX	XXXX		XXXX	
Reassurance	Informal Carer	Reassure concerned informal carer	1.7		XXXX		XXXX	
Information	Professional Carer	Determining care needs	8.1	XXXX	XXXX		XXXX	
Other	Well-being		11.1	XXXX	XXXX		XXXX	
Other	De-installation		7.3			XXXX		
Other	Earlier discharge		2.3	XXXX	XXXX		XXXX	XXXX

7 External Links

7.1 NHS Common User Interface (CUI) programme

The NHS and connecting for health have web a site "NHS Common User Interface (CUI) Programme" https://www.cui.nhs.uk/Pages/NHSCommonUserInterface.aspx.

This site has a number of design guidelines dealing with:

- Abbreviations
- Accessibility
- Alert Symbols
- Information Display
- Information Entry
- Medications Management
- Terminology

Note this is a site that requires registration to look at the guidelines.

7.2 MDDS (formerly CATCH)

The MDDS (A Method for Dependable Domestic Systems) has been developed by Guy Drewsbury (http://www.smartthinking.ukideas.com/MDDS.html). It is a checklist designed to assist in the choice of assistive technology system to meet the needs of an older person in their home.

MDDS checklist asks a number of questions in a number of areas covering the technology, the environment and the person. The checklists are spit into different topics See Figure 2: each checklist is split into three sections

1) "Key Questions" which are simple questions related to the topic.
2) "System Related Questions" which are related directly to the devices and the technology systems. These tend to be somewhat technical but are the type of questions that need to be asked to potential providers of the decided system as they will all effect how the system operates with the user.
3) "User Related Questions" which are the questions that are required to be asked about how the system will interact with the user as well as the use of the system by the user. These might range from simple observational instructions (that anyone can do) through to more complex professional assessment based questions that might require professional opinions (this is also a good way of opening dialogues with professionals that might not have been consulted at this early stage).

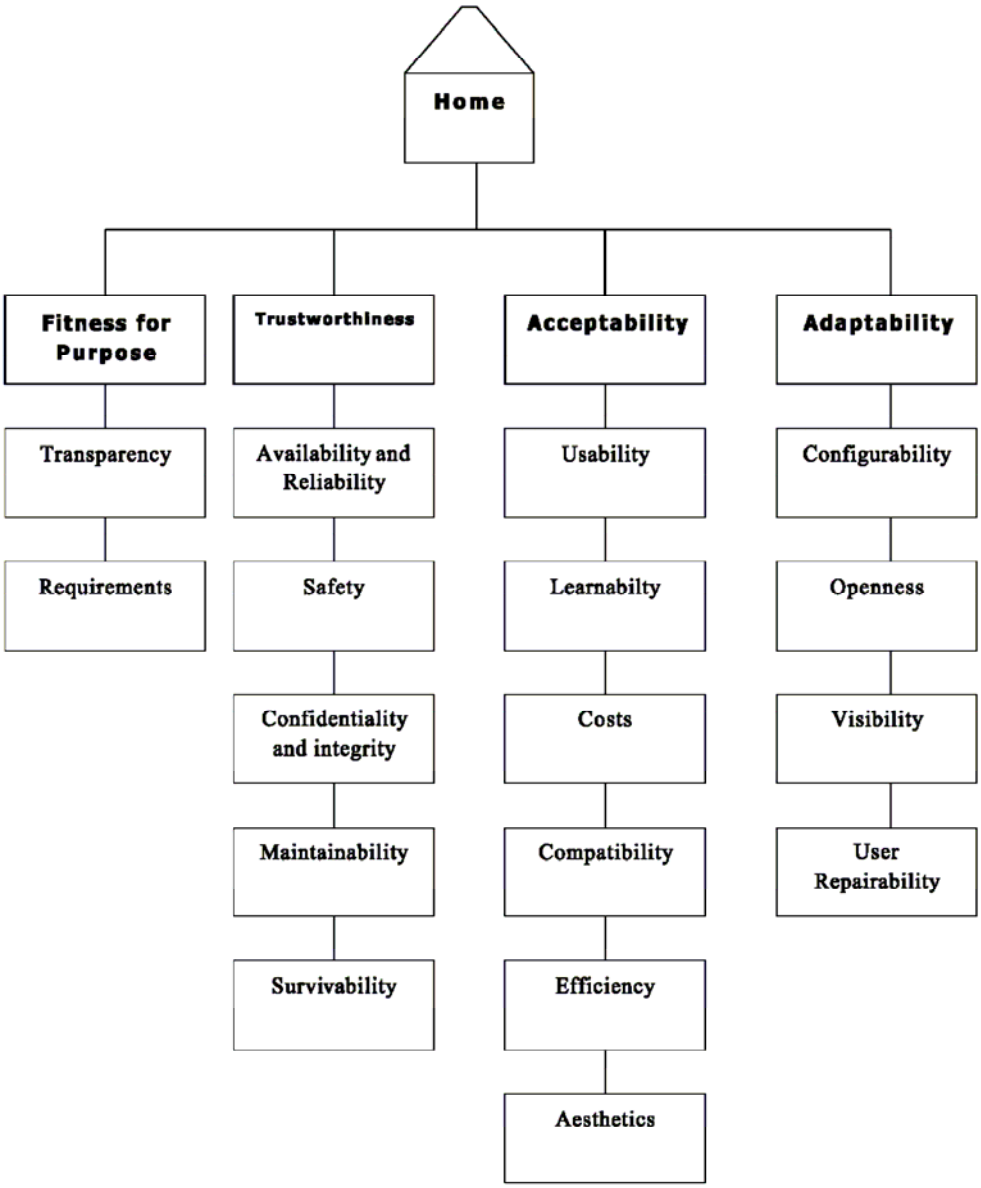

Figure 2 The Dependability Model of Domestic Systems

8 References

[1] Barnes, N, Service Usage Scenarios, SAPHE delivery D03 Issue 1.0

[2] Connell B C, Jones M, Mace R, Mueller J, Mullick A, Ostroff E, Sanford H, Steinfeld E, Story M, & Vanderheiden G, The Center for Universal Design (1997). *The Principles of Universal Design*, Version 2.0. Raleigh, NC: North Carolina State University.

[3] Miller C A, Haigh K, Dewing W “First, Cause No Harm: Issues in Building Safe, Reliable and Trustworthy Service users Care Systems”, American Association for Artificial Intelligence, 2002

[4] Newell A, Carmichael A, Gregor P and Alm N. “Information Technology for Cognitive Support (pdf)” The Human-Computer Interaction Handbook 2. 464-481 (2002)

[5] Norman, Donald A, Emotional Design, Basic Books, 2004

9 Revision History

Revision	Date	Details	Editor
01	14/02/2007	First iteration for review	Simon Rimmer
02	28/02/1007	After feedback, and addition of external links.	Simon Rimmer
03	01/03/2007	Added the barriers document to this document	Simon Rimmer
04	03/03/2007	Added look up table and moved activity analysis to Appendix	Simon Rimmer
05	06/03/2007	Updated after review. ready for release	Simon Rimmer

Appendix A User Case Tasks

This section presents the analysis of existing scenarios described in section 3 of Service Usage Scenarios [1]. The analysis of each of the barriers to acceptance for these events is given in the following tables.

Activities (activity level)	
USE – To detect changes in behaviour (event 3.1)	
Role for SAPHE	Identify abnormalities in activity data at the earliest possible stage; to provide supporting physiological measurements, which may help with diagnosis.
Sensors	Both environmental and wearable sensors can provide indications of gross activity level.
Collection (input) of info from user	
Data analysis	Abnormal pattern detection in robust evidence based manner
Provision (output) of information to stakeholders	Important that changes are proactively flagged to appropriate carer
Improvement in outcome	Quicker identification of problems resulting in less advanced medical conditions, leading to quicker recovery time and fewer secondary related problems (e.g. falls)
Involvement of stakeholders	Carers notified of change in behaviour
Limitations	Still identification of problem only and may take some time for problems to be evident from activity data.
Comment (assumptions, issues etc.)	
Barrier to acceptance	**Wearable sensors have their own issues see 5.4.** **There are a lot of problems getting people to wear their pendant alarms. They forget. It would be useful to help them establish a routine of wearing them.** **Stigmatism can be an issue and wearable sensors can be "a badge of infirmity".** **Denial of their own infirmity may be a barrier to acceptance but having clear benefits in terms of others may help. E.g. To stop the primary carer from worrying.** **Environmental sensors can generate issues of privacy. It may be difficult to show a tangible benefit to the user to gain their participation.** **People are reluctant to be "watched". The Big brother effect. This is particularly an initial reaction.** **There is a need to have clear benefits. An example of the loyalty card that is collecting a lot of information about your buying habits but most people are willing to participate because of the clear financial benefit.** **There may be issues of timeliness of any notification going to the carer.** **The Coronation Street Effect. There is a possibility to get telecare perceived as mainstream by getting it represented on favourite shows such as Coronation Street.**

Activities (Leaving/returning home)	
USE – Detect wandering (Event 7.1)	
Role for SAPHE	Similar to above richer data set should allow leaving home to be more accurately detected; it may be possible to track a wandering SU outside of their home; data from prior to wandering may help to identify triggers; may be possible to issue reminders to go back to bed if SU gets up in night e.g. to watch TV, not to go out, etc
Sensors	Identifying when the SU leaves the home is likely to be done by environmental sensors (e.g. 'blob', PIR, door contact). Wearable sensors may track the SU outside of their home.
Collection (input) of information from user	
Data analysis	Simple collating of door events; location and blob tracking; ADL inference; trending
Provision (output) of information to stakeholders	Informal or professional carers
Improvement in outcome	Fuller picture of ability to live independently in own home; reassurance for carers that they do not have to watch over SU
Involvement of stakeholders	Reduced carer involvement watching over SU; carers look for triggers in data; carers look at trends in data.
Limitations	Flagging wandering but not preventing it, in theory a system could lock the doors in the house at night but this would raise ethical and safety questions. The system can't explain to her that she is wandering or force her to stay inside, but it can alert her and her carers to the fact
Comment (assumptions, issues etc.)	A full SAPHE system may less appropriate if only looking when looking for limited specific information or if the system only needs to be in place for a short period of time to gather sufficient information.
Barrier to acceptance	**Wearable sensors have their own issues see 5.4.** **Environmental sensors can generate issues of privacy. It may be difficult to show a tangible benefit to the user to gain their participation.** **Issues of trust and false alarms.** **There may be perceived issues of security – "can anyone tell that I have left the house".** **There may be issues of timeliness of any alerts going to the carer.**

Activities (sleep)	
USE – identify related problem (Event 1.1)	
Role for SAPHE	Identification of abnormal period of time in bed.
Sensors	Likely: Environmental, e.g. bed occupancy, PIR, 'blob'. Possible: Body, e.g. accelerometer
Collection (input) of information from user	No user input for environmental. Potential to solicit feedback on quality of sleep via questionnaire, e.g. "how did you sleep?"
Data analysis	Learn typical wake up time; look for trends in sleep patterns which may be indicative of emerging problems
Provision (output) of information to stakeholders	Alert of failure to wake up; Alert of changing trends in sleep patterns e.g. wake up times
Improvement in outcome	Additional flexibility makes the solution less intrusive for SU; potential for sleep patterns to stimulate further investigation as they may be indicative of emerging medial conditions
Involvement of stakeholders	
Limitations	May still raise alerts when SU has genuine reason for remaining in bed – as with all alerts SU should be able to disable them
Comment (assumptions, issues etc.)	Monitoring sleep could have wider implications for well-being.
Barrier to acceptance	**Wearable sensors have their own issues see 5.4.** **Environmental sensors can generate issues of privacy. It may be difficult to show a tangible benefit to the user to gain their participation.** **Soliciting feedback on sleep may ideally should be done at getting up time.** **The use of simple mechanisms for specific questions may be better for compliance.** **E.g. A simple touch pad asking the question -** **How did you sleep?**  **There may be issues of timeliness of any alerts going to the carer.**

Activities (sleep, toilet)	
USE – detect UTI (Event 2.1)	
Role for SAPHE	UTI may be detected by symptomatic changes in activities e.g. disturbed sleep, increase toilet usage; perhaps physiological changes would also be detected.
Sensors	Environmental – PIR, 'blob', bed occupancy Wearable – possibly to detect physiological changes
Collection (input) of information from user	Understanding of typical patterns could initially be based on SU input, with the system revising them as it learns her behaviour. Potential feedback from service user on quality of sleep, disturbances etc.
Data analysis	Flag abnormality in activities (sleep, bathroom usage, other). This requires system to learn typical patterns.
Provision (output) of information to stakeholders	Notification of change in activities to carers. Clinicians may also be informed of problem and will be involved in diagnosis.
Improvement in outcome	UTI problem diagnosed early to prevent condition worsening or other detrimental events such as falls. SAPHE improves outcome by automatically flagging that a cause for concern exists possibly allowing for earlier detection.
Involvement of stakeholders	Clinician (e.g. GP)/carers made aware of potential problems before they become serious
Limitations	SAPHE can only highlight a problem exists which may have multiple possible diagnosis
Comment (assumptions, issues etc.)	Limitation mentioned above could have wider implications – the system may effectively flag that there is a problem but ideally data would be available diagnosis.
Barrier to acceptance	**As for Activities (sleep)** **There could be issue of 'the taboo of the toilet' and people not wanting to discuss their toilet habits. Reassurance that this is used only by the professional carers may help.**

Event 1.3 – Activities (meals)	
USE – confirm SU is eating ok	
Role for SAPHE	Increased reliability in meal detection
Sensors	Environmental – possibilities including IR, vibration, PIR, 'blob', appliance Wearable?/ 3rd Party scales
Collection (input) of information from user	Self-reporting a possibility
Data analysis	Fuse kitchen sensor data; trending for meals – missing single meal may not be a problem; look for trend in weight.
Provision (output) of information to stakeholders	All carers may be interested in meal data
Improvement in outcome	Increased reliability in detection and intelligent analysis to help identify persistent problem rather than single missed events
Involvement of stakeholders	Carers notified of cause for concern and need for further investigation.
Limitations	Reliability of meal detection could still be an issue – how do we know the SU is not making food and deciding not to eat it. Use of weight should help to overcome this limitation.
Comment (assumptions, issues etc.)	Validation of meal detection could be an issue. Could extend to take account of balance between food, weight and activity (energy expenditure).
Barriers to acceptance	**Self-reporting can be problematic if the SU does not see the direct benefit, particularly over the long term.** **Need to be careful how much detail you want as then questions can become a serious barrier over the long term.**

Falls	
USE – detect falls (Event 5.1)	
Role for SAPHE	To provide fall detection support for any where in the home, at any time, in a more flexible manner. Possible also intelligence can be used to indicate changing mobility (e.g. monitor gait, changing timescales for moving around her home etc) and need for assistive device. Underlying problems may be identified by other routes (e.g. physiological data) allowing for fall avoidance. Data for period leading up to fall event may be of use in understanding why it occurred.
Sensors	Environmental – 'blob', PIR, bed occupancy Wearable – accelerometer based fall detection; physiological for identifying potential problems before a fall occurs.
Collection (input) of information from user	Need to understand her typical patterns, this could be initially based on her comments, with the system revising them as it learns her behaviour
Data analysis	Fall motions from accelerometer; 'blob' analysis; possibly detection of abnormal lack of activity; gait analysis; in home movement patterns
Provision (output) of information to stakeholders	Priority fall alerts likely to go to CCC to ensure timely response. More subtle indicators (e.g. increasing fall likelihood, evidence of repeated falls) may go to carers; clinicians may have interest in data prior to fall to help with cause identification
Improvement in outcome	Quicker response to falls (leading to fewer additional problems); detection independent of location or time of day; may be able to prevent the fall from happening in the first place;
Involvement of stakeholders	Carer made aware of changing behaviour prior to fall; responding to fall alarms; possibly user to attach wearable sensor
Limitations	Many factors could contribute to a fall so it would be unlikely that system could prevent them all
Comment (assumptions, issues etc.)	
Barriers to acceptance	**This maybe the easiest use case to present as benefits as this tend to be a significant fear.** **Wearable sensors have their own issues see 5.4.** **Environmental sensors can generate issues of privacy. It may be difficult to show a tangible benefit to the user to gain their participation.** **There may be issues of timeliness of any alerts going to the carer.** **There may be confusion over the role if this is to sit beside existing alarm buttons. "If I fall do I raise an alarm or do I wait for the alert to get someone to contact me?"**

Clinical (COPD)	
USE – condition management (Event 6.1)	
Role for SAPHE	Richer picture through the provision of continuous long duration physiological data combined with contextual information
Sensors	All, including 3rd party COPD specific devices
Collection (input) of information from user	All
Data analysis	Long-term trending; abnormal feature extraction
Provision (output) of information to stakeholders	Clinical information likely to be of most value to professional carers e.g. GP, community matron
Improvement in outcome	Better understanding of condition and condition triggers
Involvement of stakeholders	Main stakeholder involvement likely to be professional with clinical knowledge e.g. GP, community matron
Limitations	May take significant time for professional carer to understand the information made available to them
Comment (assumptions, issues etc.)	Danger of providing too much/irrelevant information; need to ensure alignment between information provided and information seen as useful by care professional
Barriers to Acceptance	**Wearable sensors have their own issues see 5.4.** **Environmental sensors can generate issues of privacy. It may be difficult to show a tangible benefit to the user to gain their participation.** **From the professional carers point of view the information has to be useful. They have very little time to spend analysing data so it needs to fit with their needs to be quick but thorough.** **Like with any data the professional carer has to have confidence in its quality. It also has to be displayed in a way that is familiar to them, but not provide data overload.** **COPD specific devices will have to address the usual usability issue to encourage compliance. Feedback will be an important factor to give a clear benefit.**

Clinical (weight, BP)	
USE – general health indicators (Event 1.2)	
Role for SAPHE	Trend analysis; holistic picture through presentation of weight data with other physiological metrics and activity information
Sensors	3rd party scales/BP cuff; wearables; environmental
Collection (input) of information from user	
Data analysis	Long-term trend analysis; fusion of weight with meal and activity data; fusion of BP with activity data
Provision (output) of information to stakeholders	Data may be useful to clinician. Motivational feedback and/or information to service users.
Improvement in outcome	Decline picked up optimally – potentially prior to fixed thresholds being reached; may be able to provide context data; holistic view may facilitate understanding of underlying cause.
Involvement of stakeholders	SU, GP
Limitations	SU still required to self test
Comment (assumptions, issues etc.)	Weight (and possibly BP) likely to be fundamental clinical metric of value across a number of different conditions. Unsure if any practical wearable BP devices exist, so may need to rely on periodic readings. A wearable BP device is a current area of research e.g. Chinese university of Hong Kong's BSN paper or MIT's Photo-Plethysmograph approach.
Barriers to Acceptance	**Usual barriers to Wearable and Environmental Sensors** **As part of user engagement you can rely on the patient to enter his or her own BP/ Weight figures. This then gets them to know their normal range. However this can also be a barrier if people find it difficult (or uncomfortable) to enter their own data. Providing good feedback is essential to improve adherence.** **Example: A weekly report is posted to the patient showing the readings indicating whether the reading are good or bad. N.B the use of a report sent through the post is a form of push information rather than relying on the user to pull information from a set top box for example.** **Professional carers can still question the reliability of electronic devices such as BP monitors, though this should be irrelevant as its readings are relative to itself.** **Data needs to be provided to clinician in a useful form.** **Patients needs to see the clinician using the data – "what is the point in collecting all this data if no one looks at it."**

Clinical (temperature)	
USE – detect hypothermia (Event 4.1)	
Role for SAPHE	Provide continual body temperature monitoring through wearable sensors. Could adjust heating levels to help compensate but beyond scope of SAPHE; may be possible to identify reduction in well-being prior to neglecting to keep self warm (e.g. reduced well-being); devices which stimulate social interaction could be used to help with loneliness but beyond scope of SAPHE
Sensors	Wearable temperature sensor; environmental sensors for activity inference
Collection (input) of information from user	
Data analysis	Monitor his body temperature and room temperature in real-time, if it goes below prescribed levels raise alert to SU/carer
Provision (output) of information to stakeholders	SU and carers may be able to make use of temperature charts; considering SU activities may indicate other underlying causes
Improvement in outcome	Body specific temperate monitored lowering chance of hypothermia; more holistic picture provided to indicate if hypothermia is the only problem.
Involvement of stakeholders	
Limitations	Danger of still addressing specific symptoms such as low temperature rather than identifying underlying conditions such as loneliness.
Comment (assumptions, issues etc.)	
Barriers to acceptance	**Wearable sensors have their own issues see 5.4.** **Environmental sensors can generate issues of privacy. It may be difficult to show a tangible benefit to the user to gain their participation.** **From the professional carers point of view the information has to be useful. They have very little time to spend analysing data so it needs to fit with their needs to be quick but thorough**

Medication	
USE – medication compliance and optimisation (Event 1.4)	
Role for SAPHE	Maybe able to link medication changes to changing ADLs/vital signs.
Sensors	All for symptoms; 3rd Party pill box; wearables for vital signs
Collection (input) of information from user	Medication usage could be self-reported
Data analysis	Need to keep records of medication changes
Provision (output) of information to stakeholders	Carers may have interest in medication usage; could form part of condition management reviews; SU/carers alerted if medication missed; reminders to SU
Improvement in outcome	Effects of medication changes may be investigated
Involvement of stakeholders	Possibly some self-reporting; carers may be required to look at data; reminders to SU
Limitations	Self-reporting has reliability issues; instrumented pill boxes may be deemed unsuitable.
Comment (assumptions, issues etc.)	Medication compliance emerged from requirements capture as a key issue
Barriers to acceptance	**Pill boxes can be inherently difficult (clumsy) to use and difficult to refill. Pills are only one of the types of medication. The reminders need to take into account the context - where are they, when did they take their last dose and when did they last eat. This then allows the reminder to be appropriate.** **Configuring reminders could be difficult. If done by the professional carer it may not fit into the patients routine and the professional carer may have difficulty finding the time to configure it. This would still need to enable the patient to override any decisions (empowerment).** **If done by the patient themselves then it needs to be simple to use, but adhering to the rules for the medication e.g. with food. The complexity of some of the medication combinations may make this difficult.**

Information/reassurance (SU)	
USE – assist SU with understanding own condition/symptoms (Event 9.2)	
Role for SAPHE	Provide automated and intelligent linkage between this user contributed data and the sensor data
Sensors	All
Collection (input) of information from user	SU could be able to add their own comments, indicators of her self-perceived health status (e.g. simple touch options like smiley faces chosen by SU at certain / random times of the day)
Data analysis	Outside scope of SAPHE but a telecare system could provide some key vocabulary for SU to select from, the system could then cross reference and take these into account to provide user contributed annotations for the sensor data collected; data analysis required to present raw data in a form suitable for SU; trend analysis where suitable
Provision (output) of information to stakeholders	Web delivery; STB
Improvement in outcome	Information provision allows SU have more involvement with their health management leading to a better understanding of their health; deeper understanding also allows for better informed discussions with clinicians; reassurance provided by alert monitoring may contribute to improved feeling of well-being
Involvement of stakeholders	There needs to be a quick, reliable and very simple method for data capture from SU and data provision to SU; carers may also get value from having access to information particularly simple summaries to enable them to make use of the data in the short duration consultations.
Limitations	Self-reported information is most useful if compliance is high this means that the capture process should be simple and quick; it also places requirements for a suitable input and viewing terminal (e.g. tv with a keyboard)
Comment (assumptions, issues etc.)	
Barriers to Acceptance	**To make this useful you have to encourage the SU to look at the information. Finding the appropriate medium for the person is important. Some may find a paper report may be the best way to receive feedback, some may find the use of the television a suitable medium. To allow the continual development of their own involvement it is possible to provide additional education material to support their progress. This would be in the form of addition material to their existing feedback, as well as that which is supplied through the direct professional carer contact.** **Text input is difficult if the use of a keyboard is not acceptable. With the future generation of people used to sending messages via SMS, this is less likely to be an issue.**

Alarm/Reassurance (SU)	
USE – increase SU confidence in ability to live independently (Event 6.2)	
Role for SAPHE	Sophisticated trend analysis and abnormal event identification; continuous monitoring to allow abnormal symptoms to be detected any time and any place; monitor SU vital signs (e.g. breathing and SPO2) at any time and any where around home; better condition management to keeping symptoms under control and avoid emergency situations (e.g. exasperations)
Sensors	Discreet wearable sensors for specific vital signs; all sensors for improved condition management.
Collection (input) of information from user	
Data analysis	Real-time alarm monitoring; vital signs will require some processing (e.g. standard algorithms for SpO2 analysis & breathing rates); longitudinal data mining for detecting anomalies or gradual degradation in health.
Provision (output) of information to stakeholders	Information provision to SU and carers to aid condition management; carers to respond to alarms.
Improvement in outcome	SAPHE can provide continuous monitoring including when outside of the home; the reassurance provided by SAPHE should facilitate an increased sense of well-being & quality of life; better management of conditions (e.g. through providing information to allow refinement of medication regimes); reassurance that problems will be identified if they exist.
Involvement of stakeholders	Professional carers use data to check SU is managing conditions; carers may also need to posses ability to investigate further; may be possible to use information to help optimise medication regime; SU made aware of when health should prohibit certain activities e.g. when health is not up to gardening etc.
Limitations	Monitoring is continuous but still may take time for help to arrive; requires SU to want to, and be able to understand the provided data and what it means; professional carers need to have the resources and desire to work with the data collected by SAPHE; SAPHE style lifestyle monitoring is always likely to require a facility to self-raise alarms (e.g. pendants); system cannot supply immediate help and physical aids (e.g. an oxygen supply for someone with breathing difficulties) might be only way to provide real reassurance; potential increase burden on professional carers.
Comment (assumptions, issues etc.)	SAPHE system should be used in addition to the other appropriate reassurance providing devices e.g. pendent, oxygen supply, etc; any alert/alarm mechanism should be robust and transparent in its functionality.
Barriers to acceptance	**Usual issues with wearable sensors.** **Expectation of alarm response could be a problem.** **Additional work could be generated for the care providers.**

Reassurance (Informal Carer)	
USE – reassure concerned informal carer (Event 1.7)	
Role for SAPHE	SPAHE should provide further reassurance through the provision of more detailed information
Sensors	All
Collection (input) of information from user	All
Data analysis	Information should be presented in a form suitable for the specific informal carer
Provision (output) of information to stakeholders	Via (customisable) informal carer interface
Improvement in outcome	Further reassurance provided including vital signs
Involvement of stakeholders	
Limitations	Could introduce information overload
Comment (assumptions, issues etc.)	Getting the interface right is important to ensure information provided meets the needs of the informal carer
Barriers to acceptance	**Informal carers need three types of information:** **Status – How are things** **Alerts – something is going wrongs** **Analysis - what is going wrong** **Each of the types of data need to be provided in appropriate way. The barriers to acceptance relate the appropriateness of the display device and context. Expectations of timeliness and level detail need be managed. The user has to know how to understand and use the information being displayed.** **Reassurance to the patient that there is control on what and who can see the information being collected.**

Information (Professional Carer)	
USE – determining care needs (Event 8.1)	
Role for SAPHE	i) Intelligent interpretation of sensor data, detection of patterns and anomalies, measure of ADL capabilities i) Enable OLAP (online analytical processing) to allow stakeholders to see the long-term observation measured data in relation to different time break downs, e.g. by weeks, months. iii) Integrate with the existing care service systems; e.g. to provide a simple good / bad day indicator via mobile phone to assist homecare helps
Sensors	Environmental – all; wearable – all
Collection (input) of information from user	Supplementary user supplied information could be of use
Data analysis	Data mining; rules; autonomous agents
Provision (output) of information to stakeholders	Visual summaries of past health status; report of trends; report degradation in SU's health and capability to live independently
Improvement in outcome	Most appropriate level of care provided; Intelligent analysis performed by the system reduces the effort required by carers to understand and interpret data; carers are better able to tailor care packages to individual Sus – possible even down to the level where home help will know prior to their visit what a SU's recent health status was allowing them to prepare more appropriate meals or improved the use of time between home help and Sus.
Involvement of stakeholders	Summary reports should reduce requirement for carers to process reported data; should allow carers to browse simple summaries, with further details available by drilling-down into the data; need to assess how detected ADLs relate to care package
Limitations	Accuracy of interpretation and algorithms; carers required to interact with interfaces which some may not wish to or be able to do.
Comment (assumptions, issues etc.)	OLAP requires Microsoft SQL Server and ProClarity Server; details above relate to using elecare for making optimal decisions to all changes in care packages including when to move to residential care; accuracy of ADL inference.
Barriers to acceptance	**Assumes a web based interface - usual web usability issues** **Speed, accuracy, trust and conformance with existing processes and expectations is important to acceptance.** **The perception of professional carers being undermined by handing over analysis to 'agents' can be a problem.** **Additional workload for professional carers.**

Event 11.1 – Other (well-being)	
Role for SAPHE	Provide long-term trend analysis of Jane's health and general wellbeing; report this data using simple summaries, with the potential for explore / question or more specific details. This will largely be used by Jane and her family, but also by her GP in consultations. Could provide video conference / skype services to allow Jane's family to have video & audio interactions with her.
Sensors	Environment & worn
Collection (input) of information from user	
Data analysis	data mining & trend analysis / longitudinal data visualisation e.g. olap
Provision (output) of information to stakeholders	web delivery of longitudinal data; integration with GP systems; mobile phone alerts of bad days
Improvement in outcome	Jane and her family have a greater understanding of her health patterns;
Involvement of stakeholders	Everyone is able to, and should check the long-term data reports so that they can all understand Jane's health problems better
Limitations	It would take time for the system to be able to detect possible triggers of bad days; once the system can detect patterns and thus anomalies the system would be able to generate alerts automatically taking off some of the load from Jane and her family, but there would always be a need for manual exploration of the data; thus the system / report views would need to be simple to use and adapt.
Comment (assumptions, issues etc.)	
Barriers to acceptance	**Unclear benefits over the long term.** **Acceptance of the fact the SU is getting old.**

Event 7.3 – Other (de-installation)	
Role for SAPHE	Modular deployment; wearable sensors deployment only
Sensors	
Collection (input) of information from user	
Data analysis	
Provision (output) of information to stakeholders	
Improvement in outcome	
Involvement of stakeholders	
Limitations	
Comment (assumptions, issues etc.)	SAPHE system designed to be appropriate for long-term trend analysis rather than short term deployments.
Barriers to acceptance	**Installation / de-installation work (time and effort as well as impact on the home. Cables, holes etc.)** **Inconvenience to the home owner.**

Event 2.3 – Other (earlier discharge)	
Role for SAPHE	May be possible to avoid care home through greater use of remote monitoring.
Sensors	All
Collection (input) of information from user	All
Data analysis	All
Provision (output) of information to stakeholders	All
Improvement in outcome	Preferential for SU and lower cost
Involvement of stakeholders	Multiple stakeholder involvement to ensure monitoring service is in place.
Limitations	Care home may still be required
Comment (assumptions, issues etc.)	
Barriers to acceptance	**Liability could be a barrier to the service provider until the system has a proven track record and the service provider has confidence in the system's ability.** **Cost may be incurred by different organisations that are seeing reduced costs.**

Event 1.5 – Other (reminders)	
Role for SAPHE	
Sensors	
Collection (input) of information from user	
Data analysis	
Provision (output) of information to stakeholders	
Improvement in outcome	
Involvement of stakeholders	
Limitations	
Comment (assumptions, issues etc.)	
Barriers to acceptance	**The reminders need to take into account the context - where they are. This then allows the reminder to be appropriate e.g. flashing light in the kitchen rather than a buzzer in the bedroom.** **Configuring reminders could be difficult to do for the SU.**