LIFE

Listen. Innovate. Field-test. Evaluate.

LIFE METHODOLOGICAL HANDBOOK for agile cocreation of robotics solutions for ageing

Give LIFE to your robotic ideas for ageing

ACCRA

HORIZON 2020

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LIFE METHODOLOGICAL HANDBOOK for agile cocreation of robotics solutions for ageing

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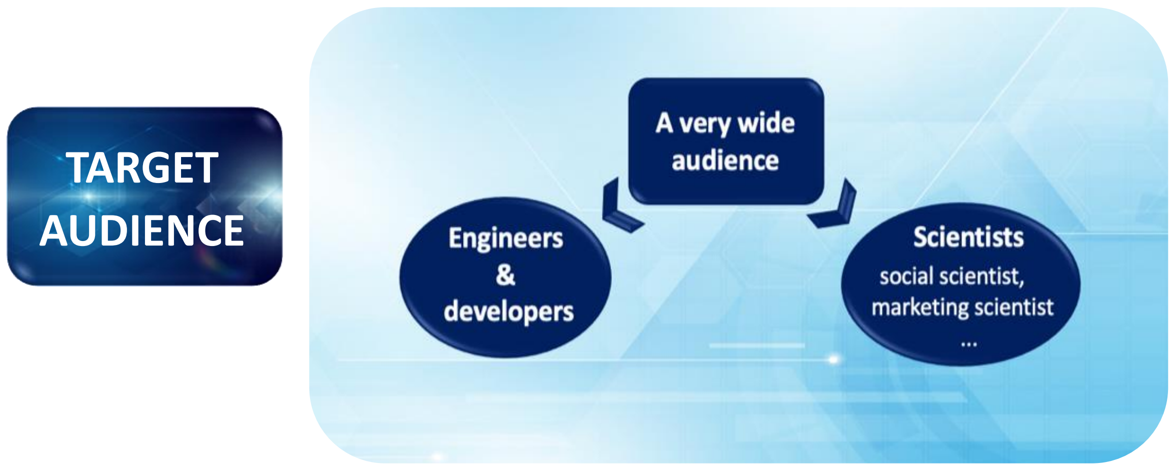
Preface

Why this handbook?

This handbook describes the LIFE Agile Cocreation Methodology produced by the ACCRA Consortium for the development of socially assisted robots dedicated to the elderlies with a loss of autonomy, in the European H2020 program. The **goal** of the LIFE methodology is to bring together robotics developers, engineers, stakeholders and end-users to cocreate robotics solutions that are more meaningful to end-users, in particular on specific targets such as the elderly. The **originality** of this methodology is that it seeks to bring together two very different entities: robotics and the elderly with a loss of autonomy. The **central axis** of this agile cocreation methodology is to position the **elderly user at the very heart** of the development of robotic solutions.

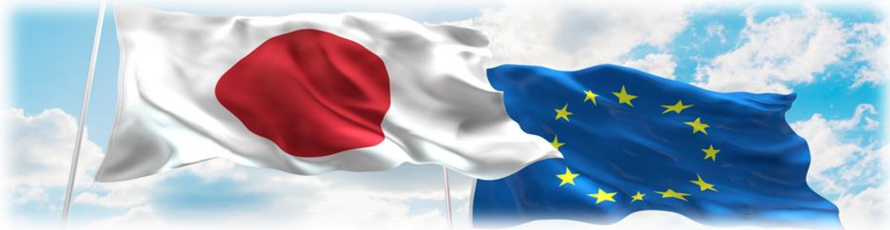
Everything starts with end-users and is verified and tested with them

The LIFE methodology is structured around 4 phases – Listen, Innovate, Field-test, Evaluate – which are presented in this handbook with practical information on how to organize, facilitate, analyze and exploit each phase. **This information helps silver economy companies and, in particular, robotics projects dedicated to the elderly** to implement an agile cocreation methodology in their projects and provides partners with implementation support.



About us

ORIGINS



The ACCRA project aims to develop **a robotics services offer dedicated to elderly people with a loss of autonomy.**

ACCRA is a **joint European-Japanese initiative** including a multidisciplinary team of 6 European partners from The Netherlands, Italy and France, and 3 Japanese partners.

ROBOTS

Two prototype robots have been selected for further development during the ACCRA project.

Buddy is a companion robot, for daily life activities, used by senior people at their home. This robot was developed by Blue Frog Robotics, a French SME.

Astro is a robot for mobility assistance and rehabilitation, used in hospitals or retirement homes. This robot was developed by Santa Anna University in Italy.

MISSION

Agile CoCreation of Robots for Ageing

- Advanced ICT Robotics based solutions for ageing
- Based on agile cocreation development process.

The **mission** of ACCRA is to enable the development of advanced ICT Robotics based solutions for extending active and healthy ageing in daily life by defining, developing and demonstrating an agile cocreation development process.

To this end, a **four-step methodology** – Listen (need study), Innovate (agile cocreation), Field-test (agile pre-experiment), Evaluate (end experiment, market assessment, sustainability assessment) has been defined and applied in **three applications** (mobility support, daily life, conversation rehabilitation) and assessed in France, Italy, Netherlands and Japan. The three applications are integrated on a FIWARE platform integrating enablers and supporting the two robotics solutions.

FUNDINGS

PARTNERS

ACCRA brings together expertise from robotics, software development, marketing, health services and health economics research.

Public Universities

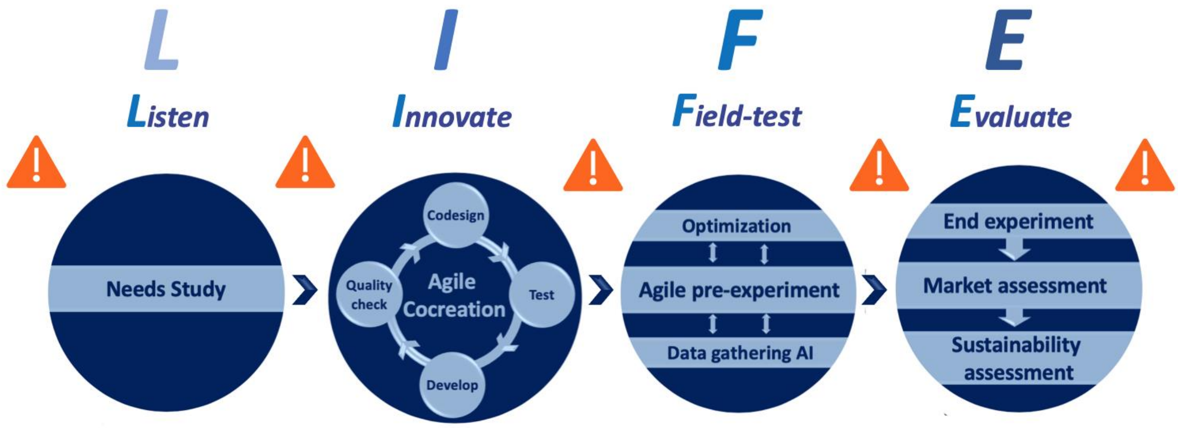
Robotics SME

Hospital

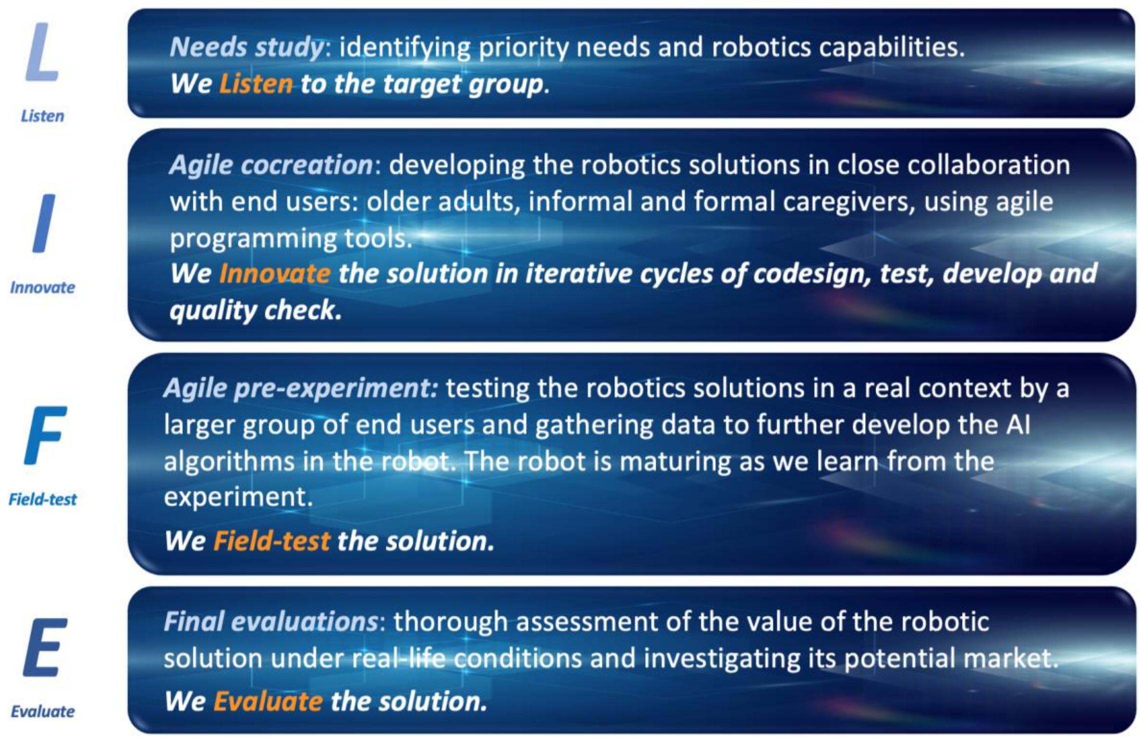
System and software engineering companies

LIFE in a nutshell

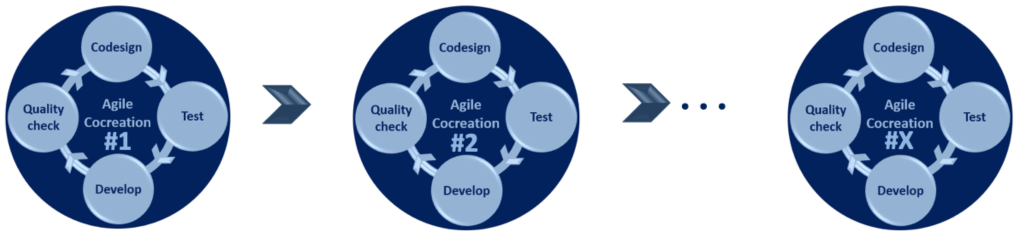
The LIFE methodology is a framework to structure the conduct of research in a robotics project in order to identify the needs of the elderly people experiencing a loss of autonomy, to cocreate robotic solutions that meet these needs, to field-test their daily use and to evaluate the solutions' sustainability.



The 4 stages of LIFE



The agile cocreation stage is the heart of the LIFE methodology. It is based on iterative cycles consisting of **4 sub-steps**: **Codesign, Test, Develop, Quality check meeting.**



Co design — **Cocreation is a consumer centric methodology based on codesign meetings gathering end-users and robotics engineers.**

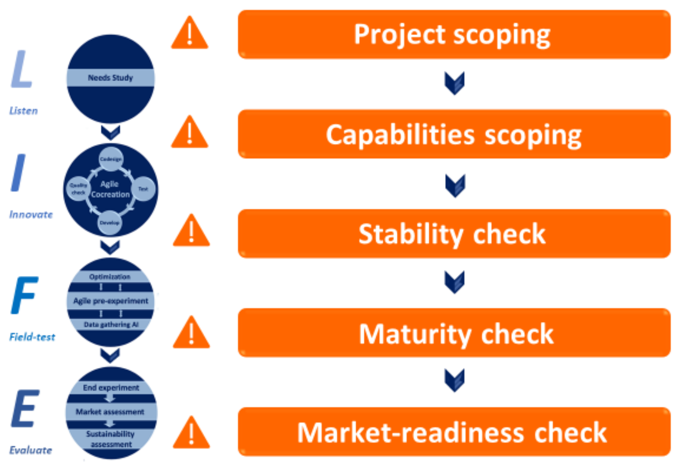
Test — **Small experiments with 2 to 4 core users** throughout the cocreation process (ideally, in real life situations: at home, at the hospital…)

Develop — **Agile development** is a technical methodology for agile robotics development. The objective is to develop and refine the robot and its functions to meet the needs and expectations of users.

Quality check — **Before each codesign session, a quality check meeting** is held. The multidisciplinary project team should perform an acceptance test to assess if the technology has reached a sufficient level to conduct a new codesign session. This check is achieved through acceptance conditions agreed at the start of the development stage. If the expected level is not reached, further development is required.

The 5 checkpoints of LIFE

Before entering the LIFE phases and in between the phases, **checkpoints** assure that the project team only goes until the next phase if the scope is clear, the goals are met, and the necessary conditions in terms of resources are in place.



Check point #1: Project scoping

Internal clarity within the project stakeholders is important. All project members should be aligned regarding the structuring elements of the project: the project timelines, the required financial and human resources and constraints, the robot development platform, the project objectives and the use cases covered by the project.

Timelines	◆ **Duration:**	◆ **Start / End:**
Resources	◆ **Financial resources** What funding? What call for projects? Budget ?	◆ **Human resources, capabilities** What kind of partners should join the project? Which skills are needed? (e.g. researcher with skills in cocreation, robotics engineer, etc.)
Robot	◆ **Which robot?** ◆ **Which development platform?** Decide on the robot development platform elements that are needed before starting cocreation.	
Objectives	◆ **Objectives:** define what you potentially can achieve, given the timeline and any budget constraints. Which degree of finalization of the robot? Is the objective to optimize the robot (for example, to meet the needs of a specific target) or to make it ready for market?	
Use cases	◆ **Definition of the use cases covered by the project** Choice and description of the use cases whose related needs will guide the development of the robotic solution.	

Why a robot development platform? The development of a robot is complex. It can be compared to the development of an automotive vehicle which typically takes up to 5 years for development from scratch and 3 years for a development based on maximum reuse. The development of a robot application should focus more on the application than on the basic robot capabilities which are included in a development platform.

What is a use case? The definition of use cases is a key structuring step of the project. Here, we refer to a use case as a typical concrete situation where a potential user experiences a need or a set of needs that could be met by the products and services which will be developed in the innovation project. For example, in the Accra project, we had three main use cases: assistance with daily life activities, mobility assistance (e.g. support with walking and rehabilitation), conversation rehabilitation.

The example of ACCRA 3 use cases	
Mobility issues & rehabilitation	People with mobility problems, risk of falling or who have returned from the hospital after falls. This profile is potentially interested in physical support and control of rehabilitation.
Daily life activities issues	Elderly people with loss of autonomy who have difficulty engaging in daily life activities.
Conversation rehabilitation	Elderly people who suffer from social isolation, have little social interaction or need to maintain their ability to communicate and their intellectual curiosity.

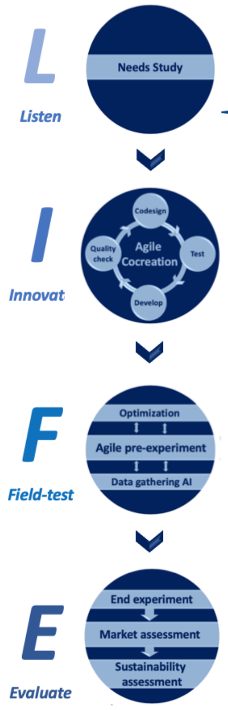
Use case description. The description of a use case includes 5 to 6 parts: the use situation, the user profile, the needs, the user ecosystem, the expected functionalities or services and if possible the potential use barriers. This description should be as realistic and fact-based as possible. For the first scoping exercise, it may be based on concrete cases identified through the practice of professionals or previous user studies. It is likely that certain elements will be the subject of hypotheses (for example, the expected functionalities and services or the barriers). Throughout the project, these use cases will be confronted with the reality of users and will be nourished thanks to the lessons learned from the studies that structure the project (needs study, codesign groups, pre-experiment, market survey, end experiment, etc.). Therefore, the use cases can be confirmed, refuted, modified, completed and refined through the user studies of the users' needs and behaviors. The use cases are a central tool for defining the services and functionalities that meet the needs of the target users.

Use case name	[USE CASE NAME]
Situation	Description of the user's situation that brings out the needs. It should specify the difficulties and issues of the elderly as well as the professional and family caregivers who interact with the senior people.
Profile	Description of the user's profile (socio-demographic characteristics, place of residence, level of autonomy, problems related to ageing, etc.)
Ecosystem	List and description of the professional and non-professional actors who provides care and assistance to the elderly person.
Needs	List and description of the senior needs and problems to be solved (and if necessary the needs of family and professional caregivers).
Functionalities and expected services	Description of the functionalities and services (to be developed during the project) aimed at meeting the needs previously described.
Barriers to address	Descriptions of the barriers to the use of the robotics solution.

Phase 1: LISTEN - Needs study

Phase 1, the core of which is the needs analysis, consists of several work stages:

Path from the Needs Study to the Agile Cocreation phase…



Needs prioritization: identification of the priority needs based on the needs analysis.

Services offering description: definition of the robotic solution and services offering that would meet the previous priority needs.

Technical feasibility: 1st evaluation of the services feasibility and definition of the related technical requirements.

Final services prioritization: selection of the final priority services, which are the services that are both priority from end-user's perspective and technically feasible.

Consumer expression of the final services: describe the final services in a way that is easily understandable by end-users.

The aim of the **needs study phase** is to identify the **priority needs** that should be addressed in the project and the **priority services** to be developed from the end-users' perspective. The needs study results allow one to **make the use cases more specific**. Once the main user needs have been understood and prioritized it is necessary to **define the broad outlines of the offer and services** that the partners wish to develop in the project in order to meet these priority needs. Then, the technical and robotic teams check the services' **feasibility** and define the related **technical requirements** in a requirements report. Based on the needs analysis and the first feasibility study of associated services, the project team should select the "**final services"** to be developed in the project.

The "**final services"** are the services that are both:
priority from end-user's perspective AND technically feasible
in terms of technique, time and resources.

Then, in order to **prepare the agile cocreation phase**, the following step is to **express those final services in a way that is easily understandable by end-users**. This is the purpose of the "User Expression of Services" chapter, that we will elaborate on later.

❶ Needs study

The first step of the methodology is the needs analysis of end-users and caregivers. On the basis of these results, the use cases are refined both from users and from technical points of view (i.e. technical requirements). Finally, the "final services" are described as outcomes of this phase. These services will be a priority both from users (elderly people and caregivers) and from a technical point of view.

Objectives. The needs study identifies the needs of the elderlies with loss of autonomy to be addressed in the project and guide accordingly the development of the robotic solutions.

Methodology. The needs investigation is based on a qualitative approach consisting of semi-structured interviews. This qualitative research technique involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on a topic. It is an effective method for getting people to talk about their personal feelings, opinions, and experiences. They are especially appropriate for addressing sensitive topics, such as ageing and loss of autonomy. Those interviews with older adults should last around one hour and should be conducted face-to-face.

Participants. The use case initial description should be used to define which senior participants to interview for the needs study and about which part of their lives this interview is about. For seniors with loss of autonomy, it is important to include both seniors with different levels of loss of autonomy and also family and professional caregivers. Family and professional caregivers, as they potentially have interactions with the robot, can be co-users of the robot, buyers or prescribers. The needs study should include at least ten interviews for each target (10 elderlies, 10 professional caregivers, 10 family caregivers) per use case (for instance, in ACCRA we had 3 use-cases: mobility, daily-life, conversation) and per country. All respondents should have the ability to provide informed consent and to perform the interview. Cognitive impairment and dementia should be considered as exclusion criteria.
An example consent form can be downloaded from our website.

Process. The process for conducting semi-structured interviews follows the following general process.

- Describes the interview objectives.
- Develop the interview guide.
- Recruit people to interview.
- Collect data.
    - Seek informed consent of the interviewees.
    - Conduct interviews with tape recording.
- Transcribe the whole interviews and the interviewer's notes.
- Analyze the results.
- Write report.

Guidelines for conducting in-depth interviews

1) ***Context and way of life***
The objective is to know the context and way of life of the person to situate the robot intervention context.

2) ***Home care***
The objective is to find out if the elderly is getting home care from professionals or relatives. If so, the idea is to understand who is helping, how often, how many hours a day or a week, and for what activities. It is important for us to know the human aids that the person receives because the caregivers could play a role in the appropriation and the use of the robot.

3) ***Needs***
The objective is to identify the elderly's needs (each use case has specific needs).
    a. Start with a general question about the person's difficulties (depending on the use case: for instance for ACCRA in terms of mobility or socialization or daily life activities…)
    b. Then ask specific questions about different types of difficulties in order to accurately and comprehensively identify their needs.

4) ***Investigation of the interest in robots.***
Have early indications on the potential attractiveness of the robot in general and whether people believe that a robot can help them in their needs.

5) ***Ask the person if they want to add other elements. Then, ask questions about socio-demographic information:*** *age, previous job, level of education, family situation…*

6) ***Thanks and conclusion of the interview.***

Guidelines for conducting the interviews and an example of an interview guide are provided here.

Guidelines for analyzing. The analysis is based on typed transcripts of the interviews. The analysis methodology is thematic content analysis, with two complementary approaches: a vertical analysis and a horizontal analysis.

After having transcribed all the recorded interviews, a content analysis is performed which consists of different stages, described by Gavard-Perret et al., (2008). This analysis should start by identifying the relevant categories and defining the data coding modalities. The category "is, in essence, far beyond the simple descriptive annotation or denominative heading. It is analysis, conceptualization, theorization in progression" (Paillé & Mucchielli, 2003, p 147). The determination of categories consists in grouping the units of analysis into homogeneous, exclusive and exhaustive categories according to their level of similarity (Bardin, 2003).

Analysis basics

1. Read all the interviews.

2. First level of coding: identify themes, units of meaning (words, sentences...) as the person express them. Be as close as possible to the text, use the words of the person, do not use theoretical concepts by now, be empirical and facts oriented.

3. Second level of coding: reformulate in more theoretical words.

4. Third level of coding: analyzing. Construct a model of understanding by looking for coherence, differences, hierarchical structures ... (Depending on what you are looking for).

5. Interpretation of results.

Then, the coding of the entire corpus is performed, starting from the established coding grid. The coding “corresponds to a transformation - made according to precise rules - of the raw data of the text" (Bardin, 2003, p 134). This analytical work is carried out by assigning the units resulting from the cutting of the corpus into the identified categories. The coding and categorizing of all the interviews is carried out in two stages. A first coding and categorizing are done in a table allowing an intra-interview reading (progress of an interview on all codified themes). This table is the support for the analysis of vertical content. Then, a second coding and categorizing is carried out in a table based on a reading inter-interviews (illustration of a theme by all the interviews). The latter allows a horizontal content analysis. Once the information has been classified, a certain number of data can be counted, if relevant. This is the calculation of the frequencies of occurrence of the different categories (Jolibert & Jourdan, 2006).

In the final synthesis, be careful to answer the following questions:

- **What are needs of the elderly?** List and describe the needs and, if relevant, differentiate the needs per the type of respondent (e.g. depending on their age, dependency level or living situation - apartment, senior residence, retirement home -, etc.)
- **What is the first perception of robots?** Do people believe that a robot can help them with their needs?

Based on the analysis, update the needs in the use case. Describing the potential user as a persona could be useful.

❷ Needs prioritization

Based on the results, the objective is to prioritize the needs and robot services and features of interest for each of the 3 types of respondents (elderlies, professional caregivers and informal caregivers). This will enable the technical teams to identify the needs to which the robot should respond in priority. This recommendation is therefore exclusively based on the end-user’s needs, it does not consider the feasibility.

❸ Services offering description

Based on needs study results, make a first description of the offer to be developed within the project. Include the robot mission, the robot description (ergonomics, features, design), the robot services (services and functionalities). The targeted robotic solution should meet every priority need.

❹ Technical feasibility

Technical teams should then evaluate roughly the feasibility of each robot features and services and describe the related technical requirements. Feasibility evaluation is based on the feasibility of services and related robotics platform and features. If the robotics platform or basic features of the robot are still not fully developed, this will take a lot of time and it is a risk for the development of services that rely on those features. The feasibility evaluation should take these considerations into account.

❺ Final services prioritization

Strategic step in the project's development, it is about selecting the final services that will be developed during the project.
The combination of the prioritization based on user needs and the feasibility evaluation enable the project team to decide which are the priority services and functionalities to be developed in the project. Thus, final services are the ones that are both priority from end-user's perspective and technically feasible (in terms of services and related robotics platform and features).

Priority services are at the crossroads of end-user's needs and technical feasibility

❻ User expression of services. The objective is to express the final priority services (that are both priority from end-user's perspective and technically feasible) in a way that is easily understandable by end-users. For each priority service, the following "User expression of services" template should be completed. This step is the meeting point between user needs (needs study results) and requirements. It is also a key strategic step to prepare cocreation: the following tables should synthesize the services that will be tested in cocreation phase.

User Expression of Services
Template instructions

NEED

E.g. NEED 1: Safety - Protective robot

- Short description of the **general need** that we want to address *(e.g. Safety).*
- Short description of the robot role to meet this general need *(e.g. Protective robot).*

THEME

Within the same need, several themes may exist *(e.g.: the need for safety encompasses the risk of falling and forgetting medication).* The theme briefly describes (in 1 or 2 words) the **central subject of the difficulty** faced by the elderly person *(e.g., theme #1: fall, theme #2: medication).*

SUB-NEED

A general need can be divided into several sub-needs. While the general need expresses a global need *(e.g. Safety),* the sub-need describes a very **specific need** *(e.g. Fall detection and prevention).* (Each sub-need corresponds to a theme).

GLOBAL SERVICE

Brief **general description of the services** which will address the need.

SERVICES

A global service sometimes includes a set of **specific services** that should be described individually. *(E.g.: Fall detection and prevention encompasses 3 services: (1) obstacles detection to avoid tripping, (2) fall detection and help, (3) physical activities to prevent the risk of fall).*

PRIORITY RANKING

When there are several services within a global service, indicate the ranking of services to be developed by order of priority. This ranking is based on the needs study analysis.

MANDATORY

Here the mandatories are important robot capabilities or features that should be implemented because they are necessary to deliver a good quality of services. However, they cannot be directly included in the services because they are not key services to the end-user, they are requirements to deliver the service. In other terms, to deliver a good quality of service, the robot "should be able to do this", "should have this feature", etc.

QUESTIONS (for codesign sessions)

In order to implement the robot services, the technical team may need more information from the users. Ask these questions here. Those questions will be included in the codesign groups facilitation guide.

Example

NEED #: [need short description] **E.g. NEED 1: Safety - Protective robot** "I want the robot to support my safety in the house"	
Theme #.#	**E.g. Theme 1.1: Fall** "I am afraid of falling in my house"
Sub-Need #.#	**E.g. Sub-Need 1.1: Falls prevention and detection** 1. I want the robot to detect dangerous situations that may cause me to fall, such as obstacles. 2. Should I fall, I want the robot to come to me and call for help if I want to. 3. Should I fall and be in a condition where I cannot call for help, I want the robot to find me and warn a caregiver. 4. I want the robot to help me to maintain my physical condition.
Global Service	E.g. Under my control, the robot helps me to prevent falls. And if I fall, it helps me to secure the rescue.
Services	E.g. a. The robot **warns me if there are obstacles** on the ground to avoid tripping b. In case of a fall, the robot **detects that I have fallen** and, if I wish, informs a relative or a caregiver. c. It helps me to practice a **physical activity adapted** to my situation in order to work my balance and to act on my muscular reinforcement.
Priority ranking	1. Fall detection 2. Fall prevention (obstacles detection) 3. Adapted physical activities
Mandatories	Buddy can hear from the other end of the apartment if I call. (Example: I fall in the shower and the robot is in the living room).
Questions *for cocreation*	1. What type of ground obstacles may cause a fall? 2. Emergency call: is it only at the request of the elderly person (Call my daughter!)? Is the robot asking the person: do you want me to call someone? Does the robot automatically call someone if the elderly person does not answer? 3. What is the priority function? (a, b or c)

L

Listen

Needs study ✦ Number of participants

Interviews with 20 older adults, 20 formal caregivers and 10 family caregivers per country.
Multiply for each use care if the target group is different

Check point #2: Capabilities scoping

All projects have constraints, not everything is possible. It is important to anticipate the range of robot capabilities the project team want to implement. Do not underestimate the effort.

Based on the needs prioritization and the results of the requirements study, the project partners should refine the **robot's MISSIONS**.	• Which **services** the robot should provide? • What are the main **situations of use** of the robot?

As a result, the partners will refine the **OBJECTIVES of the project**.

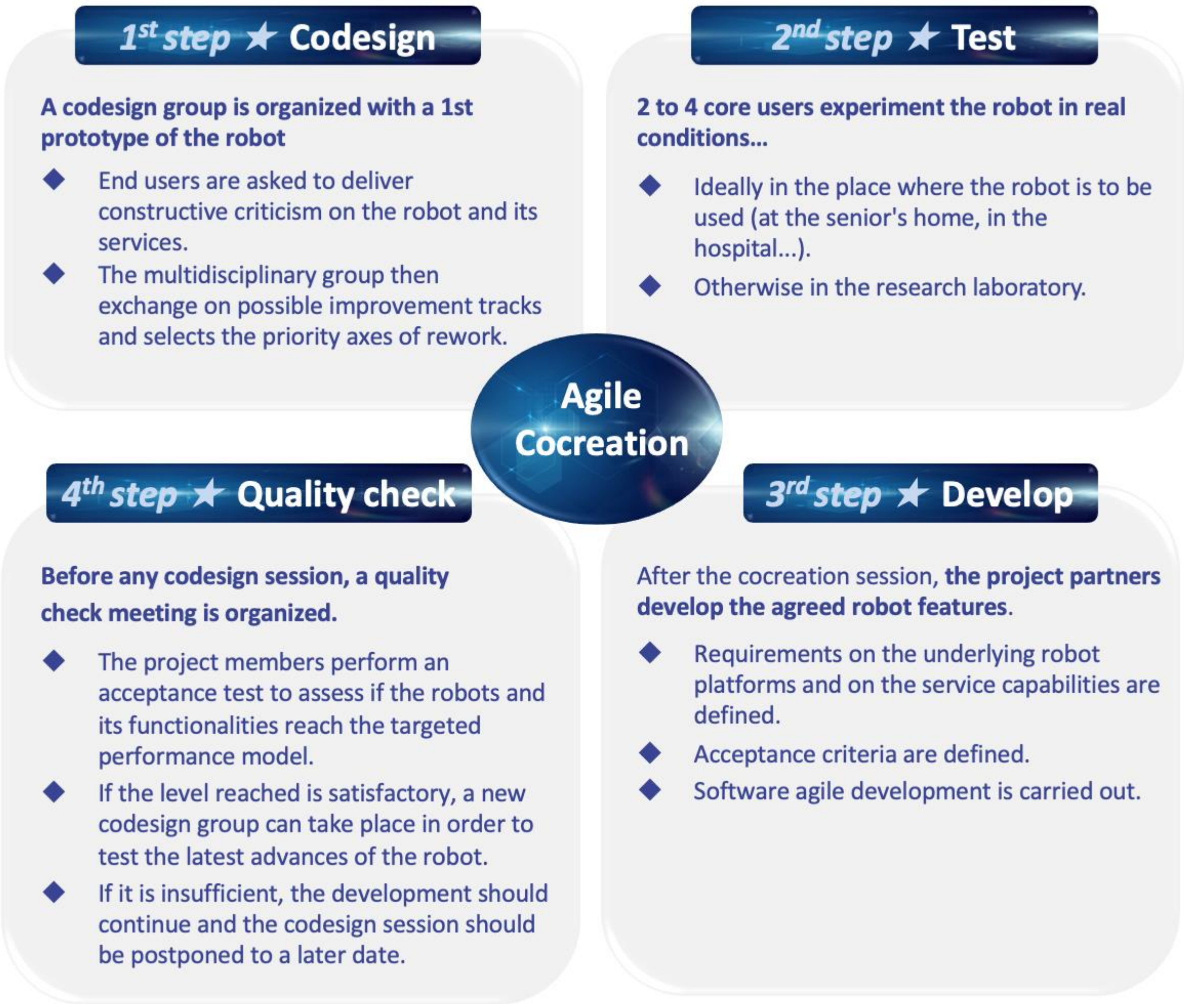
Refine the technical objectives of the project
What could be achievable? What is not?

Achievable engineering objectives	◆ What is **technically** available or feasible during the project period?
Engineering limits	◆ What is unachievable / unchangeable in the robot? (a) during the duration of the project, (b) in absolute terms.

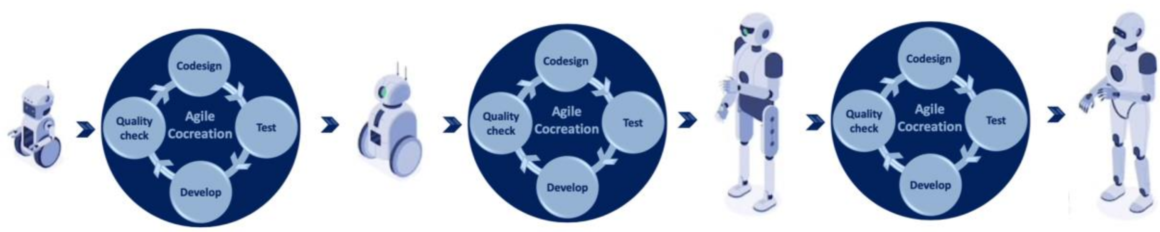
After redefining the robot's mission and technical objectives, the roadmap should be clear. All the partners should have a common vision of the priority needs, the services and functions that will be developed within the project and the technical limits. Then, the engineers will develop a first prototype of the robot and the applications that will be injected during the first codesign group of the agile cocreation phase. This prototype can also be a storyboard, mockup, etc.

Phase 2: INNOVATE - Agile cocreation

The objective of the agile cocreation methodology is to develop and improve the robotics solution (robots and associated services) thanks to cooperation between robotics engineers and end-users. The agile cocreation development process is based on iterative cycles consisting of 4 sub-steps: Codesign, Test, Develop, Quality check meeting.



A minimum of three iterations should be implemented.



Step 1: CODESIGN

By placing users (i.e. elderly people with loss of autonomy and caregivers) in the center of the innovation process, the aim of this step is to design a robotic solution and services offering that effectively meet needs, expectations and potential use of elderly people with loss of autonomy and their caregivers. The aim is to improve the robotic solution and services by proposing concrete optimization solutions, perceived as operational by the elderly people with loss of autonomy, the family and professional caregivers and the technology and robotics professionals.

A mixed approach of cocreation:
a balance between cocreation and co-evaluation

The cocreation approaches can vary from a "pure cocreation" approach centered on the generation of new ideas to a co-evaluation approach where stimuli and primers are submitted to users in order to obtain their opinion on the latter and to jointly identify the optimizations to be implemented.

- Pure "cocreation" is ideal for long-term projects, when there are no prior developments. This makes it possible not to influence users in any way and to develop a solution entirely based on users' needs and expectations.
- For time-limited or complex projects, a mixed approach may be more appropriate, integrating the co-evaluation approach on certain aspects of the project (e.g. existing robot prototypes) and the cocreation approach on the applications (specifically developed for this project). For the ACCRA project, for example, a mixed approach was chosen because of the limited duration of the project and the complexity due to the great heterogeneity of the profiles and needs of the targeted elderly people.

The cocreation methodology is based on codesign meetings with end-users and robotics engineers. The first step is the setting of a codesign group.

- Once the **1st robot's prototypes** have been developed by the project partners…
- … **a WORKING GROUP**, consisting of targeted end-users, researchers and professionals in technology and robotics, works on the optimization of the robotics solution (robots and services)…
- … in order to **better meet the end-user's needs**.

Participants

A working group - cocreation group - should be created, consisting of around 8 to 15 participants.

- 4 to 8 end-users. For older adults with a loss of autonomy, the cocreation group should involve both senior people and caregivers: family and professional caregivers.
- 2 to 4 technology and robotics professionals.
- 2 researchers with experience with doing social empirical qualitative research.

Make sure you have informed consent from each participant (elderlies and caregivers).

These cocreation groups will be working on the optimization of robotic solutions and services platform to best meet the users' needs. For elderly targets, these are primarily the needs of the elderly people with a loss of autonomy, but family and professional caregivers' needs are also incorporated, because the use of robotics is also meant to complement their tasks.

Which engineers should attend the cocreation groups?

Skills and profiles of robotics professionals

- Being able to **understand what people ask**.
- Understanding and speaking the **local language**.
- Being able to **talk to people who know nothing about robotics**. Their language should be clear and easily understandable for elderly which are unfamiliar with technological jargon.
- **Management capabilities**: they have the big picture in mind. They are able to direct solutions to evoked needs.

Cocreation posture

Two points are essential to adopt by the **teams**:

Empathetic approach, multi-expertise and user centric

- Allow the teams to meet directly with the users in order to get their point of view and advance together in the experience of using the robot, enrich it and cocreate.
- To facilitate the empathic posture, an astonishment booklet can be used: this facilitates the empathic listening during the cocreation sessions.

Collaborative approach

- The project teams are fully integrated into the codesign sessions for an immersion with the end-users and an exchange on the constraints and opportunities surrounding the robot prototype.
- During the codesign session, teams will be invited to share with users the constraints to be considered when proposing optimization paths.

The **facilitator's** posture and rules of facilitation are the following.

1) Listen carefully. **2) Facilitate expression.** **3) Move forward.**	***3 main pillars of animation***
4) Motivate and control participants. **5) Different modes of expression.**	***2 facilitation enablers***

Cocreation methods & tools

Methods and tools have been developed to address a specific target: senior people with a loss of autonomy.

- **GUARDIAN ANGELS** to promote the well-being and participation of senior frail people.

Guardian angels

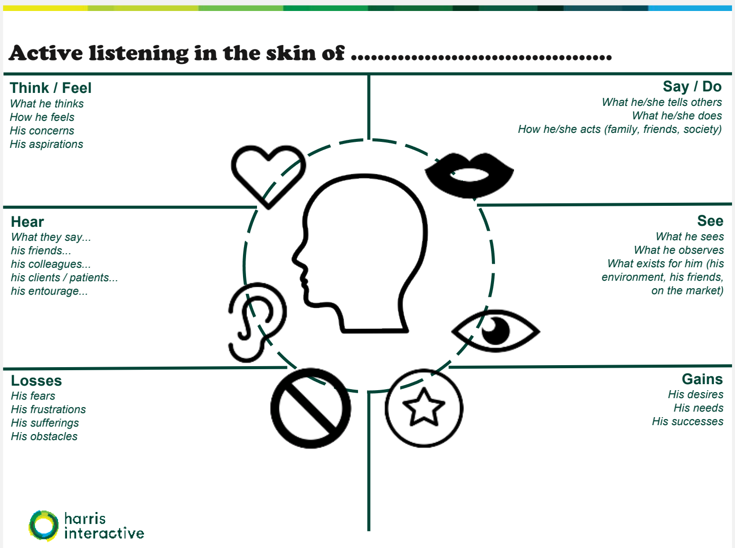
In order to promote an empathetic posture and to make sure that every elderly feels at ease, one guardian angel is attributed to each senior for all the codesign sessions. Each project participant is dedicated to a senior during all the codesign sessions. The guardian angels 'role is to make every senior feel the best possible. If the elderlies need something or have difficulty, their guardian angels should help them (bringing water, writing for them on a post-it, explaining something the elderly did not understand ...).
What is important when working on this target is that we do everything to make them comfortable, and to help them to fully participate. If some are less comfortable or more on reserve, they will have a guardian angel who can support them and for whom it will be simpler. It is a security to accompany them at best during these sessions.

- **ROLE-PLAYING** to reduce the positivity bias observed with the senior target.
- **PLACES & TOOLS** adapted to the needs of the target audience (room with disabled access, enlarged texts, large post-its...)
- **FACILITATION TOOLS** for the project members who participate in the codesign sessions: empathy cards, notebooks of astonishment. Those facilitation tools were created by Harris Interactive Institute.

Empathy cards

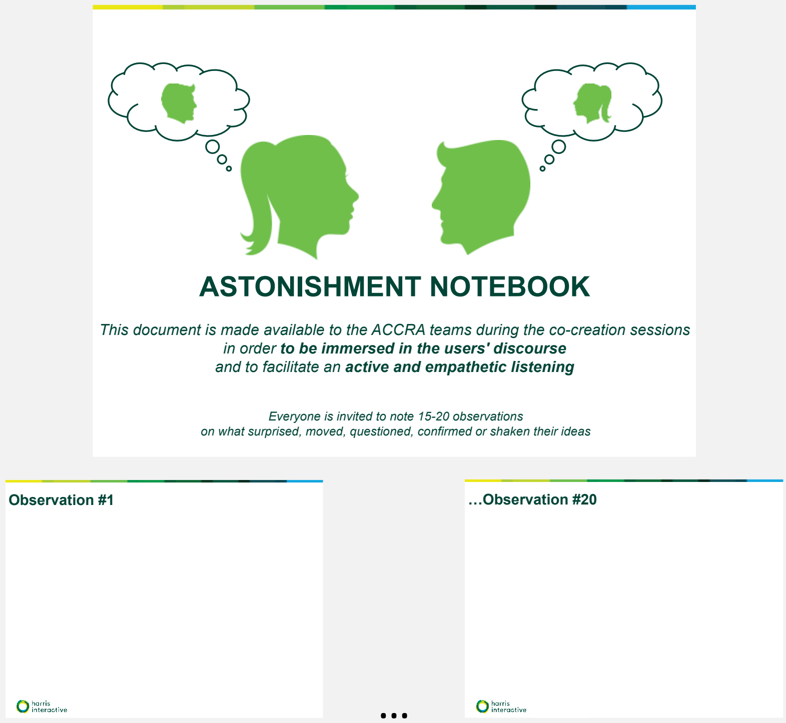
During the very first exploratory phase of the codesign session, each participant will be the active listener of one elderly. The stake is to be in their skin. Then, write on this card, what you think your elderly…thinks, feels…says, does …hears, sees, what are his/her losses, fears, sufferings, what are his/her gains, desires, needs…

The objective of this tool is to promote an empathetic posture.



Notebooks of astonishment

The objective is to be immersed in the users' discourse and to facilitate active and empathetic listening. Everyone is invited to note 15-20 observations on what surprised, questioned, moved you, confirmed or shaken your ideas.



- **TOOLS TO KEEP SENIOR PEOPLE INVOLVED BETWEEN CODESIGN SESSIONS**
  It is important to have regular interactions with users to maintain a good level of motivation and involvement. Indeed, the codesign sessions are relatively distant in time to allow engineers to adapt the robots to the expressed needs and expectations.

Key tools

- **Mission notebook** to be filled in between sessions with expectations, needs, examples of expected uses and thoughts about the robot and its functionalities.
- **Postcard** from the robot: The robot sends news to the users…
- **Photo** of the elderly and the robot taken during the codesign.
- **Poster in the senior residence**: inform about the progress made, continue to ask for inputs, reminds them that there are parts of the project.

Mandatories

Don't talk about technical functions… Talk about end-users services

First key step before starting codesign groups: each robot functionality should be translated into concrete services to end-users, in senior user language.

1 use case = 1 robot

Develop only one robot transverse to the countries that share the same use case. After the codesign meeting in every country, the results are shared across countries and the partners should agree on common modifications of the robot and they should then present the same robot at the next codesign session.

Cocreation in local language

The whole codesign session should be in local language. So, the facilitator should speak the local language. If the technical and robotic professionals do not speak the local language, a local partner or a translator should traduce what is said.

Facilitation guide

The facilitation guide (an example can be downloaded from the website) includes 5 main phases, described in the below table.

FACILITATION GUIDE	
5 MAIN PHASES	**OBJECTIVES**
Introduction 10 min	• Make the group feel at ease, introduce the subject and the "rules of life" of the group. • Presentation of the topic and explanation of the purpose of the session. • Warm-up: creative warm-up of the participants. • General portrait / description of each participant.
Exploratory phase: loss of autonomy regarding daily life, mobility or conversation 25 min	• Immerse everybody in the subject. • Identify current practices in terms of loss of autonomy. • Identify expectations around loss of autonomy.
First presentation of the prototype and associated services 60 min	• Explore quickly the potential of the robot prototype and associated services. • Identify the reasons for the motivations and barriers to use.
Detailed assessment of the robot and services 120 min	• Explore in detail the potential of the robot prototype and associated services. • Identify the specific reasons for the motivations and barriers to use. • Optimize the prototype and services.
Conclusion 15 min	• Prioritization of ideas of improvement for a rework. • Maintain a creative dynamic until the next session.

Step 2: TEST

At this stage, the tests are implemented with 2 to 4 core users for quick and easy setup. The core users will test the robot for a few hours to a few days. Users can remain the same over the iterations, this simplifies the process because after having trained a first time the seniors to use the robot, the following tests will be quicker to set up. After having explained how the robot works to the users, they will test the robot in real use conditions at home or in an institution, depending on where the robot should be used. If moving the robot proves too complex or expensive, a laboratory test can be considered, provided that it reproduces as much as possible the real conditions of use: for example, researchers and engineers should avoid to interfere during the test session, if the goal of the test is to assess the usability of a certain feature.

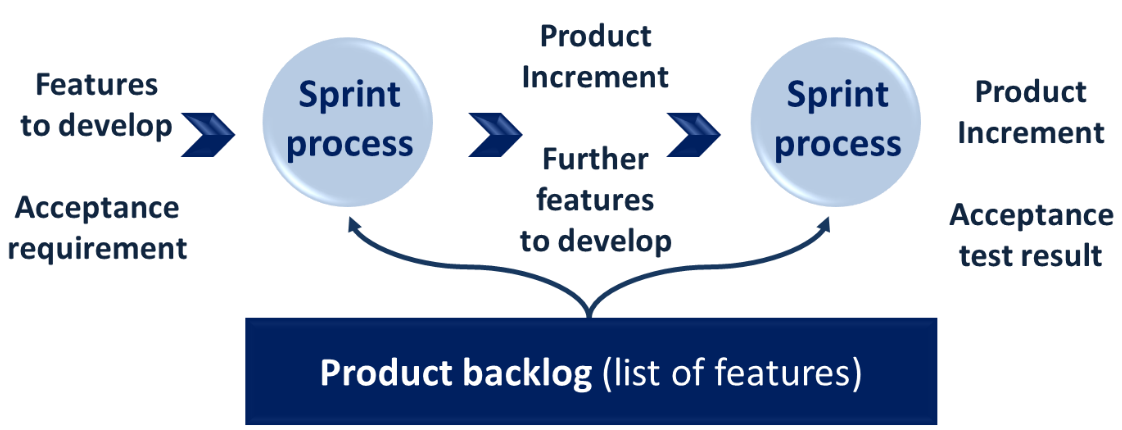
Following the test, through a semi-structured interview, the users are asked about their experience with the robot: do the robot's services, functionalities and ergonomics meet their expectations? For each of the services or functionalities tested, what is good? What needs to be improved? What other services should be offered? Is the robot easy and pleasant to use? What is difficult?... Also ask the user precise questions that allow engineers to make choices in terms of robotics development.

Analyses

After each codesign and testing session, a first debriefing of the main conclusions is made orally so that the engineers can start to rework the robot and its functionalities. Then, a full report of the results is made. The report should define which features and services should be developed or improved in priority. The final decision of the priorities to be developed is taken during the management review meeting. During this meeting, the time and resources to devote to these developments should also be decided.

Step 3: AGILE DEVELOPMENT

Agile development is based on the agile software development approach that has been defined to promote adaptive planning, evolutionary development, early delivery, and continuous improvement.



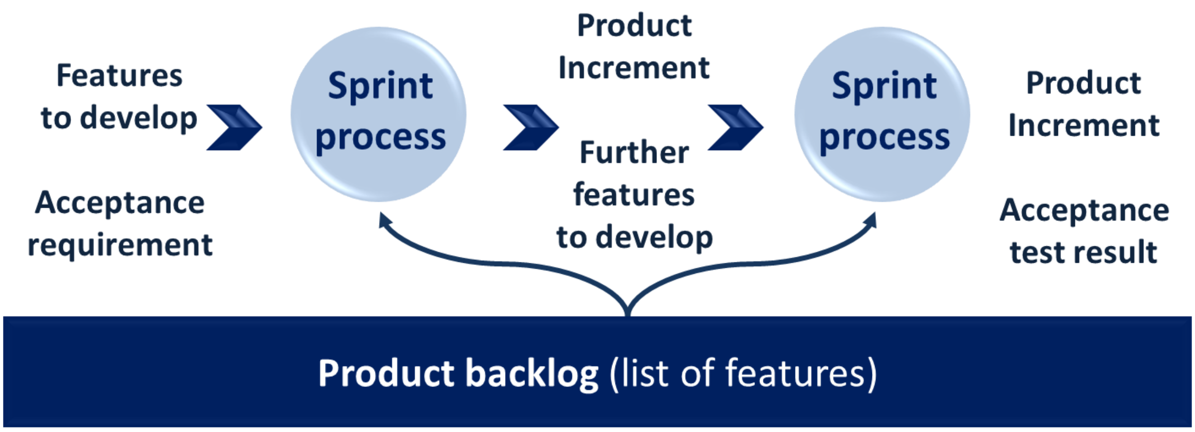
Product development is carried out in short periods called **sprints**. The objectives of sprints are agreed by members of the project team with the following specific roles:

- agile programming team, or the engineers who apply the agile approach,
- product manager,
- product owner.

The result of a sprint can be demonstrated and assessed by both the product owners and managers. Pending work is managed through a **product backlog** which is a list of features that need to be integrated in later development. The product backlog includes:

- new features,
- changes to existing features,
- bug fixes,
- infrastructure changes (platform adjustments), or
- other activities that a team may deliver in order to achieve a specific outcome (for instance acceptance tests).

A development step can include several sprints. The first sprint starts with instructions resulting from the cocreation process on features to develop and associated acceptance requirements that will be used for the quality check step. The last sprint includes results on acceptance test that will be evaluated in the quality check step.



Step 4: QUALITY CHECK MEETING

At the end of the agile development stage, when also the user testing has been done, a quality check meeting is organized. The objective is for the multidisciplinary project team to test the robot and its services and evaluate to what extent the development objectives are achieved. This is achieved through a test phase based on acceptance test results provided by the development team. If the progress is sufficient to meet the expectations of the seniors that were identified during the previous codesign meeting, then the next codesign meeting is scheduled. If the developments achieved are insufficient, they should be continued until the expected level is reached.

I

Innovate

Agile Cocreation ✦ Number of participants

✦ Codesign sessions

Sessions with:

- 10-12 participants: 4 older adults, 2 professional caregivers, 2 family caregivers, 4 cocreation team,
- 2 facilitators.

Duration per session: 2 hours.

At least 3 codesign sessions per country and per use case.

✦ Test sessions

Sessions with 1 older adult (+ caregivers to support if needed).

At least, 3 test sessions with 3 older adults and caregivers.

Check point #3: Stability check

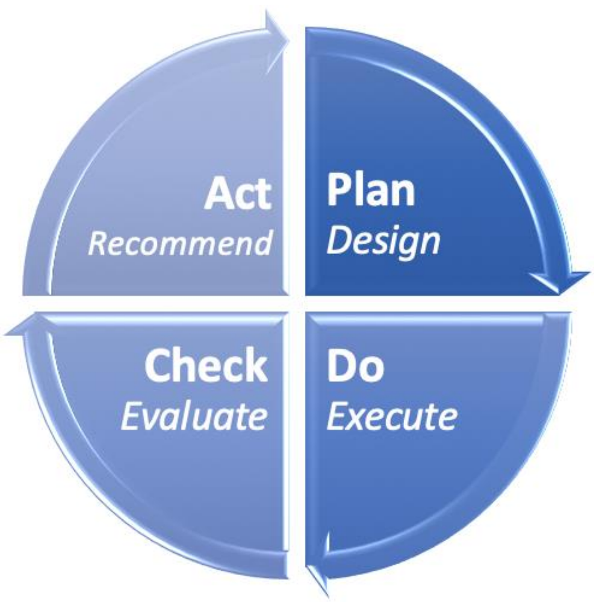
Before closing the agile cocreation phase and entering the agile pre-experimentation phase, a multidisciplinary meeting should be organized to check whether the cocreation objectives are met and whether the robot and its functionalities are stable enough to be tested under real conditions in the agile pre-experimentation.

Phase 3: FIELD-TEST – Agile pre-experiment

The aim of the agile pre-experiment is to test the functionality and user perception of the robotic solution (the robot and the services it offers) for the end-users in the real-life setting for which the robotic solution is developed. In case the robot uses machine learning, the field-test is also used to collect as much data as possible to feed the algorithm. This phase differs with the tests during the Innovate phase in the following aspects:

Testing during Innovate phase	Agile experiment during Field-test phase
• Few end-users	• Small group of end-users
• Controlled setting	• Controlled real-life setting
• Strong involvement and guidance by technicians and researchers	• Involvement and guidance by technicians and researchers
• Very short testing time	• Short, in-depth testing time
• Practical small-scale tests	• Small scale study
• Testing of separate features and functionality	• Assessment of all features, functionality and services
• Aim is improvement of the functionalities	• Aim is testing the functionalities under real-life conditions and generating data for AI analysis
• Improvements to the robot features, functionality and service are made in between the tests	• If needed, optimizations to the robot features, functionality and service are made during the pre-experiment

The field-test phase follows Deming's PDCA cycle and consists of the following four steps:



PLAN: Design the pre-experiment

Engage the field

In this step, the goals of the field-test are defined by the multidisciplinary research team. It is important that the site where the field-test is done is involved and fully engaged in this stage, because during the field-test they will be involved in testing a robotic solution that might still have technical imperfections and usability issues, and also it is likely that new issues will pop up, that were invisible with the small tests during the Innovate phase. Their commitment is crucial.

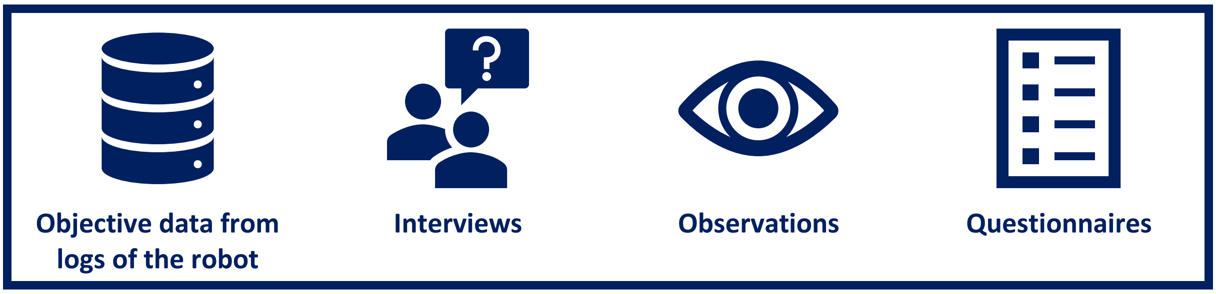
> Make sure that not only the management is engaged, but also the caregivers. They need full support from the management to be involved in this test.

Design the test

In this step, the research team has to agree on the research design for the field-test. Usually, a field-test is meant to test the feasibility and acceptability of an innovation. That means experienced safety, usability and satisfaction with the service are important aspects.

Specific for robots that are based on machine learning, the field-test can generate a lot of data to feed the algorithms and improve the robot's performance (e.g. adaptability to the user). Maybe specific services of the robot should be tested more intensively than others, so a test scenario is needed that assures optimal data gathering.

It is advised to use a multi-method approach (quantitative and qualitative) and collect data from different sources.



There are several validated, generic, instruments for the usability and acceptance assessment (for example UEQ and UTAUT (Venkatesh et al. 2003)), but also models designed specifically for robots (e.g. Godspeed (Bartneck et al. 2009) and Almere model (Heerink et al. 2010)). Complementing these instruments with qualitative data collected through interviews and observations is very important to give meaning to the numbers. Furthermore, some deeper insights are only retrievable through close observations, or even ethnographic work. Examples of questionnaires and topic lists can be found on our website.

Define what would be the optimal duration of the pre-experiment per user. This might depend on the goal of the robot, but if used intensively, a test of 1-3 weeks by 10 users will be enough to retrieve reliable input on the user experience and usability. The total duration of the pre-experiment will depend on the number of robots available for testing.

Define and recruit the users

Next, define what would be the best users for this pre-experiment. This starts with defining the relevant characteristics of the targeted end-users:

- older adults (age, sex, living situation, health issues, presence of problems for which the robotic solution is devised, and experience with technology),
- Formal caregivers: profession, level of involvement in the care for the patient,
- Informal caregiver: relation with the patient, volume of informal caregiving.

Preferable, perform the field-test with users from the target group. There is a possibility that you introduce bias in the recruited respondents because only people interested in robotics might be willing to participate. This group might be a bit younger or have a bit more experience with technology. Arrange informed consent with all participants.

DO: Execute the pre-experiment

Train the users and the helpdesk

When experimenting with robotic solutions, training the end-users is important due to the complexity of the robots. The aim of the training is to teach the users how to use the robot and to troubleshoot problems. The training should consist of the following components:

- Explain all functionalities with a demonstration on how to use them.
- Discuss and demonstrate common problems and how to fix them.
- Go through the manual so end-users know where and how they can find information on the use and troubleshooting when needed.
- Testing the functionalities by the end-user with help and feedback from the trainers.
- Giving the end-users a set of exercises to assess their ability to use the robot independently.
- Explain maintenance issues (e.g. cleaning robot, charging robot).
- Give contact information for help.
- Answer questions.

Depending on the user-group, the training can be given collectively or individually.

Conduct the pre-experiment

In this step, the pre-experiment is conducted according to the designed protocol with the researchers gathering and analyzing the data and giving support when needed. There should always be a back office for the end-users, caregivers and non-technical researchers. In this phase, it is important that the support is on-site. Depending on the duration of the pre-experiment per user, the research team decides on the frequency the user should be visited to check if everything is going well. For example, in a 3-week test, researchers should visit the users 1-2 times each week). In an agile pre-experiment, it is possible to make adaptations to the design of the field-test and to make optimizations to the robot. However, make sure that each iteration is documented well.

CHECK: Evaluate the pre-experiment

Validate the analyzed results with representatives from the group of end-users. The preferable way is to organize a focus group as it provides the opportunity for different end-users to complement each other's reflections. Also, invite the project team and the management of the care organization to this meeting. All lessons learned should be collected. The following structure could be followed:

Topic	Explanation
Icebreaker	Let people respond to images of robots, or images about ageing, let people draw their life with a robot
Explain project and robot	Not all participants are familiar with the project so give a short introduction of the project and a demo
Results of field-test	Present the methods and results of the agile pre-experiment, the field-test.
Assessment on all domains of impact of the current situation	Create a spider web of the current status with all stakeholders
Discussion on potential user	Create personas or explore the characteristics of the intended user, based on the field-test pre-experiment. Maybe the original target group does not fit anymore.
Closing	Explain how the results of the meeting will be processed

The spiderweb-exercise can be downloaded from our website.

ACT: Recommendations for future work

The field-test has given a lot of input for the optimization to the robot's features, functionalities and services, and insight in the feasibility and acceptability of the solution for the target group. This is an important input for the robot developers, but also for the research team that is responsible for the last phase of the project, in which an end experiment is executed with a stable robot. Make sure that all recommendations are documented.

F

Field-test

Agile pre-experiment ✦ Number of participants

Field-test with 10 older adults, 5-10 professional caregivers and 5-10 family caregivers.
Duration per participant: 1-3 weeks.
Total duration: 2-6 months depending on the number of robots.
(Continuous AI data gathering.)

Check point #4: Maturity check

Before closing the agile pre-experiment phase and entering the last evaluation stage, a multidisciplinary meeting should be organized to check whether the objectives are met and whether the robot and its functionalities are ready to be evaluated large-scale and marketed. This might require a new project, which needs new funding and involvement of new partners with expertise on impact assessment studies.

Phase 4: EVALUATE – Final evaluations

Step 1: END EXPERIMENT

The aim of the end experimentation phase is to assess the value of the robotic solution for the end-users in the real-life setting for which the robotic solution is developed. This phase differs from the Field-test on the following aspects:

Field-test Agile pre-experimentation	Evaluation End experimentation
• Small group of end-users • Controlled real-life setting • Close involvement and guidance by technicians and researchers • Short, in-depth testing time • Small scale study using scientific methods • Aim is testing the functionalities under real-life conditions and generating data for AI engine • If needed, improvements to the robot features, functionality and service are made during the agile pre-experiment	• Large group of end-users • Real-life setting • Distant problem solving and guidance by technicians and researchers • Long in-depth testing time • Rigorous scientific research designs • Aim is evaluation of the value of the whole solution • The technology is considered stable, there are no changes to the robot and the services.

During the end experiment, the automated data collection for the machine learning continues, and if the robot is already mature enough, to adapt to the user.

The end experimentation consists of the following steps:

1. Formulate research question

In this step, the main aim to research the value is defined by specifying the types of value and end-users. Value is a multidimensional construct, referring to the worth, importance and usefulness an object has. Many dimensions of value exist, such as functional value, monetary value, social value, psychological value, personal value, collective value, aesthetic value and moral value. The stakeholders should reach a consensus on which of these values are the focus of the research given the functionalities of the robotic solution and the end-users for whom it is developed. Hence this step encompasses defining who the end-users exactly are. End-users are actors who will work with or be affected by the robotic solution.

2. *Choose experimental design*

In this step, the stakeholders have to agree on a research design. In choosing a design the following questions need to be answered:

- Can the research question be answered with the design?
- What level of evidence is aimed for?
- Is it feasible to conduct the research (budget, time, contextual requirements, burden on participants)?
- Is the design scientific?

These questions are intertwined as the research questions define the level of evidence desired, whilst the deployment of a design is constrained by the feasibility and scientific rigor of the design. It is advised to use the design with the highest level of evidence possible (see box). The level of evidence is lower for studies with a risk of bias, unexplained inconsistency, indirectness of effects, and imprecision of estimates. The level of evidence is higher when effects are large and all plausible confounders are taken into account (GRADE 2004).

Level A ***High level***	Level A consists of high-quality studies with consistent results. Further research is highly unlikely to change the confidence in the estimated effect. This category comprises high-quality pre- and post-surveys, multi-center randomized controlled trials (RCT) and, in special cases, one large, high-quality multi-center trial.
Level B ***Moderate level***	Level B consists of studies with some limitations and consistent findings or one high-quality study. Further research is likely to have an impact on the confidence of the estimated effect and may change the estimated effect. This category comprises one-center RCTs, RCTs with severe limitations, and pre- and post-surveys.
Level C ***Low level***	Level C consists of one study with acceptable quality or inconsistent results of several studies focusing on the same outcome. Further research is very likely to change the estimated effect and have an important impact on the confidence of the estimation. This category comprises high-quality qualitative studies, quasi-experimental designs, and pre- and post-surveys with limitations.
Level D ***Very low level***	Level D evidence implies that the estimated effect is very uncertain. This category comprises low-quality qualitative studies and pre-and post-surveys with severe limitations.

(GRADE 2004)

The chosen design together with the main outcome will dictate the size of the study population, the need for a control group, and the duration of the end experiment. With regard to the methods, one will need to choose the methods that are the most appropriate to answer the research questions. It is advised to use a multi-method approach to be able to both quantify the value as deepen the understanding of why a robot is valued as it is.

3. *Specify criteria for selection of end-users*

In this step, the inclusion and exclusion criteria for every type of end-user is specified, also based on the experience from the field-test. To do so two questions should be addressed:

- **Inclusion criteria:** What are the relevant characteristics of the targeted end-users?

With regard to the inclusion criteria, the characteristics of the end-users should be described as specifically as possible. The question *For whom are we developing this robot*? should be answered as detailed as possible. Characteristics depend on the type of end-user targeted. In general, the main characteristics of the most prominent end-users are:

    - Patients: age, sex, living situation, health issues, presence of problems for which the robotic solution is devised
    - Formal caregivers: profession, level of involvement in the care for the patient
    - Informal caregiver: relation with the patient, volume of informal caregiving

- **Exclusion criteria**: Which characteristics impede the use of the robotic solution?

The exclusion criteria are based on the abilities of the end-users to use the robotic solution. To define these abilities a matrix can be made of the functionalities of the robot and the abilities necessary to use the functionalities. On the basis of the matrix the question should be answered *Under which conditions is a person unable to use the robot?* These conditions are the exclusion criteria. (See box for an example).

Functionality	Necessary ability	Necessary ability
Setting reminders	Understand how to set reminder	Cognitive impairments
	Comprehensive speech	Speech impairments
	Ability to hear reminder	Hearing impairments

4. *Define dimensions, indicators and operationalization*

In this step:

- dimensions covering the values are defined (Note that dimensions can be assigned to different values),
- indicators within these dimensions are defined,
- operationalization of these indicators are made,
- functionalities that impact the indicators are described.

To define the dimensions and indicators, existing frameworks in robotics and technology assessment are preferably used. Deciding on the dimensions and indicators is done in focus groups with all stakeholders to ascertain that all perspectives are taken into account and relevant dimensions are covered. From previous research in the field of Active Assisted Living, the following dimensions are considered important:

Examples of dimensions	Impact assessment domain
Social effectiveness Quality of life Caregiver burden	Outcomes
Acceptability Usability Usefulness of the services	User perception
Quality of the robotics platform Safety Security	Technical aspects
Cost of robot Cost of care provided Savings on care provided	Economic aspects
Fit with organizational goals Implementation	Organizational aspects
Public opinion on robotics Gender differences Privacy	Sociocultural, ethical and legal aspects

However, the stakeholders need to decide, based on their research question and availability of resources, which dimensions should be covered in the end experiment, and hence on which impact assessment domains the evaluation will focus.

Indicators and their operationalization are critically screened against the functionalities of the robot to avoid discrepancies between what the robot can do and the impact a robot can have (e.g. lessen the burden of doing household work if a robot does not have a functionality to support household work).

The result of this step is a matrix with the values, dimensions, indicators, operationalization and functionalities that have the potential to impact the value. (See box for an example).

Value	Dimension	Indicator	Operationalization	Functionality
Social value	Social effectiveness	Loneliness	Subjective loneliness Objective social activity	Remote communication
Functional value	Safety	Safe use	Perceived safety Adverse events	All

Large scale experiments with robots in elderly care looking into (cost-)effectiveness are scarce. The MAST model (Kidholm et al. 2012) or the MAFEIP tool could be used to perform a cost-effectiveness analysis.

5. Develop research instruments

In this step, research instruments are selected or developed which measure the indicators as operationalized. Besides applying methodological requirements for instrument construction, in doing so the following criteria should be taken into account:

- The instrument is a validated instrument (if available).
- The questions within the instrument are applicable to the robotic solution or it is allowed to adjust the instrument to fit the researched robot.
- The questions are comprehensible for the end-users.
- If secondary data is used, the data should be retrievable.
- One should be able to administer the total set of instruments within a timeframe that suits the burden an end-user can handle.

If the MAFEIP tool is used for a cost-effectiveness analysis, it is important that the research instruments chosen are also recommended by MAFEIP.

To assess the feasibility of administering and the comprehensibility of the instruments, the total set is tested amongst a few end-users. If necessary, the set is adapted according to the experienced results. Examples of instruments can be found on our website.

6. Construct and give training

If possible, just a manual is given to simulate the real-life use of robots. After all, when buying a product, the engineers do not come to your house to get you started. However, when experimenting with robotic solutions, training the end-users is usually a necessity due to the complexity of the robots. The aim of the training is to teach the users how to use the robot and troubleshoot problems without help. The training should consist of the same components as in the Agile experimentation.

Depending on the user-group, the training can be given collectively or individually.

7. Experiment

In this step, the experiment is conducted according to the designed protocol with the researchers gathering and analyzing the data. As experimenting with robotic solutions might be difficult for the end-users, two requirements should be put in place:

- A back office for the end-users if they experience problems they cannot solve themselves.
- A back office for technical problems which cannot be fixed by the researchers or end-users.

Both can be remote offices or on-site face-to-face visits to help end-users.

8. Validate analysis

The last step consists of a validation of the analyzed results with representatives from the group of end-users. The preferable way is to organize a focus group as it provides the opportunity for different end-users to complement each other's reflections.

Step 2: MARKET ASSESSMENT

Overall objective

The overall objective of the market survey is to quantify the attractiveness and potential of the robotic solutions among the targeted countries populations, surveying a sample of elderly people with loss of autonomy.

The market survey assesses:

- the **interest** of end-users for the project services offering,
- the **intends to adopt** or use the robot,
- the **motivations** (needs) and **barriers** to robot adoption and use.
- the different parameters of the **Business Model** in order to define the way of adoption (buying, renting, subscribing to a package of services…), place of adoption (which provider?), price…

Survey design

The survey design is a quantitative survey to carry out in one or several countries (3 countries in ACCRA project: France, Italy and the Netherlands). The data are collected via the Internet through an **online questionnaire**. A sample of **300 elderly people with a loss of autonomy** per country can be surveyed with **300 respondents per country** (For ACCRA, 1096 respondents). The survey used in the ACCRA project can be downloaded from our website.

Step 3: SUSTAINABILITY ASSESSMENT

Goal

The goal of the sustainability study is to assess what is needed to implement the robotic solution in the market. This information will help the developers of the robot to make the final steps. Robotics solutions for ageing are often not consumer products that are affordable by the older adults themselves. Therefore, it is important that care organizations see the value of the robot for their clients (and their staff) and are willing to invest.

> From the ACCRA project we learned that it is important to develop services for the robot that are also valuable for caregivers (professional caregivers or family) so there will be a higher chance of (partial) funding by a silver economy or eHealth subsidy program.

Sustainability focus group

Organize a focus group with the main stakeholders and discuss for each domain of impact the current status of the robot and the steps to the future. The different stakeholders will have different opinions and bringing them together will lead to interesting interactions. The focus group should be animated by two people. One leading the discussions and the other observing and helping the participants with the exercises. Make both audio and video recordings to facilitate the reporting. Typically, the meeting should be 2-2,5 hours including one or two short (10 min) breaks.

Who to invite?

Invite people with experience from the project, because of involvement in one or more previous phases. But also invite people who have not been involved, because they have an open mind. A focus group should be between 8-10 people to be manageable. You can organize the focus group locally, with the stakeholders involved in the evaluate phase, or with an extended group.

Participants	Examples
2 facilitators	the project staff should preferably have experience with managing groups. One is the primary animator, the other supports
3 older adults 2 family caregivers 2 professional caregivers	preferable they have different experiences from the agile experiment or final experiment
3 managers/policy makers	for example: manager geriatrics unit or home care department, innovation manager, financial department / controller

Structure

The focus group can be structured in the following way.

Topic	Explanation
Icebreaker	Let people respond to images of robots, or images about ageing, let people draw their life with a robot
Explain project and robot	Not all participants are familiar with the project so give a short introduction of the project and a demo
Results of large-scale evaluation	Present the methods and results of the experiment. Make a quick round if anyone has questions about these results.
Assessment on all domains of impact of the current situation	Create a spider web of the current status with all stakeholders and compare this to the spiderweb of the focus group at the end of the field-test. Are there significant improvements?
Explore future actions for making the robot market-ready in all domains	Which issues need still to be addressed? What would be the best business model?
Closing	Agree on how the results of the meeting will be processed

The following domains are important to discuss.

Impact assessment domain	Topics for discussion and rating the current advancement
Outcomes	What kind of outcomes are relevant for the older adults, family caregivers and professional caregivers? Is there evidence that these outcomes have been or could be achieved? Is more investigation needed?
User perception	Was the robot accepted by the users? Did the services fit their needs? Were the users satisfied with the services? Is there enough evidence that when bringing the robot to the market it will be accepted and used? Is more investigation or improvement needed?
Technical aspects	Has stability, safety and security been demonstrated? Is the robot technically ready for a process of certification? Is more investigation or improvement needed?
Economic aspects	What are important cost to take into account when bringing the robot to the market? What are important cost to take into account when implementing the robot in a care organization? What would be the best options for a business model? (subscription, co-payment, …) Is more investigation needed?
Organizational aspects	What will be the challenges to implement the robot in a care organization? What is needed in terms of marketing, training? Is more investigation needed?
Sociocultural, ethical and legal aspects	Is society ready for the robot? Is the privacy of the robot guaranteed? What are the relevant legal aspects to take into account? Is more investigation needed?

Draw from these discussions an action list for those domains that need further investigation. An example of a focus group guide and templates can be downloaded from our website.

E

Evaluate

Final evaluations ✦ Number of participants

End evaluation

Large experiment with 50-100 older adults, their professional caregivers and family caregivers.
Duration per participant: 3-6 months.
Total duration: 12-24 months depending on the number of robots.

Market assessment

Market survey with, at least:

- 300 older adults per country and per use case,
- If relevant, 300 family caregivers per country and per use case.

Sustainability assessment

Focus groups with:

- 3 older adults, 2 professional caregivers, 2 family caregivers, 3 Management / Policy / Finance.
- 2 facilitators (project staff).

Further information on participants:

- Older adults, professional and family caregivers: preferable they have different experiences from the agile experiment or end evaluation.
- Facilitators: the project staff should preferably have experience with managing groups. One is the primary animator, the other supports.
- Management / Policy / Finance: for example, manager geriatrics unit or home care department, innovation manager, financial department / controller.

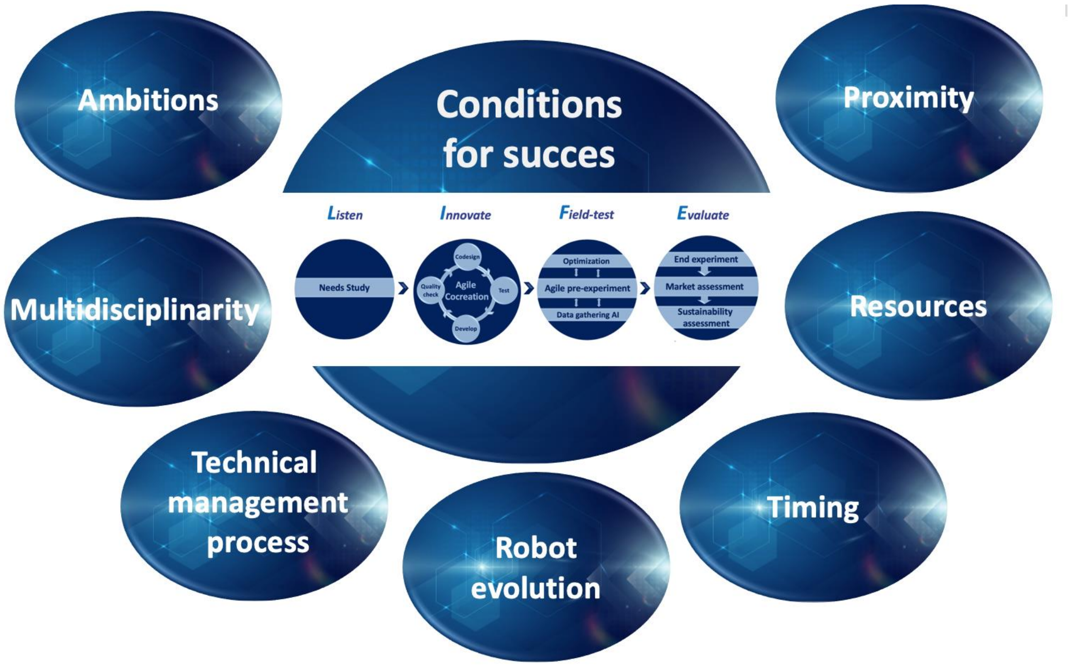
Check point #5: Market-readiness check

Before closing the project, a multidisciplinary meeting should be organized to check whether:

- the objectives are met,
- the robot and its functionalities are ready for the market.

Conditions for success

In order to successfully implement the LIFE methodology, we recommend being vigilant on the following points: define clear and realistic ambitions, set up a multidisciplinary team, implement a strong technical management process, ensure a satisfactory evolution of the robot between the phases of the project, have a short development time to ensure agility, manage the phases requiring the most agility ensuring geographical proximity between the robot and the user test fields.



Ambitions

The project team should agree on **clear and realistic ambitions**.
The goals of the project should consider the actual state of the robot.

- **Step 1** Get a realistic view of the robot's state of advancement.
- **Step 2** Set clear and realistic objectives in terms of robot capabilities development.

Multidisciplinary team

The project team should be multidisciplinary with strong connections between different kind of expertise and knowledge working together.

Technical management process

It is important to have a strong technological management process to successfully manage priority, time and resources. The management process should be supported by 2 key meetings.

❶ **Management review meeting** after testing
Following the analysis of the results of each test phase, a first meeting is organized in order to decide on the next developments of the robot, the expected level of performance and the methodologies for future user tests. Consider time, financial and human resources allocations in the project.

Prework	- Presentation of the analysis results of the latest user tests carried out. - Proposal of the services to be implemented for the next user test. - Agreement on an initial development platform - Proposal of the next user test methodology.
Decisions	- Decide which services and functions should be developed, within the agreed robot capabilities development - Decide time and resources to devote to these developments. - Choose the user testing methodology.
Conditions for success	- The project group reaches agreement on how decisions are taken. - Appointing a leader with experience on co-creation management.

❷ **Quality check meeting** before testing
Before each user test session, a quality check meeting is held to check the robot's optimizations: the multidisciplinary project team should test and assess whether the technology has reached a sufficient level to conduct the next user test session.

Prework	- Implementation of the robot and functionalities developments which have been decided in the management review meeting.
Decisions	- If the expected level is reached, the next user test session can be scheduled. - If the expected level is not reached, further development is required before conducting a new user test.
Conditions for success	- Multidisciplinary team (technical and non-technical people). - Appointing a leader with experience on co-creation management.

The next step is only taken if the objective of the previous stage has been achieved. For example, all the optimizations identified in the agile cocreation should be implemented on the robot before starting the agile pre-experiment. If the next test phase is performed while the robot has not evolved sufficiently, users' comments will be recurrent.

⇨ Loss of time, human and financial resources.

Robot's evolution

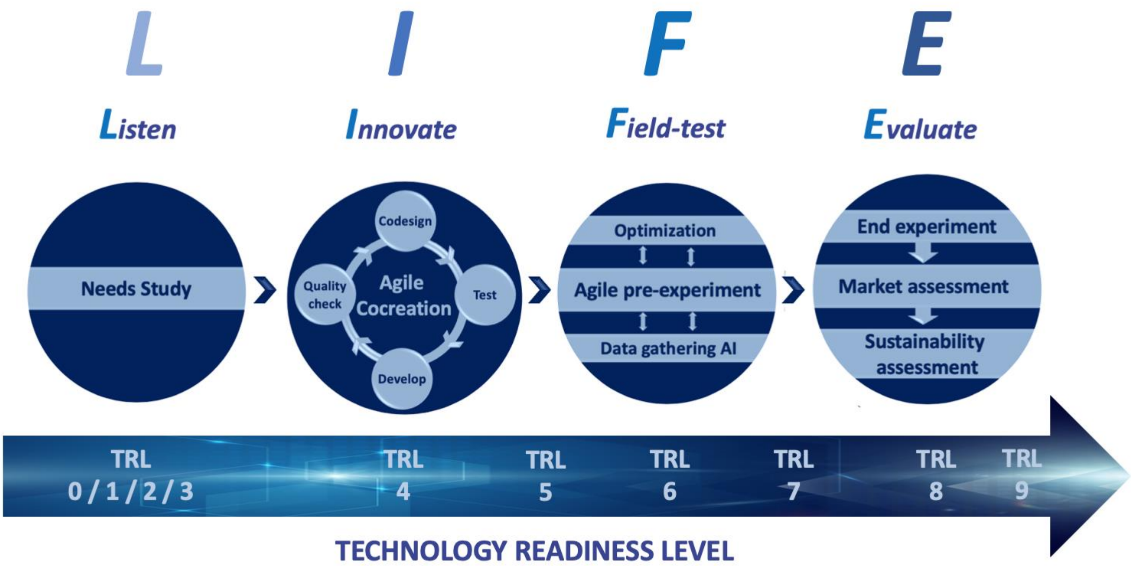
The robot should evolve significantly between each step…

- So that robot improvements are visible to end-users.
- So that each user test stage provides new lessons to further refine the robot's ergonomics and functions.

… to meet users' expectations better and better.

- Always focus on the most visible and important improvements from the users' point of view (main needs to be met, main barriers to overcome).

The LIFE methodology follows the technology readiness levels.



Technology Readiness Level	Topics for discussion and rating the current advancement
TRL 1	Basic principles observed
TRL 2	Technology concept formulated
TRL 3	Experimental proof of concept
TRL 4	Technology validated in lab
TRL 5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7	System prototype demonstration in operational environment
TRL 8	System complete and qualified
TRL 9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space

Time
&
Resources

✓ **Plan & allow enough time between the robot's test phases with the user.** (Reworking the robot and its functionalities between codesign sessions, optimization before the agile pre-experiment, finalization before the end experiment…)

✓ **Do not underestimate the resources required.**

Time and resources

For an **agile process,** the **development time** should be **short** in order to quickly propose the improvements required by users (especially during the agile cocreation process). **Resources** should be planned and organized accordingly.

Proximity

Many international or European projects integrate several countries and yet, to be agile, robots and users should be close.

2 KEY ADVANTAGES OF GEOGRAPHICAL PROXIMITY

❶ **Speed and flexibility of the meetings** gathering the robot and the users. That is key to test the robot quickly and regularly with users by limiting the cost of complex and expensive transportation of the robot across countries.

❷ Technicians and end-users **speak the same national language**.

Within the framework of international projects, proximity can be managed by carrying out the phases requiring the most agility (tests and agile pre-experiment) only in the countries developing the robot so that the engineers can quickly improve the robot as they learn from the tests and pre-experiments.

Further information

Thank you for your interest in the LIFE Methodology Handbook. Please check our website for more information on the LIFE methodology, an e-learning series, and access to the supplementary materials.

This handbook was initiated by the partners of the ACCRA project with the support of Harris Interactive Institute. This project has received funding from the European Union's Horizon 2020 research and innovation program and the NICT.

Curious about the robots we used in ACCRA? These YouTube videos might be interesting for you:

Buddy experience in France   Buddy experience in The Netherlands   ASTRO experience in Italy

References

Bardin, L. (2003). *L'analyse de contenu.* Paris : Presses Universitaire de France.

Bartneck, C., Croft, E., Kulic, D. & Zoghbi, S. (2009). Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots. *International Journal of Social Robotics*, 1(1), 71-81

Blanchet, A., & Gotman, A. (2001). *L'enquête et ses méthodes : l'entretien.*

Gavard-Perret, M.-L., Gotteland, D., Haon, C., & Jolibert, A. (2008). Méthodologie de la recherche. *Réussir son mémoire ou sa thèse en sciences de gestion.*

GRADE Working Group. (2004). Grading quality of evidence and strength of recommendations. BMJ, 328(7454), 1490-4.

Heerink, M., Kröse, B., Evers, V. et al. (2010). Assessing Acceptance of Assistive Social Agent Technology by Older Adults: the Almere Model. *International Journal of Social Robotics* 2, 361–375. https://doi.org/10.1007/s12369-010-0068-5

Jolibert, A., & Jourdan, P. (2006). *Marketing Research: méthodes de recherche et d'études en marketing*. Paris: Dunod.

Kidholm, K., Ekeland, A. G., Jensen, L. K., Rasmussen, J., Pedersen, C. D., Bowes, A., Flottorp, S. A., & Bech, M. (2012). A model for assessment of telemedicine applications: mast. International journal of technology assessment in health care, 28(1), 44–51. https://doi.org/10.1017/S0266462311000638.

Paillé, P., & Mucchielli, A. (2003). L'analyse qualitative en sciences sociales et humaines. *Armand Colin,* Paris.

Venkatesh, V., Morris, M.G., Davis, G. B. & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*. 27(3): 425–478.