ALFRED

Personal Interactive Assistant for Independent Living and Active Ageing

D8.2.1 Piloting & Validation I: Individual Usability

Deliverable Lead: NFE

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Short Abstract:

This deliverable presents the results of the second and third cycle of the iterative evaluation. Additionally it presents the final details of validation of the project in terms of the different pilots and ongoing usability studies that are organized by the End User Organisations in France, Germany and the Netherlands.

SEVENTH FRAMEWORK PROGRAMME

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Executive Summary

This D8.2.1 is a follow up of D8.1.2 of WP8 Piloting & Validation, where results are given on the first iterative evaluation and the planning of the pilot methodology. This D8.2.2 gives the results of the second and third iterative evaluation. It gives the final pilot planning for pilot 1 and 3. This D8.2.1 is simultaneously released with D8.2.2 which is a confidential deliverable. This deliverable contains summarized information on the final results of the Iterative Evaluations to protect possible business opportunities of the ALFRED project. For the complete version, please consult D8.2.2.

The approach of the ALFRED project is to involve target groups continuously in the development of the system through Iterative Evaluations. The aim of this approach is to provide to the system developers continuous recommendations from the end users in order to obtain final results that are easy to use by older people and are adapted to their requirements and needs. The first Iterative Evaluation in M12 (reported on in D8.1.2) of the project was focused, among others, on the WoZ methodology to obtain more insight on voice interaction and older people.

This document continues this approach by reflecting the results of the second and third Iterative Evaluation Cycles in section 2. These cycles focus on different technical components of the ALFRED system. The results of the second and third sessions are analysed and reported back to the technical partners, reflected in this deliverable. In D8.2.2 (the confidential version) technical partners are informed on problems and necessary improvements through a set of simple tables with recommendations. The recommendations are ranked in priorities based on the amount of incidences during the usability sessions.

In the second Iterative Cycle the ALFREDO Marketplace, the Dance with ALFRED app and the ALFRED T-Shirt were tested with a total of 12 Test Persons (TPs). The ALFREDO Marketplace received a good user rating in general, the main issues were related to navigational and data entry problems. Most participants enjoyed playing the “Dance with ALFRED” game and especially had fun with the multiplayer modus. On the other hand, more challenging levels and a better introduction on how to play the game were desired. The main problems with the T-shirt was the position of the sensor unit in front of the chest. This and the thick material caused a discomfort and lead to excessive sweating of the users.

The third Iterative Cycle evaluated was the User Profile Editor, the (improved) ALFRED T-Shirt and the connected health app, the Dancicians game and the (improved) ALFREDO marketplace. A total of 25 TP’s were involved. The User Profile Editor was considered easy to use, but the majority of the users experience inconsistencies in the user interface. Suggestions are given to improve usability. The ALFRED T-shirt was received positive as users liked the idea to check their health status, but doubts were raised on data sharing. Different recommendations are given to improve usability and improve data transparency. The Dancicians game (before Dance with ALFRED) remains difficult for users. Although many improvements were made compared to Cycle 2, there are still some usability issues

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that must be tackled. Finally the ALFREDO marketplace received very good ratings and only minor recommendations.

Finally this deliverable extends further on the pilot methodology which was initially described in D8.1.2. Section 3 describes the pilot methodology on the Integrated ALFRED system in pilot 1, the Netherlands and pilot 3, France. These two pilots start with a final Iterative Evaluation on the Integrated ALFRED system. This final evaluation will define the task success rates as suggested by the reviewers. The success rates will provide for innovative input on the added value and ease of use of voice interaction for older people, using the ALFRED system and ALFRED apps. The results will be given in D8.2.3 (public version) and D8.2.4 (private version). After this phase, a total of 20 end users will use the ALFRED system independently at home. With the results of the pilot, the final KPI's that are defined here, can be given in D8.4.

In section 4 the pilot methodology for the German pilot is shortly described. D8.3 will follow up on this section, extending also further on the KPI's for this pilot.

The Iterative Evaluations show that early prototype testing with users is very valuable for the final prototypes as the developers are able to obtain users recommendations and start adapting their solution at an early stage of the development. This early testing helps also the end-user partners to plan and define the ideal final validation (pilot) test settings, as the researchers are very much involved in the development and have seen the earlier versions of the system components. The pilots, as the technical development, have been developed in an iterative process adjusting to the reality of each moment.

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1 Introduction

ALFRED – Personal Interactive Assistant for Independent Living and Active Ageing – is a project funded by the Seventh Framework Programme of the European Commission under Grant Agreement No. 611218. It will allow elderly people to live longer at their own homes with the possibility to act independently and to actively participate in society by providing the technological foundation for an ecosystem consisting out of four pillars:

- **User-Driven Interaction Assistant** to allow older people to "talk" to ALFRED and to ask questions or define commands in order to solve day-to-day problems.
- **Personalized Social Inclusion** by suggesting social events to older people, considering his interests and his social environment.
- A more **Effective & Personalized Care** by allowing medical staff or carer to access vital signs of older people monitored by (wearable) sensors.
- **Physical & Cognitive Impairments Prevention** by incorporating serious gaming to improve the physical and cognitive condition by offering games and quests to older people.

1.1 ALFRED Project Overview

One of the major problems today is the increasing isolation of older people, who do not actively participate in society either because of missing social interactions or because of age-related impairments (physical or cognitive). ALFRED will allow overcoming this problem with an interactive virtual butler for older people, which is fully voice controlled.

The ALFRED project is wrapped around the following very clear main objectives:

- Empowering people with age related dependencies to live independently for longer by delivering a virtual butler with seamless support for tasks in and outside the home. The virtual butler ALFRED will have a very high end-user acceptance by using a fully voice controlled and non-technical environment.
- Prevailing age-related physical and cognitive impairments with the help of personalized, serious games.
- Fostering active participation in society for the ageing population by suggesting and managing events and social contacts.
- Improved care process through direct access to vital signs for carers and other medical stuff as well as alerting in case of emergencies. The data is collected by unobtrusive wearable sensors monitoring the vital signs of older people.

To achieve its goals, the project ALFRED conducts original research and applies technologies from the fields of Ubiquitous Computing, Big Data, Serious Gaming, the Semantic Web, Cyber Physical Systems, the Internet of Things, the Internet of Services, and Human-Computer Interaction. For more information, please refer to the project website at http://www.alfred.eu.

1.2 Deliverable Purpose, Scope and Context

This deliverable gives the results of the second and third iterative user evaluations that were made on different ALFRED components with older end users. It gives a set of recommendations in simple tables that are used by the technical partners to improve these components. The deliverable proceeds with detailing the final iterative evaluation on the Integrated ALFRED system within the usability perspective and plans the three pilots. Pilot 1 in the Netherlands and pilot 3 in France will run the pilot on the Integrated ALFRED system and Pilot 2 in Germany will focus on the health aspects of ALFRED with specialized medical staff.

1.3 Document Status and Target Audience

This document is listed in the Description of Work (DoW) as “confidential”, as it provides confidential information business components of ALFRED that are key to exploitation and can therefore not be used by external parties.

1.4 Abbreviations and Glossary

A definition of common terms and roles related to the realization of ALFRED as well as a list of abbreviations is available in the supplementary document “Supplement: Abbreviations and Glossary”, which is provided in addition to this deliverable.

Further information can be found at http://www.alfred.eu.

1.5 Document Structure

The following Chapter 2 describes the results of the second iterative evaluation which was in the spring of 2015 with older end users in Germany, France and the Netherlands. The evaluation included different ALFRED components, such as the ALFREDO market place, the Dancicians game and the sensor T-shirt. Based on this, a set of recommendations was developed that was communicated back to the technical partners. The third evaluation sessions took place in November and December of 2015 in the same countries and also included different ALFRED components, including notably the profile editor and the health monitoring app. The results of these evaluations are also provided to the technical partners as recommendations for the integrated ALFRED system.

Following up on D8.1.2, chapter 3 then proceeds to describe the detailed pilot methodology. It first describes the pilot methodology in Pilot 3 France and Pilot 1 the Netherlands, where the integrated version will first be tested in a final usability session to define the success rate of the tasks and then will be tested in the homes of older end users. The final section will describe the methodology for the German pilot which will focus on health aspects of the ALFRED system.

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2 Key Findings from Iterative Evaluations

Within the ALFRED project the development of prototypes is accompanied by iterative evaluations. These evaluations are a continuous process to ensure that project results can be easily used by older people. Test Participants (TPs), of all target user groups are recruited by the end user partners (France, Germany and the Netherlands).

The first Iterative evaluation was in M12 and results were reported in D8.1.2. The process of Iterative Evaluations went on and this section will give the results for Cycle 2 (in Spring 2015) and Cycle 3 (in Fall 2015).

2.1 Iterative Evaluations Cycle 2

The aim is to give the key findings of cycle 2 user studies, organised in spring 2015. The details of the used methodologies can be found in D8.1.2 and in the cycle 2 workbook (see Annex 1). All data from the three countries was collected in a common Excel file and then analysed by the responsible end-user partners.

2.1.1 Summary

This section contains the results of the second prototype evaluation, including the ALFREDO marketplace, the game “Dance with ALFRED” and the ALFRED Sensor T-shirt. The After Scenario Questionnaire (ASQ) and Post-Study System Usability Questionnaire (PSSUQ) were used to evaluate the usefulness and usability of the currently available prototypes with older adults.

Altogether 12 (9 females, 3 males) seniors participated in the testing. Table 1 shows general information about the Test Participants in Cycle 2.

Table 1: Test Participants in Cycle 2

	Netherlands (NFE)	**France (ESE)**	**Germany (CHA)**	**Total**
Number of participants	6	3	3	12
Number of Female and Male participants	4(F), 2(M))	2 (F), 1 (M)	3 (F)	9(F), 3(M)
Average age of participants	74	70.3	73	72.4

The users had to perform 4 tasks with the ALFREDO Marketplace. 2 tasks and 6 questions had to be answered for the dancing game and finally 2 tasks and 9 questions needed to be answered for the Sensor T-shirt.

The ALFREDO Marketplace received a good user rating in general, the main issues were related to navigational and data entry problems. Most participants enjoyed playing the “Dance with ALFRED” game and especially had fun with the multiplayer modus. On the

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other hand, more challenging levels and a better introduction on how to play the game were desired. Despite the necessary tight fit of the ALFRED Sensor T-shirt, the participants had no trouble when they were putting on the T-shirt, also the ALFRED logo on the shirt received positive remarks. The main problems with the T-shirt was the position of the sensor unit in front of the chest. This and the thick material caused a discomfort and lead to excessive sweating of the users.

In the second part of the test, the ALFREDO marketplace was tested, which has been done with four tasks. Moreover, each individual task was evaluated by the tester with the ASQ and the PSSUQ was filled in after the second part of the task sets. The PSSUQ consisted of 19 questions (one overall satisfaction question was added) divided by four sub-measures (Both the ASQ and the PSSUQ are fully described in D8.1. Annex A for the ASQ and Annex B for the PSSUQ questionnaires).

The third and final part of the test consisted of the game 'Dance with ALFRED'. After finishing these questions, participants were thanked for their help and the test was over. In the Netherlands and France, the average sessions took around 45 minutes. In Germany, sessions took 20 min longer, as the T-shirt was tested as well.

2.1.2 Participants

Test participants are recruited by the end user partners (France, Germany and the Netherlands), using national projects and services to reach them. All participants visited the end users offices to be part of the iterative evaluations. Participants were guided with a workbook (including an Informed Consent, see Annex 2).

During the intake information about the participants was gathered regarding their year of birth, gender, nationality, household income, marital status, living situation, education, employment, residential situation, self-rated health, vision, hearing, motor control and the self-rated mobility level.

In the intake questionnaire participants were also asked about their technological attitude and behaviour. 7 Test Persons (TP) had a mobile phone, 4 had an Android smartphone, and one had a senior smartphone. 8 participants had a positive attitude towards technology and 4 participants had a neutral attitude towards it.

4 participants had a lot of experience with technology, 4 considered themselves to be average and 4 participants said they had little experience with technology. This corresponded with the results to the question "*What is your use of ICT Tools (computer, smartphone, tablets*?", where 6 participants answered that they used technology on a daily base and 3 participants said they used technology on a weekly base ("*I check my e-mail every Tuesday, but that is enough for me*") and 2 used their mobile phone on rare occasions only. The online activities of the participants differ; checking e-mail and searching the web (public transport information, road directions, looking up the news) are the main activities. Participants with a smartphone also use the text messaging or WhatsApp. Other activities mentioned were online shopping and playing games.

Finally, as games were a part of this testing round, participants were also asked some questions related to this. Four participants loved to play games, two thought it was fun once in a while, three people had a neutral opinion about playing games, one participant did not really like it and two participants really did not like playing games. 10 participants played games sometimes and two indicated playing games very often. When asked what

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games participants played (multiple answers were possible), eight participants mentioned card games, five mentioned board games, and three mentioned puzzles and one mentioned parlour games, either online or offline. In Annex 2 “Overview of Test Participants Cycle 2” the extended information on the TP’s can be found.

2.1.3 Evaluation Tasks and Results

This section contains the results of the second prototype evaluation, including the Sensor T-shirt, the ALFREDO Marketplace and the Dance with ALFRED Game. The specific tasks were defined together with the partners developing each component, once it was clear that which app prototypes and which of their functionalities were ready to be tested. Moreover, the technical partners also detailed the type of end-user feedback would be the most valuable.

The evaluation was performed with two test administrators guiding the session and one test person. One person guided the user through the questionnaires and questions, another observed, helped and monitored the different tasks that needed to be done.

Based on the findings, recommendations are made for improvements of each part of the ALFRED system that was tested. Recommendations are given based on the problem identified by the user, and classified based on priority. Priority is given to certain problems based on impact, frequency of occurrence and persistence of an error. Some TP’s suggestions for improvements are also included in the recommendations.

2.1.3.1 ALFRED Sensor T-shirt

The first part of the test consisted of tasks about the ALFRED sensor T-shirt. This component is focused on health data and therefore, for the Cycle 2, the early smart t-shirt prototype was only tested in Germany (at CHA) where medical staff was present. The users had to perform 2 tasks with 9 questions to answer. They needed to try on the T-shirt and to activate the sensors. Users had the choice between two sizes of the T-shirt.

In order to gain a more detailed insight on how satisfied the users were with the sensor T-shirt, they were instructed to wear it for a period of one day (12 hours); or as long as they could tolerate to wear the shirt in their daily environment while performing everyday activities. After sending the material (Sensor T-shirt and questionnaire) back to the end users office, they participate a short telephone interview to gather additional comments.

In the current test 3 users were tested, 2 of them normally wear T-shirts in size small and 1 in a size medium. The users had little trouble putting on the T-shirt despite the necessary tight fit of the shirt. This was an initial concern of the seniors and also the end-user organisation, since putting on a compression type shirt like the ALFRED sensor T-shirt requires a great amount of flexibility in the shoulder joints.

The activation switch of the sensor unit of the T-shirt is not suitable for seniors due to its small size and poor accessibility. The transmission of the signal from T-shirt to the Nexus 5 smart phone worked without any problems during the test session. However, the position of the sensor unit on the T-shirt has to be changed for comfort and aesthetic reasons. Future sensor T-shirts should be made out of thinner and cooler fabric with better air permeability. Alternatively, the T-shirt could be substituted by a chest belt (which can be made from the same material as the T-shirt) which only covers the area where the sensors need to have contact with the skin of the user. This could reduce the heat which gets

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trapped under the current T-shirt and avoid issues with putting on and off the T-shirt in users with reduced flexibility of the shoulder joints. A sleeveless shirt would be another option to further reduce excessive sweating experienced by the users

The transmission of the vital parameters and body position from the T-shirt to the Nexus smartphone worked equally well for both participants regardless of the tested size of the T-shirt. With the currently described issues the users would not want to wear the sensor T-shirt for a prolonged period of time.

2.1.3.2 ALFREDO Marketplace

The users had to perform 4 tasks with 12 questions to answer. They needed to change their username, check the apps that were already downloaded, check the new apps are available in the Marketplace as well as try to update current apps.

The concept of a marketplace was unfamiliar to most users and had to be explained before the test by the test administrators. When starting with the first task, a lot of participants were nervous, as they were not sure what to expect of an online marketplace. However, most participants found the tasks not as hard as expected. Unfortunately, there were technological issues which made it impossible for the participant to complete the first task by him/herself; in all cases the test administrator had to intervene and point out the way the name could be changed. Regarding the second, third and fourth task, some participants experienced difficulties understanding the concept of an application. For some participants, the questions itself were difficult and so the test administrator had to explain the meaning of the question beforehand. For a lot of participants (especially those who did not have a smartphone), the idea of ‘my apps’, ‘newest apps’ and ‘update apps’ was difficult to understand, as they did not know what an app is.

Except for the previous comments, users were in general quite positive about the size of the buttons and the icons. The buttons were big enough and the icons were clear. Participants especially liked that there was a description below every icon, even though they did not know what they all meant (e.g. my apps). In general, participants liked the design of the application, the colours, the size of the buttons and the pictograms used – even if they could not extract the exact meaning from them right away.

2.1.3.3 Dance with ALFRED

The users had to perform two tasks and answer 6 open questions in order to get important feedback for the Dance with ALFRED game: the first was to just play the game on medium level as an introduction. The second was to play the game again, on the same level or on easy or hard mode, depending on the participants’ performance before. The participants chose an instrument and started playing autonomously; the test administrator monitored the experiment.

The final number of participants for this part of the test was 11, because one of the participants left after finishing the tasks for the ALFREDO Marketplace. Most remaining participants had fun trying the game and were enthusiastic about this concept, as some of them did not expect it to be for older people. They all tried the game in medium modus first. In the second try, eight participants played the game in hard mode, as they wanted a bigger challenge. The other three participants played the game in medium mode for a second time.

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When participants were asked what they liked about the game, almost everyone answered that they liked to play it together with someone else. Others liked the aspect of exercising: "*I have a home trainer but this is way more fun!*" In order to improve the accessibility of the game, a short introduction on how to play the game should be included.

2.1.4 ASQ Ratings

First and foremost, ASQ ratings show that users in general were satisfied with *the ease of completing the tasks* 2, 3, and 4, time it took them complete it and the information they received from the screen. All mean values were below 3, with the highest mean value being 2.92 and the lowest 1.83. Considering that the ASQ has a rating from 1-7 where 1 means a high satisfaction and 7 means a low satisfaction, this rating can be considered to be a high general satisfaction value. Lowest values were found for *the ease of task completion* (*M* = 1.83, *SD* = 0.94) and (M = 2.25, SD = 1.91) of the second on fourth task. In general, the participants found it easy to find the place to download new apps, even if they did not succeed immediately. Task 1 only showed a medium satisfaction ranging from 3.33 to 3.75. By looking at the values it can be seen that the German users were particularly dissatisfied with this task by rating it either with a score of 6 or 7. The reasons for this were mainly the small size of the keyboard and the wrong ordering of the buttons in order to change the user name.

Additional reasons are probably also that these users all had little (N =2) or medium (N =1) and only used ICT tools rare (N =2) or once a week (N =1) technological experience and did own basic mobile phones. The Dutch and French users had fewer problems with this task and three of the Dutch users even were very satisfied with this task, which can be explained with the fact that in these countries the testers were more familiar with the usage of ICT-tools. Dutch and French users also used ICT tools more often and 6 users use it daily and 3 weekly. The difference in the satisfaction in these tasks between German and French users can also be seen in the large variance in task 1, which ranges from 4.06 on the amount of time that it took users to complete the task to 4.57 to the amount of supporting information that was provided.

The mean values for supportive information while completing the tasks, were higher for task 2 (*M* = 2.92, *SD* = 3.72), task 3 (M = 2.75, SD = 1.84) and task 4 (M = 2.50, SD = 1.55). The marketplace doesn't provide any support information in case the users had navigational problems. The fact that for some users the keys of the Nexus phone were not clear confirms this. The mean ASQ score of task 4 (2.25) was lower than in task 3 (2.7) and task 2 (2.53). The users were probably more familiar with the app in the last task and therefore the lowest values were experienced here. This corresponds with the finding that it was not difficult to find the right place for app updates but there were no applications that needed to be renewed. Participants did not understand this from the instructions given on the screen and often thought they were in the wrong place.

The following table summarizes these findings.

Table 2 ASQ Ratings in Cycle 2

ASQ Ratings (1=high satisfaction, 7=low satisfaction)

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Parameters	M (mean)
Ease of task completion	
Task 1	3.53
Task 2	1.83
Task 3	2.7
Task 4	2.25
Ease of supporting information while completing	
Task 1	2.92
Task 2	2.75
Task 4	2.50
ASQ Score	
Task 2	2.53
Task 3	2.7
Task 4	2.25

2.1.5 PSSUQ Ratings

The results of the PSSUQ can be divided in four subsections, of which the first entails the overall satisfaction of the user with the system and is calculated by the mean of all 19 questions. The rating (1 – 7) is the same as for the ASQ. The overall satisfaction was rather high (*M* = 2.72, *SD* = 0.48) which indicates that users were in general very satisfied with the ALFREDO marketplace.

The second subsection, system quality, is derived from question 1 – 8. It measures whether the system is efficient and whether users feel comfortable using it. Values were low (*M* = 2.52, *SD* = 0.28), which means users were satisfied. Especially questions regarding the feeling on how comfortable the system can be used (*M* = 2.17, *SD* =2.15) and one's believe of being able to learn how to use the system in a quick and easy way (*M* = 2.08, *SD* = 2.08) had lower values.

The third subsection regarding information quality is being calculated by the answers to question 9 – 15 and shows how well a system is capable of providing the right kind and amount of information to participants. Average values showed a positive feeling (*M* = 3.0, *SD* = 0.49), however the highest values (lowest satisfaction) were found in this section. Information about clear error messages (*M* = 3.75, *SD* = 0.93) and help from the system when a mistake was made (*M* = 3.75, *SD* = 1.66) were rated higher. Ratings were still in the positive aspect of satisfaction (below a value of 4) but rated less positive than the other questions. There are two explanations for this. First of all, a lot of users were confused

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when they could not find anything (e.g. in the last task) and they found the information ("no updates found") not sufficient enough, as they were not aware that they did not have any applications downloaded at all. A second explanation is that a lot of users were unsure of having seen any error messages (*"I don't think I have seen any error messages so I don't know how to answer this question"*). Therefore, these participants rated the question with the middle, neutral answer, which is rated a 4 in the statistical procedure.

The final subsection of the PSSUQ is about the internal quality of the system. Does the system have all the right capabilities and does it have a good interface? The average value showed that users were in general satisfied with the internal quality of the system (*M* = 2.6, *SD* = 0.47). They were especially positive about the interface (*M* = 2.08, *SD* = 1.72), which corresponds with findings of users who liked the colours and thought the pictograms with words under them were very clear and understandable.

The following table summarizes the findings based on the PSSUQ.

Table 3 PSSUQ Ratings Cycle 2

PSSUQ Ratings (1=high satisfaction, 7=low satisfaction)	
Parameters	M (mean)
Overall satisfaction (Q1-Q19)	2.72
System quality (Q1-Q8)	
Total average value	2.52
How comfortable can the system be used	2.17
Belief to become quickly productive with the system	2.08
Information quality (Q9-Q15)	
Total average value	3.0
Clear error messages	3.75
Support for mistakes	3.75
Internal quality of the system (Q16-Q19)	
Total average value	2.6
Interface	2.08

2.2 Iterative Evaluations Cycle 3

The aim is to give the key findings of the user studies in Cycle 3, organised in fall 2015. The details of the used methodology can be found in D8.1.2 and the Cycle 3 workbook

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(see Annex 3) that gives the predefined tasks performed by the users. The results of the study were collected and analysed for description in the following section.

2.2.1 Summary

The Iterative Evaluation Cycle 3 was done in France and in the Netherlands in November 2015 and in Germany in December 2015. This section contains the results of the third prototype evaluation, including the User Profile Editor, the ALFRED T-shirt and the connected health app, the Dancicians game and the ALFREDO marketplace. The Post-Study System Usability Questionnaire (PSSUQ) was used to evaluate the usefulness and usability of the currently available prototypes with older adults. Altogether 25 (22 females and 3 males) participated in the testing in the Netherlands, France and Germany.

In the User Profile Editor (developed by TIE/WP5) users needed to create, edit and update his/her own user profile with a visual user-interface. The ALFRED T-shirt (developed by AITEX/WP6) was worn by users to measure vital data and to track on his/her health status with the connected mobile app. The Dancicians game (developed by TUDA/WP7) challenged the users to move with a sound stimulating body and mind and the ALFREDO Marketplace (developed by WORLD/WP3) users could check the availability of new apps. The recommendations of all the tested applications are sorted in tables and prioritized by how many times a recommendation was mentioned by the participants.

2.2.2 Participants

Representatives from the primary target groups were involved in the testing as demonstrated by the following table:

Table 4 Test Participants in Cycle 3

	Netherlands (NFE)	France (ESE)	Germany (CHA)	Total
Number of participants	19	3	3	25
Number of Female and Male participants	17(F) 2(M)	2(F) 1(M)	3(F) 0(M)	22(F) 3(M)
Average age of participants	75	68	73	72

Five of the participants had a smartphone (four Android, one iOS). 18 Participants had a normal mobile phone and 2 seniors only had a home phone. From the total of participants only 2 people said to have a negative attitude towards technology (technology makes place of social inclusion), 14 people had a positive attitude towards technology, 9 said to be neutral. There were huge differences in the technological experiences of the participants. Only 3 rated themselves very high experienced, 9 high experienced, 7 medium experienced, 3 low experienced and 3 very low experienced. Most of the

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participants make daily use (16) of different ICT tools and although the amount and type of activities differ, most of the participants use ICT for e-mail and/or playing games and/or in general web searching.

The initial purpose (as planned in D8.1.2) of involving more participants in the Dutch evaluation was to have a more reliable test case on the speech interaction within the different applications and draw conclusion and develop guidelines on development of speech interaction. Due to delay of the technical delivery, the testing of speech interaction is postponed, and an additional iterative testing cycle of ALFRED Alpha version (more information in section 3.1.1.1) will be implemented just before the pilot in France and the Netherlands.

It was decided to maintain the initial plan of the bigger test pool in the Netherlands, as an added value compared to the earlier Cycle 1 and Cycle 2. The large test pool in Cycle 3, made it possible to test the ALFRED components with different ALFRED target groups (see the group definitions in D2.3).

When we look at the three defined target groups, 8 participants belong to the Primary Target Group (PTG)[1] PTG1[2] and 10 participants to the PTG2[3] or PTG3[4]. In France all the three participants belong to the PTG1 but one of the testers' is also Secondary Target Group (STG)1[5] as she is taking care of a family member. In Germany three participants were part of the predefined PTG1 group and one user was taking care of both her parents so he can be considered a user of the STG1 group as well. 24 of the participants live independently at their home, one of them in a home for older people. Annex 4 (Overview of test participants Cycle 3) gives further information on the TP's characteristics.

2.2.3 Evaluation Tasks and Results

This section contains the results of the third prototype evaluation, including the User Profile Editor, the ALFRED Sensor T-shirt, the game 'Dancicians' and the ALFREDO Marketplace. The Post-Study System Usability Questionnaire (PSSUQ) was used to evaluate the usefulness and usability of the currently available prototypes with older adults.

In the result analysis focuses on providing testers' recommendations for the technical partners and not on defining task success rates. Moreover, this Evaluation Cycle is focused on different components of the ALFRED system and therefore there is no added value in measuring success rates. In the final Iterative Evaluation (described in Chapter 3.1.1)) success rates will be included on each of the tasks, taking also up the comments of the EC reviewers.

The evaluation was performed with two test administrators guiding the session and one participant. One person guided the user through the questionnaires and questions, another observed, helped and monitored the different tasks that needed to be done.

[1] See the specific definitions in D2.3 User Stories Report.
[2] Independently living and autonomous older adults 60+
[3] Independently living older adults 60+ having informal caregiver's support
[4] Independently living older adults 60+ having formal caregiver's support
[5] Informal caregiver

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2.2.3.1 User Profile Editor

This application was tested the first time with users in this cycle. The users had to perform 5 tasks with 7 questions to answer with the User Profile Editor. They needed to register and log in, to edit and use their own profile, to add a new contact, to look for their own health statistics and to log off (see Annex 3 for further task definitions).

In general, the users considered that the user profile was relatively easy to create, but the majority of the users experience inconsistencies in the user interface: the way they needed to save changes and to add information in an easier way. Also the language (only an English version) was experienced by most participants as a problem. Moreover, some suggestions were given to improve the usability. For the User Profile Editor, recommendations are the following:

2.2.3.2 Sensor T-shirt

The ALFRED T-shirt had already been tested in Germany during the iterative testing cycle 2 but this was the first time in France and in the Netherlands. All the three countries tested the linked health data app for the first time.

The users had to perform 3 tasks with 11 questions to answer regarding the comfort and usability of the Sensor T-shirt (see the tasks in the workbook in Annex 3). They needed to try on the T-shirt, to insert and activate the sensors and to connect the T-shirt with the ALFRED application. Although the all testers agreed to try on the T-shirt, the results do not confirm that everybody is ready to wear it on a more regular basis to monitor their health. An often mentioned sentence was "*if I get more complaints*", "*if my health gets worse*" or "*if it is necessary*". In consequence, the most testers would agree to wear a smart T-shirt only under certain conditions, notably if they have health problems.

A special attention must be paid to t-shirt sizes as those are sized very small. Moreover, the testers liked the app related to the t-shirt and the idea to be able to check on their health status and be informed about potential changes in their health but they want to be able to decide with whom this data is shared.

The following table lists the users' recommendations for the t-shirt:

2.2.3.3 Dancicians

The previous version of this game was called "Dance with ALFRED" and it was tested in the three countries in the iterative testing cycle 2, and in the cycle 3 a new version of the game "Dancicians" was tested in these three countries.

The users had to perform 3 tasks with 6 questions to answer about the experiences of the exergame. The users were asked to play the game in the offline mode and to choose a (one of the five options) sound. The second task was to restart the game and to choose another instrument and the third task was to play the game in the online mode, with another player (the researcher) (see Annex 4 for the task definitions).

Not all participants performed the three different tasks, because they experienced motivational difficulties. The main problem was that the music stopped when participants made a mistake in the game, as some kind of playful punishment. It would be highly suggested to keep the music playing even if an incorrect move of the player is detected and just give visual feedback in case an error was detected by the game. On the other

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hand, the participants also liked the game, because of the challenge in making the right move (with another person), it was comparable with the gym class some participants were in.

Even though improvements have been made since the very first version of the game (i.e. Dance with ALFRED), this game (Dancicians) remains difficult for many players. The game gives instructions to do movements but it is often not sensing correctly when the player is moving, which can easily decrease the player's motivation. However, the effort made in the game layout and musical options were appreciated by the testers.

2.2.3.4 The ALFREDO Marketplace

This app was only tested in Germany due to timing issues. The following only gives the results from Germany. The ALFREDO marketplace for older adults was tested with the representatives of primary target group's users, whereas the ALFREDO marketplace for caregivers was tested by the researchers from the end-user partner organizations.

The users had to perform 4 tasks and to answer 12 questions. They were asked to change their username, to find the list with the apps already downloaded, to see possible new apps available for download and to find the possibility to update apps (into newer versions).

Furthermore, the end-user partner researchers tested the second version of the ALFREDO marketplace designed for the caregivers that are the STG of the project. The following table lists the recommendations from the researches. Moreover, this application will be tested by the actual STG during the forthcoming ALFRED pilot phase aiming to validate the integrated ALFRED system.

2.2.4 PSSUQ Rating

A description on how the PSSUQ ratings can be interpreted was already previously given in section 2.1.5.2.2. The testers were asked to fill in the PSSUQ questionnaire in the very end of the testing session. In this cycle we tested the overall satisfaction of the user with the system which. This showed similar values (M= 2.9, SD=1.51) compared to the last testing cycle. The second subsection is calculated by the mean values from questions 1-8 measures whether the system is efficient and whether users feel comfortable using it. This cycle has slightly worsened the values (M=2.9, SD=1.5) compared to the previous iteration *(M* = 2.52, *SD* = 0.28). The third subsection of the PSSUQ questionnaire regards information quality and is being calculated by the answers to question 9 – 15 and shows how well a system is capable of providing the right kind and amount of information to participants. Values were on a similar level (*M* = 2. 9 *SD* = 1.53) compared to the last test with ALFRED (*M* = 3.0, *SD* = 0.49). The final subsection of the PSSUQ Is about the internal quality of the system. Does the system have all the right capabilities and does it have a good interface? Also in this section of the PSSUQ the values of the previous (*M* = 2.6, *SD* = 0.47) tests are fairly close to the observations which were made in the last test session (*M* = 2.8, *SD* = 1.48).

The user ratings of ALFRED remain on a high level and confirm the results from the previous tests that were conducted and show that the different ALFRED components that were tested already can provide a high user satisfaction besides the relative immaturity of

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some of the functions which were tested. Despite the fact that no major changes, neither on the negative nor the positive side could be observed, the results are still promising and show that even in a broader population of seniors, the users still did not experience any significant problems using ALFRED apps. Future tests in the ALFRED pilots will evaluate an integrated version of ALFRED which is likely to open these users a broader range of potential benefits.

Table 5 PSSUQ Ratings Cycle 3

PSSUQ Ratings (1=high satisfaction, 7=low satisfaction)	
Parameters	M (mean)
Overall satisfaction (Q1-Q19)	2.9
System quality (Q1-Q8)	
Total average value	2.9
Information quality (Q9-Q15)	
Total average value	2.9
Internal quality of the system (Q16-Q19)	
Total average value	2.6

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3 Pilot on the Integrated ALFRED Solution

Pilot 1, the Netherlands and Pilot 3, France, test the integrated ALFRED system in a real life surrounding at the homes of end users. Both pilots test the system with 10 TP's each, 20 persons in total. The pilots have the aim to provide for qualitative input on the Usability, End user and Economic perspective of the integrated ALFRED System as described in D8.1.2.

These pilots are a follow up of the Iterative Evaluations that have been performed throughout the technical development. Whereas the iterative evaluations focus on testing the different apps of the ALFRED system, Pilot 1 and Pilot 3 target to test the integrated ALFRED system in two phases. First a final iterative evaluation will be made on to define the overall usability and success rate of the tasks by older end users.

After this validation, the Dutch and French pilots will test the integrated ALFRED system at home of older people, as part of their daily life. The integrated ALFRED system includes 25 Apps (see Annex 5) and the ALFRED infrastructure, including the voice interaction. The pilots will be concluded with a focus group session where all TPs participate to discuss on the results of the project, which will provide final qualitative feedback from the testers.

The following sections give an overview of the methodology and the planning of these pilots. In the annexes (see Annex 6 and 7) the two workbooks for the pilot running can be found. These will be updated with the release of the Alpha and Beta version of the ALFRED system.

3.1.1 Pilot Methodology

The pilot methodology in Pilot 1 and Pilot 3 will follow the methodology as described in Section 3: Pilot methodology of D8.1.2, focusing on usability, user and economic perspectives. Some adaptations have been made on the methods of evaluation and timeline, adapting to input from reviewers as well as progress in technical development. These are shortly explained in this section. In Annex 7 the Workbook can be found for the two pilots, giving further insight on the methodology. This Workbook will be updated once the technical results are available.

3.1.1.1 Usability Perspective

The initial plan as described in D8.1.2 was to test the integrated ALFRED system and speech interaction in the last iterative evaluation in M26 and reported in this deliverable. However, as the final integration is finally foreseen in M30 as Milestone 5, this report focuses on the results of the iterative evaluations of the different ALFRED components.

An additional Iterative Evaluation is implemented in M31 (April 2016) on the Alpha version of the integrated ALFRED system. The Iterative Evaluation will follow the same methodology as in the previous Iterative Evaluations, but additionally it will include an analysis of the success rate of the tasks with the speech interaction. Also, in this session the user will receive a workbook with different tasks. The tasks range from downloading an app up to calling a contact or checking on physical parameters. In Annex 6 the Workbook

for this session is included with a preliminary set of tasks that will be adapted as soon as the Integrated ALFRED system is available.

Additionally, the final Iterative Evaluation will measure success rates of each of the tasks, taking also up the comments of the reviewers. With the Workbook, Critical Incidents will be measured, the duration of the task will be measured and a log will be kept on errors and support by test leaders. Each task will obtain a rating from 0 (not successful), 0.5 partial success to 1 complete success. The rating of all the TP's for all tasks will be logged and a success rate will be derived.

The final results of the usability perspective on the Integrated ALFRED System will be available in D8.2.3 and 8.2.4. This report will also give the results on the final usability KPI's. There will be a short timeframe to refine the apps based on this evaluation round, after which the final integrated ALFRED system will be available for testing at the homes of older people.

Table 6 The Final Usability KPIs

Concept	KPI	Strategic Goal
Ease of use of the final ALFRED system.	Success rate based on the failure, partial successes and successes.	A success rate of 80%
Adaptation of the needs of older end users and uptake of end user input.	Rise of PSSUQ and ASQ satisfaction levels towards the final usability cycle.	Increase of satisfaction levels (excluding the WoZ tests).

3.1.1.2 Economic Perspective

In Pilot 1 and Pilot 3 an analysis will be made on business models and how to bring ALFRED on the market and reach older customers. This analysis will be made together with end users. After running the integrated ALFRED system at the homes of older people, a focus group session will be maintained with all TP's to discuss their experience with the system. This discussion will include business model aspects, such as unique selling points of ALFRED, customer segments, marketing channels, prices, subscriptions, etc. The structured interview for this session will be elaborated in month 32 when the session will take place. From this focus group session, the economic KPIs will be derived as indicated in D8.4.

Table 7 The Final Economic KPIs

Concept	KPI	Strategic Goal
ALFRED impact on end user willingness to buy Alfred.	Percentage of TPs interested in buying the ALFRED system. Either with a lump sum or with a subscription.	50% of the TP's.

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3.1.1.3 End User Perspective

As described in D8.1.2, the pilots will apply the TAM methodology to define the acceptance and added value of ALFRED for the target users. The behavioural intention will be measured with a standardized formal questionnaire on the intention of use (see Annex 7). The actual use will be tracked through log files and a diary. The end users will use ALFRED during two weeks at their homes. The log files will track the amount of time the users use different ALFRED apps and components as a part of their everyday life. After this phase the data will be gathered and the actual use can be compared to the intended use of the ALFRED system. Based on this, data conclusions can be made to measure the acceptance of the solution. Additionally, a final PSSUQ will be used to define the usefulness of the solution with end users. Deliverable 8.4 will report these results, giving the KPI results for the ALFRED system. The following table gives an overview of the End User KPIs that will be reported on.

Table 8 The Final End User KPIs

Concept	KPI	Strategic Goal
Acceptance of ALFRED by older end users – User Driven Interaction Assistant	Amount of successfully sent messages with ALFRED per user.	5 messages per user
Acceptance of ALFRED by older end users – User Driven Interaction Assistant	Amount of successfully made calls to contacts per user.	10 calls per user
Acceptance of ALFRED by older end users – Social Inclusion	Amount of suggestions that were successfully responded by the end user.	3 events per user
Acceptance of ALFRED by older end users – Effective and Personalized Care	Amount of successful checks on physical parameters per end user.	6 checks per user
Perceived ease of use and usefulness for older end users	The intention of use is higher after using ALFRED for two weeks.	5% higher value in the Intention of use questionnaire at the end of the pilot

3.1.2 Implementation of the Pilot Methodology

The implementation of the Pilot methodology will follow the structure as described in D8.1.2, including the recruitment, profile of the TP's, amount of TP's and the drop-out strategy. The pilots will set up a helpdesk as described in D8.1.2, in case support is needed. Although end users are expected to use ALFRED independently, a helpdesk may be required in case the prototype still has some deficiencies, notably the users may still face different system bugs.

As indicated the Dutch and the French pilot will include twenty TP's, ten in each research study. The setup and timeline of the pilot has been slightly modified to include the

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previously described Iterative Evaluation with the usability study and success rates, adjusting to the technical developments. The actual use of the ALFRED system at the homes of older people has therefore been reduced from three to two weeks. The following table gives an overview of the time planning in the pilot and the workbook in Annex 7 gives the overview of the methods used in sequence, as well as the ethical forms that are included. The ethical management process will be continuously monitored as defined in D8.1.1.

Table 9 Pilot Planning Timeline

Month	Pilot Task	Details
M31 (April, 2016)	Usability test on Alpha Version Integrated ALFRED.	Usability test in the Netherlands and France with 10 end users on the Alpha Test, with the aim to polish the solution.
M32 (May, 2016)	First testing wave with 10 older adults (5 testers in France and 5 testers in the Netherlands) at their home during two weeks and with at least one informal caregiver.	Each TP receives instructions for the pilot period and the TP to use the ALFRED solution during two weeks.
M32 (June, 2016)	Focus group session with the TPs.	Focus group session with five TPs at a time in each country will be organized to discuss the added value of ALFRED and the business model. Data will be processed.
M33 (July, 2016)	Second testing wave with 10 older adults (5 testers in France and 5 testers in the Netherlands) at their home during two weeks and with at least one informal caregiver.	Each TP receives instructions for the pilot period and the TP to use the ALFRED solution during two weeks. In between the two testing waves there is at least one week so that the test administrator has time to address the various issues that might have been raised during the first piloting wave.
M35 (August, 2016)	Focus group session with the TPs.	A focus group session with five TP will be organized to discuss the added value of ALFRED and the business model. Data will be processed.
M36 (September, 2016)	Gathering and analysis of data.	Preparation of D8.2.1 and 8.4.

3.1.3 Equipment Planning

The equipment planning has remained largely the same as described in D8.1.2 and is summarized in the table below.

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Table 10 Testing Material for the Pilot Phase Pilot 1 and Pilot 3

Amount pilot 1	Amount pilot 3
10 Android Smart Phones	5 Android Smart Phones
5 Sensor t-shirts	4 Sensor t-shirts
5 serious game packages	4 Serious game packages

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4 Pilot 2 Hospital Environment

In this pilot CHA will evaluate the efficacy and usability of the ALFRED back Trainer as well as the usability of the AITEX sensor T-Shirt.

CHA is planning to test the ALFRED Back Trainer on a cohort of 60 seniors with a condition of low back pain. In the pilot 2, CHA wants to test the efficacy of the ALFRED Back Trainer in order to help reduce or prevent low back pain. This will be done by comparing a battery of physical investigations of the users in a pre-/post investigation. CHA will investigate, pain, balance, ability to react, flexibility of the spine, muscle strength, ability to cope with activities of daily life, sleep quality, H20 consumption and other relevant parameters around the users' health.

It is planned to include 60 users in the pilot 2. The users will be divided into 3 groups, a randomized controlled trail can be performed. 20 users will train with the ALFRED Back Trainer, 20 will receive identical exercises as the users that train with the ALFRED Back Trainer but will not get the additional benefits of the biofeedback which is provided by the ALFRED Back Trainer. The third group will serve as a control group and will perform usability tests with the sensor T-Shirt and potentially some other tasks related to usability issues. Overall the pilot 2 will assess usability issues of the ALFRED Back Trainer and the sensor T-Shirt as well as socioeconomic and health data.

4.1 Background

Low-back pain (LBP), or pain between the lower ribcage and the legs, is one of the most common complaints of discomfort. During a lifetime 60-80% will experience LBP and up to 86% of these people will have another episode at some point in time. Especially chronic low back pain is hence a large socioeconomic burden which seems to be growing, in spite of technological advances in diagnostics and intervention.

Cost of illness studies evaluate the cost of a particular disease and the resulting economic burden on society. All parties involved patients, clinicians and third-party payers should be aware of the costs to appropriately allocate health care resources. Recent studies estimated total costs of LBP concluded that mean indirect costs accounted for 78% of total costs, pointing out that direct medical costs seem to contribute far less to the cost of LBP than indirect costs. A breakdown of direct costs revealed physical therapy (17%) and inpatient services (17%) to be the largest proportion, followed by pharmacy (13%) and primary care (13%).

There are no total cost estimates from the United States but estimates ranging up to 90 Billion US Dollars of direct costs put the economic burden of LBP into perspective.

4.1.1.1 Ethiopathology

The back is rather susceptible to be effected by discomfort and pain because it supports most of the body's weight during most activities of daily life. Additionally, the back has to fulfil two conflicting functions. One the one hand it needs to provide mobility while on the other hand it also needs to guarantee enough stability, so that the musculoskeletal structures will not be injured during motion.

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It is well documented that LBP is an extremely common health problem with high prevalence rates and often being recurrent. While in most incidences LBP tends to disappear by itself after a few days, many people who suffered from an initial episode of LBP will experience recurrent episodes of LBP over the cause of their lives which have a tendency to become chronic with increasing age. Furthermore, older age is also associated with an increased incidence of LBP. After analysing the severity of pain it was found that older people experience less frequent benign or mild back pain but a higher prevalence of disabling or severe episodes. Twisting or lifting a heavy load the wrong way can sprain or strain the muscles and ligaments in the back, causing acute back pain. In addition, the cushiony discs between the backbones, or vertebrae, tend to disintegrate with age, reducing how much shock absorption they can provide. Recent literature suggests, that spinal instability is an important cause of LBP and disability as well as increases the risk of recurrence. Within the ALFRED project a specific exercise system was designed in collaboration with TUDA which enables a selective training of the stabilizing spinal muscles in order to prevent or reduce LBP in older adults. The following section will briefly introduce the various types of spinal musculature, the concept of clinical spinal stability which is the underlying theoretical background for the development of the ALFRED back trainer which will be tested in Pilot 2 starting in M30.

4.1.2 Scientific Background

This section will specify some relevant definitions and terms in order to summarize the concept of the ALFRED back trainer and the underlying theoretical ratio behind the exercise concept.

4.1.3 Clinical Spinal Instability

A commonly used definition for spinal instability is the following: “A significant decrease in the capacity of the stabilizing system of the spine to maintain the intervertebral neutral zones within the physiological limits so that there is no neurological dysfunction, no major deformity, and no incapacitating pain.” Understanding this definition requires deeper insight in the terms of the “stabilizing system” and the “neutral zones”.

The spinal stabilizing system consists of three subsystems: a neural or motor control unit, muscles surrounding the spine and the spinal column itself. Loads are carried by the spinal column and information about the position, motion and quantity of load is sent to the neural control unit. The neural control unit in turn transforms information into action, which is carried out by the muscles.

Normally all these subsystems work in harmony and by doing so provide the necessary mechanical stability of the spine. The neutral zone Panjabi described is the “part of the range of intervertebral motion, measured from the neutral position, in which spinal motion can occur with minimal nonmuscular passive resistance from the spine”.

Abnormal motion would coinhere with an increase of the neutral zone. This would force the stabilizing system to react by stiffening muscles surrounding the spine and actively decrease the neutral zone. Panjabi used a ball-in-a-bowl analog for this. In a healthy subject the ball would move freely within the neutral zone, after injury or degenerative changes the ball would be able to move beyond the neutral – and therefore pain free zone. After the adaption of muscles, the neutral zone would have decreased again and the

subject would be pain free. This analogy leads to a very important aspect of stabilization and therefore possible cause of LBP – muscles.

4.1.3.1 Muscles

Panjabi postulated that in vitro critical load calculations for the lumbar spinal column alone were around 90N, which is a lot less than the estimated in vivo loads of 1500N. This would suggest, that only through the stiffening effect of the muscles the increased load and stability of the spine is even possible.

Models which analyse the stability of the lumbar spine distinct between local and a global system of muscles. Local stabilizers (M. Multifidus) were muscles with insertion or origin at the lumbar vertebrae and global stabilizers with origin on the pelvis and insertions on the thoracic cage.

Examining literature especially the transversus abdominis muscles and the lumbar multifidus muscles seem to play an important role in LBP origin and treatment. The M. Multifidus make up two thirds of overall spinal stability, therefore being the largest stability contributing factor. The multifidus is made up of several fascicles that rise from the processus spinosus and lamina of each vertebra and insert in caudal direction between two and five spinal levels onto the zygaphophyseal joint capsule, mammillary process, lamina, medial posterior superior iliac spina as well as dorsal sacrum. Compared to all other lumbar muscles the lumbar multifidus has characteristic short and strong muscle fibres with a high cross-sectional area due to a high mass. This in turn allows a dense arrays of muscle fibres and makes the lumbar multifidus ideal for stability purposes.

It has been suggested that elevated intra-abdominal pressure, and contraction of the thoracic diaphragm and transversus abdominis provide a mechanical contribution to the control of spinal intervertebral stiffness. Additionally the ability to contract the lumbar multifidus muscles, which as mentioned play a large role in non-specific LBP, has been suggested to be related to the ability to contract the transversus abdominis. It is only logical then that TrA muscle dysfunction seems to be associated with higher long-term incidence rates of LBP as well.
The transverse abdominis muscles connect to the lumbar vertebrae through the thoracacolumbar fascia, which forms a corset resembling structure around the trunk, which controls intra-abdominal pressure as well as vertebral stiffness.

Until recently most exercise regimes to prevent and reduce LBP have focused on the larger muscle groups and the basic idea was that a strong back will be less susceptible to LBP. Local stabilizers like the M. multifidus and transversus abdominis were until recently almost neglected in most major exercise programs. There are two reasons for this. Firstly, the katabolic effect of LBP on the local stabilizers was only recently discovered in specific ultrasound investigations across a wide section of the population. This observation helped to explain the underlying factors which lead to recurrent episodes of LBP and chronic LBP. In the majority of subjects which have experienced a first episode of LBP the size of the local stabilizing muscles remains reduced compared to asymptomatic subjects, ever after the symptoms of the initial episode have resolved. This obviously leads to reduced stability of the spine, which leads to excessive movement between the spinal segments, which further on will cause trauma to the surrounding spinal tissue, hence a recurrent episode of LBP.

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Secondly the local stabilizing muscles are very difficult to train and it is hard to see to the outside eye, if these muscles are activated at all. The reason for this is that these muscles are located very close to the spine and contraction of these muscles are not visible as any type of motion of the trunk which can been seen from the outside. For this reason it was until recently not possible to quantify the quality of the local stabilizing muscles of the spine. However, a physiological contraction of these muscles is needed to stimulate symmetrical growth of these muscles which is needed to regain spinal stability and prevent or reduce recurrent episodes of LBP.

4.2 ALFRED Back Trainer

The ALFRED back trainer was developed on the latest principles of spinal stabilisation exercises to prevent and reduce recurrent episodes of LBP. It will use up to date biofeedback technology which allows a simple and efficient way to control to quantify the symmetrical activation of the spinal stabilizing muscles in a clinical environment. The basic components of the back trainer consists of two commercially available Nintendo Wii Balance boards and a tablet PC. Vital parameters of the users can be measured with the ALFRED sensor T-shirt. A more detailed description of the ALFRED back trainer, the planned exercises and exact pilot details will be stated in the upcoming deliverable D8.3.1.

4.3 Timeframe for Pilot 2

The following table describes the timeframe which is planned for Pilot 2.

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Table 11 Timeframe Pilot 2

Month	Pilot Task	Details
M28 (January)	Finalize documents for the pilot	All questionnaires are finalized and developed.
M28-30 (January-March)	Recruitment of participants	60 seniors will be recruited by M30.
M29 (February)	Pretest	All questionnaires, ALFRED back trainer, sensor T-shirt, pilot sequence and general set up will be pretested with seniors.
M29 (February)	Return pretest feedback	The gathered feedback from the pretest will be returned to the technical partners.
M29 (February)	Preparation of D8.3.1	Planning, writing and finalizing D8.3.1.
M30 (March)	Start Visit 1	Perform entry examination and assessment with users.
M30-M33 (March-June)	Start Visit 2	25 exercise session with the users, usability tests, performing pilot related tasks.
M34-M35 (July-August)	Data analysis	Data analysis of the back trainer and the other pilot related tasks.
M35-M36 (August-September)	Dissemination, preparation	Preparation, planning and writing of D8.3.1, beginning of scientific dissemination.

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5 Conclusion

The end-user partners and their research work with the relevant target groups is essential for the viability of the developed ALFRED solution as the end-users validate the usability and the usefulness of the system. This continued testing with real end-users was initiated at the very start of the system development developed and it goes on until the final testing of the integrated ALFRED system in the pilot evaluations.

The iterative testing cycles showed that early mock-up testing with users is very valuable for the final prototypes as the developers are able to obtain users recommendations and start adapting their solution at an early stage of the development. This early testing helps also the end-user partners to plan and define the ideal final validation (pilot) test settings, as the researchers are very much involved in the development and have seen the earlier versions of the system components. The pilots have, as the technical development, been developed in an iterative process adjusting the reality of each moment.

The final validation of the ALFRED system will focus on two different aspects: Pilot 1(NFE, the Netherlands) and Pilot 3 (ESE, France) will evaluate the integrated ALFRED system with individual users at their home environment whereas the Pilot 2 (CHA, Germany) focuses on evaluating the health impact (on lower back pain) of the ALFRED apps in a clinical environment. The aim of these final validations is to evaluate the users' acceptance guiding the commercialisation of the ALFRED solution beyond the ALFRED research project.

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Annex 1: Overview Test Participants Cycle 2

TP	Year of Birth	Gender	Nationality	Household income	Marital status	Living situation	Education	Employment	Residential situation	Self rated health
				0 = no comment			1 = Primary education			
				1 = 500-1000 €	1 = Single	1 = Living alone	2 = Lower vocational education	1 = Retired	1 = Living independently at home	1 = Poor
				2 = 1000-2000 €	2 = Married	2 = Living with Children	3 = Intermediate vocational education	2 = Employed	2 = Independent planned housing, congregate housing	2 = Not so good
				3 = 2000-3000 €	3 = Divorced	3 = Living with partner, no children	4 = Intermediate secondary education	3 = Unemployed	3 = Home for older people	3 = Fair
				4= > 3000 €	4 = Widowed	4 = Living with partner and children	5 = Higher secondary education	4 = Voluntary work		4 = Good
							6 = Higher vocational education	5 = Other		5 = Very good
							7 = University			
1	1943	F	DEU	3	2	3	7	1	1	4
2	1943	F	DEU	4	2	3	7	1	1	4
3	1940	F	DEU	4	2	3	5	1	1	4
4	1935	M	NLD	3	2	3	3	1	1	4
5		F	NLD	1	1	1	2	4	1	4
6	1952	F	NLD	0	2	3	2	5	1	5
7	1947	F	NLD	3	2	1	3	1 & 4	1	4
8	1941	F	DEU	0	4	1	3	1 & 4	1	4
9	1932	M	DEU	0	4	1	3	5	1	2
10	1941	M	ITA	0	4	1	5	5	1	4
11	1941	F	FRA	0	2	3	7	5	1	4
12	1952	F	FRA	0	1	3	7	4	1	4

TP	Vision	Hearing	Motor control A	Motor control B	Self rated mobility level	Technological Experience	Attitude on Technology	Use of ICT tools	Type of phone
	1 = Yes, without difficulty	1 = Yes, without difficulty	1 = Yes, without difficulty	1 = Yes, without difficulty	1 = Poor	1 = Very high	1 = Positive	1 = Daily	1 = Normal mobile phone
	2 = Yes, with minor difficulty	2 = Yes, with minor difficulty	2 = Yes, with minor difficulty	2 = Yes, with minor difficulty	2 = Not so good	2 = High	2 = Neutral	2 = Weekly	2 = Senior mobile phone
	3 = Yes, with major difficulty	3 = Yes, with major difficulty	3 = Yes, with major difficulty	3 = Yes, but I need some help	3 = Fair	3 = Medium	3 = Negative	3 = Monthly	3 = Smartphone (Android)
	4 = No, not able to	4 = No, not able to	4 = No, not able to	4 = No, I'm not able to	4 = Good	4 = Low		4 = Rarely	4 = Smartphone (Apple)
					5 = Very good	5 = Very low		5 = Never	5 = Other
1	1	1	1	1	5	3	2	2	1
2	1	2	1	1	4	4	2	4	1
3	1	2	2	1	5	4	2	4	1
4	1	1	1	1	4	4	1	2	1
5	1	1	1	1	4	3	1	1	1
6	1	2	1	1	4	4	1	2	2
7	1	1	1	1	4	1	1	1	3
8	1	1	1	1	4	3	1	1	1 & 3
9	1	1	1	1	4	3	2	2	1
10	1	2	2	1	4	2	1	1	3
11	1	1	1	1	4	2	1	1	1
12	1	1	1	1	5	2	1	1	3

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Annex 2 Overview Test Participants Cycle 3

TP	Year of Birth	Gen-der	Nationality	Household income	Marital status	Living situation	Education	Employment	Residential situation	Self rated health
				0 = no comment			1 = Primary education			
				1 = 500-1000 €	1 = Single	1 = Living alone	2 = Lower vocational education	1 = Retired	1 = Living independently at home	1 = Poor
				2 = 1000-2000 €	2 = Married	2 = Living with Children	3 = Intermediate vocational education	2 = Employed	2 = Independent planned housing, congregate housing	2 = Not so good
				3 = 2000-3000 €	3 = Divorced	3 = Living with partner, no children	4 = Intermediate secondary education	3 = Unemployed	3 = Home for older people	3 = Fair
				4= > 3000 €	4 = Widowed	4 = Living with partner and children	5 = Higher secondary education	4 = Voluntary work		4 = Good
							6 = Higher vocational education	5 = Other		5 = Very good
							7 = University			
1	1947	F	FRA	0	2	3	7	1	1	3
2	1941	M	ITA	0	4	1	5	1	1	4
3	1952	F	FRA	0	1	3	7	4	1	4
4	1943	F	DEU	3	2	3	7	1	1	3
5	1943	F	DEU	4	2	3	7	1	1	4
6	1940	F	DEU	4	2	3	5	1	1	4
7	1927	M	NLD	3	4	4	6	1	2	4
8	1943	M	NLD	3	2	4	1	1	1	4
9	1933	F	NLD	0	4	4	2	1	2	3
10	1944	F	NLD	0	2	4	3	1 & 4	1	3
11	2015	F	NLD	2	2	4	2	1	2	2
12	1933	F	NLD	0	4	4	5	1 & 4	1	3
13	1950	F	NLD	0	2	4	2	1 & 4	1	3
14	1937	F	NLD	0	4	4	2	2	1	5
15	1936	F	NLD	2	4	4	2	1	3	4
16	1939	F	NLD	0	4	4	5	1	2	4
17	1945	F	NLD	2	2	4	2	4	1	5
18	1953	F	NLD	2	4	1	5	2	1	4
19	1948	F	NLD	3	2	4	3	1	1	4
20	1950	F	NLD	0	2	4	2	1 & 4	1	4
21	1944	F	NLD	0	2	4	5	5	1	4
22	1926	F	NLD	2	4	4	1	1	1	4
23	1923	F	NLD	0	4	4	5	1	2	3
24	1942	F	NLD	1	4	4	2	1 & 4	2	3
25	1944	F	NLD	0	1	2	2	1	1	5

TP	Vision	Hearing	Motor control A	Motor control B	Self rated mobility level	Technological Experience	Attitude on Technology	Use of ICT tools	Type of phone	Involved in testcycle 1 & 2
	1 = Yes, without difficulty 2 = Yes, with minor difficulty 3 = Yes, with major difficulty 4 = No, not able to	1 = Yes, without difficulty 2 = Yes, with minor difficulty 3 = Yes, with major difficulty 4 = No, not able to	1 = Yes, without difficulty 2 = Yes, with minor difficulty 3 = Yes, with major difficulty 4 = No, not able to	1 = Yes, without difficulty 2 = Yes, with minor difficulty 3 = Yes, but I need some help 4 = No, I'm not able to	1 = Poor 2 = Not so good 3 = Fair 4 = Good 5 = Very good	1 = Very high 2 = High 3 = Medium 4 = Low 5 = Very low	1 = Positive 2 = Neutral 3 = Negative	1 = Daily 2 = Weekly 3 = Monthly 4 = Rarely 5 = Never	1 = Normal mobile phone 2 = Senior mobile phone 3 = Smartphone (Android) 4 = Smartphone (Apple) 5 = Other	1 = yes 2 = no
1	1	1	1	2	5	1	1	1	3	2
2	1	2	2	1	4	2	1	1	3	1
3	1	1	1	1	5	2	1	1	3	1
4	1	1	1	1	5	3	2	2	1	1
5	1	2	1	1	4	4	2	4	1	1
6	1	2	2	1	5	4	2	4	1	1
7	2	2	1	1	3	2	1	1	5	2
8	1	1	1	1	4	2	1	1	1	2
9	1	1	2	1	3	5	2	4	1 & 5	2
10	1	1	1	1	3	3	2	1	1 & 5	2
11	1	1	2	1	2	2	1	1	2	2
12	1	1	1	1	4	3	1	2	1	2
13	2	1	2	1	4	2	3	1	1	2
14	1	1	1	1	4	4	2	1	1	2
15	1	2	1	1	3	5	2	5	1	2
16	1	1	2	1	3	3	2	2	1	2
17	1	2	1	1	5	1	1	1	3	2
18	1	1	1	1	4	3	1	1	1	2
19	1	1	1	1	4	1	1	1	4	2
20	1	2	1	1	5	2	1	1	1	2
21	1	1	1	1	5	2	1	1	1	2
22	1	1	1	1	4	3	1	1	1	2
23	1	2	1	1	3	5	2	5	5	2
24	2	1	1	1	4	2	1	1	1	2
25	1	1	1	1	5	3	3	2	1 & 5	2

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Annex 3: Overview of the ALFRED Apps included in the Integrated ALFRED system

Table of 25 ALFRED apps

App name	Related user story
1. Navigation	
US039	As an older person I would like to use ALFRED for navigation
US038	As an older person I would like to receive support to use the public transport
US041	As an older person I would like to receive support to have a taxi on time
US075	As an older person I would like to use ALFRED to navigate to an event or concert and help me when I am lost.
US076	As an older person I would like to use ALFRED to help me navigate despite my mild cognitive impairments
2. Alarm Clock	
US036	As an older person I would like to receive a wakeup call from ALFRED in the morning checking on me if I am ok
3. Reminder	
US053	As an older person I would like to receive a medicine reminder from ALFRED
US067	As an older person I would like to receive reminders on my appointments
US105	As a medical caregiver I would like ALFRED to remind people to exercise regularly
US054	As an older person, I would like to be able to see whether I already have taken my pills in order to avoid overdose.
US055	As a medical caregiver, I want to be able to see if the patient has taken her medicine.
4. Health Monitor	
US087	As an older person, I would like to see my vital parameters myself on the phone
5. Body Posture	
US104	As an older person, I would like ALFRED to remind me to keep a good body posture
6. Battery Warner	
US021	As an older person, I would like ALFRED to inform me about a low battery when leaving the house.
US068	As an older person I would like to receive a reminder from ALFRED on all the things I need to bring with me when I leave the house
7. Chat	
US028	As an older person, I would like ALFRED to help to communicate with my friends and family
US057	As an older person I would like to use ALFRED to send messages

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US050	As a medical caregiver, I would like to use video calls in case of emergency
US083	As an older person, I would like to just press one button to call my caregiver
8. News	
US048	As an older person I would like to use ALFRED to hear about the news
9. Contact	
US064	As an older person I would like to use ALFRED to maintain my contact list in my phone
10. Meeting	
US066	As an older person I would like to insert my meetings into ALFRED using speech
11. SG - Dancicians	
US101	As an older person, I would like to do guided exercises with ALFRED. ALFRED should also use sensors to capture health data while I am doing exercises
12. Tutorial	
US015	As an older person I would like to have an introduction conversation with ALFRED so I can learn everything about him and he about me.
13. Agenda	
US037	As an older person I would like receive day and night rhythm support with agenda reminders
14. Help	
US051	As an older person, I would like ALFRED to contact the nearest caregiver when I ask ALFRED for urgent help.
US049	As an older person I would like to use ALFRED to contact help in case of an emergency
US058	As an older person I would like to ALFRED detect falls and send an emergency to a specific contact.
15. Questionnaire	
US060	As an older person, I would like to ALFRED to ask spontaneous questions but it would be better to program it during certain times of the day
US061	As an older person, I would like ALFRED to initiate questions, but it should be in the domains of my interest such as cinema, exhibitions, cooking...
16. Meet	
US070	As an older person I would like to use ALFRED to set up social groups of people with similar diseases
US078	As an older person I would like to use ALFRED to organize a meeting with a group of friends at a certain place
17. Weight Control	
US082	As an older person, I would like to help me to control my body weight
18. SG - Back Trainer	

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US108	As an older person, I would like to have training for specific muscle groups
US113	As an older person I would like to games that require the combination of mental and physical exercise, such as opposing motion exercises of the arms and legs
19. SG - Balance Bike	
US110	As an older person, I would like to be able to see my training performance.
20. SG - City Explorer	
US098	As an older person, I would like ALFRED to give me goals and missions that encourage me to do new activities and exercises and to go out.
US116	As an informal caregiver, I would like to have a game that the carer could play together with the user (i.e. with the patient), which would enable to monitor the users' state of health but also have some fun time together
21. SG - Puzzle Arena	
US107	As an older person, I would like to have some games that show me how good my memory and physical health is.
22. Show Events	
US072	As an older person I would like to use ALFRED to learn about art expositions or a museum.
23. Rate Events	
US073	As an older person I would like to use ALFRED to learn about all the social activities that are organized in my neighborhood
US074	As an older person I would like to use ALFRED to get a personalized invitation to a social event, so it motivates more to go
US080	As an older person I would like to get suggestions for sports classes in my neighborhood
US081	As an older person I would like ALFRED to enable me to have face to face contacts as well, not just virtual contacts over ALFRED
US103	As an older person, I would like to receive suggestions about local sport classes
24. Profile	
US006	As an older person I would like to be able to manage my privacy and data settings
25. Settings	
US033	As an older person, I would like be able to customize my preferences in the different functionalities of the solution.

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