Smart and adaptive interfaces for INCLUSIVE work environment

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Deliverable 2.1 - Summary of human model methodology to select operator grouped by tasks

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Executive Summary

This deliverable contains a methodology to group operators by their individual capabilities, creating user profiles for the human-machine interfaces. Thereby we consider profiles for each measurement dimension.

The a-priori measurement relates to the user's given and mostly static characteristics, which will be assessed beforehand and saved for the individual operator. With real-time profiling the operator's actual strain and emotional level, the system will be able to react to the user's needs within a few seconds after mental overload was detected. In the longitudinal profile, information about the operator's experience with regard to his/her task performance will be saved and used for continuous support via structure maps, e.g. during the whole time of employment.

In a first step, requirements will be discussed that are based on earlier results in the project. These consists in requirements of the target users and system requirements that were defined in Deliverable D1.1.

Relating to these requirements, we identifiy the profile parameters containing information about the required characteristics that sholud be met by the system as defined in D1.1. Furthermore, we develop clusters for each profile type, aiming at grouping target users and adapting the system towards one of the defined clusters. Therefore we either use established clusters or develop reasonable user groups. The respective degree of adaption and teaching will be defined later in the adaption/teaching module, based on findings of the laboratory investigations.

Moreover, we point out possible limitations, due to ethical, social and legal implications, before we provide alternate solution approaches to react to implementation barriers. Finally we give an overview of all user profile parameters and clusters.

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1 Introduction

To select an operator with regard to supporting her/him whilst working with the machines, information about her/his capabilities is required to adjust the degree of adaption and teaching given by the HMI. We use different types of user profiles to achieve this objective (see Figure 1). The a-priori profiling contains static user data that can be assessed “offline” in advance. The real-time profile uses “online” strain data for real-time support of the operator. The longitudinal user profile creates a performance based HMI profile to support the operator in long term.

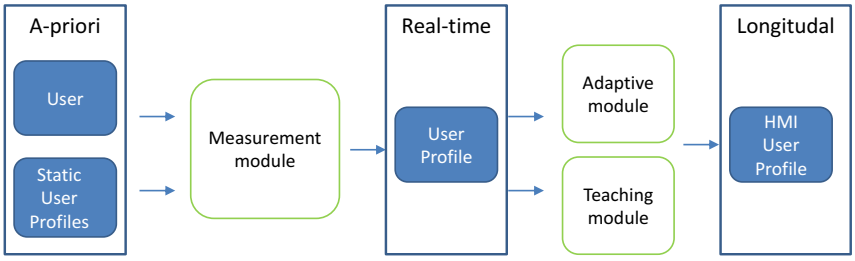

Figure 1: Different types of user profiles according to system architecture

To briefly describe each profiling type, requirements need to be defined regarding the user and the system. This will be done in the following sections. In the next step, we design each user profile type in detail, describing and clustering each belonging parameter, before we discuss possible limitations for implementation derived, e.g. from legal or social implications.

2 Requirements for user profiles

In the following we will describe requirements with regard to designing user profiles which can be derived from target users of the INCLUSIVE system and the system itself.

2.1 Requirements regarding target users

The INCLUSIVE approach aims at compensating workers limitations due to their capabilities (discussed in Deliverable D2.2) while taking advantage of their experience. Specifically, there are three main user groups (elderly, disabled, inexperienced) we will focus on in the project. Table 1 summarizes characteristics of each user group.

Table 1: Target user characteristics (see Deliverable D1.1)

Group 1: Elderly	Group 2: Disabled	Group 3: Inexperienced

• Changes in psychical + physical conditions
  ○ Perception
  ○ Cognition
  ○ Action
• High experience
• Lower affinity towards modern computerized devices
	• Disabilities of upper limps
	• Blindness
	• Deafness
	• Cognitive disabled
	• illiterate
		• Low level of education
		• Lack of experience in industrial processes
		• Higher affinity towards modern computerized devices

Focus on information processing	**Focus on (?) information processing & training**	**Focus on training**

Group 1 is mainly characterized by changes in capabilities due to aging processes of information processing, which therefore lead to limitations in perception, cognition and action. These changes are important to know, before designing static user profiles in the adaption module. In addition this kind of users are likely to have high working experience, but lower affinity towards computerised devices, addressed in the INCLUSIVE project, resulting in difficulties in utilizing modern automated machines that come with complex HMIs. All these characteristics may lead to a higher mental strain during task execution. Therefore the focus of implementation of the INCLUSIVE system should lie on information processing together with technical support, dependent on specific use case requirements.

Group 2 consists of disabled users with physical impairments or limited cognitive abilities, e.g. disabilities of the upper limbs, impairments in perception or cognitive disabilities. The resulting limitations introduce difficulties in handling complex machine HMIs self-sufficient without any support given. Depending on the individual operator, the INCLUSIVE system should support information processing as well as individual initial training.

The third group includes persons at the beginning of their working life, who might have low education, limited experience in industrial processes and limited expertise in the use of automated machines and computerized HMIs. The developed system should give them support especially in training issues.

User profiles designed for the INCLUSIVE system will consider these characteristics for supporting capabilities of the target users a-priori, which will be described in Section 3.1.

2.2 Requirements regarding the INCLUSIVE system

Moreover, according to requirements definition done in Deliverable D1.1 (see Appendix A, B, C) the system should be able to meet the following aspects:

[R1] The interface adapts to the level of **skills** of the operator
[R2] The system can be used by low **educated** operators
[R3] The system can be used by **physically and cognitively impaired** operators
[R4] The system can be used by people with low **computer skills**
[R5] The system enforces the **correct procedures**
[R6] The operator feels **satisfied** from the interaction experience
[R7] Interaction with the system generates a low level of **stress** for the operators

The following Table 2 summarizes how the INCLUSIVE system will meet system requirements according to Deliverable D1.1:

Table 2: System requirements per use case

	Use case 1	Use case 2	Use case 3
R1	The level of experience of the operators will be assessed, measuring their performance while executing tuning operations on the woodworking machines, and when executing routine maintenance operations.	The level of experience of the operators will be assessed, measuring their performance while controlling a robot to bend a standard metal part, and when replacing a malfunctioning tool.	The level of experience of the operators will be assessed, measuring their performance while performing changeover of the format parts required by the individual containers, and while performing fault recovery procedures.
R2	The level of education of the operators will be assessed based on prior information		
R3	For each operator, the presence of severed or missing fingers will be assessed based on prior information.	For each operator, blindness or deafness will be assessed based on prior information. The INCLUSIVE system will also evaluate, off-line, the level of the blindness or deafness	none
R4	The level of computer skills of the operators will be assessed using an off-line tool.		
R5	Correctness of the procedures will be assessed measuring the execution time, and the kind of errors that are made by the operators		
R6	The satisfaction of the operators will be assessed using questionnaires to collect data from the operators after the execution of tuning operations on the woodworking machines, and of routine maintenance operations		

R7	The cognitive workload of the operators will be assessed, based on measurements of physiological indicators taken while executing tuning operations on the woodworking machines, and when executing routine maintenance operations. These measurements will be complemented by data collected with questionnaires, to assess the overall stress level, both on-line and off-line

2.2.1 Overview requirements regarding types of user profiles

The above mentioned system requirements will be met by user profiles, as Table 3 shows:

Table 3: How user profiles meet system requirements

	Static user profile (A-priori)	Dynamic user profile (real-time)	HMI user profile (longitudinal)
[R1] experience	x (?)		x
[R2] education	x		
[R3] impairments	x		
[R4] computer skills	x		
[R5] correctness of procedures			x
[R6] satisfaction		x	
[R7] cognitive workload		x	

3 User profiles

3.1 Static user profiles (a-priori)

The static user profile includes “unchanging” attributes, such as constitutional characteristics (age, gender, etc.) or learned capabilities respective knowledge.

Static variables are:

- age
- education
- impairments
- computer skills
- language

These will be described in detail for implementing user profiles in the following.

3.1.1 Age

With age several changes in physical conditions occur that are central influencing factors for human-machine interaction, since information processing capabilities are different due to changes in perception, cognition and action. The main changes in physical conditions due to aging and the beginning age are shown in Table 4:

Table 4: Changes in physical conditions due to age

Condition	Changes	Age	Literature
Visual Perception	Accomodation	50 years	Grandjean (1986)
	Light sensitivity		Mayer et al. (1988)
	Colour perception	30 – 80 years (55 years)	Helve & Krause (1972), Schieber (2005)
	Contrast	20-80 years (50 years)	Guski (1996); Owsley (1983)
	Visual acuity	60 years	Bouwhous (1992)
	Object extraction		Park & McLaughlin (2011)
	Field of vision	60 years	Collins et al. (1989)
	Depth perception	40 - 60 years	Mouroloulis (1999)
Auditory	Auditory acuity	30 – 40 years	Forzad (1990), Kline (1996)

perception	Frequency	50 years	Schieber (1992)
	Spatial perception		Kline (1996)
	Speech decoding		Guski (1996)
Haptic perception	Pressure, touch	30 years	Bartlett et al. (1998), Saup (1993)
	Vibration	60 years	Charness et al. (2012)
Cognition	Working memory	60 - 70 years	Fleischmann (1989)
	Episodic memory		Zacks 2000
	Learning	50 years	Schaie & Willis (2010), Baltes et al. (1998), Park et al. (1997)
	Reaction	20-60 years (40years)	Vercruyssen (1993)
	Focused attention	For complex tasks	McDowd & Shaw (2000)
	Divided attention	For complex tasks	McDowd & Shaw (2000)
	Selective attention	For complex tasks	Olbrich (1990)
	Fluide intelligence	30 years	Horn (1982)
Action	Strength	30 years	Poljakov (1991)
	Mobility of upper limps	60 years	Hackel et al. (1992)
	precision		Smith et al. (1999)

Regarding the ages of changes in physical conditions, two main ages can be identified when people's capabilities start to impair according to literature:

- At the age of 30 to 40 auditory perception, haptic perception, fluid intelligence and muscle strength start to decrease
- At the age of 50 to 60 visual perception, auditory frequency perception and vibration perception memory and learning worsen, the mobility of the upper limps becomes impaired

Therefore, users can be clustered by age in three groups (Table 5):

Table 5: Age clusters

Clusters	Adaption/teaching level
x < 30 years	None – low

31 years < x < 50 years	Medium
x > 50 years	High

The here shown degree of adaption and teaching level (2nd column of Table 5) will be concretised in the adaption and teaching module.

3.1.2 Education

As system requires the user's education will be assessed based on prior information. This will be done by the ISCED Standard Classification, which gives six education levels, as Table 6 shows. The education level ranges from level 0, which corresponds to children's education level to level 6, which describes tertiary education level, for example a doctor's degree.

Table 6: International Standard Classification of Education ISCED 1997

Level	Description	Characteristics	Criteria
0	Pre-primary education	Initial stage of organized instruction, designed primarily to introduce very young children to a school-type environment, i .e. to provide a bridge between the home and a school-based atmosphere.	school or centre based; the minimum age of the children catered for; and the upper age limit of the children.
1	Primary education or first stage of basic education	Normally starting between the ages of 5 - 7, designed to give a sound basic education in reading, writing and mathematics along with an elementary understanding of other subjects.	the beginning of systematic studies characteristic of primary education, e.g. reading, writing and mathematics. entry into the nationally designated primary institutions or programmes; and the start of compulsory education where it exists.
2	Lower secondary education or second stage of basic education	Designed to complete basic education, usually on a more subject-oriented pattern. It builds upon the learning outcomes from primary education (ISCED level 1) and aims to lay the foundation for lifelong learning and human development.	the beginning of subject presentation using more qualified teachers than for level 1; and full implementation of basic skills and foundation for lifelong learning. entry is after some 6 years of primary education
3	Upper secondary education	More specialized education typically beginning at age 15 or 16 years and/or completes secondary education in preparation for tertiary education, or to provide skills relevant to employment, or both.	the typical entrance qualifications (some nine years of full-time education since the beginning of level 1 the minimum entrance requirements (usually the

			completion of level 2)
4	Post-secondary non-tertiary education	Programmes that straddle the boundary between upper- and post-secondary education from an international point of view. ISCED level 4 programmes, considering their content, cannot be regarded as tertiary programmes. They are often not significantly more advanced than programmes at ISCED level 3 but they serve to broaden the knowledge of participants who have already completed a programme at level 3.	It requires as a rule the successful completion of level 3, i.e. successful completion of any programme at level 3A or 3B, or, for 3C programmes, a cumulative theoretical duration of typically 3 years at least.
5	First stage of tertiary education	Tertiary programmes having an educational content more advanced than those offered at ISCED levels 3 and 4. These programmes may be academically based or practically oriented / occupationally specific. Entry to these programmes normally requires the successful completion of ISCED level 3A or 3B or a similar qualification at ISCED level 4A. All degrees and qualifications are cross-classified by type of programmes, position in national degree or qualification structures and cumulative duration at tertiary.	normally the minimum entrance requirement to this level is the successful completion of ISCED level 3A or 3B or ISCED level 4A; level 5 programmes do not lead directly to the award of an advanced research qualification (level 6); and these programmes must have a cumulative theoretical duration of at least 2 years from the beginning of level 5
6	Second stage of tertiary education (advanced research education)	Tertiary programmes leading to the award of an advanced research qualification, e.g. Ph.D. T hese programmes are therefore devoted to advanced study and original research and are not based on course-work only. It typically requires the submission of a thesis or dissertation of publishable quality which is the product of original research and represents a significant contribution to knowledge.	It typically requires the submission of a thesis or dissertation of publishable quality which is the product of original research and represents a significant contribution to knowledge.

Since machine operators usually went through basic education level and are not required to have any advanced research education, the user profile can be grouped as follows:

Table 7: Education clusters

Clusters	Adaption/teaching level
Level 2	Very high
Level 3	High
Level 4	Medium
Level 5	None – low

The here shown degree of adaption and teaching level (2nd column of Table 7) will be concretised in the adaption and teaching module.

3.1.3 Impairments

Moreover the static user profiles will include several impairments of operators within the use cases. According to Deliverable D1.1 mainly persons with the following impairments will be considered (Table 8):

Table 8: Impairment clusters

Clusters	Adaption/teaching level
Disabilities of upper limbs	Adaption of action
Blindness	Adaption of perception (auditory)
Deafness	Adaption of perception (visual)
Cognitive disabilities	Adaption of information processing + teaching

The here shown degree of adaption and teaching level (2nd column of Table 8) will be concretised in the adaption and teaching module.

3.1.4 Computer skills

As defined in system requirements the operator's computer skills will be assessed to adapt the system towards individual capabilities. According to the OECD[1] international research study[2], computer skills can be divided into four levels, as described in Table 9, which also will be used for clustering (Table 10):

Table 9: Computer skills

Level	Description
Below Level 1	Tasks are based on well-defined problems involving the use of only one function within a generic interface to meet one explicit criterion without any categorical or inferential reasoning, or transforming of information. Few steps are required and no sub-goal has to be generated. E.g.: Delete an email message.
Level 1	Tasks typically require the use of widely available and familiar technology applications, such as email software or a web browser. There is little or no navigation required to access the information or commands required to solve the problem. The problem may be solved regardless of the respondent's awareness and use of specific tools and functions (e.g. a sort function). The tasks involve few steps and a minimal number of operators. At the cognitive level, the respondent can readily infer the goal from the task statement; problem resolution requires the respondent to apply explicit criteria; and there are few monitoring demands (e.g. the respondent does not have to check whether he or she has used the appropriate procedure or made progress towards the solution). Identifying content and operators can be done through simple match. Only simple forms of reasoning, such as assigning items to categories, are required; there is no need to contrast or integrate information. E.g.: Find all emails from a specific person.
Level 2	At this level, tasks typically require the use of both generic and more specific technology applications. For instance, the respondent may have to make use of a novel online form. Some navigation across pages and applications is required to solve the problem. The use of tools (e.g. a sort function) can facilitate the resolution of the problem. The task may involve multiple steps and operators. The goal of the problem may have to be defined by the respondent, though the criteria to be met are explicit. There are higher monitoring demands. Some unexpected outcomes or impasses may appear. The task may require

[1] Organisation of Economic Co-operation and Development
[2] https://www.nngroup.com/articles/computer-skill-levels/ (access: July 19th 2017)

	evaluating the relevance of a set of items to discard distractors. Some integration and inferential reasoning may be needed. E.g.: You want to find a sustainability-related document that was sent to you by a specific person in October last year.
Level 3	At this level, tasks typically require the use of both generic and more specific technology applications. Some navigation across pages and applications is required to solve the problem. The use of tools (e.g. a sort function) is required to make progress towards the solution. The task may involve multiple steps and operators. The goal of the problem may have to be defined by the respondent, and the criteria to be met may or may not be explicit. There are typically high monitoring demands. Unexpected outcomes and impasses are likely to occur. The task may require evaluating the relevance and reliability of information in order to discard distractors. Integration and inferential reasoning may be needed to a large extent. E.g.: You want to know what percentage of the emails sent by a specific person last month were about sustainability.

Table 10: Computer skills clusters

Clusters	Adaption/teaching level
Below Level 1	Very high
Level 1	High
Level 2	Medium
Level 3	None – low

The here shown degree of adaption and teaching level (2nd column of Table 10) will be concretised in the adaption and teaching module.

3.1.5 Overview static user profile clusters

In this section we provide a summary of the clusters of the static user profiles (see Table 11).

Table 11: Summary of static user profiles

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Age	<= 30 years	31 – 50 years	> 51 years	
Education	Level 2	Level 3	Level 4	Level 5
Impairments	Upper limbs	Blindness	Deafness	Cognitive disabilities
Computer skills	Below level 1	Level 1	Level 2	Level 3

3.2 Dynamic user profiles (real-time)

The dynamic user profile includes real-time strain measurement data representing the actual "online" manipulated variable for adaption and teaching module. Depending on the actual user's strain level, the system can adapt towards the user's needs during machine operations.

The measurements will be conducted via analysis of physiological indicators, such as heart rate, skin conductance, pupil diameter, gaze data, cerebral activity and skin temperature as discussed in Deliverable D2.2.

The provided data will be saved temporarily during the machine operation and only be used for "online" adaption. Therefore we define clusters regarding the level of real-time adaption and teaching. Table 12 shows an example for a possible clustering for the user's strain.

Table 12: Clusters of dynamic user profiles

Clusters	Adaption/teaching level
No strain (base line)	No real-time adaption
Low strain	Low real-time adaption
Medium strain	Medium real-time adaption
High strain	High real-time adaption
Very high strain	System stops

The interpretation of the degree of strain (1st column of Table 12) belonging to one cluster, will be done after analyzing the laboratory studies results.

The here shown degree of adaption and teaching level (2nd column of Table 12) will be concretised in the adaption and teaching module.

Moreover, if possible the system will access the user's emotional status in real-time using speech input of the operator. The system will then also adapt to the measured actual emotional state.

3.3 HMI user profiles (longitudinal)

The longitudinal user profile contains information about the task performance of the user. The data can be used to develop structural knowledge maps of each operator, e.g. regarding her/his training evolution. Moreover, the user will be supported by the adaption and teaching module dependent on her/his level of experience that will be derived from performance indicators, such as execution time, steps, mistakes and redundancies.

The degree of experience of an operator can be derived from Table 13. The interpretation of performance indicators concerning the experience levels, e.g. number of mistakes characterizing a beginner level, will be done within the laboratory investigations based on the received results.

Table 13: Experience level description

Level	Description
No experience	No knowledge or experience of a particular thing.
Beginner	At the beginning of learning a skill or taking part in an activity. Already achieved fundamental skills necessary for position.
Intermediate	Advanced skills that allow employee to adapt and meet some complex or non-routine situations.
Advanced	Highly proficient and specialized skills that allow employee to function in situations that are varied, complex, and/or non-routine.
Expert	Comprehensive and authoritative knowledge of or skill in a particular field.

To consider the whole target group, the operator's experience can reach from "no experience" to "expert", as Table 14 shows.

Table 14: Experience clusters

Clusters	Adaption/teaching level
No experience	Very high

Beginner	High level
Intermediate	Medium level
Advanced	Low level
Expert	None

The here shown degree of adaption and teaching level (2nd column of Table 14) will be concretised in the adaption and teaching module.

3.4 Limitations

Implementing user profiles as described above, can be critical especially regarding the user's health records. The main limitations for the implementation can be derived from the ELSI[3]-analysis which was conducted and documented in Deliverable D1.2. The resulting relevant ELSI design recommendations (DR) for user profiling are:

- [DR2] The system considers anonymized personal data
- [DR3] The system uses collected data not for any disadvantage for the employee
- [DR4] The system depicts relevant user requirements and prevents discrimination

These requirements should be paid special attention to and have been addressed in Deliverables D10.1 and D10.2, where it has been discussed how the INCLUSIVE system will deal with anonymized data to protect privacy and prevent stigmatization.

These requirements should be paid special attention to and treated case-by-case, since law regulations are not similar in all project partner's countries.

A possible solution approach is to define different scenarios for different degrees of profiling. E.g.:

Scenario 1: User profile is saved by the system

In this scenario the operator's profile is known to the machine, meaning the a-priori and longitudinal data can be used for the operator's support. The user profile can either contain the full amount of user data, or consist of a reduced number of item, if the use case requires. In this case a detailed a-priori assessment regarding capabilities can be conducted and saved for each operator. Moreover, the performance evolution is assessed in the longitudinal user profile.

Scenario 2: User profile is not saved by the system

The second scenario implies that data storage of the user profile is impossible or unintended. In this case neither the a-priori data, nor the longitudinal data will be saved. Meaning, in this situation there is no access to comprehensive user capabilities data. A short questioning about the most important user characteristics before each operation can be used to adapt the machine towards the user's capabilities.

[3] Ethical, social and legal implications

4 Methodology to select operator grouped by tasks

The here provided approach for developing user profiles aims at simplifying individual characteristics by using user groups for the adaption and teaching implementation. Each user's characteristics that is given here, was derived from system requirements that were defined in advance. The provided clusters were built to support users with comparable characteristics in a similar way. The numerical interpretation of the non-static clusters, such as strain, emotion and experience will be done after analysing the laboratory study results, in which we will define a reasonable classification. In this regard, the following Table 15 summarizes the methodology to select an operator grouped by task:

Table 15: Methodology to select an operator grouped by task

		Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
A-priori	Age	x < 30 years	31 years < x < 50 years	X > 50 years		
	Education	Level 2	Level 3	Level 4	Level 5	
	Impairments	Disabilities of upper limbs	Blindness	Deafness	Cognitive disabilities	
	Computer skills	Below level 1	Level 1	Level 2	Level 3	
Real-time	Strain	No strain	Low strain	Medium strain	High strain	Very high strain
	Emotion	Tba, e.g.: fear, satisfaction, joy, happiness				
Longitudinal	Experience	No experience	Beginner	Intermediate	Advanced	Expert

5 Summary

This deliverable provides a methodology to select operators grouped by task by means of user profiles. This methodology has been derived from earlier defined requirements regarding the target user groups and the INCLUSIVE system with respect to the INCLUSIVE use cases.

According to the three measurement module dimensions (a-priori, real-time, longitudinal), we developed user profiles for each type of dimension, referring to characteristics of each user group, in particular to elderly, impaired and inexperienced operators.

The here developed capabilities clusters, will be evaluated in the laboratory investigations, and will be basis for the subsequent development of the adaption and teaching module.

6 Annexes

APPENDIX A – System requirements for use case 1: woodworking machine by SCM

			R1	R2	R3	R4	R5	R6	R7
			The interface adapts to the level of skills of the operator	The system can be used by low educated operators	The system can be used by physically and cognitively impaired operators	The system can be used by people with low computer skills	The system enforces the correct procedures	The operator feels satisfied from the interaction experience	Interaction with the system generates a low level of stress for the operators
USE CASE 1	1.1	The system should provide guided procedures for ordinary maintenance	X				X		X
	1.2	The virtual tool store should correctly represent the physical tool store					X		X
	1.3	The system should guide the operator in the setup of the working area	X				X		X
	1.4	Studying the manual should not be necessary	X	X	X		X	X	
	1.5	The system should be effectively usable by inexperienced operators	X					X	X
	1.6	Procedures should adapt to the operator's skills	X			X		X	X
	1.7	Portable interfaces should be available, to guide the operators in the working area			X		X	X	
	1.8	The system should be usable by operators with different age	X			X			
	1.9	The system should be usable by operators with different level of work experience	X				X		
	1.10	The system should be usable by operators with physical impairments			X			X	
	1.11	The execution time should be improved						X	X
	1.12	The number of errors should be reduced						X	X

APPENDIX C – System requirements for use case 2: robotic cell by GIZELIS

			R1	R2	R3	R4	R5	R6	R7
			The interface adapts to the level of skills of the operator	The system can be used by low educated operators	The system can be used by physically and cognitively impaired operators	The system can be used by people with low computer skills	The system enforces the correct procedures	The operator feels satisfied from the interaction experience	Interaction with the system generates a low level of stress for the operators
USE CASE 2	2.1	The system should be usable by low educated operators		X		X			
	2.2	Programming by code writing should not be necessary		X		X			
	2.3	Choice of the wrong tools should be prevented	X				X		
	2.4	Choice of the wrong material thickness should be prevented	X				X		
	2.5	The correct value of the air pressure should be automatically selected	X				X		
	2.6	The system should be usable for physically impaired people			X			X	
	2.7	Problem solving should be possible also for unskilled operators	X		X		X		
	2.8	The system should guide the operator according to common practice solutions	X			X	X		
	2.9	The system should suggest the operator what parameters need to be changed, based on the desired result	X	X			X		X

APPENDIX B – System requirements for use case 3: production line by KHS

			R1	R2	R3	R4	R5	R6	R7
			The interface adapts to the level of skills of the operator	The system can be used by low educated operators	The system can be used by physically and cognitively impaired operators	The system can be used by people with low computer skills	The system enforces the correct procedures	The operator feels satisfied from the interaction experience	Interaction with the system generates a low level of stress for the operators
USE CASE 3	3.1	Specific prior training should not be necessary	X				X		
	3.2	The system should be comfortable for all the users	X	X	X	X		X	X
	3.3	Operators should feel confident when using the system					X	X	X
	3.4	The presence of supervisors should be avoided					X		X
	3.5	Operations should be performed in the correct sequence, according to the manual					X		
	3.6	The correct operational mode should be selected					X		
	3.7	The system should be usable by inexpert operators, or with a low education level	X	X					
	3.8	The stress level during the use of the system should be low							X
	3.9	Hands-free interaction should be possible			X				