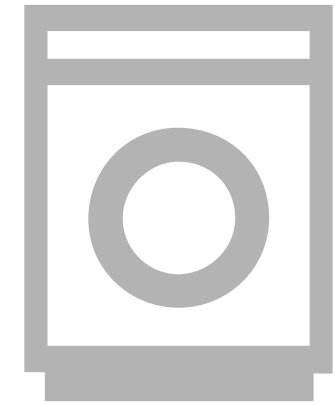

Appendix 1:

user*fit* in the design of an intelligent washing machine

The design task

The intended product is an intelligent washing machine for elderly and disabled users which can automatically detect the kind of load that has been placed in the machine and can select an appropriate wash programme. It is also anticipated that the machine will be able to detect problems with the its use e.g. electrical faults, and water leakage, and raise appropriate alarms. Another perceived advantage of the machine is that it can be connected to a home bus system, and either receive commands from that communication bus or sent messages to it. This allows the machine to be controlled remotely if necessary, and also makes it easy to connect any specialised input devices that might be required for a particular disability group. The washing machine can also send messages to any external monitoring system regarding its own status, whether for example there is a fault with the machine or not, whether the door has been left open etc.

More details about how to use USERfit are given below. An example of an intelligent washing machine development is used to illustrate more clearly how these tools may be used in practice.

In this particular example there is already a concept for a product, and a good idea would be to start with a summary of what has already been decided. Where there is no idea for a product it will probably be better to start with user and activity analysis in order to obtain ideas for products that are needed. Figure A:1 shows the route through the USERfit methodology which was followed in this particular case. As a well defined idea for a product existed and the developers were adapting an existing washing machine, it was decided to start with the Product Analysis (PA), and then to clarify what was known about how the product would be used and the environment that it would operate in. After the Environmental Context (EC) and Product Environment (PE) tools had been used, it was decided to look in more detail at the attributes of the products users (UA tools) and the activities that would take place (AA tools). As a result of these analyses there was some redefinition of what the product might do, and so the Product Analysis tool was filled in again. The emerging specification was checked against the desired attributes that emerged from User and Activity Analysis, with the Product Attribute Matrix (PAM) and after discussion the emerging specification was revised and documented in the Requirement and Design Summaries (RS and DS).

Durng the same time an evaluation strategy was discussed and subsequently detailed evaluation plans were produced. These were documented in the Usability Evaluation (EU) planning tools. Finally the results of the evaluation were summarised in the Usability Evaluation Summary (UE 3).

Note:

The example is loosely based on the author's experience in developing a similar product within TIDE–funded work. The example, however, is ficticious and any similarities with the development process concerned are coincidental.

The following is a retrospective account of how USERfit could have been applied at the time.

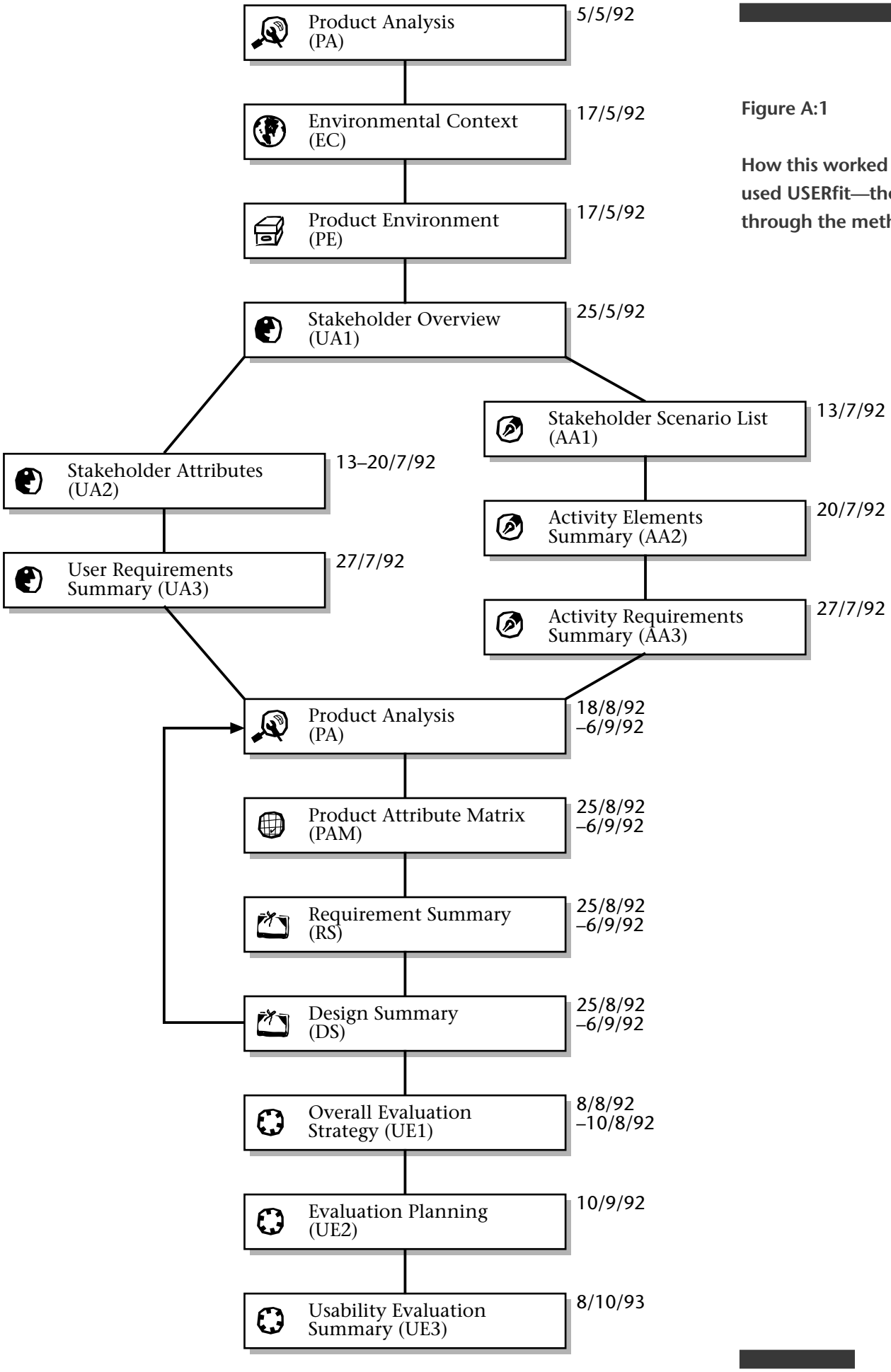

Figure A:1

How this worked example used USERfit—the route through the methodoology

First steps in the design process

The design team began this development task with the Product Analysis Tool. Please note that other starting points were open to them. For example they could have begun with User Analysis in order to identify users and specify their needs or with a Usability Evaluation to establish the extent to which existing products already meet the needs of elderly people.

Date 5/5/92

Product Analysis (PA)

Product /Service Title and Description
Intelligent Washing Machine- Note this is a development of an existing product. The idea has come from engineers who have built a prototype machine.

Broad Specification/ Design Objectives	***Rationale***	***Detailed Operational Features***	***Actions Needed***
Machine connected to home bus-allowing potential use by a wide range of disability groups with special control devices.	Extends possible application areas, including use by disability groups and remote control and monitoring.	Conformance to European Home Standard	Technical issue- standards needs to be examined.
Automatic selection of wash	Useful for elderly people to just have a simple on/off operation?	Single key press for wash, but due to technical limitations a separate wool wash button is needed	Is this acceptable to users? Note- specific target is elderly.
Automatic fault detection e.g. leakage and door open	Safety features for use with elderly people	Local alarm, and potential for remote alarms	Is this acceptable to users? Note- specific target is elderly.
Front loading machine	Based on an existing product	Conventional door with lock release activated after a time delay and only when machine is off.	Is this acceptable to users? Note- specific target is elderly.
Indicator that machine is on	Basic good design feature	Single LED mounted on the front panel of the machine.	Is this acceptable to users? Note- specific target is elderly.
Styled as a conventional washing machine	Based on existing product to appeal to the consumer market and to elderly. Also because it is based on an existing machine.	Conventional styling i.e. an all white machine.	Is this acceptable to users? Note- specific target is elderly.
Auditory alarms	Useful for visually impaired people and also to bring attention to problems with the machine generally	Single beeping tone for door open, leak and machine malfunction.	Is this acceptable to users? Note- specific target is elderly.

Outcome and next steps

The product analysis revealed that a number of design decisions had already been made, and that the concept was to have a simplified washing machine for elderly and disabled people which could also be connected to a home bus. This would allow a variety of different input devices to be connected to the machine in the future, allowing control by those who are severely disabled. Technical limitations meant that the machine would not be able to select woollen clothes automatically and the developers were not sure whether having two buttons would be acceptable or not. They decided that some user analysis was required, and in this particular case decided to bring in the services of some human factors practitioners to assist in data capture. The developers also decided to look at the environmental context tool in order to summarise what else they already knew about how the product would be used.

Date 17/5/92

Environmental Context (EC)

Product /Service Title and Description
Intelligent Washing Machine

Initial Queries	***Details***	***Issues Requiring Attention***	***Actions Needed***
What is the product/ service?	An intelligent washing machine forming part of a wider home automation initiative	Some details of the specification need checking with users	Get involvement of some experts on elderly people?
Why is there a need for the product/service?	Seems like a good idea- many elderly people have problems with technology and there are over 50 million in Europe	Need for a clearer view as to its value	Survey of user opinions needed
Where did the idea for the product originate?	University Research Department in Electronics		
Who will purchase this product/service?	Elderly and disabled people themselves	Will they be able to afford this technology?	Need to understand the market for consumer products and elderly people
Who are the primary end users?	Elderly and disabled people		
How and when will this service be used?	As per normal washing activities.	Possible value of having delayed action to save power (cheap rate usage)	Check with end users if this would be useful
Where will this product/service be used ?	In the domestic home		
How will the development of this product/service be financed?	Partly through EU funding	What will the production costs be?	Get productions engineers to scope possible costs

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Outcome and next steps

The developers clarified that this product would be designed for use with elderly people and that potentially there was a large market in Europe for consumer products with this group. However they also realised that they were not really very clear as to the value of the machine for its intended users and whether users would want some of its features. They reiterated the need to get more information from users as to the likely acceptance of some of these features. It was also agreed that they needed to look more closely at the demographics of elderly people and whether they would be likely to be able to afford home automation technology. They also agreed that more detailed manufacturing costings were needed.

They decided to look at the product environment tool as well during their meeting , and found this form difficult to complete at this stage of the project. They completed as much as they could after a group discussion amongst themselves.

Date 17/5/92

Product Environment (PE)

Product /Service Title and Description
Intelligent Washing Machine

Function	***Who will do this?***	***How will this be done?***	***Design implications***	***Actions Needed***
Training needs	Installers/electrical contractors?	Informally?	Needs to be simple to use	Ensure design is simple as possible
Documentation	Developers	After product has been designed a developer will write this.		
Installation	Specialist company needed for the bus technology – but plumbing contractors can be used for the machine itself	Specialist companies paid for installing the bus technology.	Needs to be simple to install – but companies don't exist as yet.	When will such companies be providing services? Consult marketing
Maintenance	Separate service company. Users performing routine maintenance.	Service contract	Maintenance instructions will also have to be produced.	Think about resources needed
Support	Is this needed?			Think about this, get users views?
Decommission	Same as installers	Not sure, but should not be a major task apart from communication bus aspects.		Might need to think how a whole system would be installed/taken out. The washing machine is part of a larger system.

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Outcome and next steps

The product environment tool summarised their views and revealed a number of unresolved issues. The design team were unclear who would provide user training, but felt that the it should be largely a walk up and use product. They saw the installation of the bus technology as being a specialist activity and realised that there would need to be close links with such companies. However as yet there were no installers of home bus technology in Europe, which would mean that they would not have an immediate market for such a product. They also realised that they had not thought about maintenance issues in the design, and that in addition they did not know how much support elderly people might need from the product. They felt that they ought to consult marketing experts in order to answer some of these questions and also look closer at what end users might require.

User Analysis Procedures

An external ergonomics consultancy was brought into the project and asked to find out more about user requirements. The consultants agreed to summarise their investigations using USERfit, and conducted a number of investigations. They also looked at the forms which had been filled in, and raised a concern that they had regarding the plans for producing documentation. They argued that the documentation should be produced in parallel with the product development rather than afterwards, as the process of producing documentation would assist in highlighting potential problems with the product.

The consultants held a number of group discussions with experts on elderly people, and in addition interviewed a small number of elderly people in their homes. They also identified that they needed to talk to informal care providers e.g. family. The first activity carried out was a stakeholder analysis to try and identify the range of people who would be influenced by the product, and who therefore should be consulted. The User Mapping Tool was used to assist in this process, by helping to identify relevant stakeholder groups, and possible costs/benefits of using ithe product.

Date 25/5/92

User Analysis (UA1)

Product /Service Title and Description
Intelligent washing mchine

Stakeholder Overview

Stakeholder Category	***Stake/role in product/service***	***Design Implications***	***Actions Needed***
Elderly people	End users and purchasers?	Many elderly people are on low incomes. Due to inexperience with technology-product needs to be very simple	Check whether they are intended as purchasers?
Disabled people	End users and purchasers?	Not clear what categories of disability would be covered- Note elderly people also can be disabled.	Need to firm up on intended user groups
Relatives /informal carers	May also be end users, and use on behalf of other users- probably occasional users. May train users to operate equipment and also perform any routine maintenance	These procedures should be as simple as possible. The product should be as maintenance free as possible.	The maintenance that will be needed has to be clearly defined
Formal Care Providers	May also need to use the product for users, or at least be familiar with the technology		Might be worth discussing the project with them. Could they be purchasers?
Installers/ Maintenance Engineers	To install bus technology and the machine itself	Installers of bus technology do not exist yet?	Try and identify who would perform these duties- The developers may need to do this themselves.

Outcome and next steps

As a result of the stakeholder overview it was agreed that there was some ambiguity as to who the target group for the product were as elderly and disabled people didn't form one group. Clarification was needed whether the young disabled were a target for the product, and if so what disability groups would be served. It was agreed after discussion with the developers to concentrate data capture activities on elderly people, and those elderly people with disability, rather than on the young people who were disabled.

In addition it was realised that there was still some ambiguity as to who would install and maintain such technology, and that it was likely that the developers themselves would have to take on this role. Concerns were also raised as to whether end users could take on the role of purchasers, as it was understood that elderly people were on low incomes. It was also unclear what routine maintenance would be required with the machine and it was agreed that this needed to be explored.

It was decided to concentrate a more detailed analysis on all those parties who were identified as being potential users of the product, and that occasional as well as regular users opinions should be sought. The following gives a completed example for those stakeholders identified as being direct users i.e. elderly people and informal carers

Techniques to gather such information were explored and it was decided to run Group Discussions with elderly people, and informal carers, as well as engaging in Direct Observation.

Stakeholder Title and Description
Elderly User

Stakeholder Attributes

Attribute	***Functional Implications***	***Desired Product Characteristics***	***Actions Needed***
Wide range of variability in the capabilities of elderly people. Poor mobility, vision and hearing common	Need to provide universal design, and no reliance on one single sensory mode.	Use of sound as well as visual indications for displays	Ensure that visual and auditory cues are both provided to give feedback of operation
Focus on elderly people	Simplicity of design needed, need to facilitate handling of washing	Simple controls	
Probably more female users	?	?	Maybe need to get opinions as to what are attractive features for women?
Users will need to have reasonable cognitive capacities - to put washing in machine, add detergent, and remember to switch the machine on	Product therefore not suitable for dementia patients	Aim to make it as simple as possible-perhaps think about these problems in the future	None at this time
Physical capacities less important, but user will need to be able to put clothing in the machine. Elderly people may have limited strength and reaching capabilities	Will not be suitable for quadriplegics, or those with severe upper limb disabilities	Front loading machine slightly easier to use for such groups, but not ideal. A raised plinth for the machine could help	Design a raised plinth as an optional feature.
Visual impairment common	Needs to be usable by visually impaired elderly people	Good tactile feedback from controls as well as auditory cues	Ensure tactile feedback is provided and the views of visually impaired people are represented.
Some users will have limited education	Important to rely on written instructions as little as possible	Should be a walk up and use product with recognisable icons or symbols for key functions	Aim for users to be able to use the machine without reference to an instruction manual- ensure this is apart of the product evaluation criteria

Stakeholder Attributes

Stakeholder Title and Description
Elderly user (continued)

Attribute	***Functional Implications***	***Desired Product Characteristics***	***Actions***
Thrift culture and many elderly people are on low incomes	Elderly people may not buy such technology for themselves	Need to market product for service providers? – product has to be very reliable and seen as being cost effective	Explore needs of service providers for such a product.
	Running costs must be low	Cheap to operate/maintain	Check likely running costs
Elderly people not particularly motivated to use technology	Product needs to be carefully marketed, and be simple to operate	Single button to operate machine	None
Many will have little experience of using technology	Product should not appear to be advanced technology	Machine needs to look like a conventional washing machine.	Get input from a stylist?
User group at high risk from accidents	Safety of products important and alarm features also useful	Leak detection and machine door being open detected, along with internal faults	Not clear what kinds of accidents elderly people have with washing machines. How can we find out ?

Stakeholder Title and Description
Relatives/ informal carers

Stakeholder Attributes

Attribute	***Functional Implications***	***Desired Product Characteristics***	***Actions Needed***
May also be elderly/ disabled themselves	Needs to be simple to set up and use	As for elderly users, but maintenance also needs to be simple.	Define maintenance needs
Could cover a wide age range	Design for least able group i.e. elderly people who are also disabled	As for elderly users	
Probably more likely to be female	Again aim for simplicity of design and a product which does not appear too advanced	As for elderly users	
Could cover a wide range of capabilities and education	Again aim for walk up and use	Simple to learn to use and maintain	Effort needed to develop training materials – start to consider them now

Outcome and next steps

The analysis revealed that the washing machine needed to be as simple to use as possible and that there needed to be some redundancy in the forms of feedback given to users. Both audio and visual cues should be provided so that it could be used by elderly people who are also visually impaired as well as the hard of hearing. It was identified that many users may also have some mobility problems and that therefore large easy to use controls were needed. It was also agreed that a front loading machine was likely to be better than a top loading machine, and that to facilitate clothing being put into the machine an optional raised plinth could be useful. It was realised that there was insufficient information on what routine maintenance would be required in using the machine and it was agreed that this should be resolved by the developers.

Where possible it was identified that the machine should be designed for walk up and use operation, and that training should be minimised along with any reliance on written instructions.

One of the selling points of the product was that it could improve home safety, but the design team realised that they did not know enough about what kinds of accidents elderly and disabled people had in the home. It was agreed that this should be explored in more detail, by looking at any relevant literature and if necessary interviewing elderly people.

The analysis also revealed that formal service providers should be considered in more detail, as such services might act as funding bodies for such technology, and where a user had no access to informal care, also be responsible for assisting the user in the use of the product. To this end an analysis of service providers attributes was performed, based on interviews with a small number of care providers.

Stakeholder Title and Description
Formal care providers

Stakeholder Attributes

Attribute	***Functional Implications***	***Desired Product Characteristics***	***Actions***
No significant disability	None	None	None
More likely to be middle aged women	Needs to be simple to set up and use	Maintenance also needs to be simple	Define maintenance needs
Some may have limited education and experience of using technology	Again aim for simplicity of design – keep the product like a conventional washing machine	Simple product – walk up and use. Single button to operate	
Likely to see technology as a low priority in care	Simplicity of design?	Product perceived as simple to use	
May not be motivated to use advanced technology themselves	Again aim for walk up and use	Simple to learn to use and maintain	Effort needed to develop simple training materials

Outcome and next steps

This analysis again reiterated the need to be clear what maintenance would be required with using the machine. These analyses were then summarised in user requirement summary reports to be fed into the later phases of design.

Date 27/7/92

User Analysis (UA3)

Stakeholder
Elderly User

Requirements Summary

Desired Product Characteristics	***Possible Conflicts***	***Priorities for Development***
Use of sound as well as visual indications for displays	May make the interface less than optimal for a given user- possible option to switch these on and off?	High
Simple controls	Some disabilities may need specialist input devices-need to think about being able to connect other input devices	High
Large door to machine	Possible weight of door?	High
Aim to make it as simple as possible to use	None	High
Front loading machine slightly easier to use for such groups	Opinion mixed, however	Medium
A raised plinth for the machine could help in facilitating use	Important to include it as an optional feature	High
Good tactile feedback from controls as well as auditory cues	None	High
Should be a walk up and use product	May not be possible	Medium
Need to market product for service providers- product has to be very reliable and seen as being cost effective	Need to explore market demand for high cost but high quality product, as the technology may be expensive.	High?
Cheap to operate	None	High
Simple to use and maintain the product	Maintenance has not been clarified	High
Machine needs to look like a conventional washing machine.	None	Low
Leak detection and machine door being open detected, along with internal faults	Internal fault detection could make the machine very expensive- is this really needed	Medium

User Analysis (UA3)

Date 27/7/92

Requirements Summary

Product /Service Title and Description
Relatives

Desired Product Characteristics	***Possible Conflicts***	***Priorities for Development***
As for elderly users, but maintenance also needs to be simple	None – but maintenance still needs to be defined.	High
Simple to learn to and maintain		High

User Analysis (UA3)

Requirements Summary

Product /Service Title and Description
Formal care providers

Desired Product Characteristics	***Possible Conflicts***	***Priorities for Development***
As for elderly users, but maintenance also needs to be simple	None	High
Simple product	May conflict with use of advanced technology in the machine. Must appear simple to users even if it is sophisticated technology	High
Simple to learn to use and maintain	As above	High

Activity Analysis Procedures

As a parallel activity the ergonomics consultancy also looked in some detail at the activities that the users would need to undertake in using the product. Again emphasis was given to understanding the activities of the main user group i.e. elderly people, but in addition the needs of less regular users e.g. family and care providers were also looked at. This analysis was carried out using group discussions with elderly people and also by performing a simple task analysis, based on direct observation of elderly people using washing machines.

The Activity Analysis Tools summarise the developers understanding of the activities undertaken by the different categories of stakeholder which are relevant for consideration. The first form summarises the primary attributes of the activities undertaken by each stakeholder group. In order to understand activity based requirements it is important to understand the context in which a product will be used, and what it will be used for.

The second form provides a breakdown of each scenario, into its constituent activities along with any implications that have been raised for the design, and the desired product attributes that result from these. The last form summarises the desired product attributes that come from this analysis, any conflicts there may be, and any priorities for development.

The first phase in using these tools is to obtain an understanding of the range of activities that will be supported by the product, and to list them as separate usage scenarios. A usage scenario is a defined here as a definable set of activities which logically belong together i.e. perform the same purpose and have largely the same attributes. For elderly people washing clothes is one usage scenario that the product is designed to support, and another clearly separate scenario is coping with problems. They are viewed as being separate scenarios because they have very different characteristics. Washing clothes is a regular activity for example, whilst coping with washing problems or emergencies is normally very infrequent. A simple Task Analysis was used to identify these scenarios, coupled with Interviews and Direct Observation.

Where a product can be used for a very broad range of activities e.g. a communication aid, it is important to identify scenarios representative of the full range of possible activities rather than trying to cover all possibilities. Task analysis will assist in identifying representative scenarios. The overview of relevant scenarios will be obtained by a variety of means. These will include observation, task analysis and other appropriate techniques. In

addition these analyses will provide the more detailed information needed to describe the attributes of each scenario. Attributes of these activities will also be summarised to include such aspects as their context of use, how, where and when activities will be performed, how frequently they will be performed, social and ethical considerations, and the implications of failure.

The use of this with the automated washing machine is illustrated. The usage scenarios identified for the elderly user are for washing clothes, and in coping with problems. Each scenario is described along with its attributes. In the next table each scenario is broken down into its constituent elements, and the functional implications of these summarised. These are then discussed in the specific context of the product being developed to result in desired product characteristics, and any actions that need to take place. A summary of these desired characteristics is then provided for each stakeholder, which also records possible conflicts and priorities for development.

It will be found that there is considerable overlap between this activity and the user analysis, and some redundancy of issues raised will be found. This is not a problem, as the two perspectives are different ways of looking at the same problem, and some redundancy should be expected.

Date 13/7/92

Activity Analysis (AA1)

Product /Service Title and Description
Intelligent washing machine

Stakeholder Elderly user

Stakeholder Scenario List

List of Scenarios	Attributes of Scenarios	Actions Needed
- Perform washing	Product used for a narrow application i.e. washing clothes	None
	Domestic washing machine located in kitchens, washrooms?	Need to be clear where else in Europe the product may be used
	During day or at night with cheap electricity	Do we need a timer facility?
	Machine to be plumbed in	Is this acceptable to elderly people?
	Large manual aspect of transferring clothes into and out of the machine. Some cognitive tasks i.e. measuring detergent and switching machine on	Make these as simple as possible
	Currently performed regularly e.g. approximately twice a week. Note- visually impaired elderly users may wash clothes more frequently	Ensure machine can support different sizes of loads
- Cope with problems	Hopefully should be very rare.	What emergency conditions are supported automatically
	The consequences of failure to detect emergencies or faults with the machine is unlikely to be critical, apart from possible damage due to flooding	Emphasis on safety aspects of the product

Outcome and next steps

Information on the users activities raised questions about where such a machine might be used, and identified some washing habits of elderly people. Most elderly people use large loads to save on costs, but the visually impaired tend to be an exception. Visually impaired people often soil their clothes through daily activities such as eating, and therefore are perhaps more likely to use a machine with smaller loads and more regularly. Other points identified were whether users wanted a timer function and whether all elderly people would be happy with a fully plumbed in washing machine that had to be left on all the time. Clarification from the developers as to the range of faults that could automatically detected was also seen to be needed.

Date 13/7/92

Product /Service Title and Description
Intelligent washing machine

Stakeholder Overview

Stakeholder Relative

List of Scenarios	***Attributes of Scenarios***	***Actions Needed***
- Perform washing	May be performed regularly-on behalf of user	
- Train users	Should only be needed when the machine is first installed	
- Cope with problems	May only be able to provide assistance indirectly i.e. giving advice remotely. This could be a problem .	Need to be clear what can be supported automatically
- Perform routine maintenance	Unclear	Need to identify what maintenance is needed

Outcome and next steps

Activities to be performed by relatives were also explored and it was identified that helping the users cope with problems could be difficult, as it was unlikely that they would be familiar with such a sophisticated washing machine. However this would not be a problem in some cases as the relative might also use the machine for the elderly person when they visited. More specific problems were seen as possible where relatives were required to perform any routine maintenance, and it was considered a matter of urgency for developers to specify what kind of maintenance would be needed.

Product /Service Title and Description
Intelligent washing machine

Stakeholder Installer/Maintenance engineer

Stakeholder Scenario List

List of Scenarios	*Attributes of Scenarios*	*Actions Needed*
- Install machine	Specialist skills needed – task only performed once for each installation. It is not clear how installation sites may differ.	Identify what skills will be needed Check how different sites may differ.
- Repair machine	Very skilled, can normal service engineers cope with the technology?	Identify what training and support will be needed for engineers
- Train users?	Specialist task, which may also need support after initial installation	Will the maintenance engineer train end users or do we need other specialists? We need to think about service and support aspects.now.

Outcome and next steps

In addition it was clear that the maintenance aspects of the product had not been considered in detail, or the role to be taken by other parties e.g. the installation engineers. These were issues that also needed resolving with the developers.

The primary scenarios identified were then broken down into more detail. The key scenarios to explore are those involving direct use by regular or occasional users, but all scenarios have some relevance for the design activity. For the purposes of illustration only those relevant to the elderly user are described.

Date 20/7/92

Activity Elements Summary

Stakeholder & Scenario: Elderly User / Perform Washing
The scenario covers the washing of clothes using an automated washing machine for assistance. This is largely a sequential activity, following the order of elements given.

Activities in Scenario	***Functional Implications***	***Desired Product Characteristics***	***Actions Needed***
- Collect washing	Not facilitated by a washing machine	Automatic system for collecting washing, but outside the scope of the project	None
- Open door	Can be difficult for some elderly people	Easy to use door with specially designed door release	Consider options
- Put washing in machine	A problem for many elderly, not supported directly by the machine	Large door Automatic system?	Explore possibilities of supporting this
- Measure/Add Detergent	Not really a problem, but adds to the complexity of the machine if not supported	Automatic dispenser from a hopper that could be filled once a month	Check if this will be possible to implement
- Close door	Can be difficult for some elderly people	Easy to use door with specially designed door release	Consider options
- Select programme	Common for elderly people to use one programme only	Single button operation for system	Check if this is possible
- Turn machine on/off	Facility to wash using cheap rate electricity	Single operating button Timer needed	 Is this possible to implement?
- Open door	Can be difficult for some elderly people	Easy to use door with specially designed door release	Consider options As above ~~Explore options~~
- Remove washing	As with putting washing in machine but more of a problem due to wet washing	Large door automatic system?	
- Dry clothes	A problem for many elderly people	Integrated tumble drier with machine?	Check if this will be possible to implement

Outcome and next steps

In the example of the intelligent washing machine it is anticipated that having a large door will assist putting washing in the machine, even though it will not directly support the activity. Conversely the machine will directly support choosing the wash programme by the machine selecting this automatically.

A detailed analysis of users activities showed that a major problem that elderly people faced in washing was in the transfer of clothing to and from the machine and that a system to automatically collect the washing would be highly acceptable to users. This was discounted as being outside the scope of this particular project during discussions with the developers, but it was agreed to support putting washing into the machine as much as was possible. This included having a large easy to use door, and an easy to use door release mechanism.

Another suggestion given was for the machine to automatically add detergent, as otherwise the machine moved away from the objective of being very simple to operate i.e. by a single key press. Another suggestion was to integrate a tumble drier with the washing machine, as it was noted that taking the wet washing out of a machine and then hanging it out to dry were major problems with elderly users of washing machines.

Date 20/7/92

Stakeholder & Scenario: Elderly User / Cope with problems
The scenario covers the detection of faults with the washing machine, raising an alarm if necessary and making the machine safe

Activity Elements Summary

Activities in Scenario	***Functional Implications***	***Desired Product Characteristics***	***Actions Needed***
- Detect fault	User may not detect fault	Automatic detection of faults and switching off of machine needed	Investigate fail safe procedures
- Raising alarm	User needs to be able to get support	Helpline / maintenance	Investigate fail safe procedures
- Making machine safe	User may not be able to switch off power supply and water	Linked to wider system to control water and power to provide fail safe operation?	Think about product in the wider context of home automation

Outcome and next steps

It was also noted that there was a lack of information about the range of emergency conditions that would be supported. The high level analysis indicated that there was some ambiguity as to the extent to which problems could be automatically detected and the actions that would be needed on the part of users. The more detailed analysis suggested that it would be of value for the machine to be as automatic as possible in making the home safe, as end users may not detect faults themselves, and also not know what to do in an emergency. It was also noted that it was common for stop taps and fuse boxes to be in inaccessible places and that remote control of the wider environment might also be needed to make product usage safer. It was also identified that it was important to know how a user could gain assistance in an emergency e.g. a helpline to ring.

Date 27/7/92

Activity Analysis (AA3)

Stakeholder
Elderly users

Requirements Summary

Desired Product Characteristics	***Possible Conflicts***	***Priorities for Development***
Automatic system for collecting washing, but outside the scope of the project		Not Applicable
Easy to use door	None	High
Large door	Weight of door for frail elderly?	High
Automatic system for putting washing in machine?		Not Applicable
Automatic dispenser for detergent	None–supports simple use	High
Single operating button	As above	Medium
Timer	Likely to make operation more complicated	Medium
Integrated tumble drier with machine? Elderly people have problems with other aspects of washing which are not supported with the technology.	Adding to cost of machine and operating costs. Would it be acceptable in hot climates?	Medium
Automatic detection of faults and switching off of machine needed– avoidance of water damage critical	False alarms could be a problem	High
Help line/maintenance	Again could add to the cost of the product/service	Not actually a product attribute– make a note of this as service requirement
Linked to wider system to control water and power in the home?	Adds to the short term cost but would be of value for the future– However there are problems because of a lack of agreed standards	High priority for the future

Outcome

These analyses were then summarised, and possible conflicts identified. Some concern was raised that the need for a large door might conflict with the elderly person needing products that did not require a great deal of physical strength, as a larger door might also be heavier. In addition although having a timer was desirable feature from an operational point of view it would add to the complexity of the product and move away from the single key press philosophy. However as most washing machine users did not report a problem with programming their machines (most users stuck to very simple programmes) then it was argued that this might not be a problem.

Having an integrated tumble drier could solve some of the problems users were likely to face with the machine, but this would probably add to its cost.

Some concerns were also raised that if the machine produced false alarms then its monitoring system would not be acceptable. If it could be made reliable, it was acknowledged that this would be a useful design feature, especially if user actions in such emergencies were minimised.

These issues were then raised in a Group Discussion meeting with the developers, where more clarification was sought. The developers confirmed that for this project it would not be possible to integrate a tumble drier into the machine, but agreed to look closely at the maintenance aspect of the project in more detail.

They confirmed that the machine had a washable filter that should be cleaned every three months or so, and that this was seen as something that an able person without technical skills could perform. In the current production machine which was being used as the basis for this development, this was located at the front of the machine very close to the floor. The filter had to be taken out of its housing, which had a screw fitting. This cover was about 7 cm in diameter. Given that carers may also have some disability themselves, the consultants thought that this would not be easy for them or elderly people to use, and the developers were asked to consider its redesign. Discussions had already led to some changes in the intended product specification and these were documented by filling in the Product Analysis form a second time.

Date 18/8/92

Product Analysis (PA)

Product /Service Title and Description
Intelligent Washing Machine- Note this is a development of an existing product. The idea has come from engineers who have built a prototype machine.

Broad Specification/ Design Objectives	***Rationale***	***Detailed Operational Features***	***Actions Needed***
Machine connected to home bus-allowing potential use by a wide range of disability groups with special control devices.	Extends possible application areas, including use by disability groups and remote control and monitoring.	Conformance to European Home Standard	Technical issue-standards needs to be examined.
Automatic selection of wash	Useful for elderly people to just have a simple on/off operation?	Single key press for wash, but a separate wool wash button is needed. Will this be acceptable?	No answers from user surveys. To be tested during evaluation
Automatic fault detection e.g. leakage and door open	Safety features for use with elderly people	Local alarm, and potential for remote alarms	Priority given to safety features due to user survey results
Front loading machine	Based on an existing product	Conventional door with lock release activated after a time delay and only when machine is off.	
Easy access to machine for adding and removing clothing	Mnay elderly peoplehave problems with manipulating clothing	Large door with easy open feature	Requested after user survey, will modify door release on existing machine
Indicator that machine is on	Good design to show machine is working	Single LED on the front panel of the machine.	
Styled as a conventional washing machine	Based on existing product to appeal to the consumer market and to elderly. Also because it is based on an existing machine.	Conventional styling i.e. an all white machine.	
Auditory alarms	Useful for visually impaired people and also to bring attention to problems with the machine generally	Single beeping tone for door open, leak and machine malfunction.	
Simple maintenance	Needs to be maintainable by non specialist staff	Simple removable filter	Need to check whether this is acceptable to users

Page ***of***

Outcome and next steps

The revised product analysis took into account the preliminary discussions that had taken place after the user surveys had taken place. The main additions to the specification were in explicitly including the need for a large and easy to use door on the product, and in ensuring that maintenance was simple.

The Product Attribute Matrix Procedures

In order to look more closely at the degree of match between the emerging requirements for the intelligent washing machine and its emerging specification, the development team used a Product Attribute Matrix. This was initially filled in by the consultants who then discussed it with the development team. The Product Attribute Matrix Tool cross references the product specification with desired attributes or requirements from activity and user analysis. The idea behind this is to produce a simple summary matrix where attributes of the product act as column headings in a table, and desired attributes act as row headings. The developer then systematically evaluates whether the product being produced appears to address requirements or not. A PAM was produced for each user group, but the use of the approach is only illustrated with elderly users.

Product Attribute Matrix (PAM)

Product /Service & Stakeholder:
Intelligent washing machine – Elderly user

Product Specification / ***Product Specification***	Conformance to Standard	Two button operation	Local alarm	Remote alarm	Front loading with safety lock	Large, easy-open door	LED Indicator	Conventional Styling	Single beeping tone - for errors
Cost of development	High	Low	High	High	Low	Low	Low	Low	Low
Priority	High	High	High	High	High	High	Med.	Low	Low
End User Requirements (UA3)									
Sound and visual indicators							✘		✘
Simple controls		✓							
Large door to machine						✓			
Simple to use		?							
Front loading					✓				
Raised plinth (optional)									
Use of tactile feedback on controls									
Walk up and use		✓							
Need to market product for service providers - reliability and cost effectiveness									
Cheap to operate									
Simple to use & maintain		✓							
Conventional styling								✓	
Leak and Fault detection			✓	✓					✘

Matrix continues on pages A:36 and A:37 with Activity Requirements

Date 25/8/92

Product Attribute Matrix (PAM)

Simple removable filter									Priority	SUMMARY
Low										
High										
									High	✘
									High	✓
									High	✓
									High	?
									Medium	✓
									High	✘
									High	✘
									Medium	✓
									High?	✘
									High	✘
?									High	?
									Low?	✓
									High	✘

Matrix continues on pages A:36 and A:37 with Activity Requirements

Product Attribute Matrix (PAM)

Product /Service & Stakeholder:
Intelligent washing machine – Elderly user

Product Specification / ***Product Specification***	Conformance to Standard	Two button operation	Local alarm	Remote alarm	Front loading with safety lock	Large, easy-open door	LED Indicator	Conventional Styling	Single beeping tone - for errors
Cost of development	High	Low	High	High	Low	Low	Low	Low	Low
Priority	High	High	High	High	High	High	Med.	Low	Low
Activity Requirements (AA3)									
Automatic system for collecting washing									
Easy to use door						✓			
Large door						✓			
Automatic system for putting washing in machine									
Automatic dispenser									
Single operating button		✘							
Timer									
Integrated tumble drier									
Automatic detection of faults and switching off machine				✓					
Help line/information									
Linked to wider time control	✓								
SUMMARY	✓	✘	✓	✓	✓	✓	✘	✓	✘

Date 25/8/92

Product Attribute Matrix (PAM)

Simple removable filter									Priority	SUMMARY
Low										
High										
									N/A	N/A
									High	✓
									High	✓
									N/A	N/A
									High	✘
									Medium	✘
									Medium	✘
									Medium	✘
									High for future	
									N/A	N/A
									High for future	
?										

Outcome and next steps

The matrix shows the anticipated match between desired attributes of the product (rows), and the features already being considered (columns). The rows and columns for the PAM came directly from the product specification (PA), user analysis (UA) and activity analysis (AA).

Discussion then led to the matrix being summarised, both in terms of whether the emerging product specification met desired features, and whether product features could be matched to desired attributes. The analysis revealed that the given specification did not address the need for visual and auditory cues in use, as a single tone was used to indicate all types of errors, and there was only an LED indicator which showed that the unit was operating. During discussion it was agreed that the user would have feedback that the machine was running by other cues i.e. the sound of the motor and pump, and so this aspect was not critical. However it was agreed that the specification would not assist the visually impaired in determining what had gone wrong with the machine, and this was noted by a cross being placed in the summary column.

It was noted that there had been a general requirement to make the machine simple to use, and that one of the arguments for having the product was that the user did not have to programme the machine. Having to have two operating buttons moved away from this, but it was agreed that the acceptability of this to users was not known. A question mark was placed in the summary column to indicate that this was an unresolved issue.

The need for an optional raised plinth was also discussed and this also noted as missing from the current specification.

The value of controls giving tactile feedback was discussed, and although this had not been explicitly specified the developers stated that they had always intended that the controls would have a positive action, and give tactile feedback as to their status. They thought it so obvious that they had not included it in their description of the machine. It was marked with a cross in the summary as the current specification did not explicitly cover this.

The discussion also raised the issue of who the product was to be marketed for, i.e. whether it was for service providers or for elderly users. The developers felt that it should be targeted at a consumer market, and when pressed said that they thought it would be marketed at the upper end of the consumer market, and that there were elderly people who would be able to afford the product. They also believed that there was a large general consumer market for the

product, if it could be shown to be usable by a wide section of the population, and could be integrated with future home automation systems.

They agreed that the product had to be reliable and cost effective to use, but could not specify how this was going to be achieved. For this reason a cross was placed in the column.

They had no idea whether the machine would be cheaper to operate than a conventional unit, but felt that it should not be as wasteful of water and power as a conventional machine. They agreed to look at this in more detail, with the objective that the machine should be at least as cheap to operate as a more conventional washing machine.

Discussing maintenance, the developers felt that the removable filter would be easy to change, and this would be the only user serviceable component. Discussion revealed that the filter would need cleaning more than with a conventional machine as a clogged filter could mislead the machines automatic detection of washing loads. The developers thought that this would be acceptable. The consultants were less convinced of this and a question mark was recorded until this issue had been resolved by further investigation.

It was noted that elderly people had problems with collecting washing and transferring it to and from a washing machine, but saw direct support for this e.g. robotics as being outside the scope of the current project. These were marked as not being applicable in the summary column.

The need for an automatic detergent dispenser was also discussed and it was agreed that this would be a useful addition to the specification. The development team agreed to look at the feasibility of doing this within the current work. A cross was marked to show that this had not been resolved.

The need for a single operating button had already been discussed and so this issue was not raised again, however a cross was placed in the summary to indicate the issue had not been resolved.

The need for a timer was also discussed and no conclusion was reached. One argument was that this was a desired feature to save money, but there were major concerns that this could not be implemented in a simple way on the machine. This was marked with a cross to show that it was unresolved and the developers agreed to explore how it might be achieved without making the machine complex in operation.

The need for an integrated tumble drier was also discussed, and concerns were raised that this would add significantly to purchasing and operating costs. It was accepted that this could be of benefit in ensuring that elderly people did not have to carry wet and therefore heavy washing, but again the cost was a concern. This issue was unresolved at the meeting.

This discussion was then summarised in a Requirements Summary

Date 25/8/92

Requirements Summary (RS)

Product /Service Title and Description
Intelligent washing machine

Desired Feature	***Degree of Match with Specification***	***Actions Needed***
Use of sound as well as visual indications for displays	Specification poor as no indication of different types of errors are given	To improve the auditory feedback given. Design this to include multiple tones/and or voice announcement
Simple controls	Seems fairly good but made more complex by having two operating buttons	Need to determine whether this is acceptable
Large door to machine	No problem anticipated	
Aim to make it as simple as possible to use	May be made more complex by having two buttons	Need to determine whether this is acceptable
Front loading machine slightly easier to use for such groups	No problem	
A raised plinth for the machine could help in facilitating use	Not included in specification	Agreed to develop an optional plinth.
Good tactile feedback from controls as well as auditory cues	Not in specification but intended by developers	Include this in specification
Should be a walk up and use product	Should be covered by it being an intelligent machine needing two buttons to operate.	
Need to market product for service providers- product has to be very reliable and seen as being cost effective	Anticipated reliability and cost not specified	Needs to be considered. Also a closer definition of market sector is needed. Now arguing that elderly will purchase for themselves and that there is a wider consumer market.
Cheap to operate	Not proven	Needs to be investigated
Simple to use and maintain the product	Not proven that the removable filter will be easy to use	Perform pilot study to determine how easy the current design is to use.
Machine needs to look like a conventional washing machine.	No problem	
Leak detection and machine door being open detected, along with internal faults	No major problem, but as noted before there is no differentiation in messages	Consider redesign of this feature.

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Requirements Summary (RS)

Date 25/8/92

Product /Service Title and Description
Intelligent washing machine

Requirements for Design Summary

Desired Feature	*Degree of Match with Specification*	*Actions Needed*
Automatic system for collecting washing, but outside the scope of the project	Not applicable	
Easy to use door	Some redesign needed. Door needs to be as large as possible with a mechanism allowing operation by the frail elderly	Get advice as to appropriate operating force needed. Redesign and pilot with end users
Large door	No problem anticipated	
Automatic system for putting washing in machine?	Not applicable	
Automatic detergent dispenser	Not included in specification	To be explored for inclusion
Single operating button	Not possible due to technical limitations	Not thought to be a serious problem but will be investigated
Timer	Not included-some concerns that it will introduce complexity	Possibility of adding a simple timer will be included as the feature is desirable.
Integrated tumble drier with machine? Elderly people have problems with other aspects of washing which are not supported with the technology.	Not included	The feasibility of doing this in the project will be explored.
Automatic detection of faults and switching off of machine needed- avoidance of water damage critical	Included	
Help line/maintenance	Outside the scope of the functional specification, but the need to consider these issues is noted	Think about practical aspects of supporting the product.
Linked to wider system to control water and power in the home?	Needed for future development, but part of the technical specification rather than a functional issue.	Continue developing the product to allow connection to the home bus

Outcome and next steps

The PAM was also looked at in order to identify whether any features included in the specification did not appear to match any requirements. It was noted that the proposed two button operation did not come from user requirements but rather was a technical limitation, which the developers confirmed that they could not easily solve. The use of a single LED indicator to show that the machine was switched also did not match known user requirements, but it was agreed that this was not a significant design issue. The developers agreed to ensure that it would be a large and bright LED, and would be placed in a prominent position. It was also agreed that a single tone to indicate a range of errors with the machine did not match any requirements, and that alternatives would be explored. These included the use of more than one tone, and/or recorded speech messages.

Once the PAM was largely complete, discussion also took place regarding the anticipated cost of components of the specification, and some indication of priorities given. This allowed the top two rows of the PAM also to be completed. This in turn allowed some trade off to be made in terms of the development effort. In this particular example there were no features which were anticipated to be expensive to implement but were of low priority, and fortunately the only low priority features were also inexpensive to implement. This meant that in this case no trade off needed to be discussed.

An additional activity engaged in during these discussions was to move towards operationalising the revised specification in practical terms. This was seen as being important for subsequent detailed design, and also in developing evaluation plans. In order to assist in this process the developers also looked at relevant design guidelines or prescriptions, which included recommendations for the maximum forces that should be used to operate controls, and some guidance as to the use of auditory feedback i.e. the use of low frequency tones.

Design Summary (DS)

Date 25/8/92

Product /Service Title and Description
Intelligent Washing machine

Functional Specification	***Priority***	***Operational Details***
Conformance to European Home Standard	High	Draft standard (Version 1.1) to be followed in the technical specification. This has no implications for the products functionality.
Single key press for wash, but dve to technical limitations a separate wool wash button is needed. Will this be acceptable?	High	This is being considered for redesign, but if included will consist of a large red on/off button (2.5 cm in diameter) mounted at the top right of the machine, and a smaller green button mounted towards top centre labelled with a wool icon. Need to identify an appropriate icon. It has been recommended that controls should require no more than .6N force to operate.
Local alarm, and potential for remote alarms	High	Auditory alarms to be provided for machine door open, water leak, and machine malfunction. See below for details. All of these can be remotely monitored. In addition there will be an alarm to indicate the wash has finished.
Conventional door with lock release activated after a time delay and only when machine is off.	High	Use of existing washing machine door and release mechanism is anticipated unless radical change is needed. Door is 40 cm in diameter with a lever operation. The force needed to operate this is unknown, but earlier recommendations will be complied with where possible.
Large door with easy open feature	High	See above
Single LED mounted on the front panel of the machine.	Medium	Single round 8mm red LED. Will explore using a larger unit
Conventional styling i.e. an all white machine.	Low	Will use existing machines styling. No problems anticipated with this as the manufacturer reports good user acceptance of the design.
Single beeping tone for door open, wash finished, leak and machine malfunction.	Low	Single tone in the 1000 Hz range currently specified. Understood that 4 tones may be needed. Suggest 600, 700, 800 and 900 Hz, with higher tones to indicate severity of alarm.
Simple removable filter	High	Located at the machine front close to the floor. The screw fitting filter comes out of its housing for cleaning. This cover has a 7 cm diameter. The acceptability of this will be evaluated and the possibility of redesign considered.

Outcome and next steps

As a result of these discussions further development took place. The developers decided to use four different tones to differentiate between the different types of error conditions, and confirmed that it would not be possible to replace the two operating buttons with a single unit. A small pilot study was conducted which showed that the existing washing machines filter could easily be cleaned by most people, but that the operator had to bend down to use it. It was not considered feasible to redesign this in the project, as the whole machine would have to be re configured. Another small study looked at the existing door mechanism for the product and concluded that this was acceptable.

The designers discussed in detail whether it would be possible to develop a timer for the machine, and came up with a simple design option. This was to have the main on/off button to also be a knob with a pointer. When pushed normally there would be immediate operation, but when twisted to a particular time, the washing machine would only start when that time was reached.

The possibility of having an integrated tumble drier was also discussed, but it was agreed that this would involve too much of a redesign of the existing machine, and that in addition it would add to purchase and operating costs significantly. The developers also discussed the possibility of an automatic detergent dispenser and agreed that it would be possible to develop within the project. The development team then met with the consultants in order to revise the Product Analysis, PAM, Requirements Summary and to produce a final Design Summary, before producing a final specification. The revised PAM is not included in this example as the procedure is identical to that already described. However the other forms are included for completeness.

Product Analysis (PA)

Date 6/9/92

Product /Service Title and Description
Intelligent Washing Machine- Note this is a development of an existing product. The idea has come from engineers who have built a prototype machine.

Broad Specification/ Design Objectives	***Rationale***	***Detailed Operational Features***	***Actions***
Machine connected to home bus-allowing potential use by a wide range of disability groups with special control devices.	Extends possible application areas, including use by disability groups and remote control and monitoring.	Conformance to European Home Standard	None required
Automatic selection of wash	Useful for elderly people to just have a simple on/off operation?	Single key press for wash, but separate wool wash button is needed. Will this be acceptable?	No answer from user surveys. To be tested during evaluation
Automatic fault detection e.g. leakage and door open	Safety features for use with elderly people	Local alarm, and potential for remote alarms	Priority given to safety features due to user survey
Front loading machine	Based on an existing product	Conventional door with lock release activated after a time delay and only when machine is off.	No problems identified – no action needed
Easy access to machine for adding and removing clothing	Elderly have problems with manipulating clothing	Large door with easy open feature	None required pilot study showed no problems with this aspect of the existing machine
Indicator that machine is on	Good design to show machine is working	Single LED mounted on the front panel of the machine and auditory tone to indicate wash cycle is complete.	Agreed to use a larger LED
Styled as a conventional washing machine	Based on existing product to appeal to the consumer market and to elderly people. Also because it is based on an existing machine.	Conventional styling i.e. an all white machine.	None required
Auditory alarms	Useful for visually impaired users and also to bring attention to problems with the machine generally	Multiple tones now being used, with more urgent alarms being indicated by higher frequencies	This will be evaluated in the study

Product Analysis (PA)

Product /Service Title and Description
Intelligent Washing Machine– Note this is a development of an existing product. The idea has come from engineers who have built a prototype machine.

Broad Specification/ Design Objectives	***Rationale***	***Detailed Operational Features***	***Actions***
Simple maintenance	Needs to be maintainable by non specialist staff	Simple removable filter	No major problems identified
Timer	Allows machine to be used with cheap rate power	Very simple timer designed which does not add significantly to the complexity of the machine	This will be evaluated in the study
Tactile Feedback from Controls	Improves usage for visually impaired people in particular, but also good general design practice	Controls have a positive action, and it is clear what state they are in by touch	None required
Automatic Detergent Dispenser	Makes the product simpler to use	Detergent hopper designed which only has to be filled periodically	To be evaluated

Requirements Summary (RS)

Date 6/9/92

Product /Service Title and Description
Intelligent washing machine

Desired Feature	***Degree of Match with Specification***	***Actions Needed***
Use of sound as well as visual indications for displays	A much better match as different sounds are now used for different conditions. However there is no visual display for the different error conditions	None– as resources do not permit continued specification
Simple controls	Seems fairly good but made more complex by having two operating buttons	Need to determine whether this is acceptable
Large door to machine	No problem anticipated	
Aim to make it as simple as possible to use	May be made more complex by having two buttons	Need to determine whether this is acceptable
Front loading machine slightly easier to use for such groups	No problem anticipated	
A raised plinth for the machine could help in facilitating use	Not included in specification	Agreed to develop an optional plinth.
Good tactile feedback from controls as well as auditory cues	Good match now provided	
Should be a walk up and use product	Should be covered by it being an intelligent machine needing two buttons to operate.	
Need to market product for service providers– product has to be very reliable and seen as being cost effective	Anticipated reliability and cost not specified	Needs to be considered. Also need definition of market sector. Now arguing that elderly people will purchase for themselves and that there is a wider consumer market.
Cheap to operate	Not proven	Needs to be investigated
Simple to use and maintain the product	Filter seems easy to wash, apart from user having to bend down	No action–Impossible to redesign within the constraints of the project
Machine needs to look like a conventional washing machine.	No problem	

Date 6/9/92

Requirements Summary (RS)

Product /Service Title and Description
Intelligent washing machine

Desired Feature	***Degree of Match with Specification***	***Actions Needed***
Leak detection and machine door being open detected, along with internal faults	Messages now differentiated	
Automatic system for collecting washing, but outside the scope of the project	Not applicable	
Easy to use door	Existing design appears to be acceptable	No action needed now
Large door	No problem, existing door appears acceptable	As above
Automatic system for putting washing in machine?	Not applicable	
Automatic detergent dispenser	Not included in specification	This feature to be developed
Single operating button	Not possible due to technical limitations	Not thought to be a serious problem but will be investigated
Timer	Not included–some concerns that it will introduce extra complexity	A simple timer will be included, as the feature is desirable.
Integrated tumble drier with machine? Elderly people have problems with other aspects of washing which are not supported with the technology.	Not included	Too expensive to include – therefore no action needed
Automatic fault detection and machine shut-off of needed–critical to avoid of water damage	Included	
Help line/maintenance	Outside the scope of the functional specification, but the need to consider these issues is noted	Think about practical aspects of supporting the product.
Linked to wider system to control water and power in the home?	Needed for future development, but part of the technical specification rather than a functional issue.	Continue developing the product to allow connection to the home bus

Design Summary (DS)

Date 7/9/92

Product /Service Title and Description
Intelligent Washing machine

Functional Specification	***Priority***	***Operational Details***
Conformance to European Home Standard	High	Draft standard (Version 1.1) to be followed in the technical specification. This has no implications for the products functionality.
Single key press for wash, but dve to technical limitations a separate wool wash button is needed. Will this be acceptable?	High	This is being considered for redesign, but if included will consist of a large red on/off button (2.5 cm in diameter) mounted at the top right of the machine, and a smaller green button mounted towards top centre labelled with a wool icon. Need to identify an appropriate icon. It has been recommended that controls should require no more than .6N force to operate.
Local alarm, and potential for remote alarms	High	Auditory alarms to be provided for machine door open, water leak, and machine malfunction. See below for details. All of these can be remotely monitored. In addition there will be an alarm to indicate the wash has finished.
Conventional door with lock release activated after a time delay and only when machine is off.	High	Expectse of existing washing machine door and release mechanism. Door is 40 cm in diameter with a lever operation. the force needed to operate this is unknown, but earlier recommend-ations will be complied with where possible.
Large door with easy open feature	High	See above
Single LED mounted on the front panel of the machine.	Medium	Single round 15 mm red LED will now be used
Conventional styling i.e. an all white machine.	Low	Will use existing machines styling. No problems anticipated with this as the manufacturer reports good user acceptance of the design.
Single beeping tone for door open, wash finished, leak and machine malfunction.	Low	Agreed to now have four tones but all to be below 900 Hz because of problems with elderly hearing high frequencies. Frequencies of 6, 7, 8 and 900 Hz to be used.
Simple removable filter	High	Located at the front of the machine close to the floor. The filter is taken out of its housing for cleaning and has a screw fitting. This cover is about 7 cm in diameter.

Design Summary (DS)

Product /Service Title and Description
Intelligent Washing machine

Functional Specification	***Priority***	***Operational Details***
Very simple timer designed which does not add significantly to the complexity of the machine	Medium	Simple twist action knob as part of an on/off switch. Knob turns gradually as time elapses with the pointer normally being on the current time. The button can be twisted to point to any time during a 24 hour period, and when pushed the switch will not operate until that time has been reached.
Controls have a positive action, and it is clear what state they are in by touch	High	All controls are click action and also are depressed by 2 cm when they have been operated.
Detergent hopper designed which only has to be filled periodically	High	Hopper only has to be filled after about 10 washes, and also gives a warning (unspecified) when nearly empty.

Usability Evaluation Procedures

In addition to refining the specification for the product, the developers were also encouraged to consider how the products usability would be evaluated, and the criteria which should be met for the product to be considered successful. Developers were encouraged to consider these issues early in the development cycle, as their discussion would be likely to assist in the refinement of the specification. The first step was to consider an overall evaluation strategy which listed the kinds of investigation to be performed and what they were to be used for.

In order to assist in defining these activities the developers looked at all the evaluation methods section of the handbook. These included Direct Observation, Group Discussion, Diary Methods, Questionnaires, Interviews, User Trials, Field Trials and Expert Opinions.

Date 8/8/92

Usability Evaluation (UE1)

Product /Service Title and Description
Intelligent washing machine

Overall Evaluation Strategy

Purpose	***Type of Evaluation Planned***	***Details of Plan***
To observe use in a natural setting	Field Trial	Intended to install the product in one home for three months and monitor its usage over that time.
To look at specific tasks and events which would normally only be rarely observed.	User Trials	A sample of potential users. Idea is to have about 10 elderly people who can use the product during an experimental session of about an hour
To provide a wider perspective on possible problems with the product.	Expert Opinions	Experts on elderly people to be brought together to discuss the product in a group discussion after having the opportunity to experiment with it.

The next phase of the evaluation planning was to consider what usability goals would be set to ensure that the desired features identified in the Requirements Summary had been satisfied. This in turn would lead to a discussion of the activities that should be performed by users in the evaluation studies to ensure that all of these usability goals are satisfied. The Evaluation Planning tool summarises the usability goals to be measured, and lists how this will be achieved. This includes the user based activities which will be used as a source of information, the types of investigations needed, the measurement procedures and any measurement criteria which will be applied. The discussion which took place in order to complete this also assisted in defining the attributes of any users that might be needed for trials. In this example it was clear that any sample of elderly users should also include the visually impaired and the hard of hearing as the system was designed to cope with a range of sensory capability in elderly users. This lead to a revised overall evaluation strategy.

It should be noted that the process followed in developing evaluation strategies and plans may in itself identify new requirements from the product, and so this should be viewed as part of the iterative design cycle. Forcing developers to explicitly think about evaluation early in the development cycle, may also act to crystallise design objectives, and their perceptions of what will constitute a successful product.

Usability Evaluation (UE1)

Date 10/8/92

Product /Service Title and Description
Intelligent washing machine

Overall Evaluation Strategy

Purpose	***Type of Evaluation Planned***	***Details of Plan***
To observe use in a natural setting	Field Trials	Intended to install the product in one home for three months and monitor its usage over that time.
To look at specific tasks and events which would normally only be rarely observed.	User Trials	A sample of potential users. Idea is to have about 10 elderly people who can use the product during an experimental session of about an hour. It is now clear that these need to have some participants who are either visually impaired or hearing impaired, in order to identify how well the product can be used with these groups. Note – those with a severe physical disability cognitive disabilitywill not be included.
To provide a wider perspective on possible problems with the product.	Expert Opinion	Experts on elderly people to be brought together to discuss the product in a group discussion after having the opportunity to experiment with it.

Date 10/9/92

Usability Evaluation (UE2)

Product /Service Title and Description
Intelligent washing machine

Evaluation Planning

Desired Feature	***Product Usability Goals***	***Activities***	***Type of Study***	***Measurement Procedures***	***Pass/Fail Criteria***
Use of sound as well as visual indications for displays.	Whether elderly, hard of hearing and visually impaired people can use the product	The elderly user puts their washing into the machine and then switches the machine on to work immediately. This scenario also includes removing the washing after the machines cycle has finished after having been informed that the washing cycle is complete.	Field trials	Subjective opinions of elderly users and carers during use, direct observation and videotaping	Favourable response to product, and no major problems observed
Good tactile feedback from controls as well as auditory cues	Whether it is easy to learn to use the machine and whether errors are made in use		User Trials	Observed performance of tasks, any errors made in use	As above
	Whether the product is easy to use		Expert Opinion	Subjective opinions of experts	No major problems perceived
Simple controls- Aim to make it as simple as possible to use	That wool wash is selected when appropriate and the user sets the machine back to its normal function	The elderly person copes with using the machine for a wool wash, and setting the machine back to normal functioning	Field Trials	Any actual errors in use. May get elderly person to try the task out	Error free operation
			User trials	Whether in controlled tasks a person can set it, and once used whether they forget to set it back to normal	As Above
Large door to machine Easy to use door	Ease with which washing can be manipulated in and out of the machine	Covered in the above scenario		Observing users putting clothing in and out of the machine	Lack of observed difficulty
A raised plinth for the machine could help in facilitating use	Whether the plinth is likely to make it easier to use for some users	Above scenario repeated for the mobility impaired users (not wheelchair users)	User trials Expert opinion	Observing users putting clothing in and out of the machine	Lack of observed difficulty

Date 10/9/92

Product /Service Title and Description
Intelligent washing machine

Evaluation Planning

Desired Feature	*Product Usability Goals*	*Activities*	*Type of Study*	*Measurement Procedures*	*Pass/Fail Criteria*
Should be a walk up and use product	That a minimum of training is needed. That the users can operate the machine to wash clothing for themselves after a one hour training session	First time use of the machine	Lab. trials Field trials Expert opinion	Observation and videotape, interviews Observation, interviews ie. if this is a problem	No assistance needed in use As above Subjective opinion
Product has to be very reliable and seen as being cost effective	More a technical evaluation, but the field trial will give some indications of reliability		Field trials		Number of reported breakdown during trial period
Cheap to operate	More a technical evaluation, but the field trial will give some indications of cost		Field trials		Electricity, water, and detergent consumed.
Simple to use and maintain the product	Whether it is easy to identify the filter needs washing, and to perform this operation	The machines water filter becomes clogged in use.	Lab. trials Expert opinion	Whether in controlled tasks a person can identify the fault and rectify it Opinions of experts as to whether there is a problem	Awareness of fault. Ability to clean filter. Note- this is not high priority for the elderly user as it was agreed that carers would probably do this. Subjective opinion

Product /Service Title and Description
Intelligent washing machine

Evaluation Planning

Desired Feature	***Product Usability Goals***	***Activities***	***Type of Study***	***Measurement Procedures***	***Pass/Fail Criteria***
Machine needs to look like a conventional washing machine.	End user acceptance of the products appearance	None specifically	Lab. trials	Subjective opinion	Positive comments about product styling
Leak detection and machine door being left open detected, along with internal faults	Safety in operation	The machine leaks during operation, and the elderly person has to cope with this i.e. ensuring that the home is not flooded.	User trials Expert opinion	Whether a person can detect the leak and make the machine safe Opinions of experts as to whether there is a hazard or not	Time taken to make the machine safe Subjective Opinions of safety
	More part of a technical evaluation, what are the implications for the clothes	The elderly person washes their clothes but forgets to activate the wool wash button.	N/A		
	More part of a technical evaluation, what are the implications of this for the clothes	The elderly person forgets to switch off the wool wash setting	N/A		
	Unclear- again not really part of this evaluation	The elderly person forgets they have put washing in the machine.	N/A		
Leak detection and machine door being open detected, along with internal faults	Safety in operation	The machine leaks during operation, and the elderly person has to cope with this i.e. ensuring the home is not flooded.	User trials Expert opinion	Whether a person can detect the leak and make the machine safe Opinions of experts as to whether there is a hazard or not	Time to make machine safe Subjective Opinions of safety

Date 10/9/92

Product /Service Title and Description
Intelligent washing machine

Evaluation Planning

Desired Feature	*Product Usability Goals*	*Activities*	*Type of Study*	*Measurement Procedures*	*Pass/Fail Criteria*
Automatic system for collecting washing, but outside the scope of the project	Not applicable				
Automatic system for putting washing in the machine	Not applicable				
Automatic Detergent Dispenser	Whether users can identify when the detergent dispenser needs filling, and also how to perform this	The elderly user identifying the need to refill the detergent dispenser and managers to do this without assistance	Field trial User Trials Expert Opinion	Subjective opinions of elderly and carers during use, direct observation and videotaping Observed performance of tasks, any errors made in use Subjective opinions	Good response & no major problems observed As above No major problems perceived
Single operating button	Not applicable				
Timer	Whether users can operate the timer for the machine to come on as intended.	The elderly person puts their washing into the machine and then switches the machine on to operate at night	Field trial Lab. Trials Expert Opinion	Elderly users asked to set up the timer if they don't use it normally, and their performance observed Set tasks for using the timer, any problems and errors being recorded Expert opinion as to the ease of use of the timer facility	Timer coming on at the time expected. As above Subjective opinion

Product /Service Title and Description
Intelligent washing machine

Evaluation Planning

Desired Feature	***Product Usability Goals***	***Activities***	***Type of Study***	***Measurement Procedures***	***Pass/Fail Criteria***
Integrated tumble drier	Not applicable				
Automatic detection of faults and switching off of machine needed— avoidance of water damage critical	Ability of users to detect and differentiate between different conditions (Particularly hearing impaired). That the user can easily put the machine into a safe state	There is a failure of the power supply to the home. There is a failure of the water supply to the home. There is a failure of a major component e.g. water pump.	User Trials Expert Opinion	Whether in controlled tasks a person can make the machine safe? Opinions of experts as to whether there is a hazard or not	Not sure this needs more discussion, what are the implications of component water and/ or power failure
Help line/Maintenance	Not possible in this evaluation				
Linked to a wider system to control water and power in the home?	Not applicable in this evaluation				
Safe to use	Safety in operation	The elderly person forgets to close the door to the machine. Any hazard also posed by an undetected open door will also be determined.	Expert Opinion	Opinions of experts as to whether there is a hazard or not	No hazard identified

Outcome and next steps

This document was used to show how the desired attributes that had been identified during product specification would be evaluated, and the first part of this activity was to transform these into usability goals which should be satisfied in any product. For example one of the desired features was that there should be audio as well as visual cues for operation, the intention being that the hard of hearing and visually impaired user should be able to use the machine. Thus a usability goal is for elderly, hard of hearing and visually impaired people to be able to operate the machine. Essentially this activity is recording the logic used in deciding that a product attribute is desired, and where necessary ensuring that it is termed in a way which can then form the objective of any evaluation activity.

It can be very effective to carry out evaluation planning in this way, as the evaluation plans are clearly focused on the desired attributes of the product which is to be evaluated, and it can then be relatively easy to determine whether the product which has been built does actually satisfy these requirements. However the developer should be sensitive to the fact that it is also possible to work towards an evaluation plan from a consideration of general usability goals, and to then decide how these would be satisfied in a particular product specification. For example with many products we can identify many common usability goals. These can include ease of use, ease of learning, comfort in use, safety, motivation to use etc., and we can develop evaluation plans by trying to decide what attributes of the product would satisfy these general objectives. Thus in the case of the washing machine we might argue that ease of use was a very important goal to be met, as otherwise elderly people would not accept the technology being developed. This could lead us to discussing in general terms how we would determine whether this had been satisfied during any evaluation trials.

However as indicated previously it can be very effective to start from what we believe the requirements and needs of our target population to be, and to use the desired features identified in user and activity analysis as a basis for subsequent planning. This should help us ensure that the objectives and criteria that we develop are based on users opinions as to what is important, rather than on developers perceptions of those needs.

The next phase of the planning is then to determine what activities on the part of users would be evidence that these goals have been met, and to describe a scenario or model of possible usage which could be used to measure this. Task analysis

techniques can assist in this process, which is to identify the common ways the product may be used and the activities which should take place during evaluation. In designing new products this is often a creative process however, as there may be no existing activities to analyse, and the developer may have to extrapolate from their own experience of how similar products are operated.

Having identified the activities which should to be examined in order to assess whether usability goals are being satisfied, it remains to identify how these activities are to be evaluated and the measurement techniques to be used. In addition to this, decisions need to be made on appropriate criteria for deciding whether an objective has been met or not. Thus we might say that a favourable response to the product by end users, coupled with a lack of reported problems might be our criteria in one setting, whilst in other cases it may be an error free performance, or subjective ratings of comfort. The developer should move to try and operationalise these are much as possible, as otherwise it will be difficult to determine how well a product is performing. Many usability goals are vague and ill defined e.g. ease of use, and so need discussing in the particular context in which the product will operate. For example, in some cases speed of operation may be considered critical, whilst in others error free operation may be considered paramount.

The activity of exploring how a product may be used and evaluated can also reveal gaps in the initial specification for a product, and the developers using these tools may decide to revisit the specification phase of design, before the final product is built. It is strongly recommended that evaluation planning take place before a product is constructed, as the evaluation plan should be an integrated part of the development process rather than being considered as an afterthought when design has finished.

Usability Evaluation (UE3)

Date 8/10/93

Usability Evaluation Summary

Product /Service Title and Description
Intelligent washing machine

Product's Usability Goals	***Have these criteria been satisfied?***	***Actions Needed***
Whether it is easy to learn to use the machine and whether errors are made in use	Some concerns raised about the use of the wool wash button, this was confusing for users. Some problems with the reliability of the machine in field trials User in field trial overfilled the machine	Can the product be redesigned to automatically detect woollen washes. Need to identify problems in reliability before final release Machine needs to give some warning if it is overfilled.
Ease with which washing can be manipulated in and out of the machine	As anticipated elderly users did have some problems, particularly with wet washing	Think about developing an integrated tumble drier in the future
Whether the visually impaired user can use the product	Some problems understanding the error tones	Will develop a voice announcement system
Whether the plinth is likely to make it easier to use for some users	Experts agreed that this was useful, but recommend more testing with users (particularly mobility impaired).	Further trials with mobility impaired users. This will include paraplegic wheelchair users as well as those with less serious disability.
That a minimum of training is needed. That the users can operate the machine to wash clothing for themselves after a one hour training session	No problem with this	
Safety in operation	No major hazards identified and the open door indicator was seen as being particularly useful for the visually impaired	
Whether users can identify when detergent dispenser needs filling, and also how to perform this	Some problems here as no indicator was actually built. Users had to keep checking the level of detergent which defeated the purpose of having the dispenser.	Redesign needed to ensure that users are given a clear indication of when the dispenser needs filling.
Whether users can operate the timer for the machine to come on as intended.	No problems in using this function	

Date 8/10/93

Usability Evaluation (UE3)

Product /Service Title and Description
Intelligent washing machine

Usability Evaluation Summary

Product's Usability Goals	***Have these criteria been satisfied?***	***Actions Needed***
That the wool wash is selected when appropriate and the user sets the machine back to its normal function	See above- this was one of the major problems	Redesign for single-button operation
Whether elderly people can identify error conditions and differentiate between them. Particularly hearing impaired.	See above- some problems in differentiating the tones used	Redesign of error messages needed
That the user can easily put the machine into a safe state	See above- no real problems with the machine itself	Redesign of error messages needed
Whether it is easy to identify the filter needs washing, and to perform this operation	Some potential problems with this as there is no indication given that the filter needs cleaning. Laboratory trials did show however that many elderly would be likely to be able to do this for themselves, which was better than initially anticipated.	Some indication that the filter needs cleaning, or a redesign of the machine so that a filter is not needed? If possible the filter should be located in a more accessible position in the top of the machine

Final outcome and associated actions

The final phase of the USERfit process is to record the results of the evaluations which have taken place once the product has been constructed, and to decide on any actions needed. Agreement needs to be reached as to how well usability goals have been met, and any actions such as modifications to the product that are required agreed. For example it was recorded that there were some problems with the ease of use of the product, as having two operating buttons introduced some confusion, and made it difficult to use. Thus an action was to see whether the product could be improved to make it single key operation. In addition to identifying problems with existing features, the evaluation should also identify additional needs or requirements which had not been anticipated. For example, the trials revealed that there was a requirement for the machine to indicate that it had been overfilled with washing, which had not been identified as a desirable feature in the earlier analysis.

Appendix 2:

user*fit* in the design of a communication aid

This example shows that in a practical design setting one might only utilise parts of USER*fit*. The example focuses on the need to make explicit some of the user group attributes, and to define some specific characteristics of the product.

The design task

This example is built around the development of a communication aid. The scenario is that there is a small company that produces a hand held communication device for people with impaired speech. They have had some indications that there is a need for a similar device for children with cerebral palsy, but that the earlier existing product does not satisfy the requirements for this group. There is however, no precise understanding of how the new device should be designed. Since there is a new user group in question, it was decided to start with the User Analysis tool. The handbook recommends that the User Analysis is accomplished in a workshop setting.

Previous product.

The "Letstalk" is a small handheld communication device. It may store up to 500 spoken messages that might be accessed through a menu system. There is a small 15 characters display and 16 buttons (1.5 x 1.5 cm) that may be labelled with pictures, symbols, letters or numbers. The different messages are normally chosen by means of a menu system, by showing different menu items in the display. The vocabulary size may be configured to 16, 50, 100, or 500 messages; with 16 messages each one might be accessed directly without the use of the menu system. The device is battery operated, and weighs 0.7 kg. The messages are recorded individually for each user, as are the menu items shown on the display.

The first workshop was held with two of the developers, two carers from a local nursery school for children with cerebral palsy, and the mother of one of the children at the school. The selection of participants was based on their practical knowledge of the problem area, and there were no large overheads involved in setting up and running the workshop.

The group worked for four hours and filled in the three forms of the User Analysis.

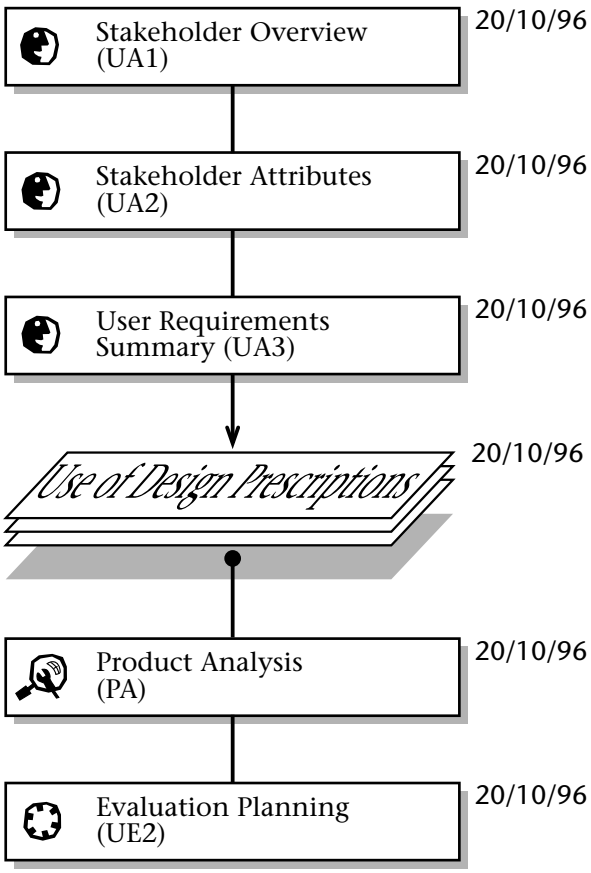

Figure A:2

How this worked example used USERfit—the route through the methodoology

Date 20/10/96

User Analysis (UA1)

Product /Service Title and Description
Communication aid for children with Cerebral Palsy (CP)

Stakeholder Overview

Stakeholder Category	***Role in product/service***	***Design Implications***	***Actions Needed***
Children with CP	Direct users	Users requirements are further analysed in form UA2	Background Research to find out what kind of products that are in the market for this group
Carers in nursery schools	Communication partner Purchaser Support and train direct user Adapt equipment to user needs Order service/ maintenance Change batteries	Manuals etc. should be targeted at the carers. Adaptation to individual users should be possible without special technical skills. Address of service agency should be available directly from the product	There should be a separate activity to design the documentation. One document aimed at parents and carers should guide communication partners. There should be some Background Research to find out what a competitive price is.
Parents	Communication partner Support and train direct user Recommend service/ maintenance Change batteries	Easy fault detection. Standard battery holders	One document aimed at parents and carers should guide communication partners
Service/ maintenance engineers	Maintain and repair	Unclear at the moment.	Find easy and cheap routines for repair and maintenance. Compare costs of repair to costs of new purchase

The group decided to recommend a market survey to identify similar products for price and quality comparisons. The product's documentation should be targeted towards carers and parents. A separate activity should be started to estimate the frequency, cost and routines for maintenance and repair. Although it was recognised that parents and carers were important stakeholders and users of the equipment as communication partners, trainers, by recording messages and changing batteries, it was decided that only the direct users should be analysed further at this stage by the Stakeholder Attribute tool (UA2). The implications of training, maintenance etc. could be analysed at a later stage by using the Product Environmental tool.

Date 20/10/96

Stakeholder
Communication aid for children with Cerebral Palsy (CP)

Stakeholder Attributes

Attribute	*Functional Implications*	*Desired Product Characteristics*	*Actions Needed*
Age range 5 - 12 years	Should not require any scholastic aptitudes Products appearance should fit into the users environment. Should be possible to adapt equipment to users development	Should have a general "toy-like" look-and-feel Should be easy to adapt to a changing vocabulary.	
Gender Both		Look-and-feel should not favour one gender	
Capacities Cognitive: Large variations from normal to retarded.	Should be usable for users with both small and large vocabularies	Product should either be adaptable or should come with different vocabulary sizes .	Background research on typical vocabulary size for this group. Cost implications for the two alternatives should be clarified. Conduct a small survey on the usage of a device with adaptable vocabulary size among a comparable user group (the previous product)
Many users cannot read.	Reading ability should not be required.	Should be possible to label buttons with pictures/symbols.	
Physical: Most users will have mild to severe problems with fine hand movements.	Usage should require a minimum of physical effort. Equipment might be dropped.	Buttons should be large and easy to access. Solid casing	Look up guidelines or recommendation for button size, finger guides, pressure etc.

User Analysis (UA2)

Date 20/10/96

Stakeholder
Communication aid for children with Cerebral Palsy (CP)

Stakeholder Attributes

Attribute	*Functional Implications*	*Desired Product Characteristics*	*Actions Needed*
Most users have problems with gross motor movements.	Many users may not be able to use a hand-held device.	Need not be hand held	
	May be problematic to move the equipment.	Transportation should be easy.	Clarify possibilities for integration/ combination with wheel chair.
Affective: Frustration dve to limited communication opportunities may cause negative emotional reactions.	Equipment might be tossed around, hit, etc..	Solid casing	
Sensory: Vision and hearing are often affected	Sufficient size of symbols and loudness of sound output.	Adjustable/optional symbol size. Adjustable sound output.	
Developmental potential	There is always potential for further development of language and vocabulary in this group	It should be easy to expand and/or change vocabulary	
Educational range From none to elementary school	Might be used in a classroom situation	Adjustable sound volume	
Culture/ Socio-economic status User will usually have a wish to be perceived as "normal"	Equipment should not be too conspicuous	Should probably have different appearances (colours etc.) depending on age and preferences	Clarify costs implications of a range of design options
Size of group Unclear			Background research needed!
Assessment of motivation to use Probably OK, but should be more accurately assessed			Need for more information.

After this exercise it was recommended that a limited interview study be carried out among users and users' helpers of the earlier product. The aim should be to clarify how people both with a limited and a full vocabulary actually use and configure an adaptable communication aid (the present product). The motivation to use such devices should also be addressed in the study.

Several costs implications should be clarified, as should the size of the potential market.

The desired product characteristic was then taken further in the User Requirements Summary (UA3) while the remaining actions will be addressed in the Product Analysis (PA).

User Analysis (UA3)

Date 20/10/96

Stakeholder
Communication aid for children with Cerebral Palsy (CP)

Requirements Summary

Desired Product Characteristics	***Possible Conflicts***	***Priorities for Development***
Should have a general "toy-like" look-and-feel	May not be desired by the oldest children	Medium
Look-and-feel should not favour one gender	None	Medium
Product should either be adaptable or should come with different vocabulary sizes	Adaptability may interfere with ease of use and must rely on help from others. Producing a series will have cost implication	High
Should be possible to label buttons with pictures/symbols	Requires buttons with a minimum size.	High
Buttons should be large and easy to access	Requires buttons with a minimum size.	High
Solid casing	Can be contrary to the desired look-and-feel?	Medium
Transportation should be easy	May require a minimum weight.	Medium
Need not be hand held	None	Low
Adjustable/optional symbol size	Requires buttons with a minimum size.	Medium
Adjustable sound output	High volumes may be disturbing to others not attending conversation.	High
It should be easy to expand and/or change vocabulary	May interfere with simplicity of usage	High
Should probably have different appearances (colours etc.) depending on age and preferences	None	Medium

After the workshop an interview study was conducted among 5 parents that had children with a rather limited vocabulary which used the old communication device, and 5 carers with experience in supporting users using that equipment. There was also interviews conducted with three users with a full vocabulary. It became evident that the users with the smallest vocabulary had several cognitive, motor and motivational problems in using the old equipment, even though it could be "adapted" to the size of their vocabulary.

Based on results from the interviews, marketing and background research, it was then decided that the new product should be specially designed for users with a vocabulary of 16 concepts or less, and that it should be possible to label all buttons with pictures. There were no recommendation that the device should be hand held demanding the simultaneous use of two hands, but it should be easy to move and to mount on a wheelchair.

At this stage there seemed to be three viable technological options: 1) base the product on a hand held pen-operated computer, 2) design a dedicated device with 16 large buttons (plus controls), or 3) integrate a digital sound recorder and a "concept keyboard" (an input device with a pressure sensitive surface on to which zones with different shapes and sizes can be defined and marked with different overlays).

To guide this decision the handbook section on prescriptions was reviewed with emphasis on recommendations for mental and motor impairment. The following recommendations were regarded as relevant sources to make this first choice, although some of the recommendations were aimed at quite different application areas:

From the Design Prescriptions

Well-designed displays for cognitive rehabilitation need to take into account the specific deficits of the intended user. In general, interface designs should be predicated on the view that each cognitively disabled person is unique, and therefore, a single type of display will not be useful for all patients.

.....

The input modality for cognitive rehabilitation software should be designed to match the user's capabilities. Patients with language production deficits should not use a command language, but could use a menu, data form, or direct manipulation interface with fewer problems. In contrast, those with word-finding deficits should not interact with menus or data forms either, and would likely be restricted to direct manipulation.

.....

INPUT/INTERFACE CONTROL Decrease visual and procedural complexity of control techniques. Recommended input techniques for low cognitive load include: touch window, light pen, touch pad, programmable membrane keyboard (often with picture cues), voice activation. Minimise need for visual tracking of target items.

.....

Reduce number of different choices to perceive/select. Avoid requiring users to press more than two keys at one time. Present choices in prompts (voice or graphic) and menus rather than typed commands or memorised sequences.

Utilise task-related motivation features as much as possible in addition to stimulus/response re-enforcement (usually pictures or graphics). Use game features, competition, fantasy, intermediate goals, humour, or novelty to vary task and maintain interest.

Spacing, positioning and sizing controls to allow manipulation by individuals with poor motor control or arthritis.

Keeping things as simple as possible.

Limiting the number of choices where practical.

Using simple screen layouts, or providing the user with the option to look at one thing at a time.

Minimise ambiguity.

Presenting information in as many (redundant) forms as possible/practical(i.e., visual, audio and tactile) or providing as many display options as possible.

Using attention-attracting (e.g. underlining, boldfacing) and grouping techniques (e.g., putting a box around things or colour blocking).

Integrating, grouping and otherwise arranging controls to indicate function or sequence of operation.

Allow flexible time limits for task completion. Prompt user at excessive delays on possible actions or problem solutions.

Hiding (or layering) seldom used commands or information.

The requirements to avoid ambiguous situations, keeping things simple and limiting the number of choices, were seen as arguments against the 16 button design, since it would leave several buttons unused for many of the intended users. The possibility to mask out unused buttons was considered, but seen as a less than optimal solution. The use of buttons with fixed size also acted against this option.

The flexibility of the computer was regarded as very attractive since it supported many of the requirements on individualisation, but it also laid responsibilities on carers to perform the adaptations. It was especially regarded as difficult to have a free choice of pictures and symbols since they had to be in a digital format. Further, the potential candidates for pen-based computers were all judged to make too great demands on the dexterity of the user, since they all required pointing with a small pen in a rather restricted area.

The concept keyboard solution was regarded as having a great flexibility regarding the layout, size and shapes of the "buttons", choice of pictures and symbols and was seen as simpler (for carers) to adapt to the individual user.

It was decided that the equipment should have two separate user interfaces; one for primary users and one for the carers and helpers. The interface for the carers should be hidden to the users, and will not be discussed further in this example.

Given that there are means to record the messages, to define the sensitive areas and to print or draw pictures and symbols on the overlay and match them to a set of recorded messages, there are still several functional characteristics to be designed.

There are the questions of how to turn the device on/off, the characteristics of the membrane (the surface of the concept keyboard) and overlays, the casing, the sound quality and the timing of the output.

From the prescriptive material the following recommendations were seen as being directly or indirectly relevant

Safety and Robustness: Mobility impaired people include those who are not confined to wheelchairs but are weak or poorly co-ordinated and can only walk with aid. Therefore, there may be a fairly high incidence of bumping into the equipment and neither the client nor the equipment should be damaged.

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Avoid switching contexts or operating modes without obvious cues. Provide consistent feedback about system status and how to change to a different status, particularly how to exit system.

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Minimising dual purpose controls.

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Avoiding controls that require twisting or complex motions (e.g., push and turn). (Note: there are rotating knobs that do not require twisting.)

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Locating controls so that the user can reach and use them with the least change in body position.

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Reducing the number of controls

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Where possible, make products automatic or self adjusting, thus removing a need for the controls (e.g., TV fine tuning and horizontal hold)

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Limit the number of activities occurring simultaneously. An upper memory limit for non disabled persons is approximately seven conceptual units.

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Minimising the need for strength by minimising force required as much as possible or by providing adjustable force on mechanical controls. The power needed to press a key should be between 0.3 and 0.6 Newtons. Preferably, the required power should be adjustable.

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The pressure required to activate a key should be between 0.5N and 0.9N.

.....

There should be no significant difference in the pressure required to activate a key between keys of the same key group.

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Providing textured controls (avoid slippery surfaces/controls).

.....

Eliminating any timed responses (or make the times adjustable).

.....

Reducing or eliminate lag/response times.

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Where many keys must be located in close proximity, providing an option that delays the acceptance of input for a preset, adjustable amount of time (i.e., the key must be held down for the preset amount of time before it is accepted). This helps some users who would otherwise bump and activate keys on the way to pressing their desired key. Note: this option must be difficult to accidentally invoke and be provided on request only, as it can have the effect of making the keyboard appear to be "broken" to naive users.

.....

Repeat Keys: Delays the onset of key repeat, allowing users with limited co-ordination time to release keys.

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SlowKeys: Requires a key to be held down for a set period before key press acceptance. This prevents users with limited co-ordination from accidentally pressing keys.

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A capability to adjust and completely switch off the repeat rate should be provided.

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Locating controls, keyboards, etc. so they are within easy reach of those who are in wheelchairs or have limited reach.

.....

Making keyboards adjustable from horizontal. (0 - 15 degrees is standard)

.....

Standard Interface for Special Input Devices: People with severe degrees of mobility impairment may use a variety of specially-tailored input devices such as head-sticks, or breath control tubes. These usually have to be separately interfaced to each item of equipment they are to control, which makes them unreasonably costly for a population which already has to cope with high living costs. If all equipment had a standard interface, the costs of being severely disabled could be reduced.

.....

Systems should have an externally available connection point(s) (standard or special port{s}) for adaptive input devices; the connection should be an industry or company standard; and the computer should treat the input from the adaptive devices the same as input from other standard input devices such as keyboard, mouse, or tablet.

.....

Systems would preferably provide a standard way of connecting at least two momentary contact (SPST) input switches.

.....

Date 20/10/96

Product Analysis (PA)

Product /Service Title and Description
Communication aid for children with Cerebral Palsy (CP)

Broad Specification/ Design Objectives	***Rationale***	***Detailed Operational Features***	***Actions Needed***
Casing and mounting:			
Toy-like appearance	User analysis	Solid wood casing, in different colours.	
Robust	User analysis and prescription	Should stand a drop from 1 m height.	
Easy to reach	Prescriptions	Dimensions 40x20x5 cm.	
Tilt able	Prescriptions	Adjustable to 45 degrees from base.	
Easy to transport	User analysis and prescriptions	Weight max. 0.5 kg	
Mountable on wheelchair	User analysis	Special clip for mounting on wheelchair	
Controls:			
One on/off button with light indication	Prescriptions	2x4 cm yellow button that is lit when equipment is "on".	Must be placed so that equipment is not unintentionally turned off during ordinary use
Automatic time-out	Prescriptions	Time-out after 10 minutes of non use	
External input:			
Possibility to connect to external switch	Prescriptions	Standard interface to two momentary contact (SPST) input switches	
Membrane			
Appropriate pressure sensitivity	Prescriptions	Between 0.3 and 0.9 Newton (Two prescriptions giving different recommendations)	More information on product and user characteristics needed!
Timing etc.:			
Should not be activated by accident	Prescriptions	Trade-off between required time down and pressure.	Conduct usability trials with the most common membranes on the market

Product Analysis (PA)

Date 20/10/96

Product /Service Title and Description
Communication aid for children with Cerebral Palsy (CP)

Broad Specification/ Design Objectives	***Rationale***	***Detailed Operational Features***	***Actions Needed***
Should not repeat unintentionally	Prescriptions	Should be possible to choose whether input is accepted during sound output or not. (Some users may want to express several messages in a row).	Usability trials
Immediate response	Prescriptions	Delays should not be longer than 0.3 seconds?	
Overlays: Overlays should have appropriate surface and should not interfere with characteristics of membrane	Prescriptions and practical implication from the use of a concept keyboard	Should come with paper in appropriate size and a plastic surface to cover the paper	Should be tested as a part of the user trial

The workshop concluded that a usability trial should be conducted in order to establish the appropriate characteristics regarding timing and pressure sensitivity of the product. In order to perform the user trial a prototype was set up. Two different concept keyboard with different pressure characteristics were interfaced to a PC that allowed recording of digital sound and sound output. Two different set of overlays were also prepared.

Since the study had a rather limited scope, it was decided to skip the Overall Evaluation Strategy (UE1), and go directly to Usability Evaluation(UE2).

The completion of the Usability Evaluation form was carried out by two members of the company's design team.

Usability Evaluation (UE2)

Date 20/10/96

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Evaluation Planning

Desired Feature	***Product Usability Goals***	***Activities***	***Type of Study***	***Measurement Procedures***	***Pass/Fail Criteria***
Should not be activated by accident	Minimise user errors	Turn on/off	User trials	Proportion of activation through membrane	0 % errors
					10% errors
		Move equipment.		As above	
		Remove object from membrane.		As above	10% errors
		Pressing areas of different size		Proportion of erroneous activation	0–5 % errors depending on size of area.
Should not repeat unintentionally	Minimise user errors	Pressing areas of different size		Proportion of erroneous repetitions	5% erroneous repetitions
Immediate response	User satisfaction		Lab test	Latency time	Fastest better

Setting the pass/fall criteria proved to be the most difficult decisions to be made, and it was recommended that they should only be treated as broad objectives. In the end the product had to be based on an available concept keyboard, and the goal was therefore to find the better of the two candidates rather than the best possible design.

To test the response times of the two concept keyboards it was decided to perform laboratory tests without users.

The detailed test for the trial was design according to the section on User Trials in the handbook. The tasks should be designed not only to cover two different concept keyboards, but also two different kinds of overlay material and different "time-before-activation" conditions. Each user should also be tested on both small and large sizes of the sensitive areas of the concept keyboard.

It was decided to test 8 potential users with both concept keyboards. They should be recruited from the nursery school, and it was aimed at including users with severe physical handicaps.

Since the anticipated error rates were rather small, it became evident that each of the tasks had to be performed a number of times by each participant. It had to be taken into account that there might be some carry-over of experience from using one keyboard to the other, and that each participant might become more familiar with the equipment and the test situation during the trial.

Final comment

The example ends here. But since design is an iterative activity, the question of improving the product's usability will continue to live with the product. After the user trial there should be enough information to revise the product design and go into sufficient production to allow a number of the units to be evaluated. It would then be a matter of how many resources could be put into further evaluation. At some point there would certainly be a need for an assessment of usability based on a realistic use of the product over some time. In order to achieve these evaluation objectives the use of interviews, field trials and direct observation should be considered, probably in some combination. It might then be appropriate to revisit the information gathered at earlier stages of design in order to compare early assumptions with later insights. This might lead to a revision of the user requirements, leading to new product specifications etc.